BS EN 61217:2012

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Radiotherapy equipment — Coordinates, movements and scales

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National foreword

This British Standard is the UK implementation of EN 61217:2012. It is identical to IEC 61217:2011. It supersedes BS EN 61217:1996+A2:2008, which will be withdrawn on 11 January 2015.

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CENELEC

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Foreword

The text of document 62C/530/FDIS, future edition 2 of IEC 61217, prepared by SC 62C, "Equipment for radiotherapy, nuclear medicine and radiation dosimetry", of IEC/TC 62, "Electrical equipment in medical practice" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61217:2012.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2012-10-11
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2015-01-11

This document supersedes EN 61217:1996 + A1:2001 + A2:2008.

EN 61217:2012 constitutes a technical revision to include imager and focus coordinate systems in 3.12. Beyond this subclause, changes were only introduced where needed to include the above coordinate systems.

In this standard, the following print types are used:

– Requirements and definitions: roman type.

– *Test specifications: italic type.*

– Informative material appearing outside of tables, such as notes, examples and references: in smaller type. Normative text of tables is also in a smaller type.

– TERMS USED THROUGHOUT THIS STANDARD THAT HAVE BEEN LISTED IN THE INDEX OF DEFINED TERMS: SMALL CAPITALS.

The verbal forms used in this standard conform to usage described in Annex H of the ISO/IEC Directives, Part 2. For the purposes of this standard, the auxiliary verb:

– “shall” means that compliance with a requirement or a test is mandatory for compliance with this standard;

– “should” means that compliance with a requirement or a test is recommended but is not mandatory for compliance with this standard;

– “may” is used to describe a permissible way to achieve compliance with a requirement or test.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive(s) see informative Annex ZZ, which is an integral part of this document.

Endorsement notice

The text of the International Standard IEC 61217:2011 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60976:2007	NOTE	Harmonized as EN 60976:2007 (not modified).
IEC 61168:1993	NOTE	Harmonized as EN 61168:1994 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60601-1 + corr. December + corr. December	2005 2006 2007	Medical electrical equipment - Part 1: General requirements for basic safety and essential performance	EN 60601-1 + corr. March + A11	2006 2010 2011
IEC 60601-1-3	2008	Medical electrical equipment - Part 1-3: General requirements for basic safety and essential performance - Collateral Standard: Radiation protection in diagnostic X-ray equipment	EN 60601-1-3 + corr. March	2008 2010
IEC 60601-2-1	2009	Medical electrical equipment - Part 2-1: Particular requirements for the basic safety and essential performance of electron accelerators in the range 1 MeV to 50 MeV	EN 60601-2-1	201X[1)]
IEC 60601-2-11	1997	Medical electrical equipment - Part 2-11: Particular requirements for the safety of gamma beam therapy equipment	EN 60601-2-11	1997
IEC 60601-2-29	2008	Medical electrical equipment - Part 2-29: Particular requirements for the basic safety and essential performance of radiotherapy simulators	EN 60601-2-29 + A11	2008 2011
IEC/TR 60788	2004	Medical electrical equipment - Glossary of defined terms	-	-
IEC 62083	2009	Medical electrical equipment - Requirements for the safety of radiotherapy treatment planning systems	EN 62083	2009

1) To be published.

Annex ZZ
(informative)

Coverage of Essential Requirements of EU Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers the relevant essential requirements as given in Annex I of the EC Directive 93/42/EEC for ERs 9.1 and 11.2.1 last sentence only.

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive concerned.

WARNING: Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

CONTENTS

INTRODUCTION 8
1 Scope and object 10
2 Normative references 10
3 Coordinate systems 10
3.1 General 10
3.2 General rules 11
3.3 Fixed reference system ("f") (Figure 1a) 12
3.4 GANTRY coordinate system ("g") (Figure 4) 12
3.5 BEAM LIMITING DEVICE or DELINEATOR coordinate system ("b") (Figure 5) 13
3.6 WEDGE FILTER coordinate system ("w") (Figure 7) 13
3.7 X-RAY IMAGE RECEPTOR coordinate system ("r") (Figures 6 and 8) 14
3.8 PATIENT SUPPORT coordinate system ("s") (Figure 9) 14
3.9 Table top eccentric rotation coordinate system ("e") (Figures 10 and 11) 15
3.10 Table top coordinate system ("t") (Figures 10, 11, 18 and 19) 15
3.11 PATIENT coordinate system ("p") (Figures 17a and 17b) 16
3.12 Imager coordinate system ("i") and focus coordinate system ("o") 17
3.12.1 General 17
3.12.2 The imager coordinate system ("i") 17
3.12.3 Focus coordinate system ("o") 18
4 Identification of scales and digital DISPLAYS 18
5 Designation of ME EQUIPMENT movements 19
6 ME EQUIPMENT zero positions 19
7 List of scales, graduations, directions and DISPLAYS 20
7.1 General 20
7.2 Rotation of the GANTRY (Figures 14a and 14b) 20
7.3 Rotation of the BEAM LIMITING DEVICE or DELINEATOR (Figures 15a and 15b) 20
7.4 Rotation of the WEDGE FILTER (Figures 7 and 14a) 20
7.5 RADIATION FIELD or DELINEATED RADIATION FIELD 21
7.5.1 General 21
7.5.2 Edges of RADIATION FIELD or DELINEATED RADIATION FIELD (Figure 16a) 21
7.5.3 DISPLAY of RADIATION FIELD or DELINEATED RADIATION FIELD (Figures 16a to 16k) 22
7.6 PATIENT SUPPORT isocentric rotation 23
7.7 Table top eccentric rotation 23
7.8 Table top linear and angular movements 24
7.8.1 Vertical displacement of the table top 24
7.8.2 Longitudinal displacement of the table top 24
7.8.3 Lateral displacement of the table top 24
7.8.4 Pitch of the table top 24
7.8.5 Roll of the table top 24
7.9 X-RAY IMAGE RECEPTOR movements 24
7.9.1 X-RAY IMAGE RECEPTOR rotation 24
7.9.2 X-RAY IMAGE RECEPTOR radial displacement from RADIATION SOURCE (SID) 25
7.9.3 X-RAY IMAGE RECEPTOR radial displacement from ISOCENTRE 25

7.9.4 X-RAY IMAGE RECEPTOR longitudinal displacement 25
7.9.5 X-RAY IMAGE RECEPTOR lateral displacement 25
7.10 Other scales 25
Annex A (informative) Examples of coordinate transformations between individual coordinate systems 57
Annex B (informative) Coordinate transformations between IEC and DICOM PATIENT coordinates 64
Bibliography 65
Index of defined terms 66

Figure 1a – Coordinate systems for an isocentric RADIOTHERAPY EQUIPMENT (see 3.1) with all angular positions set to zero 27
Figure 1b – Translation of origin Id along Xm, Ym, Zm and rotation around axis Zd parallel to Zm (see 3.2d)) 28
Figure 1c – Translation of origin Id along Xm, Ym, Zm and rotation around axis Yd parallel to Ym (see 3.2d)) 28
Figure 2 – X Y Z right-hand coordinate mother system (isometric drawing) showing ψ, φ, θ directions of positive rotation for daughter system (see 3.2a)) 29
Figure 3 – Hierarchical structure among coordinate systems (see 3.2c) and 3.2e)) 30
Figure 4 – Rotation (φg = 15°) of GANTRY coordinate system Xg, Yg, Zg in fixed coordinate system Xf, Yf, Zf (see 3.4) 31
Figure 5 – Rotation (θb = 15°) of BEAM LIMITING DEVICE or DELINEATOR coordinate system Xb, Yb, Zb in GANTRY coordinate system Xg, Yg, Zg, and resultant rotation of RADIATION FIELD or DELINEATED RADIATION FIELD of dimensions FX and FY (see 3.5) 32
Figure 6 – Displacement of image intensifier type X-RAY IMAGE RECEPTOR coordinate system origin, Ir, in GANTRY coordinate system, by Rx = –8, Ry = +10, Rz = –40 (see 3.7) 33
Figure 7 – Rotation (θw = 270°) and translation of WEDGE FILTER coordinate system Xw, Yw, Zw in BEAM LIMITING DEVICE coordinate system Xb, Yb, Zb, the BEAM LIMITING DEVICE coordinate system having a rotation θb = 345° (see 3.6) 34
Figure 8 – Rotation (θr = 90°) and displacement of X-RAYIMAGE RECEPTOR coordinate system Xr, Yr, Zr in GANTRY coordinate system Xg, Yg, Zg (see 3.7) 35
Figure 9 – Rotation (θs = 345°) of PATIENT SUPPORT coordinate system Xs, Ys, Zs in fixed coordinate system Xf, Yf, Zf (see 3.8) 36
Figure 10 – Table top eccentric coordinate system rotation θe in PATIENT SUPPORT coordinate system which has been rotated by θs in the fixed coordinate system with θe = 360° – θs (see 3.9 and 3.10) 37
Figure 11a – Table top displaced below ISOCENTRE by Tz = –20 cm (see 3.9 and 3.10) 37
Figure 11b – Table top coordinate system displacement Tx = + 5, Ty = Le + 10 in PATIENT SUPPORT coordinate system Xs, Ys, Zs rotation (θs = 330°) in fixed coordinate system Xf, Yf, Zf (see 3.9 and 3.10) 38
Figure 11c – Table top coordinate system rotation (θe = 30°) about table top eccentric system. PATIENT SUPPORT rotation (θs = 330°) in fixed coordinate system Tx = 0, Ty = Le (see 3.9 and 3.10) 38
Figure 12a – Example of BEAM LIMITING DEVICE scale, pointer on mother system (GANTRY), scale on daughter system (BEAM LIMITING DEVICE), viewed from ISOCENTRE (see 3.2f)2) and Clause 4) 39
Figure 12b – Example of BEAM LIMITING DEVICE scale, pointer on daughter system (BEAM LIMITING DEVICE), scale on mother system (GANTRY), viewed from ISOCENTRE (see 3.2f)2) and Clause 4) 40

Figure 12c – Examples of scales (see Clause 4) 40
Figure 13a – Rotary GANTRY (adapted from IEC 60601-2-1) with identification of axes 1 to 8, directions 9 to 13, and dimensions 14 and 15 (see Clause 5) 41
Figure 13b – ISOCENTRIC RADIOTHERAPY SIMULATOR or TELERADIOTHERAPY EQUIPMENT, with identification of axes 1; 4 to 6; 19, of directions 9 to 12; 16 to 18 and of dimensions 14; 15 (see Clause 5) 42
Figure 13c – View from radiation source of teleradiotherapy radiation field or radiotherapy simulator delineated radiation field (see Clause 5) 43
Figure 14a – Example of ISOCENTRIC TELERADIOTHERAPY EQUIPMENT (see 7.2 and 7.4) 44
Figure 14b – Example of ISOCENTRIC RADIOTHERAPY SIMULATOR equipment (see 7.2) 45
Figure 15a – Rotated (θb = 30°) symmetrical rectangular RADIATION FIELD (FX × FY) at NORMAL TREATMENT DISTANCE, viewed from ISOCENTRE looking toward RADIATION SOURCE (see 7.3) 46
Figure 15b – Same rotated (θb = 30°) symmetrical rectangular RADIATION FIELD (FX × FY) at NORMAL TREATMENT DISTANCE, viewed from RADIATION SOURCE (see 7.3) 46
Figure 16a – Rectangular and symmetrical RADIATION FIELD or DELINEATED RADIATION FIELD, viewed from RADIATION SOURCE (see 7.5) 47
Figure 16b – Rectangular and asymmetrical in Yb RADIATION FIELD or DELINEATED RADIATION FIELD, viewed from RADIATION SOURCE (see 7.5) 47
Figure 16c – Rectangular and asymmetrical in Xb RADIATION FIELD or DELINEATED RADIATION FIELD, viewed from RADIATION SOURCE (see 7.5) 48
Figure 16d – Rectangular and asymmetrical in Xb and Yb RADIATION FIELD or DELINEATED RADIATION FIELD, viewed from RADIATION SOURCE (see 7.5) 48
Figure 16e – Rectangular and symmetrical RADIATION FIELD, rotated by θb = 30°, viewed from RADIATION SOURCE (see 7.5) 49
Figure 16f – Rectangular and asymmetrical in Yb RADIATION FIELD, rotated by θb = 30°, viewed from RADIATION SOURCE (see 7.5) 49
Figure 16g – Rectangular and asymmetrical in Xb RADIATION FIELD, rotated by θb = 30°, viewed from RADIATION SOURCE (see 7.5) 50
Figure 16h – Rectangular and asymmetrical in Xb and Yb RADIATION FIELD, rotated by θb = 30°, viewed from RADIATION SOURCE (see 7.5) 51
Figure 16i – Irregular multi-element (multileaf) contiguous RADIATION FIELD, viewed from RADIATION SOURCE, with element motion in Xb direction (see 7.5) 52
Figure 16j – Irregular multi-element (multileaf) two-part RADIATION FIELD, viewed from RADIATION SOURCE, with element motion in Xb direction (see 7.5) 53
Figure 16k – Irregular multi-element (multileaf) contiguous RADIATION FIELD, viewed from RADIATION SOURCE, with element motion in Yb direction (see 7.5) 54
Figure 17a – PATIENT coordinate system (PATIENT is supine) 55
Figure 17b – Rotation of PATIENT coordinate system 55
Figure 18 – Table top pitch rotation of table top coordinate system Xt, Yt, Zt (see 3.10 and 7.8.4) 56
Figure 19 – Table top roll rotation of table top coordinate system Xt, Yt, Zt (see 3.10. and 7.8.5) 56
Figure B.1 – Coordinate transformations between IEC and DICOM PATIENT coordinates 64

Table 1 – ME EQUIPMENT movements and designations 19
Table 2 – Individual coordinate systems 26
Table A.1 – Rotation matrices 58

INTRODUCTION

RADIOTHERAPY is performed in medical centres where a variety of ME EQUIPMENT from different MANUFACTURERS is usually concentrated in the RADIOTHERAPY department. In order to plan and simulate the TREATMENT, set up the PATIENT and direct the RADIATION BEAM, such ME EQUIPMENT can be put in different angular and linear positions and, in the case of MOVING BEAM RADIOTHERAPY, can be rotated and translated during the IRRADIATION of the PATIENT. It is essential that the position of the PATIENT, and the dimensions, directions, and qualities of the RADIATION BEAM prescribed in the treatment plan, be set up or varied by programmes on the radiotherapy EQUIPMENT with accuracy and without misunderstanding. Standard identification and scaling of coordinates is required for ME used in RADIOTHERAPY, including RADIOTHERAPY SIMULATORS and ME EQUIPMENT used to take images during or in connection with RADIOTHERAPY, because differences in the marking and scaling of similar movements on the various types of ME EQUIPMENT used in the same department may increase the probability of error. In addition, data from ME EQUIPMENT used to evaluate the tumour region, such as ultrasound, X-ray, CT and MRI should be presented to the treatment planning system in a form which is consistent with the RADIOTHERAPY coordinate system. Coordinate systems for individual geometrical parameters are required in order to facilitate the mathematical transformation of points and vectors from one coordinate system to another.

A goal of this standard is to avoid ambiguity, confusion, and errors which could be caused when using different types of ME EQUIPMENT. Hence, its scope applies to all types of TELERADIOTHERAPY ME EQUIPMENT, RADIOTHERAPY SIMULATORS, information from diagnostic ME EQUIPMENT when used for RADIOTHERAPY, recording and verification equipment, and to data input for the TREATMENT PLANNING process.

Movement nomenclature is classified as defined terms according to IEC/TR 60788:2004 as well as terms defined in IEC 60601-2-1 and IEC 60601-2-29 (see index of defined terms).

This standard is issued as a publication separate from the IEC 60601 series of safety standards. It is not a safety code and does not contain performance requirements. Thus, the present requirements will not appear in future editions of the IEC 60601-2 series, which deals exclusively with safety requirements.

IEC 60601-2-1, IEC 60601-2-11, IEC 60601-2-29, IEC 60976, IEC 60977, IEC 61168 and IEC 61170 include ME EQUIPMENT movements and scale conventions. A number of changes and additions have been made in this standard.

A major value of a standard coordinate system is its contribution to safety in RADIOTHERAPY TREATMENT PLANNING. The scales that are demonstrated in this standard are consistent with the coordinate systems described herein. USERS may use other scale conventions. It is anticipated that MANUFACTURERS will normally employ the scale conventions of this standard for new ME EQUIPMENT.

It is anticipated that future amendments may address the following:

– three-dimensional RADIOTHERAPY SIMULATORS;
– CT type RADIOTHERAPY SIMULATORS.

Amendment 2, published in 2007, had extended the rotation of the PATIENT support devices around the Z-axis in the IEC fixed coordinate system to two additional rotations – rolling around the PATIENT'S longitudinal axis and pitching around the patient's transversal axis.

The use of the two new additional degrees of freedom (pitch and roll) generalizes the coordinate systems to include systematically 3 rotations and 3 translations, therefore supporting 6 degrees of freedom in a systematic way. Modern patient support devices with 6 degrees of freedom can use a combined translation and rotation to get the same result as the eccentric table top rotation. When changing table position data using the new IEC systems, the definition of isocentric rotations is sufficient to transfer all treatment-related information. The eccentric table top coordinate system is however maintained for backward compatibility.

NOTE It is quite common in proton therapy to use a treatment chair, where the PATIENT can be rotated and tilted, while the beam line has a fixed direction.

RADIOTHERAPY EQUIPMENT – COORDINATES, MOVEMENTS AND SCALES

1 Scope and object

This International Standard applies to equipment and data related to the process of TELERADIOTHERAPY, including PATIENT image data used in relation with RADIOTHERAPY TREATMENT PLANNING SYSTEMS, RADIOTHERAPY SIMULATORS, isocentric GAMMA BEAM THERAPY EQUIPMENT, isocentric medical ELECTRON ACCELERATORS, and non-isocentric equipment when relevant.

The object of this standard is to define a consistent set of coordinate systems for use throughout the process of TELERADIOTHERAPY, to define the marking of scales (where provided), to define the movements of ME EQUIPMENT used in this process, and to facilitate computer control when used.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60601-1:2005, *Medical electrical equipment – Part 1: General requirements for basic safety and essential performance*

IEC 60601-1-3:2008, *Medical electrical equipment – Part 1-3: General requirements for basic safety and essential performance – Collateral Standard: Radiation protection in diagnostic X-ray equipment*

IEC 60601-2-1:2009, *Medical electrical equipment – Part 2-1: Particular requirements for the basic safety and essential performance of electron accelerators in the range 1 MeV to 50 MeV*

IEC 60601-2-11:1997, *Medical electrical equipment – Part 2: Particular requirements for the safety of gamma beam therapy equipment*

IEC 60601-2-29:2008, *Medical electrical equipment – Part 2-29: Particular requirements for the basic safety and essential performance of radiotherapy simulators*

IEC 60788:2004, *Medical electrical equipment – Glossary of defined terms*

IEC 62083:2009, *Medical electrical equipment – Requirements for the safety of radiotherapy treatment planning systems*

3 Coordinate systems

3.1 General

An individual coordinate system is assigned to each major part of the ME EQUIPMENT which can potentially be moved in relation to another part, as illustrated in Figure 1a and summarized in Table 1. Furthermore a fixed reference system is defined. Each major part (e.g. GANTRY, RADIATION HEAD) is always stationary with respect to its own coordinate system.

Perspective views of an ISOCENTRIC medical ELECTRON ACCELERATOR and a RADIOTHERAPY SIMULATOR are shown in Figures 1a, 14a and 14b. Isometric projection drawings of coordinate systems are shown in several Figures 1a, 14a and 14b. In the figures, an elliptic (isometric projection) arrow around an axis of a coordinate system always shows clockwise rotation of that coordinate system about that axis when viewed from its origin and in the positive direction.

NOTE In the following description of individual coordinate systems, counter-clockwise (ccw) rotations are sometimes described in which the axis of rotation is not viewed from the origin of the individual coordinate system.

The definitions of coordinate systems, as stated in the following subclauses, allow mathematical transformations (rotation and/or translation) of the coordinates from one system to any other coordinate system. See Annex A for examples of coordinate transformations.

3.2 General rules

Following requirements apply:

a) All coordinate systems are Cartesian right-handed. The positive parameter directions of linear and angular movements between systems are identified in Figure 2. With all coordinate system angles set to zero, all coordinate system Z axes are vertically upward.

b) Coordinate axes are identified by a capital letter followed by a lower-case letter, representing coordinate system identification.

c) Coordinate systems have a hierarchical structure (mother-daughter relation) in the sense that each system is derived from another system. The common mother system is the fixed reference system. Figure 3 and Table 2 show the hierarchical structure which is divided into two sub-hierarchical structures, one in relation to the GANTRY, the second in relation to the PATIENT SUPPORT.

d) The position and orientation of each daughter coordinate system (d) is derived from its mother coordinate system (m) by translation of its origin Id along one, two or three axes of its mother system and then by rotation of the daughter system about one of the daughter translated system axes.

   NOTE 1 The mechanical motions of parts of the ME EQUIPMENT may follow a different sequence, as long as the ME EQUIPMENT ends up in the same position and orientation as it would have done if the indicated sequence had been followed.

   Figures 1b and 1c show examples of translation of the daughter system origin Id along the mother system coordinate axes Xm, Ym, Zm.

   Figure 1b shows translation of origin Id along Xm, Ym, Zm and rotation about axis Zd which is parallel to Zm.

   Figure 1c shows translation of origin Id along Xm, Ym, Zm and rotation about axis Yd which is parallel to Ym.

   EXAMPLE The BEAM LIMITING DEVICE coordinate system is derived from the GANTRY system and the latter from the fixed system. Thus, a rotation of the GANTRY system causes an analogous rotation of the coordinate axes of the BEAM LIMITING DEVICE coordinate system in the fixed system and the origin of the BEAM LIMITING DEVICE system (position of the RADIATION SOURCE) is displaced in the fixed system (in space).

e) A point defined in one system can be defined in the coordinates of the next higher system (its mother) or the next lower system (its daughter) by applying a coordinate transformation, see Figure 3 and Annex A. Thus, it is possible to calculate, for a point defined in the BEAM LIMITING DEVICE system, its coordinates in the table top system by application of successive coordinate transformations (rotations and translations of the origin, as defined in 3.2d)), going first from the BEAM LIMITING DEVICE system upwards to the fixed system (i.e. BEAM LIMITING DEVICE system to GANTRY system to fixed system) and from this downwards to the table top system (i.e. fixed system to PATIENT SUPPORT system to table top eccentric rotation system, if available, to table top system). Such a coordinate transformation may considerably facilitate the solution of complex geometrical problems encountered in treatment planning, as well as minimize errors in the positioning of ME EQUIPMENT.

f) Notations

1) Capital letters are used for coordinate axis identification and lower-case letters are used for coordinate system identification.

EXAMPLE Yg means y axis of the GANTRY system.

2) The rotation of one coordinate system with respect to its mother system about one particular axis of its own system is designated by the rotation angle which identifies the axis about which it rotates (ψ about X, φ about Y, and θ about Z), and by a lower-case letter identifying the system involved.

EXAMPLE θb = 30° means rotation of the "b" system with respect to the “g” system by an angle of 30° (clockwise as viewed from ISOCENTRE) around axis Zb of the "b" system (see Figures 12a, 12b and also Figure 5, where θb = 15°).

3) The linear position of the origin of a coordinate system within its mother system is designated by capital letters identifying the daughter coordinate system and by the designation of the coordinate axis of the mother system along which it is translated.

EXAMPLE Ry = (numerical value) means position of the origin of the X-RAY IMAGE RECEPTOR coordinate system along coordinate axis Yg (of its mother system).

4) For a movable component part which does not have its own coordinate system, its position within the system in which it moves is designated by a capital letter identifying the device in movement and a lower-case letter identifying the coordinate axis of the coordinate system along which it moves.

EXAMPLE X1 [Xb] = (numerical value) means position of RADIATION FIELD or DELINEATED RADIATION FIELD edge X1 along axis Xb of the BEAM LIMITING DEVICE system.

NOTE 2 When a component part position can be displaced along only one coordinate axis, then the designation of this coordinate axis can be omitted. Thus, for the above example, X1 = (numerical value) is sufficient.

5) The position of a point within a coordinate system is given by the numerical values of its coordinates in that system.

EXAMPLE Coordinate values of a point in the X-RAY IMAGE RECEPTOR system
xr = +20 cm
yr = −10 cm
zr = 0 cm

g) For rotational transformations involving more than one rotation the sequence of the rotations must be kept consistent. If the rotational sequence varies, the resulting transformation matrix and the orientation of the axes will be different.

The sequence in which the rotations shall be applied is the sequence in which these rotations are described in Clause 3 of this standard.

NOTE 3 $M_{ab}^{-1} = M_{ba}$ (see A.1).

3.3 Fixed reference system ("f") (Figure 1a)

The fixed coordinate system "f" is stationary in space. It is defined by a horizontal coordinate axis Yf directed from the ISOCENTRE toward the GANTRY, by a coordinate axis Zf directed vertically upward and by a coordinate axis Xf, normal to Yf and Zf and directed to the viewer's right when facing the GANTRY. For ISOCENTRIC EQUIPMENT the origin If is the ISOCENTRE Io and, therefore, Yf is the rotation axis of the GANTRY.

3.4 GANTRY coordinate system ("g") (Figure 4)

The "g" coordinate system is stationary with respect to the GANTRY and its mother system is the "f" system. Its origin Ig is the ISOCENTRE. Its coordinate axis Zg passes through and is directed towards the RADIATION SOURCE. Coordinate axes Yg and Yf coincide.

The "g" system is in the zero angular position when it coincides with the "f" system.

The rotation of the "g" system is defined by the rotation of coordinate axes Xg, Zg by an angle φg about axis Yg (therefore about Yf of the "f" system).

An increase in the value of φg corresponds to a clockwise rotation of the GANTRY as viewed along the horizontal axis Yf from the ISOCENTRE towards the GANTRY.

3.5 BEAM LIMITING DEVICE or DELINEATOR coordinate system ("b") (Figure 5)

The "b" coordinate system is stationary with respect to the BEAM LIMITING DEVICE or DELINEATOR system and its mother system is the "g" system. Its origin Ib is the RADIATION SOURCE. Its coordinate axis Zb coincides with and points in the same direction as axis Zg. The coordinate axes Xb and Yb are perpendicular to the corresponding edges X1, X2, Y1 and Y2 of the RADIATION FIELD or DELINEATED RADIATION FIELD (see 7.5).

NOTE The positions of the RADIATION FIELD edges are defined by the coordinate system. The coordinate system is not defined by the RADIATION FIELD edges.

For ME EQUIPMENT which allows varying the distance from the ISOCENTRE to the RADIATION SOURCE (e.g. some RADIOTHERAPY SIMULATORS), this SAD-movement corresponds to a linear displacement of the "b" coordinate system along the Zg axis of its mother system (“g” system).

The "b" system is in the zero angular position when the coordinate axes Xb, Yb are parallel to and in the same directions as the corresponding axes Xg, Yg.

The rotation of the "b" system is defined by the rotation of the coordinate axes Xb, Yb about axis Zb (therefore about axis Zg of the "g" system) by an angle θb.

An increase in the value of angle θb corresponds to the clockwise rotation of the RADIATION FIELD or DELINEATED RADIATION FIELD as viewed from the ISOCENTRE towards the RADIATION SOURCE (see Figures 15a, 15b).

3.6 WEDGE FILTER coordinate system ("w") (Figure 7)

The "w" coordinate system is stationary with respect to the WEDGE FILTER and its mother system is the "b" system. Its origin, Iw, is a defined point such that the coordinate axis Yw is directed towards the thin edge of the WEDGE FILTER and in its zero position axis Zw passes through the RADIATION SOURCE, coincides with axis Zb and points in the same direction as Zb.

NOTE 1 The MANUFACTURER or USER may choose the location of Iw to suit the design of the WEDGE FILTER DEVICE. For example it is possible to define Iw as the point of intersection of axis Zw with a particular surface of the WEDGE FILTER.

In the zero angular position of the "w" system (θw = 0) and of the "b" system (θb = 0) the thin edge of the WEDGE FILTER (end, along Yw, with highest transmission) is toward the GANTRY and the coordinate axes Xw, Yw are parallel to the corresponding axes Xb, Yb.

The rotation of the "w" system is defined by the rotation of coordinate axes Xw, Yw about axis Zw (parallel to axis Zb of the "b" system) by an angle θw.

An increase in the value of angle θw corresponds to the counter-clockwise rotation of the WEDGE FILTER about Zw (parallel to axis Zb) as viewed from the RADIATION SOURCE.

At the zero angular position of the "w", "b" and "g" coordinate systems, a positive longitudinal displacement of the origin Iw corresponds to the movement of the WEDGE FILTER thin edge toward the GANTRY, along Yb and a positive lateral displacement corresponds to the movement along Xb to the viewer's right when facing the GANTRY.

NOTE 2 For convenience of access, mechanical WEDGE FILTERS may be inserted transversely. In such cases, WEDGE FILTER orientation angles also apply. If, for example, with the "b" and "g" systems in zero angular positions (θb = 0 and φg = 0), the WEDGE FILTER is inserted with the thin edge directed to the viewer's left when facing the GANTRY, the angle θw corresponds to 90°. In the same conditions, when the WEDGE FILTER is inserted with the thin edge directed to the viewer's right when facing the GANTRY, the angle θw corresponds to 270°.

3.7 X-RAY IMAGE RECEPTOR coordinate system ("r") (Figures 6 and 8)

The "r" coordinate system is stationary with respect to the X-RAY IMAGE RECEPTOR (e.g. image intensifier, RADIOGRAPHIC FILM in RADIOGRAPHIC CASSETTE HOLDER, RADIATION sensitive foil/plate) and its mother system is the "g" system. Its origin Ir is at the centre of the IMAGE RECEPTION AREA.

In the zero angular position of the "r" system, the coordinate axes Xr, Yr, Zr are parallel to the corresponding axes Xg, Yg, Zg of the "g" system.

The rotation of the "r" system is defined by the rotation of the coordinate axes Xr, Yr about Zr (parallel to axis Zg) by an angle θr.

An increase in the value of angle θr corresponds to a counter-clockwise rotation of the X-RAY IMAGE RECEPTOR as viewed from the RADIATION SOURCE.

In the zero position of the "r" system, its origin Ir is at the ISOCENTRE. This may not be mechanically achievable, but it defines the origin of the displacement of the "r" system along Zg.

NOTE 1 The distance (SID) from the RADIATION SOURCE to the X-RAY IMAGE RECEPTOR PLANE may also be DISPLAYED for use in determining the geometric magnification of the image.

The values of Rx, Ry and Rz are the lateral, longitudinal and vertical displacements of the origin Ir of the IMAGE RECEPTION AREA along Xg, Yg and Zg respectively.

NOTE 2 When there are several different devices (such as RADIOGRAPHIC FILM or IMAGE INTENSIFIER), used as X-RAY IMAGE RECEPTORS on a given ME EQUIPMENT, each device may have its own origin, Ir.

3.8 PATIENT SUPPORT coordinate system ("s") (Figure 9)

The "s" coordinate system is stationary with respect to that part of the PATIENT SUPPORT which rotates about the vertical axis Zs. This rotation is achieved by the part commonly designated as the turntable. The mother system of the “s” system is the "f" system. Its daughter system is the eccentric rotation coordinate system “e”.

NOTE 1 The "s" system applies to both ISOCENTRIC PATIENT SUPPORTS and non-ISOCENTRIC PATIENT SUPPORTS. The former are characterized by a vertical rotation axis stationary in space, whereas, in the latter, this axis is movable linearly along directions parallel to the coordinate axes Xf and Yf.

The origin Is of the "s" system is on the vertical axis of rotation, Zs, at a distance from the floor equal to the ISOCENTRE to floor distance.

In the zero position of the PATIENT SUPPORT, Is is at the ISOCENTRE and the coordinate axes Xs, Ys, Zs of the "s" system coincide with the corresponding axes Xf, Yf, Zf of the "f" system.

The rotation of the "s" system is defined by the rotation of the coordinate axes Xs, Ys about axis Zs (parallel to Zf) by an angle θs.

An increase in the value of angle θs corresponds to the counter-clockwise rotation of the PATIENT SUPPORT as viewed from above.

NOTE 2 For non-ISOCENTRIC PATIENT SUPPORTS the values of lateral and longitudinal displacements of the origin Is along the coordinate axes Xf and Yf are designated Sx and Sy.

NOTE 3 As the height of Is is fixed, Sz = 0. The vertical displacement of the table top with reference to the ISOCENTRE is treated in 3.9; it is designated Tz.

3.9 Table top eccentric rotation coordinate system ("e") (Figures 10 and 11)

An ISOCENTRIC PATIENT SUPPORT can have provision for table top rotation about a vertical axis, Ze, displaced by a distance –Le from the coordinate axis Zs of the “s” system, along the coordinate axis Ys of the "s" system.

The "e" coordinate system is stationary with respect to the eccentric rotation device. Its mother system is the PATIENT SUPPORT "s" system. Its daughter system is the table top “t” system. The origin Ie of the eccentric system is on the vertical axis of eccentric rotation at a distance from the floor equal to the ISOCENTRE to floor distance.

NOTE 1 For ISOCENTRIC PATIENT SUPPORTS without the provision of eccentric rotation and for non-ISOCENTRIC PATIENT SUPPORTS the "e" system coincides with the "s" system.

In the zero position of the eccentric system, the coordinate axes Xe, Ye and Ze are parallel to the coordinate axes Xs, Ys and Zs of the "s" system with Ie distant from Is by –Le on Ys axis.

The rotation of the "e" system is defined by the rotation of the coordinate axes Xe, Ye about the coordinate axis Ze (parallel to Zs) by an angle θe.

An increase in the value of angle θe corresponds to a counter-clockwise rotation of the table top about Ze axis as viewed from above.

Hence, the rotation of the "s" system by an angle of θs and the rotation of the "e" system by the complementary angle θe = 360° – θs result in a lateral translation of the table top parallel to itself.

NOTE 2 The rotation of the "e" system causes not only a rotation of the table top by an angle θe about the eccentric axis of rotation, but also a displacement of the origin It of the table top system "t" relative to the "s" system.

3.10 Table top coordinate system ("t") (Figures 10, 11, 18 and 19)

The "t" coordinate system is stationary with respect to the table top and its mother system is the "e" system. Its origin is at the specified point located on the median axis of the table top, which is at the intersection of the median axis of the table top and the vertical axis Zs of the PATIENT SUPPORT coordinate system when the angle θe of the eccentric vertical rotation (if available) is zero and when the table top is:

– horizontal;
– laterally centred in the "e" system;
– longitudinally fully withdrawn away from Zs.

The coordinate axis Yt coincides with the longitudinal median axis of the table top and the coordinate axis Zt is normal to the table top.

In the zero position of the "t" system:

– the origin It is at minimum distance from Ie (table top fully withdrawn);
– Yt and Ye coincide and are in the same direction;
– coordinate axes Xt and Zt are parallel to and in the same direction as the corresponding axes Xe, Ze.

NOTE 1 When the isocentric and eccentric angular position angles θs and θe are zero (or the eccentric movement is not available) and the "t" system is in its zero position, the coordinate axes Xt, Yt, Zt coincide with coordinate axes Xf, Yf and Zf of the fixed system.

Tx, Ty and Tz are the lateral, longitudinal and vertical displacements of the origin It of the table top system corresponding to movement along the three corresponding coordinate axes Xe, Ye, Ze, in the eccentric system, or Xs, Ys, Zs in the PATIENT SUPPORT system if eccentric rotation is not available.

NOTE 2 The purpose of defining the coincidence of the origin It with the ISOCENTRE with the table top fully withdrawn is to ensure that the longitudinal position of the table top in the “s” or “e” system is expressed by a positive number for all patient treatments. It is not necessary that this origin be actually marked on the table top at the isocentre position, since this may not be practical with removable panels, table top extensions, etc. It is only necessary that the origin It be obtainable from a known distance to an accessible and visible marked point on the table top.

NOTE 3 Table tops with different possible ranges of longitudinal mechanical motion, e.g. made by different MANUFACTURERS, could have different positions for the table top origin It.

The rotation of the "t" system about the axis Xt (pitch of the table top) is defined as rotation angle ψt.

An increase in the value of ψt corresponds to clockwise rotation of the table top as viewed from the table top coordinate system origin along the positive Xt axis.

The rotation of the "t" system about axis Yt (roll of the table top) is defined as rotation angle φt.

An increase in the value of φt corresponds to a clockwise rotation of the table top as viewed from the table top coordinate system origin along the positive Yt axis.

3.11 PATIENT coordinate system ("p") (Figures 17a and 17b)

The "p" coordinate system is stationary with respect to the PATIENT, and its mother system is the "t" system. Its origin Ip is at a suitably chosen point defined in relation to the PATIENT’s anatomy.

NOTE Each PATIENT will have an individual origin Ip whose anatomical position will have been chosen as a suitable point in relation to the intended treatment site and technique. However, this point need not be in or on the PATIENT. For example, if a beam direction shell is used, it would be logical to use a point on the shell (or its base if attached to the table top).

With reference to Figure 17a, the coordinate axis Xp is parallel to the intersection of a PATIENT coronal plane and a transverse plane. Coordinate axis Yp is parallel to the intersection of a PATIENT’s sagittal and coronal planes. The coordinate axis Zp is parallel to the intersection of a PATIENT’s sagittal plane and a transverse plane. The positive Xp axis is oriented to the PATIENT’s left, the positive Yp axis points superiorly within the PATIENT and the positive Zp axis is directed anteriorly within the PATIENT.

NOTE 2 It is to be noted, that some rotations of the PATIENT SUPPORT SYSTEM used for treatments, and thus also rotations of the PATIENT, may result in deformation of the patient anatomy, if the resulting position of the PATIENT in relation to the fixed systems is not identical to the position used for imaging for treatment planning

In the zero angular position of the "p" system the axes Xp, Yp, Zp are parallel to the corresponding axes Xt, Yt, Zt of the "t" system.

Rotation of the "p" system about the axis Xp is defined as rotation angle ψp.

An increase in the value of ψp corresponds to clockwise rotation of the PATIENT as viewed from the PATIENT's right-hand side.

Rotation of the "p" system about axis Yp is defined as rotation angle φp.

An increase in the value of φp corresponds to a clockwise rotation of the PATIENT as viewed in the direction from foot to head of the PATIENT.

Rotation of the "p" system about axis Zp is defined as rotation angle θp.

An increase in the value of θp corresponds to a clockwise rotation of the PATIENT as viewed from behind the PATIENT.

The values of Px, Py and Pz are the lateral, longitudinal and vertical displacements from It of the origin Ip of the PATIENT coordinate system along Xt, Yt and Zt respectively.

3.12 Imager coordinate system ("i") and focus coordinate system ("o")

3.12.1 General

For imaging systems which are either not mechanically attached to the GANTRY or which use a source different from the treatment source the below described Imager coordinate system (“i”) and the optional focus coordinate system (“o”) shall be used.

NOTE More than one “i” coordinate systems can exist when more than one imager is located in the TREATMENT ROOM.

3.12.2 The imager coordinate system ("i")

The “i” coordinate system is stationary with respect to any imaging system in the treatment room, and its mother system is the “f” system. Its origin is at the origin of the image of the concerning imager system.

The axes Xi, Yi and Zi are parallel to the X, Y, and Z axes of the imager system. If the imager only has X and Y axes the Xi and Yi axes are parallel to the X and Y axes of the imager system and the Zi axis is perpendicular to both these axes.

NOTE There are other types of imager systems, i.e. using ultrasound or light, which are not covered in this standard.

In the zero angular position of the “i” system the axes Xi, Yi and Zi are parallel to the corresponding axes Xf, Yf and Zf of the “f” system.

The values of Ix, Iy and Iz are the displacements of the origin Ii of the imager system along Xf, Yf and Zf respectively.

The rotation of the "i" system about the axis Xi is defined as rotation angle ψi.

An increase in the value of ψi corresponds to clockwise rotation of the imager system as viewed from the Imager coordinate system origin along the positive Xi axis.

The rotation of the "i" system about axis Yi is defined as rotation angle φi.

An increase in the value of φi corresponds to a clockwise rotation of the Imager system as viewed from the Imager coordinate system origin along the positive Yi axis.

The rotation of the "i" system about axis Zi is defined as rotation angle θi.

An increase in the value of θi corresponds to a clockwise rotation of the Imager system as viewed from the Imager coordinate system origin along the positive Zi axis.

3.12.3 Focus coordinate system ("o")

The “o” coordinate system is stationary with respect to the focus of a X-ray tube used to generate the X-RADIATION for the imager system and its mother system is the corresponding “I” system. Its origin is at the focus position of the X-RAY TUBE.

The positive Zo axis is pointing in the same direction as the positive Zi axis.

The values of Ox, Oy and Oz are the displacements of the origin Io of the focus along Xi, Yi and Zi respectively.

4 Identification of scales and digital DISPLAYS

The requirements for the provision of scales for ME EQUIPMENT positions are contained in the relevant IEC safety standards.

Where scales are provided, they should comply with the specifications of this clause. All scales and digital DISPLAYS should be easily readable from normal working positions; they should be clearly labelled in terms which make their function and reading unambiguous. All linear scales should be graduated in centimetres or millimetres, but not both. Numbers (except zero) should always be preceded by a sign (for example –2, –1, +1, +2) when used for linear scales and linear digital DISPLAYS. Mechanical linear scales should have subdivision markers at intervals of 0,5 cm or less. Digital linear DISPLAYS should have subdivision digits at 0,1 cm intervals.

NOTE The "+" sign is not required when a value can never be negative (e.g. RADIATION FIELD or DELINEATED RADIATION FIELD dimensions FX and FY). It is not required that the OPERATOR actually type a "plus" sign when calling for a "plus" numerical value, only that a "+" sign be DISPLAYED with such numerical values.

All rotation scales and angular digital DISPLAYS should be graduated in degrees, using only positive numbers without signs, for example: 358°, 359°, 0°, 1° and 2°.

Words or word abbreviations (not characters or symbols) should be used on visual display terminals (VDTs) to DISPLAY the identification of the various movable parts.

The zero positions and directions of the increasing values of the scales should correspond with the requirements of Clauses 6 and 7

Examples are shown in Figures 12a, 12b and 12c.

5 Designation of ME EQUIPMENT movements

The movements of ME EQUIPMENT are designated as follows (see Figures 13a, 13b and 13c).

Table 1 – ME EQUIPMENT movements and designations

Axis (1)	Rotation of GANTRY
Axis (2)	Roll of the RADIATION HEAD[a]
Axis (3)	Pitch of the RADIATION HEAD[a]
Axis (4)	Rotation of the BEAM LIMITING DEVICE or DELINEATOR
Axis (5)	ISOCENTRIC rotation of the PATIENT SUPPORT
Axis (6)	Rotation of the table top about the eccentric support
Axis (7)	Pitch of the table top
Axis (8)	Roll of the table top
Direction (9)	Vertical displacement of the table top
Direction (10)	Lateral displacement of the table top
Direction (11)	Longitudinal displacement of the table top
Direction (12)	Displacement of RADIATION SOURCE from axis (1)[b]
Direction (13)	Displacement of RADIATION SOURCE from floor at GANTRY angular position zero[b]
Dimension (14)	Dimension FX of the RADIATION FIELD or DELINEATED RADIATION FIELD in the Xb direction at a specified distance from the RADIATION SOURCE (usually at the NORMAL TREATMENT DISTANCE)
Dimension (15)	Dimension FY of the RADIATION FIELD or DELINEATED RADIATION FIELD in the Yb direction at a specified distance from the RADIATION SOURCE (usually at the NORMAL TREATMENT DISTANCE)
Direction (16)	X-RAY IMAGE RECEPTOR and/or RADIOGRAPHIC CASSETTE HOLDER X motion perpendicular to axis (1) and axis (4)
Direction (17)	X-RAY IMAGE RECEPTOR and/or RADIOGRAPHIC CASSETTE HOLDER Y motion parallel to axis (1)
Direction (18)	X-RAY IMAGE RECEPTOR and/or RADIOGRAPHIC CASSETTE HOLDER Z motion parallel to axis (4)
Axis (19)	Rotation of the X-RAY IMAGE RECEPTOR and/or RADIOGRAPHIC CASSETTE HOLDER
Direction (20)	Displacement from RADIATION BEAM AXIS to RADIATION FIELD or DELINEATED RADIATION FIELD edge X1 at a specified distance from the RADIATION SOURCE (usually the NORMAL TREATMENT DISTANCE)
Direction (21)	Displacement from RADIATION BEAM AXIS to RADIATION FIELD or DELINEATED RADIATION FIELD edge X2 at a specified distance from the RADIATION SOURCE (usually at the NORMAL TREATMENT DISTANCE)
Direction (22)	Displacement from RADIATION BEAM AXIS to RADIATION FIELD or DELINEATED RADIATION FIELD edge Y1 at a specified distance from the RADIATION SOURCE (usually at the NORMAL TREATMENT DISTANCE)
Direction (23)	Displacement from RADIATION BEAM AXIS to RADIATION FIELD or DELINEATED RADIATION FIELD edge Y2 at a specified distance from the RADIATION SOURCE (usually at the NORMAL TREATMENT DISTANCE)

[a] The pitch and roll of the RADIATION HEAD axes (2) and (3), and the vertical displacement of the RADIATION SOURCE, direction (13), are retained as designations for continuity with IEC 60601-2-1, but for simplicity they are not addressed further in this standard.

[b] This applies to the scale on RADIOTHERAPY SIMULATORS which provide variation of the RADIATION SOURCE to axis distance.

6 ME EQUIPMENT zero positions

With all linear displacements along coordinate axes X, Y, Z and all rotational angles ψ, φ, θ set to zero, the ME EQUIPMENT positions are as follows:

a) The RADIATION BEAM AXIS is directed vertically downward and passes through the ISOCENTRE.

b) The X1 and X2 edges of the rectangular RADIATION FIELD or DELINEATED RADIATION FIELD are perpendicular to the Y1 and Y2 edges, and are parallel to the GANTRY rotation axis Yg. The edges are oriented so that the total available angles of the clockwise and counter-clockwise rotation of the BEAM LIMITING DEVICE or DELINEATOR are equal, or as nearly equal as practicable.

c) The direction of increasing WEDGE FILTER transmission (i.e. the thin end) is toward the GANTRY.

d) The longitudinal median axis of the table top coincides with the GANTRY rotation axis.

e) The table top is fully withdrawn away from the GANTRY.

f) The X-RAY IMAGE RECEPTOR is centred on and normal to the RADIATION BEAM AXIS and the X-RAY IMAGE RECEPTOR PLANE passes through the ISOCENTRE.

g) The longer dimension of the RADIOGRAPHIC CASSETTE HOLDER is parallel to the GANTRY rotation axis Yg and the plane defined by the RADIOGRAPHIC CASSETTE HOLDER is perpendicular to the rotational axis of the BEAM LIMITING DEVICE or DELINEATOR.

7 List of scales, graduations, directions and DISPLAYS

7.1 General

With all ME EQUIPMENT parts initially in zero angular and linear positions, the SCALE READINGS and directions are as follows.

7.2 Rotation of the GANTRY (Figures 14a and 14b)

Reading from 0° to 359° increases in clockwise direction when the GANTRY is viewed from the ISOCENTRE.

Designation: GANTRY angle

φg = _________

NOTE There is a discontinuity in the rotation due to GANTRY drive, wind-up cables and hoses, etc. For example, assume this permits a rotation from beam up (180°) through beam down (0° or 360°) to beam up (180°) where there is a stop. If the previous treatment was with a 360° clockwise arc from 180° to 180°, then the next arc treatment should either be counter-clockwise or the GANTRY should be returned before IRRADIATION to the desired starting angle for a clockwise arc for the next treatment. This requires historical data in order to prepare instructions.

7.3 Rotation of the BEAM LIMITING DEVICE or DELINEATOR (Figures 15a and 15b)

Reading from 0° to 359° increases in counter-clockwise direction when the BEAM LIMITING DEVICE or DELINEATOR is viewed from the RADIATION SOURCE.

Designation: Beam limiting device or delineator angle

θb = _________

7.4 Rotation of the WEDGE FILTER (Figures 7 and 14a)

Reading from 0° to 359° increases in counter-clockwise direction when the WEDGE FILTER is viewed from the RADIATION SOURCE.

Designation: WEDGE FILTER orientation

θw = _________

NOTE The WEDGE FILTER may not have been provided with capability for rotation around axis Zb, but may have been provided with facility for insertion at cardinal angles (0°, 90°, 180° and 270°). In such cases, the WEDGE FILTER orientation DISPLAY also applies (e.g. WEDGE FILTER orientation θw = 270°).

7.5 RADIATION FIELD or DELINEATED RADIATION FIELD

7.5.1 General

The BEAM LIMITING DEVICE or DELINEATOR often consists of symmetrical pairs of movable elements which restrict the RADIATION FIELD or DELINEATED RADIATION FIELD to a rectangle symmetrically positioned relative to the axis (4) of rotation of the BEAM LIMITING DEVICE or DELINEATOR.

When the BEAM LIMITING DEVICE or DELINEATOR can be controlled in such a way that the rectangular RADIATION FIELD or DELINEATED RADIATION FIELD is not symmetrically positioned relative to the axis of rotation of the BEAM LIMITING DEVICE or DELINEATOR, the RADIATION FIELD or DELINEATED RADIATION FIELD produced is an asymmetrical FIELD.

When the elements of the BEAM LIMITING DEVICE or DELINEATOR consist of independently movable elements, i.e., a multi-element (multileaf) BEAM LIMITING DEVICE, then an irregular (multiple element) RADIATION FIELD or DELINEATED RADIATION FIELD is produced.

The application of this standard includes the situation where an edge or element of the RADIATION FIELD or DELINEATED RADIATION FIELD crosses over the axis (4) of rotation of the BEAM LIMITING DEVICE or DELINEATOR.

The dimensions of the RADIATION FIELD or DELINEATED RADIATION FIELD are measured in the plane normal to the axis (4) of rotation of the BEAM LIMITING DEVICE or DELINEATOR at a specified distance from the RADIATION SOURCE (usually the NORMAL TREATMENT DISTANCE).

7.5.2 Edges of RADIATION FIELD or DELINEATED RADIATION FIELD (Figure 16a)

7.5.2.1 General

The RADIATION FIELD or DELINEATED RADIATION FIELD edges X1 and X2 are parallel to the GANTRY rotation axis, and edges Y1 and Y2 are perpendicular to the GANTRY rotation axis when the rotation angle of the BEAM LIMITING DEVICE or DELINEATOR is set to zero. The positions of the RADIATION FIELD or DELINEATED RADIATION FIELD edges in the plane defined above, characterizing the configuration of the RADIATION FIELD or DELINEATED RADIATION FIELD, are given by the coordinate values of edges X1 and X2 along the coordinate axis Xb, and by the coordinate values of edges Y1 and Y2 along Yb.

Figure 16a shows a RADIOTHERAPY SIMULATOR BEAM LIMITING DEVICE defining a RADIATION FIELD which need not be scaled and is larger than the DELINEATED RADIATION FIELD by a margin which need not be uniform.

7.5.2.2 Edges X1 and X2

When the viewer faces the GANTRY, edge X2 is on the right side of edge X1.

When an edge is at the right side of the axis (4) of rotation of the BEAM LIMITING DEVICE or DELINEATOR, its position reading has a positive value.

When an edge is at the left side of the axis (4) of rotation of the BEAM LIMITING DEVICE or DELINEATOR its position reading has a negative value.

7.5.2.3 Edges Y1 and Y2

Edge Y2 is on the GANTRY side of edge Y1.

When an edge is on the side of the axis (4) of rotation of the BEAM LIMITING DEVICE or DELINEATOR toward the GANTRY, its position reading has a positive value.

When an edge is on the side of the axis (4) of rotation of the BEAM LIMITING DEVICE or DELINEATOR away from the GANTRY, its position reading has a negative value.

7.5.2.4 Multi-element edges

For multi-element (multileaf) BEAM LIMITING DEVICES (see Figures 16i, 16j and 16k), the same rules apply to the edges of each element but each element is identified by its element order number X101 to X1N, X201 to X2N, Y101 to Y1N and Y201 to Y2N.

X201 and X2N are further to the right than X101 and X1N, when the viewer faces the GANTRY.

Toward the GANTRY, the elements are in the following order:

X101, X102, ... X1N

X201, X202, ... X2N

Y201 and Y2N are closer to the GANTRY than Y101 and Y1N.

From the left to the right when the viewer faces the GANTRY, the elements are in the following order:

Y101, Y102, ... Y1N

Y201, Y202, ... Y2N

NOTE N may be greater than 9, hence the use of two digits with leading zeros.

7.5.3 DISPLAY of RADIATION FIELD or DELINEATED RADIATION FIELD (Figures 16a to 16k)

Following requirements apply:

a) For a symmetrical rectangular RADIATION FIELD or DELINEATED RADIATION FIELD, only the dimensions FX and FY, which are the distances between edges X1 and X2, and Y1 and Y2, need be DISPLAYED.

   FX = algebraic value of X2 minus algebraic value of X1

   FY = algebraic value of Y2 minus algebraic value of Y1

   FX and FY are always DISPLAYED without a "+" or "–" sign.

   Designation:

   RADIATION FIELD or DELINEATED RADIATION FIELD dimension FX = _________

   RADIATION FIELD or DELINEATED RADIATION FIELD dimension FY = _________

   When two numbers are given for a rectangular RADIATION FIELD or DELINEATED RADIATION FIELD in a treatment prescription, dimension FX precedes dimension FY.

   For example, a 10 cm × 12 cm RADIATION FIELD means FX = 10 cm, FY = 12 cm.

b) For an asymmetrical rectangular RADIATION FIELD or DELINEATED RADIATION FIELD, dimensions FX and FY are DISPLAYED together with the positions X1, X2 and Y1, Y2 of the RADIATION FIELD or DELINEATED RADIATION FIELD edges relative to the axis (4) of rotation of the BEAM LIMITING DEVICE or DELINEATOR.

Designation:

Edge positions X1 = ± _____

X2 = ± _____

RADIATION FIELD OR DELINEATED RADIATION FIELD dimension

FX = ____

Edge positions Y1 = ± _____

Y2 = ± _____

RADIATION FIELD OR DELINEATED RADIATION FIELD dimension

FY = ____

NOTE It should be noted that setting two coupled BEAM LIMITING DEVICES or DELINEATOR elements to get a symmetrical field dimension FX, for example, and then moving them as an entity, may produce an asymmetrical field, having a different size from FX.

c) For an irregular RADIATION FIELD or DELINEATED RADIATION FIELD (e.g. with multi-element BEAM LIMITING DEVICES) one of the following requirements should be fulfilled:

1) either: the coordinates of the edge of each element making up the irregular field are DISPLAYED together with the order number of the element. For example: X103, X203 for element 03. The distances between opposite element edges are also DISPLAYED.

FX03 = algebraic value of X203 – algebraic value of X103

Designation: FX03 = ______

X103 = ± ______

X203 = ± ______

2) or: the edge of each element should be represented by a graphical DISPLAY, together with numerical and graphical DISPLAY of the error in the position of each element.

7.6 PATIENT SUPPORT isocentric rotation

Reading from 0° to 359° increases in a counter-clockwise direction when viewed from above.

Designation: PATIENT SUPPORT angle

θs = ______

NOTE The same scale convention applies to non-ISOCENTRIC PATIENT SUPPORTS.

7.7 Table top eccentric rotation

Reading from 0° to 359° increases in a counter-clockwise direction when viewed from above.

Designation: table top eccentric rotation angle

θe = ______

7.8 Table top linear and angular movements

7.8.1 Vertical displacement of the table top

Reading increases in an upward direction from the most negative to the most positive value (zero reading corresponds to the top surface of the table top at ISOCENTRIC height).

Designation: table top vertical

Tz = ± ______

7.8.2 Longitudinal displacement of the table top

Reading increases from zero to maximum value when the table top moves toward the GANTRY.

Designation: table top longitudinal

Ty = ______

7.8.3 Lateral displacement of the table top

Reading increases from the most negative to the most positive value when the table top moves from the left to the right as viewed looking toward the GANTRY.

Designation: table top lateral

Tx = ± ______

7.8.4 Pitch of the table top

Reading increases from 0° to 359° in a clockwise direction when viewed from the table top coordinate system origin along the positive Xt axis.

Designation: table top pitch

ψt = ______

7.8.5 Roll of the table top

Reading increases from 0° to 359° in a clockwise direction when viewed from the table top coordinate system origin along the positive Yt axis.

Designation: table top roll

φt = ______

7.9 X-RAY IMAGE RECEPTOR movements

7.9.1 X-RAY IMAGE RECEPTOR rotation

Reading from 0° to 359° increases in a counter-clockwise direction when viewed from the RADIATION SOURCE.

Designation: X-RAY IMAGE RECEPTOR angle

θr = ______

7.9.2 X-RAY IMAGE RECEPTOR radial displacement from RADIATION SOURCE (SID)

Reading changes from the most negative value to the least negative value when the X-RAY IMAGE RECEPTOR moves toward the RADIATION SOURCE (zero is at the RADIATION SOURCE).

Designation: RADIATION SOURCE to X-RAY IMAGE RECEPTOR distance

SID = ______

7.9.3 X-RAY IMAGE RECEPTOR radial displacement from ISOCENTRE

Reading changes from zero at the ISOCENTRE to the most negative value as the X-RAY IMAGE RECEPTOR moves away from the RADIATION SOURCE.

Designation: ISOCENTRE to X-RAY IMAGE RECEPTOR distance

Rz = ______

7.9.4 X-RAY IMAGE RECEPTOR longitudinal displacement

Reading increases from the most negative to the most positive value when the X-RAY IMAGE RECEPTOR moves toward the GANTRY. Zero is at the ISOCENTRE.

Designation: X-RAY IMAGE RECEPTOR longitudinal displacement

Ry = ± ______

7.9.5 X-RAY IMAGE RECEPTOR lateral displacement

Reading increases from the most negative to the most positive value when the X-RAY IMAGE RECEPTOR moves from left to right when the viewer is facing the GANTRY and further from the GANTRY than the ISOCENTRE. Zero is at the ISOCENTRE.

Designation: X-RAY IMAGE RECEPTOR lateral displacement

Rx = ± ______

7.10 Other scales

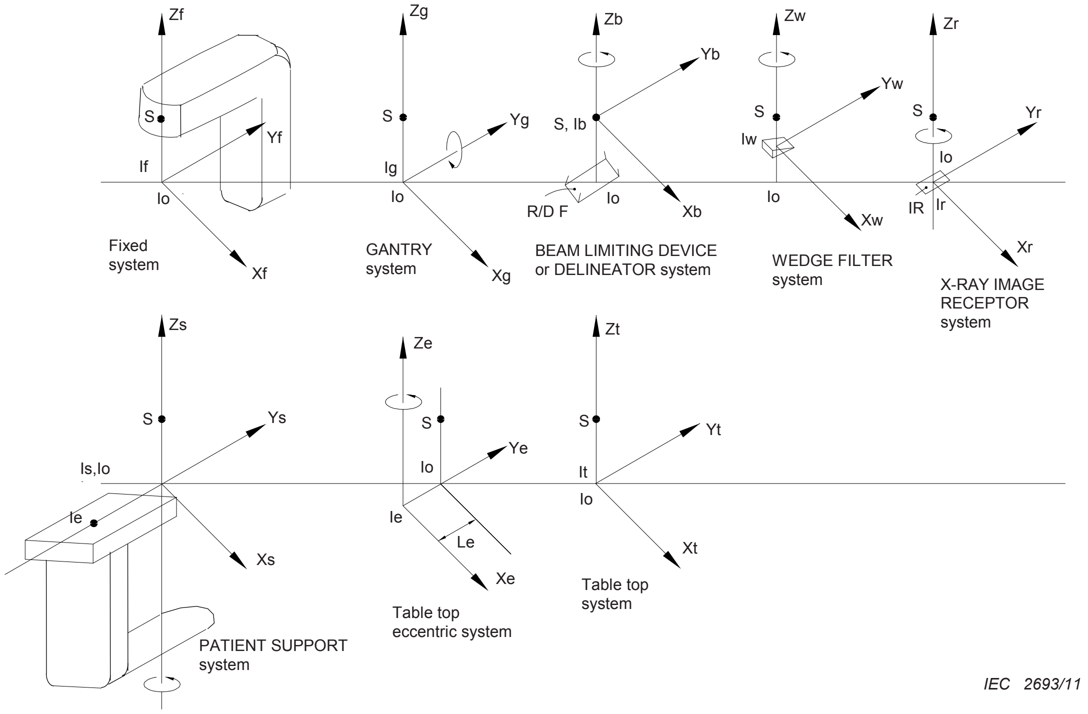
For ISOCENTRIC ME EQUIPMENT, the zero of the scale indicating the distance from the GANTRY axis of rotation to the RADIATION SOURCE is at the ISOCENTRE.

The zero of the scale indicating the distance from the RADIATION SOURCE along the RADIATION BEAM AXIS is at the RADIATION SOURCE.

The zero of the scale indicating the distance from the ISOCENTRE along the RADIATION BEAM AXIS is at the ISOCENTRE.

Table 2 – Individual coordinate systems

System designation	Mother system	System origin	Device rotation about axis by angle	Device linear displacement
f – Fixed	None	If	None (reference system)	None (reference system)
g – GANTRY	f	Ig ISOCENTRE	ISOCENTRIC GANTRY about Yg by φg	RADIATION SOURCE along Zg X-RAY IMAGE RECEPTOR Rx Ry Rz along Xg Yg Zg
b – BEAM LIMITING DEVICE or DELINEATOR	g	Ib RADIATION SOURCE	BEAM LIMITING DEVICE or DELINEATOR about Zb by θb	Plane at NORMAL TREATMENT DISTANCE along Zb RADIATION FIELD or DELINEATED RADIATION FIELD edges along Xb and Yb WEDGE FILTER along Xb and Yb
w – WEDGE FILTER	b	Iw Selected point on WEDGE FILTER	WEDGE FILTER about Zw by θw	
r – X-RAY IMAGE RECEPTOR	g	Ir Centre of IMAGE RECEPTION AREA	X-RAY IMAGE RECEPTOR about Zr by θr	
s – PATIENT SUPPORT	f	Is On rotation axis of the turntable	PATIENT SUPPORT about Zs by θs	
e – Table top eccentric rotation	s	Ie On eccentric axis of rotation	Table top about Ze by θe	Table top along Xe, Ye, Ze
t – Table top	e	It On the median axis of the table top	Table top about Xt by ψt Table top about Yt by φt	PATIENT along Xt, Yt, Zt
p – PATIENT	t	Ip Selected point in relation to PATIENT	PATIENT about Xp by ψp, Yp by φp and Zp by θp	
i – Imager	f	Ii Origin of the imager system	Imager about Xi by ψi Imager about Yi by φi Imager about Zi by θi	Imager along Xf, Yf, Zf
o – focus	i	Io Focus of imager system	None	Focus along Xi, Yi, Zi

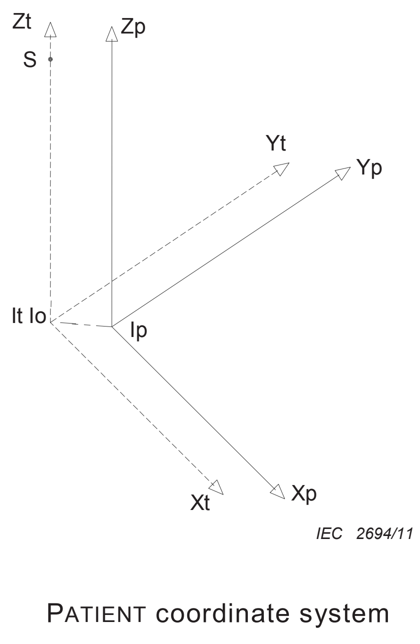


S = RADIATION SOURCE

Io = ISOCENTRE

R/D F = RADIATION FIELD or DELINEATED RADIATION FIELD

IR = X-RAY IMAGE RECEPTOR



PATIENT coordinate system

Figure 1a – Coordinate systems for an isocentric RADIOTHERAPY EQUIPMENT (see 3.1) with all angular positions set to zero

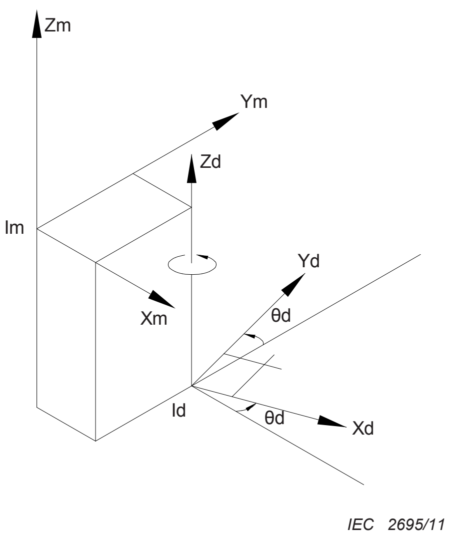


Figure 1b – Translation of origin Id along Xm, Ym, Zm and rotation around axis Zd parallel to Zm (see 3.2d))

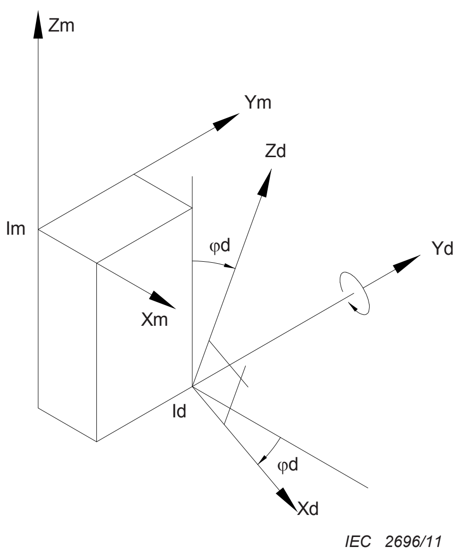
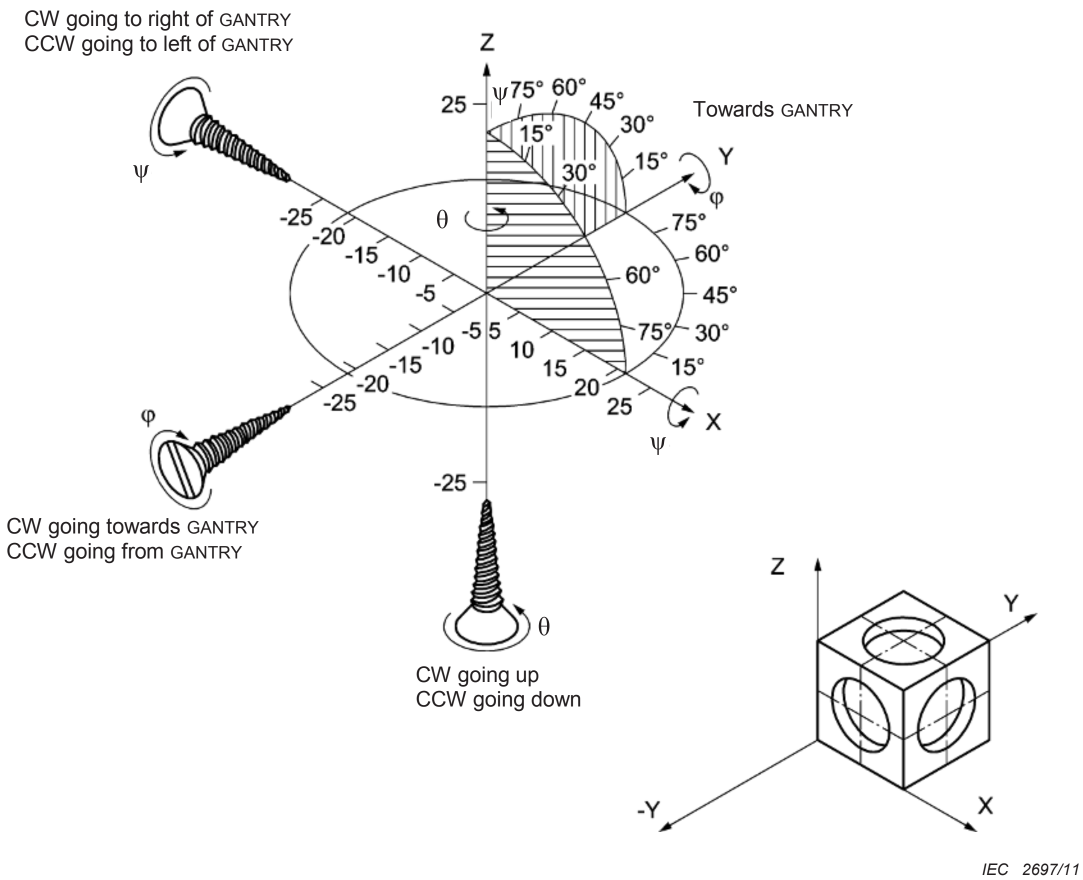


Figure 1c – Translation of origin Id along Xm, Ym, Zm and rotation around axis Yd parallel to Ym (see 3.2d))



ψ = Rotation of Y and Z around X

φ = Rotation of Z and X around Y

θ = Rotation of X and Y around Z

NOTE For the fixed coordinate system, X and Y are parallel to the floor and Z is vertically up.

Figure 2 – X Y Z right-hand coordinate mother system (isometric drawing) showing ψ, φ, θ directions of positive rotation for daughter system (see 3.2a))

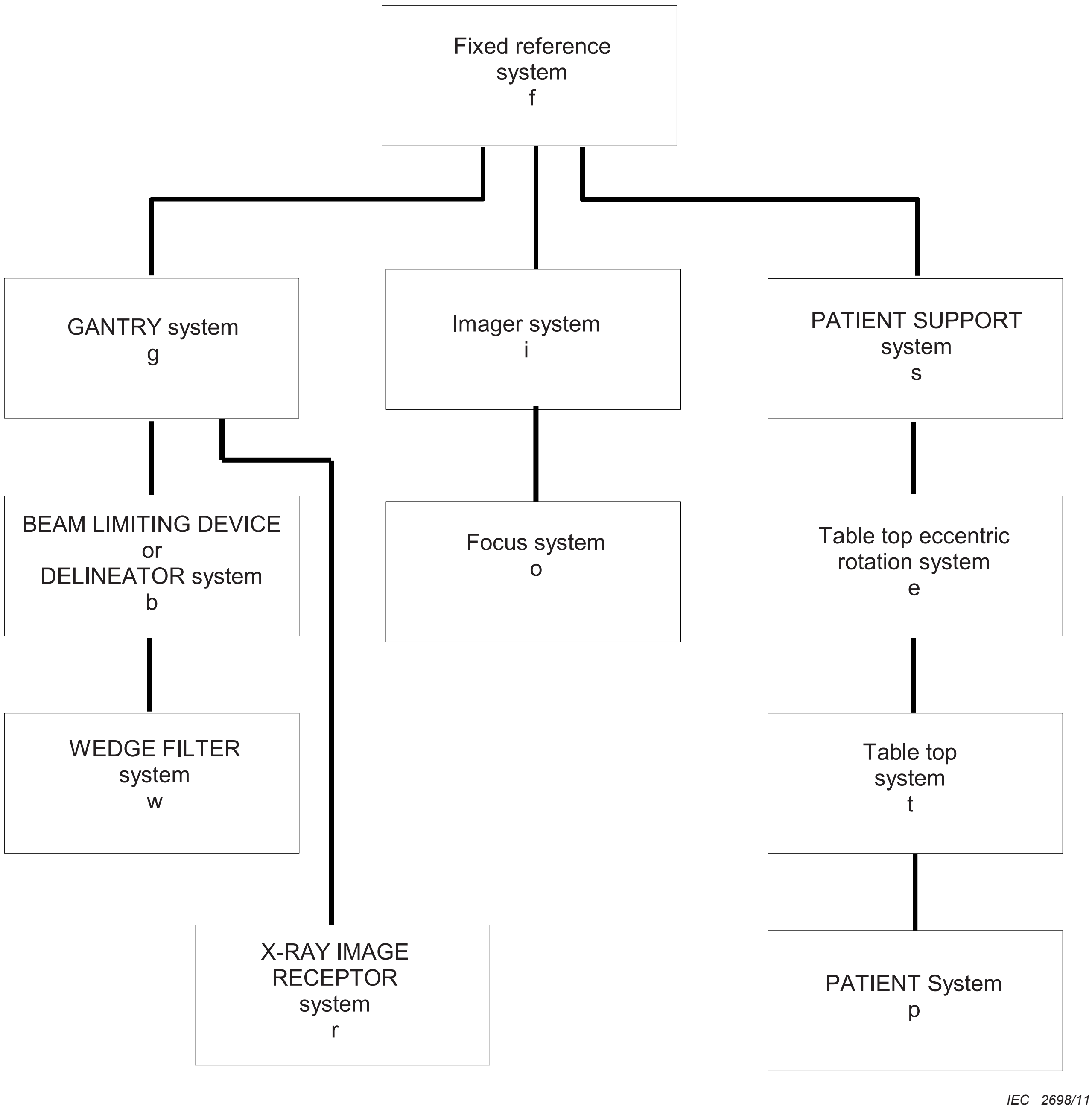


Figure 3 – Hierarchical structure among coordinate systems (see 3.2c) and 3.2e))

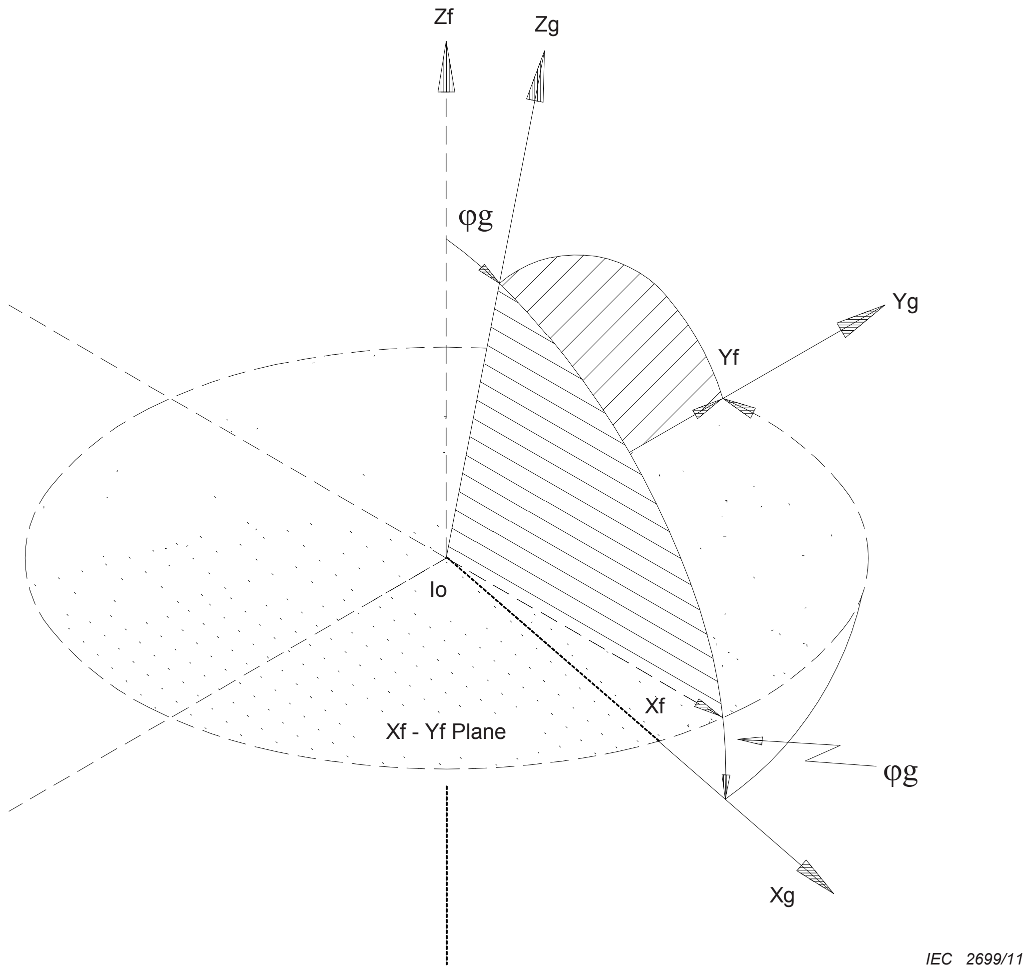


Figure 4 – Rotation (φg = 15°) of GANTRY coordinate system Xg, Yg, Zg in fixed coordinate system Xf, Yf, Zf (see 3.4)

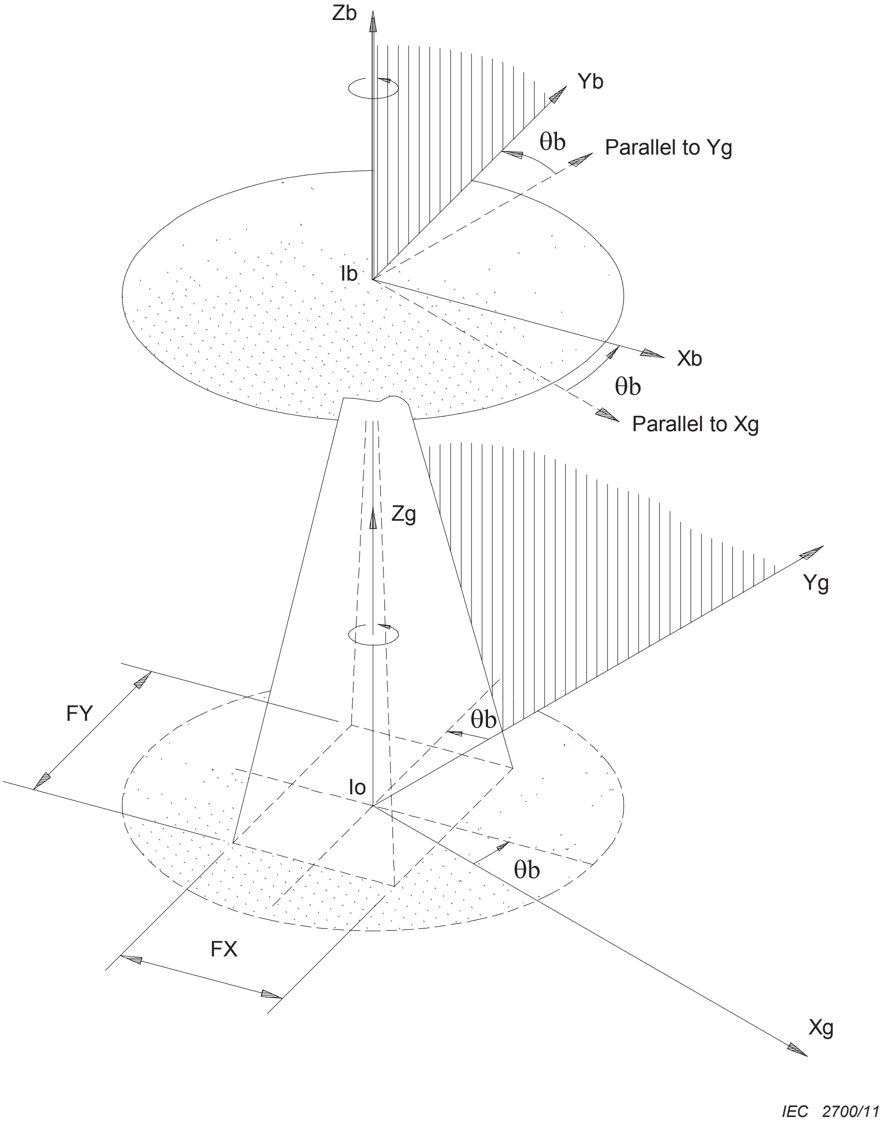
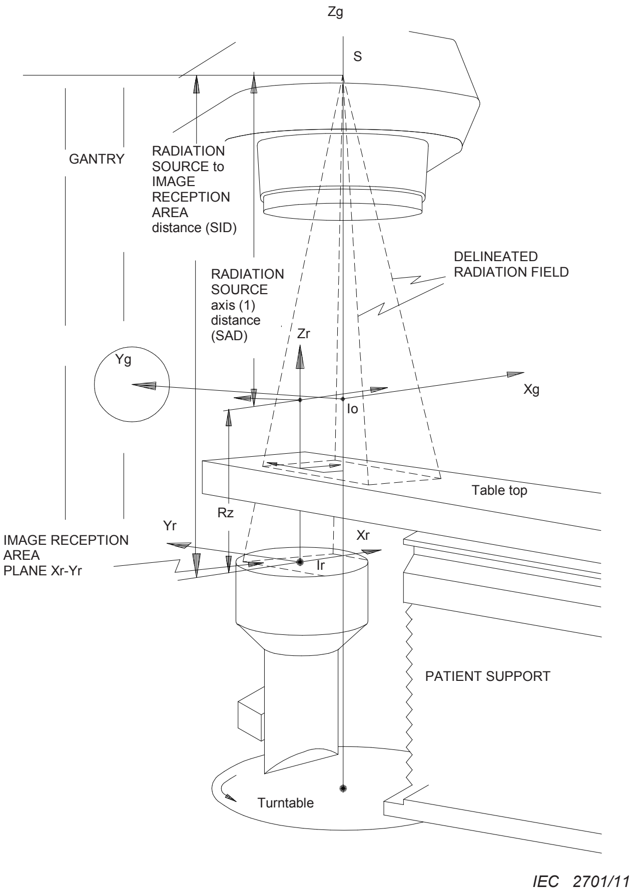


Figure 5 – Rotation (θb = 15°) of BEAM LIMITING DEVICE or DELINEATOR coordinate system Xb, Yb, Zb in GANTRY coordinate system Xg, Yg, Zg, and resultant rotation of RADIATION FIELD or DELINEATED RADIATION FIELD of dimensions FX and FY (see 3.5)



NOTE 1 Rx = Displacement of Ir parallel to Xg. Rx shown = −8 cm.

Ry = Displacement of Ir parallel to Yg. Ry shown = +10 cm.

Rz = Displacement of Ir parallel to Zg (commonly called radial displacement of X-RAY IMAGE RECEPTOR)

Rz shown = −40 cm.

NOTE 2 See Figure 8 for displacement of Rx, Ry.

Figure 6 – Displacement of image intensifier type X-RAY IMAGE RECEPTOR coordinate system origin, Ir, in GANTRY coordinate system, by Rx = –8, Ry = +10, Rz = –40 (see 3.7)

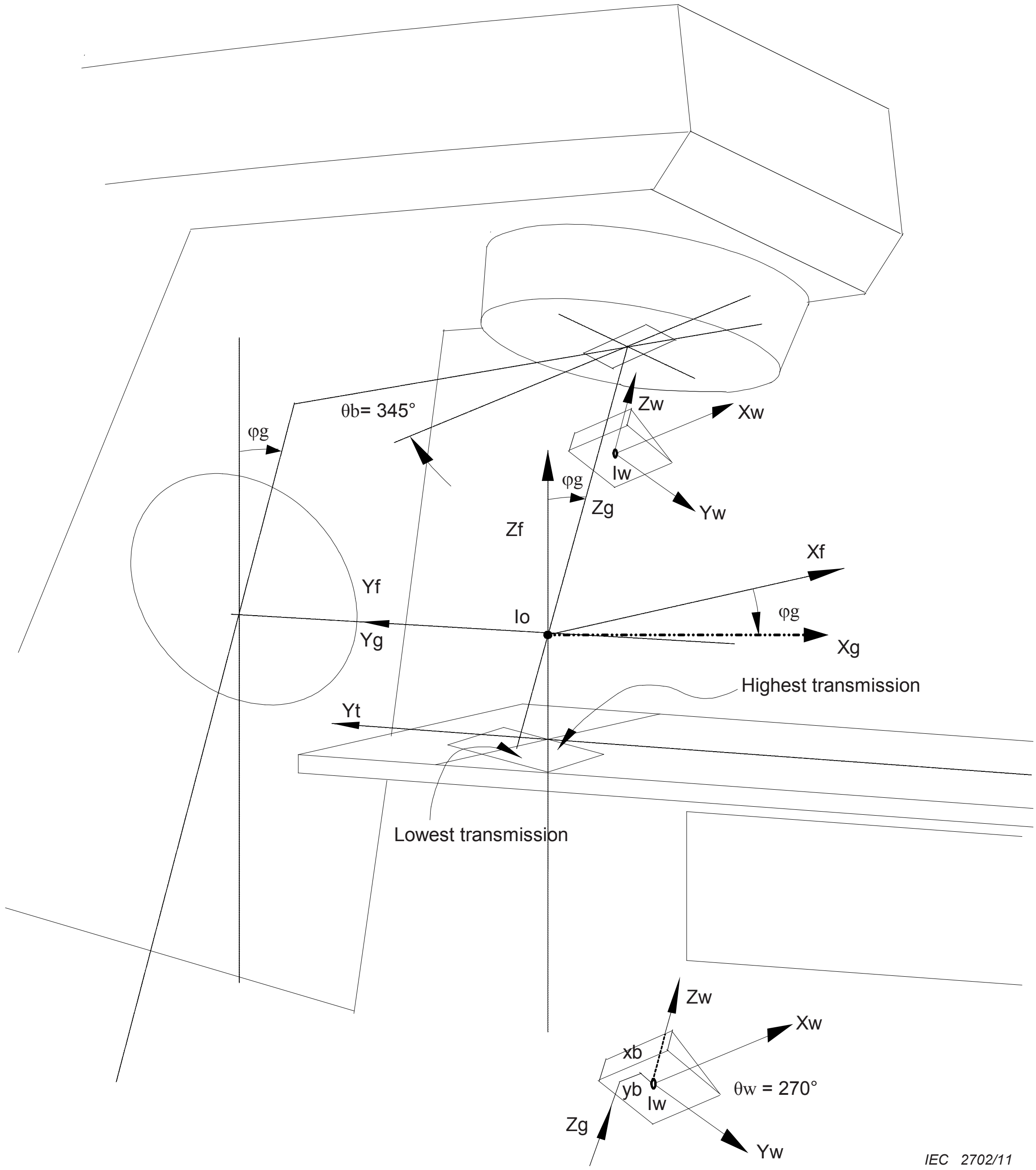


Figure 7 – Rotation (θw = 270°) and translation of WEDGE FILTER coordinate system Xw, Yw, Zw in BEAM LIMITING DEVICE coordinate system Xb, Yb, Zb, the BEAM LIMITING DEVICE coordinate system having a rotation θb = 345° (see 3.6)

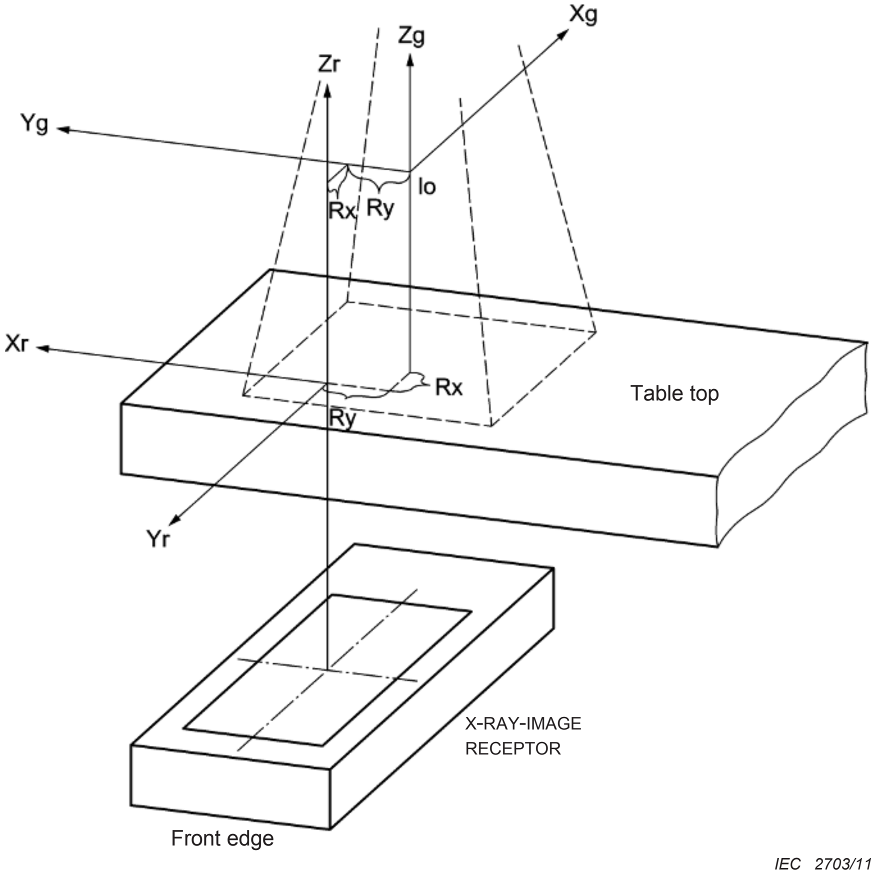


Figure 8 – Rotation (θr = 90°) and displacement of X-RAY IMAGE RECEPTOR coordinate system Xr, Yr, Zr in GANTRY coordinate system Xg, Yg, Zg (see 3.7)

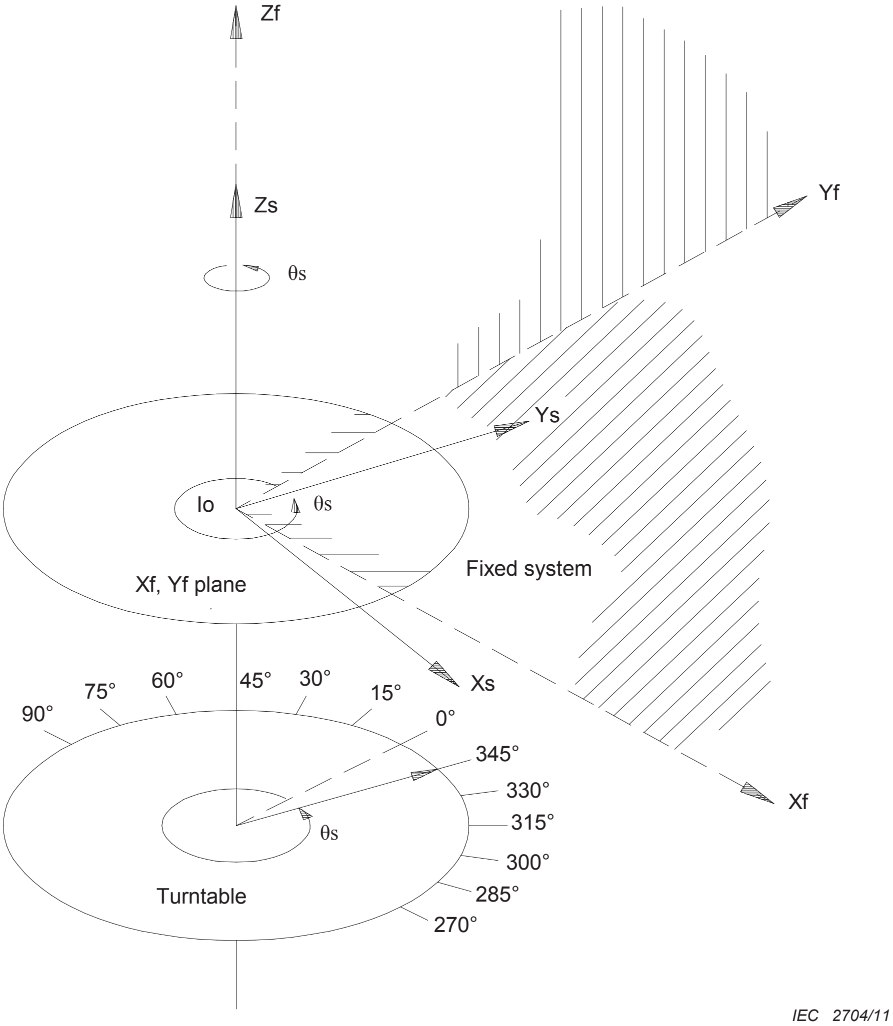
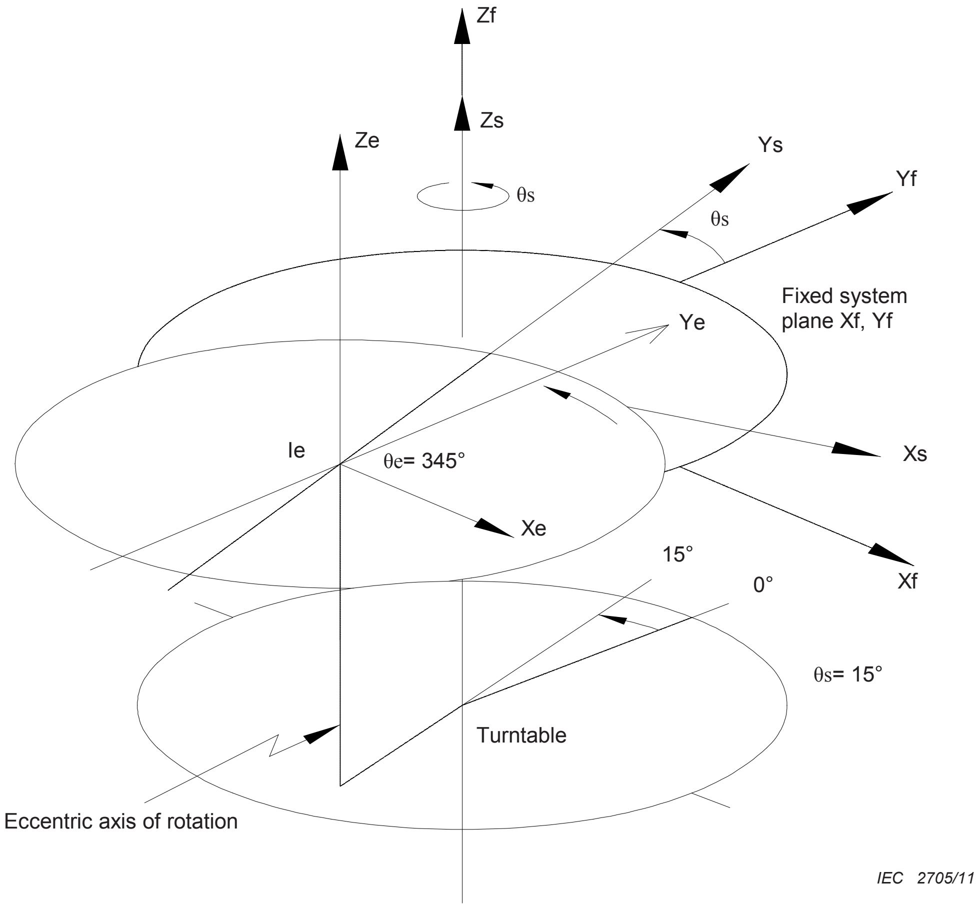


Figure 9 – Rotation (θs = 345°) of PATIENT SUPPORT coordinate system Xs, Ys, Zs in fixed coordinate system Xf, Yf, Zf (see 3.8)



NOTE Xe is parallel to Xf and Ye is parallel to Yf because θe = 360° – θs

θs = 15°

θe = 345°

Figure 10 – Table top eccentric coordinate system rotation θe in PATIENT SUPPORT coordinate system which has been rotated by θs in the fixed coordinate system with θe = 360° – θs (see 3.9 and 3.10)

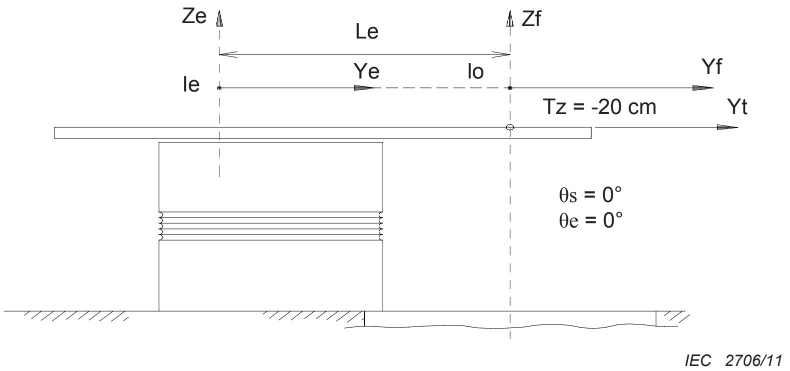


Figure 11a – Table top displaced below ISOCENTRE by Tz = –20 cm (see 3.9 and 3.10)

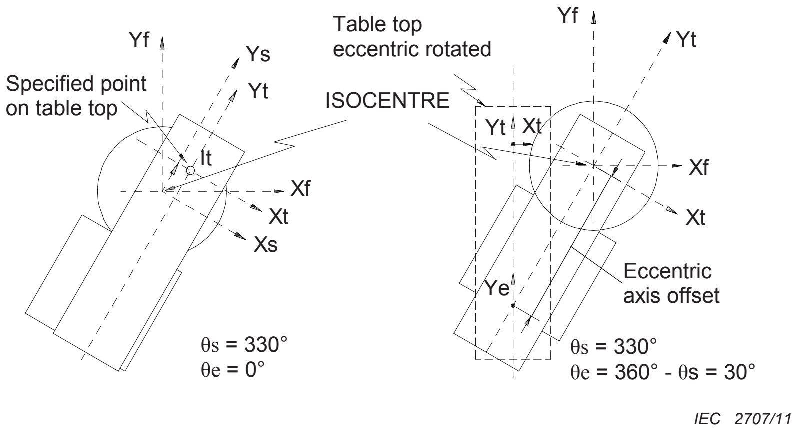


Figure 11b – Table top coordinate system displacement Tx = + 5, Ty = Le + 10 in PATIENT SUPPORT coordinate system Xs, Ys, Zs rotation (θs = 330°) in fixed coordinate system Xf, Yf, Zf (see 3.9 and 3.10)

Figure 11c – Table top coordinate system rotation (θe = 30°) about table top eccentric system. PATIENT SUPPORT rotation (θs = 330°) in fixed coordinate system Tx = 0, Ty = Le (see 3.9 and 3.10)

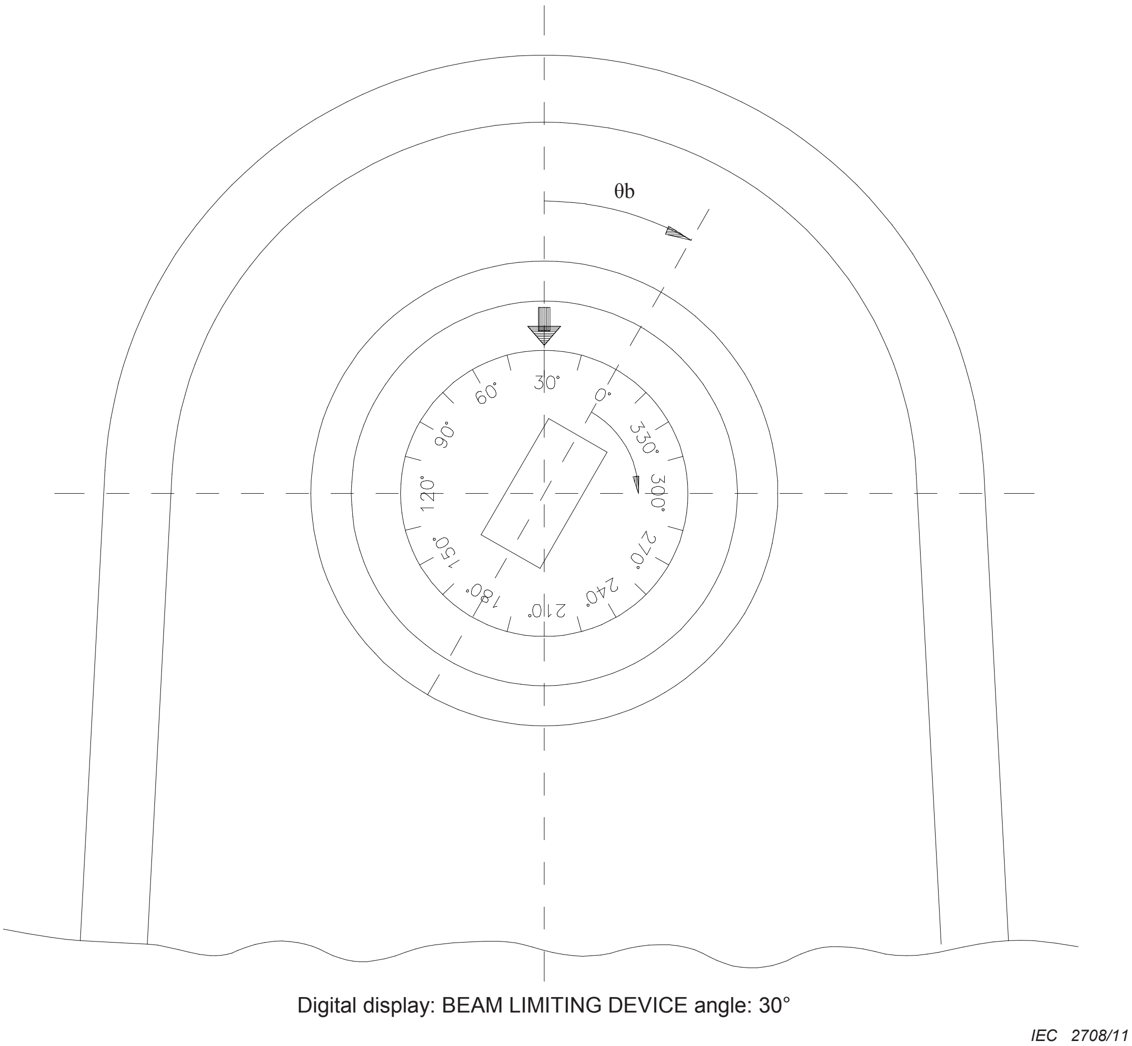


Figure 12a – Example of BEAM LIMITING DEVICE scale, pointer on mother system (GANTRY), scale on daughter system (BEAM LIMITING DEVICE), viewed from ISOCENTRE (see 3.2f)2) and Clause 4)

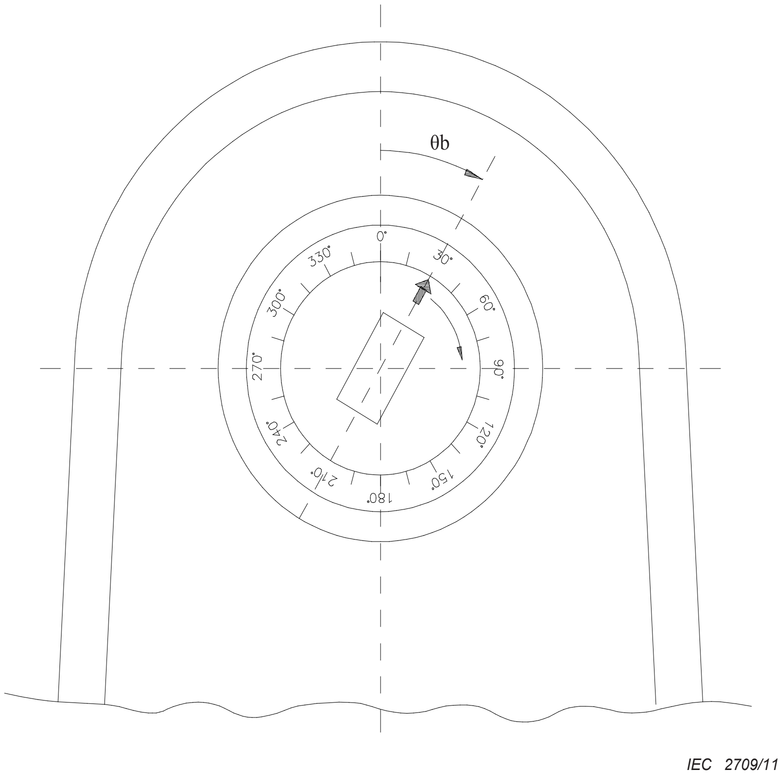


Figure 12b – Example of BEAM LIMITING DEVICE scale, pointer on daughter system (BEAM LIMITING DEVICE), scale on mother system (GANTRY), viewed from ISOCENTRE (see 3.2f)2) and Clause 4)

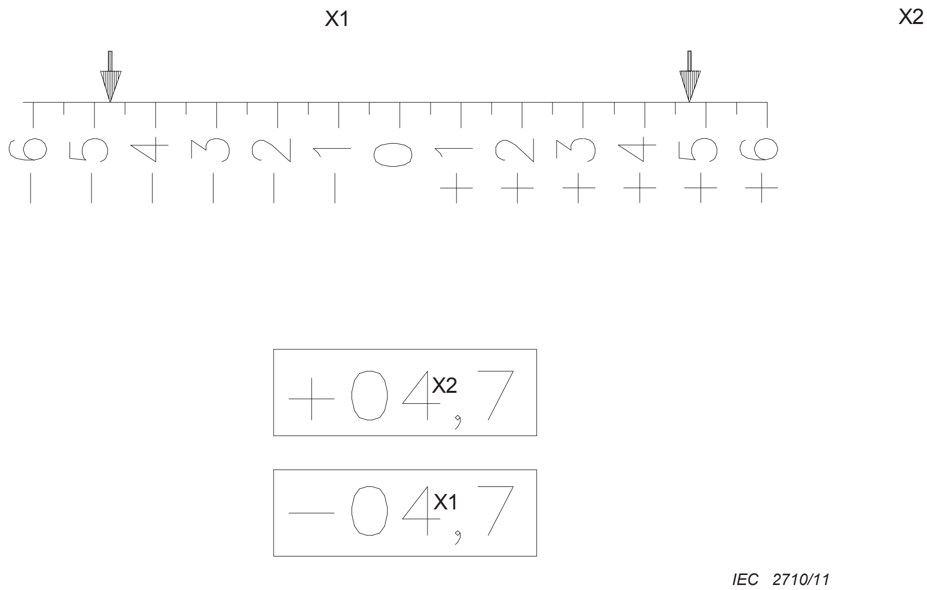
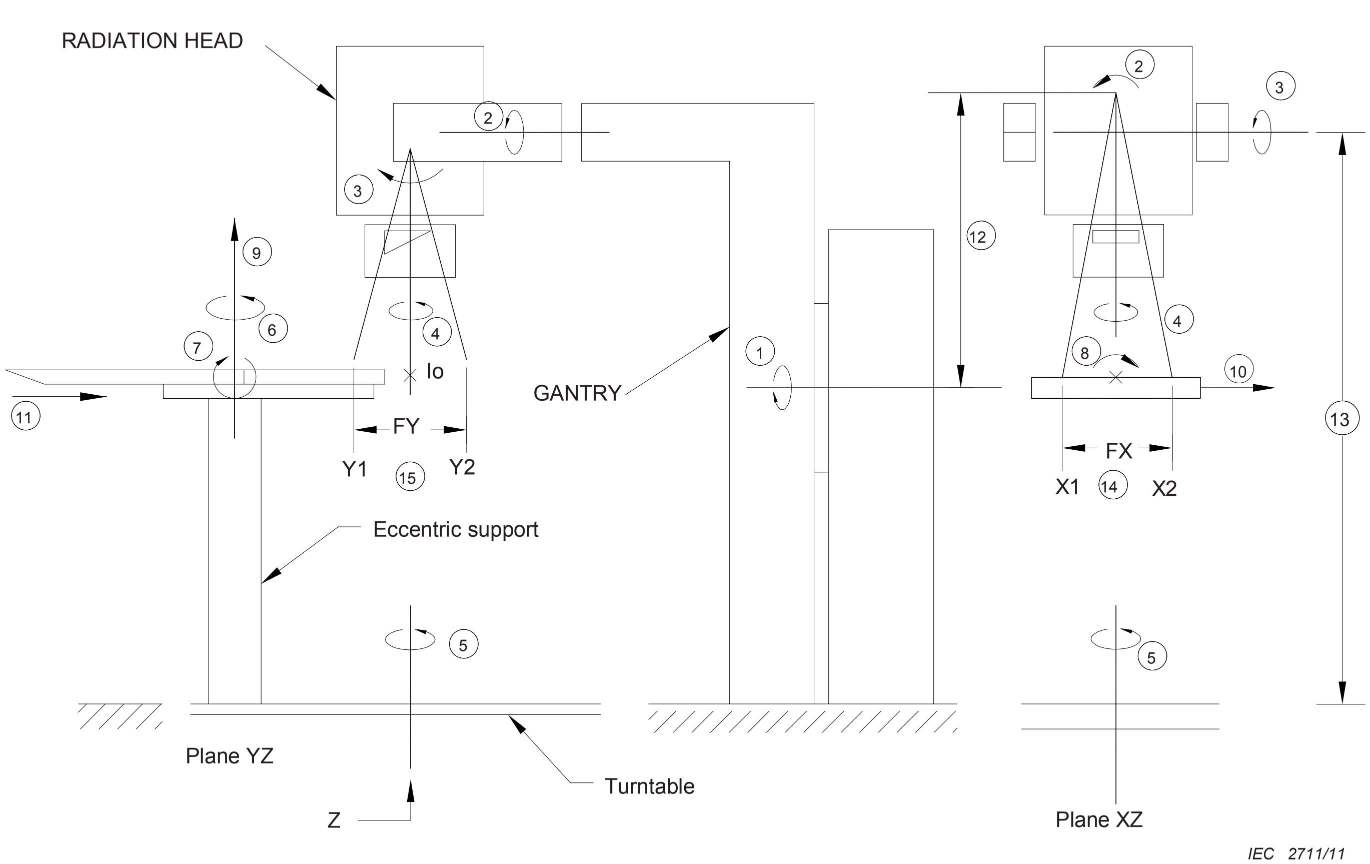


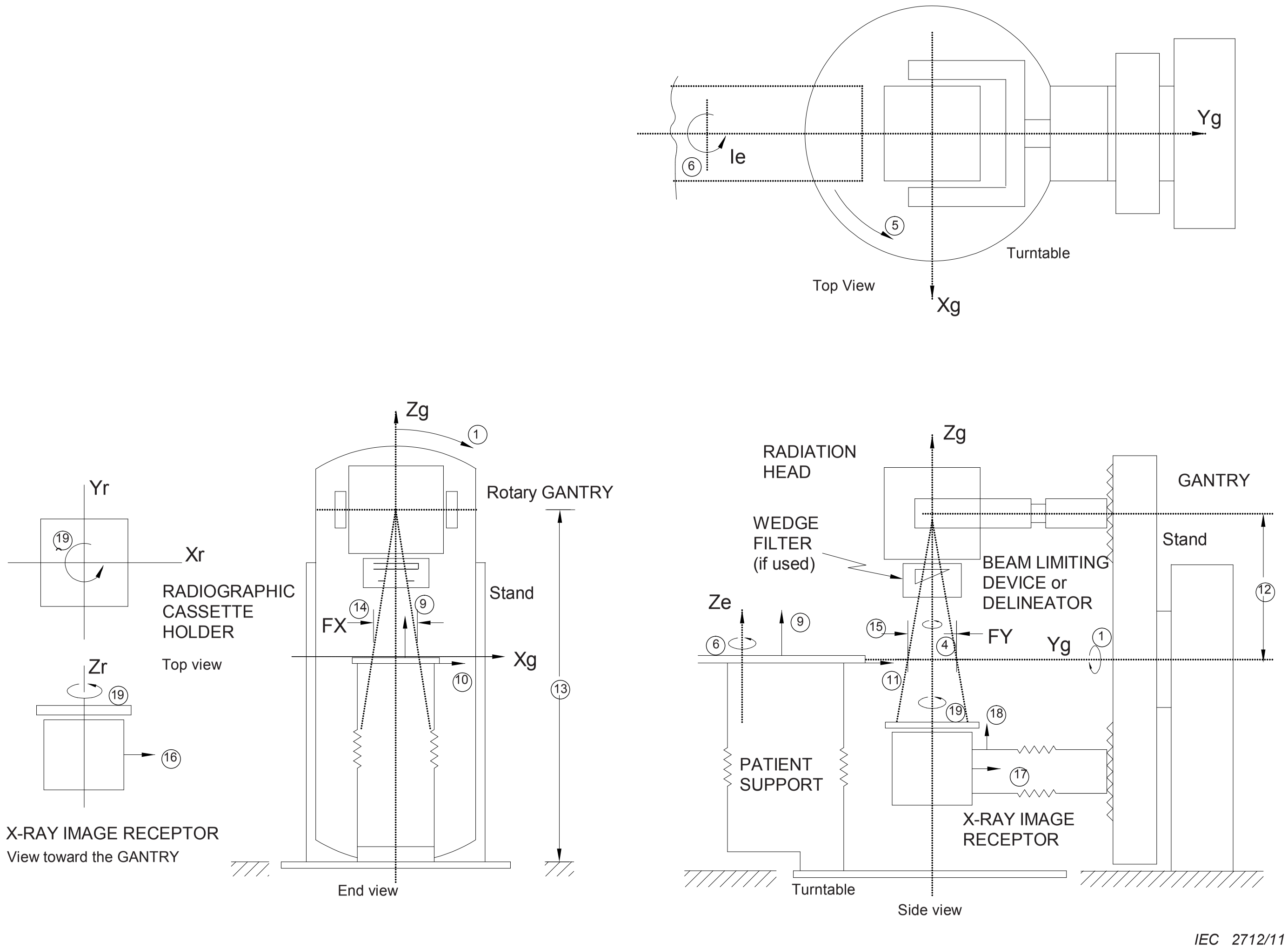
Figure 12c – Examples of scales (see Clause 4)



NOTE 1 The axes, directions and dimensions corresponding to the numbers on these figures are listed in Clause 5.

NOTE 2 The elliptical arrows show clockwise rotations looking towards GANTRY for axes 1 and 8, away from GANTRY for axis 2, from right side of GANTRY for axes 3 and 7, up from ISOCENTRE for axis 4, up from ISOCENTRE for axis 5, up from table top for axis 6.

Figure 13a – Rotary GANTRY (adapted from IEC 60601-2-1) with identification of axes 1 to 8, directions 9 to 13, and dimensions 14 and 15 (see Clause 5)



NOTE Cassette holder motions:
Direction (17): motion parallel to axis (1);
Direction (18): motion perpendicular to directions (16) and (17);
Axis (19) : rotation.

Figure 13b – ISOCENTRIC RADIOTHERAPY SIMULATOR or TELERADIOTHERAPY EQUIPMENT, with identification of axes 1; 4 to 6; 19, of directions 9 to 12; 16 to 18 and of dimensions 14; 15 (see Clause 5)

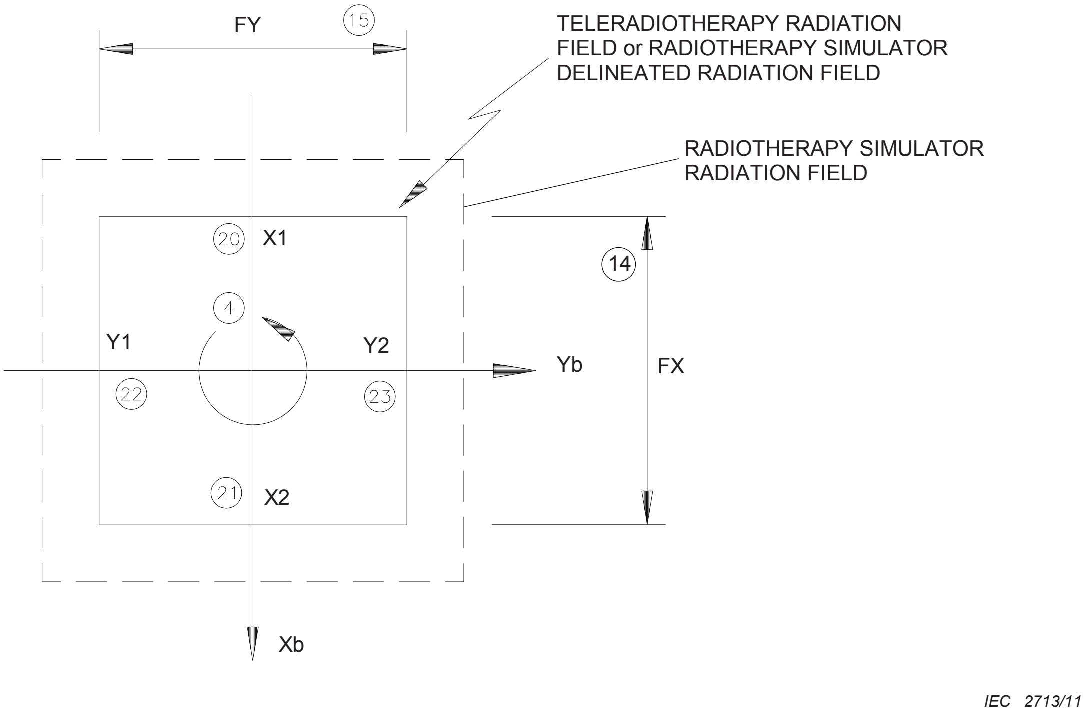
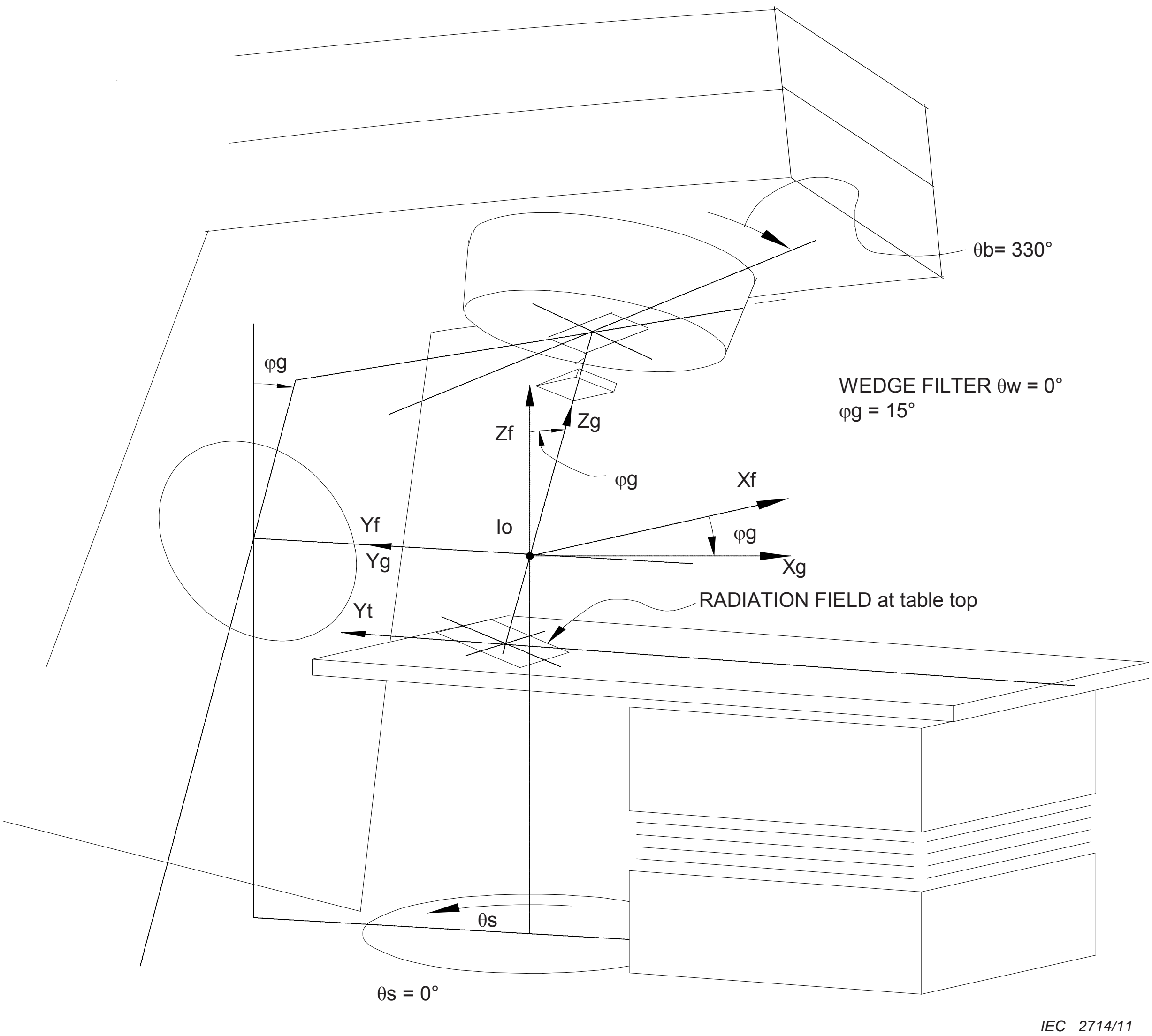
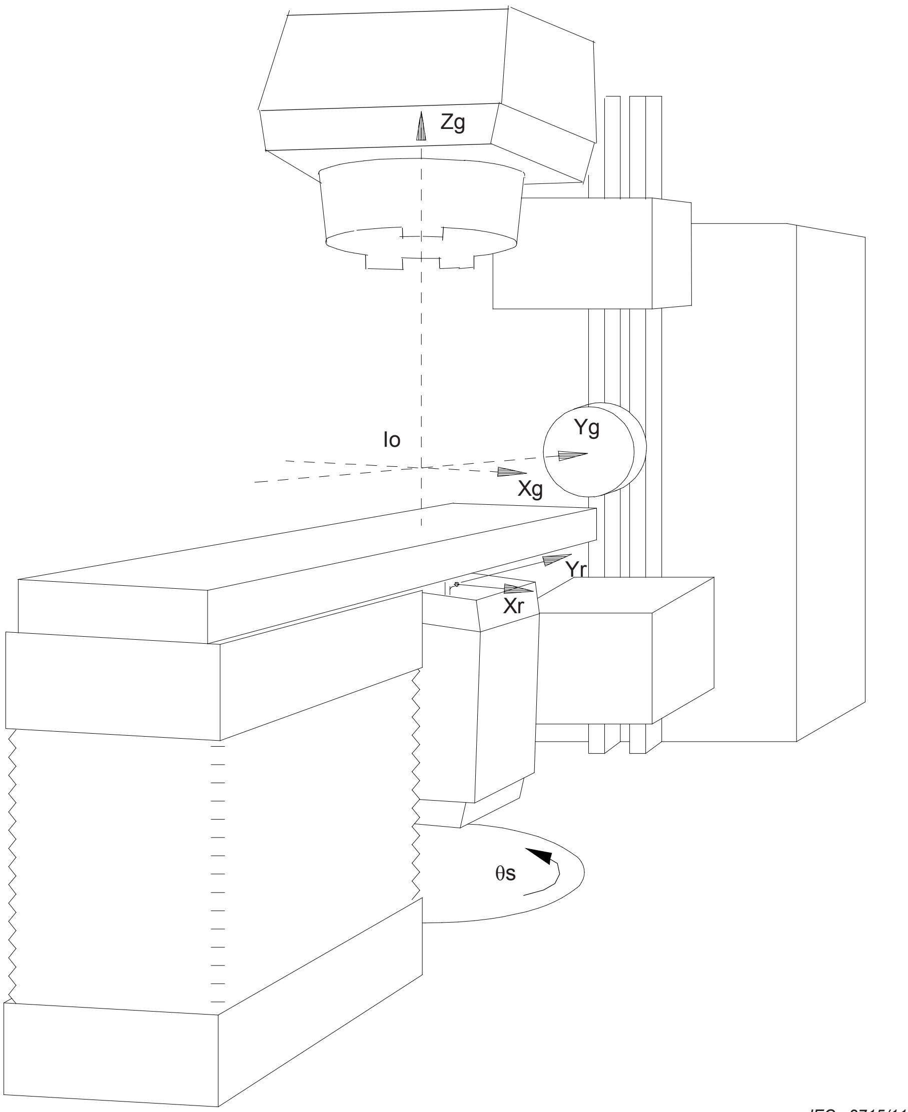


Figure 13c – View from radiation source of teleradiotherapy radiation field or radio-therapy simulator delineated radiation field (see Clause 5)



φg = 15°
θb = 330°
θw = 0°
θs = 0°
θe = 0°
Tx = 0, Ty = +10, Tz = –15
FX = 10,0, FY = 20,0

Figure 14a – Example of ISOCENTRIC TELERADIOTHERAPY EQUIPMENT (see 7.2 and 7.4)



NOTE 1 Xr is parallel to Xg;
Yr is parallel to Yg;
but in perspective view.

NOTE 2 All angles zero.

NOTE 3 Tz is negative.

Figure 14b – Example of ISOCENTRIC RADIOTHERAPY SIMULATOR equipment (see 7.2)

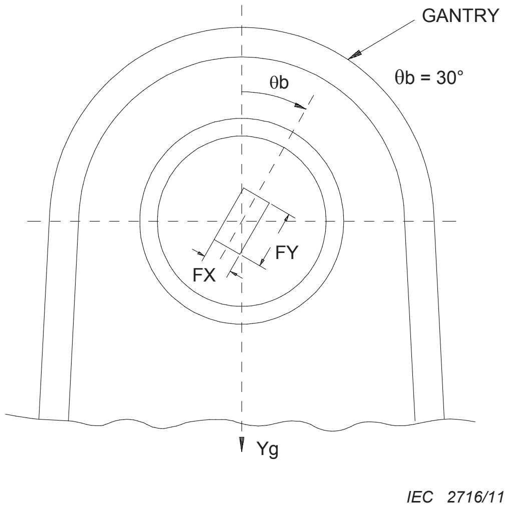


Figure 15a – Rotated (θb = 30°) symmetrical rectangular RADIATION FIELD (FX × FY) at NORMAL TREATMENT DISTANCE, viewed from ISOCENTRE looking toward RADIATION SOURCE (see 7.3)

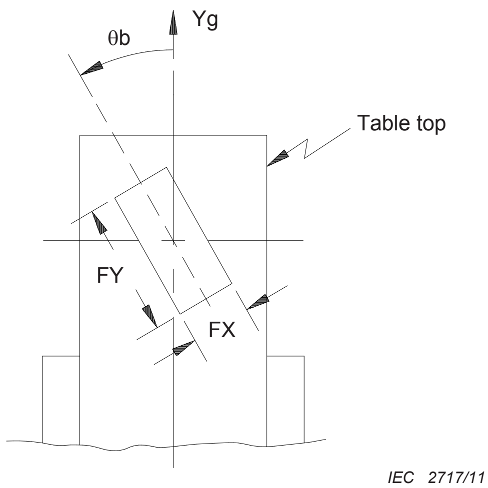
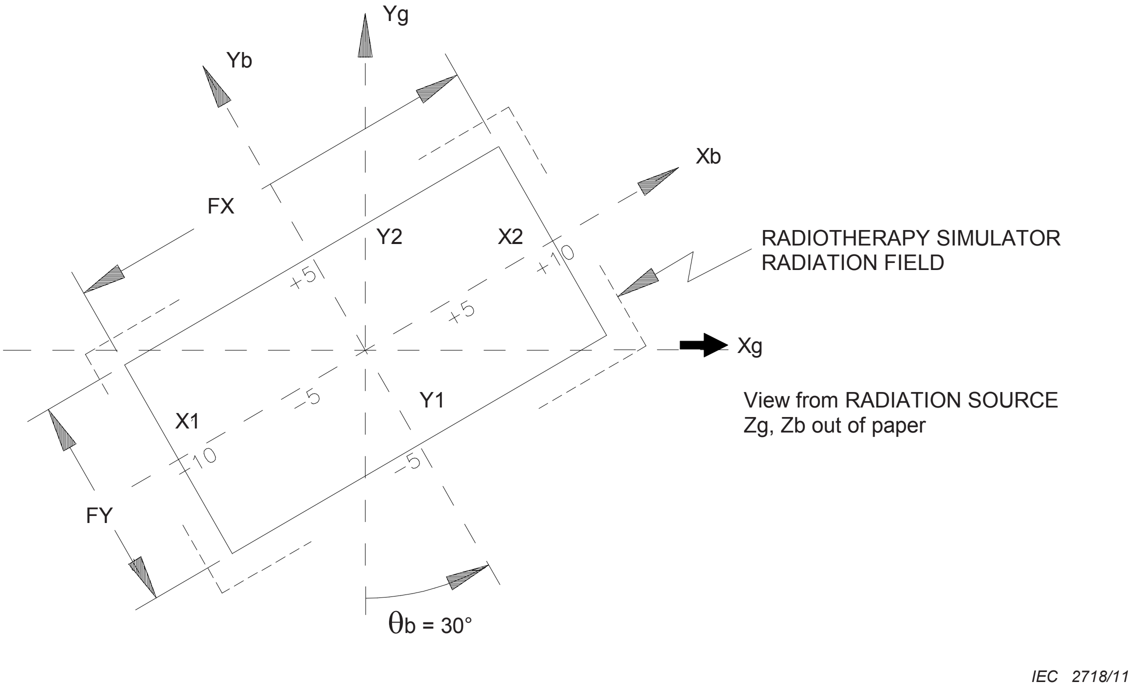
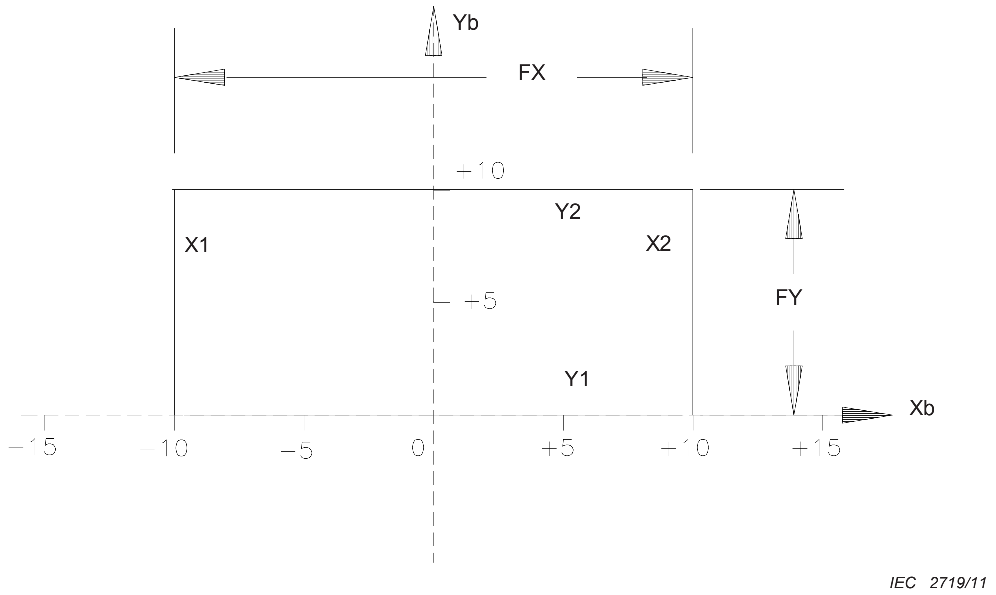


Figure 15b – Same rotated (θb = 30°) symmetrical rectangular RADIATION FIELD (FX × FY) at NORMAL TREATMENT DISTANCE, viewed from RADIATION SOURCE (see 7.3)



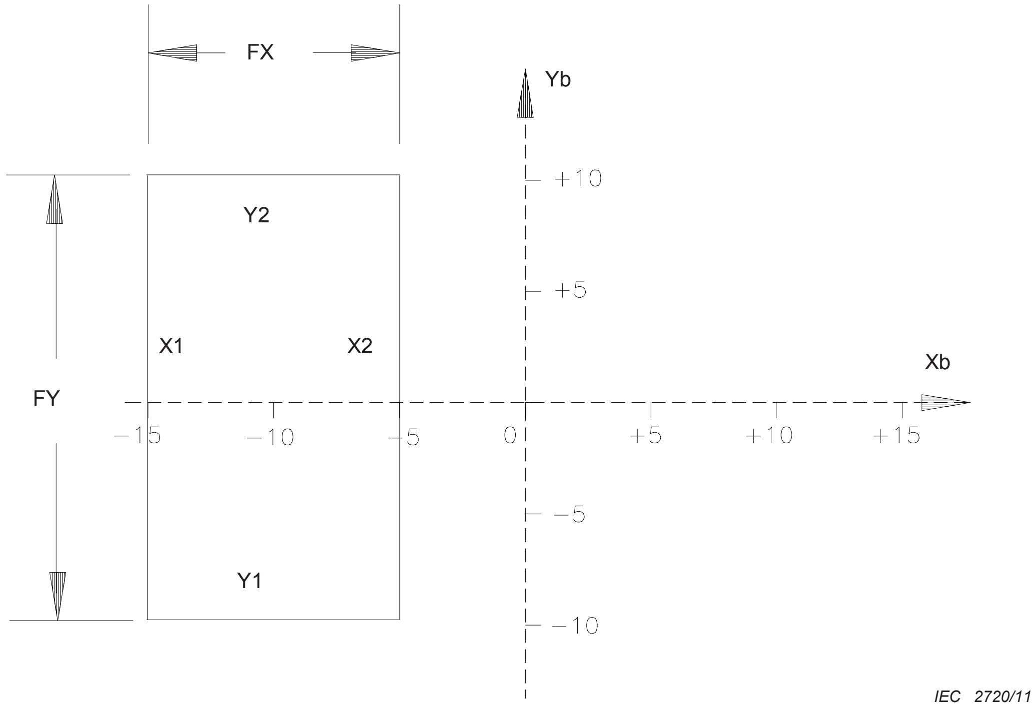
BEAM LIMITING DEVICE angle θb = 30°
FX = 20
FY = 10

Figure 16a – Rectangular and symmetrical RADIATION FIELD or DELINEATED RADIATION FIELD, viewed from RADIATION SOURCE (see 7.5)



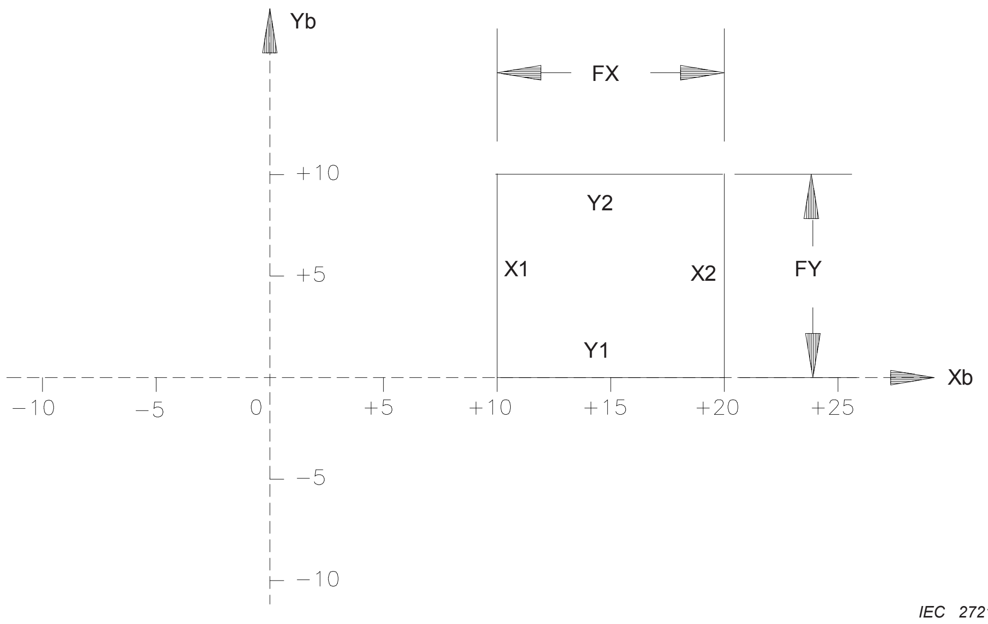
BEAM LIMITING DEVICE angle θb = 0°
FX = 20
FY = 10
Y1 = 0
Y2 = +10

Figure 16b – Rectangular and asymmetrical in Yb RADIATION FIELD or DELINEATED RADIATION FIELD, viewed from RADIATION SOURCE (see 7.5)



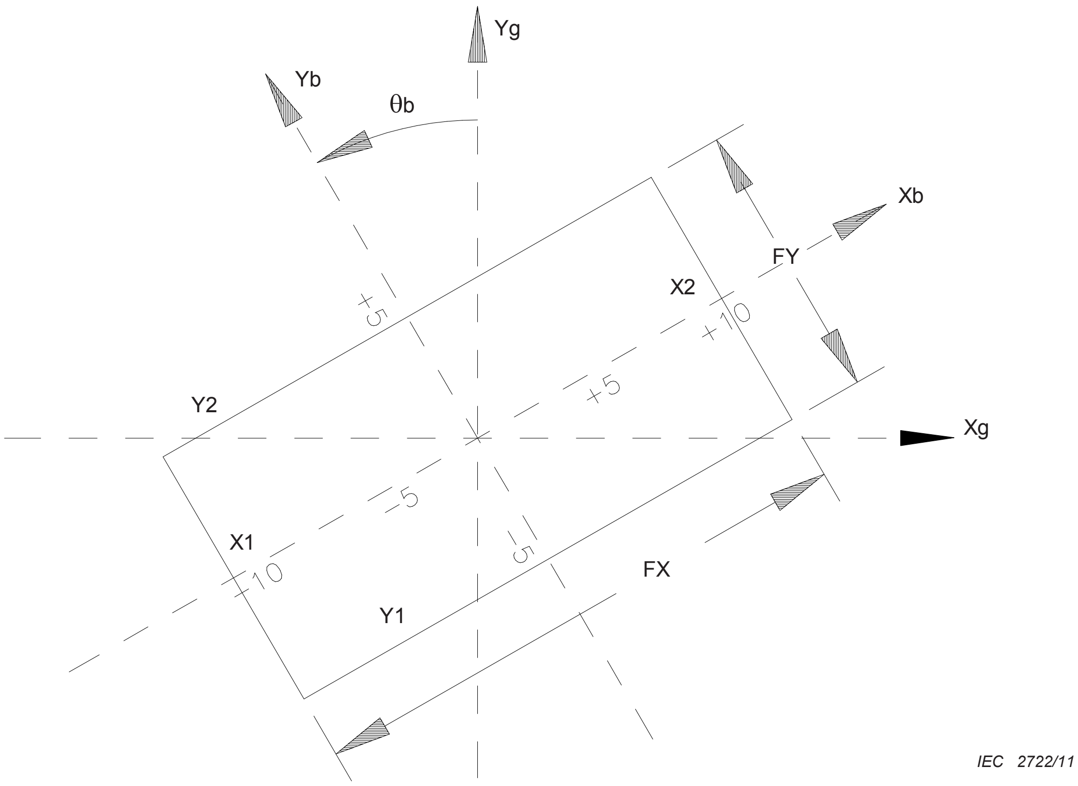
BEAM LIMITING DEVICE angle θb = 0°
FX = 10
X1 = −15
X2 = −5
FY = 20

Figure 16c – Rectangular and asymmetrical in Xb RADIATION FIELD or DELINEATED RADIATION FIELD, viewed from RADIATION SOURCE (see 7.5)



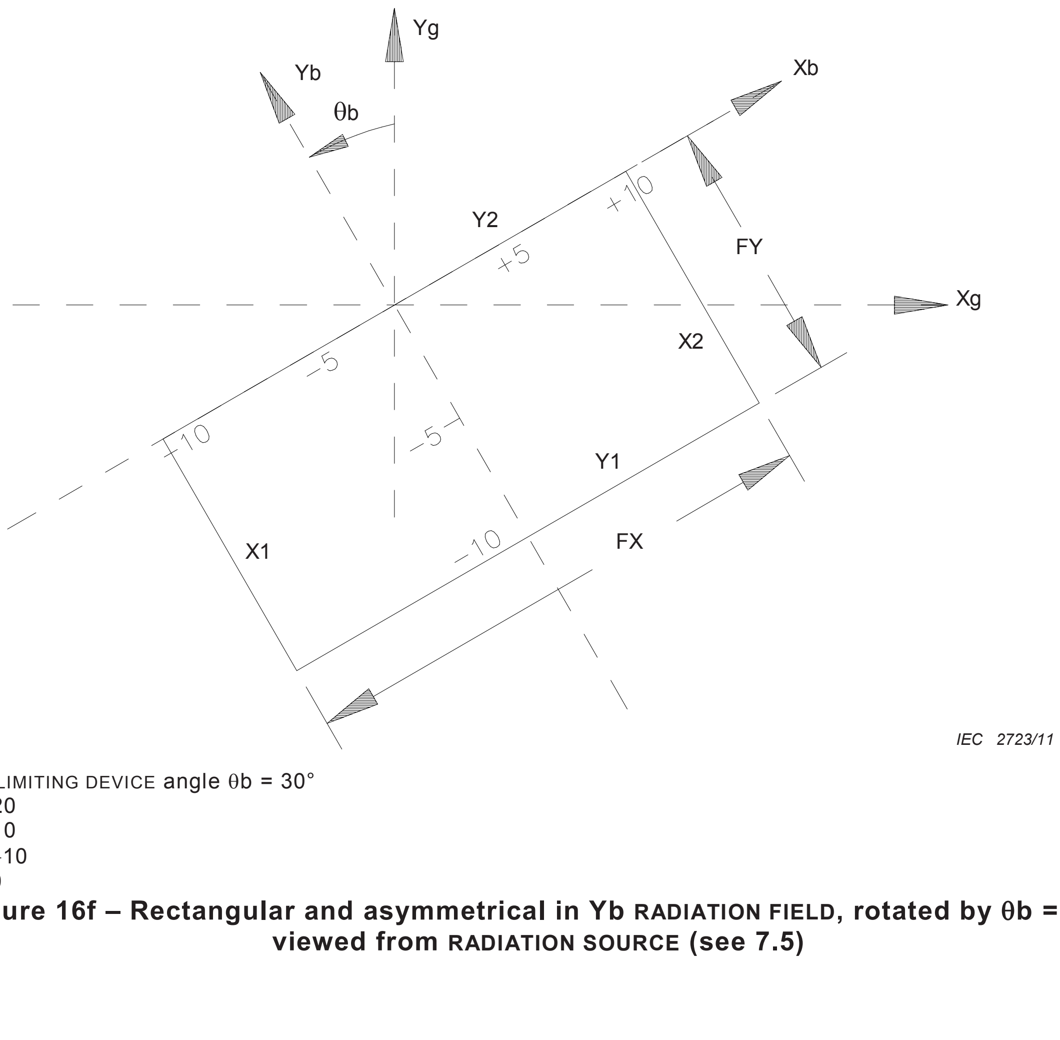
BEAM LIMITING DEVICE angle θb = 0°
FX = 10
X1 = +10
X2 = +20
FY = 10
Y1 = 0
Y2 = +10

Figure 16d – Rectangular and asymmetrical in Xb and Yb RADIATION FIELD or DELINEATED RADIATION FIELD, viewed from RADIATION SOURCE (see 7.5)



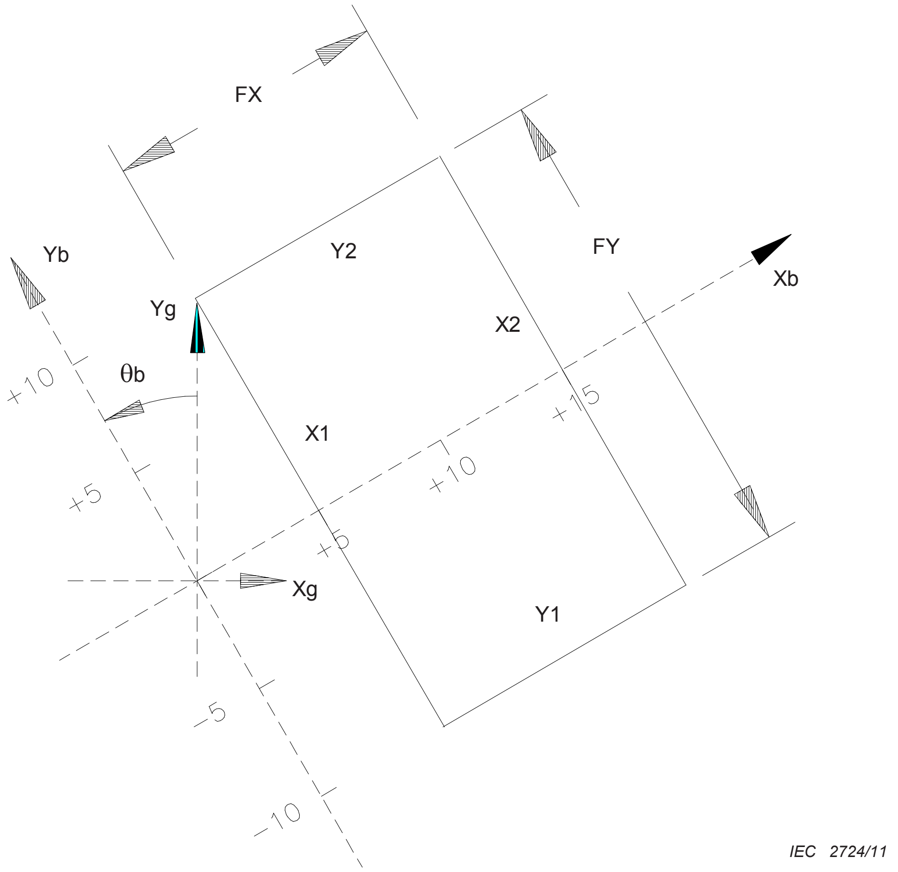
BEAM LIMITING DEVICE angle θb = 30°
FX = 20
FY = 10

Figure 16e – Rectangular and symmetrical RADIATION FIELD, rotated by θb = 30°, viewed from RADIATION SOURCE (see 7.5)



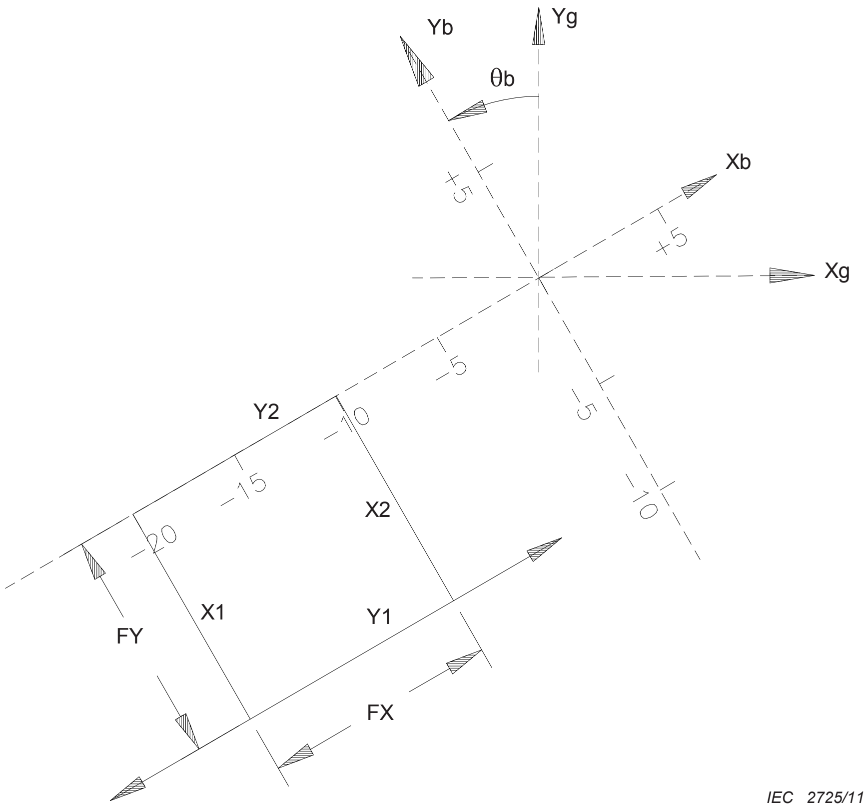
BEAM LIMITING DEVICE angle θb = 30°
FX = 20
FY = 10
Y1 = −10
Y2 = 0

Figure 16f – Rectangular and asymmetrical in Yb RADIATION FIELD, rotated by θb = 30°, viewed from RADIATION SOURCE (see 7.5)



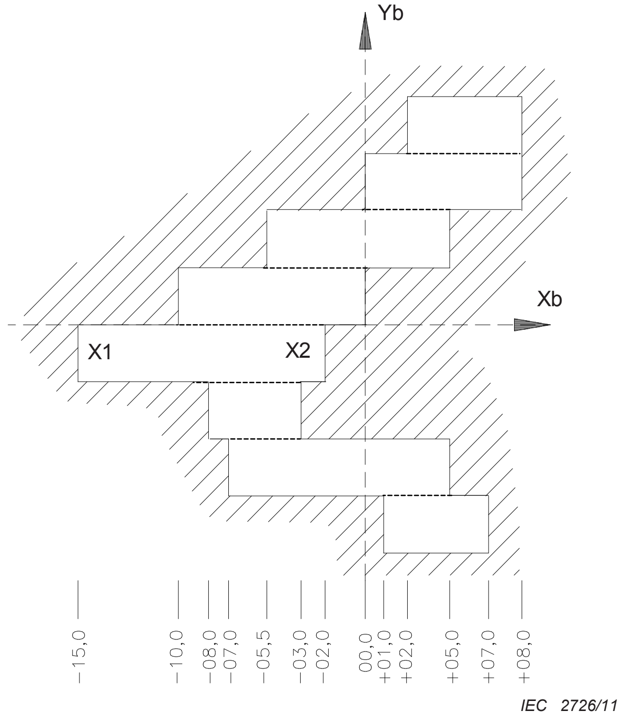
BEAM LIMITING DEVICE angle θb = 30°
FX = 10
X1 = +5
X2 = +15
FY = 20

Figure 16g – Rectangular and asymmetrical in Xb RADIATION FIELD, rotated by θb = 30°, viewed from RADIATION SOURCE (see 7.5)



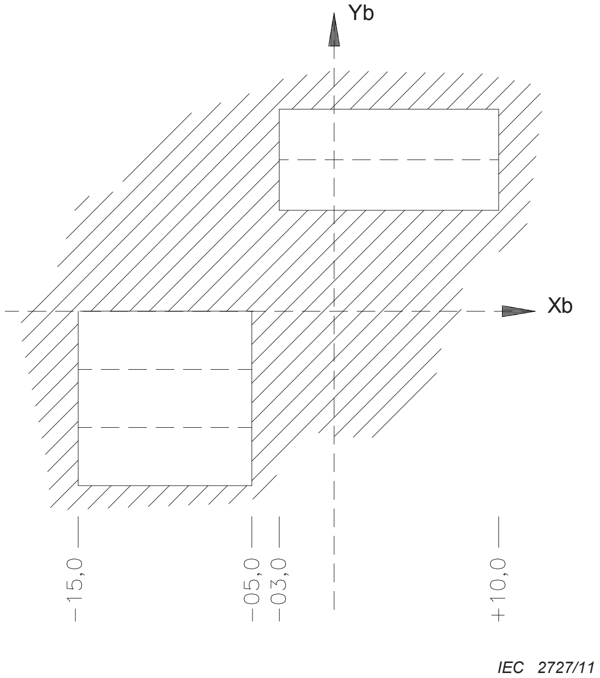
BEAM LIMITING DEVICE angle θb = 30°
FX = 10
X1 = −20
X2 = −10
FY = 10
Y1 = −10
Y2 = 0

Figure 16h – Rectangular and asymmetrical in Xb and Yb RADIATION FIELD, rotated by θb = 30°, viewed from RADIATION SOURCE (see 7.5)



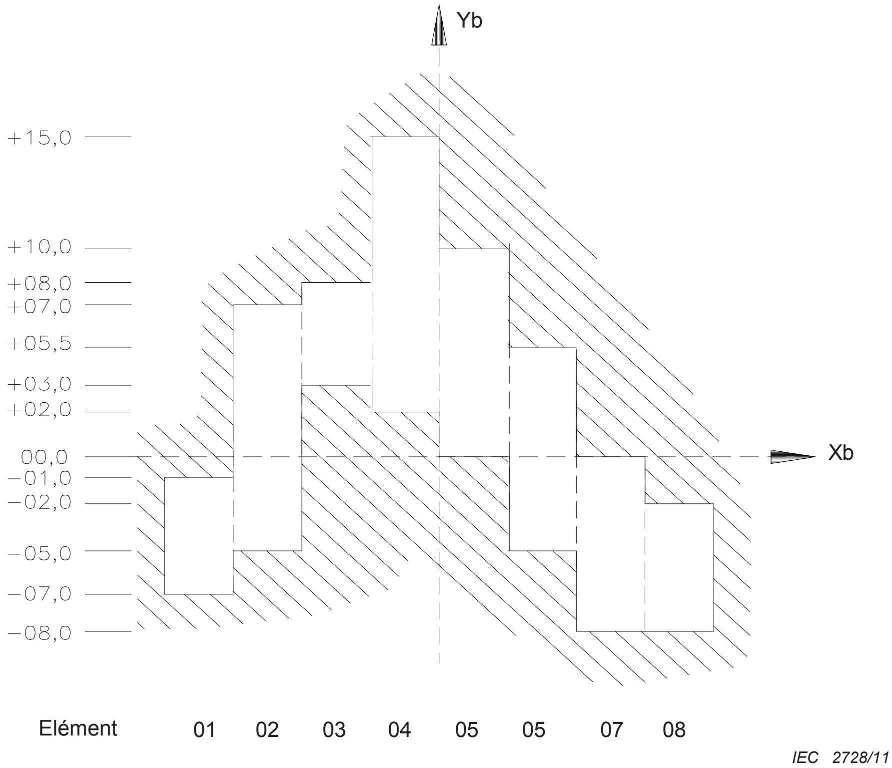
Element	Size FX	Edge X1	Edge X2
08	06,0	+02,0	+08,0
07	08,0	00,0	+08,0
06	10,5	–05,0	+05,0
05	10,0	–10,0	00,0
04	13,0	–15,0	–02,0
03	05,0	–08,0	–03,0
02	12,0	–07,0	+05,0
01	06,0	+01,0	+07,0

Figure 16i – Irregular multi-element (multileaf) contiguous RADIATION FIELD, viewed from RADIATION SOURCE, with element motion in Xb direction (see 7.5)



Element	Size FX	Edge X1	Edge X2
08	13,0	–03,0	+10,0
07	13,0	–03,0	+10,0
04	10,0	–15,0	–05,0
03	10,0	–15,0	–05,0
02	10,0	–15,0	–05,0

Figure 16j – Irregular multi-element (multileaf) two-part RADIATION FIELD, viewed from RADIATION SOURCE, with element motion in Xb direction (see 7.5)



Element	Size FY	Edge Y1	Edge Y2
08	06,0	–08,0	–02,0
07	08,0	–08,0	00,0
06	10,5	–05,0	05,5
05	10,0	00,0	+10,0
04	13,0	+02,0	+15,0
03	05,0	+03,0	+08,0
02	12,0	–05,0	+07,0
01	06,0	–07,0	–01,0

Figure 16k – Irregular multi-element (multileaf) contiguous RADIATION FIELD, viewed from RADIATION SOURCE, with element motion in Yb direction (see 7.5)

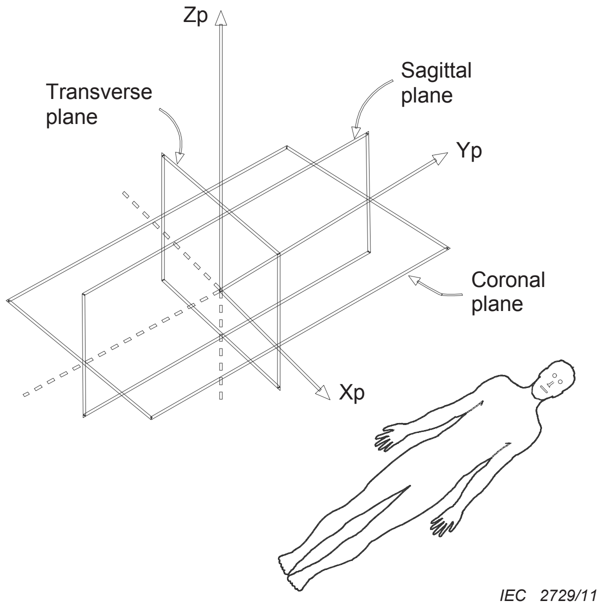


Figure 17a – PATIENT coordinate system (PATIENT is supine)

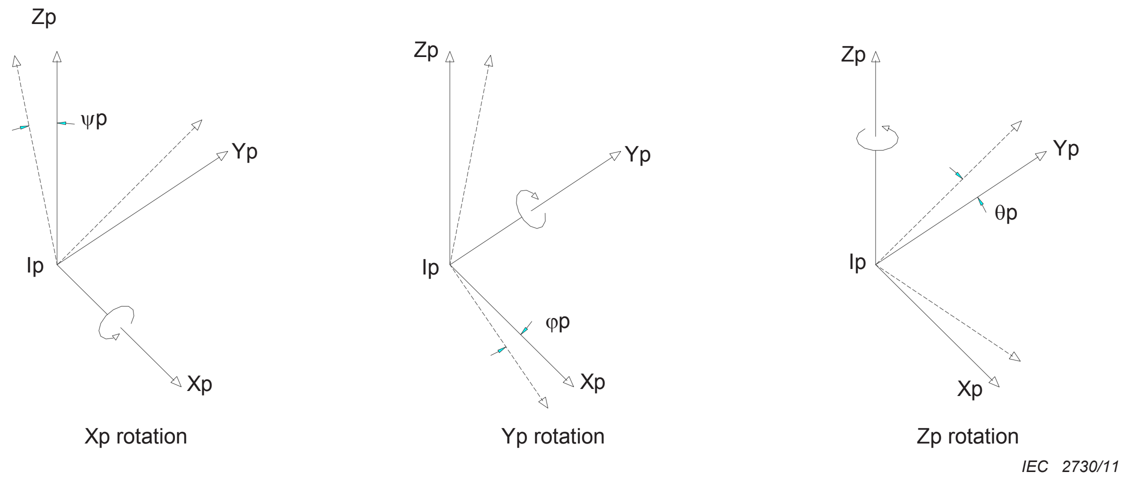


Figure 17b – Rotation of PATIENT coordinate system

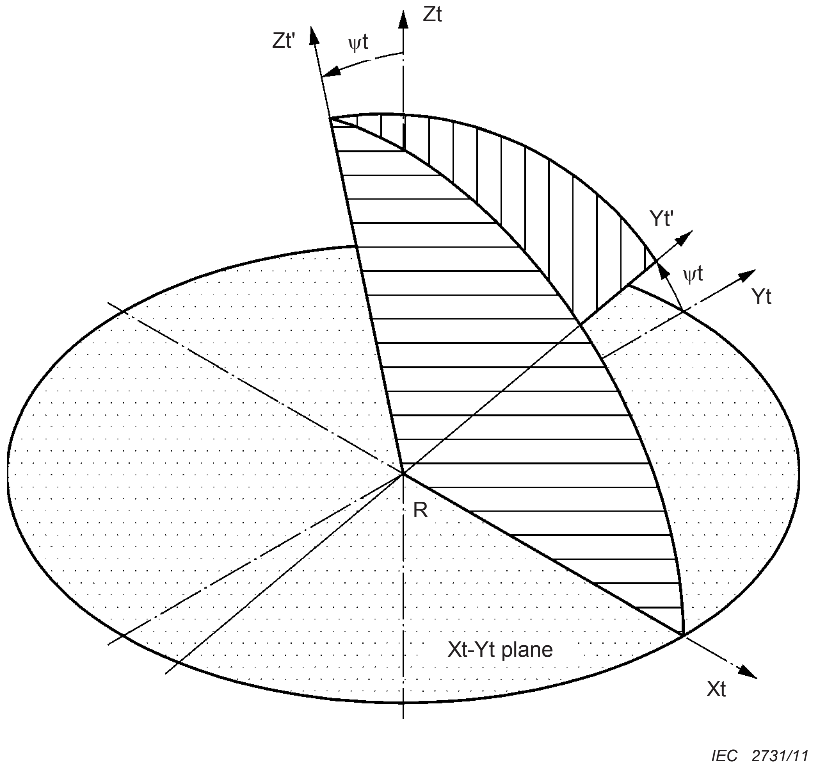


Figure 18 – Table top pitch rotation of table top coordinate system Xt, Yt, Zt (see 3.10 and 7.8.4)

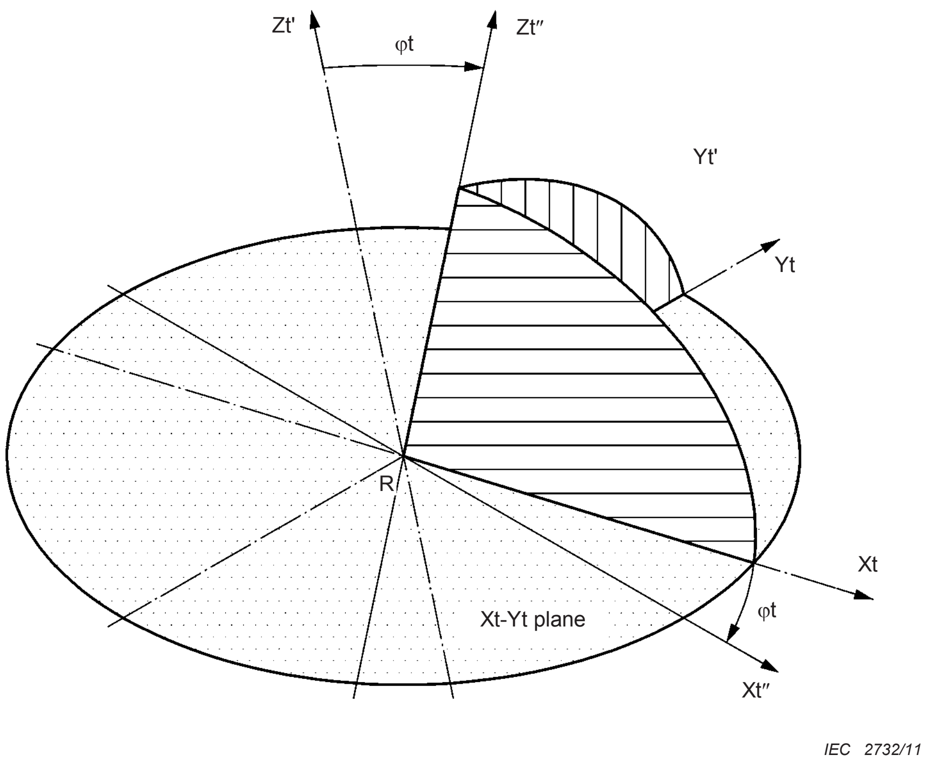


Figure 19 – Table top roll rotation of table top coordinate system Xt, Yt, Zt (see 3.10. and 7.8.5)

Annex A
(informative)

Examples of coordinate transformations between individual coordinate systems

A.1 Designations

In this annex the following designations are used:

$\vec{V}_a$	is the vector of the origin of the "a" system expressed in terms of its mother system;
$\vec{V}_{ab}$	is a vector in the "a"-system expressed in terms of the "b" system;
M_{ab}	is the transformation matrix corresponding to the transformation from the "a" system into the "b" system;
$M_{ab}^{-1} \equiv M_{ba}$	is the inverse matrix of M_{ab}; as M_{ab} is a rotation matrix the inverse matrix can be calculated by interchange of columns and rows of M_{ab}.

A.2 Transformation from mother into daughter system and vice versa

Let $\vec{V}_o$ be a vector to some point in the mother system "m".

If the coordinates of the origin of the daughter system "d" are $\vec{V}_d$ and the daughter system has been rotated relative to the mother system, then the coordinates of $\vec{V}_o$ in the daughter system are:

$$\vec{V}_{md} = M_{md} \cdot \left(\vec{V}_o - \vec{V}_d\right)$$

The back transformation from the daughter system into the mother system can be done using the equation:

$$\vec{V}_o = M_{dm} \cdot \vec{V}_{md} + \vec{V}_d$$

The contents of M_{md} and M_{dm} depend on the coordinate system axis around which the rotation has been effected. The matrices are listed in Table A.1.

Table A.1 – Rotation matrices

Rotation axis	Rotation angle	M_{md}	$M_{dm} \equiv M_{md}^{-1}$
X	ψ	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\psi & \sin\psi \\ 0 & -\sin\psi & \cos\psi \end{bmatrix}$	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\psi & -\sin\psi \\ 0 & \sin\psi & \cos\psi \end{bmatrix}$
Y	φ	$\begin{bmatrix} \cos\varphi & 0 & -\sin\varphi \\ 0 & 1 & 0 \\ \sin\varphi & 0 & \cos\varphi \end{bmatrix}$	$\begin{bmatrix} \cos\varphi & 0 & \sin\varphi \\ 0 & 1 & 0 \\ -\sin\varphi & 0 & \cos\varphi \end{bmatrix}$
Z	θ	$\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$	$\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

A.3 Transformations from the fixed system into the table top system and the WEDGE FILTER system

A.3.1 General

In the following the transformations from the fixed system into the table top system and from the fixed system into the WEDGE FILTER system are described, together with the back transformations. If, in practice, a certain rotation is not used, the rotation angle of the corresponding matrix is zero. The rotation matrix is then the unit matrix.

A.3.2 Transformation from the fixed system into the table top system

Let $\vec{V}_o$ be the vector to some point in the fixed system.

If the PATIENT SUPPORT has been rotated by the angle θs relative to the fixed system, the coordinates of $\vec{V}_o$ in the PATIENT SUPPORT system are

$$\vec{V}_{fs} = M_{fs} \cdot \vec{V}_o$$

$$\text{where } M_{fs} = \begin{bmatrix} \cos\theta s & \sin\theta s & 0 \\ -\sin\theta s & \cos\theta s & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

If the coordinates of the origin of the table top eccentric system in the PATIENT SUPPORT system are:

$$\vec{V}_e = \begin{bmatrix} 0 \\ E_y \\ 0 \end{bmatrix}$$

and the table top eccentric system has been rotated by the angle θe relative to the PATIENT SUPPORT system, the coordinates of $\vec{V}_o$ in the table top eccentric system are:

$$\vec{V}_{fe} = M_{se} \cdot \left(\vec{V}_{fs} - \vec{V}_e\right)$$

where $M_{se} = \begin{bmatrix} \cos\theta e & \sin\theta e & 0 \\ -\sin\theta e & \cos\theta e & 0 \\ 0 & 0 & 1 \end{bmatrix}$

If the coordinates of the origin of the table top system in the table top eccentric system are:

$$\vec{V}_t = \begin{bmatrix} 0 \\ Ty \\ 0 \end{bmatrix}$$

then the coordinates of $\vec{V}_o$ in the table top system are:

$$\vec{V}_{ft} = \vec{V}_{fe} - \vec{V}_t$$

or $\vec{V}_{ft} = M \cdot \vec{V}_o - \vec{V}$

where $M = \begin{bmatrix} m_{11} m_{12} m_{13} \\ m_{21} m_{22} m_{23} \\ m_{31} m_{32} m_{33} \end{bmatrix} = M_{se} \cdot M_{fs}$

and $\vec{V} = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = M_{se} \cdot \vec{V}_e + \vec{V}_t$

The matrix coefficients are:

$$m_{11} = \cos\theta e \cdot \cos\theta s - \sin\theta e \cdot \sin\theta s = \cos(\theta e + \theta s)$$

$$m_{12} = \cos\theta e \cdot \sin\theta s + \sin\theta e \cdot \cos\theta s = \sin(\theta e + \theta s)$$

$$m_{13} = 0$$

$$m_{21} = -\sin\theta e \cdot \cos\theta s - \cos\theta e \cdot \sin\theta s = -\sin(\theta e + \theta s)$$

$$m_{22} = -\sin\theta e \cdot \sin\theta s + \cos\theta e \cdot \cos\theta s = \cos(\theta e + \theta s)$$

$$m_{23} = 0$$

$$m_{31} = 0$$

$$m_{32} = 0$$

$$m_{33} = 1$$

NOTE $(\theta e + \theta s) = \theta t$.

The vector coefficients are:

$v_1 = \mathrm{Ey} \cdot \sin\theta\mathrm{e}$

$v_2 = \mathrm{Ey} \cdot \cos\theta\mathrm{e} + \mathrm{Ty}$

$v_3 = 0$

The back transformation equation is: $\vec{V}_\mathrm{o} = M^{-1} \cdot \left(\vec{V}_\mathrm{ft} + \vec{V}\right)$.

A.3.3 Transformation from the fixed system into the WEDGE FILTER system

Let $\vec{V}_\mathrm{o}$ be a vector to some point in the fixed system.

If the GANTRY system has been rotated by the angle φg relative to the fixed system, the coordinates of $\vec{V}_\mathrm{o}$ in the GANTRY system are:

$$\vec{V}_\mathrm{fg} = M_\mathrm{fg} \cdot \vec{V}_\mathrm{o}$$

where $M_\mathrm{fg} = \begin{bmatrix} \cos\varphi\mathrm{g} & 0 & -\sin\varphi\mathrm{g} \\ 0 & 1 & 0 \\ \sin\varphi\mathrm{g} & 0 & \cos\varphi\mathrm{g} \end{bmatrix}$

If the coordinates of the origin of the BEAM LIMITING DEVICE system in the GANTRY system are:

$$\vec{V}_\mathrm{b} = \begin{bmatrix} 0 \\ 0 \\ \mathrm{Bz} \end{bmatrix}$$

and the BEAM LIMITING DEVICE system has been rotated by the angle θb relative to the GANTRY system, the coordinates of $\vec{V}_\mathrm{o}$ in the BEAM LIMITING DEVICE system are:

$$\vec{V}_\mathrm{fb} = M_\mathrm{gb} \cdot \left(\vec{V}_\mathrm{fg} - \vec{V}_\mathrm{b}\right)$$

where $M_\mathrm{gb} = \begin{bmatrix} \cos\theta\mathrm{b} & \sin\theta\mathrm{b} & 0 \\ -\sin\theta\mathrm{b} & \cos\theta\mathrm{b} & 0 \\ 0 & 0 & 1 \end{bmatrix}$

If the coordinates of the origin of the WEDGE FILTER system in the BEAM LIMITING DEVICE system are:

$$\vec{V}_\mathrm{w} = \begin{bmatrix} 0 \\ 0 \\ \mathrm{Wz} \end{bmatrix}$$

and the WEDGE FILTER system has been rotated by the angle θw relative to the BEAM LIMITING DEVICE system, the coordinates of $\vec{V}_\mathrm{o}$ in the WEDGE FILTER system are:

$$\vec{V}_{fw} = M_{bw} \cdot \left(\vec{V}_{fb} - \vec{V}_{w}\right)$$

where $M_{bw} = \begin{bmatrix} \cos\theta w & \sin\theta w & 0 \\ -\sin\theta w & \cos\theta w & 0 \\ 0 & 0 & 1 \end{bmatrix}$

$$\vec{V}_{fw} = M^{*} \cdot \vec{V}_{o} - \vec{V}^{*}$$

where M* = $\begin{bmatrix} m^{*}_{11} m^{*}_{12} m^{*}_{13} \\ m^{*}_{21} m^{*}_{22} m^{*}_{23} \\ m^{*}_{31} m^{*}_{32} m^{*}_{33} \end{bmatrix} = M_{bw} \cdot M_{gb} \cdot M_{fg}$

and $\vec{V}^{*} = \begin{bmatrix} v^{*}_{1} \\ v^{*}_{2} \\ v^{*}_{3} \end{bmatrix} = M_{bw} \cdot M_{gb} \cdot \vec{V}_{b} + M_{bw} \cdot \vec{V}_{w}$

The matrix coefficients are:

$$m^{*}_{11} = \cos\theta w \cdot \cos\theta b \cdot \cos\varphi g - \sin\theta w \cdot \sin\theta b \cdot \cos\varphi g = \cos(\theta w + \theta b) \cdot \cos\varphi g$$

$$m^{*}_{12} = \cos\theta w \cdot \sin\theta b + \sin\theta w \cdot \cos\theta b = \sin(\theta w + \theta b)$$

$$m^{*}_{13} = -\cos\theta w \cdot \cos\theta b \cdot \sin\varphi g + \sin\theta w \cdot \sin\theta b \cdot \sin\varphi g = -\cos(\theta w + \theta b) \cdot \sin\varphi g$$

$$m^{*}_{21} = -\sin\theta w \cdot \cos\theta b \cdot \cos\varphi g - \cos\theta w \cdot \sin\theta b \cdot \cos\varphi g = -\sin(\theta w + \theta b) \cdot \cos\varphi g$$

$$m^{*}_{22} = -\sin\theta w \cdot \sin\theta b + \cos\theta w \cdot \cos\theta b = \cos(\theta w + \theta b)$$

$$m^{*}_{23} = \sin\theta w \cdot \cos\theta b \cdot \sin\varphi g + \cos\theta w \cdot \sin\theta b \cdot \sin\varphi g = \sin(\theta w + \theta b) \cdot \sin\varphi g$$

$$m^{*}_{31} = \sin\varphi g$$

$$m^{*}_{32} = 0$$

$$m^{*}_{33} = \cos\varphi g$$

NOTE (θw + θb) is the total angle of rotation of the WEDGE FILTER within the "g" system. Since θw is usually confined to one of the four cardinal angles 0°, 90°, 180° or 270°, the evaluation of sin (θw + θb) and cos (θw + θb) is relatively simple.

The vector coefficients are:

$$v^{*}_{1} = 0$$

$$v^{*}_{2} = 0$$

$$v^{*}_{3} = Bz + Wz$$

The back transformation equation is:

$$\vec{V}_o = M^{*-1}\left(\vec{V}_{fw} + \vec{V}^*\right)$$

A.3.4 Transformation from the table top system into the WEDGE FILTER system

Let $\vec{V}_o$ be a vector to some point in the table top system. According to A.3.2 and A.3.3 the coordinates of this point in the fixed system are:

$$\vec{V}_{tf} = M^{-1} \cdot \left(\vec{V}_o + \vec{V}\right)$$

and in the WEDGE FILTER system:

$$\vec{V}_{tw} = M^* \cdot \left(M^{-1}\left(\vec{V}_o + \vec{V}\right)\right) - \vec{V}^*$$

A.4 Numerical examples

USERS can verify their own transformation calculations, for example in software development, with the help of the following numerical examples.

A.4.1 Transformation from the mother system into the daughter system

Let the coordinates of the origin of the daughter system in the mother system be $\begin{bmatrix} 0 \\ 0 \\ 80 \end{bmatrix}$.

Let the coordinates of a point in the mother system be $\begin{bmatrix} 10 \\ -20 \\ 5 \end{bmatrix}$.

If the rotation angle θ around the Z-axis is 30°, the coordinates in the daughter system of this point are:

$$\begin{bmatrix} -1{,}3 \\ -22{,}3 \\ -75 \end{bmatrix}$$

A.4.2 Transformation from the daughter system into the mother system

Let the origins of the mother system and the daughter system coincide.

Let the coordinates of a point in the daughter system be $\begin{bmatrix} -30 \\ 15 \\ 0 \end{bmatrix}$.

If the rotation angle φ around the axis Y of the mother system is 70°, then the coordinates of this point in the mother system are:

$$\begin{bmatrix} -10{,}3 \\ 15 \\ 28{,}2 \end{bmatrix}$$

A.4.3 Transformation from the fixed system into the table top system

Referring to A.3.2 and with the following assumptions:

$$\vec{V}_o = \begin{bmatrix} 8 \\ 11 \\ 20 \end{bmatrix} \quad \theta s = 15° \quad Ey = -70 \quad \theta e = 40° \quad Ty = 30,$$

the coordinates of $\vec{V}_o$ in the table top system are

$$\begin{bmatrix} 58{,}6 \\ 23{,}4 \\ 20 \end{bmatrix}$$

A.4.4 Transformation from the fixed system into the WEDGE FILTER system

Referring to A.3.3 and with the following assumptions:

$$\vec{V}_o = \begin{bmatrix} 9 \\ 17 \\ -3 \end{bmatrix} \quad \varphi g = 50° \quad Bz = 100 \quad \theta b = 12° \quad Wz = -40 \quad \theta w = 90°,$$

the coordinates of $\vec{V}_o$ in the WEDGE FILTER system are:

$$\begin{bmatrix} 14{,}9 \\ -11{,}4 \\ -55{,}0 \end{bmatrix}$$

Annex B
(informative)

Coordinate transformations between IEC and DICOM PATIENT coordinates

In order to convert coordinates from the IEC convention to the DICOM convention shown in Figure B.1, a rotation of 90° in the negative direction (ccw) about the x-axis must be performed. The rotation matrix is shown below (see Table A.1):

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\psi p & \sin\psi p \\ 0 & -\sin\psi p & \cos\psi p \end{bmatrix}$$

Where ψp is equal to –90°, the matrix now becomes:

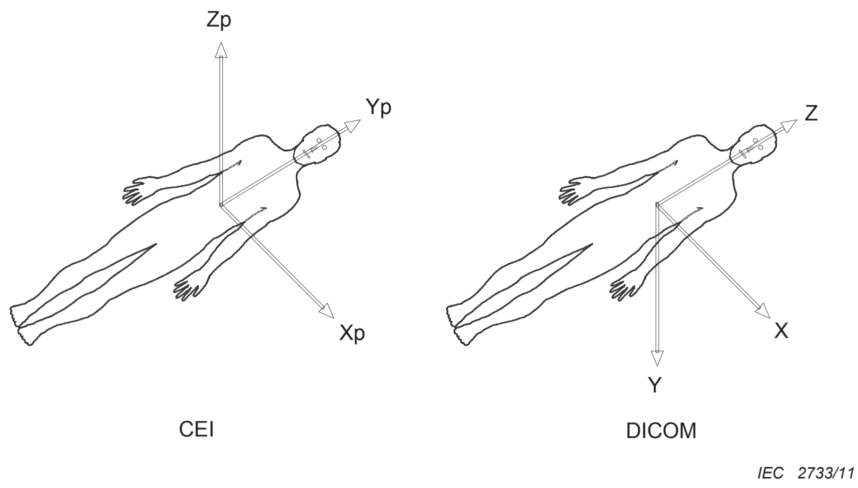
$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix}$$

Similarly in order to convert from the DICOM convention to the IEC convention the rotation matrix (see Table A.1) is:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\psi p & -\sin\psi p \\ 0 & \sin\psi p & \cos\psi p \end{bmatrix}$$

Where ψp is equal to –90°, the matrix becomes:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{bmatrix}$$



NOTE If the origins of the IEC and DICOM systems do not coincide, a translational transformation will be necessary also.

Figure B.1 – Coordinate transformations between IEC and DICOM PATIENT coordinates

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PATIENT .... IEC 60601-1:2005, 3.76
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RADIATION BEAM .... IEC/TR 60788:2004, rm-37-05
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RADIATION SOURCE .... IEC/TR 60788:2004, rm-20-01
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TREATMENT ROOM .... IEC/TR 60788:2004, rm-20-23
USER .... IEC/TR 60788:2004, rm-85-01
WEDGE FILTER .... IEC/TR 60788:2004, rm-35-10
X-RAY IMAGE RECEPTOR .... IEC/TR 60788:2004, rm-32-29
X-RAY TUBE .... IEC 60601-1-3:2008, 3.83

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