

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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Radiotherapy equipment – Coordinates, movements and scales

Appareils utilisés en radiothérapie – Coordonnées, mouvements et échelles

[IEC 61217:2011](#)

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**RADIOTHERAPY EQUIPMENT –  
COORDINATES, MOVEMENTS AND SCALES**

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International standard IEC 61217 has been prepared by subcommittee 62C: Equipment for radiotherapy, nuclear medicine and radiation dosimetry, of IEC technical committee 62: Electrical equipment in medical practice.

This second edition cancels and replaces the first edition, published in 1996, amendment 1, published in 2000 and amendment 2, published in 2007. This edition constitutes a technical revision to include imager and focus coordinate systems in Subclause 3.12. Beyond this Subclause, changes were only introduced where needed to include the above coordinate systems.

The text of this particular standard is based on the following documents:

FDIS	Report on voting
62C/530/FDIS	62C/539/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.



This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

In this standard, the following print types are used:

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- *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.

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## 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.

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# 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*

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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  $I_d$  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  $I_d$  along the mother system coordinate axes  $X_m$ ,  $Y_m$ ,  $Z_m$ .

Figure 1b shows translation of origin  $I_d$  along  $X_m$ ,  $Y_m$ ,  $Z_m$  and rotation about axis  $Z_d$  which is parallel to  $Z_m$ .

Figure 1c shows translation of origin  $I_d$  along  $X_m$ ,  $Y_m$ ,  $Z_m$  and rotation about axis  $Y_d$  which is parallel to  $Y_m$ .

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 ( $\psi$  about X,  $\phi$  about Y, and  $\theta$  about Z), and by a lower-case letter identifying the system involved.

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

- 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 OF 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. <https://standards.iteh.ai/catalog/standards/sist/fc619fdb-79dd-41db-8b95-779d95553514/iec-61217-2011>

- 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  
 $x_r = +20$  cm  
 $y_r = -10$  cm  
 $z_r = 0$  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  $X_g, Z_g$  by an angle  $\varphi_g$  about axis  $Y_g$  (therefore about  $Y_f$  of the "f" system).

An increase in the value of  $\varphi_g$  corresponds to a clockwise rotation of the GANTRY as viewed along the horizontal axis  $Y_f$  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  $I_b$  is the RADIATION SOURCE. Its coordinate axis  $Z_b$  coincides with and points in the same direction as axis  $Z_g$ . The coordinate axes  $X_b$  and  $Y_b$  are perpendicular to the corresponding edges  $X_1, X_2, Y_1$  and  $Y_2$  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  $Z_g$  axis of its mother system ("g" system).

The "b" system is in the zero angular position when the coordinate axes  $X_b, Y_b$  are parallel to and in the same directions as the corresponding axes  $X_g, Y_g$ .

(standards.iteh.ai)

The rotation of the "b" system is defined by the rotation of the coordinate axes  $X_b, Y_b$  about axis  $Z_b$  (therefore about axis  $Z_g$  of the "g" system) by an angle  $\theta_b$ .

<https://standards.iteh.ai/catalog/standards/sist/fc619fdb-79dd-41db-8b95-1e06217201>

An increase in the value of angle  $\theta_b$  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,  $I_w$ , is a defined point such that the coordinate axis  $Y_w$  is directed towards the thin edge of the WEDGE FILTER and in its zero position axis  $Z_w$  passes through the RADIATION SOURCE, coincides with axis  $Z_b$  and points in the same direction as  $Z_b$ .

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

In the zero angular position of the "w" system ( $\theta_w = 0$ ) and of the "b" system ( $\theta_b = 0$ ) the thin edge of the WEDGE FILTER (end, along  $Y_w$ , with highest transmission) is toward the GANTRY and the coordinate axes  $X_w, Y_w$  are parallel to the corresponding axes  $X_b, Y_b$ .

The rotation of the "w" system is defined by the rotation of coordinate axes  $X_w, Y_w$  about axis  $Z_w$  (parallel to axis  $Z_b$  of the "b" system) by an angle  $\theta_w$ .

An increase in the value of angle  $\theta_w$  corresponds to the counter-clockwise rotation of the WEDGE FILTER about  $Z_w$  (parallel to axis  $Z_b$ ) 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  $I_w$  corresponds to the movement of the WEDGE FILTER thin edge toward the GANTRY, along  $Y_b$  and a positive lateral displacement corresponds to the movement along  $X_b$  to the viewer's right when facing the GANTRY.