

AS/NZS 4495:1997

IEC 1217:1996

Australian/New Zealand Standard[®]

**Radiotherapy equipment—
Coordinates, movements and scales**



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STANDARDS AUSTRALIA
1 The Crescent,
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STANDARDS NEW ZEALAND
Level 10, Radio New Zealand House,
155 The Terrace,
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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee HE/3, Medical Electrical Equipment.

This Particular Standard is identical to and has been reproduced from IEC 1217:1996, *Radiotherapy equipment—Coordinates, movements and scales*. The even numbered pages of the original publication are in French and are omitted from this Standard. Some pages of the original, which relate to IEC administrative matters, are omitted from this Standard.

In the text of this Standard, SMALL CAPITALS are used for terms which are listed in annex E.

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601-2-11	Medical electrical equipment, Part 2: Particular requirements for the safety of gamma beam therapy equipment	—	
601-2-29	Medical electrical equipment, Part 2: Particular requirements for the safety of radiotherapy simulators	—	
976	Medical electrical equipment—Medical electron accelerators—Functional performance characteristics	4434	Medical electrical equipment—Medical electron accelerators
		4434.1	Part 1: Functional performance characteristics
977	Medical electrical equipment—Medical electron accelerators in the range 1 MeV to 50 MeV—Guidelines for functional performance characteristics	4434.2	Part 2: Periodic function performance testing

IEC		AS/NZS	
1168	Radiotherapy simulators—Functional performance characteristics	—	
1170	Radiotherapy simulators—Guidelines for functional performance characteristics	4213 4213.2	Radiotherapy simulators Part 2: Guidelines for functional performance characteristics

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INTRODUCTION

RADIOTHERAPY is performed in medical centres where a variety of 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 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 EQUIPMENT used in RADIOTHERAPY, including RADIOTHERAPY SIMULATORS, because differences in the marking and scaling of similar movements on the various types of EQUIPMENT used in the same department may increase the probability of error. In addition, data from 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 EQUIPMENT. Hence, its scope applies to all types of TELERADIOTHERAPY EQUIPMENT, RADIOTHERAPY SIMULATORS, information from diagnostic EQUIPMENT when used for RADIOTHERAPY, recording and verification EQUIPMENT, and to data input for the treatment planning process.

Movement nomenclature is to be classified as defined terms according to IEC 788 and appendix AA of IEC 601-2-1 and IEC 601-2-29 (see annex E).

This standard is issued as a publication separate from the 601 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 601-2 series, which deals exclusively with safety requirements.

IEC 601-2-1, IEC 601-2-11, IEC 601-2-29, IEC 976, IEC 977, IEC 1168 and IEC 1170 include EQUIPMENT movements and scale conventions. A number of changes and additions have been made in this standard. These are summarized in annex D.

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 EQUIPMENT.

If MANUFACTURERS provide other optional scale conventions when requested by USERS, such as to match existing EQUIPMENT in a USER'S facility or to comply with local convention or regulations, such EQUIPMENT cannot be said to comply with this standard.

It is also anticipated that MANUFACTURERS may provide, as options, scales to convert a USER'S existing EQUIPMENT to the scale conventions of this standard.

This standard does not address non-ISOCENTRIC EQUIPMENT and pitch or roll movements of the RADIATION HEAD, due to limited clinical use.

It is anticipated that future amendments may address the following:

- PATIENT coordinate system;
- Three-dimensional RADIOTHERAPY SIMULATORS;
- CT type RADIOTHERAPY SIMULATORS;
- non-ISOCENTRIC EQUIPMENT.

AUSTRALIAN/NEW ZEALAND STANDARD

**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 EQUIPMENT used in this process, and to facilitate computer control when used.

2 Coordinate systems

An individual coordinate system is assigned to each major part of the 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. 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) for the transfer of a point or vector coordinates in one system to any other coordinate system. See annex A for examples of coordinate transformations.

2.1 General rules

2.1.1 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.

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

2.1.3 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.

2.1.4 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 – The mechanical motions of parts of the EQUIPMENT may follow a different sequence, as long as the 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).

2.1.5 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 2.1.4), 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 EQUIPMENT.

2.1.6 Notations

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

Example: Y_g means y axis of the GANTRY system.

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

2.1.6.3 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: $R_y = (\text{numerical value})$ means position of the origin of the X-RAY IMAGE RECEPTOR coordinate system along coordinate axis Y_g (of its mother system).

2.1.6.4 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: $X_1 [X_b] = (\text{numerical value})$ means position of RADIATION FIELD or DELINEATED RADIATION FIELD edge X_1 along axis X_b of the BEAM LIMITING DEVICE system.

NOTE – 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, $X_1 = (\text{numerical value})$ is sufficient.

2.1.6.5 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

$x_r = +20 \text{ cm}$

$y_r = -10 \text{ cm}$

$z_r = 0 \text{ cm}$

2.2 Fixed reference system ("f") (figure 1a)

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

2.3 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 I_g is the ISOCENTRE. Its coordinate axis Z_g passes through and is directed towards the RADIATION SOURCE. Coordinate axes Y_g and Y_f 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 ϕ_g about axis Y_g (therefore about Y_f of the "f" system).

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

2.4 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 6.4).

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 EQUIPMENT capable of variation of 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 θ_b .

An increase in the value of angle θ_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).

2.5 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, lw, 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 lw to suit the design of the WEDGE FILTER DEVICE. For example it is possible to define lw 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 ($\theta_w = 0$) and of the "b" system ($\theta_b = 0$) 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 θ_w .

An increase in the value of angle θ_w 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 lw 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 ($\theta_b = 0$ and $\phi_g = 0$), the WEDGE FILTER is inserted with the thin edge directed to the viewer's left when facing the GANTRY, the angle θ_w 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 θ_w corresponds to 270° .

2.6 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 lr 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 X_r , Y_r about Z_r (parallel to axis Z_g) by an angle θ_r .

An increase in the value of angle θ_r 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 I_r is at the ISOCENTRE. This may not be mechanically achievable, but it defines the origin of the displacement of the "r" system along Z_g .

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 R_x , R_y and R_z are the lateral, longitudinal and vertical displacements of the origin I_r of the IMAGE RECEPTION AREA along X_g , Y_g and Z_g 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 EQUIPMENT, each device may have its own origin, I_r .

2.7 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 Z_s . 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 X_f and Y_f .

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

In the zero position of the PATIENT SUPPORT, I_s is at the ISOCENTRE and the coordinate axes X_s , Y_s , Z_s of the "s" system coincide with the corresponding axes X_f , Y_f , Z_f of the "f" system.

The rotation of the "s" system is defined by the rotation of the coordinate axes X_s , Y_s about axis Z_s (parallel to Z_f) by an angle θ_s .

An increase in the value of angle θ_s 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 I_s along the coordinate axes X_f and Y_f are designated S_x and S_y .

NOTE 3 – As the height of I_s is fixed, $S_z = 0$. The vertical displacement of the table top with reference to the ISOCENTRE is treated in 2.9; it is designated T_z .

2.8 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, Z_e , displaced by a distance $-L_e$ from the coordinate axis Z_s of the "s" system, along the coordinate axis Y_s 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 I_e 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 X_e , Y_e and Z_e are parallel to the coordinate axes X_s , Y_s and Z_s of the "s" system with I_e distant from I_s by $-L_e$ on Y_s axis.

The rotation of the "e" system is defined by the rotation of the coordinate axes X_e , Y_e about the coordinate axis Z_e (parallel to Z_s) by an angle θ_e .

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

Hence, the rotation of the "s" system by an angle of θ_s and the rotation of the "e" system by the complementary angle $\theta_e = 360^\circ - \theta_s$ 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 θ_e about the eccentric axis of rotation, but also a displacement of the origin I_t of the table top system "t" relative to the "s" system.

2.9 Table top coordinate system ("t") (figures 10 and 11)

The "t" coordinate system is stationary with respect to the table top and its mother system is the "e" system. Its origin I_t 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 Z_s of the PATIENT SUPPORT coordinate system when the angle θ_e of the eccentric vertical rotation (if available) is zero and when the table top is:

- horizontal;
- laterally centered in the "e" system;
- longitudinally fully withdrawn away from Z_s .

The coordinate axis Y_t coincides with the longitudinal median axis of the table top and the coordinate axis Z_t is directed vertically upward (normal to the table top).

In the zero position of the "t" system:

- the origin I_t is at minimum distance from I_e (table top fully withdrawn);
- Y_t and Y_e coincide and are in the same direction;
- coordinate axes X_t and Z_t are parallel to and in the same direction as the corresponding axes X_e , Z_e .

NOTE 1 – When the ISOCENTRIC and eccentric angular position angles θ_s and θ_e are zero (or the eccentric movement is not available) and the "t" system is in its zero position, the coordinate axes X_t , Y_t , Z_t coincide with coordinate axes X_f , Y_f and Z_f of the fixed system.

T_x , T_y and T_z are the lateral, longitudinal and vertical displacements of the origin I_t of the table top system corresponding to movement along the three corresponding coordinate axes X_e , Y_e , Z_e , in the eccentric system, or X_s , Y_s , Z_s in the PATIENT SUPPORT system if eccentric rotation is not available.

NOTE 2 – It is assumed that the table top has no provision for rotation about any horizontal axis (pitch and roll). The rotation of the table top in space is defined by the rotation of the "s" system or/and the "e" system.

NOTE 3 – The purpose of defining the coincidence of the origin It with the ISOCENTRE with the table top fully withdrawn is that, for all patient treatments, the longitudinal position of the table top in the "s" or "e" system will carry a positive number. 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 by a known distance to an accessible and visible marked point on the table top.

NOTE 4 – 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.

3 Identification of scales and digital DISPLAYS

The requirements for the provision of scales for 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 obvious. 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°, 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 5 and 6.

Figures 12a, 12b, 12c show examples.

4 Designation of EQUIPMENT movements

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

Table 1 – EQUIPMENT movements and designations

Axis (1)	Rotation of GANTRY
Axis (2)	Roll of the RADIATION HEAD ¹⁾
Axis (3)	Pitch of the RADIATION HEAD ¹⁾
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 ¹⁾
Axis (8)	Roll of the table top ¹⁾
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) ²⁾
Direction (13)	Displacement of RADIATION SOURCE from floor at GANTRY angular position zero ²⁾
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)
¹⁾ The pitch and roll of the RADIATION HEAD and table top, axes (2), (3), (7) and (8), and the vertical displacement of the RADIATION SOURCE, direction (13), are retained as designations for continuity with IEC 601-2-1, but for simplicity they are not addressed further in this standard. ⁽²⁾ This applies to the scale on RADIOTHERAPY SIMULATORS which provide variation of the RADIATION SOURCE to axis distance.	

5 EQUIPMENT zero positions

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

- 1) The RADIATION BEAM AXIS is directed vertically downward and passes through the ISOCENTRE.
- 2) 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.
- 3) The direction of increasing WEDGE FILTER transmission (i.e. the thin end) is toward the GANTRY.
- 4) The longitudinal median axis of the table top coincides with the GANTRY rotation axis.
- 5) The table top is fully withdrawn away from the GANTRY.
- 6) 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.
- 7) 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.

6 List of scales, graduations, directions and DISPLAYS

With all EQUIPMENT parts initially in zero angular and linear positions, the scale readings and directions are as follows.

6.1 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

$\phi_g = \underline{\hspace{2cm}}$

NOTE - There is a discontinuity in the rotation due to GANTRY drive, wind-up cables and hoses, etc. For example, assume these permit 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.

6.2 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

$\theta_b = \underline{\hspace{2cm}}$

6.3 *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

$\theta_w = \underline{\hspace{2cm}}$

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°, 270°). In such cases, the WEDGE FILTER orientation DISPLAY also applies (e.g. WEDGE FILTER orientation $\theta_w = 270^\circ$).

6.4 *RADIATION FIELD or DELINEATED RADIATION FIELD*

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).

6.4.1 *Edges of RADIATION FIELD or DELINEATED RADIATION FIELD (figure 16a)*

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.

6.4.1.1 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.

6.4.1.2 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.

6.4.1.3 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.

6.4.2 DISPLAY of RADIATION FIELD or DELINEATED RADIATION FIELD (figures 16a to 16k)

6.4.2.1 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.

$FX = \text{algebraic value of } X2 \text{ minus algebraic value of } X1$

$FY = \text{algebraic value of } Y2 \text{ minus algebraic value of } Y1$

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 x 12 cm RADIATION FIELD means FX = 10 cm, FY = 12 cm.

6.4.2.2 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 = ± _____

$$X_2 = \pm$$
RADIATION FIELD or DELINEATED RADIATION FIELD dimension

FX =

Edge positions $Y1 = \pm$ _____

$$Y_2 = \pm \underline{\hspace{2cm}}$$
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.

6.4.2.3 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.

either 1 – 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 = $\pm$ _____

X203 = $\pm$ _____

or 2 – 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.