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**Radionuclide imaging devices – Characteristics and test conditions –
Part 1: Positron emission tomographs**

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IEC 61675-1

Edition 3.0 2022-03
REDLINE VERSION

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 11.040.50

ISBN 978-2-8322-5071-6

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RADIONUCLIDE IMAGING DEVICES –
CHARACTERISTICS AND TEST CONDITIONS –****Part 1: Positron emission tomographs**

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61675-1:2013. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 61675-1 has been prepared by subcommittee 62C: Equipment for radiotherapy, nuclear medicine and radiation dosimetry, of IEC technical committee 62: Electrical equipment in medical practice. It is an International Standard.

This third edition cancels and replaces the second edition published in 2013. This edition constitutes a technical revision.

This edition includes the following significant technical change with respect to the previous edition: requirements have been changed or newly created regarding the technical aspects of SPATIAL RESOLUTION, sensitivity measurement, SCATTER FRACTION, COUNT RATE performance, image quality, PET/CT registration accuracy and time-of-flight resolution.

The text of this International Standard is based on the following documents:

Draft	Report on voting
62C/811/CDV	62C/828/RVC

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

The language used for the development of this International Standard is English.

In this document, the following print types are used: terms defined in Clause 3 of this document or as noted: small capitals.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 61675 series, published under the general title *Radionuclide imaging devices – Characteristics and test conditions*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

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INTRODUCTION

Further developments of POSITRON EMISSION TOMOGRAPHS allow most of the tomographs to be operated in fully 3D acquisition mode. To comply with this trend, this document describes test conditions in accordance with this acquisition characteristic. In addition, today a POSITRON EMISSION TOMOGRAPH often includes X-RAY EQUIPMENT for COMPUTED TOMOGRAPHY (CT). For this document, PET-CT hybrid devices are considered to be state of the art, dedicated POSITRON EMISSION TOMOGRAPHS not including the X-ray component being special cases only.

While the test methods specified herein are optimized for the PET component of PET-CT hybrid devices, they may also be used for the PET component of PET-MR hybrid devices.

The test methods specified in this document have been selected to reflect as much as possible the clinical use of POSITRON EMISSION TOMOGRAPHS. It is intended that the tests be carried out by MANUFACTURERS, thereby enabling them to declare the characteristics of POSITRON EMISSION TOMOGRAPHS in the ACCOMPANYING DOCUMENTS. This document does not indicate which tests will be performed by the MANUFACTURER on an individual tomograph or which class-standards may be used to characterize the performance of POSITRON EMISSION TOMOGRAPHS by the MANUFACTURER.

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RADIONUCLIDE IMAGING DEVICES – CHARACTERISTICS AND TEST CONDITIONS –

Part 1: Positron emission tomographs

1 Scope

This part of IEC 61675 specifies terminology and test methods for declaring the characteristics of POSITRON EMISSION TOMOGRAPHS. POSITRON EMISSION TOMOGRAPHS detect the ANNIHILATION RADIATION of positron emitting RADIONUCLIDES by COINCIDENCE DETECTION.

~~No test has been specified to characterize the uniformity of reconstructed images, because all methods known so far will mostly reflect the noise in the image.~~

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 TR 60788:2004, *Medical electrical equipment – Glossary of defined terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TR 60788:2004 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

tomography

radiography of one or more layers within an object

[SOURCE: IEC TR 60788:2004, rm-41-15]

3.1.1

transverse tomography

~~TOMOGRAPHY that slices a three-dimensional object into a stack of OBJECT SLICES which are considered as being two-dimensional and independent from each other and at which the IMAGE PLANES are perpendicular to the SYSTEM AXIS~~

3.1.1

emission computed tomography

ECT

imaging method for the representation of the spatial distribution of incorporated RADIONUCLIDES in selected two-dimensional slices through the object

3.1.1.1

projection

transformation of a three-dimensional object into its two-dimensional image or of a two-dimensional object into its one-dimensional image, by integrating the physical property which determines the image along the direction of the PROJECTION BEAM

Note 1 to entry: This process is mathematically described by line integrals in the direction of PROJECTION (along the LINE OF RESPONSE) and called "Radon transform".

3.1.1.2

projection beam

beam that determines the smallest possible volume in which the physical property which determines the image is integrated during the measurement process

Note 1 to entry: The PROJECTION BEAM's shape is limited by SPATIAL RESOLUTION in all three dimensions.

Note 2 to entry: The PROJECTION BEAM mostly has the shape of a long thin cylinder or cone. In POSITRON EMISSION TOMOGRAPHY, it is the sensitive volume between two detector elements operated in coincidence.

3.1.1.3

projection angle

angle at which the PROJECTION is measured or acquired

3.1.1.4

sinogram

two-dimensional display of all one-dimensional PROJECTIONS of an OBJECT SLICE, as a function of the PROJECTION ANGLE

Note 1 to entry: The PROJECTION ANGLE is displayed on the ordinate, and the linear projection coordinate is displayed on the abscissa.

3.1.1.5

object slice

physical property that corresponds to a slice in the object and that determines the measured information and which is displayed in the tomographic image

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3.1.1.6

image plane

plane assigned to a plane in the OBJECT SLICE

Note 1 to entry: Usually, the IMAGE PLANE is the midplane of the corresponding OBJECT SLICE.

3.1.1.7

system axis

axis of symmetry, characterized by geometrical and physical properties of the arrangement of the system

Note 1 to entry: For a circular POSITRON EMISSION TOMOGRAPH, the SYSTEM AXIS is the axis through the centre of the detector ring. For tomographs with rotating detectors, it is the axis of rotation.

3.1.1.8

tomographic volume

juxtaposition of all volume elements which contribute to the measured PROJECTIONS for all PROJECTION ANGLES

3.1.1.8.1

transverse field of view

dimensions of a slice through the TOMOGRAPHIC VOLUME, perpendicular to the SYSTEM AXIS

Note 1 to entry: For a circular TRANSVERSE FIELD OF VIEW, it is described by its diameter.

Note 2 to entry: For non-cylindrical TOMOGRAPHIC VOLUMES, the TRANSVERSE FIELD OF VIEW may depend on the axial position of the slice.

3.1.1.8.2

axial field of view

AFOV

field which is characterized by dimensions of a slice through the TOMOGRAPHIC VOLUME, parallel to and including the SYSTEM AXIS

Note 1 to entry: In practice, the AXIAL FIELD OF VIEW is specified only by its axial dimension, given by the distance between the centre of the outmost defined IMAGE PLANES plus the average of the measured AXIAL RESOLUTION.

3.1.1.8.3

total field of view

field which is characterized by dimensions (three-dimensional) of the TOMOGRAPHIC VOLUME

3.1.2

positron emission tomography

PET

EMISSION COMPUTED TOMOGRAPHY utilizing the ANNIHILATION RADIATION of positron emitting RADIONUCLIDES by COINCIDENCE DETECTION

3.1.2.1

positron emission tomograph

tomographic device, which detects the ANNIHILATION RADIATION of positron emitting RADIONUCLIDES by COINCIDENCE DETECTION

3.1.2.2

annihilation radiation

ionizing radiation that is produced when a particle and its antiparticle interact and cease to exist

3.1.2.3

coincidence detection

method which checks whether two opposing detectors have detected one photon each simultaneously

Note 1 to entry: By this method, the two photons are concatenated into one event.

Note 2 to entry: The COINCIDENCE DETECTION between two opposing detector elements serves as an electronic collimation to define the corresponding PROJECTION BEAM or LINE OF RESPONSE (LOR), respectively.

3.1.2.4

coincidence window

time interval during which two detected photons are considered being simultaneous

3.1.2.5

line of response

LOR

axis of the PROJECTION BEAM

Note 1 to entry: In PET, the LINE OF RESPONSE is the line connecting the centres of two opposing detector elements operated in coincidence.

3.1.2.6

total coincidences

sum of all coincidences detected

3.1.2.6.1

true coincidence

result of COINCIDENCE DETECTION of two gamma events originating from the same positron annihilation

3.1.2.6.2**scattered true coincidence**

TRUE COINCIDENCE where at least one participating photon was scattered before the COINCIDENCE DETECTION

3.1.2.6.3**unscattered true coincidence**

the difference between TRUE COINCIDENCES and SCATTERED TRUE COINCIDENCES

3.1.2.6.4**random coincidence**

result of a COINCIDENCE DETECTION in which participating photons do not originate from the same positron annihilation.

3.1.2.7**singles rate**

COUNT RATE measured without COINCIDENCE DETECTION, but with energy discrimination

3.1.3**two-dimensional reconstruction**

image reconstruction at which data are rebinned prior to reconstruction into SINOGRAMS, which are the PROJECTION data of transverse slices, which are considered being independent of each other and being perpendicular to the SYSTEM AXIS

3.1.4**three-dimensional reconstruction**

image reconstruction at which the LINES OF RESPONSE are not restricted to being perpendicular to the SYSTEM AXIS so that a LINE OF RESPONSE may pass several transverse slices

3.2**image matrix**

<nuclear medicine> matrix in which each element corresponds to the measured or calculated physical property of the object at the location described by the coordinates of this MATRIX ELEMENT

3.2.1**matrix element**

smallest unit of an IMAGE MATRIX, which is assigned in location and size to a certain volume element of the object (VOXEL)

3.2.2**pixel**

MATRIX ELEMENT in a two-dimensional IMAGE MATRIX

3.2.1.2**trixel**

MATRIX ELEMENT in a three-dimensional IMAGE MATRIX

3.2.3**voxel**

volume element in the object which is assigned to a MATRIX ELEMENT in a two- or three-dimensional IMAGE MATRIX

Note 1 to entry: The dimensions of the VOXEL are determined by the dimensions of the corresponding MATRIX ELEMENT via the appropriate scale factors and by the systems SPATIAL RESOLUTION in all three dimensions.

3.3 point spread function PSF

scintigraphic image of a POINT SOURCE

3.3.1 physical point spread function

<tomographs> two-dimensional POINT SPREAD FUNCTION in planes perpendicular to the PROJECTION BEAM at specified distances from the detector

Note 1 to entry: The PHYSICAL POINT SPREAD FUNCTION characterizes the purely physical (intrinsic) imaging performance of the tomographic device and is independent of for example sampling, image reconstruction and image processing. A PROJECTION BEAM is characterized by the entirety of all PHYSICAL POINT SPREAD FUNCTIONS as a function of distance along its axis.

3.3.2 axial point spread function

profile passing through the peak of the PHYSICAL POINT SPREAD FUNCTION in a plane parallel to the SYSTEM AXIS

3.3.3 transverse point spread function

reconstructed two-dimensional POINT SPREAD FUNCTION in a tomographic IMAGE PLANE

Note 1 to entry: In TOMOGRAPHY, the TRANSVERSE POINT SPREAD FUNCTION can also be obtained from a LINE SOURCE located parallel to the SYSTEM AXIS.

3.4 spatial resolution

<nuclear medicine> ability to concentrate the count density distribution in the image of a POINT SOURCE to a point

3.4.1 transverse resolution

SPATIAL RESOLUTION in a reconstructed plane perpendicular to the SYSTEM AXIS

3.4.1.1 radial resolution

TRANSVERSE RESOLUTION along a line passing through the position of the source and the SYSTEM AXIS

3.4.1.2 tangential resolution

TRANSVERSE RESOLUTION in the direction orthogonal to the direction of RADIAL RESOLUTION

3.4.2 axial resolution

SPATIAL RESOLUTION along a line parallel to the SYSTEM AXIS

Note 1 to entry: AXIAL RESOLUTION only applies for tomographs with sufficiently fine axial sampling fulfilling the sampling theorem.

3.4.3 equivalent width EW

width of that rectangle having the same area and the same height as the response function, e.g., the POINT SPREAD FUNCTION

Note 1 to entry: EW better reflects scatter tails of the response function than FWHM or FWTM.

[SOURCE: IEC TR 60788:2004, rm-34-45, modified – Note to entry added.]

3.4.4 full width at half maximum FWHM

for a bell-shaped curve, distance parallel to the abscissa axis between the points where the ordinate has half of its maximum value

[SOURCE: IEC TR 60788:2004, rm-73-02]

3.5 recovery coefficient

measured (image) ACTIVITY concentration of an active volume divided by the true ACTIVITY concentration of that volume, neglecting ACTIVITY calibration factors

Note 1 to entry: For the actual measurement, the true ACTIVITY concentration is replaced by the measured ACTIVITY concentration in a large volume.

3.6 slice sensitivity

ratio of COUNT RATE as measured on the SINOGRAM to the ACTIVITY concentration in the phantom

Note 1 to entry: In PET, the measured counts are numerically corrected for scatter by subtracting the SCATTER FRACTION.

3.7 volume sensitivity

sum of the individual SLICE SENSITIVITIES

3.8 count rate characteristic

function giving the relationship between observed COUNT RATE and TRUE COUNT RATE

[SOURCE: IEC TR 60788:2004, rm-34-21]

3.8.1 count loss

difference between measured COUNT RATE and TRUE COUNT RATE, which is caused by the finite RESOLVING TIME of the instrument

3.8.2 count rate

number of counts per unit of time

3.8.3 true count rate

COUNT RATE that would be observed if the RESOLVING TIME of the device were zero

[SOURCE: IEC TR 60788:2004, rm-34-20]

3.9 scatter fraction SF

ratio between SCATTERED TRUE COINCIDENCES and the sum of SCATTERED plus UNSCATTERED TRUE COINCIDENCES for a given experimental set-up

3.10 point source

RADIOACTIVE SOURCE approximating a δ -function in all three dimensions