TECHNICAL REPORT

IEC TR 61948-1

First edition
2001-02

**Nuclear medicine instrumentation –
Routine tests –**

**Part 1:
Radiation counting systems**

*Instrumentation en médecine nucléaire –
Essais de routine –*

*Partie 1:
Systèmes compteurs de rayonnement*

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC 61948-1, which is a technical report, has been prepared by subcommittee 62C: Equipment for radiotherapy, nuclear medicine and radiation dosimetry, of IEC technical committee 62: Electrical equipment in medical practice.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
62C/255/CDV	62C/265A/RVC

Full information on the voting for the approval of this technical report 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 3.

In this technical report the following print types are used:

– requirements, compliance with which can be tested, and definitions: in roman type;
– notes, explanations, advice, introductions, general statements, exceptions and references: in smaller roman type;
– *test specifications: in italic type;*
– TERMS DEFINED IN CLAUSE 3 OF THIS TECHNICAL REPORT OR LISTED IN ANNEX A: SMALL CAPITALS.

The requirements are followed by specifications for the relevant tests.

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

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

This document, which is purely informative, is not to be regarded as an International Standard.

NUCLEAR MEDICINE INSTRUMENTATION – ROUTINE TESTS –

Part 1: Radiation counting systems

1 Scope and object

This technical report describes test methods of counting instruments for measuring RADIONUCLIDES *in vivo* and *in vitro* without the option of imaging. ACTIVITY meters (dose calibrators) are excluded.

2 Reference documents

IEC 60788:1984, *Medical radiology – Terminology*

IEC 61145:1992, *Calibration and usage of ionization chamber systems for assay of radionuclides*

IEC 61303:1994, *Medical electrical equipment – Radionuclide calibrators – Particular methods for describing performance*

3 Terminology and definitions

For the purposes of this part of IEC 61948, the definitions given in IEC 60788, IEC 61303 and IEC 61145 and the following definitions apply (see annex A). Defined terms are printed in small capital letters.

3.1
QUALITY CONTROL
part of the quality assurance in nuclear medicine including tests of instruments with appropriate test methods

NOTE Includes both ACCEPTANCE TESTING and ROUTINE TESTING.

3.2 Methodology

3.2.1
ACCEPTANCE TEST
test carried out at the request and with the participation of the user or his representative to ascertain by determination of proper performance parameters that the instrument meets the specifications claimed by the vendor

NOTE AN ACCEPTANCE TEST should be carried out at the time of installation and when appropriate after major service. During or immediately after ACCEPTANCE TESTING, REFERENCE DATA are collected to be used as a standard for comparison with future ROUTINE TESTS.

3.2.2
ROUTINE TEST
test of a piece of equipment or its components which is repeated at specified intervals, to establish and document changes from the initial status described by REFERENCE DATA

NOTE A ROUTINE TEST could be carried out by the user with simple methods and equipment.

3.2.3
REFERENCE DATA
a set of data measured immediately after ACCEPTANCE TESTING, using test methods designed for ROUTINE TESTING

3.3
***IN VIVO* COUNTING SYSTEM**
instruments designed to directly measure the ACTIVITY of radioactive substances in the body

3.3.1
ORGAN COUNTING SYSTEM
instrument used for radiation detection of incorporated radioactive substances in specific organs or regions of the body

3.3.2
WHOLEBODY COUNTER
instrument for estimating the amount of RADIONUCLIDES in the body and, if possible, identifying the RADIONUCLIDES and estimating the spatial distribution of RADIONUCLIDES and their ACTIVITIES within the body. WHOLEBODY COUNTERS have a high sensitivity that is essentially independent of the distribution of ACTIVITY in the body. For minimizing the detection threshold, appropriate shielding of background radiation is necessary.

3.4
***IN VITRO* COUNTING SYSTEM**
instrument designed to estimate the ACTIVITY of radioactive substances in a sample

NOTE *IN VITRO* COUNTING SYSTEMS are usually equipped with a scintillation or semi-conductor detector.

3.4.1
WELL-TYPE DETECTOR
in vitro measuring instrument utilizing a detector with a well to detect photons from a sample inserted into the well of the detector

3.4.1.1
WELL-COUNTER
instrument utilizing nearly 4 π geometry counting with a WELL-TYPE DETECTOR into which the sample can be inserted

3.4.1.2
SAMPLE CHANGER
counting system with a WELL-TYPE DETECTOR and a mechanism for automatically changing samples in the well of the detector

3.4.1.3
MULTI-DETECTOR COUNTER
instrument consisting of an array of WELL-TYPE DETECTORS to determine the ACTIVITY in multiple samples simultaneously

3.4.2
LIQUID SCINTILLATION COUNTER
counting system utilizing a liquid scintillator in which the radioactive material is distributed

NOTE Usually the LIQUID SCINTILLATION COUNTER is used for measuring samples with β-emitting RADIONUCLIDES.

3.4.3
CERENKOV COUNTER
counting system which detects the Cerenkov radiation emitted from the sample

NOTE CERENKOV COUNTERS are used for measuring samples with β-emitting RADIONUCLIDES that have a particle energy larger than the Cerenkov threshold. Under special conditions, a LIQUID SCINTILLATION COUNTER can be used as a CERENKOV COUNTER.

3.5
ENERGY CALIBRATION
process of establishing a relation between the window setting of the pulse height analyzer and the energy of the photons

3.6
ENERGY RESOLUTION
a term used to characterize the ability of a radiation detector to distinguish between photons of different energies

NOTE The ENERGY RESOLUTION can be expressed as the ratio of the photopeak full width at half maximum (FWHM) to photopeak energy expressed as a percentage.

3.7
RADIONUCLIDE
radioactive nuclide [IEC 60788]

3.8
ACTIVITY
Letter symbol: *A*
quantitative indication of the radioactivity of an amount of RADIONUCLIDE in a particular energy state at a given time. ACTIVITY is determined as the quotient of d*N* by d*t*, where d*N* is the expectation value of the number of spontaneous nuclear transitions from that energy state in the time interval d*t*:

$$A = \frac{\mathrm{d}N}{\mathrm{d}t}$$

The unit of ACTIVITY is the reciprocal second (s^{-1}). The special name of the unit of ACTIVITY is the becquerel (Bq), 1 Bq being equal to one transition per second. The earlier unit of ACTIVITY was the curie (Ci), 1 Ci being equal to $3{,}7 \times 10^{10}$ transitions per second [IEC 60788].

4 Test methods

ROUTINE TESTING includes tests with and without radioactive sources. If radioactive test sources are used, the count loss as determined by the count rate performance measurement at ACCEPTANCE TESTING shall not exceed 5 %, unless otherwise specified.

4.1 ENERGY CALIBRATION

The ENERGY CALIBRATION procedure establishes the relationship between the window setting (dial reading) of the pulse height analyzer and the energy of the photons. As a part of the ENERGY CALIBRATION, a reference point has to be fixed on the energy scale.

A RADIONUCLIDE with a photon energy appropriate for the energy range used shall be selected. The dial reading of the pulse height analyzer will be set to a value corresponding to the photon energy. Using a small window less than the FWHM of the photopeak, the high voltage and/or gain are varied until the maximum count rate is observed.

To establish/check the stability of the ENERGY CALIBRATION over the whole energy range, the centerline of the photopeak of RADIONUCLIDES with different photon energies is determined. Maintaining the same narrow window, high voltage and gain, the readings to observe the maximum count rate are determined, using at least three RADIONUCLIDES with different photon energies covering the desired energy range.

NOTE If only one RADIONUCLIDE is used, the setting of the reference point is valid for this nuclide.

4.2 Sensitivity check

Sensitivity shall be checked with a reference source containing a long-lived RADIONUCLIDE of appropriate photon energy. The measuring geometry and functional settings of the instrument must be fixed and stated.

NOTE A change in sensitivity may require energy recalibration.

4.3 Preset window setting

To check the correction function of the preset window setting, a RADIONUCLIDE has to be measured, first with the appropriate preset window setting and second with the corresponding manual setting (window dial). Ideally, the count rate should be the same.

NOTE This test should be done after ENERGY CALIBRATION.

4.4 ENERGY RESOLUTION

To determine the photopeak full width at half maximum (FWHM), the pulse height spectrum can be obtained by measuring the count rate at different dial readings using a narrow window. The energy window width should not exceed 1/5 of the FWHM.

4.5 COUNTING PRECISION

For testing the COUNTING PRECISION the chi-square test shall be used. For a set of *n* observed count values (N_i) in a preset time interval, a mean value ($\overline{N}$) can be calculated. For each measurement N_i and a preset constant time interval, about 10 000 counts shall be collected. The count loss should not exceed 10 %.

The value of chi-square can be calculated by

$$\chi^2 \equiv \frac{\sum\limits_{(i-1)}^{n} \left(N_i - \overline{N}\right)^2}{\overline{N}}$$

For a number of 10 measurements, the value for chi-square should be

$$3,3 \leq \chi^2 \leq 16,9$$

4.6 Background

The background has to be determined for each energy and window setting commonly used.

4.7 Frequency of ROUTINE TESTS

ROUTINE TESTS shall be carried out at the time intervals given in table 1.

Table 1 – Frequency of ROUTINE TESTS

Test	Frequency
Background	Daily*
Sensitivity**	Daily*
ENERGY CALIBRATION	Twice per year
ENERGY RESOLUTION	Twice per year
COUNTING PRECISION	Twice per year
Preset window setting	Twice per year

* Each day the instrument is used.

** If sensitivity changes appreciably all the tests should be repeated.