

Nuclear instrumentation — Liquid-scintillation counting systems — Performance verification



Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Engineering Sector Board to Technical Committee NCE/8, upon which the following bodies were represented:

- AEA Technology
- British Nuclear Forum
- British Nuclear Fuels plc
- Electricity Association
- GAMBICA (BEAMA Ltd.)
- Health and Safety Executive
- Institution of Nuclear Engineers
- Ministry of Defence

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National foreword

This British Standard has been prepared under the direction of the Engineering Sector Board and is the English language version of IEC 1304:1994 *Nuclear instrumentation — Liquid-scintillation counting systems — Performance verification*, published by the International Electrotechnical Commission (IEC).

IEC 1304 was produced as a result of international discussions in which the United Kingdom took an active part.

Cross-reference

International Standard	Corresponding British Standard
IEC 1304	BS 5541:1978 <i>Specification for dimensions of vials for liquid scintillation counting</i> (Identical)

The Technical Committee has reviewed the provisions of ISO 582:1977 to which normative reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Introduction

Liquid-scintillation counting systems are widely used for radionuclide assay in industrial applications, nuclear medicine and life-science research. A typical system is a combination of a sample-changing device with a liquid-scintillation spectrometer such that a number of samples may be counted automatically. The liquid-scintillation spectrometer usually consists of a sample chamber, two horizontally opposed photomultiplier tubes viewing the sample chamber and the associated electronics to detect and record the presence of radioactivity in the sample. The sample compartment may be either air-cooled or refrigerated (controlled temperature).

The liquid-scintillation counter is so named because the usual radioactive sample assayed is either dissolved or dispersed in a solution containing one or more organic scintillators. This International Standard is particularly useful for tritium and carbon-14 counting but is applicable also for counting of other radionuclides.

1 Scope and object

The purpose of this International Standard is to provide the user with a means of verifying the performance of typical liquid-scintillation counting systems. Measures of performance considered in this standard are:

- counting system efficiency;
- reproducibility of sample and background count rates.

This standard does not cover the calculation of sample activity for *quenched* samples. Accordingly, this standard does not deal with sample preparation, efficiency correlation (quench correction) procedures, or the identification of unknown radionuclides.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 582:1977, *Dimensions of vials for liquid scintillation counting*.

3 Definitions and symbols

3.1 Definitions

For the purpose of this International Standard, the following definitions apply.

background check source

sealed vial of liquid-scintillation solution containing no added radioactive material

background count rate (in radioactivity counters)

count rate recorded by the instrument when measuring a background check source

check source

radioactive source, not necessarily calibrated, that is used to confirm the continuing satisfactory operation of an instrument

counting channel

region of the pulse-height spectrum that is defined by upper and lower boundaries set by discriminators

counting efficiency

ratio of the count rate, R , to the disintegration rate, A , usually expressed as a percentage:

$$E = (R/A) \times 100$$

counting region

identifies the first and last memory location of a contiguous series to be summed in a multichannel analyser

gain, photomultiplier tube

ratio of the signal output current to the photoelectric signal current from the photocathode

liquid-scintillation solution

solution consisting of a solvent (or mixture of solvents) and one or more scintillator solutes

organic-scintillator solute material

organic compound that can absorb radiant energy and immediately (typically within 10^{-9} s) re-emit this energy as photons in the ultra-violet range

pulse height analyser

circuit that produces an output signal if it receives an input pulse whose amplitude falls between preset upper and lower values

pulse height analyser, multichannel

circuit that accepts all input pulses and assigns each pulse to a memory location corresponding to its amplitude

quenched sample

counting sample (material of interest plus liquid-scintillation solution) that contains chemical impurities that reduce the photon output

resolving time

minimum time that shall exist between successive events if they are to be counted as separate events

unquenched sample

counting sample (material of interest plus liquid-scintillation solution) that contains a minimum of quenching admixtures (coloured species and chemical impurities) that would reduce the light output to the photomultiplier tubes

vial

glass or plastic sample container which meets the dimensional specifications of IEC 582

3.2 Symbols

- A = activity of the radionuclide contained in the check source. In this standard, activity is expressed in disintegrations per unit time. (The recommended unit for activity is the becquerel, where 1 Bq = 1 transition per second.)
- B = background count rate, counts per unit time
- E = counting system efficiency: $E = (R/A) \times 100$
- i = any individual measurement in a series of measurements; used as subscript notation, for example, n_i
- n = number of measurements in a series
- N = total number of counts accumulated in an individual measurement
- R = net count rate in an individual measurement, counts per unit time
- t = counting time
- t_c = elapsed counting time for a short-lived radionuclide, expressed in the same units of time as the half-life
- λ = radioactivity decay constant
- s = computed standard deviation of a measured distribution
- $\hat{\sigma}$ = an estimate of σ
- σ = true standard deviation for the measured distribution
- $\bar{N}$ = average of n measurements of N as defined by equation (1)
- χ^2 = statistical quantity used to compare the observed variance of a distribution with a hypothetical variance; $\chi^2 = s^2/\sigma^2$
- X^2 = computed value of χ^2 for a real distribution; see 5.2.2.4.2, equation (4)