

Determination of the detection limit and decision threshold for ionizing radiation measurements —

**Part 2: Fundamentals and application
to counting measurements with the
influence of sample treatment**

ICS 17.240

National foreword

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The UK participation in its preparation was entrusted to Technical Committee NCE/2, Radiation protection and measurement, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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Summary of pages

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Determination of the detection limit and decision threshold for ionizing radiation measurements —

Part 2:

Fundamentals and application to counting
measurements with the influence of sample
treatment

*Détermination de la limite de détection et du seuil de décision des
mesurages des rayonnements ionisants —*

*Partie 2: Principes fondamentaux et application aux mesures par comptage,
avec l'influence du traitement d'échantillon*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11929-2 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*, Working Group WG 17 (formerly WG 2), *Radioactivity measurements*.

ISO 11929 consists of the following parts, under the general title *Determination of the detection limit and decision threshold for ionizing radiation measurements*:

- $\frac{3}{4}$ *Part 1: Fundamentals and application to counting measurements without the influence of sample treatment*
- $\frac{3}{4}$ *Part 2: Fundamentals and application to counting measurements with the influence of sample treatment*
- $\frac{3}{4}$ *Part 3: Fundamentals and application to counting measurements by high resolution gamma spectrometry, without the influence of sample treatment*
- $\frac{3}{4}$ *Part 4: Fundamentals and application to measurements by use of linear scale analogue ratemeters, without the influence of sample treatment*

Annex A of this part of ISO 11929 is for information only.

Introduction

This part of ISO 11929 addresses the field of ionizing radiation measurements in which events (in particular pulses) on samples are counted after treating them (e.g. aliquotation, solution, enrichment, separation). It considers, besides the random character of radioactive decay and of pulse counting, all other influences arising from sample treatment, (e.g. weighing, enrichment, calibration or the instability of the test setup).

In general, it can be assumed that the results of such measurements follow a mixture of Poisson distributions. Special kinds of mixtures of Poisson distributions are negative binominal distributions [1, 3, 8].

It is assumed part of ISO 11929 that the results from counting of samples and blanks follow a negative binominal distribution. If the influence of sample treatment and instability of the device is small in comparison to statistical counting errors, the results may be Poisson distributed. In this case, ISO 11929-1 can be applied for specification of the statistical values as long as the dispersion test [2] indicates that the Poisson distribution cannot be rejected.

It is also assumed that the duration of measurement is small compared to the half-life of the radionuclides concerned and that the instrument dead time losses are negligible.

This part of ISO 11929 was prepared in parallel with other International Standards prepared by WG 2 (now WG 17): ISO 11932:1996, *Activity measurements of solid materials considered for recycling, re-use or disposal as non-radioactive waste*, and ISO 11929-1, ISO 11929-3 and ISO 11929-4 and is, consequently, complementary to these documents.

The other parts of ISO 11929 deal with counting measurements which do not take sample treatment into consideration, analogue pulse rate-measurement, and specific problems which occur when this part of ISO 11929 is applied (e.g. in the case of spectrometric measurements or continuous monitoring of radioactivity effluents).

Determination of the detection limit and decision threshold for ionizing radiation measurements —

Part 2:

Fundamentals and application to counting measurements with the influence of sample treatment

1 Scope

This part of ISO 11929 specifies suitable statistical values which allow an assessment of the detection capabilities in ionizing radiation measurements with the influence of sample treatment. For this purpose, statistical methods are used to specify the following two statistical values characterizing given probabilities of error.

- $\frac{3}{4}$ The decision threshold, which allows a decision to be made for each measurement with a given probability of error as to whether the registered pulses include a contribution by the sample.
- $\frac{3}{4}$ The detection limit, which specifies the minimum sample contribution which can be detected with a given probability of error using the measuring procedure in question. This consequently allows a decision to be made as to whether a measuring method defined in this part of ISO 11929 satisfies certain requirements and is consequently suitable for the given purpose of measurement.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this part of ISO 11929. For dated references, subsequent amendments to, or revisions of, such publications do not apply. However, parties to agreements based on this part of ISO 11929 are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML Guide to the Expression of Uncertainty in Measurement. Geneva 1993.

3 Terms and definitions

For the purposes of this part of ISO 11929, the following terms and definitions apply.

3.1

measuring method

combination of a specific sample treatment procedure and the use of a measuring instrument for counting measurements under given conditions

3.2

decision threshold

critical value of a statistical test for the decision between the null hypothesis $\rho_s = \rho_0$ and the alternative hypothesis $\rho_s > \rho_0$.

NOTE It should be the value R_n^* which, when exceeded by the determined value R_n , is taken to indicate that the null hypothesis should be rejected. The statistical test should be designed such that the probability of wrongly rejecting the hypothesis (error of the first kind) is equal to a value α which is fixed prior to commencement of the measurement

3.3 detection limit

smallest expectation value of the net counting rate that can be detected on given probabilities and, therefore, the smallest difference $\rho_n = \rho_s - \rho_0$ associated with the statistical test concerned for the decision between the hypothesis $\rho_s = \rho_0$ and the alternative hypothesis $\rho_s > \rho_0$ and having the following characteristic: if in reality $\rho_n \geq \rho$, the probability of wrongly not rejecting the hypothesis $\rho_s = \rho_0$ (error of second kind) shall be at most equal to a value β which is fixed prior to commencement of the measurement

NOTE The difference between using the decision threshold and using the detection limit is that measured values are to be compared with the decision threshold while the detection limit is to be compared with the guideline value.

3.4 confidence interval

interval including the true value of ρ_n in at least $(1 - \gamma) \times 100$ % of all cases

3.5 sample

whole amount or an aliquot of an inactive material, the content of radioactive nuclides of which has to be determined by ionizing radiation measurement after treatment

3.6 blank

aliquot of an inactive material with properties similar to the sample, which will be treated and measured in the same way as the sample

3.7 background effect

measured counting rate from the blank and radiation from external sources and radionuclides in the detector and shielding

3.8 gross effect

measured counting rate from the sample (sample contribution) and the background radiation

3.9 net effect

(sample contribution) gross effect minus the background effect

3.10 guideline value

value constituted by requirements on measuring procedures arising for scientific, legal or other reasons which are specified, for example, as activity, activity concentration, dose rate, etc.

NOTE If necessary, a calibration factor can be determined using a radioactive reference standard.