

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

**Part 8: Fundamentals and application
to unfolding of spectrometric
measurements without 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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Summary of pages

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

Part 8:

Fundamentals and application to unfolding of spectrometric measurements without the influence of sample treatment

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

*Partie 8: Principes fondamentaux et leur application à la déconvolution
des spectres des mesurages de rayonnements ionisants négligeant
l'influence de la préparation d'un échantillon*



Contents		Page
Foreword.....		iv
Introduction		v
1	Scope.....	1
2	Normative references	1
3	Terms and definitions.....	1
4	Quantities and symbols.....	3
5	Statistical values and confidence interval.....	5
5.1	Principles	5
5.1.1	General aspects	5
5.1.2	Model	6
5.2	Decision threshold	7
5.3	Detection limit	8
5.4	Confidence limits	8
6	Application of this part of ISO 11929	9
6.1	Specific values	9
6.2	Assessment of a measuring method	9
6.3	Assessment of measured results.....	9
6.4	Documentation	9
7	Values of the distribution function of the standardized normal distribution	10
Annex A (informative) Example of application of this part of ISO 11929.....		12
Bibliography		20

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 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11929-8 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

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

- *Part 1: Fundamentals and application to counting measurements without the influence of sample treatment*
- *Part 2: Fundamentals and application to counting measurements with the influence of sample treatment*
- *Part 3: Fundamentals and application to counting measurements with high resolution gamma spectrometry, without the influence of sample treatment*
- *Part 4: Fundamentals and applications to measurements by use of linear-scale analogue ratemeters, without the influence of sample treatment*
- *Part 5: Fundamentals and applications to counting measurements on filters during accumulation of radioactive material*
- *Part 6: Fundamentals and applications to measurements by use of transient mode*
- *Part 7: Fundamentals and general applications*
- *Part 8: Fundamentals and applications to unfolding of spectrometric measurements without the influence of sample treatment*

Introduction

This part of ISO 11929 gives basic information on the statistical principles for the determination of the detection limit, of the decision threshold and of the limits of the confidence interval for general applications of nuclear radiation measurements.

ISO 11929-1 and ISO 11929-2 deal with integral counting measurements with or without consideration of the sample treatment. High-resolution spectrometric measurements, which can be evaluated without unfolding techniques, are covered in ISO 11929-3 while evaluations of spectra via unfolding have to be treated according to this part of ISO 11929. ISO 11929-4 deals with measurements using linear scale analogue ratemeters, ISO 11929-5 with monitoring of the concentration of aerosols in exhaust gas, air or waste water, and ISO 11929-6 with measurements by use of a transient measuring mode.

Parts 1 to 4 were elaborated for special measuring tasks in nuclear radiation measurements based on the principles defined by Altschuler and Pasternack [1], Nicholson [2], Currie [3]. ISO 11929-7 gives a general Bayesian-statistical approach for the determination of decision thresholds, detection limit and confidence intervals by separating the determination of these characteristic quantities from the evaluation of the measurement. Consequently ISO 11929-7 is generally applicable and can be applied to any suitable procedure for the evaluation of a measurement. Parts 5, 6 and 7 and this part of ISO 11929 are based on methods of Bayesian statistics (see [5] in the Bibliography) for the determination of the characteristic limits (see [6] and [7] in the Bibliography) as well as for the unfolding (see [8] in the Bibliography).

This part of ISO 11929 makes consequent use of the general approach of ISO 11929-7 and describes explicitly the necessary procedures to determine decision thresholds, detection limits and confidence limits for physical quantities which are derived from the evaluation of nuclear spectrometric measurements by unfolding techniques, without taking into account the influence of sample treatment (see [4] in the Bibliography). There are many types of such quantities, for example, the net area of a spectral line in gamma- or alpha-spectrometry.

Since the uncertainty of measurement plays a fundamental role in this part of ISO 11929, evaluations of measurements and the determination of the uncertainties of measurement have to be performed according to the Guide for the Expression of Uncertainty in Measurement.

For this purpose, Bayesian statistical methods are used to specify statistical values characterized by the following given probabilities:

- The *decision threshold*, which allows a decision to be made for each measurement with a given probability of error as to whether the result of a measurement indicates the presence of the physical effect quantified by the measurand.
- The *detection limit*, which specifies the minimum true value of the measurand 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 checked using this part of ISO 11929 satisfies certain requirements and is consequently suitable for the given purpose of measurement.
- The *limits of the confidence interval*, which define an interval which contains the true value of the measurand with a given probability, in the case that the result of the measurement exceeds the decision threshold.

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

Part 8: Fundamentals and application to unfolding of spectrometric measurements without the influence of sample treatment

1 Scope

This part of ISO 11929 specifies a method for determination of suitable statistical values which allow an assessment of the detection capabilities in spectrometric nuclear radiation measurements, and of the physical effect quantified by a measurand (for example, a net area of a spectrometric line in an alpha- or gamma-spectrum) which is determined by evaluation of a multi-channel spectrum by unfolding methods, without the influence of sample treatment. For this purpose, Bayesian statistical methods are used to specify characteristic limits.

2 Normative references

The following referenced documents are indispensable for the application 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.

BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML, *Guide to the expression of uncertainty in measurement*, Geneva, 1993

BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML, *International vocabulary of basic and general terms in metrology*. 2nd edition, Geneva, 1993.

ISO 11929-3:2005, *Determination of the detection limit and decision threshold for ionizing radiation measurements — Part 3: Fundamentals and application to counting measurements with high resolution gamma spectrometry, without the influence of sample treatment*

ISO 11929-7:2005, *Determination of the detection limit and decision threshold for ionizing radiation measurements — Part 7: Fundamentals and general applications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

measuring method

any logical sequence of operations, described generically, used in the performance of measurements

NOTE Adapted from the International Vocabulary of Basic and General Terms in Metrology:1993.