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Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for measurements of ionizing radiation — Fundamentals and application

Détermination des limites caractéristiques (seuil de décision, limite de détection et extrémités de l'intervalle de confiance) pour mesurages de rayonnements ionisants — Principes fondamentaux et applications

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

This first edition of ISO 11929 cancels and replaces ISO 11929-1:2000, ISO 11929-2:2000, ISO 11929-3:2000, ISO 11929-4:2001, ISO 11929-5:2005, ISO 11929-6:2005, ISO 11929-7:2005 and ISO 11929-8:2005, which have been technically revised, specifically with reference to the type of statistical treatment of the data.

Introduction

The limits to be provided according to this International Standard by means of statistical tests and specified probabilities allow detection possibilities to be assessed for a measurand and for the physical effect quantified by this measurand as follows:

— the “decision threshold” gives a decision on whether or not the physical effect quantified by the measurand is present;

— the “detection limit” indicates the smallest true value of the measurand which can still be detected with the applied measurement procedure; this gives a decision on whether or not the measurement procedure satisfies the requirements and is therefore suitable for the intended measurement purpose;

— the “limits of the confidence interval” enclose, in the case of the physical effect recognized as present, a confidence interval containing the true value of the measurand with a specified probability.

Hereinafter, the limits mentioned are jointly called “characteristic limits”.

Since measurement uncertainty plays an important part in this International Standard, the evaluation of measurements and the treatment of measurement uncertainties are carried out by means of the general procedures according to ISO/IEC Guide 98-3; see also References [1, 2]. This enables the strict separation of the evaluation of the measurements, on the one hand (Clause 5), and the provision and calculation of the characteristic limits, on the other hand (Clause 6). This International Standard is based on Bayesian statistics according to References [6 to 19], such that uncertain quantities and influences, which do not behave randomly in measurements repeated several times or in counting measurements, can also be taken into account.

Equations are provided for the calculation of the characteristic limits of an ionizing radiation measurand via the “standard measurement uncertainty” of the measurand (hereinafter “standard uncertainty”). The standard uncertainties of the measurement, as well as those of sample treatment, calibration of the measuring system and other influences are taken into account. However, the latter standard uncertainties are assumed to be known from previous investigations.

Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for measurements of ionizing radiation — Fundamentals and application

1 Scope

This International Standard specifies a procedure, in the field of ionizing radiation metrology, for the calculation of the "decision threshold", the "detection limit" and the "limits of the confidence interval" for a non-negative ionizing radiation measurand, when counting measurements with preselection of time or counts are carried out, and the measurand results from a gross count rate and a background count rate as well as from further quantities on the basis of a model of the evaluation. In particular, the measurand can be the net count rate as the difference of the gross count rate and the background count rate, or the net activity of a sample. It can also be influenced by calibration of the measuring system, by sample treatment and by other factors.

This International Standard also applies, in the same way to:

— counting measurements on moving objects (see B.2);

— measurements with linear-scale analogue count rate measuring instruments (hereinafter called ratemeters, see B.3);

— repeated counting measurements with random influences (see B.4);

— counting measurements on filters during accumulation of radioactive material (see B.5);

— counting spectrometric multi-channel measurements, if particular lines in the spectrum are to be considered and no adjustment calculations, for instance, an unfolding, have to be carried out (see C.2 to C.4);

— counting spectrometric multi-channel measurements if evaluated by unfolding methods (see C.5), in particular, alpha- and gamma-spectrometric measurements (see C.5.5 and C.5.6, respectively).

This International Standard also applies analogously to other measurements of any kind if the same model of the evaluation is involved. In this sense, it is also applicable to measurements with albedo dosimeters [18]. Further practical examples can be found in other International Standards, for example ISO 18589[21], ISO 9696[22], ISO 9697[23], ISO 9698[24], ISO 9699[25], ISO 10703[26], ISO 7503[27] and ISO 28218[28].

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.

ISO 31-0, *Quantities and units — Part 0: General principles*

ISO 31-9, *Quantities and units — Part 9: Atomic and nuclear physics*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 31-0, ISO 31-9, ISO/IEC Guide 98-3, ISO/IEC Guide 99 and ISO 3534-1 and the following apply.

3.1
measurement procedure
set of operations, described specifically, used in the performance of particular measurements according to a given method

[ISO/IEC Guide 99:2007, 2.6]

3.2
measurand
particular quantity subject to measurement

[ISO/IEC Guide 99:2007, 2.3]

NOTE In this International Standard, a measurand is non-negative and quantifies a nuclear radiation effect. The effect is not present if the true value of the measurand is zero. An example of a measurand is the intensity of an energy line in a spectrum above the background in a spectrometric measurement.

3.3
result of a measurement
value attributed to a measurand, obtained by measurement

[ISO/IEC Guide 99:2007, 2.9]

3.4
uncertainty of measurement
uncertainty
non-negative parameter, which characterizes the dispersion of the values which could reasonably be attributed to the measurand

[ISO/IEC Guide 99:2007, 2.26]

See also ISO/IEC Guide 98-3.

NOTE The uncertainty of a measurement derived according to ISO/IEC Guide 98-3 comprises, in general, many components. Some of these components can be evaluated from the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which can also be characterized by standard deviations, are evaluated from assumed or known probability distributions based on experience and other information.

3.5
model of evaluation
set of mathematical relationships between all measured and other quantities involved in the evaluation of measurements

NOTE The model of evaluation does not need to be an explicit function; it can also be an algorithm realized by a computer code.

