
Capability of detection —

Part 6: Methodology for the determination of the critical value and the minimum detectable value in Poisson distributed measurements by normal approximations

Capacité de détection —

*Partie 6: Méthodologie pour la détermination de la valeur critique et
de la valeur minimale détectable pour les mesures distribuées selon la
loi de Poisson approximée par la loi Normale*



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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 69, *Application of statistical methods*, Subcommittee SC 6, *Measurement methods and results*.

This second edition cancels and replaces the first edition (ISO 11843-6:2013, corrected version issued in 2014), of which it constitutes a minor revision. The changes compared to the previous corrected version are as follows:

- the following updates have been made to add clarity or to correct typographic and obvious errors:
 - in [Formula \(2\)](#) and the related Note, “±” is replaced with “+”;
 - in [5.4](#), 2nd paragraph, “100(1- α /2)%” is replaced with “100(1- α)%”, and “described below by the general theory of estimation” is inserted at the end,
 - in [Clause 6 e\)](#), [Figure 1](#), and [Annex C](#) 3rd paragraph, the average values (\bar{y}_b , \bar{y}_d and \bar{y}_g) are used;
 - in [Annex C](#), 3rd paragraph, 1st sentence, “independent” is inserted before “variables”;
 - in the line below [Formula \(C.1\)](#), $I_k(\bullet)$ is consistently replaced with $I_y(\bullet)$;
 - in [E.2](#), 2nd paragraph, the text has been slightly reworded for clarity;
- thorough the text, minor editorial modifications have been made in line with the 2018 edition of the ISO/IEC Directives, Part 2.

A list of all parts in the ISO 11843 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Many types of instruments use the pulse-counting method for detecting signals. X-ray, electron and ion-spectroscopy detectors, such as X-ray diffractometers (XRD), X-ray fluorescence spectrometers (XRF), X-ray photoelectron spectrometers (XPS), Auger electron spectrometers (AES), secondary ion mass spectrometers (SIMS) and gas chromatograph mass spectrometers (GCMS) are of this type. These signals consist of a series of pulses produced at random and irregular intervals. They can be understood statistically using a Poisson distribution and the methodology for determining the minimum detectable value can be deduced from statistical principles.

Determining the minimum detectable value of signals is sometimes important in practical work. The value provides a criterion for deciding when “the signal is certainly not detected”, or when “the signal is significantly different from the background noise level”[1]-[8]. For example, it is valuable when measuring the presence of hazardous substances or surface contamination of semi-conductor materials. RoHS (Restrictions on Hazardous Substances) sets limits on the use of six hazardous materials (hexavalent chromium, lead, mercury, cadmium and the flame retardant agents, perbromobiphenyl, PBB, and perbromodiphenyl ether, PBDE) in the manufacturing of electronic components and related goods sold in the EU. For that application, XRF and GCMS are the testing instruments used. XRD is used to measure the level of hazardous asbestos and crystalline silica present in the environment or in building materials.

The methods used to set the minimum detectable value have for some time been in widespread use in the field of chemical analysis, although not where pulse-counting measurements are concerned. The need to establish a methodology for determining the minimum detectable value in that area is recognized[9].

In this document the Poisson distribution is approximated by the normal distribution, ensuring consistency with the IUPAC approach laid out in the ISO 11843 series. The conventional approximation is used to generate the variance, the critical value of the response variable, the capability of detection criteria and the minimum detectability level[10].

In this document:

- α is the probability of erroneously detecting that a system is not in the basic state, when really it is in that state;
- β is the probability of erroneously not detecting that a system is not in the basic state when the value of the state variable is equal to the minimum detectable value (x_d).

This document is fully compliant with ISO 11843-1, ISO 11843-3 and ISO 11843-4.

