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For Comments Only

Draft Indian Standard

Measurement uncertainty for metrological applications — Repeated measurements and nested experiments

ICS 17.020

NATIONAL FOREWORD

(Formal clauses to be added later on)

The text of the International Standards has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standards' appear referring to this standard, they should be read as 'Indian Standards'.

In this adopted standard, reference appears to an International Standards for which no Indian Standards exists. The technical committee have reviewed the provisions of the following International standards referred in this standard and has decided that they are acceptable for use in conjunction with this standards:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 3534-1:1993, Statistics — Vocabulary and symbols — Part 1: Probability and general statistical terms	IS 7920 (Part 1):2012, Statistical — Vocabulary and symbols: Part 1 general statistical terms and terms used in probability (Third Revision)	Identical
ISO 3534-3:1999, Statistics — Vocabulary and symbols — Part 3: Design of experiments	IS 7920 (Part 3) :2018/ ISO 3534-3:2013, Statistics — Vocabulary and symbols: Part 3 design of experiments (Third Revision)	Identical
ISO 5725-1, Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions	IS 15393 (Part 1):2003/ ISO 5725-1:1994, Accuracy (Trueness And Precision) of measurement methods and results: Part 1 general principles and definitions	Identical
ISO 5725-2, Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method	IS 15393 (Part 2):2003/ ISO 5725-2:1994, Accuracy (Trueness And Precision) of measurement methods and results: Part 2 basic method for the	Identical

for the determination of repeatability and reproducibility of a standard measurement method	determination of repeatability and reproducibility of a standard measurement method (Withdrawn)	
ISO 5725-3, Accuracy (trueness and precision) of measurement methods and results — Part 3: Intermediate measures of the precision of a standard measurement method	IS 15393 (Part 3):2003 ISO 5725-3:1994, Accuracy (Trueness And Precision) of measurement methods and results: Part 3 intermediate measures of the precision of a standard measurement method	Identical
ISO 5725-4, Accuracy (trueness and precision) of measurement methods and results — Part 4: Basic methods for the determination of the trueness of a standard measurement method	IS 15393 (Part 4):2003 ISO 5725-4:1994, Accuracy (Trueness And Precision) of measurement methods and results: Part 4 basic methods for the determination of the trueness of a standard measurement method (Withdrawn)	Identical
ISO 5725-5, Accuracy (trueness and precision) of measurement methods and results — Part 5: Alternative methods for the determination of the precision of a standard measurement method	IS 15393 (Part 5):2003 ISO 5725-5:1998, Accuracy (Trueness And Precision) of measurement methods and results: Part 5 alternative methods for the determination of the precision of a standard measurement method	Identical
ISO 5725-6, Accuracy (trueness and precision) of measurement methods and results — Part 6: Use in practice of accuracy values	IS 15393 (Part 6):2003 ISO 5725-6:1994, Accuracy (Trueness And Precision) of measurement methods and results: Part 6 use in practice of accuracy values	Identical

Annex A is normative only.

Note: The technical content of the document is not available on website. For details, please refer the corresponding ISO/TS 21749: 2005 or kindly contact:

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Scope

This Technical Specification follows the approach taken in the *Guide to the expression of the uncertainty of measurement* (*GUM*) and establishes the basic structure for stating and combining components of uncertainty. To this basic structure, it adds a statistical framework using the analysis of variance (ANOVA) for estimating individual components, particularly those classified as Type A evaluations of uncertainty, i.e. based on the use of statistical methods. A short description of Type B evaluations of uncertainty (non-statistical) is included for completeness.

This Technical Specification covers experimental situations where the components of uncertainty can be estimated from statistical analysis of repeated measurements, instruments, test items or check standards.

It provides methods for obtaining uncertainties from single-, two- and three-level nested designs only. More complicated experimental situations where, for example, there is interaction between operator effects and instrument effects or a cross effect, are not covered.

This Technical Specification is not applicable to measurements that cannot be replicated, such as destructive measurements or measurements on dynamically varying systems (such as fluid flow, electronic currents or telecommunications systems). It is not particularly directed to the certification of reference materials (particularly chemical substances) and to calibrations where artefacts are compared using a scheme known as a "weighing design". For certification of reference materials, see ISO Guide 35[14].

When results from interlaboratory studies can be used, techniques are presented in the companion guide ISO/TS 21748[15]. The main difference between ISO/TS 21748 and this Technical Specification is that the ISO/TS 21748 is concerned with reproducibility data (with the inevitable repeatability effects), whereas this Technical Specification concentrates on repeatability data and the use of the analysis of variance for its treatment.

This Technical Specification is applicable to a wide variety of measurements, for example, lengths, angles, voltages, resistances, masses and densities.

Introduction

Test, calibration and other laboratories are frequently required to report the results of measurements and the associated uncertainties. Evaluation of uncertainty is an on-going process that can consume time and resources. In particular, there are many tests and other operations carried out by laboratories where two or three sources of uncertainty are involved. Following the approach in the *Guide to the expression of uncertainty of measurement* (*GUM*) to combining components of uncertainty, this document focuses on using the analysis of variance (ANOVA) for estimating individual components, particularly those based on Type A (statistical) evaluations.

An experiment is designed by the laboratory to enable an adequate number of measurements to be made, the analysis of which will permit the separation of the uncertainty components. The experiment, in terms of design and execution, and the subsequent analysis and uncertainty evaluation, require familiarity with data analysis techniques, particularly statistical analysis. Therefore, it is important for laboratory personnel to be aware of the resources required and to plan the necessary data collection and analysis.

In this Technical Specification, the uncertainty components based on Type A evaluations can be estimated from statistical analysis of repeated measurements, from instruments, test items or check standards.

A purpose of this Technical Specification is to provide guidance on the evaluation of the uncertainties associated with the measurement of test items, for instance as part of ongoing manufacturing inspection. Such uncertainties contain contributions from the measurement process itself and from the variability of the manufacturing process. Both types of contribution include those from operators, environmental conditions and other effects. In order to assist in separating the effects of the measurement process and manufacturing variability, measurements of check standards are used to provide data on the measurement process itself. Such measurements are nominally identical to those made on the test items. In particular, measurements on check standards are used to help identify time-dependent effects, so that such effects can be evaluated and contrasted with a database of check standard measurements. These standards are also useful in helping to control the bias and long-term drift of the process once a baseline for these quantities has been established from historical data.

Clause 4 briefly describes the statistical methods of uncertainty evaluation including the approach recommended in the *GUM*, the use of check standards, the steps in uncertainty evaluation and the examples in this Technical Specification. Clause 5, the main part of this Technical Specification, discusses the Type A evaluations. Nested designs in ANOVA are used in dealing with time-dependent sources of uncertainty. Other sources such as those from the measurement configuration, material inhomogeneity, and the bias due to measurement configurations and related uncertainty analyses are discussed. Type B (non-statistical) evaluations of uncertainty are discussed for completeness in Clause 6. The law of propagation of uncertainty described in the *GUM* has been widely used. Clause 7 provides formulae obtained by applying this law to certain functions of one and two variables. In Clause 8, as an example, a Type A evaluation of uncertainty for a gauge study is discussed, where uncertainty components from various sources are obtained. Annex A lists the statistical symbols used in this Technical Specification.