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TECHNICAL NOTE

The Use of “Accuracy” and Related Terms in the Specifications of Testing and Measurement Equipment

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The following members of DR 2-75 “TN on the use of “Accuracy” and related terms in the specifications of testing and measurement equipment” took part in the preparation of this Technical Note. The Reportership comes under Division 2 “Physical measurement of light and radiation”.

Authors:

Bergen, A. (Chair)	Australia
Blattner, P.	Switzerland
Sperling, A.	Germany
Young, R.	Germany

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CONTENTS

Summary	1
1 Introduction	1
2 Definitions	1
3 Background notes on accuracy, error, precision and uncertainty	5
4 Correct use of terms	9
4.1 Accuracy, error, uncertainty, and tolerance	9
4.2 Reproducibility and repeatability	10
5 The concepts of quality indices and tolerance intervals	10
6 Recommended expressions for specifications of testing and measurement equipment	11
6.1 Expressions relating to properties of an instrument	11
6.1.1 Example formats for expressing conformity to tolerance intervals/limits and quality indices	12
6.1.2 Example formats for expressing compliance with a standard	12
6.2 Expressions relating to an instrument's measurement performance	12
6.2.1 Example format of expressing the performance of a photometer	13
6.2.2 Example format of expressing the performance of a colorimeter	13
6.2.3 Example format of expressing the performance of a spectrophotometer	13
6.3 Expressions for specifying an instrument's required measurement performance	13
6.3.1 Example formats for expressing conformity to tolerance intervals/limits and quality indices	14
6.3.2 Example formats for expressing required compliance with a standard	14
6.3.3 Example format for expressing the required performance of an integrating sphere system	14
6.4 Combined expressions	14
References	15

Summary

This Technical Note provides guidance on the correct use of the terms "accuracy", "error", "tolerance", "reproducibility", and "repeatability" in relation to the properties and specifications of testing and measurement instruments on the one hand, and the terms "error" and "uncertainty", and a measurement instrument's sensitivity in relation to a measurement process or a calibration on the other hand. It also summarizes the concepts of quality indices and tolerance intervals and provides guidance for acceptable methods of specifying the performance of equipment and for expressing specifications for the requirements of equipment to be used for a specific purpose. This will be of assistance to equipment manufacturers in producing brochures, manuals, and datasheets as well as tender specification writers in producing technical specifications for procurement of equipment that use the above terms correctly.

1 Introduction

Many measurement instruments have technical specifications and datasheets that say, for example, "Accuracy: 4 %". This is an inappropriate use of the term "accuracy" because, as described in 4.1 of this document, an "accuracy" is not a quantity and cannot be assigned a value. This document describes how to use the term "accuracy" correctly, as well as giving examples of acceptable expressions that could be used in place of the incorrect expression used in the example here. Furthermore, some other commonly misused terms are discussed, and examples of correct use are given.

The primary reference used for the definitions of these terms is the International Vocabulary of Metrology (VIM), which is produced by the Joint Committee for Guides in Metrology (JCGM 2012a). For the accepted definitions of these terms and selected other related terms, extracted from the VIM, please refer to Clause 2. The remaining clauses give a more practical interpretation of these terms and describe correct use.

However, the terms "accuracy", "tolerance", "reproducibility", and "repeatability" as defined in the VIM are assigned to measurement instruments or test procedures and do not necessarily give a reliable information about the "correctness" of a measurement result in general. The reliability of measurements is dealt with in the "Guide to the expression of uncertainty in measurement" (GUM) (JCGM 2008). This is important to mention, as the uncertainty of a measurement always depends additionally on environmental parameters and other factors influencing the whole measurement process. From this it follows that uncertainty cannot be appointed to a single measurement device but to a measurement value.

2 Definitions

2.1

measurement accuracy

accuracy of measurement

accuracy

closeness of agreement between a measured quantity value and a true quantity value of a measurand

NOTE 1 The concept 'measurement accuracy' is not a quantity and is not given a numerical quantity value. A measurement is said to be more accurate when it offers a smaller measurement error.

NOTE 2 The term "measurement accuracy" should not be used for measurement trueness and the term "measurement precision" should not be used for 'measurement accuracy', which, however, is related to both these concepts.

NOTE 3 'Measurement accuracy' is sometimes understood as closeness of agreement between measured quantity values that are being attributed to the measurand.

NOTE 4 Rigorously speaking, and according to the GUM, the true quantity value of a measurement is always unknown.

[Source: JCGM 200:2012, Term 2.13; Note 4 added]

2.2

measurement trueness

trueness of measurement

trueness

closeness of agreement between the average of an infinite number of replicate measured quantity values and a reference quantity value

NOTE 1 Measurement trueness is not a quantity and thus cannot be expressed numerically, but measures for closeness of agreement are given in ISO 5725.

NOTE 2 Measurement trueness is inversely related to systematic measurement error, but is not related to random measurement error.

NOTE 3 "Measurement accuracy" should not be used for 'measurement trueness'.

[Source: JCGM 200:2012, Term 2.14]

2.3

measurement precision

precision

closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions

NOTE 1 Measurement precision is usually expressed numerically by measures of imprecision, such as standard deviation, variance, or coefficient of variation under the specified conditions of measurement.

NOTE 2 The 'specified conditions' can be, for example, repeatability conditions of measurement, intermediate precision conditions of measurement, or reproducibility conditions of measurement (see ISO 5725-1:1994 (ISO 1994a)).

NOTE 3 Measurement precision is used to define measurement repeatability, intermediate measurement precision, and measurement reproducibility.

NOTE 4 Sometimes "measurement precision" is erroneously used to mean measurement accuracy.

[Source: JCGM 200:2012, Term 2.15, modified – reference in NOTE 2 added]

2.4

measurement error

error of measurement

error

measured quantity value minus a reference quantity value

NOTE 1 The concept of 'measurement error' can be used both
a) when there is a single reference quantity value to refer to, which occurs if a calibration is made by means of a measurement standard with a measured quantity value having a negligible measurement uncertainty or if a conventional quantity value is given, in which case the measurement error is known, and
b) if a measurand is supposed to be represented by a unique true quantity value or a set of true quantity values of negligible range, in which case the measurement error is not known.

NOTE 2 Measurement error should not be confused with production error or mistake.

NOTE 3 The concept of measurement error assumes that the reference quantity value is a "true" quantity value, and hence that the measurement error can be expressed as an absolute amount without