# Study on Uncertainty Measurement in Testing During Research Work

Nitu Gupta [1]Pratibha Gupta[2], M.D. Choudhary[3]
*[1] Head of Department of Applied Chemistry ,Dr.BabasahabAmbedkar college of engineering & Research*
*Email : neetusgupta@rediffmail.com*
*[2]Technical Manager (Lab) Miltech Industry, MIDC, Nagpur, MS*
*Email: pra_sim2000@yahoo.co.in*
*[3]Dean ,Professor & Head, Department of appliedScience, BDCOE, Sevagram, Wardha, MS*
*Email:mahendrachoudary@gmail.com*

**Abstract:** "Testing" is a term that covers a huge range of activities. Not every test is a measurement. However, for those tests that includes measurements, for that uncertainty of measurement is a important topic. The purpose of measurement is to determine the value for a quantity of interest Every measurement has uncertainty associated with it. Measurement devices, calibration standards, reagents, and tools are not perfect. Environmental conditions, processes, procedures, and people are also imperfect and variable.

***Keyword*** *: Uncertainty Measurement , Testing & Calibration .*

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## I. Introduction

It is important to distinguish between **measurement uncertainty**, which is a measure of thebounds within which a value may be reasonably presumed to lie, and **measurement error**,which is the difference between an indicated value and the corresponding presumed truevalue. The measurement error is a quantity which often can be evaluated and, from thisknowledge, a correction to the measurement can be applied. However, the identification of an error and its subsequent correction may not be possible with exactitude and this inexactitudewill of itself contribute to the measurement uncertainty. Similarly, errors must be distinguished from mistakes or blunders. By their very naturemistakes and blunders cannot be quantified or allowed for as part of the measurementuncertainty.

A further common source of confusion is the use of the term **tolerance**. A tolerance is properly the limiting or permitted range of values of a defined quantity. The classic exampleis the tolerances (minimum and maximum) of a particular dimension of a manufacturedcomponent, usually set to ensure proper engagement with a mating part. To be able tomeasure the component and ensure that the tolerances are met, the measurement uncertaintymust clearly be smaller than the tolerance. A minimum ratio of 1 to 4 is often recommended.

The term **tolerance** is also applied to measuring instruments, when it is meant to indicate theacceptable range of values indicated by the instrument when set up and tested by themanufacturer. In this usage, the tolerance is one contribution to measurement uncertaintywhen using the instrument. It is important, when a tolerance associated with measurement ismet, to understand and to properly interpret its intended use.

## II. Purpose of measurement

The purpose of measurement is to determine the value for a quantity of interest. Examples include the boiling point of water at 1 atmosphere of pressure, the durometer hardness of a Rubber specimen, the tensile strength of a rubber compound, and the length of a textile specimen at 23°C.

### Measurand

Before a measurement can be made, we have to know what we are to measure (the "measurand"), the method and procedure to be used, the test conditions, the measurement devices and systems to be used, and other relevant factors

- Measurement uncertainty is important not only for calibrations but in any test that involves measurements.

### Measurement uncertainty

- A non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used.
- Think of it as a parameter associated with the result of a measurement that characterizes the dispersion of

the quantity values that is attributed to the measurand.

- Uncertainty in a measurement quantity is a result both of our incomplete knowledge of the value of the measured quantity and of the factors influencing it

**Sources of uncertainty of measurement**

1. Incomplete definition of the quantity being measured;
2. Imperfect realization of the definition of the quantity being measured;
3. Non-representative sampling;
4. Inadequate knowledge of the effects of environmental conditions on the measurement or imperfect measurement of environmental conditions;
5. Personal bias in reading analog instruments, including the effects of parallax;
6. Finite resolution or discrimination threshold;
7. Inexact values of measurement standards and reference materials;
8. Inexact values of constants and other parameters obtained from external sources and used in the data-reduction algorithm;
9. Approximations and assumptions incorporated in the measurement method and procedure;
10. Variations in repeated observations of the measurand under apparently identical conditions.

These sources of uncertainty are not necessarily independent and some or all can contribute to the variations in repeated observations. Not only can uncertainties be introduced by measurement equipment and test methods, but also by the person performing the test, data analysis, the environment, and a host of other factors.

## III. Description

### Measurement Uncertainty in testing

Tests are performed in accordance with test procedures. The use of recognized standard procedures (e.g., IS 3400 Pt1 ) eliminates many potential sources of measurement uncertainty. Definitions, Calculations, and other information necessary to evaluate the test data are contained in such test procedures. The procedure addresses test measurement statistics and uncertainty at the level necessary to meet test requirements. Some of the most commonly used terms and concepts follow.

**Precision**

Closeness of agreement between indications or measured quantity values obtained by repeated measurements on the same or similar objects under specified conditions. Measurement precision is usually expressed as standard deviation, variance

**Repeatability**

Repeatabilityis a condition of measurement, out of a set of conditions that includes the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicate measurements on the same or similar objects over a short period of time.

This involves precision under repeatability conditions, i.e. conditions where test results are obtained with the same method on the same or similar test items in the same laboratory by the same operator using the same equipment at the same location within short intervals of time. Repeatability may be expressed in terms of multiples of the standard deviation.

*Repeatability standard deviation* is the standard deviation of test results obtained under repeatability conditions

**Reproducibility**

Reproducibilityis precision under reproducibility conditions, i.e. conditions where test results are obtained with the same method on the same or similar test items in different laboratories, by different operators, using different equipment, in different locations, or on different days. Reproducibility may be expressed in terms of multiples of the standard deviation.

*Reproducibility standard deviation* is the standard deviation of test results obtained under reproducibility conditions. The conditions under which reproducibility is determined should be clearly specified.

**Trueness (Measurement Accuracy9):** the closeness of agreement between a measured quantity value and a true quantity value of a measurand.

**Measurand:** refers to the particular quantity to be measured in a test. Any uncertainty analysis must begin with a clear understanding of the quantity to be measured, the measurand.

(The area of a square piece of material is calculated from **two input quantities**, length and width. These quantities may be affected by **influence quantities** such as temperature and the resolution of the measuring instrument)

**Combined standard uncertainty:** is calculated by squaring all the significant Type A and Type B uncertainties, adding them together, and then taking the square root of the sum. This is sometimes called the “root-sum method”.

**Expanded uncertainty:** is the combined standard uncertainty multiplied by a **coverage factor, k.** The expanded uncertainty defines an *interval* around the measured value. The value of the measurand is expected to be within this interval to an established confidence level, usually 95%.

**Type A evaluation** (of uncertainty): is an evaluation of uncertainty by the statistical analysis of a series of observations. (Type A uncertainties are not random errors.)

Type A uncertainties are based upon repeated measurements from a controlled process and are described by the familiar Normal (or "Standard") probability distribution that yields an average and standard deviation for the set.

Type A uncertainties can be calculated as STDEV/SQRT(COUNT).

Type A uncertainty estimates apply standard statistical methods to test data based on the assumption of a normal probability distribution.

**Type B evaluation** (of uncertainty): is an evaluation of uncertainty by means other than the statistical analysis of series of observations. (Type B uncertainties are not systematic errors.)

Type B uncertainties are assumed to have infinite degrees of freedom because they are not improved by additional repeated measurements.

Uncertainties based on normal distributions are Type B if they are not the result of our own measurement data. (In the example, the Sr calculated from the five tensile tests is Type A. The SR values listed in ASTM D638 tables are Type B.)

**Normal Distribution**

For a standard uncertainty or standard deviation value of ±a reported at a coverage or multiplication factor of k, the standard uncertainty is

$U_N = a/k$

**Rectangular distribution**

The rectangular, or "continuous", is another very common distribution for Type B uncertainties. It applies to tolerances, specifications, and reference book values, among many other parameters. It is also the default distribution to be used whenever the actual distribution is not known.

The equation for the standard uncertainty of a continuous distribution of equal values between the limits +a to –a, the standard uncertainty is

$U_R = A/\sqrt{3}$

Table 1 :Type of Distributions

| | | |
|---|---|---|
| Normal | a/k | a/2 |
| Rectangular | a5774.03 | a/√3 |
| triangular | a4082.06 | a/√6 |
| U-shaped | a7071.02 | a/√2 |

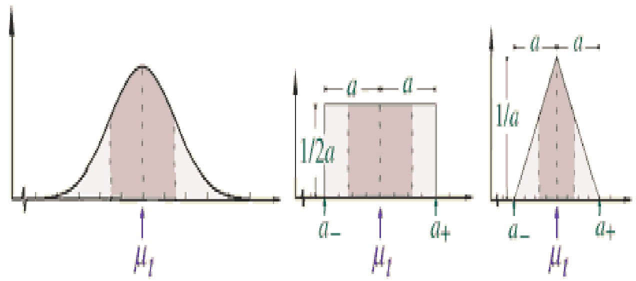


Fig 1 : Types of Distribution graphically

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