

**Covering Note to EL/07-01/99/583**

## **Uncertainty in Testing**

The new standard ISO/IEC 17025 contains detailed requirements for the estimation of measurement uncertainty and its expression in test reports or calibration certificates. In this connection the standard differentiates between calibration and testing (see e.g. 5.4.6.1 and 5.4.6.2). Therefore for testing laboratories it will be highly important how compliance with these requirements will be assessed by the accreditation bodies after the implementation of the new standard.

The following position paper on uncertainty of testing was drafted after thorough discussion by the EA / EUROLAB Permanent Liaison Group (PLG). Its aims at highlighting the problems involved in the estimation of uncertainty of test results and advocates feasible approaches in different sectors.

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## Uncertainty in testing

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### Introduction

### Scope

This paper is not intended as a "requirement paper" but as a policy paper to start a discussion process on an extremely important question for both laboratories and accreditors namely how and when to state an expression of uncertainty with the result of a measurement or a test.

### Background

The most common guide for the estimation of measuring uncertainties is the GUM<sup>1</sup> where it is presumed, that the relevant factors influencing the uncertainty are considered. This means, that not only the uncertainty of the measuring process has to be taken into consideration. Much more, all the activities, starting with the sampling process (if relevant) followed by the process of sample preparation, the measurement process and finally the (statistical) calculation of the final result have to be considered. This means that when we discuss the topic "measuring uncertainty in the field of testing", we should keep in mind that there is not only an uncertainty connected to the pure measurement process, which may arise from the stability of a measuring instrument. We have to consider contributions, like the sampling, human and environmental influence, instrumentation, definition of the testing procedure and so on.

### The estimation of the measurement uncertainty

The scientific theory concerning statistics is stated in literature<sup>2 3 4</sup>. It will be applied where the influencing factors are clear-cut and where comparisons and repetitive measurements can be performed rather easily. But uncertainty is not only related such type of test results. We also have to keep in mind that there are many technical issues, which have a probabilistic behaviour and simply go/no go tests. You can find examples from e.g. probabilistic fracture mechanics, fire testing, NDT etc. In such cases, the measuring uncertainty will consist of an estimation of the possibility of wrong positive or a wrong negative results.

Guidance for the assessment and expression of uncertainty for use in laboratory work is given in literature but there may be also regional documents in use with differing interpretations. The situation can not be harmonised between technical fields or between the groups of interested parties<sup>5</sup>. Quite often, it can be a contractual arrangement between the laboratory or the conformity assessment body and its client.

The scientific approach or as mentioned in the GUM the type B approach. is practically the only one which is applicable in praxis. Using this technique the assessment of uncertainty components is the most difficult step - the uncertainty of a single measuring instrument is usually the most easy problem and in most cases derived from the traceability chain<sup>6</sup> and as such stated by the calibration laboratory. Many components are not amenable to statistical analysis and have to be assessed from experience and professional judgement. They also have different importance as their magnitude may vary. It is a necessary service to the customer to exclude those of little importance. The combination of uncertainty components can be performed in different ways. It is normally done by addition according to Gauss (quadratic addition). However, if there are relations between individual components, the application of a simple quadratic addition can be wrong. Also intercomparison can be a proper way to estimate uncertainty in certain cases.

For those cases where we can use the expression "uncertainty" properly there is an approach recommended by Nordtest<sup>8</sup>. In the same paper it is also shown that for the other cases we need a completely new way of thinking.

### **Use and interpretation of uncertainties**

The expression of uncertainties can be made in various fashions. In the guidelines the recommended way is to state an expanded uncertainty for the result, which corresponds to the standard uncertainty, and then multiply it by the k-factor (generally approximately 2 for 95% and 3 for 99% confidence interval).

Uncertainty becomes extremely important as soon as a result comes close to limit values. A common interpretation of such results is suggested in the ILAC Guide<sup>9</sup>. Even the use of these rules can cause problems for the laboratory's clients. It is therefore important that the fixing of specification limits has to be done by keeping in mind the possible uncertainties connected to the available testing methods. The values should be fixed in the regulations (standards, legal acts etc.) in such a way that there is a safety interval and that the expected uncertainty of the method is already taken into consideration to avoid fruitless discussions between client and laboratory. This means that politics have to be influenced which can not be achieved by single laboratories.<sup>3</sup>

The interpretation of uncertainties needs professional judgement, sometimes complex mathematical and theoretical modelling, which opens the next field of discussion.

### **The need for uncertainties**

In principle, uncertainty is needed by everybody who uses testing and measurement results because it is a measure for the quality of the result and therefore a precondition for the validation of test methods for specific purposes.

The **laboratories** need a tool for evaluating and validating their testing procedures. Uncertainty is not the only one, but an important characteristic of a testing procedure. It plays an important role if results of two or more testing procedures are compared and if proficiency tests are planned or evaluated. Therefore laboratories need to

know the upper limit of their measuring uncertainties, even if these are not reported in the testing report.

There is already sectoral oriented work done e.g. in chemistry. where a very scientific paper has been established.

In **calibration** the indication of the uncertainty has to be reported as it is a basic value for all other work that will be done later with the instrument, e.g. in the validation of the test methods the instrument will be involved.

The **customers** want safe, easy to understand results. Quite often they are not trained enough to understand what the testing uncertainty means. However, uncertainty is also an important feature to describe the quality of the result. It can help to solve problems (e.g. wrong expectations by clients) between the laboratory and its customers. On the other hand the uncertainty may be an important part of the result (e.g. comparing results).

**Accreditation bodies** use also the uncertainty question to assess the competence of laboratories but depending on the accreditation body or even worse the single assessor the depth may vary very much. Generally agreed and usable documents including typical examples are needed to achieve consensus, harmonisation and a fair competition.

In the field of standardisation there are many standards that include statements on uncertainty but even more often there is no indication at all. However sometimes there is no real evaluation behind those statements (mainly in older ones) and nobody knows the uncertainty of the uncertainty....

Testing is not simply the combination of various measurements. It can also include other processes and even complex considerations. Authorities can be unhappy with uncertainties. especially when reaching limit values of specifications. Customers may argue in the same way because they may be uncertain by reading a result plus minus something. However, the measuring uncertainty, if it is stated in a correct way, leads to a better understanding of the service a laboratory can provide. This will, at the end, lead to a better customer satisfaction.

Concerted work has to be started by the interested parties to produce a much understanding in the market.

### **Recommended actions for the future development**

As mentioned before the state of the art of implementing principles of determination and reporting of measurement uncertainties is different in the various technical fields, that of uncertainty of a complete test even more. Future guidance should consider this fact.

A general paper on the ILAC and/or EA/EUROLAB level should be elaborated. The paper should provide guidance to laboratories and accreditation bodies, standardising and governmental organisations in a similar way as it has already been done for the concept of validation (at the moment there are documents dealing

with measurement uncertainty or result uncertainty, where result is the combination of measurements).

It is recommended, if needed, to start in parallel sectoral programs for evaluating typical examples of determining uncertainties in co-operation of accreditors and laboratories, if possible. with standardisation bodies and to establish a guidance paper on how to establish, to report and to use measuring uncertainties and what we understand under the term measuring uncertainty. To properly handle the question of thresholds, limit values should always be fixed in such a way that there is a safety interval and that the uncertainty of the involved methods is taken into account

To elaborate and implement such a paper a European network involving all relevant European bodies including also industry and authorities should be established. Financing could be provided for instance through the 5th framework program<sup>9</sup>.

It must be our first principle to give our customers (industry society etc.) clear but correct and complete figures and easy to understand reports.

<sup>1</sup> GUM: Guide to the expression of uncertainty in measurement, BIPM/IEC/IFCC/ISO/OIML/IUPAC/IUPAC, 1995

<sup>2</sup> ISO: "Guidance to the expression of uncertainty in measurements" 1. ed. 1993, ISBN 9267 10188 9

<sup>3</sup> EURACHEM Guide: 'Quantifying Uncertainty in Analytical Measurement'. 1995 (Available through LGC)

<sup>4</sup> French Standardisation: Procedure for estimating, expressing and using uncertainty in measurement and test results. Draft documentation brochure (1 July 1997)

<sup>5</sup> Tenby Industries Ltd: Calculation & Reporting Uncertainties of Measurements in Testing. 1996

Swiss Accreditation Service: Dok. 706.d "Validierung von Prüfverfahren" 29.11.96  
BMTA "Estimating Uncertainties in Testing" April 1995

<sup>6</sup> ILAC-G6. Guidelines on Assessment and Reporting of Compliance with Specifications

<sup>7</sup> EAL-R2: Expression of the Uncertainty of Measurement in Calibration

<sup>8</sup> NORDTEST Uncertainty - to a certain level, position paper 005, 1998

<sup>9</sup> Network on accuracy and reliability in testing (NART), draft proposal EA/EUROLAB