Dealing with uncertainties in european standards

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"Uncertainty" should have always been a key word in the field of standardization as many standards are devoted to providing methods for measuring quantities of all kinds. However, it is only relatively recently that it was realized that all metrological standards should absolutely and systematically deal with uncertainties. This resulted in specific guidance given in 2004 at the European level on the "uncertainty of measurement concept in European Standards" provided by CEN (the European Standardization Committee) to all those contributing to the drafting of European standards. This paper reports about this guidance that applies to all fields of metrology and, in particular, to acoustics.

L'incertitude devrait toujours avoir été un mot clé dans le domaine de la normalisation puisque les normes sont destinées à fournir des méthodes de mesure pour toutes sortes de choses. Toutefois, ce n'est que relativement récemment qu'on a pris conscience que toutes les normes en métrologie devraient absolument et systématiquement prendre en compte les incertitudes. Cela a abouti à un guide spécifique paru en 2004 au niveau européen sur «le concept d'incertitude de mesure dans les normes européennes» produit par le CEN pour tout ceux qui contribuent à éditer des normes européennes. Cet article présente ce guide qui s'applique à tous les domaines de la métrologie et en particulier, à l'acoustique.

It is at the international level and in the field of standardization that uncertainty emerged as a key issue in the 1990s. The reason is that measurement methods fall well in with standardization and markets are now worldwide. At the European market level, the Technical Board (BT) of CEN has set up in 2000 its WG 122 "Uncertainty of measurements" to investigate the issue in European standards, with the aim to providing a coherent methodology across sectors to ensure a reliable interpretation of measurement results. The Group made recommendations on how to develop guidance for CEN technical committees. An important seminar was held in 2002. The outcome of the whole exercise was a document "Implementation of the concept of measurement uncertainty in European standards" and CEN technical bodies were asked, when possible, to implement the guidance and recommendations given in that document.

The initial CEN BT resolution

The decision that guidance should be given to standardizers on how to address uncertainty in European standards was taken by CEN BT (Technical Board) in April 2003. The resolution is reproduced hereafter.

Resolution BT 21/2003

Subject: Report of BT/WG 122

BT,

- gratefully acknowledging the important efforts made by CEN/BT WG 122 «Uncertainty of Measurement» in researching this topic on behalf of CEN;
- recognizing the positive contribution made by the successful seminar held in 2002;
- appreciating the recommendations and proposals made by CEN/BT WG 122;
- noting the report (BT N 6831) and its recommendations; - decides,
- to ask CEN technical bodies and other relevant bodies to be aware of the guidance and recommendations contained in that report;
- to ask CEN technical bodies, when possible and necessary,

to implement the guidance and recommendations within the limits allowed by available resources and without compromising the need to deliver European Standards as quickly as possible;

- that the BOSS will be complemented accordingly.

This Resolution is applicable as from: 2003-04-24

A technical and political challenge

The now widely recognized need to deal with uncertainty in measurement standards has brought an extra burden to standardizers. On the one hand, the issue is technically difficult and it has sensitive political side-aspects. Reaching a consensus when drafting a standard is always a complex matter. Adding the uncertainty issue is making it even harder. On the other hand, it is common knowledge that it takes too long to draft standards and rules are presently enforced (at national, European and international levels) to reduce drafting time down to 3 years. Including one more technically and politically sensitive topic and at the same time shortening the time-scale is a challenge. The CEN guidance was written with these contradictory requirements in mind.

Key features of the CEN guidance

The guidance is … only "guidance" i.e. standardizers may not follow it. However, it is clear that no one can really go round it nowadays and the issue can no longer be ignored by standard makers. It stresses that, although efforts must be made to take uncertainty aboard measurement standards, this must keep within the limits allowed by available resources and without compromising the need to deliver European standards as quickly as possible.
It stresses very important and very true facts that all parties concerned do not have necessarily in mind:

- The negative aspect behind the word "uncertainty", which makes everyone think of faults, mistakes and errors should be fought against. Uncertainty should be seen positively as it implies confidence in the validity of results.
- Making decisions without taking account of the uncertainty is only apparently easy. Serious mistakes may be made resulting in disputes and adverse consequences.
- Uncertainty is a preventive tool that will avoid in the end unpleasant surprises.

It provides a useful and easy checklist to assess the need for implementation of the uncertainty of measurement concept in standards and guides through the decision process. It also provides a list of reference standards and documents.
It is publicly available on CEN Website *www.cenorm.be/boss*.

The CEN guidance : Version 1 of September 2004
Guidance - Uncertainty of measurement concept in European Standards
Source: Resolution BT 21/2003

The CEN guidance as taken from CEN/BOSS is repeated hereafter word for word.

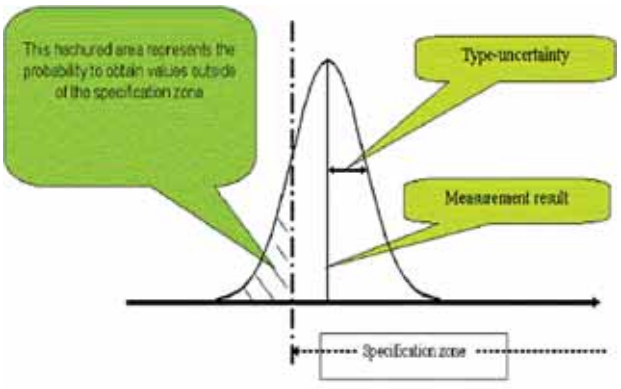
1 Introduction and definitions

When possible and necessary, the Technical Board of CEN (BT) asks CEN technical bodies and other relevant bodies to implement the guidance and recommendations about uncertainty of measurement (see below) within the limits allowed by available resources and without compromising the need to deliver European Standards as quickly as possible (resolution BT 21/2003).
Consequently, this document gives guidance to all technical bodies in charge of drafting standards. It provides a checklist to assess the need for implementation of the uncertainty of measurement concept in standards and guide them through their decision process.

1.1-Background

It is of common knowledge that measurement results are never perfectly accurate. In practice the sources of systematic and random errors which can affect the results of measurement are numerous (even for the most careful operators).
To describe this lack of perfection, the term «uncertainty» is used. Although the concept of uncertainty may be related to a «doubt», in the real sense the knowledge of uncertainty implies increased confidence in the validity of results.

The figure below illustrates the decision difficulty when uncertainty could affect the compliance of a product to a specification limit (this figure illustrates the case of a Gaussian distribution, but the difficulty is the same in the case of all other kinds of distribution).



This margin of doubt should be quantified to be able to make a consistent decision. In fact a key consideration is the degree of risk associated with the decision making process.

Without knowledge of the accuracy (trueness and precision) of measurement methods and/or the uncertainty of measurement results, it may appear very easy to make decisions. But, in practice, these decisions may be incorrect and sometimes lead to serious consequences, if the measurement uncertainty is not taken into account.

For example, in the *economical field*, when rejecting instead of accepting a good product during a certification process or, conversely, when accepting a bad product by error. In the *legal field*, when returning a verdict of guilty instead of not guilty in case of market surveillance or of accident. In the *human field*, when falsely classifying dangerous products as safe. In the *ethical field*, when having overly optimistic or unduly pessimistic interpretation of results leading to a non - fair competition between manufacturers and between testing laboratories, etc.

So, it is vital to quantify the reliability of the measurement results to greatly reduce any disputes and adverse consequences of legal proceedings. This is of particular importance if we consider the growing number of cases of litigation in Europe and the liability problems of manufacturers in case of accidents.

1.2 Reference standards
Several reference standards ask directly or indirectly (through the control of the measuring equipments) for the estimation of the uncertainty of measurement, such as:

- EN ISO 9001:2000 «Quality management systems – Requirements»
This standard specifies in 7.5.1 c) the use of suitable equipment, in 7.5.2 b) the approval of equipment and in 7.6 where necessary to ensure valid results, measuring equipment shall
a) be calibrated or verified at specified intervals or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded;
b) be adjusted or re-adjusted as necessary;
c) etc.

- EN ISO 10012 : 2003 «Measurement management systems – Requirements for measurement processes and measuring equipment»
This standard specifies particularly in 7.3.1 Measurement uncertainty :
«The measurement uncertainty shall be estimated for each measurement process covered by the measurement management system, etc.»

- EN/ISO/IEC 17025-2000 «General requirements for the competence of testing and calibration laboratories»
This world-wide reference standard for the accreditation of laboratories specifies, in particular in 5.4.6, that testing laboratories shall have and shall apply procedures for estimating the uncertainty of measurement and, in 5.10.3.1 c), that test report, when the uncertainty affects compliance to a specification limit, shall include a statement on the estimated uncertainty of measurement.

This standard can also be used as reference document by non-accredited laboratories as the other EN ISO 9001 and EN ISO 10012 standards. In fact, the very large majority of measurements in the world is made in industry and without any kind of accreditation. Industry is using measurements for the control of the quality of their products. The economical consequence of these measurements is much larger than the few accredited measurements. So, the same requirements concerning the uncertainty of measurement can be applied.

2 Policy guidance

The assessment for possible introduction of 'Uncertainty of measurement' into standards should be carried out by the Technical Committees (TCs) (Working Group (WG), Subcommittee (SC), Joint WG, BT Task Forces (BTTF), etc.) before creation of a new work item (WI).
The assessment should be conducted using the checklist provided in this document. CEN/BT WG 122 'Uncertainty of measurement' in researching this topic on behalf of CEN made some recommendations and proposals presented at the 53rd CEN/BT meeting in Brussels, 2003-04-23/24.

The CEN/BT, noting the report (BT N 6831) and its recommendations, decided to ask CEN technical bodies and other relevant bodies to be aware of the guidance and recommendations contained in that report.

The full report is available.

3 Checklist

Uncertainty of Measurements in Standard
Check-list steps
Questions
Yes
No
If ...then ...else

1
Do you intend to draft a standard for product specifications and measurement or for measuring methods ?

If **no** then go to 7 else go to 2

2
Could the absence of information on Uncertainty of measurement lead to possible disputes and negative consequences ?

If **no** then go to 6 else go to 3

3

Can this work be achieved without delaying the overall time frame for European Standard production ?
(3 years timeframe with maximum 2 x 9 months extension)

If **no** then go to 6 else go to 4

4

Do you have experts in your TC that could deal with the uncertainty of measurements aspects ?

If **no** then go to 4 else go to 5

5

You could consider to deal with uncertainty of measurement in your standard

-

6

Annex to your standard the 'Measurement of uncertainty' leaflet published by the 'Swedish National Testing and Research Institute' (see 5.1.3).link to be added

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7

No inclusion of 'Uncertainty of measurement' concept is necessary

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4 Laboratory Contacts

Please take note of these contact points and go back to the checklist.

Contacts

Company
Secretariat
Web site

EA: European Co-operation for Accreditation Laboratory
EA Secretariat
c/o Cofrac
37, rue de Lyon
75012 Paris
FRANCE
Phone : + 33 1 44 68 82 25
Fax : + 33 1 44 68 82 21
http://www.european-accreditation.org/

EURACHEM: Establishing system for the international traceability of chemical measurements
University of Lisbon
Faculty of Sciences
Dept. of Chemistry and Biochemistry
Edifício C8, Campo Grande
1749-016 Lisbon
PORTUGAL

Phone :+ 351 21 7500894
Fax : + 351 21 7500088
http://www.eurachem.ul.pt/index.htm

Euro lab a.i.s.b.l: European federation of national associations of measurement, testing and analytical laboratories

Eurolab@bam.de
http://www.eurolab.org

EUROMET: European Collaboration in Measurement Standards
Please find hereafter a short cut to numerous contact points in Europe: Euromet contacts
http://www.euromet.org

5. Supporting tools

5.1 Reference documents

5.1.0 Resolution BT 21/2003: Report of BT/WG 122

5.1.1 Basic documents:

- Guide to the expression of uncertainty in measurement (GUM), 1995
- Accuracy (trueness and precision) of measurement methods and results (ISO 5725)
- Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation (ISO/TS 21748)
- Fundamental standards - Metrology and application of the statistics - Help to the process for estimation and the use of the measurement and test results uncertainty (AFNOR FD X 07 - 021, 1999)

5.1.2 Some examples of sectorial standards (non-exhaustive):

- Geometrical Product Specifications (GPS) - Inspection by measurement of workpieces and measuring equipment - Part 1: Decision rules for proving conformance or non-conformance with specifications (EN ISO 14253-1: 1998)
- Geometrical Product Specifications (GPS) - Inspection by measurement of workpieces and measuring equipment - Part 2: Guide to the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product (ENV ISO 14253-2:2001)
- Geometrical Product Specifications (GPS) – Inspection by measurement of workpieces and measuring equipment – Part 3: Guidelines for achieving agreements on measurement uncertainty statement (prENV ISO 14253-3)
- Petroleum products – Determination and application of precision data in relation to methods of test (EN ISO 4259)

5.1.3 Other interesting documents:

- Measurement uncertainty leaflet (SP INFO 2000 27 uncertainty pdf), Magnus Holmgren et al. SP Swedish National Testing and Research Institute
- Introducing the concept of uncertainty of measurement in testing in association with the application of the standard ISO / IEC 17025, ILAC - G17: 2002
- EA Guidelines on the expression of uncertainty in quantitative testing , EA-4/16
- Expression of the uncertainty of measurement in calibration, EAL - 4/02; December 1999
- Measurement uncertainty in testing, Eurolab technical report N°. 1/2002 : June 2002
- Quantifying uncertainty in analytical measurement, EURACHEM / CITAC Guide CG4, Second edition QUAM : 2000. 1
- The expression of uncertainty and confidence in measurement, NAMAS M 3003
- A beginner's guide to uncertainty of measurement, Stephanie Bell, Measurement good practice guide N° 11, 1999, National Physical Laboratory, Teddington, UK
- Assessment of uncertainties of measurement for calibration and testing laboratories, (Cook Book), Ron Cook (CSIRO National Measurement Laboratory); NATA, ISBN 0-909307-46-
- 27 exemples d'évaluation d'incertitude d'étalonnage, (27 examples of evaluation of calibration uncertainty), Collège Français de Métrologie (2004, deuxième édition)
- Estimer l'incertitude - Mesures Essais (Assessing uncertainty - Measurement and tests), Christophe Perruchet, Marc Priel, Afnor 2000, ISBN: 2-12-460703-0
- Guideline for evaluating and expressing the uncertainty of NIST measurement results, Barry N. Taylor and Chris E. Kuyatt, NIST Technical Note 1297, 1994 edition
- Evaluating the measurement uncertainty: fundamentals and practical guidance, Ignacio Lira, Institute of Physics Publishing, ISBN 0-7503-0840-0

5.2 Useful links

National Institute of Standards and Technology (NIST) : Uncertainty of measurements : http://physics.nist.gov/cuu/uncertainty
Science Help Online Chemistry
http://www.fordhamprep.com/gcurran/sho/sho/links/linkindex2.htm
European co-operation for Accreditation (EA) guidelines on the expressio of uncertainty in quantitative testing
http://www.european-accreditation.org/pdf/EA-4-16rev00.pdf