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"Guide to the Expression of Uncertainty in Measurement" by the International Organization for Standardization

(advertised by G. D'Agostini)

Abstract

The ISO has recently published a *Guide* containing the recommendations of the Comité International des Poids et Mesures about the expression of experimental uncertainties, as well the motivations, a detailed description of the procedures and practical examples. This note is simply intended to be an an invitation to a critical reading of the *Guide*.

Introduction

After 15 years of work by the most authoritative organizations of metrology, a *Guide* has been published[1], in order to establish general rules for evaluating and expressing uncertainty. These rules are intended to be applicable to a broad spectrum of measurements - "from the shop floor to fundamental reaserch". The goal is to achieve a worldwide consensus which, "like the nearly universal use of the SI has brought coherence to all measurements, would permit the significance of a vast spectrum of results in science (...) to be readily understood and properly interpreted".

As this note is not intended to be a summary or a scholium of the *Guide*, I have just picked up some information and citations (within " ") which should provoke enough the people sensitive to the subject.

What there was before?

Essentially the chaos.
Many contradictory cooking recipes can be found in text books, with - to my knowledge - the remarkable exception of the DIN norms[2].

Organizations which supported the development of the Guide

BIPM	Bureau International des Poids et Mesures
IEC	International Electrotechnical Commission
IFCC	International Federation of Clinical Chemistry
ISO	International Organization for Standardization
IUPAC	International Union of Pure and Applied Chemistry
IUPAP	International Union of Pure and Applied Physics
OIML	International Organization of Legal Metrology

Picked up for you from the Guide

- **Error or uncertainty?**
  - "error: result of a measurement minus a true value of the measurand";
  - "uncertainty: parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand".
- **'Random' and 'systematic' uncertainty?**
  "The uncertainty in the result of a measurement generally consists of several categories according to the way in which their numerical value is estimated:
  - A. those which are evaluated by statistical methods,
  - B. those which are evaluated by other means.

  These categories (...) are not substitutes for the words 'random' and 'systematic'. The term *systematic uncertainty* can be misleading and should be avoided".
- **What is probability?**
  "(...) In contrast to this frequency-based point of view of probability an equally valid viewpoint is that probability is a measure of the *degree of belief* that an event will occur.
  (...) Recommendation INC-1 (...) implicitely adopts such a viewpoint of probability (...)" .

- **"Safe" estimate of uncertainties?**
  "(...) the best evaluation of the uncertainty (...) must be given (...)
  The method stands, therefore, in contrast to certain older methods that have the following two ideas in common:

  - The first idea is that the uncertainty reported should be 'safe' or 'conservative' (...) In fact, because the evaluation of the uncertainty of a measurement result is problematic, it was often made deliberately large.
  - The second idea is that the influences that give rise to uncertainty were always recognizable as either 'random' or 'systematic' with the two being of different nature; (...)"

- **Uncertainty as "maximum error bounds"?**
  "The combined uncertainty and its components should be expressed in the form of standard deviations.
  (...) if the 'maximum error bound' (the largest conceivable deviation from the putative best estimate) is used (...) the resulting uncertainty (...) will be unusable by anyone wishing to incorporate it into subsequent calculations (...)".

- **How to report category B uncertainties?**
  "(...) should be characterized by quantities (...) which may be considered as approximations to the corresponding variances, the existence of which is assumed."

- **Combining the uncertainties?**

  - "Any detailed report of the uncertainty should consist of a complete list of the components, specifying for each the method used to obtain its numerical value";
  - "the combined uncertainty should be characterized by the numerical value obtained by applying the usual method for combination of variances".

- **Correlated results?**
  "Where appropriate, the covariance should be given".

Conclusions

Let us conclude with a last citation from the *Guide*:

"Although this *Guide* provides a framework for assessing uncertainty, it cannot substitute for critical thinking, intellectual honesty, and professional skill. The evaluation of uncertainty is neither a routine task nor a purely mathematical one; it depends on detailed knowledge of the nature of the measurand and of the measurement. The quality and utility of the uncertainty quoted for the result of a measurement therefore ultimately depend on the understanding, critical analysis, and integrity of those who contribute to the assignment of its value".

References

[1] *Guide to the Expression of uncertainty in measurement*, ISO, Geneva, Switzerland, 1993 (ISBN 92-67-10188-9).

[2] DIN Deutsches Institut für Normung, DIN 1319 Teile 1-4 (only parts 1-3 are available in english), Beuth Verlag GmbH, Berlin, Germany, 1985.