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Measurement error: two opposite definitions

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Opposite definitions of measurement error in relevant documents

The determination of the measurement error in the procedure of the calibration of instruments and the application of the correction curve are crucial for traceable measurements.

However, the definitions of the measurement error are opposite in the standards used in metrology and the medical standards (ex. IEC 60601-2-24:2012 used for medical electrical equipment).

Metrological standards

The standards applied in metrology are:

- International vocabulary of metrology – Basic and general concepts and associated terms (VIM), 3rd edition, JCGM 200:212
- Evaluation of measurement data- Guide to the expression of uncertainty in measurement (GUM), JCGM 100:2008

According to these standards, the measurement error is defined as

- measurement error: measured quantity value minus a reference quantity value (definition 2.16 [1])
- error (of measurement): result of a measurement minus a true value of the measurand (definition B.2.19 [2])

Related to this, we have the relative measurement error defined as:

- error of measurement divided by a true value of the measurand (definition B.2.20 [2])

Expressing the relative error in formula, we get

$$A = \frac{100\ (r - Q)}{Q}\ (\%)$$

where

Q is the reference flow rate determined by the reference measurement method (e.g. gravimetric method)

r is the rate set at the instrument (e.g. 1 mL/h)

A is the relative flow measurement error or systematic error

Standards for medical electrical equipment

One of the standards applied for the medical electrical equipment is:

- IEC 60601-2-24:2012, Medical electrical equipment – Part 2-24: Particular requirements for the basic safety and essential performance of infusion pumps and controllers

The overall mean percentage flow error (relative measurement error) is defined in equation (5) in section 201.12 in IEC 60601-2-24:2012 as

$$A = \frac{100\ (Q - r)}{r}\ (\%)$$

where

Q is the reference flow rate determined by the reference measurement method (e.g. gravimetric method)

r is the rate set at the instrument (e.g. 1 mL/h)

A is the relative flow measurement error or systematic error

[2] B.2.22 Definition of systematic error: mean that would result from an infinite number of measurements of the same measurand carried out under repeatability conditions minus a true value of the measurand (reference value).

Correction applied to the measurement results

The calibration of the instrument gives the measurement error for a specific flow rate with respect to the reference flow rate. In general, the measurement results of the instrument are then corrected with these measurement errors to take into account the calibrated measurement errors of the instrument. Using the following definitions [2]:

- corrected result: result of a measurement after correction for systematic error (definition B.2.13)
- uncorrected result: result of a measurement before correction for systematic error (definition B.2.12)
- correction: value added algebraically to the uncorrected result of a measurement to compensate for systematic error (definition B.2.23)
- Note 1: the correction is equal to the negative of the estimated systematic error (definition B.2.23)

Therefore, the correction applied is according to [2]:

Corrected result = uncorrected result – systematic error

Corrected result = set flow rate *r* – (set flow rate *r* – *Q*), where (set flow rate *r*-*Q*) is the systematic error.

This correction will depend on the definition of A. Depending on the definition of *A* according to [2] or [3], the correction is either the negative systematic error or the positive systematic error:

- Corrected result = uncorrected result – systematic error, where systematic error = set flow rate *r* – *Q* according to [2]
- Corrected result = uncorrected result + systematic error, where systematic error = *Q* - set flow rate *r* according to [3]

If the measurement error or the relative measurement error are taken from a measurement report or a calibration report, the exact definition of the measurement error or the relative measurement error has to be known. The correction applied to the uncorrected result will depend on the definition.
Therefore, two opposite definitions of measurement errors might lead to false corrected results.

Harmonisation of these definitions would simplify or even avoid any confusion.

References

- [1] International vocabulary of metrology – Basic and general concepts and associated terms (VIM), 3rd edition, JCGM 200:212
- [2] Evaluation of measurement data- Guide to the expression of uncertainty in measurement (GUM), JCGM 100:2008
- [3] IEC 60601-2-24:2012, Medical electrical equipment – Part 2-24: Particular requirements for the basic safety and essential performance of infusion pumps and controllers