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Automated liquid handling systems – Uncertainty of the measurement procedures

DTR stage

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Foreword

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This document was prepared by Technical Committee ISO/TC 48, *Laboratory Equipment*.

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Introduction

The examples given in this document are informative and support the requirement found in the ISO 23783 series to perform an estimation of measurement uncertainty when calibrating automated liquid handling systems (ALHS) according to the measurement procedures described in ISO 23783-2. The examples in this document are based on the principles of ISO/IEC Guide 98-3.

Automated liquid handling systems – Uncertainty of the measurement procedures

1 Scope

This document describes the measurement uncertainty analysis of the measurement procedures described in ISO 23783-2, following the approach described in ISO/IEC Guide 98-3.

This document also includes the determination of other uncertainty components related to the liquid delivery process and the device under test (DUT) to estimate the overall measurement uncertainty of delivered volumes by an automated liquid handling system (ALHS).

~~3~~2 Normative references

ISO~~-~~ 23783-1, *Automated liquid handling systems ~~–~~— Part 1: Vocabulary and general requirements*

ISO/IEC~~–~~ Guide~~–~~ 98-3, *Uncertainty of measurement ~~–~~— Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC~~-~~ Guide~~-~~ 99, *International vocabulary of metrology ~~–~~— Basic and general concepts and associated terms (VIM)*

~~4~~3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 23783-1, ISO/IEC Guide 98-3, and ISO/IEC Guide 99 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at ~~https://www.iso.org/obp~~https://www.iso.org/obp

— IEC Electropedia: available at ~~https://www.electropedia.org/~~https://www.electropedia.org/

~~5~~4 General procedure for the uncertainty calculation

The evaluation of measurement uncertainty in this document follows the ISO/IEC Guide 98-3 "Guide to the Expression of Uncertainty in Measurement (GUM)." The method has the following steps:

a) ~~1.~~Expressing, in mathematical terms, the relationship between the measurand and its input quantities.

b) ~~2.~~Determining the expected value of each input quantity.

c) ~~3.~~Determining the standard uncertainty of each input quantity.

d) ~~4.~~Determining the degree of freedom for each input quantity.

e) ~~5.~~Determining all covariance between the input quantities.

f) ~~6.~~Calculating the expected value for the measurand.

g) ~~7.~~Calculating the sensitivity coefficient of each input quantity.

h) ~~8.~~Calculating the combined standard uncertainty of the measurand.

i) 9. Calculating the effective degrees of freedom of the combined standard uncertainty.

j) 10. Choosing an appropriate coverage factor, *k*, to achieve the required confidence level.

k) 11. Calculating the expanded uncertainty.

In this document, the uncertainty of the measurement procedure is separated in three different clauses:

— the uncertainty components associated with the measuring system, see Clause 6; Clause 6;

— the uncertainty components associated with the device under test (ALHS), see Clause 7; and Clause 7;

— the uncertainty components associated with the liquid delivery process, see Clause 8. Clause 8.

65 Modelling of the measurement

Each measurement procedure has specific uncertainty components associated with the measuring system. These uncertainty components are described in the respective annex for each procedure. See Annex AAnnex A for the dual-dye ratiometric photometric procedure, Annex BAnnex B for the gravimetric procedure, and Annex CAnnex C for the optical image analysis of droplets.

76 Standard uncertainty components associated with the measuring system

7.16.1 General information on standard uncertainty components estimation

It is possible to experimentally estimate the standard uncertainty of measurement, $u(x)$, for a quantity x, by performing multiple measurements of x under repeatability conditions. This is called a type A evaluation according to ISO/IEC Guide 98-3. The standard deviation of the obtained values is a measure of the repeatability of the measurement. The standard uncertainty associated with x can be a standard deviation based on previous experience (in the case where a single measurement of x is made), or the standard deviation of the mean equal to stdev(x)/sqrt(n) (in the case where x is the average of n readings).

See ISO Guide 98-3:2008, 4.2 for more information on type A evaluation of standard uncertainty.

In addition to repeated measurements, the systematic component of the uncertainty of measurement for a quantity x is estimated by other means. This is called a type B evaluation according to ISO/IEC Guide 98-3. For example, one can obtain information for that estimation by considering the manufacturer's specifications of the ALHS (e.g., resolution, linearity, drift, temperature dependence, etc.).).

Often the manufacturer's specifications are given in the form of an interval covering the measurement value, with no additional information regarding distribution or coverage. In those cases, the measurement can be assumed to follow a uniform or rectangular distribution. This distribution is characterised by a constant probability inside the interval while the probability outside the interval is zero.

The interval can be used in a type B evaluation to give the variance of x in the form shown in Formula (1):Formula (1):

$$u^2(x) = \frac{(a_+ - a_-)^2}{12} \quad (1)$$

where $u^2(x)$ is the variance of the variable x;

a_+ and a_- give the upper and lower limits of the interval of the variable x.

$$u^2(x) = \frac{(a_+ - a_-)^2}{12} \quad (1)$$

where

