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■ Editorial

Jean-François Magana

BIML Director

Implementation of OIML Recommendations: Inquiry results

Every four years in conjunction with the International Conference, the BIML carries out an inquiry among OIML Member States and Corresponding Members concerning the degree of implementation of OIML Recommendations.

Previously we used to mail out paper forms, which once returned required a significant amount of analytical work before any conclusions could be drawn, thus reducing the effectiveness of the project.

At the end of 2008 for the first time, this inquiry was carried out online via our web site, the results being fed directly into a permanent database. We are already seeing interesting preliminary results.

Firstly, in our opinion this inquiry is now easier to complete by Members. Whilst we are aware that the interface remains somewhat basic and that its user-friendliness can be further improved, Members may fill in the forms progressively, over several sessions if they so wish.

As of today 24 countries have responded either partially or fully, and several others have perused the form but have not yet submitted their responses.

Secondly, one key advantage of this inquiry is that we can link the answers to other data stored in our databases, thus allowing interpretations in terms of (for example) population or even gross national income (GNI) concerned by the regulations in question.

This already shows very clearly which categories are most covered by national regulations and also which OIML publications are the most implemented. This will be a very useful tool for analyzing our priorities. Some of these results will be presented during the OIML Seminar “Stakes and priorities of legal metrology for trade” in Mombasa this October, and queries will shortly be developed on our web site to show the outcome of the inquiry.

In the meantime, we strongly encourage those Member States and Corresponding Members who have not already done so to complete this inquiry. As mentioned, so far we have only received 24 responses, which represents 26 % of the total population of OIML Member States and 76 % of their total GNI; we are therefore still in need of more responses to render this inquiry really representative of the global situation in the world. ■

UNCERTAINTY

Statistical tools for evaluating measurement uncertainty

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Summary

In this study particular emphasis is laid on the use of statistical tools when measurement uncertainty is evaluated for a single measured value, an arithmetic mean, or for a sum of values, the individual uncertainties of which are known. The uncertainty evaluated is used to judge the quality of the measurement being investigated.

1 Introduction

Nowadays, the uncertainty of measurement is evaluated by following the instructions given in the *Guide to the expression of Uncertainty in Measurement* (GUM) [1], which additionally includes the definitions of the uncertainty and types of its components, statistical tools, etc.

In this study, particular emphasis is laid on these tools and their use. A special review is given in Section 2 and their use is considered in connection with the treatment of the following subjects:

- An analogy between a physical quantity and certain components of the uncertainty (Section 3).
- The uncertainty 1) for a single measured value and 2) for an arithmetic mean (Section 4).
- Confidence levels associated with the intervals defined by the above values 1) and 2) ± their respective measurement uncertainties (Section 5).
- The uncertainty of a sum as a function of the individual uncertainties of its terms (Section 6).
- How the quality of measurement can be judged by the measurement uncertainty (Section 7)?

Section 2 is based on textbooks of statistics [2] to [4] and the first part of Section 4 the GUM. The second and last parts of Section 4 as well as Sections 3, 5 and 6 use the tools and the concepts of Section 2, e.g. the normal distribution, various formulae of the standard deviation and the concept of random variables and estimates. In Section 7 the quality of the measurement is considered. Therefore, the measurement uncertainty, reference values and additional statistical tools are used.

The terminology does not fully conform to that used in the GUM. For example, here the 'combined standard uncertainty' u_c (the square root of the sum of variances and covariances) is called the 'combined standard deviation' S_c, and the word 'uncertainty' is used only for the term 'measurement uncertainty'.

2 Concepts and formulae

2.1 Random variable

The measured values of physical and other quantities are realizations of *random variables* denoted, for example, by $\mathbf{x}$, $\mathbf{y}$, $\bar{\mathbf{x}}$ and $\mathbf{s}$. Their realizations are x, y, $\bar{x}$ and s respectively. The word 'random' refers, e.g., to the fact that all the existing influences (influence quantities) and their causes cannot be controlled sufficiently when the measured values are being determined.

2.2 Population, sample and population distribution

The *population* is an aggregate of all the conceivable observations (realizations of the random variable under investigation) that could be made. From the population a *sample* (here a random sample) can be drawn for an analysis to yield estimates (2.3) of parameters describing the whole population.

The *population distribution* of all the above observations in the population is a basis for the treatment processing of data. In many applications the population distribution is a normal distribution (2.5.2).

2.3 Estimator, estimate and variations of these

a) An *estimator* can be regarded as a formula for a sample characteristic (2.4) and an *estimate* as its numerical value [2]. An arithmetic mean obtained from a sample is, say, an estimate and a kind of statistical image of the corresponding population mean or the so-called 'true' value/result.

b) An estimate can be a *point estimate* (a single value) or an *interval estimate* (e.g. a measured value ± its measurement uncertainty). The so-called *confidence interval,* the end points of which are only given, is also an interval estimate. It covers the 'true' result of a measured value with a chosen 'reliability' or *confidence level* (cf. Figure 1), whereas a point estimate covers this 'true' result with a zero 'reliability' [5].

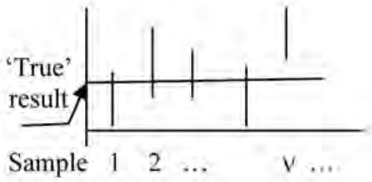

Figure 1. Imagine a long series of independent samples 1, 2, ..., ν, ... of the same size drawn from the same population. Determine an interval estimate (a vertical segment) for each sample. The end points of the intervals (segments) are realizations of random variables. The line "true' result' and a segment may have a common point the location of which is unpredictable. The frequency of cases in which a segment and the above line have a common point is approximately the confidence level.

Example: Let us deal with a rectangle A. Draw a vertical line through a point on its base and thus, divide it into rectangles B and C. The areas of B and C are to be determined. If the location of the above point is defined by a measurement the result of which is a single measured value ± its uncertainty (an interval estimate), then both the single measured value and its uncertainty have to be used when the areas of B and C are determined. As a result of this interval estimates of the areas of B and C are obtained with positive 'reliabilities'. If only the single measured value (a point estimate) was used, then point estimates of the areas of B and C are obtained with zero 'reliabilities'.

c) If a formula is given for a point or an interval estimate, then the formula is a *point* or an *interval estimator* respectively.

2.4 Sample characteristics

2.4.1 Arithmetic mean, standard deviation, variance and covariance

a) The *arithmetic mean* $\overline{x}$ of n values x ($x_1, x_2, \ldots, x_n$) is $\overline{x} = 1/n\ \Sigma x$

b) The *standard deviation* s of the n values x is defined by

$s^2 = 1/(n-1)\ \Sigma\ (x - \overline{x})^2$ (1)

s^2 or s_x^2 is the *variance* of the values x. Similarly, s_y^2 is the variance of the values y ($y_1, y_2, \ldots, y_n$).

c) The *covariance* s_{xy} is a measure of the association between the above x and y. It is defined as

$s_{xy} = 1/(n-1)\ \Sigma\ (x - \overline{x})\ (y - \overline{y})$ (1')

where $\overline{y} = 1/n\ \Sigma y$ is the arithmetic mean of the values y ($y_1, y_2, \ldots, y_n$). Note that if y = x, then $s_{xy} = s_x^2$.

2.4.2 Standard deviation s_{x+y} of n values of the sum $x + y$ ($x_1 + y_1, x_2 + y_2, \ldots, x_n + y_n$)

s_{x+y} of the above n values x + y can be defined by s_x (from $x_1, x_2, \ldots, x_n$), s_y (from $y_1, y_2, \ldots, y_n$) and s_{xy} as

$s^2_{x+y} = s_x^2 + s_y^2 + 2\ s_{xy}$ (2)

It is obtained from (1) by replacing **1**) x with x + y, **2**) $\overline{x}$ with $\overline{x+y} = \overline{x} + \overline{y}$ and **3**) by taking into account (1'). To obtain an equivalent formula to (2) consider a vector the magnitude of which is s_{x+y} [3]. Its two components are the vectors with magnitudes s_x and s_y separated by an angle ϕ (see Figure 2). Determine s^2_{x+y} using the cosine rule (Figure 2):

$s^2_{x+y} = s_x^2 + s_y^2 - 2\ s_x\ s_y \cos(180° - \phi) = s_x^2 + s_y^2 + 2\ s_x s_y \cos\phi$ (2')

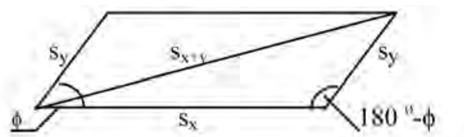

Figure 2. Using the cosine rule S_{x+y} can be expressed in terms of s_x and s_y separated by an angle ϕ [3].

2.4.3 The correlation coefficient of x and y

a) Comparing the last terms in (2') and (2) with each other we see that $s_{xy} = s_x s_y \cos\phi$. (**Note**. $s_x s_y \cos\phi$ is the scalar product of the vectors with magnitudes s_x and s_y.) $\cos\phi = s_{xy}/s_x s_y$ is known as the correlation coefficient which is usually denoted by r or r_{xy}. If y = x and $s_{xy} = s_x^2$, then $\cos\phi = r_{xx} = 1$ between two equal x's.

b) If the correlation coefficient between x and y is influenced by a third variable z, then z can make the correlation coefficient $r_{xy} = s_{xy}/s_x s_y$ spurious [4]. Especially, this is the case if there is a causal relationship between x and z and y and z. The harmful effect of z can be eliminated if the so-called significant (partial) correlation coefficient $r_{xy.z}$ [4] is used (cf. 6.3.1).

$r_{xy.z} = (r_{xy} - r_{xz}\ r_{yz})\ /\ [(1 - r_{xz}^2)(1 - r_{yz}^2)]^{1/2}$ (3)

where r_{xz} and r_{yz} are the correlation coefficients between x and z and y and z respectively. An example demonstrating the effect of z, the nature of r_{xy} and $r_{xy.z}$ is given as follows.

Example: At different ambient temperatures $z_1 < z_2 < \ldots < z_n$ and suitable conditions of humidity let us deal with the lengths x of a beam of steel and with the water contents y of a specimen of porous material. Let the values of y be weighing results of the specimen indicating changes of its water contents. Let x and y take on the values $x_1 < x_2 < \ldots < x_n$ and $y_1 > y_2 > \ldots > y_n$ at $z_1 < z_2 < \ldots < z_n$ respectively.

Plot the points the locations of which are defined by the values of x_i and y_i (i = 1, 2, ..., n) on an xy-plane. Seemingly, these points indicate values y_i with reference to x_i. Because y_i's are decreasing, so the correlation coefficient r_{xy} calculated from the values x_i and y_i is < 0. This r_{xy} as well as x_i and y_i depend on the values z_i. Thus, r_{xy} can be regarded as a total correlation of the values x_i, y_i and z_i. Therefore r_{xy} does not necessarily give information about the correlation of x_i and y_i. Their correlation is zero because x_i and y_i are independent and thus uncorrelated. This zero correlation is achieved with the aid of $r_{xy,z}$ (3) which is obtained by eliminating the effect of the values z_i from r_{xy}.

c) Two tests of significance of the correlation coefficient r of x and y are dealt with in **1**) and **2**) below. Suppose that r is obtained from a sample of size n (n pairs of values of x and y) drawn from normal distributions and that x and y are not influenced by the above-mentioned third variable z.

1) Insert the values of r and n in the following formula of t [4]

$$t = [r/(1 - r^2)^{1/2}]\,(n - 2)^{1/2}$$

If $|t| \le t_P$ where t_P is the 95 % fractile of Student's t-distribution with n – 2 degrees of freedom (cf. 2.6.2), then the 'true' value of the correlation coefficient r could be regarded as zero.

2) Insert the values of r, n and a given correlation coefficient ρ in the following formula of λ [4]

$$\lambda = 1.1513\{\log_{10}[(1 + r)/(1 - r)] - \log_{10}[(1 + \rho)/(1 - \rho)]\}\,(n - 3)^{1/2}$$

If $|\lambda| \le \lambda_P$ where λ_P is the 95 % fractile of the normal distribution (2.5.2), then there are reasons to regard r as ρ.

2.4.4 Standard deviation s_Σ of n values of the sum Σx_i with m terms ($\Sigma x_{i1} = x_{11} + x_{21} + \ldots + x_{\nu 1} + \ldots + x_{m1}$; $\Sigma x_{i2} = x_{12} + x_{22} + \ldots + x_{\nu 2} + \ldots + x_{m2}$; ... ; $\Sigma x_{in} = x_{1n} + x_{2n} + \ldots + x_{\nu n} + \ldots + x_{mn}$)

s^2_Σ for m > 2 is analogous to s^2_{x+y} for m = 2 (2') and is

$$s^2_\Sigma = \sum_i s_i^2 + 2\sum_{i>j} s_i s_j \cos\phi_{ij} \qquad (i; j = 1,2, \ldots, m; i > j) \quad (4)$$

obtained from (1) by replacing **1**) x with Σx_i, **2**) $\bar{x}$ with $\bar{\Sigma}x_i = \Sigma\,\bar{x}_i$ ($\bar{x}_i = 1/n\,(x_{i1} + x_{i2} + \ldots + x_{in})$) and **3**) by using $s_i s_j \cos\phi_{ij}$ (2.4.3 **a**) as the covariance $s_{x_i x_j}$ (1') of x_i and x_j from Σx_i (i and j run from 1 to m and are used so that i > j for ϕ_{ij} and for each s_i and s_j and x_i and x_j). s_i and s_j are standard deviations (1) from the *νth* terms $x_{\nu 1}$, $x_{\nu 2}$, ..., $x_{\nu n}$ of the values Σx_{i1}, Σx_{i2}, ..., Σx_{in} of Σx_i so that s_i is obtained if ν = i and s_j if ν = j. cos ϕ_{ij} is the correlation coefficient of x_i and x_j (2.4.3 **a**) and ϕ_{ij} an angle separating s_i and s_j (cf. ϕ in 2.4.2). More information about the terms of (4) is received from the square array [3] of points (i, j) in Figure 3.

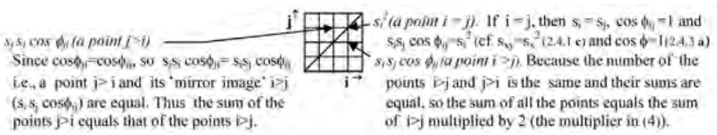

Figure 3. A square array of points (i, j). Both i and j run from 1 to m.

2.4.5 Special values of the variance s^2_Σ of Σx_i with some constant angles ϕ_{ij} (0° ≤ ϕ_{ij} ≤ 90°)

a) If x_i and x_j (i; j = 1, 2,..., m; i > j) are pairwise uncorrelated, then ϕ_{ij} between s_i and s_j is 90° (cf. Figure 2) and **cos ϕ_{ij} = 0**. According to (4)

$$s^2_\Sigma = \sum_i s_i^2 \qquad (i = 1, 2,..., m; \text{ if } m = 2;\ s^2_\Sigma = s^2_{x+y} = s_x^2 + s_y^2) \quad (5)$$

cos ϕ_{ij} = 0 means that no linear relationship exists between x_i and x_j. Other relationships are still possible.

b) If x_i and x_j (i; j = 1, 2,..., m; i > j) are pairwise correlated, then $\phi_{ij} \ne 90°$ and **cos $\phi_{ij} \ne 0$**. For example if:

$\phi_{ij} \approx 75.52°$ and **cos $\phi_{ij} \approx 1/4$,** then $2\Sigma s_i s_j \cos\phi_{ij} \approx 1/2\Sigma s_i s_j$. According to (4)

$$s^2_\Sigma \approx \sum_i s_i^2 + 1/2\sum_{i>j} s_i s_j$$

$$(i; j = 1, 2,..., m; i > j; \text{ if } m = 2;\ s^2_\Sigma = s^2_{x+y} \approx s_x^2 + s_y^2 + 1/2 s_x s_y) \quad (6)$$

$\phi_{ij} = 60°$ and **cos ϕ_{ij} = 1/2,** then $2\Sigma s_i s_j \cos\phi_{ij} = \Sigma s_i s_j$. According to (4)

$$s^2_\Sigma = \sum_i s_i^2 + \sum_{i>j} s_i s_j$$

$$(i; j = 1, 2,..., m; i > j; \text{ if } m = 2;\ s^2_\Sigma = s^2_{x+y} = s_x^2 + s_y^2 + s_x s_y) \quad (7)$$

$\phi_{ij} \approx 41.41°$ and **cos $\phi_{ij} \approx 3/4$,** then $2\Sigma s_i s_j \cos\phi_{ij} \approx 3/2\Sigma s_i s_j$. According to (4)

$$s^2_\Sigma \approx \sum_i s_i^2 + 3/2\sum_{i>j} s_i s_j$$

$$(i; j = 1, 2,..., m; i > j; \text{ if } m = 2;\ s^2_\Sigma = s^2_{x+y} \approx s_x^2 + s_y^2 + 3/2 s_x s_y) \quad (7')$$

$\phi_{ij} = 0°$ and **cos ϕ_{ij} = 1,** then $2\Sigma s_i s_j \cos\phi_{ij} = 2\Sigma s_i s_j$. According to (4)

$$s^2_\Sigma = \sum_i s_i^2 + 2\sum_{i>j} s_i s_j = (\sum_i s_i)^2$$

$$(i; j = 1, 2,..., m; i > j; \text{ if } m = 2;\ s^2_\Sigma = s^2_{x+y} = s_x^2 + s_y^2 + 2s_x s_y = (s_x + s_y)^2) \quad (8)$$

cos ϕ_{ij} = 1 means that x_i and x_j have a linear relationship. Using this, values x_{j1}, x_{j2}, ..., x_{jn} of x_j can be deduced from x_{i1}, x_{i2}, ..., x_{in} of x_i known, e.g. from measurements. This is the opposite of the above case **a**) and that called 'random' in 2.1.

c) Notes on s_Σ^2 for x – *y* and $x_1 - x_2 + x_3$ the terms of which are pairwise correlated (these $s_\Sigma^{\,2}$'s are not used in Sections 3 to 7).

$s^2_\Sigma = s^2_{x-y}$ for x – y is obtained from (2') by changing the sign of $2s_x s_y \cos\phi$ (or by replacing ϕ with 180° – ϕ in (2') or Fig. 2).

s^2_Σ for $x_1 - x_2 + x_3$ is obtained from $s^2_\Sigma = \Sigma s_i^2 + a\Sigma\, s_i s_j$ (a = 1/2, 1, 3/2 or 2, i.e., a = 2cos ϕ_{ij} in (6), (7), (7') or (8)) as follows. If x_i and x_j (i; j = 1, 2, 3; i > j) have the same signs, then the corresponding term $a s_i s_j$ is positive in $a\Sigma s_i s_j$, otherwise negative. Thus s^2_Σ for $x_1 - x_2 + x_3$ is $s^2_\Sigma = s_1^2 + s_2^2 + s_3^2 - a s_2 s_1 + a s_3 s_1 - a s_3 s_2$ ($s^2_\Sigma = (s_1 - s_2 + s_3)^2$ if a = 2).

2.5 Population parameters and normal distribution

2.5.1 Location and scale parameters and probability density function

The parameters μ and σ of normal and other distributions (for which μ and σ exist) are the constants:

$\mu = \int x\,\varphi(x)dx$ the **mean**, the **location** parameter (9')

$\sigma^2 = \int(x - \mu)^2\,\varphi(x)dx$ the **variance**, the square of the **scale** parameter σ (9)

$\varphi(x)$ (cf. $\varphi(x)$ in 2.5.2) is a non-negative function defined for every real x and is called the probability density or the frequency function. $\varphi(x)dx$ is the probability that x falls within (x, x + dx) and $\int\varphi(x)dx = 1$.

2.5.2 Normal distributions N(0, 1) and N(μ, σ), their frequency curves and distribution functions

The normal (frequency) curve of the distribution N(0, 1) is given by $\boldsymbol{\varphi(x) = 1/(\sqrt{2\pi})\exp(-x^2/2)}$ ($\mu = 0$, $\sigma = 1$). It is obtained from the derivative of the normal probability distribution function

$$\Phi(x) = 1/(\sqrt{2\pi})\int_{-\infty}^{x}\exp(-t^2/2)dt \qquad (10)$$

$\Phi(x)$ gives the probability that realizations of the normal random variable **x** with $\mu = 0$ and $\sigma = 1$ are $\leq$ x. x satisfying $\Phi(x) = 0.95$ is called the 95 % fractile.

The normal curve of the distribution N(μ, σ) is given by $\boldsymbol{\varphi(x) = 1/(\sqrt{2\pi}\,\sigma)\exp[-(x - \mu)^2/2\sigma^2]}$. It is obtained from the derivative of the probability distribution function $\Phi[(x - \mu)/\sigma]$ (cf. (10)).

2.5.3 Values x drawn from the distribution N(μ, σ), their $\bar{x}$ and the distribution of $\bar{\mathbf{x}}$

Let x_i (i = 1, 2,..., n) denote n independent values drawn from N(μ, σ). Their arithmetic mean $\bar{x}$ (2.4.1) is a realization of the random variable $\bar{\mathbf{x}}$ having the distribution $N(\mu, \sigma/\sqrt{n})$ [2, 4].

$\sigma/\sqrt{n}$ of $N(\mu, \sigma/\sqrt{n})$ can be obtained by regarding each x_i (i = 1, 2,..., n) as a realization of the random variable $\mathbf{x_i}$ having the distribution N(μ, σ). So the variance of each $\mathbf{x_i}$ is σ^2 and the variance of $\Sigma\mathbf{x_i}$ is $n\sigma^2$. The standard deviation of $\bar{\mathbf{x}} = 1/n\Sigma\mathbf{x_i}$ is obtained using the fact that the variance of $1/n\,\Sigma\mathbf{x_i}$ equals $1/n^2$(the variance of $\Sigma\mathbf{x_i}$). So *the standard deviation of* $\bar{\mathbf{x}}$ = *(the variance of* $\bar{\mathbf{x}})^{1/2} = \{1/n^2$ *(the variance of* $\Sigma\mathbf{x_i})\}^{1/2} = (1/n^2\,n\sigma^2)^{1/2} = (\sigma^2/n)^{1/2} = \sigma/\sqrt{n}$.

2.6 Confidence intervals for the parameters μ and σ of N(μ, σ)

2.6.1 Confidence interval for μ with the aid of a single measured value x_o and a known σ

Suppose x_o is randomly drawn from a normal population N(μ, σ). Let σ be known and μ unknown. The confidence interval for μ (2.3 **b**) can be obtained with the aid of x_o and σ as follows:

from $x_o - \lambda\sigma$ to $x_o + \lambda\sigma$ (11)

with a confidence level P. λ is a fractile of the normal distribution according to P. For example, P and λ can be P = 0.95 and λ = 1.96 or P = 0.997 and λ = 3.00.

2.6.2 Confidence interval for μ with the aid of $\bar{x}$, s and a fractile of Student's t-distribution

Suppose a sample of n values x is drawn from a normal population N(μ, σ) with unknown (μ, σ). With the aid of their $\bar{x}$ and s (2.4.1) a confidence interval (2.3 **b**) can be obtained for μ. It is

from $\bar{x} - t_P\,s/\sqrt{n}$ to $\bar{x} + t_P\,s/\sqrt{n}$ (12)

with a confidence level P. t_P is a fractile of Student's t-distribution according to the sample size n (or the number of degrees of freedom n – 1) and P. Examples of the correspondence between n, P and t_P are given in Table 1.

n	P	t_P
31	0.95	2.042
6	0.90	2.015
3	0.80	1.886

n	P	t_P
15	0.990	2.977
11	0.985	2.966
4	0.950	3.182

Table 1. The correspondance between n, P and t_p

2.6.3 Confidence interval for σ with the aid of s and the χ^2-distribution

Let us deal with five samples drawn from the same normal population N(μ, σ) with unknown parameters (μ, σ). The sample sizes are n = 4, 6, 11, 21 and 31 (the numbers of degrees of freedom are n – 1). Using s of the values x of each sample and the corresponding χ^2-distribution ($\chi^2/(n - 1) = s^2/\sigma^2$) [2,4] five confidence intervals (2.3 **b**) for σ are determined with the confidence level P = 0.95 = 95 %. They are:

from 0.57 s to 3.73 s (n = 4), from 0.61 s to 2.45 s (n = 6), from 0.70 s to 1.75 s (n = 11), from 0.76 s to 1.44 s (n = 21), from 0.80 s to 1.34 s (n = 31).

3 Moment of inertia and certain components of the uncertainty U

According to the GUM the components of the uncertainty U are the so-called Type A and B variances. Type A variances are obtained from series of observations with the aid of (1) ((2) or (4)). The Type B variances, on which we concentrate in the following, are regarded as moments similar to the moments of inertia of cross-sections *B* of different kinds of rigid bodies.

3.1 Moment of inertia of cross-sections *B*

Consider the cross-section *B* the outline of which is, e.g., a circle, a triangle or a truncated normal frequency curve together with its base. The moment of inertia of *B* is

$$\int y^2 dB \qquad (13)$$

where dB is an infinitesimal horizontal element of *B* and y the distance between dB and the center of gravity of *B*.

3.2 Type B variances

3.2.1 Cross-sections B with bases which are segments of lines

a) The cross-section *B* to be dealt with shall have a segment of a line as its base. This is denoted by *b* and is a part of the x-axis defined by the range of a quantity x giving rise to a Type B variance for a certain U. This range is determined and thus *b* is obtained for *B*. An analogous moment to (13) is

$$\int (x - \mu_B)^2 \, dB = \sigma^2_B \qquad (14)$$

where dB is an infinitesimal vertical element of *B* with base *b* and $x - \mu_B$ the distance between dB and a point μ_B on *b* (cf. Figure 4). μ_B is defined as

$$\mu_B = \int x \, dB \qquad (14')$$

b) The area of *B* shall be 1 and there shall be a fit between the outline of *B* and the density or frequency curve φ(x) (2.5.1) of the distribution of the values of the quantity x (values x on *b*). Use dB = φ(x)dx (cf. Figure 4) and carry out the integration of (14) with respect to x over *b*. So the Type B variance σ^2_B arising from the quantity x is obtained. This σ^2_B is similar to (9). Correspondingly, use dB = φ(x)dx for (14'). This leads to a mean similar to (9'). Usually (14') is an 'auxiliary' term, however, an exception to this is in 3.2.3.

c) For one U different Type B variances with different outlines of *B* are often used. But frequently *B*'s of some simple shapes can be common for different U's. These can be, e.g., similar to those given in 3.2.3 to 3.2.5 (cf. the Gum).

3.2.2 Nature of σ^2_B and μ_B and their influence on the uncertainty U

Frequently, *b* is obtained from measurements. So σ^2_B depending on this *b* is a random variable (2.1) and cannot equal the constant σ^2 (9). Similarly, μ_B (14') cannot equal the constant μ (9').

But also the Type A variances depending on measured values (c.f. (1), (2) or (4)) are random variables. Thus U (4.1.2 and 4.2.2) which consists of the sum of Type A and B variances is a random variable. Note that a single Type B variance σ^2_B can sometimes be obtained without measurements (cf. σ^2_B = 1/12 min^2 in 3.2.4). But this does not change the nature of the sum of Type A and B variances for U.

3.2.3 Use of isosceles triangles

Let *B* be an isosceles triangle (Figure 4). The values x at its base *b* are concentrated about μ_B so that their density φ(x) has a 'peak' at x = μ_B. This kind of 'peak' can exist, e.g., when inaccuracy in reading the indication of an analog instrument is dealt with. μ_B corresponds to the indication read and the length of *b* can sometimes only be guessed. Now the Type B variance is $\sigma^2_B = (b/2)^2/6 = b^2/24$ (note that an isosceles triangle with base *2b* is dealt with in the Gum).

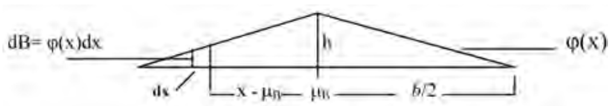

Figure 4. *B* is an isosceles triangle with base *b* and area $bh/2 = 1$. A 'small' *b* means a 'small' $\sigma^2_B = b^2/24$ but because of $bh/2 = 1$ it also means a 'large' h or a 'large' probability *hdx* at μ_B (2.5.1) and thus an almost 'correct' μ_B.

3.2.4 Use of rectangles

If *B* is a rectangle with base *b* and height *h* (*bh = 1*), then the distribution of the values x on *b* is uniform and the probability that x falls within (x, x + dx) is *hdx* (φ(x) = *h*) for all x on *b* (2.5.1). The Type B variance is $\sigma^2_B = (b/2)^2/3 = b^2/12$ (note that a rectangle with base 2*b* is dealt with in the Gum).

The uniform distribution lacks a point about which the values x on *b* would be concentrated. Therefore the uniform distribution is non-informative. Informative distributions, e.g., both the normal distribution and that in Figure 4 have such points, namely, the mean μ and μ_B respectively.

To illustrate the use of the uniform distribution let us deal with the digital rounding errors of a digital watch displaying only full minutes. If the display shows 9:00, then due to the digital rounding errors the exact time x can be anything from 9:00 to just before 9:01. This is the base *b* of the rectangle which is 'exactly' 1 min. So the Type B variance arising from the digital rounding errors of this watch is $\sigma^2_B = (1/2)^2/3$ min^2 = 1/12 min^2 which is obtained without any measurements.

3.2.5 Use of a combination of two triangles

In Figure 5 the cross-section *B* consists of two right-angled triangles with a common base $b = p + q$.

The common area of the triangles is $ph_1/2 + qh_2/2 = \alpha/2 + \beta/2$. The area is 1 if α and β are selected so that $\alpha + \beta = 2$, e.g., $\alpha = 3/2$ and $\beta = 1/2$ or $\alpha = 0$ and $\beta = 2$. σ^2_B (14) and μ_B (14') are

$\sigma^2_B = 1/4(\alpha p^2 + \beta q^2) + 1/2\ \mu_B^2(\alpha + \beta) + 2/3\ \mu_B(\alpha p - \beta q)$

$\mu_B = 1/3(-\alpha p + \beta q)$

Let us deal with the compressive strengths of cylindrical test specimens of a certain material (e.g. stone or cast iron). Therefore, a load is applied to both ends of each specimen and the load should act symmetrically about the midpoint O of the ends. Sometimes, however, the load can act eccentrically, i.e. the action point deviates slightly and randomly from O. This may cause eccentric errors giving rise to a Type B variance.

Suppose the above eccentric point can be P or Q on a line on either side of O. Let O be at 'zero', P on the (-) side and Q on the (+) side. Now let the eccentric error be at most p on the (-) side and q on the (+) side. These are characterized by the bases of the triangles in Figure 5 where (O), (P) and (Q) are the images of the above O, P and Q respectively. Together p and q give rise to a Type B variance obtained using the formula of σ^2_B given above. If, e.g., q is $q = 0.5p$ and $\alpha = 4/3$ and $\beta = 2/3$, then the Type B variance is $\sigma^2_B = 0.26\ p^2$ ($\mu_B = -1/3p$).

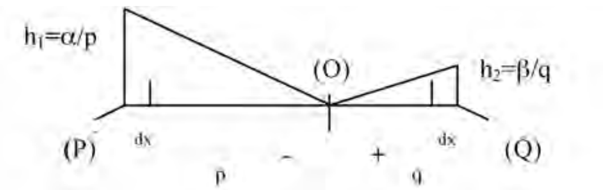

Figure 5. *B* is a combination of two right-angled triangles with base $b = p + q$ and area 1. The probability that eccentric errors influence the testing results of the above specimens is zero at (O), h_1dx at (P) and h_2dx at (Q).

4 Uncertainty U for a single measured value and for an arithmetic mean

Let us deal with the calibration of a measuring instrument which is performed **1**) by reading indications of the instrument at different points of its measuring range and **2**) by comparing the indications with the corresponding values of appropriate standards. **3**) Corrected indications are determined from the results of **1**) and **2**) and the uncertainties of these indications are evaluated.

Let the corrected indication near the maximum of the measuring range be x_o. We begin to evaluate the uncertainty U for this x_o which is a result of a single measured value in 4.1 and an arithmetic mean in 4.2.

The components of U or the Type A and B variances (Section 3 and notes in 5.1.2) for the indication x_o of the above instrument are arising **a**) from the measuring process of x_o, **b**) from the uncertainty of the standard used for x_o and **c**) from various properties of the instrument at x_o (at the point of the measuring range at which x_o is obtained). Note that if the so-called repeatability test is performed for the instrument at x_o, then the results of this test can be used to give a Type A variance for the above case **a**).

4.1 Uncertainty U for x_o which is a single measured value

4.1.1 The population from which x_o is drawn

Suppose the single value x_o is drawn from a normal population N(μ, σ) with unknown μ and σ.

4.1.2 Steps 1) to 5) and U for x_o

1) Values of Type A and B variances arising from the above cases **a**), **b**) and **c**) are determined.

2) The sum of these variances is formed and it is denoted by S_c^2.

3) Regard S_c as the combined (sample) standard deviation of the single measured value x_o.

4) The absolute value of the uncertainty U for x_o is kS_c where k is the coverage factor 2 or 3 (Gum).

5) The interval estimator (2.3 **c**) covering the 'true' value of x_o is

from $x_o - kS_c$ to $x_o + kS_c$ (from $x_o - U$ to $x_o + U$) (15)

with a confidence level given in 5.2.3. An interval estimator for a corrected indication x_o' differing from x_o is obtained from (15) by using x_o' instead of x_o and S_c is evaluated for x_o' in the same way as for x_o.

4.2 Uncertainty U for x_o which is an arithmetic mean $\overline{x}$

4.2.1 The population from which $\overline{x}$ is drawn

Let $x_{o1}, x_{o2}, \ldots, x_{on}$ denote n independent values drawn from N(μ, σ). Their arithmetic mean is the corrected indication $\overline{x}$ (= x_o) which is a realization of the random variable $\overline{\mathbf{x}}$ having the distribution N(μ, σ/√n) (2.5.3). Therefore, let us say $\overline{x}$ is drawn from N(μ, σ/√n) with unknown μ and σ.

4.2.2 Steps 1) to 5) and U for $\overline{x}$

1) Let s^2 (1) be the variance of the above values x_{ov} (ν = 1, 2, ..., n). Assign s^2 to each single x_{ov} and form the sum ns^2 (cf. $n\sigma^2$ in 2.5.3). It is a Type A variance arising from the measuring process of the n values x_{ov} (cf. **a**) in step **1**) of 4.1.2). The other variances (Type A or B) for $\overline{x}$ (= x_o) are n times those in **b**) and **c**) in step **1**) of 4.1.2.

2) The sum of the above variances is formed and is denoted by nS_c^2 (this $S_c^2 \approx S_c^2$ in step **2**) of 4.1.2).

3) Regard nS_c^2 as the combined (sample) variance of Σx_{ov}, S_c^2/n as that of $\overline{x} = 1/n\Sigma x_{ov}$ and $S_c/\sqrt{n}$ as the combined (sample) standard deviation of $\overline{x}$ (cf. $n\sigma^2$ of $\Sigma \mathbf{x_i}$ and σ^2/n and $\sigma/\sqrt{n}$ of $\overline{\mathbf{x}}$ in 2.5.3).

4) The absolute value of the uncertainty U for $\overline{x}$ is $kS_c/\sqrt{n}$. The coverage factor k and n of $\overline{x}$ shall be k = 2 and n ≥ 4 or k = 3 and n ≥ 6 (5.3.1 to 5.3.4).

5) The interval estimator (2.3 **c**) covering the 'true' value of $\overline{x}$ (= x_o) is

from $\overline{x} - k\,S_c/\sqrt{n}$ to $\overline{x} + k\,S_c/\sqrt{n}$ (from $\overline{x}$ – U to $\overline{x}$ + U) (16)

with a confidence level given in 5.3.4. An interval estimator for an arithmetic mean $\overline{x}$ (= x_o') differing from $\overline{x}$ (= x_o) is obtained from (16) by using $\overline{x}$ (= x_o') instead of $\overline{x}$ (= x_o) and $S_c/\sqrt{n}$ is evaluated for $\overline{x}$(= x_o') in the same way as for $\overline{x}$(= x_o).

5 Confidence levels used together with (15) and (16)

5.1 Tools to build up the confidence level P of (15)

5.1.1 A replacement

Consider (11) and replace σ with S_c (4.1.2) and λ with either k = 1.96≈2 or k = 3. In this way (15) is obtained from (11). According to 3.2.2 the uncertainty U = kS_c as well as S_c are random variables. Thus the replacement of the constant σ (2.5.1) with this S_c, which is random in its nature, does not make it feasible to introduce a confidence level P from (11) into (15).

One way to achieve P of (15) is to find more information about the above S_c. Therefore a number n_{eff} is defined in 5.1.2. This makes it possible to receive the information. Using this together with the procedures in 5.1.3 intervals of P's can be obtained. These cover the 'true' confidence level P of (15) with a 'reliability' >> 0 and lead to a practical P of (15) in 5.2.3.

5.1.2 n_{eff} associated with S_c for (15)

n_{eff} is a conceivable number associated with S_c (cf. ν_{eff} in Annex G of the GUM) and is similar to n in s (1), but the way how n_{eff} is associated with S_c and how n_{eff} can exactly be obtained are unknown. However, some factors influencing the value of n_{eff} are given in the following notes.

Notes: The components of U = kS_c where k = 2 or 3 (4.1.2) are Type A and B variances (Section 3). Using (1) ((2) or (4)) Type A variances are determined from measured values, the numbers n of which are known. The sum of these n's is one part of n_{eff}. The other part consists of information about Type B variances. Their effect on n_{eff} may be crucial because S_c may consist of quite a lot of Type B variances. For example, most of variances are Type B in **a**), **b**) and **c**) in step **1**) (4.1.2). To obtain them distributions are used (3.2). If the distribution is normal, then special information (3.2.4) is available and its effect on n_{eff} can be significant. If the distribution is uniform (3.2.4), then less information and less effect on n_{eff} is possible. How this information can be converted into a number for n_{eff} is unknown. Here a guess of n_{eff} for S_c is given and it is from 11 to 31 (in fact n_{eff} – 1 from 10 to 30).

5.1.3 Procedures in the form of steps which are to be taken to arrive at a confidence level of (15)

1) Use n_{eff} = 11, 21 and 31. Consider the confidence intervals of σ with n = 11, 21 and 31 in 2.6.3. Replace their s with S_c and n = 11, 21 and 31 with n_{eff} = 11, 21 and 31 respectively and write the following confidence intervals: $0.70S_c$ *to* $1.75S_c$ (n_{eff} = 11), $0.76S_c$ *to* $1.44S_c$ (n_{eff} = 21) and $0.80S_c$ *to* $1.34S_c$ (n_{eff} = 31). Regard them as intervals covering the 'true' S_c or the scale parameter σ of the population N(μ, σ) from which x_o is drawn (4.1.1) with a 'reliability' >> 50 %.

2) Use values from the largest to the smallest values within each of the above intervals. These values are used as possible σ's for normal curves $\varphi(x) = 1/(\sqrt{2\pi}\,\sigma)\exp[-(x-\mu)^2/2\sigma^2]$ (2.5.2).

3) Let μ of all the above curves be μ = x_o.

4) Determine the area under each curve φ(x) between the limits $x_o \pm k\,S_c$ (15) for k = 2 and 3. Each area depending on σ of φ(x) is a possible P of (15) (cf. Figure 6) and a point estimate covering the 'true' P of (15) with a zero 'reliability'(2.3 **b**). If the largest and the smallest possible σ's (step **2**) of each interval (step **1**) are used, then two curves φ(x) are obtained for each interval. Areas under them between the limits $x_o \pm k\,S_c$ (15) are used as end points of intervals of P's which cover the 'true' P of (15) with the same 'reliability' >> 50 % as given in step **1**).

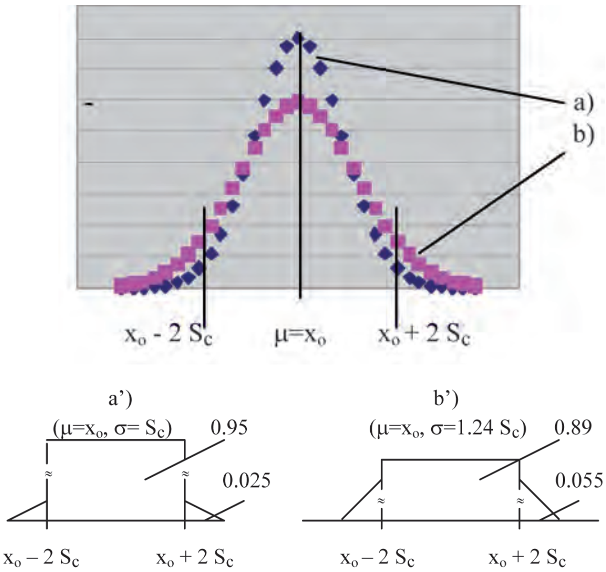

Figure 6. a) The normal curve φ(x) (step **2**) with $\mu = x_o$ and $\sigma = S_c$ and b) that with $\mu = x_o$ and $\sigma = 1.24\ S_c$ ($\sigma = S_c$ and $\sigma = 1.24\ S_c$ are possible values of σ from 0.80 S_c to 1.34 S_c; $n_{eff} = 31$). The areas (step **4**) under both these curves between the limits $x_o \pm 2\ S_c$ (15) are possible P's of (15) the values of which are given in the rough sketches a') and b').

5.2 Confidence level P of (15)

5.2.1 $n_{eff} = 31$ and interval of P's for (15)

Consider Table 2 and its first column which gives possible values of σ (step **2**) above). These are from the interval 0.80 S_c to 1.34 S_c ($n_{eff} = 31$; step **1**). For each σ there is an area (step **4**) or a possible confidence level P of (15) for both k = 2 and k = 3 (the second and third columns). With the aid of the lowest and highest values of these P's two intervals of P's of (15) are obtained, They are from 0.86 to 0.98 for k = 2 and from 0.974 to 0.999 for k = 3. Their 'reliabilities' are >> 50 % (step **1**) and **4**) and they are used as interval estimates of the 'true' P of (15) when $n_{eff} = 31$.

Possible values of the scale parameter σ (n_{eff}=31)	Possible P's for (15) (n_{eff}=31)	
	k=2	k=3
0.80 S_c	0.98	0.999
0.90 S_c	0.97	0.999
1.00 S_c	0.95	0.997
1.10 S_c	0.93	0.994
1.24 S_c	0.89	0.994
1.34 S_c	0.86	0.974

Table 2. Possible confidence levels P of (15) for k = 2 and 3 ($n_{eff} = 31$). A possible value $\sigma = \delta S_c$ ($0.80 \le \delta \le 1.34$) corresponds to a possible value of P for k = 2 and 3.

In order to compile Table 2 apply $\Phi[(x - \mu)/\sigma]$ (10) and use the following values of x, μ and σ. Choose the coordinates so that $\mu = x_o = 0$ (5.1.3). Thus $x_o \pm kS_p$ becomes $0 \pm kS_c$. Use the value $x = kS_c$. For $n_{eff} = 31$ σ equals δS_c and δ can be, e.g., 0.80, 0.90, 1.00, 1.10, 1.24 and 1.34. For each δ determine a value $\sigma = \delta S_c$. Insert each σ together with $x = kS_c$ and $\mu = 0$ in $\{\Phi[(x - \mu)/\sigma] - \Phi[(-x - \mu)/\sigma]\}$. This results in a possible confidence level P of (15) or an area under the normal curve with $\mu = 0$ and $\sigma = \delta S_c$ between $0 \pm kS_c$ ($0.80 \le \delta \le 1.34$, $n_{eff} = 31$):

$$P = \Phi(kS_c/\delta S_c) - \Phi(-kS_c/\delta S_c) = \Phi(k/\delta) - \Phi(-k/\delta)$$

(k = 2 or 3 and $0.80 \le \delta \le 1.34$) **(A)**

5.2.2 $n_{eff} = 11$ and 21 and intervals of P's for (15)

If similar tables to Table 2 are compiled for $n_{eff} = 11$ and 21 (step **1**) in 5.1.3), then their first columns include possible values of σ which according to n_{eff} can be found in Column I) of Table 3, and the other columns headed with k = 2 and 3 include P's which according to k and n_{eff} can be found in Column II) of Table 3. (Using formula (**A**) in 5.2.1 and inserting k = 2 or 3, $0.70 \le \delta \le 1.75$ for $n_{eff} = 11$ and $0.76 \le \delta \le 1.44$ for $n_{eff} = 21$ in (**A**), P's belonging to the intervals of P's are obtained. Let these intervals be the interval estimates covering the 'true' P of (15) with a 'reliability' >> 50 %.)

n_{eff}	k	I) Intervals of possible values of the scale parameter σ	II) Intervals of P's for (15)
11	2	from 0.70 S_c to 1.75 S_c	from 0.74 to 0.99
11	**3**	- " -	**from 0.913 to 0.999**
21	2	from 0.76 S_c to 1.44 S_c	from 0.83 to 0.99
21	**3**	- " -	**from 0.962 to 0.999**
31	2	from 0.80 S_c to 1.34 S_c *)	from 0.86 to 0.98 *)
31	**3**	- " -	**from 0.974 to 0.999** *)

*) Table 2

Table 3. Intervals of P's for (15) according to n_{eff} and k.

5.2.3 Practical confidence level of (15) on condition that $n_{eff} \ge 11$

a) Consider Table 3 and its Column II), k = 2 and the intervals of P's in which each P is > 0.7. Let the description *'practically with a high confidence'* replace all these P's.

b) Similarly, consider the same table and column, k = 3 and the intervals of P's in which each P is > 0.9. Let the description *'almost certainty'* replace all these P's.

c) Regard these descriptions as practical confidence levels of (15) and thus, the interval (15) covers the 'true' value of x_o practically with a high confidence if k = 2 and almost certainty if k = 3.

5.3 Confidence level P of (16)

5.3.1 Tools to build up P of (16)

a) Consider (12) and replace $s/\sqrt{n}$ with $S_c/\sqrt{n}$ (4.2.2) and t_P (≈2 or 3) with k. In this way (16) is arrived at. Next, consider n of $\bar{x}$ which is common to both (12) and (16). This n is related to s of (12) (cf. (1)) but a relation between n and S_c of (16) cannot be given. So (12) and (16) may differ from each other in such a way that it is hardly possible to introduce P of (12) into (16).

b) Rewrite (16) in the form $\bar{x} - k\,S_c/\sqrt{n} \le \mu \le \bar{x} + k\,S_c/\sqrt{n}$ (μ = the 'true' value of $\bar{x}$). This is equivalent to $-k \le \sqrt{n}\,(\bar{x} - \mu)/S_c \le k$. Denote $\sqrt{n}(\bar{x} - \mu)/S_c$ by t which thus depends on S_c. Because a number n_{eff} similar to n_{eff} in 5.1.2 can be associated with S_c, so t is also associated with n_{eff}. In order that this t could be a Student's t [2,4] with the aid of which a confidence level P of (16) could be obtained, then $\bar{x}$ (an estimator of μ) should be $\bar{x} = 1/n_{eff}\,\Sigma x_{ov}$. But now the estimator for μ is $\bar{x} = 1/n\Sigma x_{ov}$ and thus the Student's t with $\bar{x} = 1/n_{eff}\,\Sigma x_{ov}$ cannot be used here.

c) According to 4.2.1 $\bar{x}$ is drawn from a normal population N (μ, $\sigma/\sqrt{n}$). Thus P of (16) could be estimated using the procedures of 5.2. However, these are to be changed so that n_{eff} of 5.2 is replaced with n of $\bar{x}$, σ with $\sigma/\sqrt{n}$ of N (μ, $\sigma/\sqrt{n}$) and S_c with $S_c/\sqrt{n}$ (4.2.2). In the following steps **1**) to **5**) (cf. 5.1.3) suitable values of n of $\bar{x}$ are selected and intervals of P's covering the 'true' P of (16) are given but so that only their lower limits are dealt with and made known.

d) Steps **1**) to **5**):

1) If k is 2 in (16), then the smallest value of n is 4 for $\bar{x}$ and if k is 3, this n is 6.

2) Consider the confidence intervals of σ with n = 4 and 6 in 2.6.3. Rewrite these replacing s with $S_c/\sqrt{n}$ in the form *$0.57S_c/\sqrt{n}$ to $3.73S_c/\sqrt{n}$* (n = 4) and *$0.61S_c/\sqrt{n}$ to $2.45S_c/\sqrt{n}$* (n = 6). Suppose they cover respectively $\sigma/\sqrt{n}$ of the populations from which $\bar{x}$ with n = 4 and 6 are drawn (4.2.1) with a 'reliability' >> 50 %.

3) Consider two normal curves $\varphi(x) = 1/(\sqrt{2\pi}\ \sigma/\sqrt{n})\exp[-(x - \mu)^2/2(\sigma/\sqrt{n})^2]$ with n = 4 and 6. When n = 4 the parameter $\sigma/\sqrt{n}$ of $\varphi(x)$ assumes the upper limit $3.73S_c/\sqrt{n}$ of the first interval in step **2**) and when n = 6 the parameter $\sigma/\sqrt{n}$ assumes the limit $2.45S_c/\sqrt{n}$ of the second interval.

4) Let μ of both the above curves be $\mu = \bar{x}$.

5) Determine the areas under the above two normal curves $\varphi(x)$ between the limits $\bar{x} \pm kS_c/\sqrt{n}$ (16) (k = 2 and n = 4 for $\bar{x}$ or k = 3 and n = 6 for $\bar{x}$ (step **1**)). These areas will be the lower limits of two intervals of P's which cover the 'true' P of (16) with the same 'reliability' >> 50 % as in step **2**).

5.3.2 Numerical values of the lower limits of intervals of P's

In 5.3.3 it is shown that if k = 2 and n = 4 (step **1** above) the lower limit of the interval of P's covering the 'true' P of (16) is ≈ 0.72 (step **5**). If k = 3 and n = 6, then the lower limit is ≈ 0.997. If k = 2 and n > 4, or k = 3 and n > 6, then the lower limits are respectively higher than 0.72 or 0.997 and vice versa. For example, if k = 2 and n = 5, the limit is ≈ 0.88 but if k = 2 and n = 3, it is ≈ 0.42. This may show that n = 3 is not fair to use for n of $\bar{x}$ in (16) when k = 2.

5.3.3 The determination of P ≈ 0.72 and 0.997

a) *k = 2 for (16) and n = 4 for $\bar{x}$*

Consider the interval from $0.57S_c/\sqrt{n}$ to $3.73S_c/\sqrt{n}$ (n = 4) of step **2**) in 5.3.1. Write it in the form

from 0.29 S_c to 1.86 S_c (n = 4)

Insert the upper limit δ = 1.86 of this interval and k = 2 in formula (**A**) of P (5.2.1). This results in ≈ 0.72.

b) *k = 3 for (16) and n = 6 for $\bar{x}$*

Consider the interval from $0.61S_c/\sqrt{n}$ to $2.45S_c/\sqrt{n}$ (n = 6) of step **2**) in 5.3.1. Write it in the form

from 0.25 S_c to 1.00 S_c (n = 6)

Insert the upper limit δ = 1.00 of this interval and k = 3 in formula (**A**) of P (5.2.1). This results in ≈ 0.997.

5.3.4 Practical confidence level of (16)

a) If k = 2 and n = 4, then according to 5.3.2 and 5.3.3 **a**) the lower limit of the interval of P's covering the 'true' P of (16) is ≈ 0.72. If k = 2 and n > 4, the limit is > 0.72. Suppose these and higher P's can be replaced with the description *'practically with a high confidence'*.

b) If k = 3 and n = 6, then according to 5.3.2 and 5.3.3 **b**) the lower limit of the interval of P's covering the 'true' P of (16) is ≈ 0.997. If k = 3 and n > 6, the limit is > 0.997. Suppose these and higher P's can be replaced with the description *'almost certainty'*.

c) Regard these descriptions as practical confidence levels of (16) and thus, the interval (16) covers the 'true' value of $\bar{x}$ <u>practically with a high confidence if k = 2 and n ≥ 4</u> and <u>almost certainty if k = 3 and n ≥ 6</u>.

6 Uncertainty U_Σ of Σx_i in terms of the individual uncertainties U_i of x_i (i = 1, 2, ...)

6.1 Formulae for S_Σ (5) to (8) and the uncertainty U_Σ of Σx_i

Suppose **1**) x_i's (i = 1, 2, ...) are working standards, **2**) the individual uncertainties U_i of x_i's are known and **3**) the sums Σx_i of two or more x_i's are working standards as well. Let the uncertainty U_Σ of Σx_i depend on the individual U_i's of the terms in Σx_i and on the correlation coefficients cos ϕ_{ij} between each x_i and x_j in Σx_i (i; j = 1, 2, ...; i > j). Each of these cos ϕ_{ij}'s in one and the same sum Σx_i is supposed to assume a value 0, 1/4, 1/2, 3/4 or 1. In (5) to (8) s_Σ includes this cos ϕ_{ij} = 0, 1/4, 1/2, 3/4 or 1 and is presented in terms of the standard deviations s_i and s_j (cf. 2.4.4 and 2.4.5). As is explained below and in 6.2 it is possible to determine U_Σ using these s_Σ, s_i and s_j.

Form ks_Σ by introducing the coverage factor k into s_Σ in (5) to (8). This ks_Σ can be presented in terms of ks_i and ks_j (6.2). <u>Now ks_i and ks_j are replaced respectively with kS_{ci} and kS_{cj} or $kS_{ci}/\sqrt{n}$ and $kS_{cj}/\sqrt{n}$.</u> S_{cv} (ν = i or j) refers to the (combined) standard deviation S_c for x_o (4.1.2) and $S_{cv}/\sqrt{n}$ to the standard deviation $S_c/\sqrt{n}$ for $\bar{x}$ (4.2.2). Thus kS_{ci} and kS_{cj} or $kS_{ci}/\sqrt{n}$ and $kS_{cj}/\sqrt{n}$ are respectively individual uncertainties U_i and U_j either for x_o or $\bar{x}$. U_i and U_j are obtained from calibration certificates of x_i's. The uncertainty U_Σ of a sum Σx_i (Σx_i can be **1**) a sum of single values x_o, **2**) arithmetic means $\bar{x}$ or sometimes **3**) both of these) is obtained from ks_Σ which, on the basis of the above replacements, can be presented in terms of the above U_i and U_j (cf. 6.2). (Note that if Σx_i is the above sum of single values x_o and arithmetic means $\bar{x}$, then both the individual uncertainties of x_o and $\bar{x}$ are thought of being weighted with the same 'weight' 1, and used as being equivalent with the same coverage factor k.)

The case where m = 2 (2.4.2) is also dealt with as follows. Therefore, use the notations $U_\Sigma = U_{x+y}$, $U_1 = U_x$ and $U_2 = U_y$.

6.2 Formulae for U_Σ

6.2.1 The terms of the sum Σx_i are pairwise uncorrelated (cosϕ_{ij} = 0 between x_i and x_j; i; j = 1, 2,... ; i > j)

Because **cos ϕ_{ij} = 0** (ϕ_{ij} = 90°) use formula (5) and multiply it by k^2. So its left side becomes $(ks_\Sigma)^2$. Denote it by U_Σ^2. Its right side includes $(ks_i)^2$ but by carrying out the replacement in 6.1 it includes $(kS_{ci})^2$ or $(kS_{ci}/\sqrt{n})^2$. Both are denoted by U_i^2. So the right side becomes ΣU_i^2. Write $U_\Sigma^2 = \Sigma U_i^2$. Thus

$$U_\Sigma = (\sum_i U_i^2)^{1/2} \qquad (\text{if } m = 2,\ U_\Sigma = U_{x+y} = (U_x^2 + U_y^2)^{1/2}) \qquad (17)$$

6.2.2. The terms of the sum Σx_i are pairwise correlated (cosϕ_{ij} > 0 between x_i and x_j; i; j = 1, 2,... ; i > j)

a) Let **cos ϕ_{ij} = 1/4** (ϕ_{ij} = 75.52°). Use formula (6) and multiply it by k^2. So its left side becomes $(ks_\Sigma)^2$. Denote it by U_Σ^2. Its right side includes $(ks_i)^2$ and $ks_i\,ks_j$ but by carrying out the replacement in 6.1 it includes $(kS_{ci})^2$ and $kS_{ci}\,kS_{cj}$ or $(kS_{ci}/\sqrt{n})^2$ and $kS_{ci}/\sqrt{n}\ kS_{cj}/\sqrt{n}$. Both kS_{cv} and $kS_{cv}/\sqrt{n}$ (ν = i or j) are denoted by U_v. So the right side becomes $\Sigma U_i^2 + 1/2\Sigma U_i\,U_j$. Write $U_\Sigma^2 = \Sigma U_i^2 + 1/2\Sigma U_i U_j$. Thus

$$U_\Sigma = (\sum_i U_i^2 + 1/2\sum_{i>j} U_i U_j)^{1/2} \quad (\text{if } m = 2,\ U_\Sigma = U_{x+y} = (U_x^2 + U_y^2 + 1/2\, U_y U_x)^{1/2}) \quad (18)$$

b) Let **cos ϕ_{ij} = 1/2** (ϕ_{ij} = 60°). Use formula (7). Follow the same procedures as in **a**). So

$$U_\Sigma = (\sum_i U_i^2 + \sum_{i>j} U_i U_j)^{1/2} \quad (\text{if } m = 2,\ U_\Sigma = U_{x+y} = (U_x^2 + U_y^2 + U_y U_x)^{1/2}) \quad (19)$$

c) Let **cos ϕ_{ij} = 3/4** (ϕ_{ij} = 41.41°). Use formula (7'). Follow the same procedures as in **a**). So

$$U_\Sigma = (\sum_i U_i^2 + 3/2\sum_{i>j} U_i U_j)^{1/2} \quad (\text{if } m = 2,\ U_\Sigma = U_{x+y} = (U_x^2 + U_y^2 + 3/2\, U_y U_x)^{1/2}) \quad (20)$$

d) Let **cos ϕ_{ij} = 1** (ϕ_{ij} = 0°). Use formula (8) and multiply it by k^2. So its left side becomes $(ks_\Sigma)^2$. Denote it by U_Σ^2. Its right side includes ks_i but by carrying out the replacement in 6.1 it includes kS_{ci} or $kS_{ci}/\sqrt{n}$. Both are denoted by U_i. So the right side becomes $(\Sigma U_i)^2$. Write $U_\Sigma^2 = (\Sigma U_i)^2$. Thus

$$U_\Sigma = \sum_i U_i \qquad (\text{if } m = 2,\ U_\Sigma = U_{x+y} = U_x + U_y) \qquad (21)$$

6.3 Use of the formulae for U_Σ

6.3.1 An estimate of cosϕ_{ij} determined from calibration results

According to 6.1 and 6.2 cos ϕ_{ij} is the correlation coefficient of the working standards x_i and x_j (i, j = 1, 2, ...; i > j) and assumes a value 0, 1/4, 1/2, 3/4 or 1. Let x_i and x_j be obtained respectively from the results x_{i1}, x_{i2}, ..., x_{in} and x_{j1}, x_{j2}, ..., x_{jn} (2.4.4) of calibrations against appropriate reference standards z. So x_i and x_j as well as an estimate (from the above results) $rx_i\,x_j$ of cos ϕ_{ij} depend on z. But according to 2.4.3 **b**) the use of this estimate can lead to problems. To get rid of these, use formula (3) replacing its x with x_i and y with x_j. Determine $rx_ix_j.z$ which is used instead of $rx_i\,x_j$. But if **1**) the values of x_i and x_j can be determined using the same standard z, or **2**) the correlation coefficients between x_i and z (rx_i z) and x_j and z (rx_j z) are 'small' in (3), then $rx_ix_j.z \approx rx_i\,x_j \approx$ 0, 1/4, 1/2, 3/4 or 1 (to confirm that $rx_ix_j \approx$ 0, 1/4, 1/2, 3/4 or 1 use the test of significance for r in 2.4.3 **c**).

6.3.2 Notes on formulae (17) to (20) ($0 \le \cos \phi_{ij} < 1$)

a) If $\cos \phi_{ij} = 0$, then (17) is an obvious choice but if $\cos \phi_{ij} > 0$, then the formula to be used can be either (18), (19) or (20). If (17) is used irrespective of the value of $\cos \phi_{ij}$, then at least a first approximation of U_Σ is obtained.

b) In the formulae of 6.2 the individual uncertainties U_i or U_j are absolute values (4.1.2 and 4.2.2). However, in applications both their positive and negative values are used (e.g. both the end points of (15) or (16)). To be consistent with this, U_Σ should be a combination of the individual uncertainties with some cancellation of their positive and negative values. This can take place if the formulae in (17) to (20) are used (cf. examples in 6.3.4).

6.3.3. Notes on formula (21) ($\cos \phi_{ij} = 1$)

a) If (21) is used although $\cos \phi_{ij} = 1$ is not met, then an upper limit of U_Σ is obtained without the cancellation mentioned in 6.3.2 **b**).

b) The validity of $\cos \phi_{ij} = 1$ between x_i and x_j can be checked as follows. **1**) Use the known measured values x_{i1}, ..., x_{in} of x_i. **2**) Because $\cos \phi_{ij} = 1$ is supposed to be met, so use the clause following (8) in 2.4.5 and deduce values of x_j from x_{i1}, ..., x_{in} using a linear relation. Let this result in the values of x_{j1}, ..., x_{jn} of x_j. **3**) If the values of x_j were experimentally determined, then they could be, e.g., x_{j1}', ..., x_{jn}'. **4**) The question is: do the values x_{j1}, ..., x_{jn} and x_{j1}', ..., x_{jn}' really match with each other from a metrological point of view. If they do, then $\cos\phi_{ij} = 1$ could be met and there are reasons to use (21), otherwise not.

6.3.4 Examples of the application of (17) to (21)

Let us deal with three weights $x_1 = 50$ *kg*, $x_2 = 50$ *kg* and $x_3 = 10$ *kg* of OIML class M_1. Thus their sum $x_1 + x_2 + x_3$ is 110 kg. The uncertainty U_Σ is to be determined for $x_1 + x_2 + x_3$.

Let the individual uncertainties be U_1 *(50 kg) = 790 mg*, U_2 *(50 kg) = 460 mg* and U_3 *(10 kg) = 130 mg* and the correlation coefficients $\cos \phi_{ij}$ ($i; j = 1, 2, 3; i > j$) $\cos \phi_{21}$, $\cos \phi_{31}$ and $\cos \phi_{32}$. Their numerical values are given in **Ex.1**) to **Ex.3**).

Ex. 1) Let $\cos \phi_{21} = \cos \phi_{31} = \cos \phi_{32} = 0$. Thus use (17). U_Σ is

$$U_\Sigma = (\underbrace{790^2}_{U_1^2} + \underbrace{460^2}_{U_2^2} + \underbrace{130^2}_{U_3^2})^{1/2} = 923 \text{ mg}$$

This is a combination with the most radical cancellation of the positive and negative U_i's (6.3.2 **b**).

Consider the quotients of U_1, U_2, U_3, U_Σ and the maximum permissible errors (MPEs) of the corresponding weights. The MPEs are

- for the individual weights: *MPE (50 kg) = 2500 mg* and *MPE (10 kg) = 500 mg*
- for the sum 110 kg (*MPE (110 kg)* and *MPE *(110 kg))*: *MPE (110 kg) = 5500 mg* (2500 mg + 2500 mg + 500 mg) and *MPE* **(110 kg) = 3570 mg* $[(2500 \text{ mg})^2 + (2500 \text{ mg})^2 + (500 \text{ mg})^2]^{1/2}$.

The greatest quotient U/MPE is U_1 (50 kg)/MPE (50 kg) = 0.316. U_Σ/MPE(110 kg) = 0.168 and U_Σ/MPE* (110 kg) = 0.258. Thus, all the values of U/MPE, U_Σ/MPE(110 kg) and U_Σ/MPE*(110 kg) are <1/3.

Ex. 2) Let $\cos \phi_{21} = \cos \phi_{31} = \cos \phi_{32} = 1$. Thus use (21). U_Σ is

$$U_\Sigma = \underbrace{790}_{U_1} + \underbrace{460}_{U_2} + \underbrace{130}_{U_3} = 1380 \text{ mg}$$

This is 457 mg (≈U_2 (50 kg)) greater than U_Σ in Ex. 1) and is a combination without the cancellation explained in 6.3.2 **b**).

U_Σ/MPE (110 kg) = 0.250 but U_Σ/MPE*(110 kg) = 0.386 and thus >1/3.

Ex. 3) Let $\cos \phi_{21} = \cos \phi_{31} = \cos \phi_{32} = 1/4$. Thus use (18). U_Σ is

$$U_\Sigma = \{\underbrace{790^2}_{U_1^2} + \underbrace{460^2}_{U_2^2} + \underbrace{130^2}_{U_3^2} + 1/2 \times (\underbrace{460}_{U_2} \times \underbrace{790}_{U_1} + \underbrace{130}_{U_3} \times \underbrace{790}_{U_1} + \underbrace{130}_{U_3} \times \underbrace{460}_{U_2})\} = 1056 \text{ mg}$$

This is a value between U_Σ in Ex. 1) and U_Σ in Ex. 2) and both the values U_Σ/MPE(110 kg) and U_Σ/MPE* (110 kg) are <1/3. The subjective opinion of the author is that U_Σ = 1056 mg is a suitable value for the sum $x_1 + x_2 + x_3$ = 110 kg and thus, $\cos \phi_{ij} = 1/4$ could be the correlation coefficient between the values of the above weights.

7 Quality of measurement

Consider the quality of measurement as a function of the uncertainty U of the measurement being investigated, a reference value f, certain limits connected to the coverage factor k of U and additional statistical tools. The case k = 2 is dealt with here (comments are made about k = 3).

7.1 A good measurement and notes on uncertainty U

a) The measurement is a good one if by means of a simple comparison

- its error is found to be equal to or smaller than a given maximum tolerable error f, and
- using an indicator (7.4) it is possible to show that the corresponding 'true' error is likely ≤ f.

b) The primary method to evaluate an uncertainty U is to determine the Type A and B variances explained in Section 3 and Notes of 5.1.2. U is then evaluated on the basis of these variances.

If the question is, e.g. of working standards, then their uncertainties can be approximated in connection with the determination of their values as follows:

- The values are determined by means of measurements under certain conditions of use. Both the measurements and the conditions of use are standardized.
- The uncertainties are approximated using statistics on uncertainties obtained from similar working standards as those being investigated. Several statistics are needed and each of them consists of uncertainties of working standards with the same accuracy and nominal values. The uncertainties for each statistic are evaluated using the above primary way **b**).

If the uncertainty is approximated for identical working standards, then only one statistic is needed. It consists of uncertainties of working standards with the same accuracy and nominal values as those of the standards being investigated. An upper limit is determined from the uncertainties in the statistic. This is the uncertainty U of the identical standards. In front of this U the symbol (≤) is necessary. Without it the uncertainty would be misleading.

7.2 Quotient U/f

Use the uncertainty U and the maximum tolerable error f (7.1 **a**) for the measurement in question. Form the quotient U/f (U/f corresponds to U/MPE in 6.3.4; both U and f are absolute values).

If U/f meets the condition U/f < 1 (the limit 1 is for k = 2; it should be < 1 if k = 3), then the quality classes of the measurement can be defined as given in 7.3. Another limit 0.6 (for k = 2) is chosen in 7.4. With its aid a value is connected with the measurement classified into one of the classes in 7.3. This value tells about the quality of the measurement. Note that the above limits 1 and 0.6 for k = 2 can be different for different kinds of measurements. Here 1 and 0.6 are used as example limits.

7.3 Quality classes

On the basis of the condition U/f < 1 (k = 2) define the quality classes of the measurement as

Class **1**) if 1/2 ≤ U/f < 1
Class **2**) if 1/3 ≤ U/f < 1/2
Class **3**) if 0 < U/f < 1/3

Instead of U/f use f/(f + U). The reason for this will be clear from 7.4. Using f/(f + U) the above classes can be defined as

$$\left.\begin{array}{lll} \text{Class } \mathbf{1}) \text{ if } 0.5 < f/(f+U) \le 0.67 & \text{equivalent to} & 1/2\, f \le U < f \\ \text{Class } \mathbf{2}) \text{ if } 0.67 < f/(f+U) \le 0.75 & \text{equivalent to} & 1/3\, f \le U < 1/2\, f \\ \text{Class } \mathbf{3}) \text{ if } 0.75 < f/(f+U) < 1 & \text{equivalent to} & 0 < U < 1/3\, f \end{array}\right\} \quad (22)$$

7.4 Statistical angle and good measurements

7.4.1 Interpretation of the values of f/(f + U)

Each value of f/(f + U) in (22) and its reduced value f/(f + U) – 2 $s_{f/(f+U)}$ defined in 7.4.2 and 7.4.3 is thought of being a <u>probability that the measurement in Class **1**), **2**) or **3**) is a good one.</u>

Motivation. For a certain f let f/(f + U) assume a ‘large’ value, i.e., **U is ‘small’**. So the error of the measurement can ‘accurately’ be known. If this error is ≤ f, then in practice the corresponding ‘true’ error can also be ≤ f, and there is a fair chance of arriving at a good measurement (7.1**a**). But if f/(f + U) is ‘small’, i.e., **U is ‘large’,** and the error mentioned is ≤ f, then it is difficult to judge the ‘true’ error to be ≤ f. One could say that there is only a slight chance of a good measurement. Thus f/(f + U) as well as its reduced value f/(f + U) – 2 $s_{f/(f+U)}$ assume values from > 0 to < 1. These approximate the frequency (probability) of appearance of a good measurement.

7.4.2 The standard deviation of f/(f + U)

According to 7.1 **a**) a good measurement is arrived at if its error is ≤ f and the corresponding ‘true’ error is likely to be ≤ f. To show the last-mentioned condition, use f/(f + U) (a random function because its variable U is random in its nature (3.2.2)) and the standard deviation $s_{f/(f+U)}$ of f/(f + U). An approximate formula of $s_{f/(f+U)}$ [4] and some example values of $s_{f/(f+U)}$ are given in Table 4 in the case where U assumes values close to its upper limit f, 1/2f or 1/3f in Class **1**), **2**) or **3**) (22) respectively.

Class	The value of U close to	Guess of the standard deviation S_U	Standard deviation $S_{f/(f+U)} \approx [f/(f+U)^2]S_U$
1)	f	1/5 f	0.05
2)	1/2 f	1/10 f	0.044
3)	1/3 f	1/15 f	0.037

Table 4. $s_{f/(f+U)} \approx [f/(f+U)^2]\, s_U$. s_U is the standard deviation of U and $f/(f+U)^2$ the absolute value of the derivative of f/(f + U)

7.4.3 Use of $f/(f + U)$ and $f/(f + U) - 2s_{f/(f + U)}$

a) On the basis of the value of $f/(f + U)$ in (22) determine the quality class of the measurement.

b) If both the error of the measurement is 1^0) $\leq f$ and 2^0) $f/(f + U) - 2s_{f/(f + U)} > 0.6$, then the 'true' error is regarded as $\leq f$ and the measurement as a **good** one (7.1 **a**). The limit 0.6 refers to $k = 2$ (it should be > 0.6 if $k = 3$). To be on the safe side an upper limit of $s_{f/(f + U)}$ is used in 2^0). This is obtained from Table 4 according to the quality class in question.

Suppose the above condition 1^0) is met for all the measurements to be dealt with as follows. Therefore, only the fulfilment of condition 2^0) has to be checked. This is done in order of importance of the quality classes in the following:

Class **3**). Insert the lower limit 0.75 of $f/(f + U)$ (22) in 2^0). This leads to $0.75 - 2 \times 0.037 = 0.68 > 0.6$ and proves that all Class **3**) measurements meet 2^0) and the measurements are **good** ones.

Class **2**). If $f/(f + U) \geq 0.70$, then 2^0) is met (0.70 inserted in 2^0) leads to $0.70 - 2 \times 0.044 = 0.61 > 0.6$). So these Class **2**) measurements are also **good** ones (cf. the case $f/(f + U) < 0.70$ in **c**).

Class **1**). The condition 2^0) cannot be met for Class **1**) measurements and therefore these are **less good** ones except for a special case in **d**).

c) If for a Class **2**) measurement the value of $f/(f + U)$ is < 0.70 or $f/(f + U)$ equals approximately the lower limit 0.67 for Class **2**), then 0.67 inserted in 2^0) leads to $0.67 - 2 \times 0.44 = 0.58$. This $0.58 > 0.5$ is regarded as quite a large probability (7.4.1) and thus the measurement is regarded as an **almost good** one.

d) If for a Class **1**) measurement the value of $f/(f + U)$ equals approximately the upper limit 0.67 for Class **1**), then 0.67 inserted in 2^0) leads to $0.67 - 2 \times 0.05 = 0.57$. This $0.57 > 0.5$ is regarded as quite a large probability (7.4.1) and the measurement is regarded as an **almost good** one.

Example: The calibration of two weights x_1 and x_2 of 50 kg is performed and the quality of this calibration is to be judged. Let the uncertainties U of the weights x_1 and x_2 be 460 mg and 1160 mg respectively and let the errors of x_1 and x_2 be $\leq f = 2500$ mg (cf. 6.3.4; note that the weight x_2 is not an OIML weight).

Weight x_1:
$f/(f + U) = 2500/(2500 + 460) = 0.84$ and according to (22) the question is of Class **3**). On the basis of **b**) the calibration is a **good** one.

Weight x_2:
$f/(f + U) = 2500/(2500 + 1160) = 0.68$ and according to (22) the question is of Class **2**). $f/(f + U) - 2\,s_{f/(f + U)} = 0.68 - 2 \times 0.044 = 0.59$. Thus on the basis of **c**) the calibration is an **almost good** one.

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Teuvo Lammi

WOOD MOISTURE

Development of an ultrasonic method for measuring the moisture content of wood

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Abstract

The economic value of wood depends both on its quality and on its moisture content, the latter being one of the key quality components especially in trade transactions. To determine the moisture content, many methods can be used - for example the ultrasonic method. This study has proved that moisture can be measured using the ultrasonic method by means of the relation between the velocity of the wave and the moisture content: the greater the moisture content, the slower the velocity. The velocity of the wave in the axial direction is compared with that in the radial and transversal directions.

Introduction

Wood is one of Indonesia's natural resources and income sources, and can be found in the Sumatera, Kalimantan, Sulawesi and Papua forest areas. Since the moisture content can significantly affect the value of commercial transactions, calculating this element is of great importance.

Countries that import wood determine the required moisture content based on their own environmental conditions, since any significant variations can cause the wood to be more easily scratched or to warp. For countries such as Europe, the USA, Canada, and Japan, the maximum moisture requirement is 8 % (Budianto, 2006). The uniformity of the moisture content, whether between or within parts of the wood and the degree of drying, might be necessary requirements in order to arrive at good quality end products.

The determination of the moisture content nowadays uses the resistant value measurement or material capacitance. The electrical method does have practical advantages, but the dimensions of the material measured are relatively small. The result of this method controls the end product production process. Generally, moisture measurement using the electrical method does not take into account water trapped between the inner area and the surface. A high degree of moisture might cause the wood to be damaged when further processed (e.g. drying, pickling, polishing, or sharpening), therefore the quality of the wood is different from that expected.

Wood also has certain other characteristics, such as hygroscopic and anisotropic properties. The hygroscopic property causes the moisture content depending on the environment, which is why the determination of all the parameters involves a number of environmental factors such as temperature and humidity. Anisotropic properties relate to the fact that the wood has different properties depending on whether it is tested longitudinally, radially, or tangentially.

The use of measuring instruments for wood moisture content in commercial transactions in Indonesia is regulated in the *Director of Directorate of Metrology Decree* which in turn refers to OIML R 92:1989 *Wood-moisture meters - Verification methods and equipment: general provisions*. The national requirements for wood are also regulated in the Indonesian National Standard (SNI) Guidance (with the exception of the definition of the wood itself).

A number of methods for determining the quality of wood have been developed, one of which is the ultrasonic method. This technique has the advantage that it causes minimal damage to the wood, and it can accommodate large pieces of wood to be measured.

2 Research method

This study used samples of Alba *(Albizzia Falcata Back)*, Keruing *(DipterocarpusSpp)*, Borneo (*Dryobalanops Camphora)*, and Jati *(Tectona Grandis)*. The sample size of the wood had dimensions 5 cm × 5 cm × 5 cm. Moisture was created by putting the sample in water for a few days, and then heating it up in an oven until it reached a specific moisture content.

Instruments used included two ultrasonic 50 kHz transducers, a digital oscilloscope, and other electronic instruments. The travel time of the ultrasonic wave through the wood sample was measured in three directions: axial, radial, and tangential, and was determined by observing the digital oscilloscope. The velocity of the wave was calculated using the following equation:

$$v = \frac{d}{t}$$

where:

v: velocity of the ultrasonic wave in the sample (cm/s)
d: thickness of the sample (cm)
t: travel time of the ultrasonic wave (s)

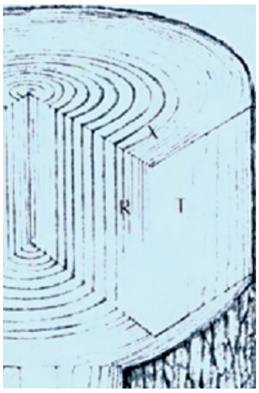

Fig.1 Wood in the axial, radial and tangential axes (Sankey)

The travel time of the ultrasonic wave in the oscilloscope is displayed in Figure 2.

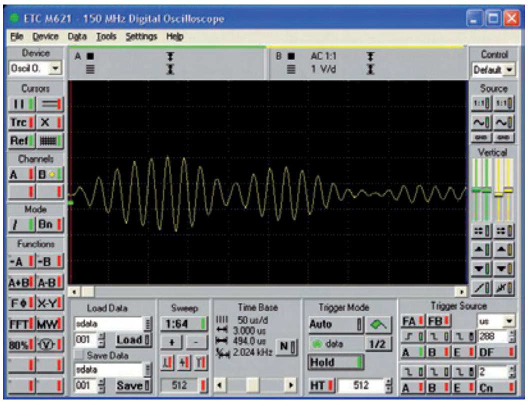

Fig. 2 (a) Determination of the time of flight

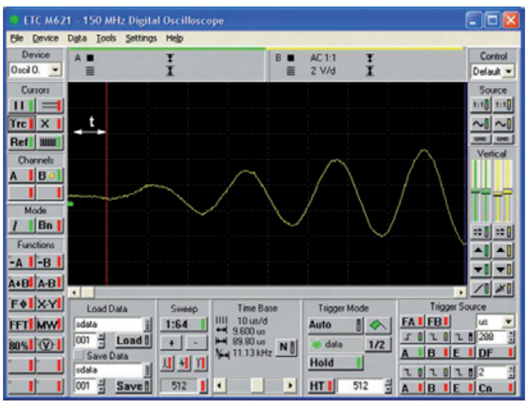

Fig. 2 (b) Zooming of the signal

The block diagram of the ultrasonic measuring system is shown in Figure 3 and the instruments are shown in Figure 4.

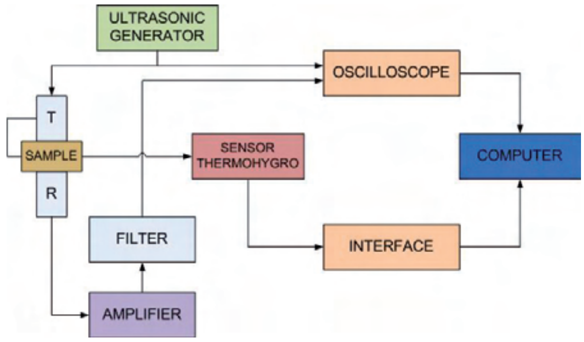

Fig. 3 Schematic of the ultrasonic instrument

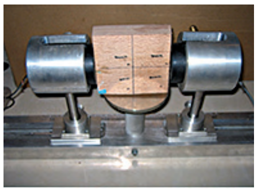

Fig. 4 Ultrasonic transducers, holder and wood sample

The actual moisture content for each wood sample can be determined using the oven method (reference method), based on OIML R 92, as follows:

$$M(\%) = \frac{m - m_0}{m_0} \times 100\%$$

where: M = moisture (%)
m = mass of the wood (g)
m_0 = mass of the dry wood (g)

3 Result and discussion

Referring to the result of the data analysis, the relationship between the velocity of the ultrasonic wave in the sample and the moisture is displayed in Figure 6. In the graphic, we see that the velocity of the ultrasonic wave in different types of wood sample decreases linearly with increasing moisture. The slope and correlation in the graph for each type of wood are:

Alba *(Albizzia Falcata Back)*
(slope = – 0.015, R^2 = 0.831)

Keruing *(DipterocarpusSpp)*
(slope = – 0.017, R^2 = 0.893)

Borneo *(Dryobalanops Camphora)*
(slope = – 0.013, R^2 = 0.893)

Jati *(Tectona Grandis)*
(slope = – 0.041, R^2 = 0.816).

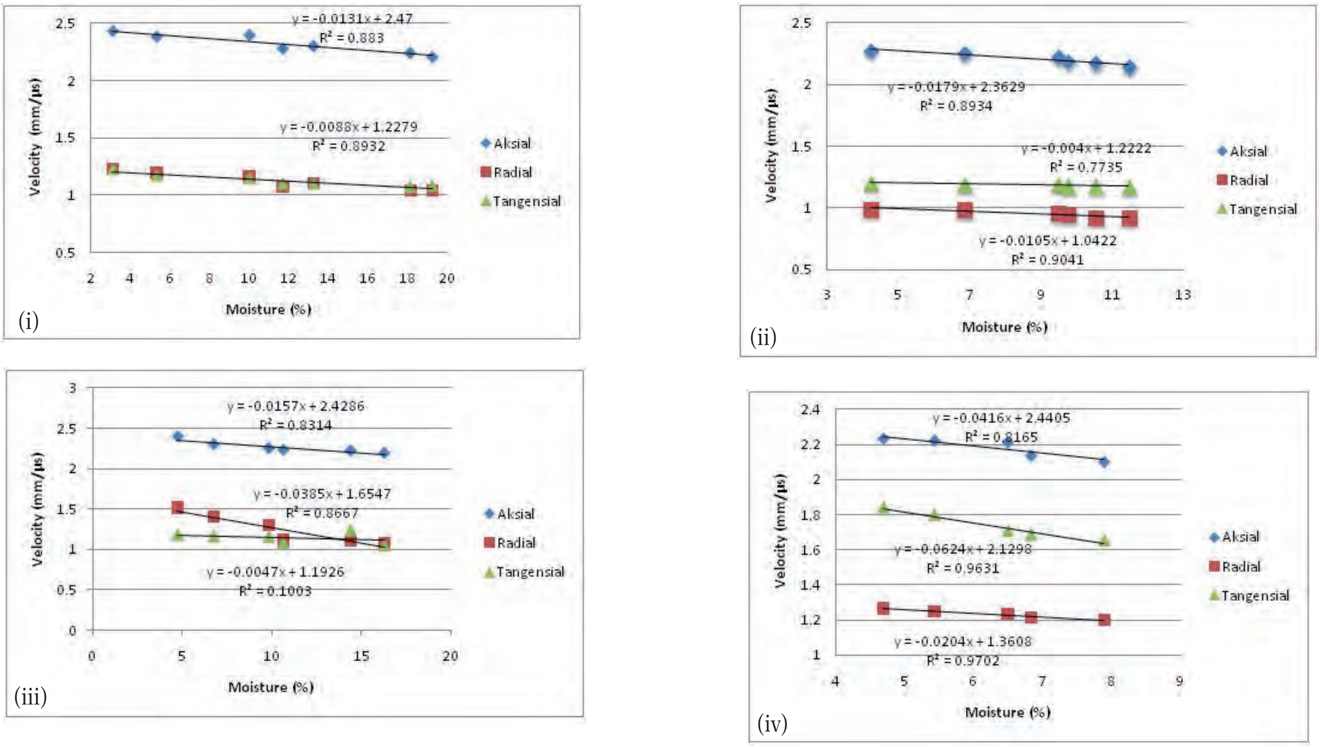

Fig. 5 Relationship between the ultrasonic velocity and the moisture content in the wood: (i) Alba, (ii) Keruing, (iii) Borneo, (iv) Jati

The velocity of the ultrasonic wave in the axial direction has a larger value than the other direction (radial and tangential). For the same value of moisture, the velocities of the ultrasonic wave for each type of wood are different to each other, and the velocity increases when the mass density of the wood decreases.

According to the graph, when the wood is dry (i.e. the moisture content is zero), the velocities of the ultrasonic waves are:

Alba *(Albizzia Falcata Back)*	2.47 mm/µs
Keruing *(DipterocarpusSpp)*	2.362 mm/µs
Borneo (*Dryobalanops Camphora)*	2.377 mm/µs
Jati *(Tectona Grandis)*	2.440 mm/µs.

4 Conclusion

This study has shown that the velocity of an ultrasonic wave can be used to determine the moisture content of wood; the velocity will decrease linearly with increasing moisture and also depends very much on the type of wood. For equal moisture contents, the velocity of the ultrasonic wave in the sample will give different values and become a large value for wood which has a smaller mass density.

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FUEL DISPENSERS

Evaluation of the influence of the liquid used in the verification of fuel dispensers and their standard calibration

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Abstract

The verification of fuel dispensers in petrol stations is performed *in-situ* by the legal metrology authorities according to internal procedures or regulations with calibrated standard volume test measures.

In order to identify the possible impact on the results, depending on which liquid (diesel or petrol) is used for the legal verification of fuel dispenser metering systems and also the liquid (water) used for the gravimetric calibration of the standard volume measures in the laboratory, several tests were conducted using two types of standard volume measure: the commonly used type made of stainless steel and another type made of carbon fiber composite material.

Introduction

Legal metrological control of the measurement of fuel volume is an extremely important activity because it directly affects millions of consumers. In order to ensure fair and accurate trade, it is essential that the volumetric measurement process of liquid fuel sold to the public is reliable.

In Portugal, the metrological verification of fuel dispensers ("petrol pumps") is performed by recognized entities. The operation takes place *in-situ*, following internal procedures, in agreement with the published legislation and using appropriate standards such as the calibrated standard volume test measures (VS). The capacity or "nominal volume" of a VS is selected according to the maximum delivery capacity of the fuel dispenser, the flow rate at which the user desires to conduct the test and the duration of the test. The Volume Laboratory of the Portuguese Institute for Quality (IPQ) performs the calibration at the highest level in Portugal of VSs for 2 L, 5 L, 20 L and 50 L capacities.

The VSs can be calibrated by the volumetric method or the gravimetric method [1], usually with water as the calibration liquid, at a reference temperature of 20 °C and with a maximum permissible error of 0.05 % [2]. However, it has been reported [3] that the liquid fuels used in the verification of fuel dispensers might lead to some variations in the results of the calibration. Hence, it was interesting to conduct comparative tests of calibration for different VSs, using different liquids.

The VSs considered in this study were the usual stainless steel "line" or "graduated neck" type (SSVS) and the new carbon fiber composite "integrated measure" type (CFVS), both for the 5 L and 20 L capacities. The liquids used in the comparative tests were water, diesel and petrol (95-octane petrol).

As the gravimetric method is based on the density of the liquid, the knowledge of its value was a prerequisite for the present study. So, the density value of the liquid first had to be determined. Then, the results of the VS calibrations using different liquids and by different methods were compared. If the water and the diesel displayed the same results for the SSVS, their results were different when using the CFSV, whatever the capacity of the VS. Comparatively, as the petrol is the more unstable liquid, it always exhibited different results than those obtained with water. The associated uncertainties of the results obtained with petrol were always the highest too.

Furthermore, due to their different physico-chemical proprieties, the liquids were expected to influence the final results given by the volumetric and the gravimetric models. In particular, the evaporation rates and the residual volume of the liquid in the VS depend on the interaction with their environment. Hence, tests consisting in determining the residual volume at different drainage periods and the evaporation at different liquid temperatures were also performed in this study.

Volume standards

Stainless steel standard volume test measures

In Portugal, the VS used in the verification of fuel dispensers are typically the "line" or "necked" type made from stainless steel. These instruments comprise an acrylic window set in a brass frame fixed to the neck of

Figure 1 VS of stainless steel

the instrument. An additional adjustable position brass plate with graduation lines corresponding to ± 0.3 %, ± 0.5 % and ± 1 % of the capacity of the instrument as shown in Figure 1, is adjustable, up or down, relatively to the brass frame. During the calibration process, the 0 % graduation line is set at a level that corresponds to the level of the nominal volume in the neck of the instrument. The SSVS is discharged and drained by holding the device upside down over a suitable recovery system.

Carbon fiber composite standard volume test measures

The "integrated test measure" (CFVS), a new type of VS (see Figure 2) made from carbon fibre composite material and lighter in weight than the equivalent volume SSVS, was first introduced in 1999 according to NWML specification 7323, with innovative features that include [4]:

- A 2-vessel construction that allows all the liquid dispensed, in excess of ca. 98.8 % of the nominal capacity of the CFVS, to pass through a valve connecting the upper neck of the main vessel to the upper end of the "measurement tube".
- Parallel milliliter and % capacity error scales bonded to the surface of the measurement tube marking the "strike" or nominal capacity level and, error levels up to 1 % in excess or deficiency, in resolution steps of 2 mL for 20 L and 1 mL for 5 L.
- Calibration conducted by raising or lowering the vertical position of a piston located at the lower end of the "measurement tube".

Figure 2 VS of carbon fiber

- A thermal expansion coefficient close to zero.
- Suspension of each “integrated test measure” when in use, by means of two short arms or “trunnions” that engage with slots in vertical legs of tubular H-frames that fit into tubular shoes on the chassis of a balanced, small weight attached to a two-wheel transport trolley.
- A level adjustment screw on the H-frame of each suspended CFVS.
- Liquid discharge through valves in the base of the main vessel.

Liquids used in the measurements

The normal calibration liquid used to perform the measurements is distilled water, with conductivity lower than 5 μS/cm or tap water with controlled measurement density, because it is the main fluid used in laboratory calibrations. Indeed, OIML R 120 mostly refers to water as liquid for the tests of the VS [2].

This study considered other liquids such as hydrocarbon fuels, because they are used on site in the petrol station verifications. The liquids used were petrol and diesel.

Experimental methods

The VS can be calibrated using two different main methods. The volumetric method is the faster, the easiest and the lowest cost method to use. The model of this method follows the equation [5]:

$$V_{20} = V_0 \times \left[1 + \gamma_P (t_P - 20) - \beta_L (t_P - 20) - \gamma_R (t_R - 20)\right] + \delta V_{men} \quad (1)$$

where:

V_{20} is the volume, at a temperature of 20 °C,
V_0 is the volume of the reference test measure,
γ_P is the cubic thermal expansion coefficient of the material of the reference test measure,
γ_R is the cubic thermal expansion coefficient of the standard volume test measure,
β_L is the cubic thermal expansion coefficient of the liquid,
t_p is the water temperature in the reference test measure,
t_R is the water temperature in the standard volume test measure,
∂V_{men} is the effect on volume due to the position of the meniscus.

However, as this method is the less accurate one, in this work, we rather focused on the gravimetric method [6]. Its model is:

$$V_{20} = (I_L - I_E) \times \frac{1}{\rho_W - \rho_A} \times \left(1 - \frac{\rho_A}{\rho_B}\right) \times \left[1 - \gamma(t - 20)\right] + \delta V_{men} \quad (2)$$

where:

V_{20} is the volume, at a temperature of 20 °C,
I_L is the result of the weighting with the standard volume test measure full of water,
I_E is the result of the weighing with the standard volume test measure empty,
ρ_W is the density of the water, at calibration temperature t,
ρ_A is the density of air,
ρ_B is the density of the mass pieces,
γ is the cubic thermal expansion coefficient of the material of the standard volume test measure,
t is the water temperature used in the calibration,
δV_{men} is the effect on volume due to the position of the meniscus.

Therefore, it can be seen that the densities of the liquids used are needed within this model.

Determination of the density of petrol and diesel

Prior to conducting the gravimetric calibration, it was necessary to determine the density of the calibration liquid. According to OIML R 120 the liquid to be used for calibration shall be distilled water with density obtained using the appropriated formulae, in the range 0 °C to 40 °C [7]. As we decided that the VS should also be calibrated using petrol and diesel it was necessary to confirm experimentally the density of these fuels at different temperatures because in the available published works [8], densities are only provided for the reference temperature 15 °C which was considered insufficient for the purposes of the desired calculations.

The densities were therefore determined for petrol and diesel at three different temperatures (19 °C, 20 °C and 21 °C) using a vibrating tube digital densimeter with a resolution of 0.001 gL^{-1}, at the IPQ Properties of Liquids Laboratory. The variation of the density with the temperature for each liquid was then determined by linear regression (together with the corresponding uncertainty).

Figures 3 and 4 display the results of the density measurements obtained for the two hydrocarbon fuels, including their respective linear regression with respect to the temperature. Then, a validation of this determination of the density values may be obtained by comparing

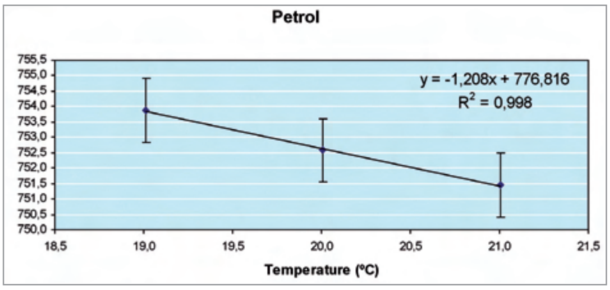

Figure 3 Determination of the petrol density

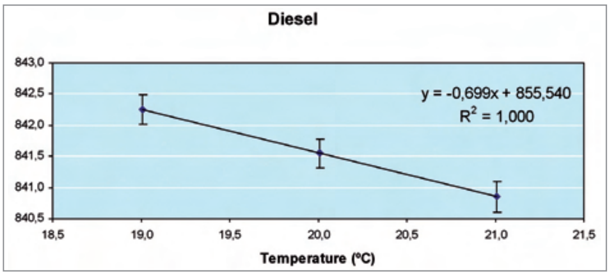

Figure 4 Determination of the diesel density

Table 1 Comparison between the values of published work [8] and those extrapolated from experimental data

Density (g/L) at 15 ºC		
Fluid	**Theoretical**	**Extrapolated from the linear regression**
Diesel	820 – 845	845.0 ± 0.4
Petrol	720 – 775	758.7 ± 1.2

the extrapolated density values with the published ones [8] for the same temperature. This is summarized in Table 1.

Hence, considering the displayed results, it can be concluded that the published values seem to correspond to the experimental determination of the hydrocarbon fluid densities.

Figures 3 and 4 still confirm that the petrol has a smaller density value than the diesel one. On the other hand, it can be seen that the petrol absolute thermal variation is greater than that of the diesel. This observation is coherent with the corresponding higher volatility value of the petrol.

Experimental results

The volume of each VS under calibration can be estimated from equations (1) and (2). The use of different liquids also allows the estimation, through equation (2). For each method, the combined standard uncertainty is calculated, following the "Guide to the Expression of the Uncertainty in Measurement" (GUM) [9].

All the tests of the study were performed at the (20.0 ± 0.5) ºC temperature. This section displays the experimental results obtained for different VS, different calibration liquids and different methods of calibration.

Calibration of VS with different calibration liquids and methods

The results of the calibrations of the two VS, with 5 L and 20 L capacities, using the different liquids, i.e. water, diesel and petrol, for the gravimetric method are summarized in Table 2 and Table 3 and the results from the volumetric method are displayed in Table 4. The absolute and relative expanded uncertainties are also presented, for a $k = 2$ coverage interval, the detailed uncertainty analysis is described in previously published work [10, 5].

Stainless steel standard volume test measures

Table 2 Gravimetric calibration of a 5 L SSVS

Fluid	Average value (L)	Uncertainty (L)	Uncertainty (%)
Water	4.999	0.002	0.04
Petrol	5.002	0.008	0.16
Diesel	4.999	0.003	0.06

Table 3 Gravimetric calibration of a 20 L SSVS

Fluid	Average value (L)	Uncertainty (L)	Uncertainty (%)
Water	20.005	0.006	0.03
Petrol	20.014	0.034	0.17
Diesel	20.007	0.009	0.05

Table 4 Volumetric calibration of SSVS of 5 L and 20 L capacities using water

VS	Average value (L)	Uncertainty (L)	Uncertainty (%)
5 L	4.999	0.003	0.06
20 L	20.003	0.006	0.03

Tables 2–4 allow us to state that the results for the two SSVS of 20 L and 5 L capacities, using the different liquids, are similar within the measurement uncertainty interval. This means that the measurements in the laboratory with water as the calibration liquid can reliably simulate the calibration *in-situ* with the other calibration liquids. However, it can also be observed that the petrol is less well simulated by the water than the diesel. At the same time, greater measurement uncertainty values are observed for the petrol than for the diesel.

Using water as the calibration liquid, the gravimetric method measurements are compared with those of the volumetric method. Also from the analysis of the Tables it can be seen that the figures for water using the gravimetric and volumetric calibration procedures are also similar.

Carbon fiber composite standard volume test measure

The results of the calibrations with this kind of VS are displayed in the following Tables, for both fuel liquids and for water. Both the gravimetric and the volumetric methods are also considered.

Table 5 Gravimetric calibration of 5 L CFVM

Fluid	Average value (L)	Uncertainty (L)	Uncertainty (%)
Water	5.000	0.002	0.04
Petrol	4.996	0.007	0.14
Diesel	4.989	0.002	0.04

Table 6 Gravimetric calibration of 20 L CFVM

Fluid	Average value (L)	Uncertainty (L)	Uncertainty (%)
Water	19.999	0.003	0.02
Petrol	19.996	0.030	0.15
Diesel	19.980	0.008	0.04

Table 7 Volumetric calibration of 5 L and 20 L CFVM using water

VS	Average value (L)	Uncertainty (L)	Uncertainty (%)
5 L	4.994	0.002	0.04
20 L	19.994	0.004	0.02

Contrary to the SSVM, with the CFVM the average values for calibration using petrol and diesel are always lower than the measured average in the calibration using water. This is due to the gravimetric method taking into account the residual value to calculate the nominal volume and the adjustment of the scale. When calibrating with the volumetric method, it can be seen, in Table 7, that the volume value of water is lower than that obtained with the gravimetric method. Therefore, the determined residual value was not actually inside the CFVM but in its 1/4 turn ball-valves by means of which the main vessel and the measurement tube of the CFVM are discharged after each test. However, this residual value was used to estimate the mass and this explains their low values observed in Tables 5 and 6.

In order to avoid mistakes in the determination of the residual volume when using the gravimetric method and according to the CFVM supplier it is necessary to open and close the valves several times after the 30 s of drainage time.

The uncertainties for the calibration of the CFVM, both for the 5 L and 20 L capacities, are lower than for the calibration the SSVM. This is due mainly to the corresponding resolution of the scales. The calibration of any standard displays a higher uncertainty value for petrol than for other liquids. This is due to the characteristics of the liquid and the corresponding density uncertainty.

Determination of residual volume at different drainage periods

When used for conducting tests, 5 L and 20 L VS are typically drained for a period of 30 s, after full discharge is completed. In order to ascertain the effect of using different drainage times, tests were performed with duration 15 s, 30 s, and 60 s, in this order, using water, diesel and petrol at 20 ºC. The following Figures display the residual volumes with respect to the drainage periods.

Stainless steel standard volume test measures

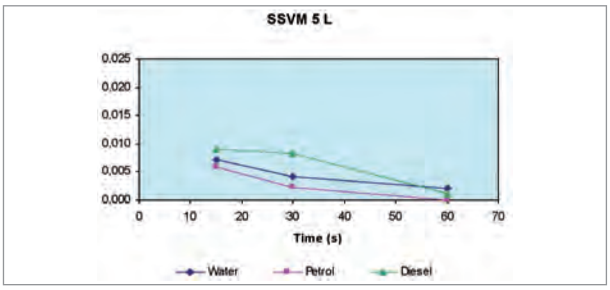

Figure 5 Residual volumes of the 5 L capacity SSVS

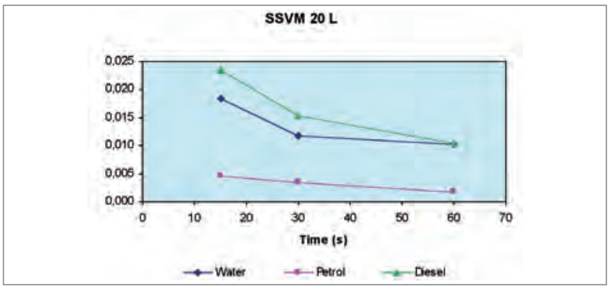

Figure 6 Residual volumes of the 20 L capacity SSVS

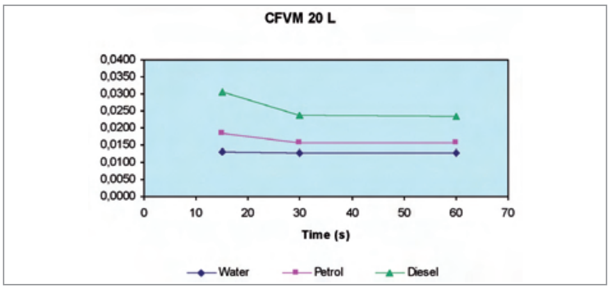

Figure 8 Residual volume of the 20 L capacity CFVS

For the SSVS, it can be observed that the residual volume is a decreasing function of the drainage time. As expected, the functions depend on the liquid. This is due to different values of viscosity and the surface tension of each liquid. The diesel has a viscosity higher than the water therefore the residual volume will be higher than the water. The petrol, as it has a lower viscosity and a higher evaporation, gives a lower value of residual volume. This suggests that the drainage time should be adjusted according to the viscosity and volatility of the test liquid.

Carbon fiber composite standard volume test measures

For the CFVS, it can be observed that the residual volume is constant for drainage times greater than 30 s. This is explained by the inner surface of this VS being very smooth and the fluid flowing in full. Indeed, in the CFSVM, some of the residual volume is retained in the valves.

Residual volumes that may be contained in the 3 × "1/4 turn" ball valves of the CFVS are not relevant when observing *in-situ* test results because, in the case of the two discharge valves (main measure vessel and measurement tube vessel) where it is possible for liquid to be trapped in the valve housing, while the valves are being opened for discharge, liquid remaining in the ball housing after the discharge is complete has no contact with the next batch of liquid delivered into the CFVS and therefore cannot interfere with the measurement of final contained volume of the incoming liquid in the measurement tube.

If desired, virtually all the fuel held in the ball housings may be drained out by rapidly opening and closing the ball valves towards the end of the each drainage period. In a similar manner, any droplets of water trapped in the 12 mm transfer tube ball valve, in the course of the calibration procedure, may be released by gently closing, opening and closing again the transfer tube valve once after the volume released from the main measure vessel passes into the measurement tube.

In order to draw some conclusions about the residual volume, differences are compared in Table 8, between the values of the two fuels with respect to the water, after 30 s of drainage time and for a temperature of 20 °C, for the two types of VS.

Two main observations can be made from Table 8. First, the residual volumes of the CFVS are greater than those of the SSVS. This is due to an accumulation of fluid in the valves. This is also explained by the lack of evaporation associated with this kind of VS. The second observation is that the residual volume when using diesel is always greater than when using petrol. This is due to the different physico-chemical properties of the fuels.

Evaporation tests at different temperatures

As the influence of the physico-chemical properties of the fluids was clearly evidenced, it turned out to be

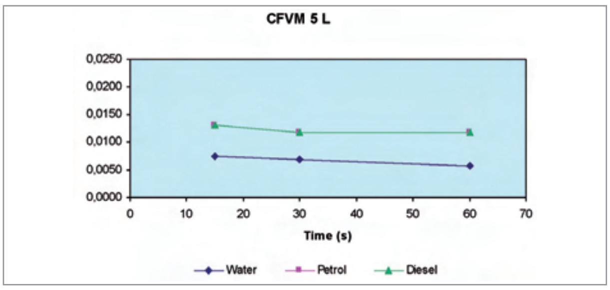

Figure 7 Residual volume of the 5 L capacity CFVS

Table 8 Difference between the residual volume using water and the fuels (L), with a 30 s drainage time

SVM	Petrol	Diesel
5 L SS	– 0.002	+ 0.004
20 L SS	– 0.008	+ 0.004
5 L CF	+ 0.005	+ 0.006
20 L CF	+ 0.003	+ 0.011

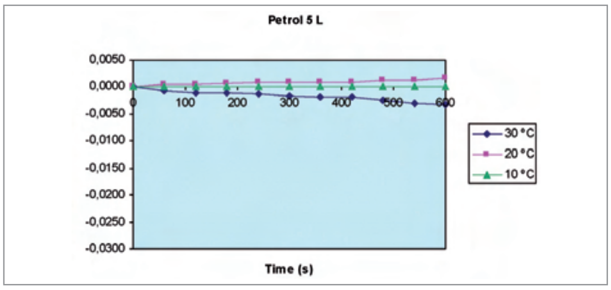

Figure 9 Evaporation tests with petrol - 5 L

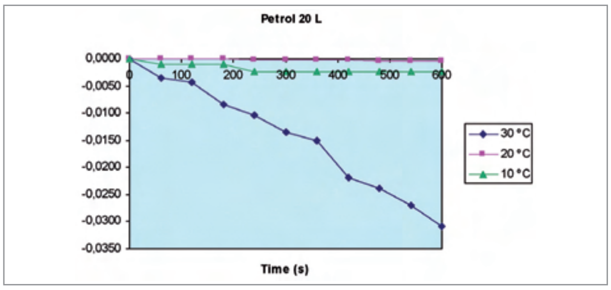

Figure 10 Evaporation tests with petrol - 20 L

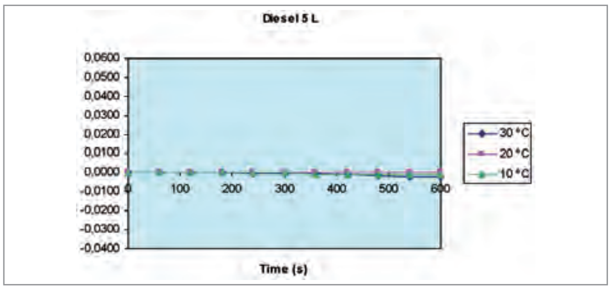

Figure 11 Evaporation tests with diesel - 5 L

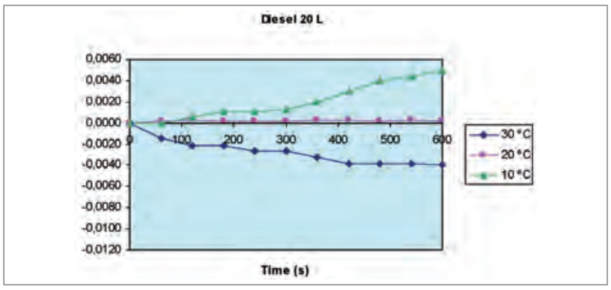

Figure 12 Evaporation tests with diesel - 20 L

necessary to perform evaporation tests on the VS of the 5 L and 20 L capacities. The VS were filled to their nominal volume with petrol and diesel, at various liquid temperatures, at constant ambient humidity and pressure. The test consisted of measuring the variation in volume during 600 s. The results are displayed in Figures 9-12.

Stainless steel standard volume test measure

The main observation from the previous Figures is that the quantity of evaporated fluid is an increasing function of the temperature and this function depends on the type of calibration fluid. Indeed, for higher temperatures, the greater the exposure time of the fuel-air and the greater the capacity of the standard volume test measure, the greater the amount of liquid that evaporates. This is particularly observed for petrol in the SSVS of 20 L where evaporation is maximum 0.15 %. For lower temperatures and higher humidity, there is absorption of water molecules causing an increase in volume.

As a consequence of these observations, one must be aware of the time spent while testing the fuel pumps, in case of higher temperatures and humidity.

Carbon fiber composite standard volume test measures

No evaporation in both 5 L and 20 L CFVS was observed, with both petrol and diesel because of the two-vessel construction.

Concluding remarks

In field measurements, the calibration conditions of the standard volume test measures used must strictly comply, in order to avoid incorrect assessment of the metrological state of equipment under test.

This paper describes several comparative tests that were performed on the standard volume test measures used in the verification of fuel dispensers, using three types of liquids: water, petrol and diesel, and with two types of VS.

After analyzing the results, it appears that a typical SSVS that comprises a shorter length, larger diameter neck with consequent lesser resolution exhibits a larger uncertainty compared to an equivalent volume CFVS equipped with a fine resolution measurement tube.

The two-wheel trolley from which one or more CFVSs may be suspended in a balanced manner as they are moved about the test site, also allows individual test measures to be accurately levelled when observing test results and provides fast and efficient discharge and drainage when the tests are completed, through bottom discharge valves in each test measure and a flexible, transparent hose system.

SSVS are heavier and more difficult to handle when full of fuel but more compact and easier to store in service vehicles or back at base when separated from their transport device.

Tests showed that SSVS are more susceptible to ambient conditions such as high temperature and high humidity.

In CFVM, no evaporation of liquids was identified. However, there was a decrease in the volume in the gravimetric calibration using water, petrol and diesel, due to improper accounting of the residual value, which was in the valves and not inside the body of the container.

In the volume calibration of this type of container and in its use *in-situ*, no decrease in volume with the liquid happens because the residual volume is not included in the mathematical model. As it is only considered in the laboratory procedure, this phenomenon does not influence the results.

Thus, both stainless steel and carbon fiber VS are suitable for the verification of fuel dispensers since the specifications for calibration are met.

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WINE

The role of Portuguese legal metrology in the field of oenology

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Abstract

This paper presents a brief overview of the Portuguese wine and vineyard sectors, focusing on the traceability chain to Portuguese national measurement standards. Brief descriptions are given of the measuring instruments used in legal and applied metrology, and of the quality control of wine production within the framework of Portuguese metrological requirements and European Community Directives.

1 Introduction

Portugal has a long-standing tradition in the export of wines: since the XVI century as an organized activity, but with Roman origins since the 1st century B.C.

The Portuguese wine growing sector is very important for the national economy both by tradition, and also because there are excellent natural and unique conditions; it represents 14 % of total agricultural production.

The trade balance has a positive evolution and table wine represents 65 % of all exports, with a value of 50 % for Porto Wine.

According to information from the Portuguese Institute of Vine and Wine, between 2000 and 2008 Portugal presented an average export balance of 439 M€/year, with a value of 547.8 M€ for the period January to September 2008.

The European Union (EU) absorbs 70 % of these exports, the French and United Kingdom markets alone accounting for 1/3 of total EU shipments.

1.1 Trade balance

The type of wine produced is correlated with each region, mostly from specific grapes selected over the years, and also with the type and production quantity of the vineyards. The Portuguese distribution of wine production is presented in Figure 1 in terms of geographical regions and Table 1 shows the corresponding volume of wine produced between 2000 and 2008, with a forecast for 2009. Wine from the Douro region (the origin of Porto wine) takes first position in terms of volume production. Total production of wine decreased in 2007, with a similar forecast for 2009.

Table 1 Evolution of total production by geographical region

Geographical region	2000/2001	2001/2002	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009 (*)
1 Minho	880.865	1.446.497	835.745	843.175	987.715	939.564	937.605	710.625	732.494
2 Trás-os-Montes	255.321	253.730	224.223	216.345	225.787	255.798	232.042	98.302	104.676
3 Douro	1.459.865	1.956.731	1.412.142	1.726.461	1.645.627	1.743.865	1.717.728	1.443.429	1.369.912
4 Beiras	1.202.146	1.390.412	1.102.113	1.211.920	1.196.325	1.353.938	1.337.992	660.095	728.957
5 Ribatejo	744.062	592.467	833.643	883.672	845.425	685.319	639.747	670.640	514.352
6 Estremadura	1.305.665	1.162.184	1.234.546	1.125.300	1.294.856	1.177.088	1.195.983	1.056.407	930.973
8Terras do Sado	329.404	262.324	347.621	426.611	373.125	338.204	428.488	418.989	336.003
7 Alentejo	434.173	646.422	594.135	817.176	825.709	693.364	961.721	930.452	803.417
9 Algarve	13.817	14.723	20.231	30.962	24.107	27.955	31.672	27.588	23.572
10 Madeira	62.429	49.106	51.084	48.627	41.213	42.656	49.245	45.592	41.231
11 Açores	21.996	14.832	21.305	9.563	21.339	8.493	10.482	12.091	10.000 (**)
Total (hL)	6.709.743	7.789.427	6.676.787	7.339.811	7.481.228	7.266.244	7.542.706	6.074.212	5.595.587

(*) Provisory values 2008-12-21
(**) Forecast 2008/2009
Source: IVV, IP

Figure 1 Portuguese geographical indications (Viniportugal)

Concerning the evolution of exports by destination country, Table 2 shows the trade balance from 2000 to October 2008 with a non-linear evolution. There was an increase in the economic balance between 2000 and 2004, and the 2007 exports value shows the best year for the sector.

1.2 The culture of grapes

All over the world, grape culture is common practice in the agricultural sector (see Table 3). According to information published by the International Organization of Vine and Wine (OIV), seven EU Member states are included in the top fifteen wine producing countries worldwide, with Portugal taking 10th place. Regarding wine consumption, Portugal takes 11th place, with France holding the top position.

The EU is the leader for the total world wine market, in terms of area (45 %), production (60 %), consumption (60 %) and international trade.

2 Institutional reform of the wine growing sector

In line with Portuguese legislation, since 2004 the wine growing sector has been restructured, focusing on the recognition and protection of geographical regions and origin designations. As a result, a major improvement in production conditions was visible with positive quality requirement consequences for consumers. Certification control was also reinforced by means of certification organizations, and the production of wine of certified higher quality increased. In this field, there is a governmental body with the authority to certify national wines and define policy and regulations.

There are several trade organizations whose aim is to promote Portuguese wines on both the domestic and certain international markets, but all products must bear the approval mark of the Institute of Vineyards and Wine.

One of Portugal's aims is to export to the global EU market; to fully accomplish this, Portugal has improved its accreditation according to ISO/IEC 17025 for those laboratories that offer support to the wine growing sector. In this way, quality assurance and measurement traceability has a strong influence on the final product, and this requirement has positive consequences on the balance of exports.

3 Legislation and reference documents

In the context of commercial transactions and control operations, the laboratories of wine and grape companies carry out quality tests, which are covered by national regulations and international standardization.

In Portugal, this practice was put into force supported by the Portuguese Institute for Quality (IPQ), in cooperation with accredited laboratories and regional metrology offices. All the requirements for these practices are in agreement with the national regulations for metrological control, the procedures are assessed regularly, and the measuring instruments concerned are traceable to national standards.

3.1 European Commission regulations

The European Commission has published a number of regulations that were adopted by national legislation and applied in the field of oenology and wine growing. This legislation covers a broad range of applications such as production control, grape quality, labeling, prepackage conditions, etc.

Table 2 Evolution of exports by destination country (€ 1000)

COUNTRY	2000	2001	2002	2003	2004	2005	2006	2007	2008 (Jan Out)
ANGOLA	8.201	12.292	15.714	24.937	29.396	33.376	40.900	47.916	42.794
UNITED KINDGOM	17.928	19.793	18.715	16.563	17.355	21.105	18.880	22.108	16.566
FRANCE	10.722	10.052	17.259	30.955	26.854	18.996	18.723	20.426	15.736
U.S.AMERICA	15.536	16.532	17.608	13.288	14.018	15.520	16.626	18.985	15.400
GERMANY	12.736	10.922	10.490	11.620	15.134	12.108	13.788	13.810	14.390
CANADA	7.547	7.604	6.984	7.338	8.362	9.834	11.763	13.546	14.037
SPAIN	15.207	6.035	8.211	10.318	8.230	7.093	10.805	15.264	13.448
BRAZIL	12.023	11.635	7.128	7.751	7.931	10.051	12.928	14.163	12.180
SWISS	5.179	5.311	6.381	6.582	7.739	7.322	9.390	11.573	11.391
ITALY	5.420	5.544	7.726	15.424	18.886	6.535	6.728	12.232	6.604
SWEDEN	8.023	6.371	4.998	4.937	6.690	7.126	7.451	6.797	6.127
BELGIUM	5.229	4.847	4.943	5.581	5.117	7.354	6.342	6.001	5.409
NORWAY	3.425	3.327	3.993	4.508	4.996	4.170	6.056	5.978	4.505
LUXEMBURG	3.419	3.404	3.661	3.620	3.725	3.999	4.133	4.366	4.093
OTHERS	31.991	28.199	27.411	28.512	32.184	32.023	37.267	45.896	37.412
Total (€)	162.586	151.868	161.222	191.936	206.615	196.612	221.782	259.062	220.091

In the context of commercial transactions and control operations, EU methods for testing wine allow methodologies to be made uniform in order to ensure accuracy and comparability of information.

Concerning the testing of wines, the EU harmonized the methods in Commission Regulation no. 2676/90 of 17 September 1990. Despite the fact that it has been amended several times since, this document was adopted as a reference to establish a regulation for the wine industry in terms of methods for testing wine. These methods are compulsory for all commercial transactions and all verification procedures, however in view of the generally limited wine testing facilities, a limited number of standard procedures were admitted, thus enabling the competence of national authorities to be established.

With this approach, chemical-physical testing is performed on wine samples, such as measurement of density, evaluation of the sugar concentration in grape musts by refractometry, alcoholic strength by volume, etc. Therefore, it is possible for researchers to provide information on what grape cultures can be grown, how to grow them, how to manage pests, different soil or water types, how grapes should be managed to achieve the desired flavor at maturity, what wine flavor profile can be expected, how consistent wine quality can be achieved, etc.

4 Measuring instruments

The IPQ has the competence to assure the traceability of measurements by calibration and certification services, and metrological control activity.

Table 3 Culture of grapes (OIV 2002)

Continent/Country	Area (km^2)	Vineyard area (km^2)
Africa	30.2 M	3 250
South Africa	1.0 M	1 290
America	42.0 M	9 500
USA	9.6 M	4 150
Argentina	2.7 M	2 080
Chile	756.0 K	1 840
Asia	43.8 M	16 100
Turkey	784.0 K	5 750
Iran	1.6 M	2 860
China	9.5 M	3 900
Oceania	9.0 M	1 760
Australia	7.7 M	1 590
New Zealand	270.0 K	170
Europe	10.5 M	47 850
EU	4.3 M	35 150
Bulgaria and Romania	340.0 K	3 510
World		78 760

According to the methodology of testing applied (see Table 5) some instruments must be submitted to calibration or verification, according to reference standards and OIML Recommendations. For this type of operation, only refractometers are covered by national legislation. Other measurement devices are covered by the rules of the national accredited body IPAC.

4.1 Density hydrometers

Hydrometers are liquid density measuring instruments commonly used in many applications, whose traceability to the SI is provided by the National Metrology

Table 4 Amended of CE nº 2676/90

Date	Official Journal/EC	Object
1991-08-02	L 214; 2348/91	Establishing a databank of the results of testing of wine products by nuclear magnetic resonance of deuterium
1992-09-12	L 266; 2645/92	Formal aspects
1995-01-17	L 11; 60/95	Formal aspects
1996-01-19	L 14; 69/96	Formal aspects
1997-05-07	L 117; 822/97	Description of the method for determination of the isotopic ratio of the water content in wines.
1997-10-04	L 272; 1932/97	Amended of EEC no. 2348/91
1999-04-14	L 99; 761/99	1) Chapter 20 (D-malic acid) is replaced by Annex I 2) Chapter 38 (Cyanide derivatives) is replaced by Annex II 3) Annex III is added as Chapter 44
2000-07-31	L 194; 1622/2000	Detailed rules for implementing Regulation (EC) No. 1493/1999 on the common organization of the wine market and establishing a Community code of oenological practices and processes
2001-08-07	L 212; 1609/2001	Amended from EEC no. 1622/2000
2003-03-11	L 66; 440/2003	1) Dosage of D-Malic acid (D(+)-Malic Acid) in wines with low levels 2) Determination by isotope mass spectrometry of the 13C/12C ratio in wine ethanol or ethanol obtained from the fermentation of musts, concentrated musts or rectified concentrated musts
2004-01-27	L 19; 128/2004	Validated method for determination of the alcoholic strength of wines using a hydrostatic balance
2005-03-02	L 56; 355/2005	Amendment of chapter 3 of the Annex to Regulation (EEC) No. 2676/90, "Alcoholic strength by volume"
2005-08-06	L 205; 1293/2005	Amendment of chapter 37: Measuring excess pressure in sparkling and semi-sparkling wines

Laboratories. Before using them for the first time, and periodically thereafter, calibration of these devices must be carried out against known and internationally recognized measurement standards.

Measurement of liquid density plays a major role in the quality assurance of wine production processes. Besides other measurement methods (see Table 5), the use of hydrometers is common practice and is employed by the majority of industrial laboratories for density measurements. There are some reasons for this, such as facilities for measuring, price and time. A hydrometer is a measuring instrument with a cylindrical glass configuration that is used to measure the sugar content of wine (or must) among other multiple applications. The instrument is floated in a test tube containing the wine or must (see Figure 2). As the density of the liquid varies with the sugar content, the flotation of the hydrometer in the wine or must will vary according to the amount of sugar.

The Portuguese laboratories of wine growing companies have several hydrometers that are traceable to IPQ by calibration. The maximum permissible errors at any value on the scale are given in Table 6.

Each of the five main series of hydrometers covers a total range of 600 kg/m^3 to 2 000 kg/m^3; their dimensions, graduation lines, scale divisions, materials and workmanship shall conform to the requirements given by the various reference standards [5,6]. All of those hydrometer characteristics are verified through calibration, at a reference temperature.

IPQ realizes about 150 hydrometer calibrations per year.

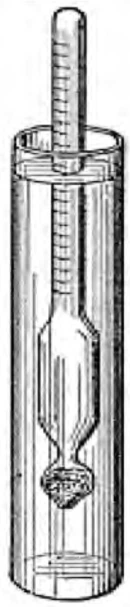

Figure 2 Hydrometer

Table 6 Maximum permissible errors for hydrometers

Series	Maximum permissible error (ISO 649)	
	kg/m^3	g/ml
L20	± 0.2	± 0.002
L50	± 0.5	± 0.0005
M50	± 1.0	± 0.001
M100	± 2.0	± 0.002
S50	± 2.0	± 0.002

4.2 Alcoholmeters

An alcoholmeter is a hydrometer which is used for determining the alcoholic strength of liquids. These types of instruments are used for the determination of the ethanol content of simple mixtures of water and ethanol, whose metrological classification is related to the measured quantity, namely:

- Type 1: alcoholmeters graduated in percentage of ethanol by volume at 20 °C;
- Type 2: alcoholmeters graduated in percentage of ethanol by mass at 20 °C;
- Type 3: alcohol hydrometers graduated in kilograms per cubic meter at 20 °C.

For obvious reasons, alcohol hydrometers play a key role in the field of oenology and wine growing. The OIML and ISO published OIML R 44 and ISO 4801 respectively for this type of measuring instrument including the requirements for alcoholmeters, such as materials for the instrument's constitution, dimensions and markings. The instruments are graduated in accordance with the International Alcoholometric Tables published by the OIML (R 22). These tables give the relation between the density versus the composition of the ethanol solution, which has applications in many fields of chemical and food industries. One advantage of this type of tables is the correlation between the surface tension and the density of the ethanol solutions at different concentrations.

According to the minimum distance between the centers of adjacent graduation lines, alcoholmeters have a class of accuracy. The maximum permissible errors (mpe) for verification (OIML R 44) and testing (ISO 4801) are related to this classification.

All these alcoholmeter characteristics are verified by calibration, at a reference temperature. IPQ realizes about 60 alcoholmeters per year.

Table 5 Testing methods performed by IPQ

Test	Method	Reference Document (other than OJEC no. 272/90)
Density	Pycnometry (reference) Hydrometry	ISO 3507:1999 ISO 649-1:1981 ISO 649-2:1981
Refractometry	Refractometer	OIML R 124:1997 OIML R 142:2008
Alcoholic strength by volume	Pycnometry (reference) Hydrometry (usual) Electronic densimetry (U-tube)	ISO 3507:1999 ISO 4801:1979 ISO 15212-1:1998 OIML R 44:1985 ISO 15212-2:2002

4.3 Refractometry

Refractometers are instruments to measure the refractive index using the phenomenon of light refraction. According to the most common definitions, the refractive index n of a homogeneous substance is the ratio of the speed of light in a vacuum to the speed of light in the substance concerned (see Figure 3).

One important application of refractometry in the field of metrology is the measurement of the

Table 7 Classification according ISO 4801

Class	Minimum mean scale spacing (mm)	Type	mpe
1	1.5	1, 2	One half scale interval
2	1.05	1, 2, 3	One scale interval

Table 8 Classification according to OIML R 44

Class	Minimum mean scale spacing (mm)	mpe
1	1.5	One half scale interval
2	1.05	One scale interval
3	0.85	

sugar content of grape must, which allows the alcohol concentration of the produced wine to be predicted. The refractive index for grape must and sugar solutions is expressed relative to air and white light. It is a dimensionless quantity (dimension 1).

Within the framework of the Portuguese Metrological System, a regulation was brought into force in 1992 that established the operational procedures as well as the requirements of the National Legal System. Consequently, all refractometer types approved by IPQ are subject to legal verification, which is undertaken according to OIML R 124:1997 [7]; in R 124 standards are prepared and used to carry out tests for metrological control and to calibrate instruments before and after the tests performed using vintage musts.

The chemical-physical principle applied is related to the must fermentation, which produces a representative quantity of alcohol, where the sugar concentration is proportional to the expected alcohol content, in terms of percentage volume of alcohol (% vol).

IPQ realizes about 50 refractometer calibrations per year. Concerning metrological control and legal metrology, the role of IPQ is to improve the scope of application of national legislation by assuring the type approval of refractometers, to realize metrological verifications, and to survey the qualified bodies that carry out periodic verification.

Portugal has more than 100 refractometers which are submitted to legal verification in the field of oenology.

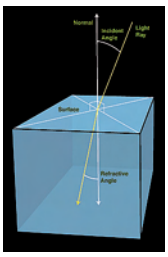

Figure 3
Angles of incidence and refraction (3D)

5 Conclusions

The sector of wine growing and oenology plays an important role in the Portuguese economy. The last decade has been a key period for the evolution of quality assurance for this type of industry, and over this period an increase in the number of accredited wine laboratories was observed with a parallel voluntary demand for calibration services. In this paper, the metrological application of three different types of instruments was described in the wine industry, with an impact on legal and applied metrology. ■

6 References

[1] European Commission Regulation No. 2676/90 of 17 September 1990

[2] ISO 15212-1:1998 Oscillation-type density meters — Part 1: Laboratory instruments

[3] ISO 15212-2:2002 Oscillation-type density meters — Part 2: Process instruments for homogeneous liquids

[4] ISO 4801:1979 Glass alcoholmeters and alcohol hydrometers not incorporating a thermometer

[5] ISO 649-1:1981 Laboratory glassware — Density hydrometers for general purposes — Part 1: Specification

[6] ISO 649-2:1981 Laboratory glassware — Density hydrometers for general purposes — Part 2: Test methods and use

[7] OIML R 124:1997 Refractometers for the measurement of the sugar content of grape musts

[8] OIML R 142:2008 Automated refractometers: Methods and means of verification

[9] OIML R 44:1985 Alcoholmeters and alcohol hydrometers and thermometers for use in alcoholometry

[10] Official Journal of the European Communities no. 272/90

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WEIGHING

Belt weighers:

Significance of the revision of OIML R 50

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Until now belt weighers (continuous totalizing automatic weighing instruments) have been used only for a restricted number of applications due to their limited accuracy.

The forthcoming OIML R 50, the revision of which was launched in 2007 by OIML TC 9/SC 2 *Automatic weighing instruments* (secretariat Morayo Awosola, National Measurement Office - NMO, UK), however, also aims at introducing a higher accuracy class, which might open new fields of use and thus result in an extended number of belt weighers to be used in the future.

If this is the case, they may become more interesting for producers of weighing instruments as well as for users. At the same time there is an adaptation of testing rules to the level of other OIML Recommendations on weighing instruments (especially EMC) and a new approach to consider the durability of the metrological properties.

These developments may be of interest to a larger group of persons dealing with weighing instruments. These persons should be informed of, and have the opportunity to make their contribution to the discussions. Since lately the PTB has been faced with a relatively large number of manufacturers applying for type approval certificates that are based on tests according to OIML R 50, the PTB - with the support of the TC 9/SC 2 Secretariat - believes it is worthwhile to inform both manufacturers and users already at this stage of the possibilities and challenges OIML R 50 may pose in the future.

Some new requirements and devices proposed may make new technical solutions necessary. Manufacturers, probably as well as users, should have the chance to see what awaits them, perhaps seizing the chance to contribute to the discussions.

So this article does not intend to describe testing of belt weighers nor their measuring principle (for information on the measuring principle and general considerations with regard to testing, readers may refer to OIML Bulletin No. 98, March 1985); rather, it seeks to highlight the background of the ongoing revision of OIML R 50:1997 [1]. It also draws readers' attention to possible future developments, showing the essentials of the ***present*** state of the revision.

Since 1997, in addition to microprocessor-based instruments, software-based systems on open platforms (PCs) or on embedded systems (operating systems such as Windows CE) have also become more and more dominant, while at the same time requirements on EMC (electromagnetic compatibility) have become more severe. With the revision of OIML R 76 *Non-automatic weighing instruments* [2] in 2006 it became obvious that R 50:1997 was no longer up to date. So OIML TC 9/SC 2 decided to revise R 50:1997 in order to adapt it to the technical state-of-the-art of R 76:2006. The following paragraphs describe the present state (May 2009) of the revision work.

1 Amendments with regard to EMC (Electromagnetic Compatibility)

EMC nowadays plays a more important part than ever. The number of sources emitting electromagnetic fields has been increasing for many years now. Not only the number of mobile phones and the corresponding necessary networks but also the number of applications of wireless technology (e.g. computer networks, wireless electronic thermometers) has increased. Liberalization of the radio communication market gave way to a less restricted use of walkie-talkies and the like. In some parts of Europe there has been and still is an intensified discussion on what the disturbance threshold of weighing instruments should be and whether the aspect of fraud and manipulation by means of electromagnetic sources affecting the weighing instruments should be taken into account. Moreover, there is a shortcoming in R 50:1997 with a view to guidance on disturbances and their intensity. All these aspects have led to R 50 being revised with regard to EMC requirements.

The surge test simulates the secondary effects of lightning strikes, yet, was for some reason not included in the 1997 edition of OIML R 50 at all. This did not seem very reasonable to members of TC 9/SC 2 because belt weighers are normally mounted outside buildings and cable length often exceeds 30 m, the latter being a criterion defined by the IEC (International Electro-technical Commission) as making a surge test indispensable. As a consequence this test has been introduced into OIML R 50 as a completely new test.

The "AC mains short time power reductions" test replaces the "voltage dips and short interruptions" test. For this test the reference is still IEC 61000-4-11 [3] (1000-4-11), however, 1000-4-11 has been developed further (partly new quality of test) and the severity level has been increased. While formerly the amplitude was decreased to 50 % and 100 % for two and one half cycles respectively, it is reduced to 80 %, 70 %, 40 % and 0 % for a time of up to 250 cycles (in extreme cases meaning a complete dropout for 5 seconds). Most electronic weighing instrument indicators would react by a shut-down due to the failure of the supply voltage. Belt weighers, yet, shall be able to stop the conveyor belt, in the event that weighing is no longer possible, a problem that has to be addressed by technical means.

The test on sensitivity to radiated electromagnetic fields has been adapted to OIML R 76:2006 and IEC 61000-4-3 [4]. This means testing at frequencies up to 2000 MHz at a field strength of 10 V/m. The lower range (below 80 MHz, down to 150 kHz) is now covered by a different test in accordance with IEC 61000-4-6 [5] unless it is a battery operated instrument without any I/O ports. For the latter instruments the field test as per IEC 61000-4-3 is performed at frequencies down to 26 MHz.

2 Amendments with regard to software requirements

The problem of securing metrologically relevant software against fraud and modification after verification is not mentioned at all in the 1997 edition of OIML R 50. However, software involved in the measuring/totalization process has to be considered as an essential part of a belt weigher. Then, of course, the software shall be identifiable and secured against replacement or modification after verification and sealing of the instrument. Software matters are now addressed within a dedicated chapter entitled “software”, which deals with “software information submitted with software controlled instruments” and with “security of legally relevant software”. Security of software is important due to the fact that the measurement on the belt weigher is normally not repeatable. When, for example, ships are unloaded the material weighed by a belt weigher is fairly distributed over a large territory and cannot be re-collected in case of doubt. The second reason is the large quantities that are weighed and of which the value accumulates, even with cheap material, to a very large amount. For that reason manipulations could be tempting for individuals involved in the weighing process or in the commercial transaction linked to it. In Europe, WELMEC Guide 7.2 [6] on software thus assigns a relatively higher risk class to belt weighers: while other weighing instruments are assigned to risk classes B and C of that Guide, belt weighers are either assigned to risk class C or to risk class D. This fact shows that European OIML members (of which most are members of WELMEC WG 7) are aware of the higher risk of fraud with belt weighers. Consequently, basic concepts in WELMEC Guide 7.2 found their way into the revision of OIML R 50.

3 Amendments with a view to new devices

While in the past belt weighers could be equipped with a printer, or, an external printer could be connected to them, now, as a substitute to the printer, the incorporation or connection of a data storage device, as already known from OIML R 76, is allowed. Software requirements as mentioned above also apply to data storage devices if they are realized by software, which is nearly always the case.

Apart from adapting OIML R 50 to technical developments already considered in other OIML Recommendations, TC 9/SC 2 also made some belt weigher specific modifications and supplements to OIML R 50.

One is the introduction of the new higher accuracy class 0.2 (orresponding to a maximum permissible in-service error of 0.2 %). In practice this class is very difficult to obtain, amongst others, also because the requirements with regard to zero stability are very high. Belt weighers, however, are subject to severe mechanical and environmental conditions, that also hardly allow higher accuracy classes to be used.

Even more important is the question of whether they do keep their metrological properties over a longer period of time. Thus a new “durability test” has been proposed, considering the often insufficient mechanical quality and stability of the load receptors, which may lead to an insufficient durability of the metrological quality. The test might be performed under laboratory conditions or in-situ. The in-situ test provides the advantage of genuine strains of normal use of a belt weigher, while in the laboratory a simulation set-up must be installed that is able to act on the belt weigher by a variety of strains, such as vibration, dust and others. This would require costly equipment. A disadvantage of an in-situ test is of course that the specific conditions under which an individual belt weigher works might not be representative. For example the belt weigher might be installed within a large hall, while belt weighers are often used in open-air conditions.

Another problem could be the material to be weighed. While the instrument chosen for the in-situ test is conveying and weighing only sand or the like, a belt weigher could also be used for more rough material as rocks and sugar beet acting quite differently on the load receptor and the load cells. However, experience in some countries has shown that belt weighers often lose their original metrological properties after a longer period of use, that period being shorter than the normal period for subsequent verification. This, however, means that over a long period of time the user employs an instrument that does not fulfill the necessary accuracy requirements. Considering the large amounts of material weighed by belt weighers, and thus the large amount of money that is involved, there seems to be no alternative to checking the durability of a belt weigher before finally approving it.

As another new concept, the idea of a family of instruments (corresponding to OIML R 76) has been introduced into the draft OIML R 50 revision. A special subgroup developed rules that suited the special conditions for belt weighers; this could be the beginning of a modular approach, which has to date not been considered at all in the context of R 50.

The proposal for a new so-called "empty belt profile device" allows correct totalizations even over fractions of the total belt length. This device determines the load profile of the empty belt, i.e. it determines the load of any part of the belt acting on the load receptor, considering this variable "dead load" when totalizing. An indispensable prerequisite for using this device is the correct determination of the belt position, so the device must be able to discern some kind of "markings" on the belt. This requirement may pose the most significant problem since optical markings could fade due to wear and tear.

Conclusion

The new OIML Recommendation R 50 will accommodate the most recent developments in the field of EMC and software matters, and will probably open up the way to new areas of use of belt weighers due to a new and better accuracy class. It will take into account the fact that the durability of belt weighers, because they are subject to significant wear and tear, should be checked within the scope of type testing. A step forward will be made to adopting a kind of modular concept, although that concept will be limited in comparison to other weighing instruments.

Acknowledgement

The author wishes to thank Mr. Morayo Awosola, Secretary of OIML TC 9/SC 2, for his excellent work in drawing up the latest draft and listing all members' comments, and hopes that the article will be an aid to analyzing what future may hold for all the interested parties. ■

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KARSTEN SCHULZ
PTB

TC/SC NEWS

OIML TC 12 Meeting

8–10 June 2009

Bled, Republic of Slovenia

CHERYL LIM
National Measurement Institute,
Australia (TC 12 Secretariat)

The sixth meeting of OIML TC 12 *Electricity meters* was hosted by the Metrology Institute of the Republic of Slovenia (MIRS) on 8–10 June 2009 in the beautiful location of Bled. Twenty delegates representing twelve P-Members attended, as well as Mr. Jean-François Magaña, BIML Director. The purpose of the meeting was to continue with the important work of developing OIML Recommendation R 46.

The meeting opened with a welcome from the Chair, Dr. Grahame Harvey (NMI, Australia). Dr Hans Bachmair (PTB, Germany) gave a brief introduction about the history of R 46, since several years had passed since the last meeting of TC 12 at which the 3 CD of R 46 had been discussed. Participants then considered the new 4th Committee Draft revision of R 46 which had been circulated prior to the meeting, together with comments on both the 3 CD and the 4 CD from TC 12 members. The first half of the meeting was dedicated to discussing critical general issues identified by participants, and the second half to addressing specific comments.

Much progress was made due to the high level of technical expertise and cooperation shown by those present. The TC 12 Secretariat would particularly like to thank our generous MIRS hosts, who worked very hard to ensure the smooth running of all aspects of the meeting and even arranged a trip to the mountains where delegates were treated to a traditional Slovenian banquet.

Some of the issues discussed during the meeting are listed below.

Scope and definitions

It was agreed that the revised R 46 will only address active energy meters at this stage, although other types may be considered later. The Secretariats of OIML TC 5/SC 1 and TC 12 will collaborate in updating the definitions for R 46 and D 11 to ensure consistency between the two Publications, as well as with the new edition of the VIM.

Software requirements

The development of smart meters has made software requirements and issues (e.g. software sealing, access to software parameters) extremely important. The BIML is in the process of drafting a document to address these matters, and organized a seminar on smart meters in Croatia immediately prior to the TC 12 meeting in Bled.

Durability requirements

France suggested that draft IEC standard 62059-32-1 may be useful to the Technical Committee and should be considered in drafting the section in R 46 on durability.

TC 12 *Electricity meters* - Composition

P-Members (22)

Australia	Austria	Brazil	Canada	Cuba	Czech Republic
Finland	France	Germany	Japan	Korea (R.)	Netherlands
Norway	Romania	Russian Federation	Serbia	Slovakia	Slovenia
Sweden	Switzerland	United Kingdom	United States		

O-Members (11)

Belgium	Bulgaria	Denmark	Egypt	Hungary	Indonesia
Ireland	Israel	P.R. China	Poland	South Africa	

Harmonics

It was recognized that the effect of harmonics is increasingly important for electricity meters. Australia, Canada, The Netherlands and the United States will jointly investigate what tests are deemed to be most appropriate.

Temperature requirements

There was considerable discussion on the best approach to this matter, in view of the extreme temperature ranges experienced by electricity meters in some countries. Finland was able to provide significant insight into the thinking behind the requirements in the MID, and will be working with The Netherlands and the United States on this area.

It is planned that the 5th Committee Draft will be circulated later this year. ■

14th International Metrology Congress:

A glimmer of hope before the summer!

22–25 June 2009 Paris, France

Sandrine Gazal
Collège Français de Métrologie

Press release – 21 July 2009

The bright orange fitted carpet on the stands certainly grabbed participants' attention, but their general impression and first reactions were very positive. As one delegate put it: "**It was a glimmer of hope in the current gloomy outlook**".

750 participants had registered to attend the whole event, **a 15 % increase over the previous Congress' attendance,** and a further 200 people who had not registered beforehand also visited just the exhibition.

30 % of participants were overseas visitors from 48 different countries - mainly from Europe, but also from North and South America, Africa, the Middle East and Asia.

Once again, the Congress brought together the key actors from the metrological world:

- **59 % were from the industrial sector**: users of measurement tools from all sectors, analysis laboratories, metrology laboratories or materials manufacturers,
- **26 % were from major national and international institutions**: national laboratories of leading European countries, government officials, accreditation institutions, international organizations,
- **10 % came from universities or research institutes**, and
- 5 % were from miscellaneous origins (hospitals, training organizations, freelance, press, etc.).

There were many new features this year, including:

- Six Round Tables that ran through the full course of the Congress with topical themes notably in the fields of business management, environmental and health issues, and future prospects for wireless equipment,
- A **Prize for the Best Conference Presentation**, which was awarded to Mr. Lübbehüsen of GE Sensing, **and a Prize for the Best Conference Poster** which was awarded to Mrs. Goyon of the BIPM,
- Business Sessions providing live discussions in the conference room between service providers/ manufacturers and participants,
- Lunches in the form of a standing buffet, which facilitated interaction and discussion among participants (although some felt slightly nostalgic and missed the traditional sit-down format!),
- Thursday's event was very much appreciated, and exhibitors stayed on until the end and attended the 4.00 pm closing party.

For the first time, we may also have found the right balance in content: the "scientists" said they found the event too "industrial" and on the other hand the "manufacturers" said that it was too "science" oriented! This possibly indicates that the right balance has been struck and in regard to the range of topics discussed, generally participants found that the program was quite exhaustive, varied and "very appealing", although some topics were missing as is inevitably the case!

The Organizing Committee also faced some tough challenges this year, including maintaining registration fees at their 2007 level, which involved making some difficult organizational decisions. But the Committee showed real management skill, building on the experience of previous events and thus succeeding in making the Congress available to the widest audience, despite prevailing global budgetary restrictions.

The fact that this edition of the International Metrology Congress was held in Paris served to make it even more appealing, and attracted a large international audience – indeed, the event is now held in high esteem by our European partners. This has reinforced prospects and opportunities for future developments both in France and abroad.

The Collège Français de Métrologie, as the main operator, is very aware of the fact that participants' expectations are ever increasing, and will dedicate the necessary time and effort to study new opportunities. It expresses its deep gratitude to all the organizations and partners who were present, and for their support of the event:

- The Organization Committee members: Acac, BEA Metrologie, BIPM, Cetiat, Cetim, EA, Euramet, Eurocopter-Group EADS, IMQ, Insa of Lyon, LNE, NPL, OIML and Renault,
- The Premium Sponsors: Stork Intermes and Hexagon Metrology,
- The technical Partners: Endress & Hauser and Trescal,
- The Institutions: the French Ministry for Industry, Economy and Finance, the French Ministry for Culture, and the Ile-de-France Region.

14ème Congrès International de Métrologie :

Le rayon de soleil avant l'été !

22–25 juin 2009 Paris, France

Sandrine Gazal
Collège Français de Métrologie

Communiqué de presse – 21 juillet 2009

La moquette des stands était orange certes … mais l'impression générale et les premiers retours reçus sont très positifs : «**un rayon de soleil dans le contexte morose actuel**» dixit un des participants.

750 participants inscrits, avec accès complet à toute la manifestation, sont venus, soit **15 % de plus que la manifestation précédente**. A ce chiffre s'ajoutent 200 visiteurs extérieurs qui ont fait le tour de l'exposition uniquement.

48 pays différents étaient représentés au Congrès, et **30 % des participants sont issus de pays étrangers**, européens principalement mais aussi Amérique du Nord et Amérique du Sud, Afrique, Moyen-Orient, Asie.

Le Congrès confirme qu'il rassemble tous les acteurs de ce milieu :

- **59 % sont des industriels** : utilisateurs de moyens de mesure dans tout type de secteur, laboratoires d'analyses, laboratoires de métrologie ou fabricants de matériels, …
- **26 % sont issus des grands organismes nationaux et internationaux** : laboratoires nationaux des grands pays européens, ministères, organismes d'accréditation, organisations internationales, …
- **10 % sont des universitaires ou des chercheurs**, et
- 5 % sont d'origines diverses (hôpitaux, organismes de formation, consultants, presse, ..)

Beaucoup de «premières» également pour cette édition, notamment :

- Six Tables Rondes sur l'ensemble du Congrès avec des thèmes très actuels dans les domaines du management de l'entreprise, de l'environnement, de la santé ou des perspectives de moyens sans fil,
- **le Prix de la Meilleure Conférence orale** pour M. Lübbehüsen de GE Sensing et **le Prix de la Meilleure Conférence Poster** pour Mme Goyon du BIPM,
- des Business Sessions qui ont permis des échanges directs en salle de conférence entre prestataires/fabricants et participants,
- les déjeuners de midi, organisés sous forme de buffet, ont généré plus d'échanges et ont permis de densifier les journées … cependant la comparaison avec l'ancienne formule assise a laissé des nostalgiques !
- la journée du jeudi a été très appréciée, les exposants sont aussi restés jusqu'au bout pour profiter de l'apéritif de clôture à partir de 16h.

Pour la première fois aussi, la manifestation semble avoir trouvé sa place : pour les «scientifiques», elle est trop «industrielle» et pour les «industriels», trop «scientifique» … ce qui signifie peut-être que le mélange n'est pas loin d'être bon. Et même si tous les thèmes possibles n'ont pas été abordés, la programmation complète et variée du Congrès est jugée comme «superbe».

La manifestation a également cette année fait la preuve d'une grande maturité et d'une vraie force. Il a fallu faire des choix d'organisation difficiles pour maintenir des tarifs d'inscription au niveau de 2007. Et ainsi faciliter la présence du plus grand nombre compte tenu des restrictions que tout le monde ressent depuis plusieurs mois.

Aujourd'hui, ce Congrès avec son envergure internationale, encore plus marquée par cette édition à Paris, est très envié par ses partenaires européens. Les perspectives d'évolution et les sollicitations, en France et ailleurs sont nombreuses.

Le Collège Français de Métrologie, porteur de l'événement, est conscient des attentes de chacun et prendra le temps nécessaire aux réflexions indispensables qui s'ouvrent ; il souhaite remercier chaleureusement tous ceux qui étaient présents et l'ensemble des partenaires du Congrès :

- les membres du Comité d'Organisation : Acac, BEA Métrologie, BIPM, Cetiat, Cetim, EA, Euramet, Eurocopter-Groupe EADS, IMQ, Insa de Lyon, LNE, NPL, OIML et Renault,
- les Premium Sponsors : Stork Intermes et Hexagon Metrology,
- les Partenaires Techniques : Endress & Hauser et Trescal,
- les soutiens institutionnels : Ministère de l'Industrie, de l'Economie et des Finances, Ministère de la Culture et Région Ile de France.

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WELMEC

25th WELMEC Committee Meeting

Rotterdam, The Netherlands

7–8 May 2009

Tanja Balkovec, WELMEC Secretary

Introduction

The 25th WELMEC Committee meeting was opened by Ms. Nataša Mejak Vukovič (WELMEC Chairperson) who began by thanking Ms. Anneke van Spronssen for hosting the meeting in Rotterdam and for her presentation on legal metrology in The Netherlands.

Following the transfer of the WELMEC Secretariat from Vienna (Austria) to Ljubljana (Republic of Slovenia), the Chairperson gave information on the new WELMEC contact details (see below) and then delegates were introduced to Ms. Tanja Balkovec, the new WELMEC Secretary (see photo).

One of the most important papers presented by Ms. Vukovič was the draft of a new WELMEC Strategy Document entitled *Procedures for WELMEC Activities, Guidelines for WGs, and Management of the WELMEC website*.

It was decided that the finalized strategy document would be drawn up by a small editorial group consisting of the Chairperson, the Vice-Chairperson, and three or four additional volunteers – the group would be presented at the next Committee meeting and would take into consideration Committee meeting discussions and the various views and comments received from Committee Members; voting would take place via e-mail by the end of the current year.

Ms. Vukovič also presented the proposals for MoUs with the EA (*European co-operation for Accreditation*) and the OIML. After some discussion and several changes to the proposed text it was agreed that the MoU with the EA should be signed by the WELMEC Chairperson at the next EA General Assembly (for further information see: www.welmec.org/news.asp#signing).

The Committee took note of the draft MoU with the OIML and asked Mr. J. F. Magana (BIML Director) to draw up a second draft, taking into account the comments expressed by Committee Members during the discussion.

The initiative to start drafting the future MoU between WELMEC and EURAMET was also welcomed by the Committee.

Another topic was the new Associate Members: Albania and Bosnia and Herzegovina gave a presentation about their respective national legal metrology structures, after which they were welcomed to WELMEC as the newest Associate Members.

The Committee agreed on a new rule that in the case of a vote by e-mail, a minimum of 50 % of Committee Members should cast their vote, and additionally there should be no negative votes in order for the vote to be considered valid.

Concerning other activities with organizations in liaison:

- Mr. Daniel Hanekuyk from the European Commission gave information about ongoing work in the EU;
- Mr. Klenovský, representing EURAMET, presented a report on EURAMET activities;
- Mr. Magana gave an update on recent developments in the OIML;
- Mr. Farrugia gave an overview of the activities of EMLMF; and
- COOMET and EA presentations were also made available.

Working Group Reports

Working Group 2

Mr. Richard presented the report and working program on behalf of Mr. Couvreur. The revision of WELMEC Guide 2 Issue 5 was approved.

Working Group 4

Mr. Lindlov, who was confirmed as the Convenor of WG 4, presented the report and working program.

Working Group 5

Mr. Turner presented the report and working program. Mr. Björkqvist presented the outcome of the EPOS inquiry, and the report on the exchange of information concerning the metrological supervision of Units of Measurements was presented.

Working Group 6

Mr. Burnett presented the report and working program. WELMEC Guide 6.3 Issue 2 and the new Guide 6.9 were accepted with minor editorial changes.

Working Group 7

Mr. Richter, who was confirmed as the Convenor of WG 7, presented the report. Mr. Magana suggested conducting a survey of the training of notified bodies and Mr. Richter agreed to take up this task. The revision of WELMEC Guide 7.2 Issue 4 was approved by the Committee.

Working Group 8

The report was presented by Ms. Lagauterie. The proposal to use Guide 8.8 for module G was approved and the e-mail procedure was agreed for the adoption of the next Correspondence Tables (MI-005, MI-006, MI-010).

Working Group 10

The report was presented by Ms. van Spronssen on behalf of Mr. Wim Volmer.

Working Group 11

Mr. Kramer presented the report. WELMEC Guide 11.1 Issue 3 was accepted with minor changes.

Ad hoc Working Group Information Exchange

Mr. Ulbig presented the report.

Delegates attending the 25th WELMEC Committee Meeting in Rotterdam, The Netherlands (7–8 May 2009)

WELMEC Secretary:
Ms. Tanja Balkovec

New WELMEC Secretariat contact details:

Grudnovo nabrežje 17
SI-1000 Ljubljana
Republic of Slovenia

E-mail: welmec.mirs@gov.si

Main decisions of the 25th WELMEC Committee meeting

- Accepted the Chairperson's Report for 2008.
- Approved the financial reports for 2008 and 2009 (accounts drawn up by the previous Austrian Secretariat, including the closing balance ledgers).
- Took note of the transfer of the WELMEC contributions to the account in The Netherlands and thanked G. Freistetter for his work.
- Welcomed Albania and Bosnia and Herzegovina as new Associate Members of WELMEC.
- Took note of the need to elect a new Vice-Chairperson in 2010.
- Approved the setting up of a small editorial group, consisting of the Chairperson, Vice-Chairperson, and three or four additional volunteers to finalize the Strategy Document to be presented at the next Committee meeting, taking into consideration the discussion at the present Committee meeting and the various views expressed by Committee Members.
- Asked the WELMEC Chairperson to finalize the *Procedures for WELMEC and Guidelines for WG activities* to be submitted for e-mail voting by the end of this year, taking into consideration the discussion at the present Committee meeting and the various views expressed by Committee Members.
- Agreed on a new rule that in the case of e-mail voting a minimum of 50 % of Committee Members had to cast their vote, and that no negative votes should be cast, in order to consider the voting as being valid.
- Asked the Chairperson to draw up a questionnaire for WELMEC Members in order to examine possible interest in continuing to use the *Type Approval Agreement* in the identified non-harmonized areas.
- Took note of the schedule to be followed in order to draw up proposals to ensure the MID is revised on time.
- Took note of the ongoing work on:
  - MID developments,
  - NAWI and MID alignment on Decision 768/2008/EC,
  - NAWI codification,
  - Simplification process,
  - Directive on Units of Measurement,
  - Directive 71/316/EEC recast,
  - New Internal Market Package,
  - Services Directive,
  - Energy Efficiency Directive (Mandate to CEN/CENELEC/ETSI),
  - Commission Statement to WELMEC on cooperation.
- Took note of the draft MoU with the OIML and asked Mr. J.F. Magana to take into account the comments expressed by Committee Members when drawing up the second draft.
- Approved the modified MoU with the European co-operation for Accreditation (EA) and authorized the WELMEC Chair to sign this MoU at the next EA General Assembly.
- Approved the revision of WELMEC Guide 6.3 Issue 2.
- Agreed on the e-mail procedure for the adoption of the next Correspondence Table (MI-005, MI-006, MI-010).

LIAISON NEWS

ISO CASCO WG 29

29–30 June & 1 July 2009

Geneva, Switzerland

RÉGINE GAUCHER, BIML

ISO CASCO Working Group 29 has started the revision of ISO/IEC Guide 65:1996 *General requirements for bodies operating product certification systems*. The revision will lead to the publication of a new standard ISO/IEC 17065, which will define the requirements for certification bodies certifying products, services and processes.

The first Working Draft has been circulated amongst ISO CASCO WG 29 members. The comments received were discussed at the meeting held on 29–30 June and 1 July 2009 in Geneva, Switzerland.

On the basis of the conclusions of the meeting, a first Committee Draft will be drawn up and circulated for comments and votes amongst ISO CASCO Members in September 2009 for a three-month consultation period.

The revision of ISO/IEC Guide 65 is closely linked to OIML technical work and in particular to that of:

- OIML TC 3, which is responsible for metrological control;
- OIML TC 3/SC 5 which is responsible for the OIML Certificate System and the MAA and in particular OIML D 29, OIML B 3 and OIML B 10; and
- OIML TC 6 which is setting up a System for prepackages.

The BIML will closely follow the work of ISO CASCO WG 29 and will continue to participate in this important liaison activity to ensure conformity between ISO/IEC and OIML requirements. ■

International Conference Center, Geneva

MAA IMPLEMENTATION

Combined R 49/R 60/R 76 CPR Meeting

R 60/R 76 CPR Meeting

17–19 June 2009 Bern, Switzerland

RÉGINE GAUCHER
Project Leader, BIML

Immediately prior to the fourth R 60/R 76 CPR Meeting held on 19 June 2009 in Bern, the BIML decided to hold a combined R 49/R 60/R 76 CPR Meeting to discuss general issues related to the implementation of the MAA, with the aim of analyzing both the experience gained and the difficulties encountered after four years of implementation, and then proposing suggestions for improvement.

1 Combined R 49/R 60/R 76 CPR meeting

The combined R 49/R 60/R 76 CPR Meeting was held on 17–18 June in Bern at the Federal Office of Metrology, METAS. Twenty-six participants attended, amongst whom:

- R 49 CPR Members, R 60 CPR Members, R 76 CPR Members;
- representatives of OIML TC 9, TC 9/SC 1, TC 3/SC 5 and the BIML; and
- several observers.

The two main issues discussed were:

1.1 The possibility, in a Declaration of Mutual Confidence (DoMC), to take into account results of tests performed by manufacturers of measuring instruments and the conditions to be defined for this

This issue was discussed further to Resolution no. 20 of the 43rd CIML Meeting in order that the CPRs would have the opportunity to make appropriate proposals to be considered by OIML TC 3/SC 5 during the revision of OIML B 3 and B 10.

It is worth highlighting the fact that the tests considered in the discussions were tests performed by manufacturers' testing laboratories which conform to ISO/IEC 17025. These tests are supposed to be conducted by the manufacturer at the request of the Issuing Participant after he has received the application for an OIML MAA Certificate and identified the instrument to be evaluated.

CPR Members agreed to give further consideration to the following proposals:

- requirements shall be the same for any testing laboratory (third-party and manufacturer's testing laboratory);
- requirements for the evaluation of testing laboratories shall be based on ISO/IEC 17025 and OIML D 30;
- OIML D 30 shall be revised to address interpretation and/or requirements to try to prevent any conflict of interest and endeavor to guarantee independence and impartiality of manufacturers' testing laboratories;
- procedures to avoid any conflict of interest, any undue commercial, financial or other pressures which might influence the technical conclusions of testing laboratories shall be defined in the quality management system of the manufacturer;
- procedures shall define the manufacturer's operation with the Issuing Participant in particular to guarantee the identification and integrity of the instrument to be tested;
- mandatory participation in intercomparisons (periodicity to be defined).

CPR Members were invited to provide the CPR Secretariat with additional comments and suggestions to complete the above-indicated inputs at the latest by 30 November 2009.

A synthesis of the proposals will be submitted to the OIML TC 3/SC 5 Secretariat to be discussed at its meeting planned in April or June 2010.

1.2 The maintenance and renewal process of DoMCs

To increase the consistency of the reports and information to be reviewed by CPR Members, the latter suggested that the maintenance process of a DoMC should include:

- the review of an internal report once a year submitted by the Issuing Participant. This report should highlight in particular:
  - results of comparisons;
  - changes in personnel, structures and organization;

- results of management reviews;
- results of internal audits;
- complaints received.

- a review of the accreditation assessment and peer assessment reports of Issuing Participants every five years. Issuing Participants whose testing laboratories are peer assessed will be responsible for organizing their peer assessments every five years under the conditions of OIML B 10-1 and of the MoU between ILAC and the OIML, in particular for the designation of the assessment team. Issuing Participants whose testing laboratories are accredited will be responsible for requiring their National Accreditation Body to include an expert from the ILAC/IAF/OIML List as soon as the relevant scope of the DoMC is included in the assessment. Considering a five year renewal period and the ILAC Guidance, all the testing laboratories will be able to submit at least one accreditation assessment report which includes the relevant scope of the DoMC.

These proposals are based on the procedures applied for the CIPM MRA and will be submitted to the TC 3/SC 5 Secretariat to be considered in the revision of OIML B 10-1.

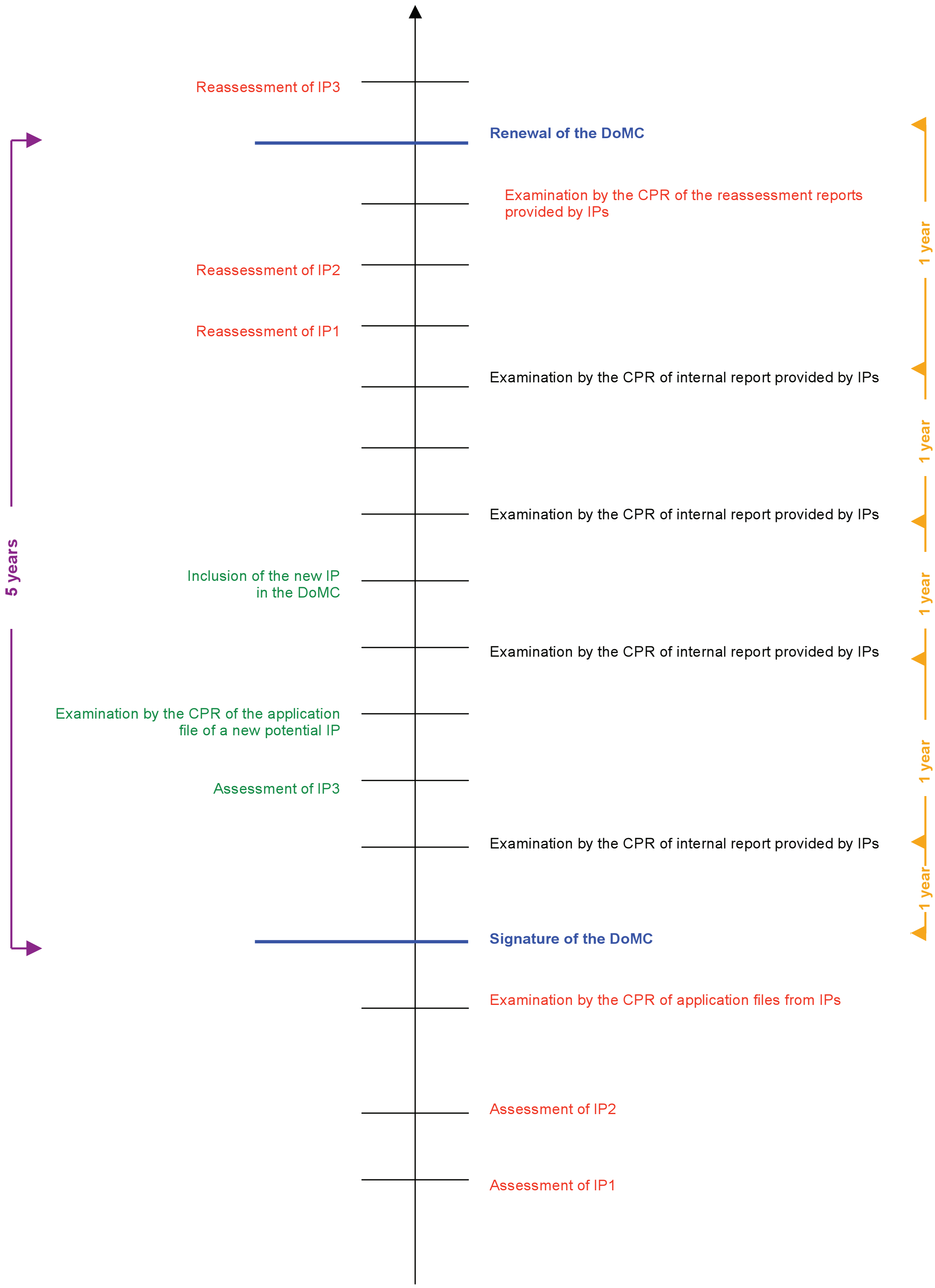
2 R 60/R 76 CPR meeting

The main purpose of this meeting was to examine the new candidacies received for participating in the R 60 and R 76 DoMCs and in particular the application files which were submitted, the accreditation assessments, and the peer assessment reports.

In addition, several other issues were discussed and in particular:

- the revision of the R 60 and R 76 DoMCs specifically to take into account changes in testing capabilities, the means used by Participants to demonstrate their competence, the withdrawal of certain additional national requirements at the request of Participants;
- the examination of candidacies for new technical and metrological experts for OIML R 76;
- the conclusions further to the intermediate documentary assessments of Issuing Participants;
- postponing the deadline for terminating the renewal of the R 60 and R 76 DoMCs to the end of September 2011 (instead of the end of September 2010 to take into account the delay in the intermediate documentary assessment process).

Download the full meeting report here:
http://workgroups.oiml.org/maa/combined-r-49-r-60-r-76-cpr-meeting/draft_minutes_49_60_76_CPR_June2009.doc



Schematic representation of the DoMC maintenance process

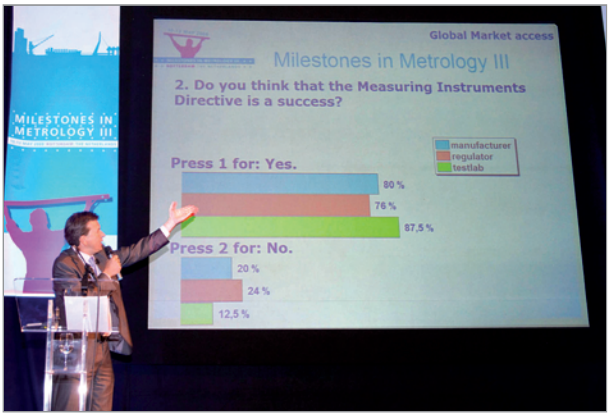
Milestones in Metrology III

A successful meeting between manufacturers, regulators and institutes

Rotterdam, The Netherlands

10–13 May 2009

Pieter van Breugel
Director, NMi, The Netherlands



A staggering 94 % of the participants at the Third Milestones in Metrology Congress stated that they will return for a Fourth Congress

With over 150 participants from 29 different countries, we can safely say that this three-yearly Congress was once again a resounding success. The event was packed with plenary sessions in the mornings and stream sessions in the afternoons, with delegates participating in in-depth discussions in all three streams: *Oil & Gas*, *Traffic*, and *Weighing*.

As is the tradition at the Milestones in Metrology Congresses, the evenings were made up of social events, which - together with the intentionally long breaks between the sessions - gave participants ample time to meet and thoroughly discuss key issues together.

Structure of the Congress

Harmonization is still an important topic, even in the wake of the introduction of the Measuring Instruments Directive (MID), and was therefore the main theme of the first day.

The second day focussed on *Software*, which is becoming increasingly important in measuring instruments, but how should it best be dealt with?

The final day raised the question of *Challenges* in metrology; a number of specific topics such as registration (intellectual property) of the CE marking, and legal metrology in the field of oenology, were presented.

Voting for the future of legal metrology

The Congress culminated in an interactive *Voting the Future* session (see photo opposite). What would happen if the future of legal metrology was in the hands of the 150 *Milestones in Metrology* participants? Every delegate was given the opportunity to express his or her opinion by choosing one of the options suggested, by voting using a wireless voting console. Anonymous voting made the results considerably more reliable, and the excitement of such a session is that all the results were immediately shown 'live' on the screen - meaning that everyone could view and analyze them within a few seconds.

During the *Voting the Future* session the hot topics evoked during the Congress were formulated into propositions.

The first question identified participants as belonging to one of three groups, thus allowing the results of subsequent questions to be better compared. Note the interesting balance: almost half of the audience was made up of manufacturers, and the other half of government officials and testing laboratories:

- Manufacturers (OEM) and suppliers of measuring equipment (48 %);
- Authorities (legislators) (25 %);
- Metrological testing laboratories (notified bodies) (27 %).

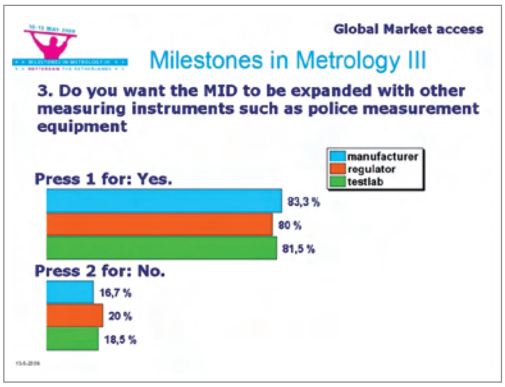
Proposals

The proposals that were submitted mainly focussed on the more sensitive issues of the conference, such as the implementation of the MID in Europe, the global OIML Mutual Acceptance Arrangement (MAA), market

surveillance, further harmonization of regulations, and the use of manufacturers' test data in approvals. The proposals also included a review of the quality of the Congress itself. (For more detailed information and the complete set of voting results, please send an e-mail to milestones@nmi.nl).

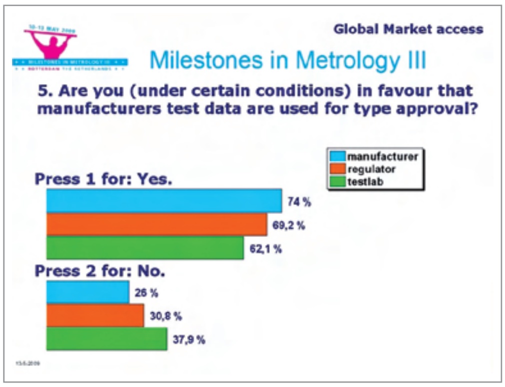
Voting results

Below is a selection of the voting results along with an explanation and interpretation by NMi. The voting results are shown separately for manufacturers, regulators and testing laboratories.



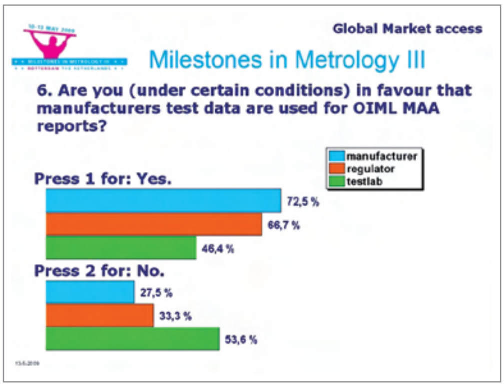
Statement 3

Regulation in Europe is not harmonized for all instruments. For example, requirements for police measuring devices such as speedometer requirements vary per country. Over 80 % of the participants would like to see more instruments included in the MID. This is important as the MID will soon be re-evaluated.



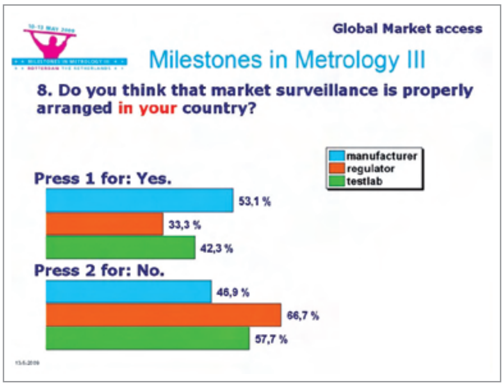
Statement 5

In general, manufacturers would like to have the opportunity to test their own product to obtain type approvals (74 %). In Europe this is permitted in many areas. The vast majority of the participants are European and this is common practice in Europe. The manufacturer is legally responsible for compliance of his products. Combined with market surveillance this is considered an alternative to ensure reliable measurements.



Statement 6

The OIML MAA is an acceptance arrangement for OIML test reports which aims at worldwide acceptance of OIML MAA reports. The current question is if, and under which circumstances, manufacturers' test results can be used in such OIML reports. The manufacturers were in favor and the testing laboratories were divided.



Statement 8

Considering the results of the previous questions about the acceptance of manufacturers' results in admission examination, it was interesting to see how one can trust the current market. A small majority said that the supervision in their own country was not properly organized. Surprisingly, two out of three regulators said that market surveillance was not properly arranged in their country!

Statement 9

It was even more interesting to turn the question around by asking whether the monitoring in neighboring countries was properly organized. More than 95 % of the authorities said that the organization in neighboring countries was *not* well organized. This was a dramatic

result, but we should take into account that in Europe (most voters were Europeans) market surveillance is currently under discussion. Inspections and re-verifications are not harmonized, resulting in different rules in the various countries.

Final statement - Conclusion

For NMi, it is important to know whether the conference was appreciated and whether it filled participants' expectations. The results show that most participants did appreciate the Congress, and so another Milestones in Metrology Congress will therefore be held in 2012. ■

Congress venue: Former Dutch Genever distillery "Hulstkamp", in Rotterdam

OIML AWARD FOR EXCELLENT ACHIEVEMENTS IN LEGAL METROLOGY

Preparations for our Mombasa meetings:

A word from Eberhard Seiler, *OIML Facilitator for Developing Country Matters*

EBERHARD SEILER

It will be my pleasure to attend the 44th International Committee Meeting in Mombasa, and I would be very happy for CIML Members or Representatives from OIML Corresponding Members to contact me there should you wish to discuss legal metrology matters that are of relevance to developing countries with me.

Despite the busy schedule planned for the OIML Kenya meetings, including one Round Table on *Metrological control* and a second being organized for Regional Bodies – plus a Seminar on *Stakes and priorities of legal metrology for trade* in addition to the CIML Meeting itself of course, I am sure that we make time to get together to exchange ideas.

I am also interested in receiving feedback from those of you who have contacted me in the past requesting information so that I can follow progress or help you to resolve any additional issues that may have cropped up in your projects since we discussed them.

During the Mombasa CIML Meeting the first *OIML Award for Excellent Achievements in Legal Metrology* will be made and I am pleased to announce that we have received a number of applications which have been evaluated and sent to the CIML President for his decision.

The winner will be announced during a special ceremony in Kenya, and I am sure that this will provide the impetus needed to encourage developing countries to come forward with their ideas and participate in the global promotion of legal metrology. Hopefully, we will receive even more applications next year – so I look forward to seeing you in Mombasa and to discussing these matters with you. ■

CAFMET 2010: Call for Papers

www.ac-metrology.com

Grand Pyramids Hotel
Mariottia Pyramids Giza - Egypt

19–23 April 2010

Introduction

CAFMET (African Committee of Metrology) is a professional, non-profit organization founded in March 2005 in response to the requirements of African organizations working in the field of metrology.

It is important that the skills developed in Africa be acknowledged, not only for economic development, but also for industrialists in African countries. Thanks to its activities, the African Committee of Metrology contributes to their recognition.

Members

Although the majority of Committee members are industrialists, the Committee is meant for all organizations or people interested in metrology. Since the first international event organized in Casablanca in April 2006, the African Committee of Metrology has seen its membership increase regularly.

Missions of CAFMET

- Promote and spread a metrology culture to organize conferences, seminars, etc.
- Assist African bodies in quality and technical systems, taking into account international standards drawn up by international organizations.
- Create a technical group of African experts.
- Facilitate the participation of African experts in other international organizations and in standardization committees.
- Provide a logistic support in the organization of interlaboratory comparisons.

Third International Metrology Conference

The Third International Metrology Conference in Africa - CAFMET 2010 - organized by the African Committee of Metrology in association with NIS (National Institute of Standards of Egypt), will be a forum for industrials and scientists to share information, ideas and experiences.

The conferences, material exhibitions and technical visits to firms have common objectives:

- promote communication between manufacturers, governmental agencies, universities, institutes of higher education and laboratories dedicated to research and development in the field of metrology industry, quality, environment, safely, health and research;
- present the evolution of metrology and its involvement in industry, quality, the environment, safety, health and research.

For further details please refer to the CAFMET web site where full details are available. ■

OIML Certificate System:

Certificates registered 2009.06–2009.08

Up to date information (including B 3): www.oiml.org

The *OIML Certificate System for Measuring Instruments* was introduced in 1991 to facilitate administrative procedures and lower costs associated with the international trade of measuring instruments subject to legal requirements.

The System provides the possibility for a manufacturer to obtain an OIML Certificate and a test report indicating that a given instrument type complies with the requirements of relevant OIML International Recommendations.

Certificates are delivered by OIML Member States that have established one or several Issuing Authorities responsible for processing applications by manufacturers wishing to have their instrument types certified.

The rules and conditions for the application, issuing and use of OIML Certificates are included in the 2003 edition of OIML B 3 *OIML Certificate System for Measuring Instruments.*

OIML Certificates are accepted by national metrology services on a voluntary basis, and as the climate for mutual confidence and recognition of test results develops between OIML Members, the OIML Certificate System serves to simplify the type approval process for manufacturers and metrology authorities by eliminating costly duplication of application and test procedures. ■

This list is classified by Issuing Authority; updated information on these Authorities may be obtained from the BIML.

Cette liste est classée par Autorité de délivrance; les informations à jour relatives à ces Autorités sont disponibles auprès du BIML.

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V.,
The Netherlands

R60/2000-NL1-02.02
Type 0765 (Class C)
Mettler-Toledo Inc., 150 Accurate Way,
Inman, SC 29349, USA

For each instrument category, certificates are numbered in the order of their issue (renumbered annually).

Pour chaque catégorie d'instrument, les certificats sont numérotés par ordre de délivrance (cette numérotation est annuelle).

OIML Recommendation applicable within the System / Year of publication

Recommandation OIML applicable dans le cadre du Système / Année d'édition

The code (ISO) of the Member State in which the certificate was issued, with the Issuing Authority's serial number in that Member State.

Le code (ISO) indicatif de l'État Membre ayant délivré le certificat, avec le numéro de série de l'Autorité de Délivrance dans cet État Membre.

Year of issue

Année de délivrance

Certified type(s)

Type(s) certifié(s)

Applicant

Demandeur

Système de Certificats OIML:

Certificats enregistrés 2009.06–2009.08

Informations à jour (y compris le B 3): www.oiml.org

Le *Système de Certificats OIML pour les Instruments de Mesure* a été introduit en 1991 afin de faciliter les procédures administratives et d'abaisser les coûts liés au commerce international des instruments de mesure soumis aux exigences légales.

Le Système permet à un constructeur d'obtenir un certificat OIML et un rapport d'essai indiquant qu'un type d'instrument satisfait aux exigences des Recommandations OIML applicables.

Les certificats sont délivrés par les États Membres de l'OIML, qui ont établi une ou plusieurs autorités de délivrance responsables du traitement des demandes présentées par des constructeurs souhaitant voir certifier leurs types d'instruments.

Les règles et conditions pour la demande, la délivrance et l'utilisation de Certificats OIML sont définies dans l'édition 2003 de la Publication B 3 *Système de Certificats OIML pour les Instruments de Mesure.*

Les services nationaux de métrologie légale peuvent accepter les certificats sur une base volontaire; avec le développement entre Membres OIML d'un climat de confiance mutuelle et de reconnaissance des résultats d'essais, le Système simplifie les processus d'approbation de type pour les constructeurs et les autorités métrologiques par l'élimination des répétitions coûteuses dans les procédures de demande et d'essai. ■

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Diaphragm gas meters
Compteurs de gaz à parois déformables

R 31 (1995)

Issuing Authority / *Autorité de délivrance*

Russian Research Institute for Metrological Service (VNIIMS)

R031/1995-RU1-2009.02
Diaphragm gas meter - G1.6, G2.5-1, G2.5-1.2, G4
Durecom Co. Ltd, 540-2, Mongnae-Dong, Danwon-Gu, Ansan City, KR-425-100 Gyeonggi-Do, Korea (R.)

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Water meters intended for the metering of cold potable water
Compteurs d'eau destinés au mesurage de l'eau potable froide

R 49 (2006)

Issuing Authority / *Autorité de délivrance*

Office Fédéral de Métrologie METAS, Switzerland

R049/2006-CH1-2009.01
Family of electromagnetic flow meters intended for the metering of cold water - Type ISOMAG
Hemina SpA, Via Piemonte 1, IT-35044 Montagnana (Pd), Italy

R049/2006-CH1-2009.02
Family of electromagnetic flow meters intended for the metering of cold water - Type ISOMAG
Isoil Industria SpA, Via F.lli Gracchi 27, IT-20092 Cinisello Balsamo (MI), Italy

R049/2006-CH1-2009.03
Family of electromagnetic flow meters intended for the metering of cold water - Type AMFLO MAG Pro
AQUAMETRO AG, Ringstrasse 75, CH-4106 Therwil, Switzerland

Issuing Authority / *Autorité de délivrance*

Laboratoire National de Métrologie et d'Essais, Certification Instruments de Mesure, France

R049/2006-FR2-2008.03
Water meter type M-MKE2 - Accuracy class: 2
Hydrometer GmbH, Industriestrasse 13, DE-91522 Ansbach, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Continuous totalizing automatic weighing instruments
Instruments de pesage totalisateurs continus à fonctionnement automatique

R 50 (1997)

Issuing Authority / *Autorité de délivrance*

National Weights and Measures Laboratory (NWML), United Kingdom

R050/1997-GB1-2009.01 Rev. 1
Milltronics MSI / MMI
Siemens Milltronics, 1954 Technology Drive, CA-Peterborough ON K9J 6X7, Canada

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic catchweighing instruments
Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique

R 51 (2006)

Issuing Authority / *Autorité de délivrance*

National Weights and Measures Laboratory (NWML), United Kingdom

R051/2006-GB1-2009.04
Versa Weigh and VersaGP Checkweighers
Thermo Ramsey Italia S.R.L., Strada Rivoltana km 6/7, IT-20090 Rodano (MI), Italy

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V.,
The Netherlands

R051/2006-NL1-2009.01
Automatic catchweighing instrument - Type: Libra R../.. P...
OCME s.r.l., Via del Popolo, IT-43100 Parma, Italy

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Metrological regulation for load cells (applicable to analog and/or digital load cells)
Réglementation métrologique des cellules de pesée (applicable aux cellules de pesée à affichage analogique et/ou numérique)

R 60 (2000)

▶ Issuing Authority / *Autorité de délivrance*

Laboratoire National de Métrologie et d'Essais, Certification Instruments de Mesure, France

R060/2000-FR2-2009.02 (MAA)
S - Type tension load cell, ZA30X series, with strain gauges, tested as a part of a weighing instrument
Scaime S.A.S, Z.I. de Juvigny, FR-74105 Annemasse Cedex, France

▶ Issuing Authority / *Autorité de délivrance*

National Weights and Measures Laboratory (NWML), United Kingdom

R060/2000-GB1-2009.02
Double-Ended Shear Beam Load Cell
CWC Central Company Limited, 7 Haplada Street, IL-60218 Or Yebuda, Israel

R060/2000-GB1-2009.03
Stainless steel compression strain gauge load cell
Transdutec S.A., CL. Joan Miró 11, ES-08930 Sant Adrià de Besós - Barcelona, Spain

R060/2000-GB1-2009.04
Stainless steel compression strain gauge load cell
Gicam S.N.C Di Carrara Danilo & Co, L.go C. Battisti 9, Piazza XI Febbraio 2, IT-22015 Gravedona (CO), Italy

R060/2000-GB1-2009.05
Strain Gauge Compression Load Cell Type T302x
Avery Weigh-Tronix Ltd., Foundry Lane, GB-Smethwick B66 2LP, West Midlands, United Kingdom

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V.,
The Netherlands

R060/2000-NL1-2009.08 (MAA)
A digital compression load cell - Type: SLC820...
Mettler-Toledo Inc., 1150 Dearborn Drive, Ohio 43085, Worthington, United States

R060/2000-NL1-2009.09 (MAA)
A tension load cell - Type: WLC...
Vishay-Transducers, 8A Hazoran Street, IL-42506 Netanya, Israel

R060/2000-NL1-2009.10 (MAA)
A compression load cell - Type: CPA and CPA SL
Captels S.A., 1 Chemin du Mazet, Z.A.E. des Avants, FR-34270 St-Mathieu de Tréviers, France

▶ Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R060/2000-DE1-2009.01
Strain gauge double bending beam load cell - Type: AMI
Keli Electric Manufacturing (Ningbo) Co., Ltd., N° 199 Changxing Road, Jiangbei District, CN-315033 Ningbo, P.R. China

R060/2000-DE1-2009.02
Strain gauge double bending beam load cell - Type: SB14
Flintec GmbH, Bemannsbruch 9, DE-74909 Meckesheim, Germany

R060/2000-DE1-2009.11
Strain gauge shear load cell - Type: FTP
Laumas Elettronica S.r.l., Via 1 Maggio 6, IT-43030 Basiicanova Parma, Italy

R060/2000-DE1-2009.12
Strain gauge single point load cell - Type: PC2H
Flintec GmbH, Bemannsbruch 9, DE-74909 Meckesheim, Germany

R060/2000-DE1-2009.13
Strain gauge double bending beam load cell - Type: PC46
Flintec GmbH, Bemannsbruch 9, DE-74909 Meckesheim, Germany

R060/2000-DE1-2009.14
Strain gauge double bending beam load cell - Type: PC3
Flintec GmbH, Bemannsbruch 9,
DE-74909 Meckesheim, Germany

R060/2000-DE1-2009.16
Strain gauge shear beam load cell - Type: SQB-SS
Keli Electric Manufacturing (Ningbo) Co., Ltd.,
N° 199 Changxing Road, Jiangbei District,
CN-315033 Ningbo, P.R. China

R060/2000-DE1-2009.17
Strain gauge double bending beam load cell - Type: UDA
Keli Electric Manufacturing (Ningbo) Co., Ltd.,
N° 199 Changxing Road, Jiangbei District,
CN-315033 Ningbo, P.R. China

R060/2000-DE1-2009.18
Strain gauge S-Type load cell - Type: ULB
Flintec GmbH, Bemannsbruch 9,
DE-74909 Meckesheim, Germany

R060/2000-DE1-2009.19
Strain gauge double bending beam load cell - Type: SB6
Flintec GmbH, Bemannsbruch 9,
DE-74909 Meckesheim, Germany

▶ **Issuing Authority / *Autorité de délivrance***
DANAK The Danish Accreditation and Metrology Fund, Denmark

R060/2000-DK1-2009.01
Compression, strain gauge load cell - Type: CA
ESIT Electronik Sistemler Imalat ve Ticaret Ltd Sirketi,
Nisantepe Mah. Fabrikalar, Sk. N° 8 Alemdag,
Umraniye, TR-34794 Istanbul, Turkey

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Nonautomatic weighing instruments
Instruments de pesage à fonctionnement non automatique

R 76-1 (1992), R 76-2 (1993)

▶ **Issuing Authority / *Autorité de délivrance***
Czech Metrology Institute (CMI), Czech Republic

R076/1992-CZ1-2009.01
Non-automatic weighing instrument, accuracy class III - Type: EC series
CAS Corporation, 19 Ganap-Ri, Gwangjuk-Myoun,
Yangju-Si, KR-482-841 Gyeonggi-Do, Korea (R.)

▶ **Issuing Authority / *Autorité de délivrance***
National Weights and Measures Laboratory (NWML), United Kingdom

R076/1992-GB1-2007.09
SW Series non-automatic weighing instruments
CAS Corporation, 19 Ganap-Ri, Gwangjuk-Myoun,
Yangju-Si, KR-482-841 Gyeonggi-Do, Korea (R.)

R076/1992-GB1-2007.09 Rev. 1
SW Series non-automatic weighing instruments
CAS Corporation, 19 Ganap-Ri, Gwangjuk-Myoun,
Yangju-Si, KR-482-841 Gyeonggi-Do, Korea (R.)

R076/1992-GB1-2008.07 Rev. 1
Non-automatic weighing instrument comprising the Torrey PI WI & WI-W Electronic weight indicators connected to a platform incorporating compatible R 60 load cell(s)
Fabricantes De Basculas Torrey S.A. De C.V.,
Ave. Los Andes 605, Col. Coyoacan C.P. 64510
Monterrey, N.L., Mexico, Mexico

R076/1992-GB1-2009.01
KS1-XX
Lesak-Zeman s.r.o., Vranovska 699/33, CZ-61400 Brno,
Czech Republic

R076/1992-GB1-2009.06
Non-automatic weighing instrument designated the B1920 'Baggage Indicator', comprising an operator panel (B1920-OP) connected to a load receptor
Avery Weigh-Tronix Ltd., Foundry Lane, GB-Smethwick
B66 2LP, West Midlands, United Kingdom

R076/1992-GB1-2009.07
Non-automatic weighing instrument designated the Magellan 8502 and 8504 scanner scale
Datalogic Scanning, Inc., 959 Terry Street, US-Oregon 97402, Eugene, United States

R076/1992-GB1-2009.08 Rev. 1
Non-automatic weighing instrument designated the AWB120
Avery Weigh-Tronix Ltd., Foundry Lane, GB-Smethwick B66 2LP, West Midlands, United Kingdom

R076/1992-GB1-2009.09
Non-automatic weighing instrument designated the Oxford/Hoyer Elevate
Joerns Healthcare Limited, High Street, Wollaston, GB-Stourbridge DY8 4PS, West Midlands, United Kingdom

Issuing Authority / *Autorité de délivrance*
NMi Certin B.V., The Netherlands

R076/1992-NL1-2000.10 Rev. 1
Non-automatic weighing instrument - Type: DS-160
Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku, JP-146-8580 Tokyo, Japan

R076/1992-NL1-2007.03 Rev. 1
Non-automatic weighing instrument - Type: SM-100.., SM-5100..
Shanghai Teraoka Electronic Co., Ltd., Tinglin Industry Developmental Zone, Jinshan District, CN-201505 Shanghai, P.R. China

R076/1992-NL1-2008.33 Rev. 1
Non-automatic weighing instrument - Type: DS-560 and DS-561
Shanghai Teraoka Electronic Co., Ltd., Tinglin Industry Developmental Zone, Jinshan District, CN-201505 Shanghai, P.R. China

R076/1992-NL1-2009.15 Rev. 2
Non-automatic weighing instrument - Type: CJ
Shinko Denshi Co., Ltd, 3-9-11 Yushima, Bunkyo-ku, JP-113-0034 Tokyo, Japan

R076/1992-NL1-2009.20
Non-automatic weighing instrument - Type: RH
Ohaus Corporation, 19A Chapin Road, US-NJ 07058 Pine Brook, United States

R076/1992-NL1-2009.23
Non-automatic weighing instrument - Type: DS-200
Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku, JP-146-8580 Tokyo, Japan

Issuing Authority / *Autorité de délivrance*
DANAK The Danish Accreditation and Metrology Fund, Denmark

R076/1992-DK1-2009.01 Rev. 1
Non-automatic weighing instrument - Type: BW / BWS / VW / CW / KW
Taiwan Scale Mfg. Co., Ltd, 282, Sec. 3, Hoping W. Road, TW-Taipei, Chinese Taipei

R076/1992-DK1-2009.01 Rev. 2
Non-automatic weighing instrument - Type: BW / BWS / VW / CW / KW
Taiwan Scale Mfg. Co., Ltd, 282, Sec. 3, Hoping W. Road, TW-Taipei, Chinese Taipei

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Non-automatic weighing instruments
Instruments de pesage à fonctionnement non automatique

R 76-1 (2006), R 76-2 (2007)

Issuing Authority / *Autorité de délivrance*
NMi Certin B.V., The Netherlands

R076/2006-NL1-2009.19
Non-automatic weighing instrument - Type: SM-50xx, SM-54xx, SM-55xx
Teraoka Weigh-System PTE Ltd., 4 Leng Kee Road, #05-03/04/05 & 11, SIS Building, SG-159088 Republic of Singapore, Singapore

R076/2006-NL1-2009.21
Indicator, as a part of a non-automatic weighing instrument - Type: XK3190-A12ss
Shanghai Yaohua Weighing System Co., Ltd, No. 4059 Shangnan Road, Pudong District, CN-200124 Shanghai, P.R. China

Issuing Authority / *Autorité de délivrance*
Physikalisch-Technische Bundesanstalt (PTB), Germany

R076/2006-DE1-2009.01
Non-automatic electromechanical weighing instrument - Type: MSX
Sartorius A.G., Weender Landstrasse 94-108, DE-37075 Göttingen, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic level gauges for fixed storage tanks
Jaugeurs automatiques pour les réservoirs de stockage fixes

R 85 (2008)

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V.,
The Netherlands

R085/2008-NL1-2009.01 Rev. 1
Automatic level gauge for measuring the level of liquid in storage tanks, model FMR 540, for free space applications, with horn antenna DN 100 or with parabolic antenna DN 200

Endress + Hauser GmbH + Co., KG, Haupstrasse 1, DE-79689 Maulburg, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic instruments for weighing road vehicles in motion
Instruments à fonctionnement automatique pour le pesage des véhicules routiers en mouvement

R 134 (2003)

▶ Issuing Authority / *Autorité de délivrance*

DANAK The Danish Accreditation and Metrology Fund, Denmark

R134/2003-DK1-2009.01
Automatic instrument for weighing road vehicles in motion - Type: LL2/AW

Tunaylar Baskül Sanayi ve Ticaret A.S., Beylikdüzü N°:6, TR-34520 Büyükçekmece, Istanbul, Turkey

OIML CERTIFICATE SYSTEM

List of OIML Issuing Authorities (by Country)

The list of OIML Issuing Authorities is published in each issue of the OIML Bulletin. For more details, please refer to our web site: www.oiml.org/certificates. There are no changes since the July 2009 issue of the Bulletin.

AUSTRALIA

AU1 - National Measurement Institute	R 49	R 50	R 51	R 60	R 76	R 85
	R 106	R 107	R 117/118	R 126	R 129	

AUSTRIA

AT1 - Bundesamt für Eich- und Vermessungswesen	R 50	R 51	R 58	R 61	R 76	R 85
	R 88	R 97	R 98	R 102	R 104	R 106
	R 107	R 110	R 114	R 115	R 117/118	

BELGIUM

BE1 - Metrology Division	R 76	R 97	R 98

BRAZIL

BR1 - Instituto Nacional de Metrologia, Normalização e Qualidade Industrial	R 76

BULGARIA

BG1 - State Agency for Metrology and Technical Surveillance	R 76	R 98

CHINA

CN1 - State General Administration for Quality Supervision and Inspection and Quarantine	R 60	R 76	R 97	R 98

CZECH REPUBLIC

CZ1 - Czech Metrology Institute	R 49	R 76	R 81	R 85	R 105	R 117/118
	R 134					

DENMARK

DK1 - The Danish Accreditation and Metrology Fund	R 50	R 51	R 60	R 61	R 76	R 98
	R 105	R 106	R 107	R 117/118	R 129	R 134
DK2 - FORCE Technology, FORCE-Dantest CERT	R 49					

FINLAND

FI1 - Inspecta Oy	R 50	R 51	R 60	R 61	R 76	R 85
	R 106	R 107	R 117/118			

FRANCE

FR1 - Bureau de la Métrologie	*All activities and responsibilities were transferred to FR2 in 2003*				
FR2 - Laboratoire National de Métrologie et d'Essais	R 31	R 49	R 50	R 51	R 58
	R 60	R 61	R 76	R 85	R 88
	R 97	R 98	R 102	R 105	R 106
	R 107	R 110	R 114	R 115	R 117/118
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The OIML is pleased to welcome the following new

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  Mrs. Magdalena Chuwa

Corresponding Member

- **Dominican Republic**

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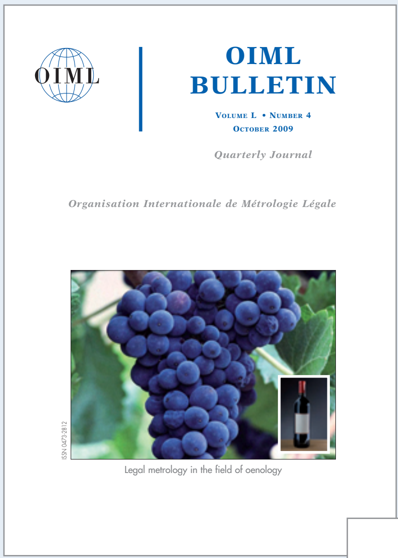

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