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Contents

OIML BULLETIN
VOLUME LVI • NUMBER 3
JULY 2015

technique

evolutions

update

SEE FEATURE, PAGE 40

Sommaire

BULLETIN OIML
VOLUME LVI • NUMÉRO 3
JUILLET 2015

technique

évolutions

informations

■ Editorial

PETER MASON
CIML PRESIDENT

OIML Seminar in Chengdu

In May of this year I had the great pleasure of attending the Seminar *Metrology in Daily Life* in Chengdu, P.R. China, which is reported on in this edition of the Bulletin.

I found the Seminar significant for a number of reasons. First, it is the first time I can remember the OIML organising such an event independently of our regular CIML meetings. We were able to do so only because of the excellent co-operation we received from our colleagues in the People's Republic of China, developed through the Advisory Group set up in 2013. Second, there was much more interaction between participants than we usually see in international meetings. This is important because if the OIML is to develop policies and initiatives that are relevant to the needs of our Members with emerging metrology systems we must listen to the views of those Members on what their needs are. Finally, I was interested to discover the way in which so many of those present were rethinking their approach to legal metrology. The emphasis on meeting the metrology needs of the citizen, rather than viewing legal metrology in terms of fixed ideas on how we do things, is something which may be relevant to how all of us approach our work, regardless of the stage of development we have reached.

The ideas emerging from Chengdu are ones which we will be developing further when the CIML meets in Arcachon in October. I think it is helpful not only that we have identified a large number of ideas but also that some clear themes are emerging. One of those themes – the need to develop the capabilities of the legal metrology staff in countries with emerging metrology systems – was not very surprising. This has been at the heart of our past initiatives to assist what we thought of as "Developing Countries". But other themes were perhaps less expected. For instance, it became clear how certificate systems which are more understandable and accessible can help economies introduce levels of regulation that would otherwise be beyond their own resources. And it was fascinating to see how so many colleagues are now thinking about the various ways organisations outside traditional legal metrology authorities can improve the confidence that citizens have in their systems.

Finally, the discussions in Chengdu confirmed what we have always understood – that these are issues which the OIML cannot tackle alone. However, we were able to start thinking about those areas where the OIML can take a lead and those where we should be looking to partner with others. There was a lot of enthusiasm for co-operation and the challenge is now for us to build on that.

I very much look forward to the Seminar in Arcachon later this year to develop the ideas presented, and I am very pleased that the Chengdu event was so successful. ■

OIML R 22

Traceability and computerization of alcoholometric tables

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Abstract

The alcoholometric tables are still used around the world by wine and spirits professionals, and were originally published by the OIML in 1973 under the reference OIML R 22, which included a mathematical model and a specification. The Recommendation was followed by a European Directive in 1976. However, both the original OIML document and other official documents, models and specifications are reproduced with inaccuracies, or even errors.

The computerization of these tables has therefore become a necessity for wines and spirits professionals.

To develop a program that meets OIML R 22 and its specifications for reliable and legitimate computerized tables, research was conducted on the traceability of the proposed model and its validation to ensure that the model was effectively leading to the first tables published by the OIML.

The work described in this article confirms the mathematical model and the specifications for generating the alcoholometric tables. A dedicated computer program was developed, allowing reliable and compliant computerized tables to be generated. This program allows both the mathematical model and some constants used in the original specification to be varied in order to check the impact on the accuracy of the calculated data. It also underlines the inaccuracies related to the use of interpolation methods unduly recommended in some tables, or to an incorrect glass expansion coefficient for the alcoholmeter.

The results of this work and particularly the dedicated program can be used as a basis for reviewing the resulting regulations and official documents.

Key Words: Alcoholometric tables, Computerization, Wines, Spirits, OIML R 22

Cet article est également disponible sur simple demande dans sa langue d'origine, le Français (écrire à bulletin@oiml.org).

Traçabilité et informatisation des tables d'alcoométrie

Les tables d'alcoométrie, encore très utilisées par les professionnels de vins et spiritueux du monde entier, sont issues d'une Recommandation de l'OIML datant de 1973 qui a publié un modèle mathématique et un cahier des charges, dont découlent ces tables. La Recommandation a été suivie d'une Directive européenne en 1976. Cependant, aussi bien dans le document original de l'OIML que dans les autres documents officiels, le modèle et le cahier des charges sont reproduits avec des imprécisions, voire des erreurs.

L'informatisation de ces tables est donc devenue une nécessité pour les professionnels des vins et spiritueux.

Afin de développer un programme respectant la R 22 et son cahier des charges pour disposer de tables informatisées fiables et légitimes, il a été entrepris une recherche sur la traçabilité du modèle proposé et sa validation pour s'assurer que le modèle conduisait bien aux premières tables publiées par l'OIML.

Les travaux décrits dans cet article ont permis de confirmer le modèle mathématique et le cahier des charges permettant de générer les tables d'alcoométrie. Il a été développé un programme informatique spécifique permettant de générer des tables informatisées fiables et conformes à la réglementation. Ce programme permet de faire varier aussi bien le modèle mathématique que certaines constantes utilisées dans le cahier des charges original, afin d'en vérifier l'impact sur les données des tables. Il fait aussi apparaître les imprécisions liées à l'utilisation de méthodes d'interpolation indûment recommandées dans certains guides, ou à la prise en compte incorrecte du coefficient de dilatation du verre de l'alcoomètre.

Les résultats de ces travaux et en particulier le programme développé peuvent servir de base à des fins de révision de la réglementation et des documents officiels qui en découlent.

Mots clés : *Tables d'alcoométrie, Informatisation, Vins, Spiritueux, OIML R 22*

1 Introduction

1.1 The use of alcoholometric tables

For over a hundred years professionals in the field of spirits and other alcoholic drinks around the world have needed tables to perform the necessary conversion calculations for certain production activities or production quality controls: conversion of density, alcohol and volume depending on the temperature, measurement of the volume of barrels, measurement of the liquid volume in barrels, etc.

These tables are also used for all commercial transactions and alcohol statements. Therefore, they are essential not only for wine and spirits professionals but also for regulators (e.g. Customs) or agencies that authenticate the volume of pure alcohol content before shipping containers of alcohol sold in bulk.

Table 1 Summary of parameters used in OIML R 22

Parameters	Symbols	Units	Scopes	Intervals
Alcoholic strength by mass	p	% mass	0 to 100	1% mass
Alcoholic strength by volume	q	% vol.	0 to 100	1 % vol.
Temperature	t	°C	–20 to 40	1 °C
Density	ρ	kg/m^3	789.24 to 998.2	0.1 kg/m^3
Volume in pure alcohol	VAP	dm^3	-	

Table 2 Summary of the synthesis functions of the alcoholometric tables of OIML R 22

1	Table I	$\rho = \rho\,(p,t)$
2	Table II	$\rho = \rho\,(q,t)$
3	Table IIIa	$\rho_{20\,°C} = \rho_{20\,°C}\,(p)$
4	Table IIIb	$q_{20\,°C} = q_{20\,°C}\,(p)$
5	Table IVa	$\rho_{20\,°C} = \rho_{20\,°C}\,(q_{20\,°C})$
6	Table IVb	$p = p\,(q_{20\,°C})$
7	Table Va	$p = p\,(\rho_{20\,°C})$
8	Table Vb	$q_{20\,°C} = q_{20\,°C}\,(\rho_{20\,°C})$
9	Table VI	$p = p\,(\rho,t)$
10	Table VII	$q = p\,(\rho,t)$
11	Table VIIIa	$p = p\,(p,t)$
12	Table VIIIb	$q_{20\,°C} = q_{20\,°C}\,(q,t)$
13	Table IXa	$p = p\,(\rho,t)$
14	Table IXb	$q_{20\,°C} = p\,(\rho,t)$
15	Table Xa $^{(1)}$	$p = p\,(\rho,t)$
16	Table Xb $^{(1)}$	$q_{20\,°C} = q_{20\,°C}\,(\rho,t)$
17	Table XIa $^{(2)}$	$VAP_{\ 20\,°C} = VAP_{\ 20\,°C}\,(p,\ t)$
18	Table XIb $^{(2)}$	$VAP_{\ 20\,°C} = VAP_{\ 20\,°C}\,(q,\ t)$
19	Table XIIa $^{(3)}$	$VAP_{\ 20\,°C} = VAP_{\ 20\,°C}\,(p,\ t)$
20	Table XIIb $^{(3)}$	$VAP_{\ 20\,°C} = VAP_{\ 20\,°C}\,(q,\ t)$

1.2 Origin of alcoholometric tables

Among all the existing tables for use in the field of beverages, the alcoholometry tables allow the conversion of the measurement of the density, alcohol and volume, depending on the temperature.

All the alcoholometric tables result from OIML R 22 [1]. This Recommendation originates from work described and summarized by Wagenbreth in two OIML Bulletins in 1973 [2], [3]. It selected a mathematical model, which is called here "Wagenbreth's model", to generate these tables. This model is based on an equation which contains 60 constants. From this model, it is possible to calculate 20 tables of various conversions, described in Annex I of the Recommendation, as well as the methodology for reconstructing these tables. The parameters found in these tables are summarized in Table 1. A summary of the functions of these tables is given in Table 2.

(1) Tables for which the density measurements (ρ) were made with a borosilicate glass apparatus, wherein the cubic expansion coefficient of the glass is 10×10^{-6} °C^{-1}

(2) These two tables give, in cubic decimetres, the volume (V) at 20 °C of pure ethanol contained in 100 dm^3 of a mixture of known alcoholic strength by mass or volume at the Celsius temperature t, assuming that the volume of 100 dm^3 was measured by a steel container calibrated at 20 °C. The cubical coefficient of expansion of steel is 36×10^{-6} °C^{-1}.

(3) These two tables give, in cubic decimetres, the volume (V) at 20 °C of pure ethanol contained in 100 kg of a mixture of known alcoholic strength by mass or by volume at the Celsius temperature (t) (it is assumed that the weighting took place in air whose density was 1.2 kg/m^3, by means of weights characterized by the conventional value of the result of their weighting in air - see OIML R 33).

OIML R 22 is associated with the publication of Tables I, II, IIIa, IIIb, IVa, IVb, Va and Vb only.

1.3 Mathematical model published by the OIML

The original OIML publication, in French, reproduced the equation leaving some ambiguities in the formula. This work was the object of a European Directive of 1976 (76/766/EEC) [4], in which the equation was deferred, but left some ambiguity about the formula. In addition, a constant is different from that published in OIML R 22.

Directive 2011/17/EU [5], although repealing Directive 76/766/EEC, does not include the equation and constants, but surprisingly, maintains the reference to the equation in the 1976 Directive repealed.

Moreover, neither of the two Directives considers a formula for the density conversion, involving the conventional value of the cubic expansion coefficient of soda-lime glass specific to alcohol hydrometers and recommended by the OIML. This formula is needed to calculate some of the alcoholometric tables including Table VIIIb: conversion of volumetric alcoholic strength at 20 °C.

The equation and constants reproduced in various official documents (sometimes with differences from the original formula) almost never refer to the correction calculation related to the coefficient of cubic expansion of the glass. This is the case of Regulation (EEC) No. 2676/90 [6] which covers the Community analysis methods for the wine sector or the collection of wines analysis methods published by the International Office of Vine and Wine (OIV) [7].

1.4 Reliability and legitimacy of the available alcoholometric tables

Among the existing tables, we can mention:

1) The Practical Guide of alcoholometry published by Adm. P. Oudin [8] in French, in paper format, is used throughout France and in many other countries. It identifies a number of conversion tables, including Table VIIIb, specific to the conversion of alcohol measurement depending on the temperature, and which also contains the factor for volume correction as a function of volume fraction (q) and temperature. It also contains Table IVa, giving the correspondence between the density (ρ) and the alcoholic strength by volume (q) expressed in % volume at 20 °C. A new edition, the 6th was published in 2015.

   In this guide, in Table VIIIb the conversions of alcohol measurement (q) depending on temperature are reported with intervals of respectively 0.1 % vol. and 0.5 °C, and the volume correction factors depending on (q) and temperature are reported with intervals of respectively 1 % vol. and 1 °C.

2) Luxembourg has published a document in five languages including French, English and German, containing Table VIIIb [9] with the same interval. Volume correction factors are not reproduced in this table.

3) The Swiss Federal Administration also issued an alcohol conversion table depending on temperature. It is simplified compared to the previous ones, offering only conversions of (q) with an interval of 0.5 % vol. and temperature of 1 °C. Volume correction factors [10] are not reproduced either.

In most cases, the tables contain reprographic errors, partially corrected in new editions.

In the latest revision of the French alcoholometry Guide (6th edition 2015), obvious errors still exist, including the following two examples:

- page 67, 8 % vol. and 3 °C, the value of 9.6 % vol. is given, clearly erroneous; given the proximity values, the value should be 9.5 % vol., as shown in other official tables.
- page 253, the scale of (q) should not read from 60 to 60.9 % vol., but from 70 to 70.9 % vol.

Many more errors can be found in the earlier editions which are still in use.

Computerized charts have been developed for personal use, but by copying data from the "paper" tables, and therefore with the risk of errors.

The French Bureau of Metrology of the Ministry of Economy, Industry and Digital DGE - SQUALPI confirms that the tables of alcoholometry guide edited by Oudin library were never verified. The publisher only received a publishing license. The tables published in this guide cannot be considered as "Official". Only the mathematical model with the equation and constants, reproduced in Directive 76/166 EEC [4] can be considered as official.

The risk of errors related to incorrect data published in tables, misinterpretation of these tables or misreading can have a significant financial impact on commercial transactions, control of production, or on the statements of pure alcohol stocks.

Moreover, according to the accuracy of the tables, it is sometimes necessary to perform interpolation to improve the accuracy. These calculations may be required by regulations, production specifications or imposed by the final customer. In this case, the risk of errors related to wrong interpolation is even greater.

2 Objectives of the work - methodology and results

2.1 Objectives

The main objective is to develop a specific program to generate the alcoholometric tables as computerized databases, while respecting OIML R 22.

To establish the specifications of the program, given the elements set out in 1.3, it was necessary to confirm the equation and associated constants, then check out some assumptions which were not specified in the original document (such as rounding rules).

This article presents the results of the initial research and the methodology for developing such a program. It also presents some additional work that was done after development of the computer program, such as the impact assessment of certain assumptions used in the Recommendation, the test of a newer mathematical model, as well as recommendations for proper use of the tables.

2.2 Methodology

In the original edition of R 22, the OIML published the first tables (up to Table Vb) and gave the applicable steps to find all the tables.

Some constants of the equation are given with 23 decimals and 16 significant digits. In the 70's, the programming languages (such as FORTRAN IV) took into account all the significant digits. However, current languages and common calculation sheets only use 15 significant digits, which can create rounding errors.

The OIML has not provided the rules for rounding: all values are presented with a single decimal in the tables published with OIML R 22. Given the absence of an international rounding rule, this creates additional uncertainty.

The generation of these tables has required the development of a sophisticated computer program that takes into account and stores 23 decimals and 16 significant digits.

The resources selected for this program are: C++ /11 that uses a standardized specific library for calculations of "large numbers" BOOST [11], C++ library and interface to the C library "MPFR", and GNU (Lesser LPG) based on the ANSI/IEEE-754 (standard for double-precision floating-point arithmetic). "BOOST" is distributed as a free software license "Boost Software License" [12].

The program was designed so that a number of factors could be varied, in order to study their influence on the final result: the number of significant digits, the rounding method, the mathematical model, the step of the parameters and the coefficient of the cubic expansion of the glass.

2.3 Results

2.3.1 Validation of the model proposed in OIML R 22

This program generated tables up to VIIIb (the conversion table of the alcoholic strength by volume measured at a given temperature, to report it at 20 °C).

Comparing the overall results of the first five tables with those published by the OIML has allowed the original equation to be corrected, to confirm the values of the constants involved and to clarify the methodology to follow up.

Good writing of the equation and associated constants, which led to the publication of tables published in OIML R 22, is given in Figure 1 (see opposite).

It could be inferred that the rounding rule used by the OIML and especially for Table VIIIb, is to round the decimal from the 2nd decimal place, as does a default spreadsheet, when no other rule is imposed.

Thanks to the computerized recording of 98000 data of Table VIIIb from the Practical Guide of alcoholometry [8], the comparison of these values with those of Table VIIIb generated by the program showed that 192 values presented a deviation of +/– 0.1 % vol.

In fact, these differences are absolute values between 0.049 and 0.051 % vol. In the table published by Luxembourg, the differences are almost all the same. However, compared to the Swiss official table, only four differences remain among the 19 values which can be compared. An extract from the comparative is given in Table 3.

These results confirm the origin of the errors, presumably typographical and their propagation by duplication, in several documents including the Practical Guide of alcoholometry.

2.3.2 Comparison of the OIML mathematical model with that of H. Bettin & Al.

The mathematical model proposed in OIML R 22 uses an international standard temperature IPTS-68, which was replaced in 1990 by the ITS-90 standard. It justified the work undertaken by Bettin H. & Spieweck F. [13] in 1990 to propose another equation and the associated constants. Based on this work, the maximum difference found for the values of table Ia, which is obtained directly from the equation, would be only 12×10^{-6} kg/m^3.

In 2006 at a conference in Brazil on metrology, Rezende Zucchini R. & de Souza Themudo [14] presented a comparison of these two models. Since this publication includes transcription errors of the constants in the equation, it is best to refer to the original document of Bettin H. & Al.

The program developed in our work has tested this model and compared the results, especially for Tables Ia and VIIIb.

For Table Ia, the differences are greater than those announced by Bettin & Al. Many values exceed 12×10^{-6} kg/m^3. The maximum calculated difference is 0.0035 kg/m^3 and is in a low temperature range (< –15 °C).

Figure 2 shows the ranges of values for the differences.

$$\rho = A_1 + \sum_{k=2}^{12} A_k \times p^{k-1} + \sum_{k=1}^{6} B_k \times (t - 20°\mathrm{C})^k + \sum_{i=1}^{n} \sum_{k=1}^{m_i} C_{i,k} \times p^k \times (t - 20°\mathrm{C})^i$$

Figure 1 Good writing of the equation and associated constants. Values of n and m: $n = 5$, $m_1 = 11$, $m_2 = 10$, $m_3 = 9$, $m_4 = 4$, $m_5 = 2$

k	A_k	B_k
1	$9.982\,012\,300 \times 10^{2}$	$-2.061\,851\,3 \times 10^{-1}$
2	$-1.929\,769\,495 \times 10^{2}$	$-5.268\,254\,2 \times 10^{-3}$
3	$3.891\,238\,958 \times 10^{2}$	$3.613\,001\,3 \times 10^{-5}$
4	$-1.668\,103\,923 \times 10^{3}$	$-3.895\,770\,2 \times 10^{-7}$
5	$1.352\,215\,441 \times 10^{4}$	$7.169\,354\,0 \times 10^{-9}$
6	$-8.829\,278\,388 \times 10^{4}$	$-9.973\,923\,1 \times 10^{-11}$
7	$3.062\,874\,042 \times 10^{5}$	
8	$-6.138\,381\,234 \times 10^{5}$	
9	$7.470\,172\,998 \times 10^{5}$	
10	$-5.478\,461\,354 \times 10^{5}$	
11	$2.234\,460\,334 \times 10^{5}$	
12	$-3.903\,285\,426 \times 10^{4}$	

k	$C_{1,K}$	$C_{2,K}$	$C_{3,K}$
1	$1.693\,443\,461\,530\,087 \times 10^{-1}$	$-1.193\,013\,005\,057\,010 \times 10^{-2}$	$-6.802\,995\,733\,503\,803 \times 10^{-4}$
2	$-1.046\,914\,743\,455\,169 \times 10^{1}$	$2.517\,399\,633\,803\,461 \times 10^{-1}$	$1.876\,837\,790\,289\,664 \times 10^{-2}$
3	$7.196\,353\,469\,546\,523 \times 10^{1}$	$-2.170\,575\,700\,536\,993$	$-2.002\,561\,813\,734\,156 \times 10^{-1}$
4	$-7.047\,478\,054\,272\,792 \times 10^{2}$	$1.353\,034\,988\,843\,029 \times 10^{1}$	$1.022\,992\,966\,719\,220$
5	$3.924\,090\,430\,035\,045 \times 10^{3}$	$-5.029\,988\,758\,547\,014 \times 10^{1}$	$-2.895\,696\,483\,903\,638$
6	$-1.210\,164\,659\,068\,747 \times 10^{4}$	$1.096\,355\,666\,577\,570 \times 10^{2}$	$4.810\,060\,584\,300\,675$
7	$2.248\,646\,550\,400\,788 \times 10^{4}$	$-1.422\,753\,946\,421\,155 \times 10^{2}$	$-4.672\,147\,440\,794\,683$
8	$-2.605\,562\,982\,188\,164 \times 10^{4}$	$1.080\,435\,942\,856\,230 \times 10^{2}$	$2.458\,043\,105\,903\,461$
9	$1.852\,373\,922\,069\,467 \times 10^{4}$	$-4.414\,153\,236\,817\,392 \times 10^{1}$	$-5.411\,227\,621\,436\,812 \times 10^{-1}$
10	$-7.420\,201\,433\,430\,137 \times 10^{3}$	$7.442\,971\,530\,188\,783$	
11	$1.285\,617\,841\,998\,974 \times 10^{3}$		

k	$C_{4,K}$	$C_{5,K}$
1	$4.075\,376\,675\,622\,027 \times 10^{-6}$	$-2.788\,074\,354\,782\,409 \times 10^{-8}$
2	$-8.763\,058\,573\,471\,110 \times 10^{-6}$	$1.345\,612\,883\,493\,354 \times 10^{-8}$
3	$6.515\,031\,360\,099\,368 \times 10^{-6}$	
4	$-1.515\,784\,836\,987\,210 \times 10^{-6}$	

Table 3 Comparison of the Table VIIIb values generated by the program with a few tables published (Values in bold and grey are those that differ from those obtained with the developed program)

t °C	q in % vol.	Our results	Practical Guide of Alcoholometry	Luxembourg official table	Swiss official table
–10	17.5	26.0	**26.1**	**26.1**	26.0
–8	23	34.5	**34.4**	**34.4**	**34.4**
–7	26	37.4	**37.5**	**37.5**	37.4
–7	36	46.9	**47**	**47**	46.9
–6	15.5	20.6	**20.7**	**20.7**	20.6
–1	27	35.7	**35.8**	**35.8**	35.7
0	68	74.3	**74.4**	**74.4**	74.3
0	71	77.2	**77.3**	77.2	77.2
3	8	9.5	**9.6**	**9.6**	9.5
3	14.5	17.8	**17.9**	**17.9**	17.8
6	57	61.8	**61.9**	**61.9**	61.8
7	25	30.0	**30.1**	**30.1**	30.0
8	5.5	6.6	**6.7**	**6.7**	6.6
11	21.5	24.5	**24.6**	**24.6**	24.5
12	1.5	2.2	**2.3**	**2.3**	2.2
12	37	40.2	**40.3**	**40.3**	40.2
18	3.5	3.7	**3.8**	**3.8**	**3.8**
27	83.5	81.4	**81.5**	**81.5**	**81.5**
35	67	61.8	**61.9**	**61.9**	**61.9**

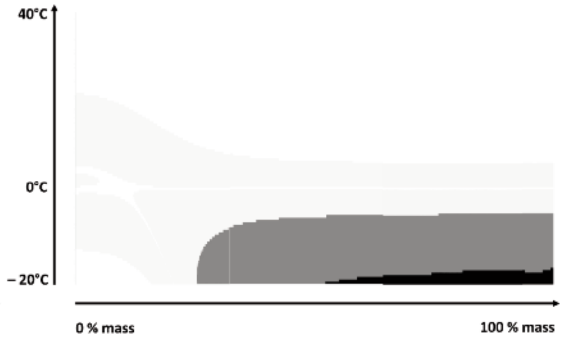

Figure 2 Highlighting the differences between the values obtained for Table Ia with the mathematical models of Wagenbreth and Bettin

- White zone: differences are less than 0.000012 kg/m^3
- Lighter grey zone: differences are between 0.000012 and 0.001 kg/m^3
- Darker grey zone: differences are between 0.001 and 0.003 kg/m^3
- Black zone: differences are larger than 0.003 kg/m^3

Figure 3 Highlighting the differences between the values obtained for Table VIIIb, with the mathematical models of Wagenbreth and Bettin

- White zone: differences are less than 0.001 % vol.
- Lighter grey zone: differences are between 0.001 and 0.01 % vol.
- Darker grey zone: differences are between 0.01 and 0.025 % vol.

However, the accuracy achieved at 10^{-2} kg/m^3 can be considered as sufficient for the practical use of this Table.

As regards Table VIIIb, the calculations of the difference of volume fractions from the two corrected mathematical models (Wagenbreth and Bettin), lead to a maximum difference of 2.5×10^{-2} % vol. It should be noted that the most significant differences (> 0.01 % vol.) are all for measuring temperatures below 11 °C. Figure 3 shows the ranges of values for the differences.

In view of the desired accuracy of 0.01 % vol., the model proposed by Bettin & Al. can be considered as identical to the one proposed in OIML R 22.

2.3.3 Visual representation of Table VIIIb values

Table VIIIb provides alcohol conversion data depending on temperature. Overwhelmingly we observe a regular interval of 0.1 % vol. between two data. Nevertheless, these intervals are sometimes 0 % vol. or 0.2 % vol. and more rarely 0.3 % vol. Specific software has coloured the data according to the interval value. Interval values that are different from 0.1 % vol. are coloured. Surprisingly, clover shapes appeared, represented in Figure 4.

2.3.4 Impact of the value of the cubic expansion coefficient of glass

The cubic expansion coefficient of glass chosen in OIML R 22 is a conventional value of 25×10^{-6}. It is used in an additional equation to correct volumetric mass values obtained from Tables IIIa or IVa to generate respectively Tables VIIIa and VIIIb.

As stipulated in NF B 35-512 [15], depending on the hydrometer's type of glass used for measuring, its volumetric expansion coefficient may differ. In this case, it is necessary to recalculate the value indicated by the aerometer R' using the following equation: $R = R' [1 + (0.000025 - \gamma)\ (\theta - t)$, for which θ is the measured temperature in °C and γ is the cubic expansion coefficient at a given temperature t (generally 20 °C).

When looking to determine the volumetric alcoholic strength and in the case of a density measurement with an aerometer R' at temperature θ, after calculation of R, Table VII allows the conversion in volumetric alcoholic strength at temperature θ, and then Table VIIIb allows the volumetric alcoholic strength at 20 °C to be obtained.

Typically, the measurement of the volumetric alcoholic strength is made with an alcoholmeter. In this case, we must first find the density equivalent R' using Table II and then calculate R, applying the above equation, and continue to obtain the previous conversions by volume at 20 °C.

Apart from the conventional value of the coefficient chosen in OIML R 22 to establish the tables, different coefficients have been found in the literature, among others 23×10^{-6} and 27×10^{-6}. The program developed in this work allows the cubic expansion coefficient of the glass used to be varied. We therefore investigated the impact of replacing the conventional value of these two values in Table VIIIb.

Indeed, for a relatively small difference of 2×10^{-6}, the observed differences are very important and can reach 1.5 % vol.

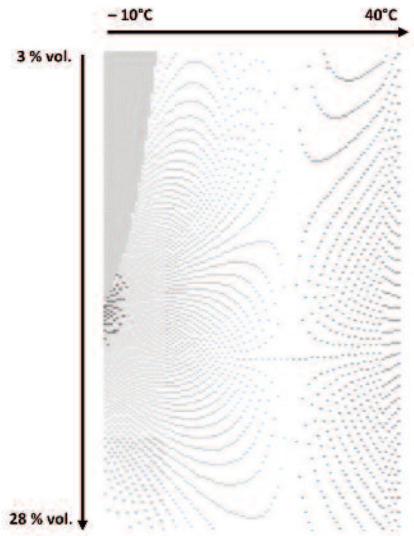

Figure 4 Extract from the imaging differences in steps between two correction values of the alcoholic strength in volume from Table VIIIb

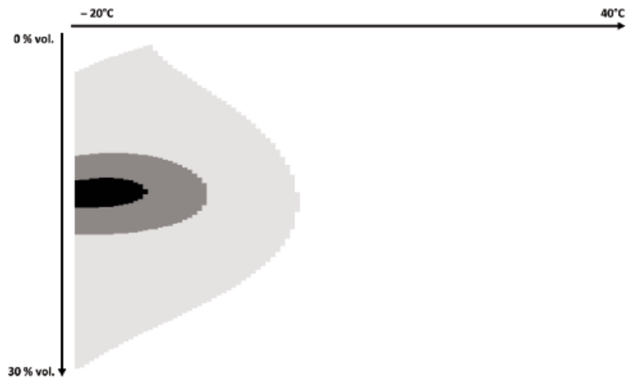

Figure 5 Highlighting the differences between the values obtained for Table VIIIb with a coefficient of cubic expansion at 23 × 10^{-6} instead of the conventional value of 25 × 10^{-6}

- White zone: differences are less than 0.1 % vol.
- Shaded area from light to dark: differences range from 0.1 to 1.5 % vol.

For example, Figure 5 highlights the temperature zones and alcoholic strength for which the differences are the most important when comparing the values in Table VIIIb calculated with a cubic expansion coefficient of 23 × 10^{-6} instead of 25 × 10^{-6} (conventional value used in OIML R 22).

In the case where the cubic expansion coefficient of the glass used to make the hydrometer is not 25 × 10^{-6} at 20 °C, Table VIIIb provides an incorrect response in a wide temperature range.

2.3.5 Calculation of the volume correction factor

When measuring the volume of a hydro-alcoholic solution at a given temperature, it is necessary to apply a correction to know the volume at 20 °C.

These correction factors are partly reported in Table VIIIb of the Practical Guide of alcoholometry, only for integer values of alcoholic strength by volume and temperature.

The Guide provides a method of interpolation (page 25 of the 6th edition) to calculate the volume of corrections for intermediate values.

Indeed, the method proposed in the Guide works with the example, but this is not the case with all values, as will be demonstrated here.

Table II of OIML R 22 allows the density (ρ) of a hydro-alcoholic solution to be determined, after measurement of the alcoholic strength by volume (q) and temperature (t). The volume correction factor can therefore be calculated by the ratio of (ρ) at measured temperature (t) and (ρ) at 20 °C.

Some examples of calculations of the volume correction factor by comparison with the values of the Guide, with and without interpolation, are reported in Table 4.

These examples show that it is more accurate to calculate this factor for all values of (q) and temperature, as a computer program can, incorporating Table II of alcoholometry. Otherwise, it is preferable to indicate the value of the volume correction factor for all values of (q) and temperature, and not encourage the user to apply a method of interpolation.

3 Conclusions

This work shows the need to change the tools used by professionals for the characterization of the alcohol content of wines and spirits. The computerization of alcoholometric tables through programs can ensure greater reliability and traceability, compared to conversions and calculations done manually.

Indeed, in this research, numerous copying errors were highlighted in tables regarded as official by many users, including official bodies. It was shown that certain guidelines for the extrapolation of the correction factor of the volume which depends on the alcoholic strength and temperature are incorrect.

It was also shown that OIML R 22, European regulations resulting from it and other official documents describe the mathematical model imprecisely and in an incomplete and sometimes erroneous manner [4] [5] [6].

Table 4 Comparison of the calculated factor volume correction using Table II of alcoholometry and the method proposed in the Practice Guide of alcoholometry

Example no.	***q* % vol.**	***t*/°C**	***ρ*/(g·l⁻¹) at *t***	***ρ*/(g·l⁻¹) at 20 °C**	**Correction factor by calculation**	**Correction factor deducted from the Guide**
1 – example p25 of the Guide	98	32.5	788.09 = average of 788.52 at 32 °C and 787.65 at 33 °C	798.9	986.5	986.5
2	55	15	923.84	919.86	**1004.3**	**1004**
3	55	16.5	922.69 = average of 923.07 at 16 °C and 922.3 at 17 °C	919.96	**1003**	**1002.5**
4	70	12.5	891.74 = average of 892.14 at 12 °C and 891.33 at 13 °C	885.56	**1007**	**1006.5**

The work undertaken has helped redefine the formal mathematical model: equations and values of the constants used by the OIML and rounding rules.

This work can serve as the basis for a revision of OIML R 22 and an update of the resulting documents.

The design of the program developed for this work allowed a number of factors to be varied and to study the impact on the values of the tables.

Factor changes studied during this work led to the following:

1) The model proposed by Bettin H. [13], simpler and more recent than the one proposed in OIML R 22, given the generally necessary accuracy, can be considered as achieving the same results. For Table Ia, the density differences are below 10^{-2} kg/m^3. For Table VIIIIb, the differences are less than 0.01 % vol., with the exception of a very small temperature and volume fraction range between 16.2 and 17 % vol. and –20 °C at –17.5 °C, for which the accuracy is between 0.01 and 0.025 % vol.
2) Tests of the change in the cubic expansion coefficient of soda-lime glass showed that it is important to check that the cubic expansion factor of hydrometers and alcoholmeters used for the measurement is really 0.000025. Otherwise, the use of Table VIIIb may become inadequate.

Comparison of the tables generated by the computer program, developed specifically for this work, with the first tables published by the OIV and Table VIIIb published in paper guides, demonstrated that the program was reliable and that the tables obtained with it comply with the regulation, as they result from the specifications of OIML R 22.

The program developed in this work can be used, should the mathematical model be re-examined or come into question, as suggested in the report of the CIML in 2003 [16].

These tables can therefore be used as computerized databases in software for wine and spirits professionals (producers, traders, brokers, laboratories, computerized management providers of production, customs, etc.).

They are currently used in LABOX®, a software program dedicated to alcohol and volume conversions depending on temperature, which also performs other useful calculations for spirits professionals such as the calculations for increasing or reducing the alcohol content of spirits, taking into account the volume contraction of the calculation or the census of pure alcohols in stock.

It is also possible with the program, which served as the basis for this work, to increase the accuracy of the values obtained with the use of the tables with a reduced interval. For example in Table VIIIb, we can change the 0.1 % vol. into 0.01 or 0.05 % vol. and replace the temperature interval of 0.5 °C by 0.1 °C.

However, the tables generated will be larger. An interval of 0.1 °C will lead to the number of values of the table to be multiplied by 5 (500 000 values, versus about 100 000 currently in the Practical Guide of alcoholometry). If the interval of (q) changes to 0.05 % vol., the multiplication factor will be 5 and 10 with an interval of 0.01 % vol. This amount of data would make the use of paper tables extremely tedious. Access to this level of accuracy is easy with the use of the computer program. This practical difference is an ultimate justification of the need to computerize the alcoholometric tables for wine and spirits professionals.

Thanks

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TANK CAPACITY

Evaluation by the least square method of the geometrical parameters and capacity of all tank types by the results of laser scanning

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1 Introduction

OIML R 71 [1] specifies the maximum permissible uncertainty for the capacity of tanks. The correct evaluation of the uncertainty of their capacity is very important when performing a verification. References [2–5] and other similar documents do not contain, in the authors' opinion, mathematically strict and objective methods for the evaluation of the geometrical parameters and the capacity of tanks as well as their uncertainty using the results of the electro-optical distance-ranging (geodetic) measuring method.

With the advent of laser scanners and total electronic scanning stations, the authors can admit that the level of development means of the measurement have significantly outrun the level of the mathematical processing facilities of the measurement results made by such instruments when calibrating tanks. The goal of this article is to eliminate this deficiency.

The running speed of modern geodetic instruments is from 15 points/second for total stations to 1 000 000 points/second for scanners. The standard deviation of the distance measurement from the instrument to the points on the surface ranges from 1–3 mm, and the horizontal and vertical angles from 1 to 5″ (arcsec) for total scanning stations and from 5 to 30″ (arcsec) for scanners. There is no method for more efficient processing of such large measurement arrays, which is why specialists from manufacturers and calibration laboratories use only part of this valuable information for calculating the capacity of tanks. For the uncertainty evaluation of the results, this huge scope of information is not used at all.

The most efficient mathematical method for solving such problems is the least square method (LSM), if we wish to use the most powerful arithmetic technique currently available. In [2, 3] LSM is applied on vertical tanks for the calculation of center coordinates and circumference radius by points that lie in one horizontal plane. We can see that some difficulties can be overcome by using the LSM method:

- the mean radius calculation of all the cylindrical tank parts on all the points whose coordinates have been defined on the tank wall;
- calculation of the dimension and the direction of the tank axis tilt;
- evaluation of the measurement uncertainty in combination with the statistic evaluation of the tank wall surface geometry uncertainty towards the approximate cylinder;
- strict evaluation by LSM of the calculated geometrical uncertainty parameters, e.g. mead radius, center coordinates, dimension and direction of the tank axis tilt;
- strict evaluation by LSM of the tank capacity uncertainty based on the evaluation of the geometrical uncertainty parameters.

In [4, 5] the processing method of the geometrical tank parameters by points coordinates on the tank wall surface is not described. Also, we are not talking about the evaluation of their uncertainty based on statistical measurement data. The principles for solving these problems using vertical tanks were laid down by the authors of this publication in [6, 2007]. In [7, 2013] these capacities were fully described for the first time for vertical tanks, but without taking into account the points coordinates correlation on the wall surface, which were obtained from the results of slope distance measurements, horizontal directions and vertical angles measurements.

2 Identifying the problem

Theoretically, the tank wall surface must be of the correct geometrical shape: cylinder, sphere, ellipsoid, cone, etc. The axes of an ellipsoid or cone cylinder must be vertical or horizontal, but in practice this is impossible. As soon as the point coordinates on the real tank wall surface are obtained using a geodetic instrument, the mid radius of the cylinder and its axis tilt can be estimated by performing a cylindrical surface approximation. The evaluation of the statistic characteristics of the tank wall deformation and roughness is carried out by radial deviation, which is the shortest distance between the real and approximation cylindrical surfaces. In other words, it is the distance from a real surface to an approximated surface (at this point). The term given to this statistical characteristic is “standard radial deviation”. This statistic characteristic includes the uncertainty of the geodetic measurements which influences the uncertainty of the geometrical parameters and therefore their capacities must be estimated. The accuracy of the evaluation of the standard radial deviation depends on the sample size (points quantity at the surface on which the coordinates are determined) and the statistical characteristics of the geodetic measurements. With the use of standard radial deviation evaluation, the A-type uncertainty of the geometrical parameters and tank capacity may be estimated.

So the main goal of the authors’ research is to develop a strict method (in the sense of the least square method) of evaluating the geometrical parameters and the capacity of tanks and their uncertainty according to the results of geodetic measurements.

Based on the least square method (LSM), a solution is proposed to evaluate the geometrical parameters of all tank types (e.g. the mean radius of the cylindrical part, tank tilt, axial tilt directional angle, radial deviations of the tank wall from an approximate cylinder, etc.) by point coordinates at the tank wall that are calculated by the measurement results of the slope distance, horizontal direction and vertical angle by totally electronic stations and scanners.

The geometrical parameters of the tank are evaluated with and without the use of a covariance matrix of the point coordinates at the tank wall surface. A general theoretical method has been developed to evaluate the interval capacity and its uncertainty of any tank, which provides adequate comparable results without regard to the tanks’ shape and dimension, their surface deformations, geodetic measurement accuracy, and also the location and quantity of the points, the coordinates of which were determined on the surfaces.

To maintain a strict record of the measurement uncertainty while performing an approximation by the LSM method, it is proposed to use their covariance matrix. A simple model of evaluation is proposed resulting in the uncertainty of the tank and the interval capacity, which includes A-type uncertainty (evaluated as the standard radial deviation) and B-type uncertainty (evaluated on the basis of metrological research into the instruments that are used during the measurements).

When mathematically developing a strict generalized method to process measurement results, one can point out the following key issues:

1) evaluation of the geometrical parameters of the tank surfaces by approximation of the measured spatial coordinates by the least square method (LSM);
2) evaluation of the uncertainty of the geometrical parameters of the tank surfaces using the LSM method;
3) calculation of the tank graduation characteristics (interval capacities) with the use of the geometrical parameters obtained and the real tank shape towards the approximating surface;
4) strict evaluation using the LSM method of the uncertainty of the tank interval capacities based on the uncertainty of the geometrical parameters of the object surface evaluated using the LSM method.

3 Evaluation of the geometrical parameters of the tank without the use of the covariance matrix of the point coordinates at the tank wall surface

The measurement model binding points coordinates on the surface and their geometrical parameters are given by equation (1):

$$\varphi_i(x_i, y_i, z_i, \tau_1 ... \tau_k) = 0 \qquad (1)$$

where:

x_i, y_i, z_i are the horizontal coordinates and the absolute height of the points on the object surface (where $i = 1...n$), which are measured by the geodetic instruments;

$\tau_1 ... \tau_k$ are the defined geometrical parameters of the object surface;

k is the quantity of the determined geometrical parameters;

n is the quantity of points at the surface at which the coordinates are determined.

The absolute height is the vertical distance from the horizontal flatness which passes through the dipping datum point [1] to the point with number i.

Due to surface roughness and coordinate measurement uncertainties, equation (1) is not fulfilled. That is why, to evaluate the determined geometrical parameters, it is necessary to establish equations of corrections, which we obtain by the partial derivation of the measurement model (1) by the measured coordinates and defined parameters:

$$\frac{\partial \varphi_i}{\partial x_i} v_{x_i} + \frac{\partial \varphi_i}{\partial y_i} v_{y_i} + \frac{\partial \varphi_i}{\partial z_i} v_{z_i} = \frac{\partial \varphi_i}{\partial \tau_1} \delta\tau_1 + ... + \frac{\partial \varphi_i}{\partial \tau_j} \delta\tau_j + ... + \frac{\partial \varphi_i}{\partial \tau_k} \delta\tau_k + l_i \tag{2}$$

or $$\vartheta_i = \frac{\partial \varphi_i}{\partial \tau_1} \delta\tau_1 + ... + \frac{\partial \varphi_i}{\partial \tau_j} \delta\tau_j + ... + \frac{\partial \varphi_i}{\partial \tau_k} \delta\tau_k + l_i$$

where:

v_{x_i}, v_{y_i}, v_{z_i} are corrections to the measured coordinates of the point with number i on the surface;

ϑ_i is the radial deviation of the tank's real surface perpendicular to the approximating surface;

$\delta\tau_1$, $\delta\tau_j$, $\delta\tau_k$ are corrections to the approximate values of the defined parameters $\tau_1^0 ... \tau_k^0$;

$l_i = \varphi_i(x_i, y_i, z_i, \tau_1^0 ... \tau_k^0)$ is the constant term of the equation of corrections.

In the matrix, the parametric equation of the corrections system (2) gives:

$$A \cdot V = B \cdot \delta\tau + l \quad \text{or} \quad \vartheta = B \cdot \delta\tau + l \tag{3}$$

where:

A is the matrix of the partial derivatives from the measurement model (1) by the measured coordinate points;

V is the correction matrix to the measured coordinate points;

ϑ is the diagonal matrix of the radial deviation of the tank's real surface from the approximation;

B is the partial derivative matrix from the measurement model (1) by the determined geometrical parameters;

$\delta\tau$ is the correction vector to the approximate values of the determined parameters;

l is the constant terms vector of the correction equation.

Taking into account that the parametric equations of corrections (2) are much greater than the determined geometrical parameters, one may build a normal equation system, which in the matrix, taking into account that $B^T \cdot \vartheta = 0$, gives:

$$B^T \cdot B \cdot \delta\tau + B^T \cdot l = 0 \quad \text{or} \quad N \cdot \delta\tau + L = 0 \tag{4}$$

Corrections to the approximate values of the determined geometrical parameters in the matrix are obtained by solving the system of linear equation (4) by the formula:

$$\delta\tau = -N^{-1} \cdot L = -Q \cdot L \tag{5}$$

where:

$N^{-1} = Q$ is the inverse matrix to the normal equation matrix.

When inserted in formula (2), the radial deviations fit into the main principles of LSM:

$$\sum_{i=1}^{n} \vartheta_i^2 = min \tag{6}$$

The standard radial deviation σ_ϑ of the tank's real surface from the approximation is calculated by the formula:

$$\sigma_\vartheta = \sqrt{\frac{\sum_{i=1}^{n} \vartheta_i^2}{n-k}} \tag{7}$$

The defined parameters, their covariance matrix and the standard deviation of the defined tank geometrical parameters are:

$$\tau_j = \delta\tau_j^0 + \delta\tau_j \tag{8}$$

$$K_{\delta\tau} = \sigma_{\vartheta}^2 \cdot Q$$
$$\sigma_{\tau_j} = \sigma_{\vartheta} \cdot \sqrt{Q_{jj}}$$

where:

Q_{jj} is the diagonal component of the inverse matrix to the normal equation matrix.

One can refer to the tank's geometrical parameters:

- parameters of its spatial attitude – coordinates of the tank's center or the point on its axis (not used to calculate the tank's capacity but obligatorily included in (1) and necessary for calculations (2) – (5));
- parameters of its spatial orientation – angles between the tank axis and the coordinate axis or planes, for example, the angle and direction (azimuth) axis tilt of a vertical cylindrical tank;
- parameters of its dimensions and shape – for example, the radius of a spherical or cylindrical tank, the minor semi-axis of an elliptical tank bottom or end, or the height of a conic tank bottom or end.

The standard radial deviation σ_{ϑ}, calculated by formula (7), comprises not only geodetic measurement uncertainties. It also comprises real surface deviations from the mathematically right shape. They appear when the tank is produced and during its deformations in use. Based on their experience in calibration, the authors would like to state that the second component exceeds the first by 5–10 times. This fact does not take into account the calculation of the geometrical parameters and the tank capacity uncertainty in accordance with the formulas mentioned in [2–5]. Practical use analysis of formulas (7) and (8) shows that failure to take into account this fact has a crucial importance on such an evaluation.

The solution proposed in this section has a practical meaning when a geodetic instrument creates a coordinate file without saving the results of the direct measurement of length and angle.

4 Covariance matrix of the point coordinates that are defined by the polar intersection of the total station or scanner

A strict solution to determine the geometrical parameters of the object by approximation of the point coordinates can be found by using a covariance matrix of the point coordinates. If the measuring instrument creates a coordinate file, then the structure of the covariance matrix is lost, but if the measuring instrument creates a file of the direct measurements – slope distance, horizontal direction and vertical angle – then during the calculation of the coordinates using special software, one can form their covariance matrix by the following formulas.

For coordinates that are defined by polar intersection:

$$\begin{aligned} x_i &= x_0 + D_i \cos(A_0 + N_i) \cos\alpha_i \\ y_i &= y_0 + D_i \sin(A_0 + N_i) \cos\alpha_i \\ z_i &= z_0 + i_0 + D_i \sin\alpha_i \end{aligned} \qquad (9)$$

where:

x_0, y_0, z_0 are the reference point coordinates over which the total station or scanner was centered;

A_0 is the reference azimuth of the alignment direction at another reference point;

D_i is the measured slope distance;

N_i is the measured horizontal direction;

α_i is the measured vertical angle;

i_0 is the measured height of the instrument over the reference point;

x_i, y_i, z_i are the defined point coordinates at the surface on which the geometrical parameters are defined.

If the reference data uncertainties and instrument height measurements are equal to zero (if the measurements were made from a point at which the coordinates are supposed to be the reference) the point coordinate covariance matrix (dual weight matrix) is calculated by:

$$q^i_{xyz} = \bar{A}_i \cdot \begin{vmatrix} q_{D_i} & 0 & 0 \\ 0 & q_{N_i} & 0 \\ 0 & 0 & q_{\alpha_i} \end{vmatrix} \cdot \bar{A}^T_i \qquad (10)$$

where:

$q_{D_i} = \sigma^2_{D_i}$, $q_{N_i} = \left(\frac{\sigma_{N_i}}{\rho} D_i \right)^2$, $q_{\alpha_i} = \left(\frac{\sigma_{\alpha_i}}{\rho} D_i \right)^2$ are dual weights of the measured slope distance, horizontal direction and vertical angle;

ρ is the radian expressed in the same units as the angle measurement standard deviation;

σ_{D_i}, σ_{N_i}, σ_{α_i} are the standard deviations of the measured slope distance, horizontal direction and vertical angle; $\bar{A}_i$ is the partial derivative matrix from equation (9) by the measured values:

$$\bar{A}_i = \begin{vmatrix} \bar{a}_{11i} & \bar{a}_{12i} & \bar{a}_{13i} \\ \bar{a}_{21i} & \bar{a}_{22i} & \bar{a}_{23i} \\ \bar{a}_{31i} & \bar{a}_{32i} & \bar{a}_{33i} \end{vmatrix} \qquad (11)$$

Such a position in the formation of a dual weight matrix would not allow us to consider the uncertainties of the point reference coordinates of the geodetic net and reference azimuth. But if we use formulas (10) and (11) it is possible to consider such a record. In fact, if we use the math of this and the next paragraphs of this publication it is possible to mathematically design the strict influence of the different random and systematic errors of geodetic instrument measurements.

Also using the math of this and the next paragraphs, it is possibly mathematically correct to model the influence of the different random and systematic errors of measurement by the geodetic instruments on the geometrical parameters and the tank capacity.

After multiplying the matrix in formula (10) we obtain the coordinate covariance (correlation) matrix (12):

$$q^i_{xyz} = \begin{vmatrix} q_{x_i} K_{x_iy_i} K_{x_iz_i} \\ K_{y_ix_i} q_{y_i} K_{y_iz_i} \\ K_{z_ix_i} K_{z_iy_i} q_{z_i} \end{vmatrix} \qquad (12)$$

where:

q_{x_i}, q_{y_i}, q_{z_i} are the dual weight of the defined coordinates;

$K_{x_iy_i}$, $K_{x_iz_i}$, $K_{y_ix_i}$, $K_{y_iz_i}$, $K_{z_ix_i}$, $K_{z_iy_i}$ are the covariance (correlation) moments.

The weight matrix of the point coordinates with i number is given in (13):

$$P^i_{xyz} = (q^i_{xyz})^{-1} = \begin{vmatrix} p_{x_i} p_{x_iy_i} p_{x_iz_i} \\ p_{y_ix_i} p_{y_i} p_{y_iz_i} \\ p_{z_ix_i} p_{z_iy_i} p_{z_i} \end{vmatrix} \qquad (13)$$

5 Evaluation of the geometrical parameters of the tank with the use of the covariance matrix of the point coordinates at the tank wall surface

The evaluation by the least square method using the covariance matrix point coordinates at the surface is fulfilled under the following conditions:

$$\sum_{i=1}^{n} P_i \cdot \vartheta_i^2 = min \qquad (14)$$

where P_i is the weight of the radial deviations.

The dual weight of the radial deviation ϑ_i and the radial deviation weight are given by :

$$\frac{1}{P_i} = Q_i = |a_{i1} a_{i2} a_{i3}| \cdot \begin{vmatrix} q_{x_i} K_{x_iy_i} K_{x_iz_i} \\ K_{y_ix_i} q_{y_i} K_{y_iz_i} \\ K_{z_ix_i} K_{z_iy_i} q_{z_i} \end{vmatrix} \cdot \begin{vmatrix} a_{i1} \\ a_{i2} \\ a_{i3} \end{vmatrix}^T_i \qquad (15)$$

$$P_i = \frac{1}{Q_i} = (A_i q^i_{xyz} A)^{-1} \qquad (16)$$

where:

q^i_{xyz} is the covariance (correlation) coordinate matrix which is calculated using formula (12);

A_i is the partial derivative matrix of equation (1) by the measured coordinates (see equations (2) and (3)).

The normal equation system in the matrix, when the coordinate covariance matrix is not singular but is received from corrected parametric equations (2) and taking into account that $B^T \cdot P \cdot \vartheta = 0$, is given by:

$$B^T \cdot P \cdot B \cdot \delta\tau + B^T \cdot P \cdot l = 0 \quad \text{or} \quad N \cdot \delta\tau + L = 0 \qquad (17)$$

where P is the matrix of the weight of the radial deviations which consist of P_i calculated by equation (16).

After solving the normal equations, corrections to the approximate values of the geometrical parameters are calculated by formula (5) and of the radial deviations by formula (3).

If necessary, corrections to the measured point coordinates are calculated by:

$$V^i_{xyz} = \begin{vmatrix} v_{x_i} \\ v_{y_i} \\ v_{z_i} \end{vmatrix} = \begin{vmatrix} q_{x_i} K_{x_i y_i} K_{x_i z_i} \\ K_{y_i x_i} q_{y_i} K_{y_i z_i} \\ K_{z_i x_i} K_{z_i y_i} q_{z_i} \end{vmatrix} \cdot \begin{vmatrix} a_{i1} \\ a_{i2} \\ a_{i3} \end{vmatrix} \cdot P_i \cdot \vartheta_i = q^i_{xyz} \cdot A_i \cdot P_i \cdot \vartheta_i \qquad (18)$$

The evaluation of the standard radial deviation of the tank is σ. Its weight is equal to unity:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} P_i \cdot \vartheta_i^2}{n-k}} \qquad (19)$$

As a check, the value that is calculated in the numerator of formula (19) can also be calculated by formula (20):

$$\sum_{i=1}^{n} P_i \cdot \vartheta_i^2 = V^T P_{xyz} V \qquad (20)$$

$$V^T P_{xyz} V = \sum_{i=1}^{n} \left(\begin{vmatrix} v_{x_i} v_{y_i} v_{z_i} \end{vmatrix} \cdot \begin{vmatrix} p_{x_i} p_{x_i y_i} p_{x_i z_i} \\ p_{y_i x_i} p_{y_i} p_{y_i z_i} \\ p_{z_i x_i} p_{z_i y_i} p_{z_i} \end{vmatrix} \cdot \begin{vmatrix} v_{x_i} \\ v_{y_i} \\ v_{z_i} \end{vmatrix} \right) \qquad (21)$$

where:

P_{xyz} is the weight coordinate matrix calculated by formula (13);

V is the correction matrix to the point coordinates from formula (3) calculated by formula (18).

The evaluation of the tank's geometrical parameters and its uncertainties is carried out using formulas (8).

We must admit that the difference between the tank's geometrical parameters estimated by the least square method and their real values would tend towards zero if the following conditions are taken into account:

1) the mathematical expectation of the tank's geometrical parameters are their real values;
2) the errors of measurement slope distance, horizontal direction and vertical angle dispersed by normal or another symmetric distributional law;
3) the measurement errors systematic components are absent;
4) the uncertainties of the reference point coordinates of the geodetic net are negligible;
5) a quantity of point coordinates at the tank's surface that are determined on the measurement results is significantly large;
6) the points whose coordinates are determined are distributed over the tank's surface evenly enough.

If one of the conditions is violated than the evaluation of the geometrical parameters would be shifted toward their mathematical expectations. The question of the evaluation of these shifts would also depend on the evaluation of the geometrical characteristics of the geodetic instruments during their calibration.

6 Evaluation of the total and interval capacities of the tank and its uncertainty

The geometrical parameters of the orientation, dimensions and shape are entered into formulas for the calculation of the total and interval capacities of the tank:

$$V_{z_f} = \psi_V(\tau_1 ... \tau_k, z_f) \qquad (22)$$

where z_f is the absolute height of the liquid in the tank with current number f, for which the interval capacity is calculated.

The evaluation of the standard deviation (A-type standard uncertainty) unimproved by the tank's interval capacity correction to height z_f is calculated by the formula:

$$u_A^2(V_{z_f}) = \sigma_{V_{z_f}}^2 = F_{V_{z_f}} \cdot K_{\delta\tau} \cdot F_{V_{z_f}}^T = \sigma_\vartheta^2 \cdot F_{V_{z_f}} \cdot Q \cdot F_{V_{z_f}}^T \tag{23}$$

where $F_{V_{z_f}} = \left| \frac{\partial\psi_V}{\partial\tau_1} \ldots \frac{\partial\psi_V}{\partial\tau_j} \ldots \frac{\partial\psi_V}{\partial\tau_k} \right|$ is the partial derivatives vector from function (22) by the tank's geometrical parameters, which play a role in the calculation of its capacity or capacity of its part.

Taking into account a large number of points whose coordinates are determined by the method of laser scanning on the tank's surface, it is proposed to calculate the terrain corrections ΔV_{z_f} by the following formulas:

$$\overline{\vartheta}_{z_f} = \frac{\sum_{i=1}^{n_{z_f}} \vartheta_i}{n_{z_f}}; \quad \Delta V_{z_f} = S_{z_f} \cdot \overline{\vartheta}_{z_f} \tag{24}$$

$$S_{z_f} = \psi_S(\tau_1 \ldots \tau_k, z_f) \tag{25}$$

where:

S_{z_f} is the tank's surface area to height z_f;

$\overline{\vartheta}_{z_f}$ is the tank's mid radial deviation to height z_f;

n_{z_f} is a number of points on the tank's surface to height z_f, whose coordinates were determined.

Such terrain corrections into the tank's interval capacities allow the accuracy of the volumetric method of measurement for tanks with a total capacity up to 20 m^3 to be improved.

The evaluation of the standard deviation (A-type standard uncertainty) of the tank's surface area to height z_f is fulfilled by formula (26):

$$u_A^2(S_{z_f}) = \sigma_{S_{z_f}}^2 = F_{S_{z_f}} \cdot K_{\delta\tau} \cdot F_{S_{z_f}}^T = \sigma_\vartheta^2 \cdot F_{S_{z_f}} \cdot Q \cdot F_{S_{z_f}}^T \tag{26}$$

where $F_{S_{z_f}} = \left| \frac{\partial\psi_S}{\partial\tau_1} \ldots \frac{\partial\psi_S}{\partial\tau_j} \ldots \frac{\partial\psi_S}{\partial\tau_k} \right|$ is the partial derivatives vector from the tank's surface area to height z_f by the tank's geometrical parameters which take part in its calculation.

The standard deviation of the mid radius deviation of the tank's wall to height z_f, which is comprised in formulas (22), is calculated by formula (27):

$$\sigma_{\overline{\vartheta}_{z_f}} = \sqrt{\frac{\sum_{i=1}^{n_{z_f}} (\vartheta_i - \overline{\vartheta}_{z_f})^2}{n_{z_f} \cdot (n_{z_f} - 1)}} \tag{27}$$

The standard deviation (A-type uncertainty) of the terrain correction ΔV_{z_f} is calculated by formula (28):

$$u_A(\Delta V_{z_f}) = \sigma_{\Delta V_{z_f}} = \sqrt{\overline{\vartheta}_{z_f}^2 \cdot \sigma_{S_{z_f}}^2 + S_{z_f}^2 \cdot \sigma_{\overline{\vartheta}_{z_f}}^2} \tag{28}$$

The adjusted terrain correction of the tank's interval capacity to height z_f and its uncertainty are calculated by formulas (29):

$$\overline{V}_{z_f} = V_{z_f} + \Delta V_{z_f}$$

$$u_A(\overline{V}_{z_f}) = \sqrt{u_A^2(V_{z_f}) + u_A^2(\Delta V_{z_f})} \tag{29}$$

For vertical cylindrical tanks, the measurement model (1) takes the form:

$$R = \sqrt{\frac{(x_i - x_o - z_i \cdot \eta_x)^2}{1+\eta_x^2} + \frac{(y_i - y_o - z_i \cdot \eta_y)^2}{1+\eta_y^2}} \tag{30}$$

where:

R is the mid internal radius of the tank's cylindrical part;

x_o, y_o are the horizontal coordinates of the point on the tank's axis if $z_o = 0$.

$$\eta_x = tg\beta_x; \quad \eta_y = tg\beta_y \tag{31}$$

where β_x, β_y are the tilt of the tank axis angles in the plane projection coordinates xz and yz.

In the formulas that calculate the interval capacities (22) and surface areas (25) of vertical cylindrical tanks, we use only three geometrical parameters:

$$V_{z_f} = \pi \cdot R^2 \cdot \sqrt{1+\eta_x^2+\eta_y^2} \cdot z_f \tag{32}$$

$$S_{z_f} = \pi \cdot R \cdot (1 + \sqrt{1 + \eta_x^2 + \eta_y^2}) \cdot z_f \qquad (33)$$

In order to simplify the understanding of this model, other important corrections such as corrections for tank deformations due to the working pressure of the liquid, corrections for tank deformation due to temperature variations (and others) have not been included.

7 Summary

1) A point coordinate covariance matrix at the tank surface, and the method for its use, have been developed in order to estimate the geometrical parameters and the tank capacity.
2) The geometrical parameters of the tank obtained by approximation results have been correlated, which leads to the evaluation of the interval capacity uncertainty with their covariance matrix obtained by the least square method.
3) A universal algorithm has been proposed for correction calculations to interval capacities of any tank surfaces for the deviation of the real shape surface from the approximation.
4) A general theoretical method for evaluating the interval capacity and its uncertainty of any tank has been developed, which provides adequate comparable results without regard to the tank's shape and dimension, its surface deformations, geodetic measurement accuracy, and also points location and quantity, the coordinates of which were determined on the surfaces.
5) The proposed method can be used as a mathematical background for developing International Recommendations for evaluating the geometrical parameters of tanks, their common and interval capacities, and their uncertainty.

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PREPACKAGES

Realization of the project "Development of a system for prepackage control"

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1 Introduction

The project to develop the metrological control of prepackaged products in Serbia was set up on a conceptual basis. It was almost entirely realized thanks to the support primarily of the Directorate of Measures and Precious Metals (DMDM) management within the Ministry of Economy, and also of the PTB project "Support of quality infrastructure in Serbia". This broad and very important legal metrology project was launched in a systematic way, using available resources and competent staff.

The project was successfully completed thanks to the regular and systematic monitoring of the relevant phases, available resources, the enthusiasm of the staff running it and the close support of the project manager. Major steps in its development were achieved in a short period of time because the vision and mission were clear, and an appropriate quality system was implemented.

Surveillance of the packers and importers of prepackaged products is the responsibility of the DMDM (among other areas), and aims to provide security for domestic producers of prepackages. It also ensures accurate labeling of prepackaged products on the domestic market, as well as when exporting products to overseas markets, with regard to the quantity in prepackages. As a prepackage contains product that is packed without the presence of the customer, it must not be possible to change the quantity without opening the package. Such surveillance also aims to protect consumers from inaccurate quantities of imported non-conforming products.

The DMDM uses internationally recognized and approved testing methods, competent and trained staff, appropriate resources and documented procedures. These factors, together with the well-recognized rules which are respected by the principles of an integrated quality management system, represent a good base for knowledge dissemination, thereby establishing methods and effective surveillance of the packers and importers of prepackages.

2 Realization of the project

The project was implemented according to the stages listed below.

2.1 "Legislative activities" phase

The Regulation on prepackaged products ("Official Gazette of the RS" No. 43/13) is the most important by-law in this area, based on the Law on Metrology ("Official Gazette of the RS" No. 30/10). EEC Directives 76/211/EC, 2007/45/EC and 75/107/EC were transposed into a regulation on prepacked products. The provisions of OIML R 87 and OIML R 79 were also taken into account during the development of the provisions of the Regulation.

In accordance with Article 14, on the date of entry into force of the Regulation, the provisions of the 16 quality regulations for specific products (in the part related to tolerable deviations from the nominal quantity) will cease to exist.

The Regulation on prepackaged products prescribes the permitted negative deviation of products marked with a mass unit or volume unit in the range from 5 g to 10 kg or 5 ml to 10 ml and the permitted negative deviation of products which have a quantity mark in units of length, area and number of pieces. It also prescribes the tolerances of unequal net quantities.

According to the Regulation, requirements for e-marking are set based on the principle of the mean value, in accordance with Directive 76/211/ EC.

Checking of products that have no "e" mark on the label includes checking inscriptions and markings, as well as a minimum with the negative deviation. The requirement specifies that the actual quantity of each prepackaged product must be in line with the nominal quantities and deviations from Table 1 in Annex 1 Section 2.2 of this Regulation, while the requirements of the mean value of the actual quantities referred to in the Annex are not applied.

The transitional period for the new Regulation gives enough time for packers and importers of prepackaged products to adapt to new tolerances. The tolerable negative errors from Table 1 in Annex 1, Section 2.2 of this Regulation are harmonized with Directive 76/211/EC and OIML R 87.

Inscriptions and markings are in accordance with OIML R 79, while the prescribed ranges of nominal quantities are in accordance with Directive 2007/45/EC.

2.2 "Procurement of equipment" phase

The necessary equipment for testing prepackaged goods was purchased and is used for the control of batches at the premises of packers and importers. This equipment is mobile and adapted for field work. It consists of a precise non-automatic weighing instrument connected to a computer interface and software for data transfer. It also includes a process densitometer of a type suitable for field work, as well as other equipment for determining density.

The software used for processing the results of measurements for the surveillance visit is in Microsoft Excel format and represents a satisfactory solution.

However, with increasing number of surveillance visits as well as an increase in the number of tested products it is necessary to establish a suitable database to record the companies visited, together with the results of tests and other information such as consumer complaints. The plan of surveillance visits is based on a risk assessment (in accordance with WELMEC principles). The database requires an adequate search facility and should be able to print out reports during visits.

Figure 1 Laboratory for prepacked products

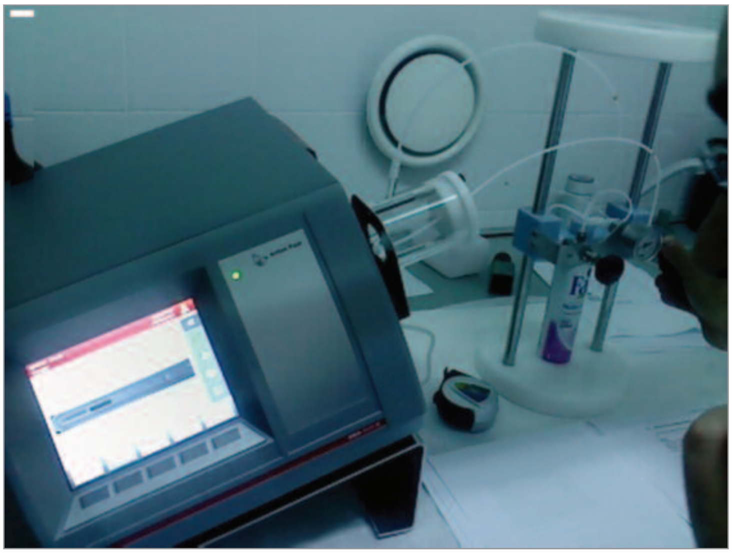


Figure 2 Equipment for the examination of aerosols

2.3 "Reference laboratory for prepackaged products" phase

The laboratory was designed to be an excellent basis for the dissemination of knowledge and establishing methods. In cooperation with the national organization of consumers, tests on certain groups of products were carried out, based on consumer complaints. It was found that there were significant deviations of actual quantities from the specified nominal quantity, to the detriment of consumers. The laboratory is equipped for testing measuring container bottles at the request of manufacturers. Also, preparation of equipment procurement was carried out such as a laboratory densitometer with an oscillating U-tube, which will provide the most accurate measurements for different types of products whose density is difficult to determine because of inhomogeneities or the presence of a gas phase, including also the examination of aerosols.

Figure 3 Training at NMO, UK, with the support of the PTB project

2.4 "Staff training" phase

The most important type of training was practical training organized by the NMO (UK), supported by the PTB project and implemented very successfully by Mr. Howard Burnett.

Figure 4 Training at NMO, UK, with the support of the PTB project

Figure 5 Staff training at the packer's premises

Figure 6 Staff training at the laboratory for prepackaged products

Two practical training sessions were organized within the PTB project at the premises of packers in the Republic of Serbia and in the DMDM laboratory. Internal training was also organized in the laboratory for prepackaged products.

A Workshop on the topic "The implementation of WELMEC guidance", within the PTB project "Support of the Quality Infrastructure in Serbia", was organized at the DMDM for the team which is responsible for performing surveillance on prepackages.

2.5 "Seminars and training of packers and importers" phase

The team from the DMDM, in cooperation with the Serbian Chamber of Commerce, held the following seminars for packers of prepackaged products:

- Seminar organized with the support of the Bureau for Cooperation with the EU and with the TAIEX department of the European Commission on "Requirements for prepackaged products, including rules on nominal quantities" held in Belgrade, in June 2010;
- "Seminar on the implementation of the Regulation on prepackaged products", held in cooperation with the Chamber of Commerce in Belgrade, in September 2013;
- "Seminar on the implementation of the Regulation on prepackaged products", held in cooperation with the Regional Chamber of Commerce Kruševac, in December 2013;
- "Seminar on the implementation of the Regulation on prepackaged products", held in cooperation with the Regional Chamber of Commerce Valjevo, in April 2014;
- "Seminar on the implementation of the Regulation on prepackaged products", held in cooperation with the Regional Chamber of Commerce Vojvodina, in November 2014;
- "Seminar on the implementation of the Regulation on prepackaged products", held in cooperation with the Regional Chamber of Commerce Kraljevo, in April 2015;
- "Seminar on the implementation of the Regulation on prepackaged products", held in cooperation with the Regional Chamber of Commerce Zrenjanin, in May 2015.

During the seminars, packers were informed about the requirements of the Regulation, and received guidance on how to properly set up their control system of quantity, through practical examples. One of the objectives was the registration of packers.

Based on the survey of participants, a large number of companies were interested in the process of obtaining approval for applying the "e" conformity mark, from the responsible authority.

2.6 "Surveillance of prepackaged products" phase

For the first time in the history of Serbian Metrology, at the end of 2013 the Sector for control and supervision implemented the new metrological supervision rules for packers and importers of prepackaged products. This supervision was performed according to established procedures and in accordance with the regular annual supervision plan. The surveillance visits were performed following monthly plans for the six offices of the Department of control and supervision: DCS Belgrade, DCS Kruševac, DCS Niš, DCS Novi Sad, DCS Zrenjanin and DCS Subotica.

Trained and competent staff performed tests on prepackaged products at the packer's and importer's premises throughout the whole territory of the Republic of Serbia.

During the surveillance visits to packers and importers, inspectors carried out tests of prepackaged products as well as supervision of measuring instruments in use.

The first year of supervision was conceived as a kind of "screening" in relation to the quantity of prepackaged products. The actual deviations were checked regarding tolerances in accordance with the new Regulation, as well as internal control mechanisms used by the producer, primarily for quantity control systems (weighing instruments, volume measuring instruments and density measuring instruments, software, packaging and filling machines, various devices for checking the quantities representing control quantity systems, etc.).

After examining the various quantity control systems as well as a variety of devices and measuring instruments and the procedures used, a comprehensive image could be built concerning what was necessary regarding the harmonization of our Regulation with European practice. The aim was to highlight any differences between the domestic practice of quantity control with European practice, and to establish to what extent professional assistance is necessary for our producers in order to harmonize their quantity control systems, especially for e-marking of prepackaged products.

Over the last year 230 surveillance visits of packers and importers were performed, which involved testing 72 000 prepackaged products and carrying out more than 1150 inspections. A significant number of non-conforming products as well as non-verified measuring instruments were found.

Figure 7 and Figure 8 TAIEX Seminar "Requirements for prepackaged products, including rules on nominal quantities", Belgrade

Figure 9 Seminar on the implementation of the Regulation on prepackaged products in the Serbian Chamber of Commerce, Belgrade

Figure 10 Seminar on the implementation of the Regulation on prepackaged products in the Regional Chamber of Commerce Zrenjanin

Figure 11 Seminar on the implementation of the Regulation on prepackaged products in the Regional Chamber of Commerce Valjevo

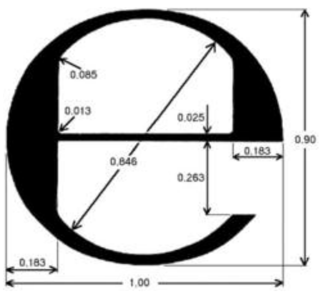


Figure 12 The mark of conformity, "e" mark

The control of measuring instruments, including those used for producing prepackaged products (non-automatic weighing instruments, density measuring instruments, automatic gravimetric filling instruments, check-weighing instruments) must be verified in accordance with the Law on Metrology.

Written records were made during the surveillance visits on prepackages as well as written records in relation to supervision of the measuring instruments in use. These can be used to institute legal proceedings if any violation of the Law on Metrology is found.

After testing of the prepackaged products sampled from a batch, according to defined sampling rules, the results were compared according to clearly defined criteria of acceptability, defined in the Regulation, and in accordance with the AQL acceptability levels. Software provides data on the number of non-conforming or inadequate products.

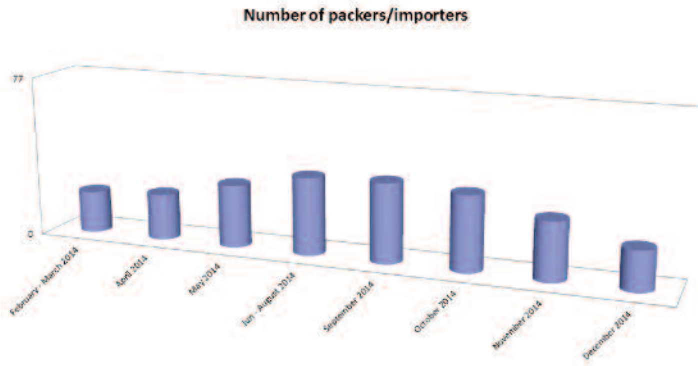
During the surveillance visits, inspectors produced a report on the packer's or importer's premises containing data on the packer/importer, the product, the packaging lines, and the tolerable negative error used by the packers, bearing in mind the transitional period of the Regulation, the method of sampling, and the results of sampling and testing. In performing surveillance, a person authorized to perform metrological surveillance can provide an expert interpretation of the Regulation as well as the necessary information in accordance with the authorizations under the Law on Metrology.

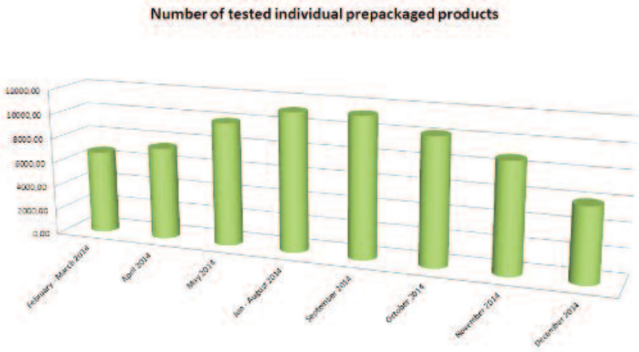
2.7 Participation in the activities of OIML TC 6 and WELMEC WG 6

WELMEC WG 6 *Prepackages* was established to achieve harmonization of the regulations that apply to prepackaged products. Its work also supports the OIML and the European Commission. WELMEC Working Group 6 has developed Guides and draft publications, and provides opinions on technical issues, bearing in mind various different approaches in OIML publications as well as in documents of the European Commission.

All the WELMEC Guides of this WG have been translated into Serbian and implemented in practice. Some of them are used as work instructions and procedures; others are intended for inspectors and some for packers, for example, the "Guide for the evaluation of measurement uncertainty in determining the actual content of prepackaged products".

In particular, it is necessary to emphasize that the "Guide for packers and importers" has been translated, professionally edited and published on the "Prepackages" web page of the official DMDM website, on which all the necessary information can be found.





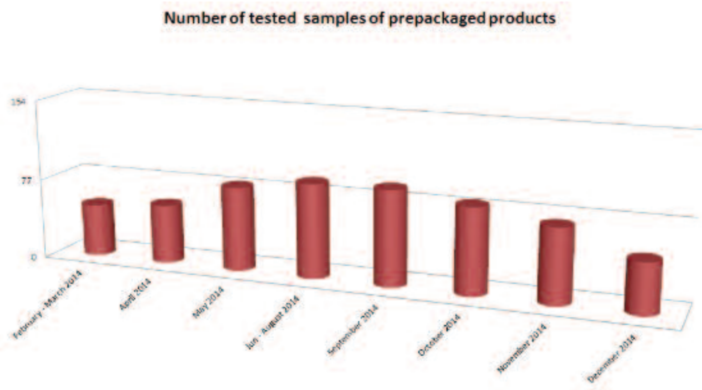


Figure 13 The one-year results of the surveillance and testing of prepackages

3 Ideas and further steps in the development of this field

Possible future tasks for the team which participates in the implementation of the Law on Metrology have been identified as follows:

- the most important task is the approval of the use of the "e" conformity mark on the basis of the explicit acceptance of procedures, upon receipt of an application to DMDM;
- the development of a Regulation on aerosols, aerosol testing methods, and procurement of the necessary equipment;
- testing of measuring container bottles, establishing of the method, approval of the producer's mark on request;
- special methods to determine the quantity of certain prepackaged products (with a share of gas phase);
- revision of, and amendment to the Regulation (prepackaged products with nominal quantity over 10 kg or 10 L);
- revision of the Regulation, introduction of the principle of mean value for products that are not marked with the conformity mark, fully in line with European practice;
- guide for consumers; and
- organization of special seminars for importers.

4 Conclusion

The project provides significant support to the Serbian economy. It was successfully completed thanks to the regular and systematic monitoring of the relevant

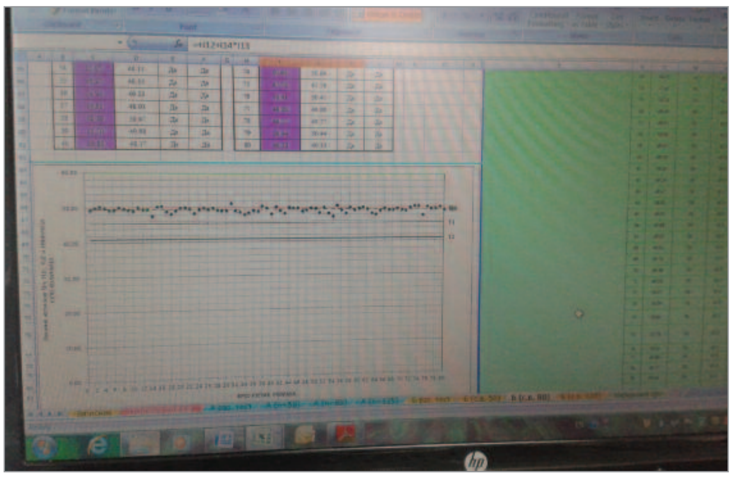


Figure 14 Software for the reference test of prepackaged products

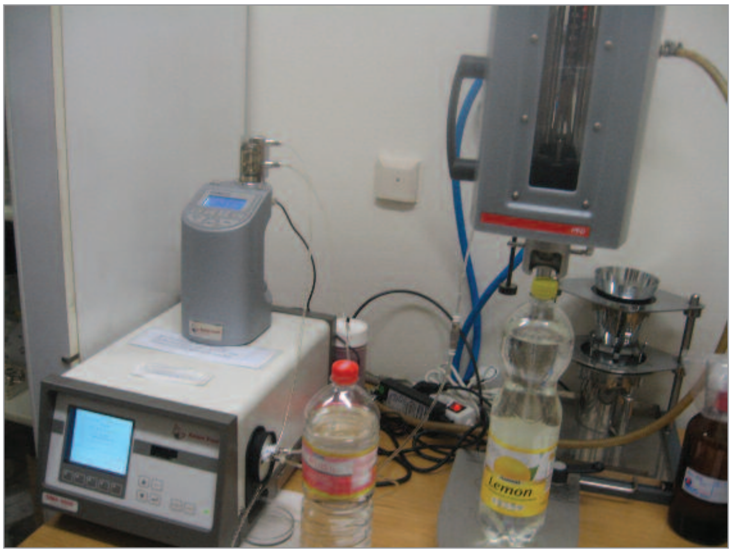


Figure 15 Special methods of determining the quantity of certain prepackaged products (with a share of gas phase)

phases, available resources, the enthusiasm of the staff running it and the close support of the project manager.

It can also be noted that very large steps in the development can be achieved in a short period, when a suitable quality system is implemented. ■

Acknowledgement

We are very grateful to Mr. Howard Burnett, Convener of WELMEC WG 6 *Prepackages* for his assistance, advice, suggestions and training regarding the Project "Development of a system for prepackage control".

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[7] Jović – Radanov B., Dragan Milanović, *Future directions for the control of pre-packed products in accordance with the new approach in the European framework*, 33rd JUPITER Conference**,** Belgrade, May 2007;

[8] Branka Radanov, *Pre-packaged products as a novelty in legal metrology of the Republic of Serbia*, JUSK ICQ 2011, Belgrade, June 2011.

OIML Systems

Basic and MAA Certificates registered 2015.03–2015.05

Information: www.oiml.org section "OIML Systems"

The OIML Basic Certificate System

The *OIML Basic Certificate System for Measuring Instruments* was introduced in 1991 to facilitate administrative procedures and lower the costs associated with the international trade of measuring instruments subject to legal requirements. The System, which was initially called "OIML Certificate System", is now called the "OIML Basic Certificate System". The aim is for "OIML Basic Certificates of Conformity" to be clearly distinguished from "OIML MAA Certificates".

The System provides the possibility for manufacturers to obtain an OIML Basic Certificate and an OIML Basic Evaluation Report (called "Test Report" in the appropriate OIML Recommendations) indicating that a given instrument type complies with the requirements of the relevant OIML International Recommendation.

An OIML Recommendation can automatically be included within the System as soon as all the parts - including the Evaluation Report Format - have been published. Consequently, OIML Issuing Authorities may issue OIML Certificates for the relevant category from the date on which the Evaluation Report Format was published; this date is now given in the column entitled "Uploaded" on the Publications Page.

Other information on the System, particularly concerning the rules and conditions for the application, issue, and use of OIML Certificates, may be found in OIML Publication B 3 *OIML Basic Certificate System for OIML Type Evaluation of Measuring Instruments* (Edition 2011) which may be downloaded from the Publications page of the OIML web site. ■

The OIML MAA

In addition to the Basic System, the OIML has developed a *Mutual Acceptance Arrangement* (MAA) which is related to OIML Type Evaluations. This Arrangement - and its framework - are defined in OIML B 10 (Edition 2011) *Framework for a Mutual Acceptance Arrangement on OIML Type Evaluations*.

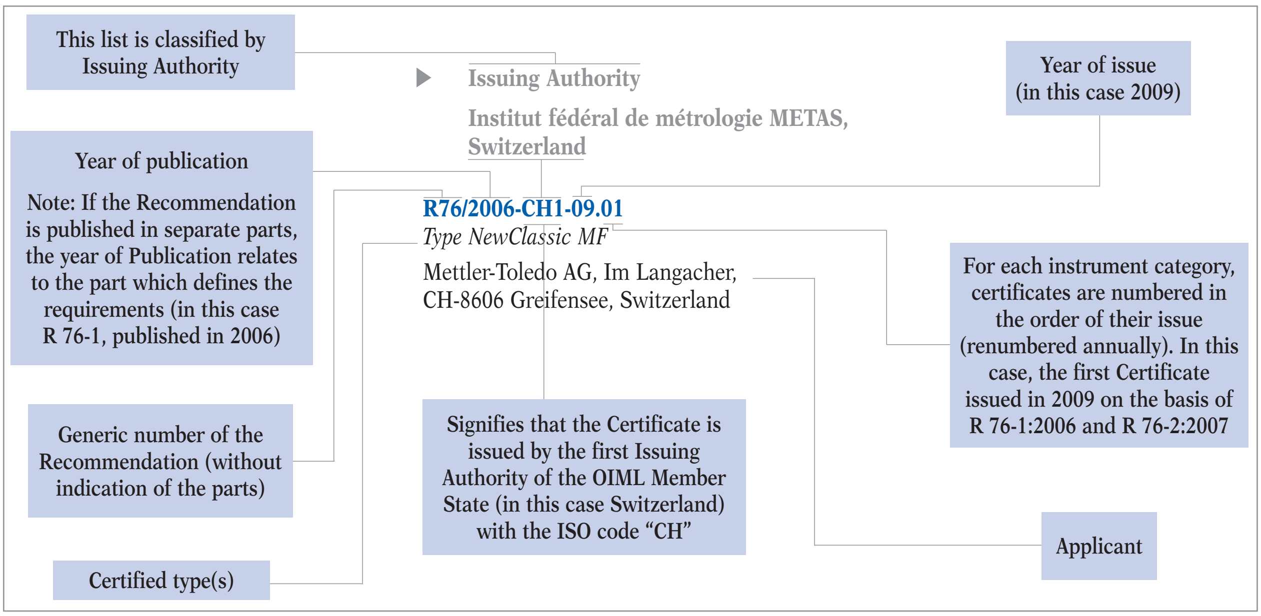
The OIML MAA is an additional tool to the OIML Basic Certificate System in particular to increase the existing mutual confidence through the System. It is still a voluntary system but with the following specific aspects:

- increase in confidence by setting up an evaluation of the Testing Laboratories involved in type testing,
- assistance to Member States who do not have their own test facilities,
- possibility to take into account (in a Declaration of Mutual Confidence, or DoMC) additional national requirements (to those of the relevant OIML Recommendation).

The aim of the MAA is for the participants to accept and utilize MAA Evaluation Reports validated by an OIML MAA Certificate of Conformity. To this end, participants in the MAA are either Issuing Participants or Utilizing Participants.

For manufacturers, it avoids duplication of tests for type approval in different countries.

Participants (Issuing and Utilizing) declare their participation by signing a Declaration of Mutual Confidence (Signed DoMCs). ■



INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Taximeters
Taximètres

R 21 (2007)

Issuing Authority / *Autorité de délivrance*

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

R021/2007-FR2-2015.01
Taximeter A.T.A. - Type: Revolution
Automatismes et Techniques Avancées SA, 30 impasse du Nid, ZA du Verdalai, FR-13790 Peynier, France

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Diaphragm gas meters
Compteurs de gaz à parois déformables

R 31 (1995)

Issuing Authority / *Autorité de délivrance*

State General Administration for Quality Supervision and Inspection and Quarantine (AQSIQ), China

R031/1995-CN1-2014.01
Type: G2.5S
Zhejiang Sapphire Meter Technology Co. Ltd., Qiantong Town, Ninghai County, CN-315636 Zhejiang Province, P.R. China

R031/1995-CN1-2014.02
Type: G1.6
Qianwei Kromschroder Meters (Chongqing) Co. Ltd., Middle section No. 69, Huangshan Avenue, Yu Bei District, CN-401121 Chonging, P.R. China

R031/1995-CN1-2014.04
Type: G2.5
Qianwei Kromschroder Meters (Chongqing) Co. Ltd., Middle section No. 69, Huangshan Avenue, Yu Bei District, CN-401121 Chonging, P.R. China

R031/1995-CN1-2014.05
Type: G4
Qianwei Kromschroder Meters (Chongqing) Co. Ltd., Middle section No. 69, Huangshan Avenue, Yu Bei District, CN-401121 Chonging, P.R. China

R031/1995-CN1-2015.03
Type: G1.6
Qianwei Kromschroder Meters (Chongqing) Co. Ltd., Middle section No. 69, Huangshan Avenue, Yu Bei District, CN-401121 Chonging, P.R. China

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Water meters intended for the metering of cold potable water and hot water
Compteurs d'eau pour le mesurage de l'eau potable froide et de l'eau chaude

R 49 (2006)

Issuing Authority / *Autorité de délivrance*

Czech Metrology Institute (CMI), Czech Republic

R049/2006-CZ1-2014.02 Rev. 1
Woltman water meter - Type: TURBO OPTIMA
PFGroup Flowmeter (LEI),
256, Boulevard Ba Hmad, 20300 Casablanca, Morocco

Issuing Authority / *Autorité de délivrance*

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

R049/2006-FR2-2012.02 Rev. 1
Water meter ITRON - Type: WOLTEX (WE)
Itron France, 11, Boulevard Pasteur, FR-67500 Haguenau, France

Issuing Authority / *Autorité de délivrance*

NMi Certin B.V., The Netherlands

R049/2006-NL1-2012.01 Rev. 4
Water meter intended for the metering of cold potable water and hot water, model "WATERFLUX 3070", class 1 and 2
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, The Netherlands

R049/2006-NL1-2012.01 Rev. 5
Water meter - Type: WATERFLUX 3070
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, The Netherlands

Issuing Authority / *Autorité de délivrance*

NMRO Certification Services (NMRO), United Kingdom

R049/2006-GB1-2007.01 Rev. 4
Family of cold-water meters utilising a common volumetric measuring element, with a normal capacity of 36 revs/litre and having a rated permanent flowrate Q_3 of 2.5 m^3/h
Elster Metering Ltd., 130 Camford Way, Sundon Park, Luton LU3 3AN, United Kingdom

R049/2006-GB1-2009.01 Rev. 4 (MAA)
Family of cold-water meters utilising a common, volumetric measuring element, with a normal capacity of 16.5 revs/litre and having a rated permanent flowrate Q_3 of 2.5 m^3/h (R250) and 4.0 m^3/h (R400)
Elster Metering Ltd., 130 Camford Way, Sundon Park, Luton LU3 3AN, United Kingdom

R049/2006-GB1-2015.01
A family of cold water meters, designated CZUS, utilising an ultrasonic measuring element and having a rated permanent flowrate Q_3 between 40 m^3/h and 1000 m^3/h
Contazara S.A, Carretera Castellon km 5.5, ES-50720 Zaragozz, Spain

Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R049/2006-DE1-2008.02 Rev. 0
Water meter intended for the metering of cold potable water - Type: Q200 Q_3=1.6 (E,P,M), Q200 Q_3=2.5 (E,P,M), SM250 (E,P,M), SM700 (E,P,M), SM800 (E,P,M)
Elster Metering Ltd., 130 Camford Way, Sundon Park, Luton LU3 3AN, United Kingdom

R049/2006-DE1-2015.02
Water meter intended for the metering of cold potable water and hot water. Single jet meter with mechanical indicating device with 7 or 8 number rollers - Type: ETKD
Zenner International GmbH & Co. KG, Römerstadt 4, DE-66121 Saarbrücken, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Continuous totalizing automatic weighing instruments (belt weighers)
Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande)

R 50 (1997)

Issuing Authority / *Autorité de délivrance*

NMRO Certification Services (NMRO), United Kingdom

R050/1997-GB1-2009.01 Rev. 2
Milltronics MSI/MM1
Siemens Milltronics, 1954 Technology Drive, CA-Peterborough ON K9J 6X7, Canada

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Continuous totalizing automatic weighing instruments (belt weighers)
Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande)

R 50 (2014)

Issuing Authority / *Autorité de délivrance*

NMRO Certification Services (NMRO), United Kingdom

R050/2014-GB1-2015.01
SA -600 Array Belt Weigher
Nanjing Sanai Industrial Automation Co., Ltd., 2 Xiyan Road, Binjiang Development Zone, Jianging, Nanjing, 211162 Jiangsu, P.R. China

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

R 51 (2006)

Issuing Authority / *Autorité de délivrance*

State General Administration for Quality Supervision and Inspection and Quarantine (AQSIQ), China

R051/2006-CN1-2014.01
Type: JW-C200, JW-C1000, JW-C2000, JW-C6000
Zhongshan Multiweigh Packaging Machinery Co. Ltd., No. 34, Zhenlian Road, Shangnan District, Fusha Town, CN-528434 Zhongshan, Guangdong, P.R. China

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*

State General Administration for Quality Supervision and Inspection and Quarantine (AQSIQ), China

R060/2000-CN1-2014.01 (MAA)
Type: SLC611
Mettler-Toledo (Changzhou) Precision Instruments Ltd., 5, Middle HuaShan Road, Xinbei District, CN-213022 ChangZhou, Jiangsu, P.R. China

Issuing Authority / *Autorité de délivrance*

NMi Certin B.V., The Netherlands

R060/2000-NL1-2015.04 (MAA)
Single point load cell, with strain gauges - Type: MLC 1A/MLC 1A MG
Balancas Marques de Jose Pimienta Marques, Ltda., Parque Industrial de Celeiros (2a Fase), Apartado 2376, 4701-905 Braga, Portugal

R060/2000-NL1-2015.05 (MAA)
Double ended shear beam load cell, with strain gauges - Type: 102FS
Anyload Transducer Co. Ltd., 6994 Greenwood Street, Unit 102, V5A 1X8 Burnaby, BC, Canada

R060/2000-NL1-2015.06 (MAA)
Compression load cell, with strain gauges - Type: ASC2
Vishay Transducers Celtron/Technologies Inc., Binguan Nan Dao Youyi Road, Hexi District, CN-Tianjin, P.R. China

R060/2000-NL1-2015.08 (MAA)
Single point load cell, with strain gauges - Type: L6E-xx-xx-xxx-XX - Series
Zhonghang Electronic Measuring Instruments Co. Ltd. (ZEMIC), Xinyuan Road, The North Zone of EDZ, Hanzhong, P.O. Box 2, CN-723000 Hanzhong- ShaanXi, P.R. China

Issuing Authority / *Autorité de délivrance*

NMRO Certification Services (NMRO), United Kingdom

R060/2000-GB1-2015.01
Bending beam load cell - Model GS-2
Transdutec, S.A., CL. Industria 1 - B1, Montgat, ES-08390 Barcelona, Spain

R060/2000-GB1-2015.02
Bending beam load cell - Model GS-2
GICAM, S.R.L., L.go C. Battisti, 9, Pzza XI Febbraio 2, IT-22015 Gravedona (CO), Italy

CATÉGORIE D'INSTRUMENT

Automatic gravimetric filling instruments
Doseuses pondérales à fonctionnement automatique

R 61 (2004)

Issuing Authority / *Autorité de délivrance*

NMi Certin B.V., The Netherlands

R061/2004-NL1-2015.02
Automatic gravimetric filling instrument - Type: VMT or VMT-C
Marmak Otomatik Ambalaj Makinalari San. Tic. Ltd. Sti., 10032 Sokak No. 19 I.A.O.S.B. Cigli, 35620 Izmir, 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*

International Metrology Cooperation Office, National Metrology Institute of Japan (NMIJ) National Institute of Advanced Industrial Science and Technology (AIST), Japan

R076/1992-JP1-2014.01 Rev. 1 (MAA)
Non-automatic weighing instrument - Type: SJ-WP series
A&D Company Ltd., 3-23-14 Higashi-Ikebukuro, Toshima-Ku, JP-170-0013 Tokyo, Japan

Issuing Authority / *Autorité de délivrance*

NMi Certin B.V., The Netherlands

R076/1992-NL1-2008.04 Rev. 1
Non-automatic weighing instrument - Type: Pioneer PA series
Ohaus Corporation, 7, Campus Drive, Suite 310, 07054 Parsippany - NJ, United States

R076/1992-NL1-2014.39
Indicator - Type: 10-I
Grupo Epelsa S.L., c/Punto Net, 3, Polígono Industrial Tecnoalcalá, ES-28805 Alcalá de Henares (Madrid), Spain

R076/1992-NL1-2014.40
Indicator - Type: ML-50, ML-100 and ML-200
Grupo Epelsa S.L., c/Punto Net, 3, Polígono Industrial Tecnoalcalá, ES-28805 Alcalá de Henares (Madrid), Spain

Issuing Authority / *Autorité de délivrance*

NMRO Certification Services (NMRO), United Kingdom

R076/1992-GB1-2010.05 Rev. 1 (MAA)
PB Series
CAS Corporation, #262, Geurugogae-ro, Gwangjeok-myeon, Yangju-si, Gyenonggi-do, Rep. of Korea

R076/1992-GB1-2012.01 Rev. 4 (MAA)
CT100 Series
CAS Corporation, #262, Geurugogae-ro, Gwangjeok-myeon, Yangju-si, Gyenonggi-do, Rep. of Korea

R076/1992-GB1-2015.01 (MAA)
MP Series
CAS Corporation, #262, Geurugogae-ro, Gwangjeok-myeon, Yangju-si, Gyenonggi-do, Rep. of Korea

R076/1992-GB1-2015.02 (MAA)
CL7200 Series
CAS Corporation, #262, Geurugogae-ro, Gwangjeok-myeon, Yangju-si, Gyenonggi-do, Rep. of Korea

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*

Czech Metrology Institute (CMI), Czech Republic

R076/2006-CZ1-2015.01
Indicator, tested as a part of a weighing instrument (for non-automatic weighing instrument) - Type: PUE 7.1
Radwag Wagi Elektroniczne Witold Lewandowski, ul. Bracka 28, 26-600 Radom, Poland

Issuing Authority / *Autorité de délivrance*

Dansk Elektronik, Lys & Akustik (DELTA), Denmark

R076/2006-DK3-2015.01
Non-automatic weighing instrument - Type: Load Line-3
Tunaylar Baskül Sanayi ve Ticaret A.S., Akcaburgaz Mah. 88 Sok. N°7, Esenyurt, Istanbul, Turkey

R076/2006-DK3-2015.02
Non-automatic weighing instrument - Type: Load Line-2
Tunaylar Baskül Sanayi ve Ticaret A.S., Akcaburgaz Mah. 88 Sok. N°7, Esenyurt, Istanbul, Turkey

R076/2006-DK3-2015.03
Non-automatic weighing instrument - Type: XE
CAS Corporation, #262, Geurugogae-ro, Gwangjeok-myeon, Yangju-si, Gyenonggi-do, Rep. of Korea

Issuing Authority / *Autorité de délivrance*

State General Administration for Quality Supervision and Inspection and Quarantine (AQSIQ), China

R076/2006-CN1-2014.01
Type: SCS-6
Xuzhou Weighing Instrument Company Limited, Qianjiang Road, Tongshan Economic Development Zone, CN-221116 Jiangsu Province, P.R. China

Issuing Authority / *Autorité de délivrance*

NMi Certin B.V., The Netherlands

R076/2006-NL1-2012.19 Rev. 1 (MAA)
Non-automatic weighing instrument - Type: PS3x
Mettler-Toledo Inc., 1150 Dearborn Drive, US-43085 Worthington, Ohio, United States

R076/2006-NL1-2012.36 Rev. 2 (MAA)
Non-automatic weighing instrument - Type: MP49
Mettler-Toledo Inc., 1150 Dearborn Drive, US-43085 Worthington, Ohio, United States

R076/2006-NL1-2012.42 Rev. 2 (MAA)
Non-automatic weighing instrument - Type MP 30
Mettler-Toledo Inc., 1150 Dearborn Drive, US-43085 Worthington, Ohio, United States

R076/2006-NL1-2013.14 Rev. 1 (MAA)
Non-automatic weighing instrument - Type: PS15
Mettler-Toledo Inc., 1150 Dearborn Drive, US-43085 Worthington, Ohio, United States

R076/2006-NL1-2013.15 Rev. 1 (MAA)
Non-automatic weighing instrument - Type: PS60
Mettler-Toledo Inc., 1150 Dearborn Drive, US-43085 Worthington, Ohio, United States

R076/2006-NL1-2014.03 (MAA)
Non-automatic weighing instrument - Type: PCSK
Grupo Epelsa S.L., c/Punto Net, 3, Polígono Industrial Tecnoalcalá, ES-28805 Alcalá de Henares (Madrid), Spain

R076/2006-NL1-2014.41
Non-automatic weighing instrument - Type: PCS
Grupo Epelsa S.L., c/Punto Net, 3, Polígono Industrial Tecnoalcalá, ES-28805 Alcalá de Henares (Madrid), Spain

R076/2006-NL1-2014.42
Non-automatic weighing instrument - Type: UHRS
Grupo Epelsa S.L., c/Punto Net, 3, Polígono Industrial Tecnoalcalá, ES-28805 Alcalá de Henares (Madrid), Spain

R076/2006-NL1-2015.01 (MAA)
Non-automatic weighing instrument - Type: RM-5801
Shanghai Teraoka Electronic Co. Ltd., Tinglin Industry Developmental Zone, Jin Shan District, CN-201505 Shanghai, P.R. China

R076/2006-NL1-2015.04 (MAA)
Weighing module - Type: AD2000
Shanghai Teraoka Electronic Co. Ltd., Tinglin Industry Developmental Zone, Jin Shan District, CN-201505 Shanghai, P.R. China

R076/2006-NL1-2015.07 (MAA)
Non-automatic weighing instrument - Type: Compella
Hill-Rom, 1069 State Route 46 East, US-47006 Batesville, Indiana, United States

R076/2006-NL1-2015.07 Rev. 1 (MAA)
Non-automatic weighing instrument - Type: Compella
Hill-Rom, 1069 State Route 46 East, US-47006 Batesville, Indiana, United States

R076/2006-NL1-2015.08 (MAA)
Non-automatic weighing instrument - Type: FM-65. . . Series
Fook Tin Technologies Ltd., 4/F Eastern Center, 1065 King's Road, Quarry Bay, Hong Kong

R076/2006-NL1-2015.12 (MAA)
Non-automatic weighing instrument - Type: AB,RJ
Shinko Denshi Co. Ltd., 3-9-11 Yushima, Bunkyo-ku, JP-113-0034 Tokyo, Japan

R076/2006-NL1-2015.14 (MAA)
Indicator or Analog Data Processing Device - Type: AE23
AE Van de Vliet BVBA, Industriedijk 14, BE-2300 Turnhout, Belgium

R076/2006-NL1-2015.15 (MAA)
Non-automatic weighing instrument - Type: DC-430MA
Tanita Corporation, 14-2, 1-Chome, Maeno-cho, Itabashi-ku, JP-174-8630 Tokyo, Japan

R076/2006-NL1-2015.16 (MAA)
Non-automatic weighing instrument - Type: AP3, BCH3, BLP3-35, BWH3, FB51, FB53, HWH3, KCH3, KP3, KWH3, PCH3, PH3, PWH3, QW, GW, RCH3, RP3, RWH3, SBH3-C, SBH3-P, SBH3-W, TCH3, TWH3
Excell Precision Co. Ltd., 6F, No. 127, Lane 235, Pao-Chiao Road, Hsin Tien, TW-Taipei Hsien, Chinese Taipei

R076/2006-NL1-2015.17 (MAA)
Non-automatic weighing instrument - Type: PS6X series
Xiamen Pinnacle Electrical Co. Ltd., 4F, Guangxia Building, North High-Tech Zone, Xiamen, CN-Fujian, P.R. China

R076/2006-NL1-2015.19 (MAA)
Indicator - Type: 480-2A, 480 Plus-2A, 482-2A, 482 Plus-2A
Rice Lake Weighing Systems, 230 West Coleman Street, US-54868 Rice Lake, Wisconsin, United States

R076/2006-NL1-2015.21 (MAA)
Non-automatic weighing instrument - Type: Ranger 3000 R31P. . ., Ranger Count 3000 RC31P. . ., Ranger 4000 R41M. . ., Ranger Count 4000 RC41M. . ., Valor 7000 V71P. . .

Ohaus Corporation, 7, Campus Drive, Suite 310, US-07054 Parsippany - NJ, United States

R076/2006-NL1-2015.22 (MAA)
Non-automatic weighing instrument - Type: SM-120

Shanghai Teraoka Electronic Co. Ltd., Tinglin Industry Developmental Zone, Jin Shan District, CN-201505 Shanghai, P.R. China

R076/2006-NL1-2015.25 (MAA)
Non-automatic weighing instrument - Type: BC Series

Mettler-Toledo Inc., 1150 Dearborn Drive, US-43085 Worthington, Ohio, United States

▶ **Issuing Authority /** ***Autorité de délivrance***

NMRO Certification Services (NMRO), United Kingdom

R076/2006-GB1-2015.05 (MAA)
Magellan 9300i or 9400i scanner/scale

Datalogic ADC, Inc, 959 Terry Street, US-97402 Eugene, OR, United States

▶ **Issuing Authority /** ***Autorité de délivrance***

Physikalisch-Technische Bundesanstalt (PTB), Germany

R076/2006-DE1-2012.03 Rev. 3
Non-automatic electromechanical weighing instrument - Type: SQP-. . .

Sartorius Weighing Technology GmbH, Weender Landstrasse 94-108, DE-37075 Gottingen, Germany

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-NL1-2015.18 (MAA)
An Indicator - Type: Intuitive 20i, Intuitive 22i

Vishay Advanced Technologies, 2 Ha'ofan St., P.O. Box 2502, 5881419 Holon, Israel

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***

NMRO Certification Services (NMRO), United Kingdom

R085/2008-GB1-2011.01 Rev. 1
AMETEK 7100 PSU Controller and AMETEK Petro-Stick probe

Dem. G. Spyrides S.A., 24 Athinon Avenue, GR-10441 Athens, Greece

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic rail-weighbridges
Ponts-bascules ferroviaires à fonctionnement automatique

R 106 (1997)

▶ Issuing Authority / *Autorité de délivrance*

NMRO Certification Services (NMRO),
United Kingdom

R106/1997-GB1-2007.01 Rev. 4
Railweight TSR4000
Avery Weigh-Tronix, Foundry Lane, Smethwick B66 2LP, United Kingdom

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Fuel dispensers for motor vehicles
Distributeurs de carburant pour véhicules à moteur

R 117 (1995) + R 118 (1995)

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V.,
The Netherlands

R117/1995-NL1-2006.03 Rev. 1
Type: Global Century Oil Mix
Wayne Fueling System Sweden AB, PO Box 50559, SE-202 15 Malmo, Sweden

R117/1995-NL1-2015.01
Fuel Dispenser for Motor Vehicles - Type: E30"x" "xxx" - Brand: Cetil
Medicion y Transporte, S.A., Calle Pelaya, 29, Pol. Ind. Rio de Janeiro, Algete, ES-28100 Madrid, Spain

▶ Issuing Authority / *Autorité de délivrance*

NMRO Certification Services (NMRO),
United Kingdom

R117/1995-GB1-2010.01 Rev. 1
Liquids other than water dispenser, designation Frontier
Gilbarco Veeder Root, Crompton Close, Basildon SS14 3BA, United Kingdom

R117/1995-GB1-2010.02 Rev. 1
Liquids other than water dispenser, designation Sprint
Gilbarco Veeder Root, Crompton Close, Basildon SS14 3BA, United Kingdom

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Dynamic measuring systems for liquids other than water
Ensembles de mesurage dynamique de liquides autres que l'eau

R 117 (2007)

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V.,
The Netherlands

R117/2007-NL1-2015.01
Density sensor (a sensor as a part of a densitometer) - Type: CDM100M; CDM100P
Emerson Process Management Micro Motion Inc., 7070 Winchester Circle, CO 80301 Boulder, United States

R117/2007-NL1-2015.02
Measurement transducer (rotary meter) - Type: TCS-700-xx
Total Control Systems, 2515 Charleston Place, IN 46805 Fort Wayne, United States

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic instruments for weighing road vehicles in motion and measuring axle loads
Instruments à fonctionnement automatique pour le pesage des véhicules routiers en mouvement et le mesurage des charges à l'essieu

R 134 (2006)

Issuing Authority / *Autorité de délivrance*

NMRO Certification Services (NMRO),
United Kingdom

R134/2006-GB1-2012.02 Rev. 1
Type: 3590E-AF09
Dini Argeo Srl, Via Della Fisica, 20, IT-41042 Spezzano di Fiorano (MO), Italy

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Gas meters
Compteurs de gaz

R 137 (2012)

Issuing Authority / *Autorité de délivrance*

NMi Certin B.V.,
The Netherlands

R137/2012-NL1-2015.02
Diaphragm gas meter - Type: JK/G2.5 & JK/G1.6
GoldCard High Tech Co. Ltd., No 158, Jinqiao Street, Economic and Technology Development Zone, Hangzou City, P. R. China

R137/2012-NL1-2015.03
Rotary displacement gas meter - Type: MRM
Metreg Technologies GmbH, Trankeweg 9,
DE-15517 Furstenwalde, Germany

Database of all OIML Certificates:

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The OIML is pleased to welcome the following new

CIML Members

Hungary:
Mr. Kristof Torok

Iran:
Mr. Khosro Madanipour

The Netherlands:
Ms. J.M. van Spronssen (Anneke)

OIML meeting

October 2015

50th CIML Meeting and associated events
Week of 19 October 2015, Arcachon, France

Bulletin online:

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Measure, analyze and innovate: an ongoing challenge!

International Congress of Metrology (CIM 2015) 21–24 September 2015

Paris (France) with the ENOVA Show

The CIM is to be the meeting point for technical exchanges between all the actors of measurement: industrial users of equipment, technical experts, public and private laboratories, manufacturers and service providers.

This congress is unique in Europe. It explores **developments in measurement techniques**, as well as R&D advances and their implication for industry. It demonstrates **how, on a daily basis, measurements improve industrial processes and risk management**.

The major topics of the Congress are presented in **six industrial round-tables**:

- Best practice in healthcare: contribution of metrology
- Energy transition: metrology meets challenges
- The world of soft metrology
- Outsourcing metrology: dream or reality?
- Agrifood: metrological advantage
- Risk management and control: new approach for ISO 9001

180 presentations will be given on a variety of topics. The main technical fields will be dealt with: mechanics, temperature, dimensional and 3D, flow, electricity, optics, etc. General topics such as uncertainty of measurement, statistics, cost optimization, etc. will also be covered.

New concerns will also be introduced: security in healthcare and agrifood, challenges related to climate change, nanotechnologies, etc.

To complete this program, **technical visits** are planned to the Observatoire de Paris, SOPEMEA and LNE.

The Congress is organized by the Collège Français de Métrologie in partnership with Euramet, *European Co-operation for Accreditation*, the BIPM, the OIML, the NCSLi, the NPL, the DFM and METAS concerning international participation. Users, professionals and academics complete this organization: A+ Métrologie, Acac, Afnor Normalisation, BEA Métrologie, CETIAT, Hexagon Metrology, Implex, LNE, PSA Peugeot Citröen, Trescal, l'Université de Bourgogne and Wika.

The main partner of the CIM 2015 is **A+ Métrologie**. The other sponsors are **CETIAT, Hexagon Metrology, Implex, Metrologic Group** and **Wika**. The Ministry of Industry and the Ministry of Culture also support the event.

Taking part at CIM provides you with an opportunity to...

... meet the "right" people who will **guide you to the "right" solutions more quickly**,

... establish a real **professional relationship with peers**,

... understand **the importance of metrology as a decision-making tool for industrial processes**, and

... **explore technologies and solutions** in tomorrow's world.

CIM 2015 is co-organized with ENOVA, a trade show dedicated to technologies in Electronics, Measurements, Vision and Optics. Both organizers created **a meeting-point between the Congress and the show at the heart of the exposition: The Metrology Village**.

Highlights of CIM 2015

- Daily animation in the **Metrology Village**: an open space which brings together visitors to the show, exhibitors concerned by the issues under discussion at the Congress, and all CIM participants.
- The opening session is on 21 September with two presentations about emerging topics in metrology:
  - "Metrology in services" by La Poste group;
  - "Metrology and forensics" by the Judicial Division of the National Gendarmerie.
- The plenary session on 23 September **"Metrology 4.0" with presentations by several key national metrology laboratories** – NIST (USA), NPL (UK) and the PTB (Germany) - about the metrology of tomorrow which is already appearing in our everyday lives.
- The intervention of **Mr. Claude Cohen Tannoudji, Nobel Prize for Physics in 1997**, during the closing session on 24 September afternoon.

Registered exhibitors in the Metrology Village on April 7

A+ Métrologie, Acalime, Aérométrologie, Alicona, AOIP, Aremeca, Automated Precision Europe, Beamex, Bruker, Carl Zeiss, Cetiat, Cofrac, Czech Metrology Institute, Delta Mu, E+E Elektronik, E2M, Ecole Supérieure de Métrologie, Endress & Hauser, Eotech, Felix Informatique, Furness Controls, GE Measurement & Control, Geomnia, Guildline Instruments, Hexagon Metrology, Implex, Innovalia Metrology, Insavalor, Insidix, JRI, Kréon Technologies, LNE, Manumesure, MB Electronique, MCE Microvu, Measurements International, Meatest, Metrologic Group, Mettler Toledo, Nikon Metrology, Olympus, Rotronic, Sematec, Sika France, Symetrie, Testo Industrial Services, TME, Trescal, Werth Messtechnik, Wika Instruments

COLLÈGE FRANÇAIS DE METROLOGIE

Full program and online registration:

www.metrologie2015.com

Press information:

General Secretariat of the Collège Français de Métrologie

+33 (0)4.67.06.20.36 - info@cfmetrologie.com - www.metrologie2015.com

OIML SEMINAR

Metrology in daily life

ANNA CYPIONKA, PTB Technical Cooperation Dept.
IAN DUNMILL, BIML Assistant Director

At the 49th CIML Meeting in Auckland, New Zealand in October 2014, the OIML advisory group on countries and economies with emerging metrology systems, chaired by Mr. Pu Changcheng of the P.R. China, announced that it intended to organize a seminar on the theme of *Metrology in daily life* in the coming year. This event was held in Chengdu, P.R. China on 14–15 May 2015.

The event was publicized by means of e-mails addressed to all Member States and Corresponding Members, and through the OIML website. The recipients of the *OIML Award for Excellent Achievements in Legal Metrology in Developing Countries* were also individually invited to attend so they could share with other attendees the experiences which had led to their receiving the Award.

Rather than being aimed at "developing countries" this seminar targeted "countries and economies with emerging metrology systems". By addressing this wider target group that includes countries which may not themselves be considered to be developing countries, but which do not have a modern operational metrology system in place, the OIML is able to broaden the impact of its work in this area. A significant number of the OIML's members fall into this group, as do most non-members.

The Seminar was structured into two parts: a needs assessment and a preliminary planning of activities.

For the needs assessment, each participant was asked to prepare a country report. A template was provided prior to the Seminar that included questions about areas requiring improvements and national action plans. On the first day, all the participants presented their country reports in a plenary session.

Based on the reports, a group of experts identified common problems and challenges for the CEEMS community. The group included the CIML President Peter Mason, former CIML Presidents Manfred Kochsiek and Alan Johnston, BIML Assistant Director Ian Dunmill, Guo Su from AQSIQ on behalf of the Chair of the Advisory Group Pu Changcheng, and Anna Cypionka as a representative of the PTB's Technical Cooperation Department. The following three challenges were identified as being most urgent for CEEMS:

- How can a legal metrology authority develop its capabilities, including the recruitment, training and retention of competent staff?

The Seminar was attended by about 100 delegates

Full room for one of the plenary sessions

- How can the efficiency of a legal metrology authority be improved by cooperation with private partners, e.g. by outsourcing to reliable service providers?
- How can a legal metrology authority improve its type approval procedures, e.g. by cooperating with other authorities in a region?

The morning of the second day was dedicated to a discussion of the above topics, to create a common understanding of the challenges between the CEEMS participants and the OIML leadership and to develop joint solutions and targeted actions.

The group of participants was quite large – about 20 international participants from 15 different countries plus around 80 participants from China – so to give everybody a chance to contribute to the discussions a participatory workshop approach was chosen. The process was facilitated by Guo Su for the Chinese participants and Anna Cypionka for the international participants.

The participants were split into three English-speaking and three Chinese-speaking groups according to their interest in the above topics. Each group discussed one of the topics. The English-speaking groups were accompanied and advised by the OIML experts.

In the beginning, each group chose a presenter to report the results in the plenary session at the end of the morning.

The groups started out with a general discussion of the topic they had chosen, including possible solutions for the CEEMS community. The main discussion points and ideas were documented on cards that were collected on pin boards. Such a visualization helped to keep everybody on track in a group discussion. Those who more easily perceived visual information were thus better able to follow the course of the discussion. Visualization also facilitated the presentation and documentation of the results of the subsequent group work.

Pu Changcheng and Peter Mason conclude the Seminar

Manfred Kochsiek and Alan Johnston analyze the notes posted by delegates

The second group work session was dedicated to the planning of concrete actions. The participants continued in the same groups, developing actions addressing the challenges they had discussed in the first session.

To give the groups some framework to work with, CIML President Peter Mason had suggested that the list of proposed actions should be organized into three categories:

- actions for the OIML,
- activities the OIML could contribute to, and
- activities the OIML might encourage others to undertake.

Again, ideas from the groups were documented on cards and then collected on one big board for all six groups jointly. Participants were asked to assign each action to one of the three categories mentioned above according to what they thought the OIML's role in taking the action should be. At the end of the morning, the presenter of each group reported back to the plenary and answered questions from the other groups.

After the sessions and discussions, the whole group was taken to Chengdu Heping Integrated Farmers' Market, to Chengdu Fangcao Community Health Service Center and to the State Grid Sichuan Electric Power Corporation Metering Center for technical visits.

An OIML Seminar Report is currently under preparation and will be published on the OIML website as soon as possible.

The ideas put forward by the Seminar participants open many avenues for future activities in each of the areas mentioned above. They will now be analyzed and used to prepare the agenda for another CEEMS seminar to be held in conjunction with the 50th CIML Meeting in Arcachon, France in October 2015. It is hoped that together, these two seminars will enable the OIML to establish strategies for cooperation with other international organizations as well as concrete actions for the future which will be of real benefit to all countries and economies with emerging metrology systems.

Chengdu Heping Integrated Farmers' Market,
Heping Community, Gaoxin District, Chengdu

The participants were split into three English-speaking and three Chinese-speaking groups to discuss the challenges facing CEEMS

OIML CERTIFICATE SYSTEM

List of OIML Issuing Authorities

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
Changes since the last issue of the Bulletin are marked in red.

		R 16	R 21	R 31	R 35	R 46	R 49	R 50	R 51	R 58	R 60	R 61	R 75	R 76	R 81	R 85	R 88	R 93	R 97	R 98	R 99	R 102	R 104	R 105	R 106	R 107	R 110	R 112	R 113	R 114	R 115	R 117/118	R 122	R 126	R 128	R 129	R 133	R 134	R 136	R 137
AT1	Bundesamt für Eich- und Vermessungswesen (BEV)							■	■	■		■		■		■	■		■	■		■	■		■	■	■			■	■	■								
AU1	National Measurement Institute (NMI)						■	■	■		■			■		■									■	■						■		■		■				
BE1	SPF Economie, PME, Classes Moyennes et Energie													■					■	■																				
BG1	State Agency for Metrology and Technical Surveillance (SAMTS)													■						■																				
BR1	Instituto Nacional de Metrologia, Normalização e Qualidade Industrial (INMETRO)													■																										
CH1	Institut fédéral de métrologie METAS	■		■			■	■	■		■	■		■					■	■				■	■	■						■						■		
CN1	General Administration of Quality Supervision, Inspection and Quarantine of P. R. China (AQSIQ)			■		■		■	■		■	■		■					■	■						■						■						■		
CZ1	Czech Metrology Institute (CMI)						■							■	■	■								■								■						■		
DE1	Physikalisch-Technische Bundesanstalt (PTB)			■	■		■	■	■	■	■	■		■		■	■		■	■	■	■	■	■	■	■	■			■	■	■		■	■	■	■		■	
DK1	The Danish Accreditation and Metrology Fund (DANAK)							■	■		■	■		■						■				■	■	■						■				■		■		
DK2	FORCE Certification A/S						■																																	
DK3	Dansk Elektronik, Lys & Akustik (DELTA)							■	■		■	■		■											■	■										■		■		
ES1	Centro Español de Metrología (CEM)						■		■		■	■		■					■	■														■						
FI1	Inspecta Oy							■	■		■	■		■		■									■	■						■								
FR1	Ministère de l'Economie, de l'Industrie et de l'Emploi (MEIE)	*All activities and responsibilities were transferred to FR2 in 2003*																																						
FR2	Laboratoire National de Métrologie et d'Essais (LNE)		■	■			■	■	■	■	■	■		■	■	■	■		■	■	■	■		■	■	■	■			■	■	■		■		■		■		■
GB1	NMRO Certification Services (NMRO)		■		■		■	■	■		■	■	■	■		■				■				■	■	■						■				■		■		
GB2	National Physical Laboratory (NPL)																		■																					
HU1	Hungarian Trade Licensing Office (MKEH)													■																										
IT1	Ministero dello sviluppo economico - Direzione generale mercato, concorrenza, consumatori, vigilanza e normativa tecnica						■																																	
JP1	National Metrology Institute of Japan / National Institute of Advanced Industrial Science and Technology (NMIJ / AIST)						■				■			■																	■	■								
KR1	Metrology and Measurement Division (KATS)													■																										
NL1	NMi Certin B.V.		■	■		■	■	■	■		■	■		■	■	■			■		■			■	■	■						■		■	■	■		■		■
NL2	KIWA Nederland B.V.						■																																	
NO1	Norwegian Metrology Service (Justervesenet)							■	■			■		■										■	■	■						■				■				
NZ1	Measurement and Product Safety Service (MAPSS Wellington)													■																										
PL1	Central Office of Measures (GUM)													■						■		■																		
RO1	Bureau Roumain de Métrologie Légale (B.R.M.L.)																		■	■							■			■	■									
RU1	Russian Research Institute for Metrological Service (VNIIMS)			■			■	■	■	■	■	■		■		■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■
SE1	Swedish National Testing and Research Institute AB (S.P.)							■	■		■	■		■		■				■					■	■						■								
SI1	Metrology Institute of the Republic of Slovenia (MIRS)													■																										
SK1	Slovak Legal Metrology						■							■																		■								
US1	NCWM, Inc.										■			■																										
VN1	Directorate for Standards and Quality (STAMEQ)													■																										

Call for papers

OIML Members
RLMOs
Liaison Institutions
Manufacturers' Associations
Consumers' & Users' Groups, etc.

- Technical articles on legal metrology related subjects
- Features on metrology in your country
- Accounts of Seminars, Meetings, Conferences
- Announcements of forthcoming events, etc.

The **OIML Bulletin** is a forum for the publication of technical papers and diverse articles addressing metrological advances in trade, health, the environment and safety - fields in which the credibility of measurement remains a challenging priority. The Editors of the Bulletin encourage the submission of articles covering topics such as national, regional and international activities in legal metrology and related fields, evaluation procedures, accreditation and certification, and measuring techniques and instrumentation. Authors are requested to submit:

- a titled, typed manuscript in Word or WordPerfect either on disk or (preferably) by e-mail;
- the paper originals of any relevant photos, illustrations, diagrams, etc.;
- a photograph of the author(s) suitable for publication together with full contact details: name, position, institution, address, telephone, fax and e-mail.

Note: Electronic images should be minimum 150 dpi, preferably 300 dpi.

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