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Farewell from the PTB:
Retirement of Prof. Dr. Manfred Kochsiek

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Editorial

Jean-François Magana
BIML Director

Tripartite Declaration

The Birkeland Report (Legal Metrology at the Dawn of the 21st Century), which was published in 1998, called for the development of a global, international metrology system, in order to address the needs of this century for social and economic development.

This challenge has been taken up by the three International Organizations dealing with metrology: the Metre Convention, the OIML and ILAC (in the order of oldest to youngest).

Cooperation between these three Organizations has constantly been increasing, and the key issue which has been worked on both jointly and individually is to develop mutual confidence, acceptance and recognition.

Each of the three Organizations has set up a Mutual Arrangement and the three Arrangements complement each other to form the first framework of a global, international metrology system. The common declaration, published in this issue of the Bulletin, encourages Governments and Standardization bodies to make use of these three Arrangements in order to eliminate barriers to trade and to reduce the costs incurred in trading to the greatest extent possible. ■

Déclaration tripartite

Le rapport Birkeland (La Métrologie Légale à l'Aube du 21ème Siècle), qui a été publié en 1998, appelait au développement d'un Système Global, International de Métrologie, afin de répondre aux besoins de ce siècle en matière de développement social et économique.

Ce défi a été relevé par les trois Organisations Internationales qui traitent de métrologie: la Convention du Mètre, l'OIML et ILAC (par ordre d'ancienneté).

La coopération entre ces trois organisations a été constamment renforcée, et un sujet essentiel a été traité dans chacune d'entre elles: développer la confiance, l'acceptation et la reconnaissance mutuelles.

Chacune des trois organisations a mis en place un Arrangement Mutuel, et ces arrangements se complètent pour former la première ossature d'un système global, international de métrologie. La déclaration commune qui est présentée dans ce Bulletin, encourage les Gouvernements et les organisations de normalisation à faire usage de ces trois arrangements afin d'éliminer les obstacles techniques aux échanges et d'éliminer les coûts commerciaux inutiles. ■

Jean-François Magaña

FLOW MEASUREMENT

First approach towards a global reference value for natural gas flow measurement at high pressure

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Abstract

Under the auspices of the BIPM (International Bureau of Weights and Measures) and the CIPM (International Conference of Weights and Measures), which is the highest metrological authority in the world, so called Key Comparisons (KC) have been conducted to obtain international reference values for all quantities of interest. Among these KCs, the flow area is of economic importance and Key Comparisons for natural gas flow at high pressure and larger flow rates as well as for compressed air have been conducted successfully among all interested National Metrology Institutes (NMIs).

The outcome of such a KC is the international Key Comparisons Reference Value (KCRV), which is considered to be the best available realization worldwide of Natural Gas Flow at high pressure (World Reference Value).

These KCs were conducted among the National Primary Standards of all nations worldwide, represented by their NMIs and were finalized in December 2004 for natural gas. The Key Comparison Reference Value was approved by the BIPM in April 2005 and was published on the BIPM web site in January 2006.

This paper describes the procedures, the participating high pressure gas facilities, the outcome and important conclusions for international as well as national gas trade. It transpires that between the United States, Europe and Asia there are significant differences in their views on metrology and their ways of disseminating reference values. An internationally accepted reference value for the gas cubic meter will be increasingly important in a liberalized gas market.

Finally, the paper offers a view of the so-called Harmonized European Reference Value for the Natural Gas Cubic Meter which has been disseminated all over Europe since May 4, 2004. In the meantime it has been accepted also on other continents as the national reference, e.g. Canada via NRC, MC and TCC.

In fact, this Harmonized European Reference Value is exactly the same as the above-mentioned CIPM/BIPM KCRV for natural gas. The metrological consequences and benefits of such a KCRV for international trade will be discussed.

The challenge of gas flow measurement

Since the 1970's there has been an increasing use of Natural Gas as an energy source, and in Europe a vast network (gas grid) has been realized to cater for an average gas consumption in Europe of over 400 billion cubic meters per year. In this expanding gas grid more and more points of transfer of ownership are installed, leading ultimately to an increasing demand for reliable and stable reference values for high pressure gas flow measurements. The principle of Third Party Access, supported in the future by direct invoicing of energy shipment, makes it of vital importance that gas transport organizations have at all times a clear knowledge about the contents of their transport grid.

Hence, long term stability of reference values is gaining importance. Although small (insignificant) changes in (national) reference values are accepted by metrologists, the impact of variations on for example invoicing will probably never be understood nor accepted. The drive for one equivalent reference value in this working field of Natural Gas resulted in an extensive cooperation between three NMIs having test facilities for High Pressure Natural Gas in Europe. The results of these activities have been verified by means of the CIPM Key Comparisons conducted under the auspices of the Consultative Committee for Mass and related quantities (CCM) of the CIPM.

International activities in flow metrology

As the metrological activities of the PTB (Germany), NMI-VSL (The Netherlands) and the LNE (France) affect the national and international trade of natural gas, the approach to the harmonization process shall be summarized here and we present the latest results to define the "European Harmonized Reference Level" or the "Harmonized European Natural Gas Cubic Meter" respectively. The procedure of the harmonization process of the natural gas cubic meter in Europe, leading to the so-called Harmonized European Gas Cubic Meter has been described in a couple of papers before and will be summarized here.

This procedure began in June 1999, instigated by the PTB and NMi-VSL and was completed in May 2004 by the definition, realization and dissemination of the harmonized European Gas Cubic Meter. All the European national metrology institutes now disseminate this reference value and all calibrations since this date make use of this reference value.

Figure 1 presents the interaction between the three primary standards of the PTB, NMi-VSL and the LNE, showing the measurement and calibration range as well as traceability sources, which finally lead to the Harmonized European Reference Value.

In parallel to the initiative of the leading European NMIs to obtain the most stable reference value, the CIPM decided to conduct KC among all national metrology institutes in order to obtain KCRVs for all subject fields, including natural gas flow at high pressure.

The PTB was elected to pilot the Key Comparisons among all the NMIs worldwide. It turned out (after four years of negotiation with all the responsible institutes in the US and Russia as well as in Asia), that for the time being only three institutes were ready to conduct their Key Comparisons at high pressure natural gas, namely the PTB, NMi-VSL and the LNE. All the other institutions in the world refrained from participation as they were not yet ready.

The outcome of such a KC is the KCRV, which can be considered to be the best available realization of that quantity. The KCs for natural gas were conducted in 2004, were approved by the Committee Consultative for Mass and related quantities (CCM) of the CIPM and were published in 2006 on the BIPM web site as well as in the international journal Metrologia, see [1].

European activities

The aforementioned Key Comparisons for natural gas flow to obtain the KCRV followed strict guidelines and recommendations of the BIPM Director's Advisory Group on uncertainties with members from all major NMIs. This expert group summarized its recommendations in [2] in a very comprehensive way. Figure 1 gives an overview of the calibration and measuring capabilities of the participating and completely independent primary standards of the PTB, NMi-VSL and the LNE.

Figure 1 shows the calibration and measuring range of the three completely independent national primary standards of the PTB, NMi-VSL and the LNE and their interaction to realize the Harmonized European Natural Gas Cubic Meter.

The European activities for the Harmonized European Gas Cubic Meter followed the same guidelines and regulations and finalized their work in May 2004. Therefore, the KCs under supervision of the CIPM/CCM can be considered to be a confirmation of the Harmonized European Gas Cubic Meter as the worldwide best available realization of the high pressure gas cubic meter. However, the rules for the harmonization process are to a certain degree much more stringent.

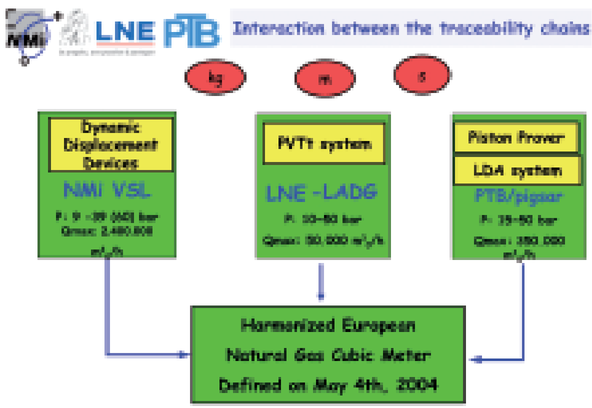

Figure 1 Calibration and measuring capabilities of the European National Facilities PTB-*pigsar*, NMi-VSL and the LNE-LADG. The diagram visualizes the interaction between the three national standards. Harmonization has been achieved mainly in the overlapping range of flow rate and pressure.

Prerequisites for the harmonization procedure

In previous papers and mainly during the FLOMEKO 2003 congress in Groningen and FLOMEKO 2004 in Guilin, the authors have already described the harmonization procedure between PTB-*pigsar* and NMi-VSL and partly with the LNE (the former BNM) in detail, see [3] and [4]. The participating facilities at NMi-VSL are presented in [5], the French high pressure facilities of the LNE-LADG are presented in [11] and the German National Standard *pigsar* has been described in [6] in detail. In addition, the conference proceedings give an update of the German facility, see [7].

The European Harmonized Reference Level or Gas Cubic Level comprises a weighted average of three different individual national realizations of the gas cubic meter (reference levels). This weighted average is based on the following metrological prerequisites:

#1. PTB, NMi-VSL and LNE operate independently realized Traceability-Chains. At NMi VSL a system based on mass comparison of gas flow is in use (basis verification system), whereas the German National facility for high pressure gas flow standards, PTB-*pigsar*, has its traceability chain in operation based mainly on a Piston-Prover as well as on LDA (volume comparison plus density determination via pressure, temperature) and the LNE-LADG applies the pVTt-method (mass comparison).

#2. The uncertainty budget of each of the systems is fully known, understood and mutually accepted.

#3. A permissible difference between the three systems smaller than the root square sum of the corresponding uncertainties (2 σ) is established.

#4. The stability of each chain (sets of reference values) is demonstrated. Stability refers to the reproducibility of the Reference Values over the years.

#5. The Degree of Equivalence is established (based on historic performance and on accepted uncertainties).

This procedure has been applied in all overlapping flow rate and pressure ranges of *pigsar*- PTB, NMi-VSL and LNE-LADG. This ancillary condition can be considered as a prerequisite which the LNE, PTB and NMi-VSL have applied to three or four sets of different turbine meters (two in series) to allow maximum overlap. In addition, a choked nozzle was also applied.

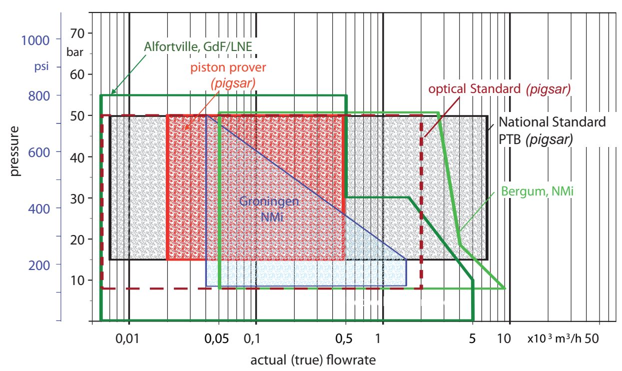

Figure 2 Calibration and measuring capabilities of the European National Facilities PTB-*pigsar*, NMi-VSL and LNE-LADG. Harmonization has been achieved mainly in the overlapping range of flow rate and pressure.

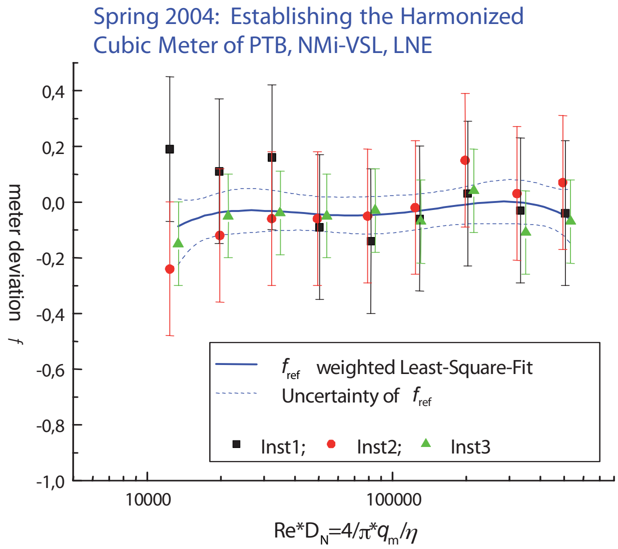

Figure 3 Visualization of an intercomparison during the harmonization procedure among the PTB (Inst3), NMi-VSL (Inst2) and LNE (Inst1) in order to obtain the common reference level, the blue line. This blue line has been taken as the Harmonized European Reference Level and has been disseminated since May 4, 2004.

Figure 2 presents the calibration and measuring capabilities of the participating NMIs in the harmonization procedure as well as in the KC procedure. The degree of overlap in flow rate and pressure ranges is quite large. This allows detailed comparisons to be made at the same conditions for flow rate as well as pressure. It should be pointed out that only a very few facilities worldwide overlap so well.

All the partners agreed to search continuously for improvements in the metrological independent traceability chains to meet future demands for more stable Reference Values with lower uncertainties. The main benefit for customers is identical and equivalent calibration of meters at any calibration test rig in Germany, The Netherlands and France. The harmonization as accomplished by the PTB, NMi-VSL and the LNE is principally open to third parties if all five prerequisites can be met and if it is practically feasible. So far, however, there is no other national facility available in the world which meets all the prerequisites.

The result of the harmonization procedure is presented in Fig. 3, which shows one of the many comparisons and the weighted mean between the three partners. All agreed to accept this weighted mean as their common reference level, which is indicated in Fig. 3 by the blue line, for which an assorted uncertainty has been calculated (see the blue dashed line in Fig. 3). It can be recognized from Fig. 3 that all uncertainty bars of the laboratories overlap nicely with the common reference level as well as with each other.

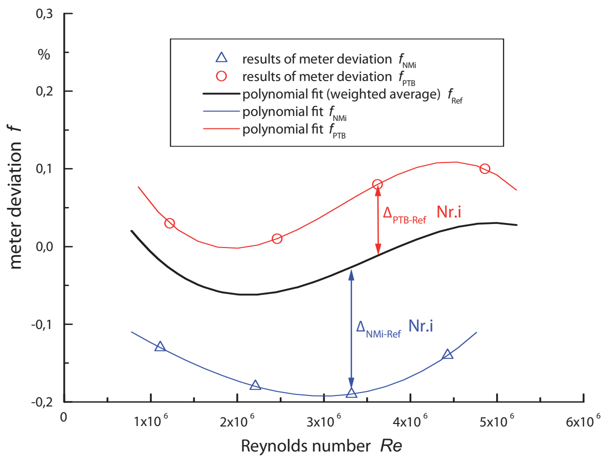

Figure 4 Schematic drawing of the weighted averaging mechanism. Results of comparison for one meter at one pressure stage and determination of differences $\Delta_{PTB\text{-}Ref}$ and $\Delta_{NMi\text{-}Ref}$. The outcome is that the participant who offers the smallest uncertainty will strongly attract the reference value towards him.

Harmonization process for reference values

To understand the technique of the weighted average applied in the harmonization process, let us discuss the method for two partners at first and then expand it to all three partners using the latest results from 2004 as shown in Fig. 3.

This method has already been explained in previous papers, e.g. [3], [4] and shall therefore merely be summarized.

Based on the facts concerning the equivalence and independence of the calibration chains, the "true value" f_{Ref} of the meter deviation shall be assumed as being the weighted average of any pair of results. In Fig. 4 a principal example of a transfer meter calibration by two partners (NMi and PTB) is given. The meters used in the transfer packages are Reynolds balanced, therefore the determination of the difference $\Delta_{PTB\text{-}Ref}$ ($\Delta_{NMi\text{-}Ref}$ respectively) to the common reference level is done with respect to the Reynolds number. In practice, each pair of measuring points is close together but is not exactly at the same Reynolds number. Thus, the polynomial approximation of the calibration curve f is used as in Fig. 4. The weighted average f_{Ref} is then calculated using polynomials. The differences $\Delta_{PTB\text{-}Ref}$ and $\Delta_{NMi\text{-}Ref}$ are determined for each measured point relative to the average polynomial.

$$f_{Ref} = w_{NMi} f_{NMi} + w_{PTB} f_{PTB} \quad \text{with} \quad w_{NMi} = \frac{1}{\frac{U_{NMi}^2}{U_{PTB}^2} + 1} \quad \text{and} \quad w_{PTB} = \frac{1}{\frac{U_{PTB}^2}{U_{NMi}^2} + 1}$$

$$\Delta_{PTB\text{-}Ref} = f_{PTB} - f_{Ref} \quad \text{and} \quad \Delta_{NMi\text{-}Ref} = f_{NMi} - f_{Ref}$$

f = meter deviation
w = weighing factor
Δ = difference
U = uncertainty (k = 2)

f_{Ref} is the deviation of the meter under test based on the harmonized high pressure cubic meter of NMi-VSL and the PTB.

This weighted average has been defined in exactly the same way as recommended by Cox, see [2], chapter 5.

Finally, all the determined differences $\Delta_{PTB\text{-}Ref}$ and $\Delta_{NMi\text{-}Ref}$ for all meters at all pressure stages were plotted on one graph depending on the Reynolds number (Figure 4) presenting the original data from 1999. The reproducibility (2 σ) of calibrations is less than half of the uncertainty budget of each participant. Nearly every result of one participant lies within the uncertainty interval of the other. Although three different meter sizes and two different pressure stages for each size were used, no significant discontinuity is observed. This is an evident demonstration of high quality and reliability of the calibration work of both partners, NMi-VSL and PTB-*pigsar*.

The determined difference $\Delta_{PTB\text{-}NMi}$ between NMi-VSL and PTB-*pigsar* increases slightly with the Reynolds number. The slope of the results of NMi-VSL is only a mathematical effect of the weighing process because the uncertainty U_{NMi} of NMi's chain increases with the pressure stage. The trends for $\Delta_{PTB\text{-}Ref}$ and $\Delta_{NMi\text{-}Ref}$ in Fig. 4 can finally be approximated by a linear function depending on the logarithm of the Reynolds number. These linear functions are used as correction functions in order to disseminate a harmonized value of cubic meter high pressure natural gas in both countries.

In Fig. 5 the harmonized reference level has been overlaid on the zero line to demonstrate the effects of weighted means.

Within the reproducibility of the results there is no significant discontinuity, although three different meter sizes and two different pressure stages for each size were used. To implement the feedback of comparison results, linear approximations of the differences $\Delta_{PTB\text{-}Ref}$ and $\Delta_{NMi\text{-}Ref}$ were determined. The uncertainty levels (2 σ) shown in the graph are the particular uncertainties of PTB-*pigsar* and NMi-VSL.

The following conclusion can be drawn from Fig. 5:

- The partner with the smallest uncertainty will strongly attract the reference value towards him. In Fig. 5 the PTB is a little closer towards the Harmonized Reference Value.

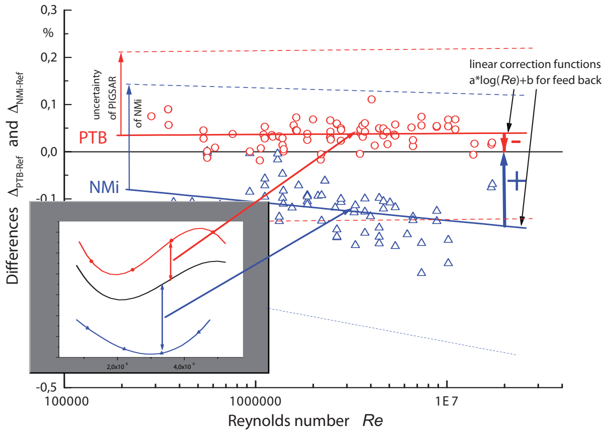

Figure 5 Summary of all the determined differences $\Delta_{PTB\text{-}Ref}$ and $\Delta_{NMi\text{-}Ref}$ for all meters in all pressure stages plotted as a function of the Re-number. The difference between both traceability chains is clearly observed but is much smaller than the uncertainties. Figure 4 shows the situation at the beginning of the harmonization procedure between the PTB and NMI-VSL in 1999.

- The cubic meter obtained at PTB-*pigsar* turned out in 1999 to be slightly too large and the cubic meter obtained at Bergum is slightly too small; therefore, both sides have to correct their results with a correction factor (which is actually a function of Re-number, pressure and flow rate).

Due to the comparison measurements we have two independent sources of information of the "true value" given by both calibration chains, hence we obtain a lower uncertainty level U_{Ref} of meter deviation f_{Ref} based on harmonization:

$$U_{Ref} = \sqrt{w_{NMi}^2 U_{NMi}^2 + w_{NMi}^2 U_{PTB}^2} \qquad \text{with} \quad w_{NMi} = \frac{1}{\frac{U_{NMi}^2}{U_{PTB}^2} + 1}$$

$$\text{and} \quad w_{PTB} = \frac{1}{\frac{U_{PTB}^2}{U_{NMi}^2} + 1}$$

U = uncertainty (k = 2)
w = weighing factor

U_{Ref} is the uncertainty of the harmonized reference value for the high pressure cubic meter of NMi-VSL and the PTB. Of course, this technique can be expanded for three partners and this was done in May 2004, when the LNE (Paris) was included in the harmonization procedure. The result is shown in Fig. 3. After a long period of improvement of all the participating facilities, the PTB and NMI-VSL are now much closer than in 1999 and before.

The positive outcome for the customer is that he always obtains the same calibration result in Germany and in The Netherlands at any test facility and he can enjoy the benefit of a very stable, low uncertainty of the harmonized reference value.

The benefit for metrology is the reduced uncertainty of the harmonized reference value.

This technique of weighted averaging was applied in the CIPM Key Comparisons conducted in 2004 and 2005, and will be described in the following chapter to show that the Key Comparison reference Value is identical to the European Harmonized Reference Value evaluated here.

Recent activities and benefits of the improvement in gas metrology and its impact on correct gas billing are described in [7].

The CIPM KCRVS and the European harmonized reference value

The CIPM decided, in accordance with the CIPM Mutual Recognition Arrangement (MRA) [8], to conduct Key Comparisons [9] among national primary standards of selected NMIs in the field of high pressure gases. This includes natural gas and compressed air and/or nitrogen. The members of the responsible CCM Working Group for Fluid Flow (WGFF) elected the PTB and NMi-VSL as the pilot laboratories for this KC.

All facilities worldwide were invited to participate, but some were not ready to. Figure 6 gives an overview of the most important high pressure gas facilities in the world. The privately operated facilities were marked with red crosses, as they did not participate and as they do not disseminate under supervision of the national metrology institutes.

It should be noted that the USA, Russia and certain Asian countries do not maintain their own national standards for high pressure natural gas calibration despite their very large gas consumption. The KCs were conducted in the Autumn of 2004 and the final results published in January 2006, see [1].

The KCs were carried out in accordance with the *Guidelines for CIPM Key Comparisons* [9] and were performed to fulfill the requirements of the CIPM MRA [8] and those of the CIPM Consultative Committee for Mass and Related Quantities [10]. The aim of these KCs is to verify the claimed Calibration and Measurement Capabilities (CMCs) of the NMIs and to quantify the degree of equivalence of the national flow standards as maintained in the participating NMIs. In addition, a CIPM KCRV should be the outcome of a key comparison. To achieve the intended quantification, these KCs are intended to produce a set of tabulated results: the first set of tables presents the measured differences between the participants and the KCRV, and the second set will quantify the laboratory-to-laboratory equivalencies with the associated uncertainties of these differences. The last set shall comprise the degree of equivalence of all laboratories to the KCRV.

The PTB was chosen to pilot the KCs among all the NMIs worldwide. It turned out after four years of negotiation with all the responsible institutes in the USA and Russia as well as in Asia, that for the time being only three institutes were ready to conduct their Key Comparisons at high pressure natural gas, namely the PTB, NMi-VSL and the LNE. All other institutions in the world refrained from participation as they were not yet ready. The outcome of such a Key Comparison is the KCRV, which can be considered to be the best available realization of that quantity.

The KCs for natural gas were conducted in 2004, approved by the Consultative Committee for Mass and related quantities (CCM) of the CIPM and published in 2006 on the BIPM web site as well as in the international journal Metrologia, see [1].

The blue arrow in Fig. 6 between TCC and the European facilities indicates the traceability between the European facilities and the Canadian national standard TCC-NRC. Since a couple of years ago, Canada is fully traceable to the European Harmonized Reference Value, which will be continuously disseminated to the North American continent.

As clearly the participants of the CIPM Key Comparisons are the same as those of the procedure for the Harmonized European Natural Gas Cubic Meter, the KCRV of the CIPM KCs must be the same as the harmonized European reference level.

Figure 7 shows the test points used for the CIPM KCs in the flow rate range between 65 and 1000 m³/h and pressures between 10, 20 and 47 bar in order to obtain the desired data for the demonstration of the equivalence of the laboratories and the KCRV, which can be considered to be the best available realization of the natural gas cubic meter.

It should be mentioned here that during the harmonization procedure much more comparison work has been done at all pressures and flow rates to obtain the best available reference values. In order to obtain the KCRV or the Harmonized Reference Value, the weighted average/mean of the calibration results at all the facilities were used, as recommended by an advisory group on statistics, see [2]. The pilot laboratory decided to follow the BIPM recommendations and the weighted mean was taken for the KCRV function. The weighing factors are the claimed and mutually recognized uncertainties (u^2) of the facilities. The KCRV will be calculated in the same way as during the harmonization procedure in Europe.

KCRV = weighted mean *y*

$$y = \frac{\frac{x_1}{u^2(x_1)} + \ldots\ldots + \frac{x_N}{u^2(x_N)}}{\frac{1}{u^2(x_1)} + \ldots\ldots + \frac{1}{u^2(x_N)}}$$

This KCRV is associated with its uncertainty u^2 as follows:

Variance associated with KCRV *y* $\frac{1}{u^2(y)} = \frac{1}{u^2(x_1)} + \ldots\ldots + \frac{1}{u^2(x_N)}$

N is the number of equivalent participants which participate using their metrological independent facilities.

Very stable transfer packages using turbine meters were selected for these KCRVs.

In order to demonstrate the excellent results of the CIPM KCs, some of the comparisons are shown in Figs. 8 and 9. A G650 transfer package was used, comprising of an Elster-Instromet turbine and ultrasonic meter put in series to perform the comparisons at three different pressures. This package shows excellent reproducibility and stability. For clarity, "non-harmonized" (namely the original facility data) are used here in the CIPM KC.

Figure 6 Overview of all high pressure calibration facilities for natural gas worldwide. The facilities in Europe (PTB, NMI-VSL and LNE) are national standards as well the Canadian facility TCC, which is under the supervision of the NRC. All other facilities are private institutes or companies which disseminate their own individual units for gas flow, which are not supervised by a national metrology institute.

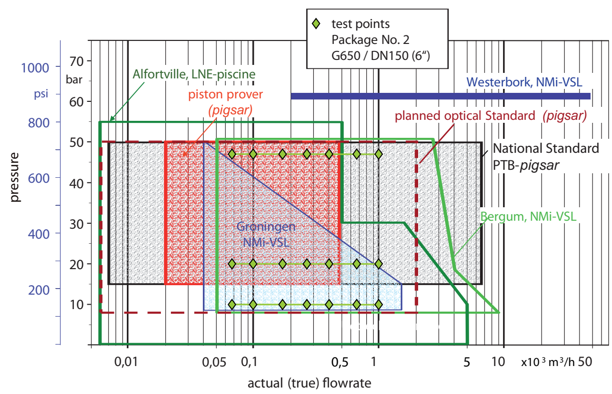

Figure 7 Visualization of selected flow rates as well as pressures during CIPM KCs among PTB-*pigsar*, LNE-LADG and NMi-VSL

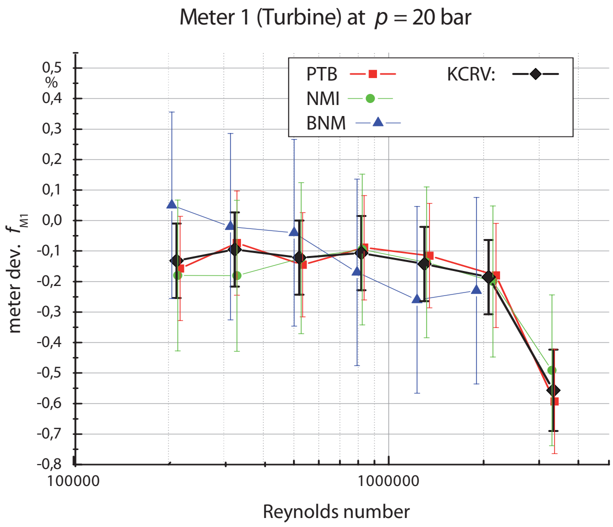

Figure 8 Calibration of a (Elster-Instromet G1000) turbine transfer standard at the PTB, NMI and LNE-LADG at 20 bar during the CIPM KCs. The high degree of equivalence is obvious, as all error bars overlap very well with all the partners and with the KCRV.

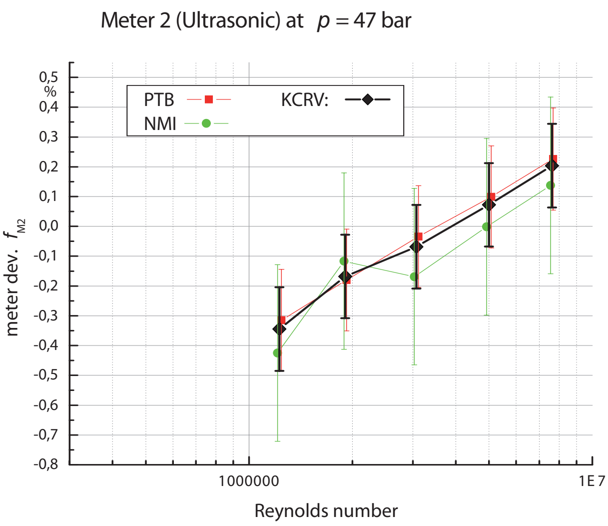

Figure 9 Calibration of an ultrasonic meter (Instromet G1000) turbine transfer standard at the PTB and NMi at 47 bar during the CIPM KCs. The high degree of equivalence is obvious, as all error bars overlap very well with all the partners and with the KCRV. The LNE could not participate here, compare with Fig. 2.

From Fig. 8 the following conclusions can be drawn:

- All NMIs are equivalent to each other within their claimed uncertainties, as all uncertainty bars overlap very nicely.
- The degree of equivalence of all three NMIs with the KCRV could not be much better. The KCRV is considered to be the best available realization of the natural gas cubic meter (flow) at high pressure. As mentioned before, this KCRV is identical to the Harmonized European Reference Level or Gas Cubic Meter. This is because the European NMIs and their calibration facilities disseminate the KCRV itself since May 4, 2004.

Figure 9 presents similar KC results using an ultrasonic meter at 47 bar.

The black lines in Figs. 8 and 9 show the KCRV function of the facilities and represent the best available realization of the natural gas cubic meter for natural gas at high pressure. The uncertainties of this KCRV function are also shown in Figs. 6 and 7 in order to demonstrate that the KCRV is associated with an inherent smaller uncertainty than the participating facilities actually have. It has been proven that the PTB, NMi-VSL and the LNE claim realistic and reliable uncertainties, namely 0.16 % for the PTB-*pigsar*, 0.30 % for the LNE-LADG and 0.23 % to 0.28 % for the NMi-VSL.

This is actually the big advantage for metrological applications, as the European facilities disseminate this (black) KCRV function. This KCRV function is marked in blue in Fig. 3. Therefore, the Harmonized European Gas Cubic Meter can claim a small uncertainty and shows (this is the most important fact) a very time-independent stability over years; compare the prerequisites for the harmonization procedure. The latter property is extremely important for companies to obtain a gas balance.

The last important benefit for the customer and metrology is that the users cannot divide the market up into a seller and buyer market by making use of even small differences between calibration facilities.

The positive outcome for the customer is that he always obtains the same calibration in Germany, in The Netherlands and in France at any test facility and he can enjoy the benefit of a very stable and low uncertainty of the harmonized reference value. In the meantime, this Harmonized European Gas Cubic Meter has been accepted in nearly all West European countries and will be disseminated in all countries and all facilities throughout Europe. It has already been accepted by the Canadian NMI, the NRC. Nearly all European calibration facilities and authorities have also accepted this reference value, which is highly acknowledged by all gas companies.

Lastly, the authors wish to point out here that the full report on the CIPM Key Comparisons is available on the BIPM web site and was also published online in the international journal Metrologia as mentioned in [1].

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http://kcdb.bipm.org/AppendixB/KCDB_ApB_search.asp

and then search for CCM.FF-K5.a to obtain access to all KC data including the full report. Click on CCM.FF-K5.a Final Report. to obtain the final report on the CIPM Key Comparisons for Natural gas at high pressure

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INFRASTRUCTURES

Development of metrology in developing economies

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Abstract

The experience of the author as a metrologist and UNIDO consultant in a number of developing countries is summarized in this paper, and guidelines for the design of laboratory buildings, identification of equipment, training of personnel and setting up of a quality system are given.

Introduction

It is well known that the successful industrial and economic development of a country depends on the advancement of its science and technology. Technological development commences with research and development and is followed by industrial production and marketing. Metrology and standardization play important roles at every stage of this process.

Measurements are continually needed during research and development, for quality control during the production process and to improve product performance and reliability. Test and measuring instruments used should have their values and accuracy certified periodically by comparison against more accurate standards. These standards should have their calibration traceable to International Standards maintained by the International Bureau of Weights and Measures (BIPM) or other advanced national laboratories.

Globalization, and related trade liberalization, is now viewed by developing countries as an opportunity to expand their industrial base and stimulate growth by exports. However, one of the major problems faced by developing countries is their inability to conform to developed country market requirements which take the form of numerous technical regulations imposed through mandatory national regulations and, to some extent, international standards.

For international trade, it is very important that products are tested using internationally accepted procedures. Many export transactions ultimately hinge on guaranteeing the quality of the goods to be supplied. Obtaining international recognition of the tests carried out in local laboratories having a traceable measurement capability thus becomes critical to ensure the success of the country's export trade.

The metrology infrastructure

The National Metrology Laboratory

A national measurement system is instituted and coordinated by a National Metrology Laboratory, which is responsible for the maintenance of the national measurement standards, for providing high level calibration facilities and for the development of measurement technology. It is usually placed in the public sector in order to provide the necessary technical credibility and commercial neutrality of its services.

In addition to the national laboratory, other laboratories (private or government) are also required to undertake testing and calibration. Each country has to develop a metrological system best suited to its needs taking into consideration its size, population and geography and the level of sophistication of its industry. Two models used in a majority of developing countries are shown in Figures 1(a) and 1(b).

The structure shown in Figure 1(a) is more common in most developing countries. In this structure, standardization and metrology activities are carried out by two different organizations. The national standards body (NSB) is responsible for standardization work while the National Metrology Institute (NMI) is responsible for the maintenance of national measurement standards. In some countries, the NMI also carries out industrial and legal metrology work. In others, the NMI restricts itself to scientific metrology work, mainly maintenance of national primary and secondary standards and the provision of calibration services to the legal metrology service and industrial metrology laboratories.

Several developing countries have adopted the model shown in Figure 1(b) where standardization and metrology activities are combined into a single body to optimize the available resources.

Legal metrology

Legal metrology is responsible for the legal/regulatory control of weights and measures by law [1] with a view to ensuring fair and correct measurement in commercial transactions. In most developing countries mass (weight), length and volume measurements and control of pre-packages are of prime importance.

In a growing number of countries, measurements concerning human health, safety and certain industrial measurements are included within the category of legal metrology. Regulation of electricity, water, gas and taxi meters also falls within the ambit of legal metrology.

Industrial metrology

Industrial metrology is mainly concerned with the measurement of length, mass volume, temperature, pressure, voltage, current and a host of other physical and chemical parameters needed for industrial production and process control. This is ensured by regular and traceable calibration of the test and measurement equipment used in the production process.

Establishment of metrology laboratories

Needs assessment

One of the most important things to do before setting up an industrial metrology service is to ascertain the calibration and measurement requirements of the country. This can be done by conducting a survey among a sample of industrial and commercial establishments using a questionnaire. The survey is done by post or e-mail as well as by visiting a number of important enterprises. It is necessary to collect data on the range, accuracy and the quantity of equipment available in the enterprises.

Identification of equipment

After doing the metrology survey a fair idea of the calibration facilities required in the country can be formed. In most developing economies the facilities required basically fall into a handful of measurement fields namely dimension, mass, temperature, pressure, force and electrical quantities. The measurement standards and other equipment required in a industrial metrology laboratory depend on the needs of the industrial sector. The equipment required for a basic industrial metrology laboratory is given in Table 1 and a comprehensive list of verification equipment required for national metrology services is given in [2].

Layout

The design of a laboratory to house the measurement standards required is an important task and there are only a few sources from which information can be gathered on such design. Useful references have been published by the National Conference of Standards Laboratories (NCSL) [3, 4]. A most frequently used guide is the OIML publication G 13 *Planning of metrology and testing laboratories* [5].

The space requirements of the laboratory depend on the quantity of equipment to be housed in the laboratory and on the number of staff members required for its operation. However, for most developing countries a laboratory of about 1200 m^2 is adequate. The layout of the laboratory would of course depend on the site layout and a possible layout is given in Figure 2.

Environmental conditions

Regardless of the climate and independent of the heating or cooling provided for comfort, metrology laboratories require special acclimatizers to obtain reproducible and comparable test results. The principal aim is to obtain:

- A stable temperature,
- Reasonably low air humidity, and
- Low air flow (especially in mass laboratories).

Generally, there are no stringent requirements on dust except that all intakes of fresh air must be filtered and all windows must be dust tight.

Temperature stability is more important than the exact setting of the ambient temperature. A constant temperature may be maintained in a number of ways. The insulation of the measurement area from any exterior surfaces that may have a different temperature is vital. This can generally be done by using an additional wall, thus providing a hollow space or by fixing a layer of insulation material (e.g. Styropur) on the interior surface of the walls. In most laboratories it is also necessary to avoid direct sunlight.

The use of a central air conditioner with individual servo-mechanical damper control in each room is a very effective method to achieve tight control of temperature and can be used when several adjacent laboratories have to be temperature controlled and kept at the same mean

Table 1 Measurement standards for a basic industrial metrology laboratory

Field	Standards	Other equipment
Dimensional	Set of gauge blocks, grade 1 Length comparator	Surface table Profilometer Optical projection microscope
Mass	One kilogram standard, class E_1 Class E_2 and F_1 weights up to 20 kg Class F_2 and M_1 weights up to 20 kg	Comparator balances up to 10 kg capacity
Temperature	Triple point of water cell Standard platinum resistance thermometer, – 40 °C to + 630 °C Working standard platinum resistance thermometer, – 40 °C to + 630 °C Standard thermocouples, Type R or Type S	Oil bath, – 40 °C to + 250 °C Salt bath + 50 °C to + 500 °C or Fluidized alumina bath, + 50 °C to + 700 °C Thermocouple furnace up to + 1100 °C Resistance bridge, suitable for four terminal resistance measurements 6 1/2 digit digital multimeter Thermocouple wire, Types K, J and others
Pressure	Working standard dead weight pressure tester (hydraulic & pneumatic) (capacity depends on the maximum capacity of the pressure gauges used in the country)	Source of compressed nitrogen gas
Force	Proving rings or secondary standard load cells (capacity depends on the capacity of material testing machines available in the country)	Force comparator (capacity depends on the maximum capacity of the proving rings/load cells that are to be compared)
Volume	Vessels up to 20 l and pipettes	Precision balance up to 30 kg capacity
Electrical	DC voltage standard AC/DC multifunction calibrator AC/DC transfer standard Kelvin varley divider Reference divider Resistance standards Capacitance standards High voltage source High voltage divider up to 100 kV, AC/DC	Resistance bridge Resistance bath

Table 2 Environmental conditions of metrology laboratories

Laboratory	Temperature	Admissible temperature variation, °C	Maximum air velocity, m/s
Dimensional metrology	20 °C (or 23 °C)	± 0.5	0.2
Mass	23 °C	± 0.5	0.2
Thermometry	23 °C	± 2	0.2
Pressure and force	23 °C	± 2	0.2
Electrical	23 °C	± 1	0.2
Electrical energy	23 °C	± 1	0.2

temperature. However, when the volume of the activities related to very high accuracy is limited it is better to provide independent laboratory air conditioners with high accuracy temperature control.

It is particularly important that the air conditioning units are provided with precision controls of temperature and humidity through sensors which can be suitably positioned in the laboratory. Many individual air conditioners are in fact only provided with internal controls and are mainly intended to keep the temperature within a few degrees while usually allowing for heat dissipation and fresh air intake. It is, therefore, necessary to provide the contractors with complete data (layout drawings, number of staff in each laboratory, heat generating sources and outside weather conditions, etc.) to design the system to meet the environmental requirements.

In the case of a mass standards laboratory, the requirements are not stringent as regards the value of the ambient temperature itself which can usually have any value between 18 °C and 27 °C. However, it must be ensured that the temperature is kept stable within at least ± 0.5 °C for periods of several hours to provide enough stability during a series of mass comparisons. High accuracy electronic scales may in this respect require temperature stabilization for longer periods than classical mechanical balances. Furthermore, air draft and pressure variations must be avoided. In this respect, many mass laboratories presently follow the requirements given in OIML R 111 (2004) [6] which specifies a temperature stability of ± 0.3 °C for calibration of Class E_1 weights.

Traceability

For a particular measurement standard or measuring instrument, "traceability" means that its value has been determined by an "unbroken chain of comparisons" with a series of higher level standards culminating in the primary standard (SI definition) for the quantity, usually maintained by the BIPM or other internationally recognized laboratory.

The establishment and maintenance of traceability of the measurement standards used at different levels of the metrological hierarchy is therefore vitally important. The responsibility of establishing and maintaining traceability to the BIPM or other international laboratory of the highest level national standards rests with the institute responsible for custodianship of national measurement standards. The responsibility for maintaining traceability of secondary and working standards as well as test and measuring instruments devolves on the organizations holding this equipment. The traceability chain is illustrated in Figure 3.

Staff and staff training

The bulk of the complicated scientific work of a metrology laboratory is carried out by metrology engineers. The term "Metrology engineer" defines the qualification of a specialist who has completed his/her under graduate education and has been properly trained in the field of metrology and measuring instruments, either as an integral part of the basic engineering course or science degree program, or through specialized programs in measurement science.

In addition it is useful to have a cadre of "Metrology technicians" to perform tasks under the supervision of the metrology engineers. The recruitment qualification is completion of secondary education including physics, chemistry or mathematics as subjects.

Both metrology engineers and technicians should be given general theoretical training in the following fields:

- Fundamental concepts of measurement,
- Essential principles and methods of obtaining measurement data in various measurement fields,
- Essential measuring instruments, sensors and systems of analog and digital signal processing,
- Methods of analyzing measurement results, evaluation of errors and uncertainties together with the application of computers,
- Methods of testing measuring instruments when exposed to influence factors.

This should be followed by more specialized training in the specific area of work to which the metrology engineer or technician is assigned. The training would consist of both theoretical and practical phases.

Further specialized training may be given by sending the engineers and technicians to a well developed metrology laboratory or institute providing training in metrology. Generally, one or two staff members should be trained in mechanical metrology (mass, length and engineering metrology), electrical metrology, thermometry, etc. depending on the need in each country. It is prudent to distribute the training among several members of staff since the retention of highly trained and skilled staff is a difficult process and, therefore, consideration should be given to this issue in awarding training opportunities. OIML Document D 14 *Training and qualification of legal metrology personnel* [7] gives a comprehensive set of guidelines.

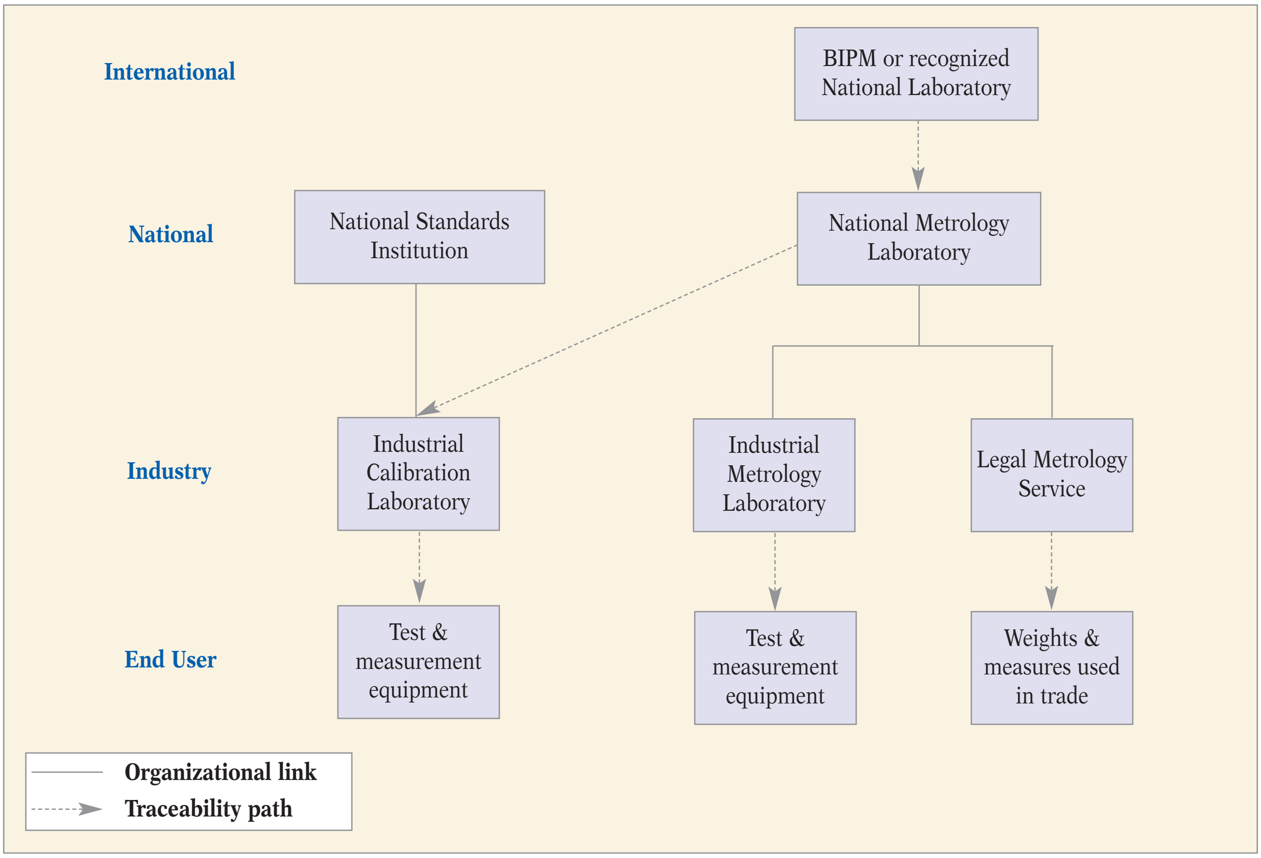

Figure 1(a) Separate National Standards Institution and National Metrology Laboratory

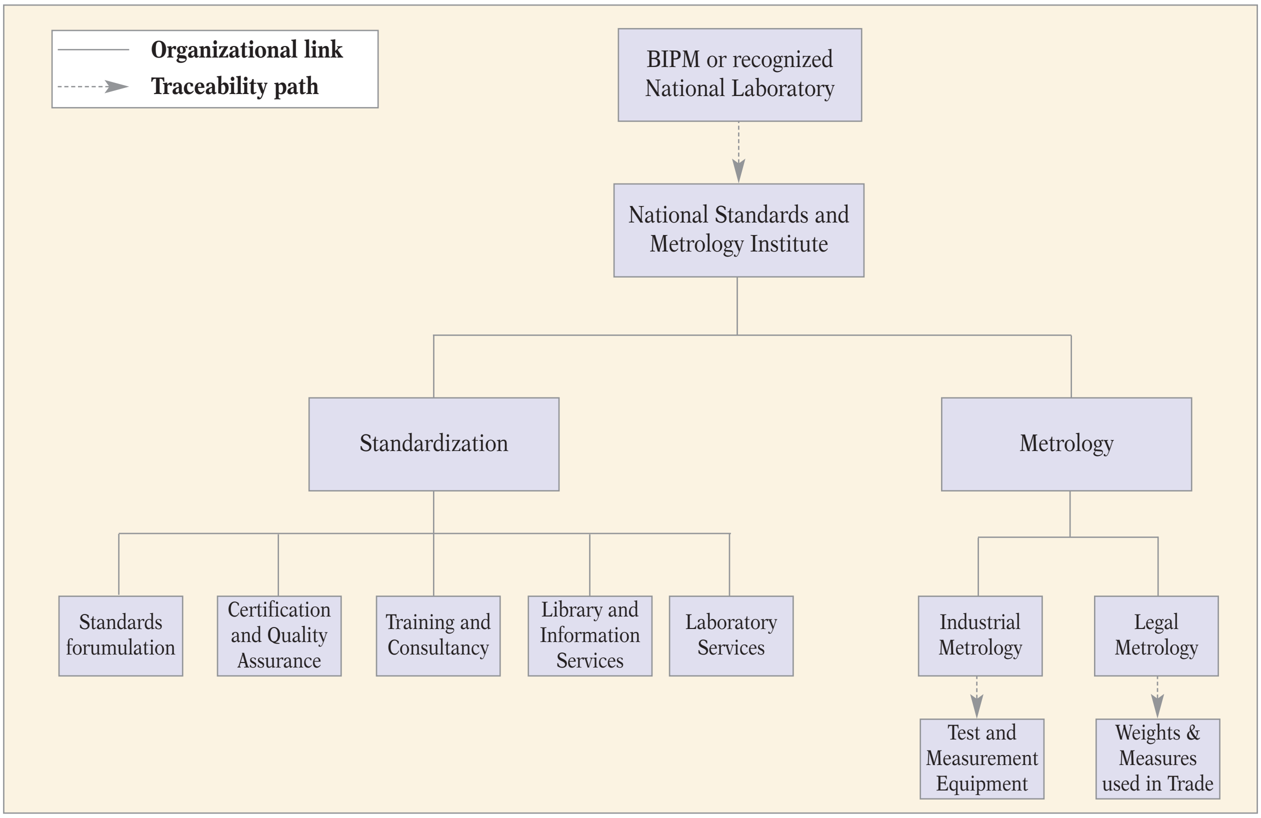

Figure 1 (b) Integrated National Standards Institution and National Metrology Laboratory

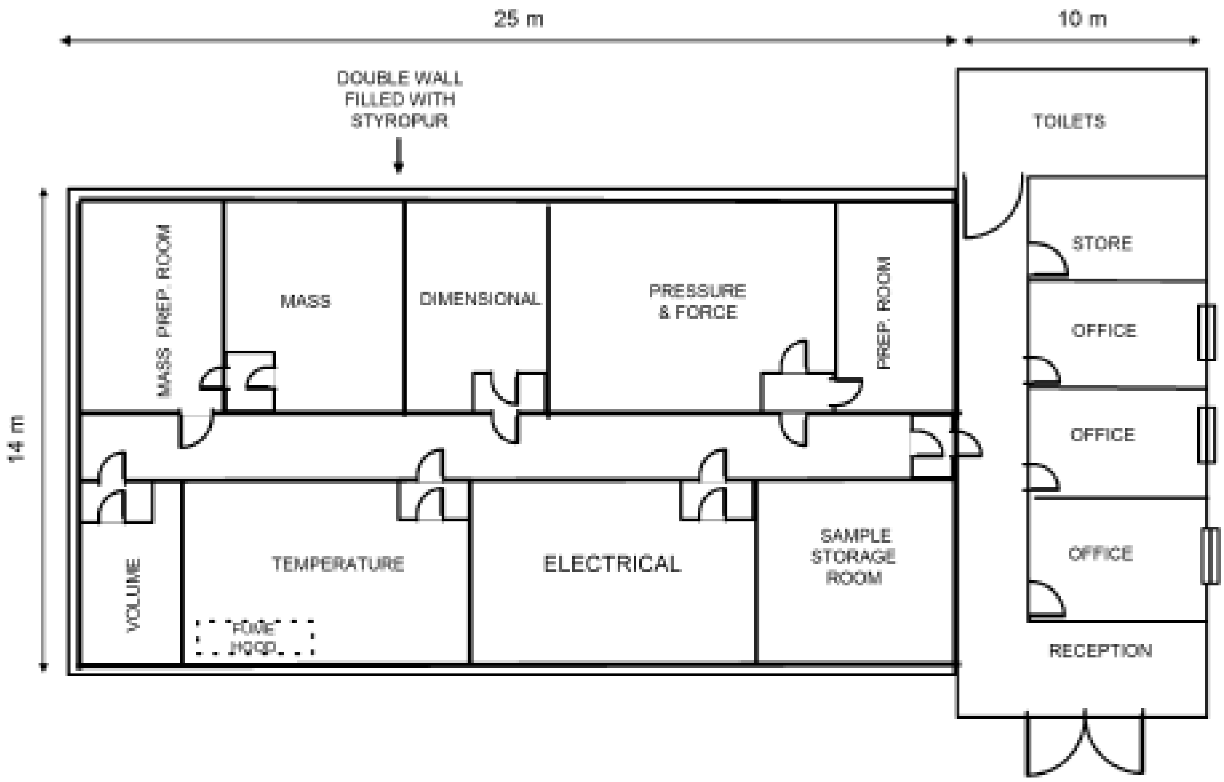

Figure 2 Possible metrology laboratory layout

Quality management system

A quality system based on the requirements of ISO/IEC 17025 [8] is a requirement in an industrial calibration laboratory. The documentation required for installing the system is given below:

- Quality manual
- Procedures manual
- Methods manual
- Facilities manual

Quality manual

The quality manual is essentially a policy document. It contains the policies the laboratory will follow against the 23 requirements specified in ISO/IEC 17025. The quality manual should contain a policy statement indicating the method of dealing with each of these requirements. An example of a quality manual statement is shown below:

The quality objectives of the laboratory are given below:

1. *Meeting the agreed requirements of its clients at all times.*
2. *Continual assessment and improvement of the performance of all activities.*
3. *Improvement of staff skills continually by training them both within and outside of the laboratory.*
4. *Maintenance of uninterrupted international traceability of its reference standards.*
5. *Continuous maintenance of laboratory equipment, accommodation and the environment at optimum levels.*

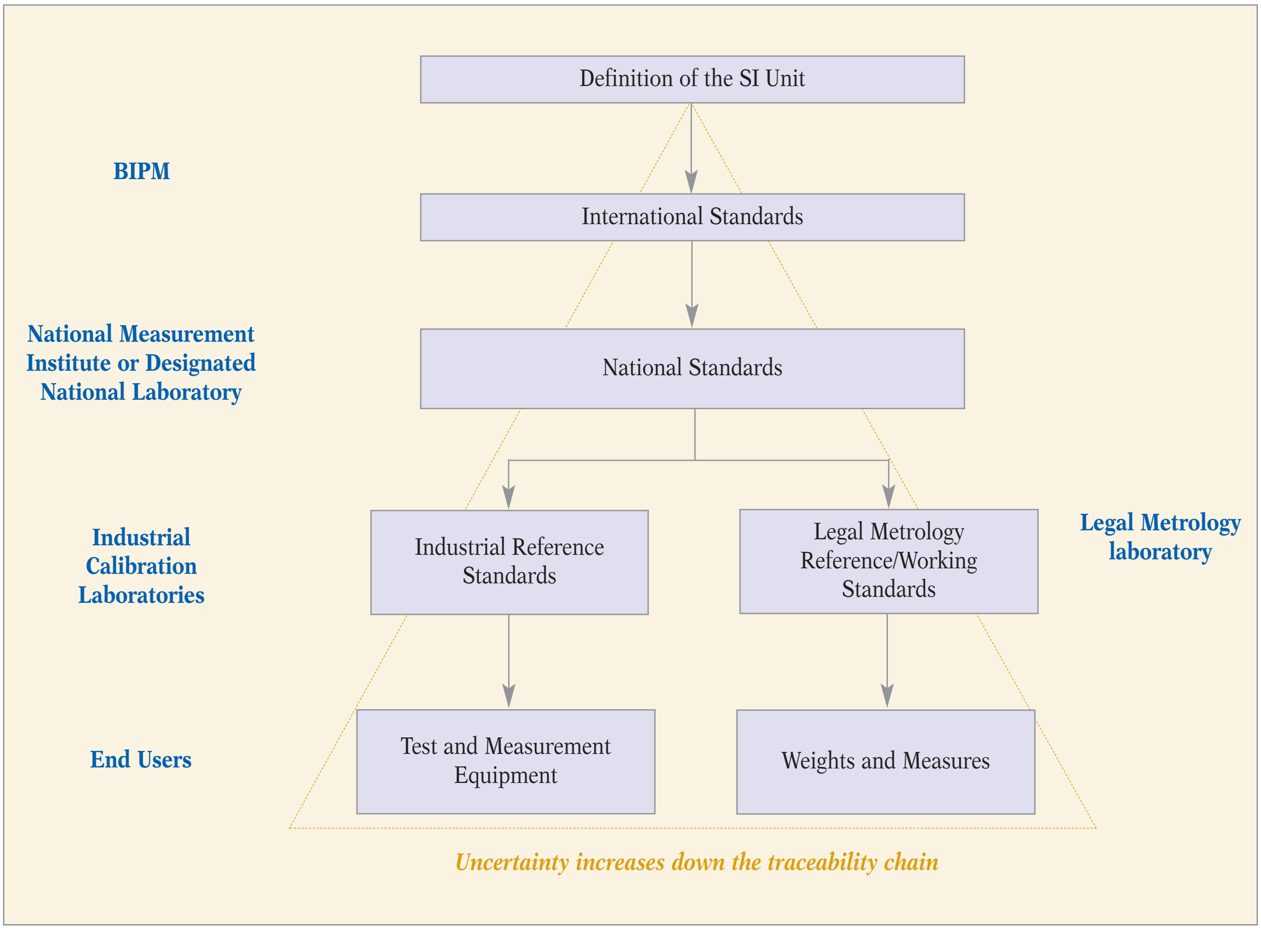

Figure 3 Traceability chain

Procedures manual

The procedures manual contains a collection of instructions to be followed in order to execute the policies given in the quality manual. These are written in simple easily understood language. An important aspect of the procedures manual is to identify the persons responsible for carrying out the procedures.

Methods manual

The methods used in calibrations or measurements are given in the methods manual. A method should be written for each type of calibration carried out in the laboratory. The methods manual may also contain work instructions.

Facilities manual

The facilities manual contains information on the building, equipment and environmental conditions of the laboratory.

Safety manual

A collection of safety procedures as applicable to the laboratory is given in the safety manual. ■

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EUROPEAN HARMONIZATION

Verification of weighing instruments in use in European countries

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Comité Européen des Constructeurs d'Instruments de Pesage (CECIP)

Abstract

The verification of weighing instruments has always been a necessity due to the sheer volume of economic exchanges whose measurements are based on the readings and measurement results of such instruments. The concept of weighing has been used since the earliest Antiquity - the Egyptians used beams to weigh and to trade; Pharaohs, Kings and states have always wanted to ensure that commercial exchanges and transactions are fair. Now of course, weighing is used in all areas of trade, industry, and in everyday life: commercial weighing with retail scales, industrial weighing with weighbridges for trucks or continuous totalizers for ship loading, medical weighing with baby scales, bed scales, or scales for laboratories, etc.

But verification has always varied considerably from one European country to another. Some countries, such as France, required total verification whatever their use, whereas for others, for example the United Kingdom, limited verification appeared to suffice.

With the elaboration of certain European Directives, the question of harmonization of the verification of the weighing instruments has become an important topic of discussion.

A comparative study of the verifications applied in Europe can shed some light on this question and may be used as a basis to reflect on the harmonization of these verifications, especially with an enlarged European Union now comprising 25 members.

The weighing instrument Directives

During the elaboration of the European Directive 90/384/CEE dated 20 June 1990 concerning nonautomatic weighing instruments (NAWI), the verification of these instruments was tackled. But very quickly, the European Commission, faced with many discrepancies between current national regulations, decided to abandon the harmonization of verification. The final text comprises only a very short Article 13 on this subject:

"Member States shall take all steps to ensure that instruments bearing the EC mark attesting conformity with the requirements of this Directive continue to conform to those requirements."

In short, each Member State has to ensure the instruments are verified, but there are no common rules.

The scope of the 90/384/CEE Directive gives us the possibility to appreciate the fields in which this verification is used:

- Determination of mass for commercial transactions;
- Determination of mass for the calculation of a toll, tariff, tax, bonus, penalty, remuneration, indemnity or similar type of payment;
- Determination of mass for the application of laws or regulations; expert opinions given in court proceedings;
- Determination of mass in the practice of medicine for weighing patients for the purposes of monitoring, diagnosis and medical treatment;
- Determination of mass for making up medicines on prescription in a pharmacy and determination of mass in analyses carried out in medical and pharmaceutical laboratories;
- Determination of price on the basis of mass for the purposes of direct sales to the public and the making-up of prepackages.

The Directive on Measuring Instruments 2004/22/CE (MID) dated 31 March 2004, which particularly covers automatic weighing instruments (AWI), does not mention verification of instruments, only their placing on the market. So, once again, no common rules were defined for the verification of instruments.

Moreover, the scope of the MID is defined as follows, in Article 2, determining the area of application of the verification:

"Member States may prescribe the use of measuring instruments mentioned in Article 1 for measuring tasks for reasons of public interest, public health, public safety, public order, protection of the environment, protection of consumers, levying of taxes and duties and fair trading, where they consider it justified."

But the following sentence:

"Where Member States do not prescribe such use, they shall communicate the reasons for this to the Commission and the other Member States"

enables a Member State to limit the scope. So the market is not harmonized, because the Directive may or may not be applicable for a certain instrument from one Member State to another. So one has two different markets, one in liaison with the Directive, the other totally free. It is not a consistent market where verification is applied equally.

We can therefore see that the two Directives do not provide any basis for the verification of weighing instruments.

The weighing instrument manufacturers have been tackling this issue through CECIP, the European Weighing Instrument Manufacturers' Committee and details are given below.

European organization of the weighing industry

CECIP was officially founded on 29 May 1959 in Milan, during its first general assembly. This assembly followed the founding meeting of CECIP in Paris on 10 December 1958 between the representatives of the weighing industry from five countries: Germany, Belgium, France, Italy, and The Netherlands, a few years after the birth of the European Community by the treaty of Rome in 1957, showing the European open view of our industry.

Today, CECIP consists of 15 Federations from the following countries: Germany, Spain, Finland, France, Hungary, Italy, The Netherlands, Poland, Slovak Republic, Czech Republic, Romania, United Kingdom, Russia, Switzerland and Ukraine. The Federations all together represent about 400 enterprises. France is represented in CECIP by COFIP, *Comité Français des Industriels du Pesage* ("French Committee of Weighing Industrials"), which is in charge of the Secretariat.

Study

In 2004 a study was realized by CECIP concerning the 15 Federations of the Committee, with a survey of eight questions. Responses were received from 11 Federations, the results of which are presented below.

Question 1 (see Table 1)

Q: Is a periodical reverification of scales statutory?

A: For the majority of the countries, the periodic verification is statutory, only two countries answered no: The Netherlands and the United Kingdom.

Question 2 (see Tables 2A and 2B)

Q: If yes, are there statutory intervals of verification of scales, with distinction between nonautomatic and automatic scales?

A: For NAWI, the statutory interval of verification is generally two years and for AWI, it is generally from one to three years.

Question 3 (see Table 3)

Q: Are there official fees for reverification, or are prices decided by the market?

A: Out of 11 answers, five are with official fees and six are with prices decided by the market.

Question 4 (see Table 4)

Q: What does a reverification include?
- a mere metrological control?
- a metrological control and supervision of the scale manufacturer?

A: The reverification generally includes a mere metrological control, sometimes with an administrative control.

Question 5 (see Table 5)

Q: Who is authorized to carry out the metrological controls?
- state verification authorities?
- accredited private verification services?
- private verification services?

A: In the majority of the countries, the metrological controls are carried out by state authorities or by accredited private services.

Question 6 (see Table 6)

Q: What quality requirements must be fulfilled by authorized private services? For example:
- requirements according to EN ISO/IEC 17025?
- requirements according to the 90/384/CEE Directive?
- other requirements?

A: The answers were very different and are distributed as follows:

- EN ISO/IEC 17025	2 countries
- 90/384/CEE Directive	3 countries
- other requirements	4 countries
- EN 45004, EN 45001, ISO 9000-2000	

Question 7 (see Table 7)

Q: Are manufacturers or private services authorized to perform metrological controls?

A: Manufacturers and private bodies are authorized to perform metrological controls only if they are accredited, for six countries out of ten.

Question 8 (see Table 8)

Q: Should the customer service of a manufacturer be organizationally separated or even completely independent from the department which carries out the metrological control at the customer's location?

A: The customer service of a manufacturer has to be independent from the department which carries out the metrological control at the customer's location for a majority of seven countries out of nine.

Conclusion

As regards this limited study, we can see that there are important differences between the 11 countries concerning the periodic verification of weighing instruments in use.

Since this study was realized in 2004, some changes in the legislation of some countries may have come about, but there is still a long way to go.

Putting a measuring instrument on the market according to the essential requirements is not enough; the instrument has to be verified periodically during its life, to make sure that it is in conformity with its metrological characteristics.

The weighing instrument manufacturers are in favor of accredited private bodies to realize these controls, as has been done in France since 1993.

We hope that this study will help the Federations of weighing instrument manufacturers, the national offices of metrology, WELMEC (European Cooperation in Legal Metrology) and the European Commission to define a common position for the future, in order to reach a real harmonization of the verification of weighing instruments in use in Europe. ■

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Table 1 – Is a periodical reverification of scales statutory?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
YES		×	×	×	×	×		×	×			×	×		
NO							×			×					

Table 2A – If yes, are there statutory intervals of verification of scales, for non automatic scales?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
1 year												×	×		
2 years		×	×	×		×		×							
3 years					×				×						

Table 2B – If yes, are there statutory intervals of verification of scales, for automatic scales?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
1 year			×									×	×		
2 years				×				×							
3 years					×				×						

Table 3 – Are there official fees for the reverification or are prices decided by the market?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
Official fees		×	×				×	×				×			
Market prices				×	×	×			×			×	×		

Table 4 – What does a reverification include: a mere metrological control or a metrological control with market surveillance?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
Mere metrol control		×		×	×	×	×	×	×	×			×		
With market surveillance			×									×			

Table 5 – Who is authorized to carry out the metrological controls?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
State authorities		×	×		×	×	×	×	×	×		×	×		
Accredited private bodies				×	×	×			×	×		×	×		
Private services										×					

Table 6 – What quality requirements must be fulfilled by authorized private services?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
EN ISO/IEC17025									×			×			
90/384/CE				×			×			×					
Others					×	×	×		×						

Table 7 – Are manufacturers or private services authorized to perform metrological controls?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
Yes if accredited					×	×	×		×	×		×			
No		×	×	×				×							

Table 8 – Should the customer service of a manufacturer be organizationally separated or even completely independent from the department which carries out the metrological control at the customer's location?

Country	CH	CZ	DE	ES	FI	FR	GB	HU	IT	NL	PL	RO	RU	SK	UA
Yes		×	×	×	×	×			×			×	×		
No							×			×					

SOFTWARE

Preparation of the first OIML Working Document on *Software in measuring instruments*

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Abstract

Software in measuring instruments had already been identified as a high priority issue by the legal metrology community at the end of 1999, when OIML TC 5/SC 2 was established with the task of preparing a guidance document on software [1] for OIML Technical Committees drawing up OIML Recommendations. The contents of the Document were based on a combination of the opinions of TC 5/SC 2 members, requirements already stated in existing OIML Recommendations, and recent experiences worldwide in the field of software in measuring instruments.

The core of the Document centers around both the requirements and the validation guidance, and addresses recent developments in technology.

Introduction

As in all other modern devices, software is taking over more and more functions in instruments used in legal metrology. In addition to the software running on the measuring instrument computer, communications and databases are implemented to enable distributed measuring systems, measuring data storage and their subsequent processing [2].

This progress is undoubtedly useful for the users, because it leads to faster measurements, higher accuracy and opens up the possibility of various analyses and further processing. For the manufacturer, the new technology simplifies realizing complex functions and gives flexibility for catering for customers' requirements.

From a metrological point of view the new technology has further aspects. For electro-mechanical, electronic, or software-controlled measuring instruments, uncertainty and dependability are the main characteristics. However, for a software-controlled instrument determining the uncertainty of the measurement - e.g. caused by the rounding algorithm or by discontinuous processing - does not cover the whole problem. Additional requirements concerning consumer protection against manipulation or for guaranteeing the conformity between a batch produced instrument and the approved type, especially if it is a complex measuring system, seem necessary. Implementing undocumented functions should not be allowed and there should be sufficient protection of the program code and parameters that are kept in the computer's memory storage or transmitted via communication lines.

Some other fields (such as the pharmaceutical, banking, automotive, military and airplane sectors) already have guidance documents or standards concerning the quality of the software. For the time being, legal metrology (and the OIML) does not have such an International Document.

At the end of 1999, immediately after the OIML Seminar on *Software in Measuring Instruments* held in Paris, it became obvious that the international legal community needed a horizontal (D-type) guidance document on software in measuring instruments, which would help OIML Technical Committees drawing up OIML Recommendations to adequately address this issue. Several days after the Seminar the annual CIML Meeting was held and OIML TC 5/SC 2 was established with the priority task of drawing up such a Document on software. The composition of TC 5/SC 2 was: Germany (PTB) and France (SDM) as leaders and responsible for the Co-Secretariat, Australia, Belgium, Belarus, Brazil, Canada, China, Cuba, Czech Republic, Denmark, Finland, Japan, The Netherlands, Norway, Romania, Russia, Slovenia, United Kingdom and United States as P-Members and Austria, Bulgaria, Egypt, Indonesia, Ireland, Poland, Slovakia, South Africa, Spain, Sweden, Switzerland and Yugoslavia as O-Members.

Development of the Document

The work was performed by a small working group composed of German (PTB), French (initially the SDM, then from November 2003 onwards the LNE) and Slovenian (MIRS, from October 2002) participants. The first task was to gather together and analyze the opinions of TC 5/SC 2 members concerning the necessary issues to be included in the Document, and their priorities. The result is presented in Table 1.

In the continuation of the work, existing software requirements and validation guidance documents were analyzed. The first group of documents formed metrology software-related documents (WELMEC, FDA, and Canadian specifications). The aim of this analysis was to make the most use of existing knowledge in this area.

Another group gave consideration to OIML Recommendations issued after 1990. The objectives of this analysis were to extract existing requirements for software in legal metrology instruments and to avoid the introduction of possible contradictory requirements in the newly developed Document.

After compiling all the necessary input data, the drafting of the skeleton and contents began in several iterations.

Document content

The Document consists of an introduction, an explanation of the scope and field of application, terminology (general, software, validation and verification terminology), instructions for use of the Document in drafting OIML Recommendations, software requirements (general and specific), type approval guidance (documentation, general requirements, definitions of the validation plan, validation methods, equipment under test), verification, assessment of severity (risk) levels, assessment of software processes and seven annexes. The requirements are additionally clarified by means of a description of practical examples.

Below, only the most noteworthy and specific issues are explained.

Requirements

In the draft Document two sets of software requirements are defined. The first set comprises general requirements that are in principle applicable to all kinds of software-controlled instruments. The second set deals with more complex instruments and measuring systems. The general software requirements address:

- Identification of software,
- Correctness of algorithms and functions,
- Protection of software from accidental or intentional misuse, and
- Support of hardware features (diagnostics).

Requirements specific for complex configurations of measuring instruments address:

- Specifying and separating relevant parts and specifying interfaces of parts,
- Shared indications,
- Storage of data, transmission via communication systems,
- Compatibility of operating systems and hardware, and portability,
- Conformity of production devices with the approved type, and
- Maintenance and re-configuration.

As an example, the specific requirement for software update is explained in more detail. Taking into consideration manufacturers' need to update the software in their instruments, special attention was paid to updating the legally relevant parts of the instrument software. The Document provides for such updating only with approved versions of legally relevant software. The software to be updated can be loaded locally (i.e. directly on the measuring device) or remotely via a network. Two ways to handle the update process are suggested: the first (verified update) is obligatorily followed by legal verification of the measuring instrument. After updating of the legally relevant software of a measuring instrument (exchange with another approved version or re-installation) it is necessary to perform a verification of the instrument and renew the securing means (if not otherwise stated in the approval certificate). The second way (traced update) does not require verification of the measuring instrument, but requires recording the event in the measuring instrument's audit trail. The procedure of a traced update comprises several steps: loading, integrity checking, checking of the origin (authentication), installation, logging and activation. The update procedure is presented in Figure 2.

Type approval

Test procedures in the framework of the type approval (e.g. those described in Document D 11) are based on well-defined test setups and test conditions and can rely on precise comparative measurements. "Testing" and "validating" software means something different. The accuracy or correctness of software in general cannot be measured in a metrological sense though there are standards how to "measure" software quality. The procedures described in the draft Document take into consideration both the needs in legal metrology and well-known validation and test methods in software engineering not having the same goal, for example the software developer who is searching for errors and optimizing performance. For each software requirement an individual adaptation of suitable validation procedures is proposed in the Document. The effort for the procedure should reflect the importance of the requirement in terms of accuracy, reliability and protection against corruption.

Question, problem or issue	Levels of importance Number of votes			Result	Chapter in which the issue is addressed
	High	Middle	Low		
Correctness	10	6	3	Important	5.1.2
Accidental misuse	11	7	2	Important	5.1.3.1
Fraud protection	17	2	-	Important	5.1.3.2
Storage & transmission of data	13	6	-	Important	5.2.3
Support of hardware, reliability	6	7	6	Less important	5.1.4
Compatibility, portability	8	9	1	Important	5.2.4
Identification of parts and interfaces	11	4	4	Important	5.2.1
Documentation	9	7	3	Important	6
Conformity with the approved type	10	8	1	Important	5.1.1 5.2.4
Maintenance and reconfiguration	9	8	2	Important	5.2.6
Verification, certification	5	11	3	Less important	7
Assessment of software processes	2	10	7	Less important	N. A.

Table 1 Important issues and their priorities

The idea of the Document is to provide the TCs responsible for elaborating Recommendations with a set of methods from which they can select the appropriate ones according to the severity level of the respective kind of measuring instrument and area of application. The following validation methods are proposed:

- Analysis of documentation and specification/ validation of the design,
- Validation by functional testing of the metrological functions,
- Validation by functional testing of the software functions,
- Dataflow analysis,
- Code inspection and walk through, and
- Software module testing.

The first three validation methods proposed above are based on the documentation of the software and do not presuppose deep IT knowledge. Dataflow analysis, code inspection and walk through require some programming experience on the part of the examiner, however, no expensive software tools are necessary as prerequisites. Only the last one, software module testing requires both higher expertise and software testing tools. To perform the latter three methods the source code of the measuring instrument's software is needed. The selection of the validation method depends on several factors which are described in chapter 8 "Assessment of severity (risk) levels", e.g. the foreseen on-site environment in which the measuring instrument will be used, the consequences of the measurement results for human or animal health, or the financial consequences and legal implications of the measurement result.

Verification

For legal verification of the instrument it is proposed to identify the software, check the validity of adjustment and check the conformity with the approved type.

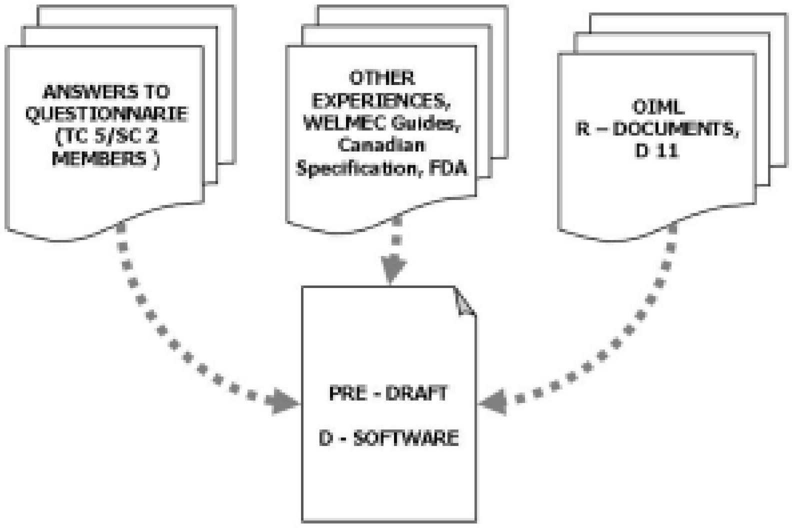

Figure 1 Sources of data for the MID-SW draft Guide

Annexes

In Annex C there is a sample test report, and Annex D contains a check list for the examination process. Annexes F and G give cross-references with Canadian specifications and the MID-Software Guide.

Conclusion

The poll of the members' needs for software requirements showed the importance of a software Document in the OIML Recommendation system. The draft Document takes into account that the extent of legally regulated measuring instruments varies very much from country to country. The existing experiences and knowledge were taken into consideration to a great extent. Responses to a pre-draft endorsed the proposed structure and contents of the future Document in general.

The First Working Draft (1 WD) of the document was distributed to P-and O-members and to liaison organizations on January 30, 2006. The Secretariat of TC 5/SC 2 encourages its members and all those concerned to comment on this draft, at the latest by May 31, 2006. ■

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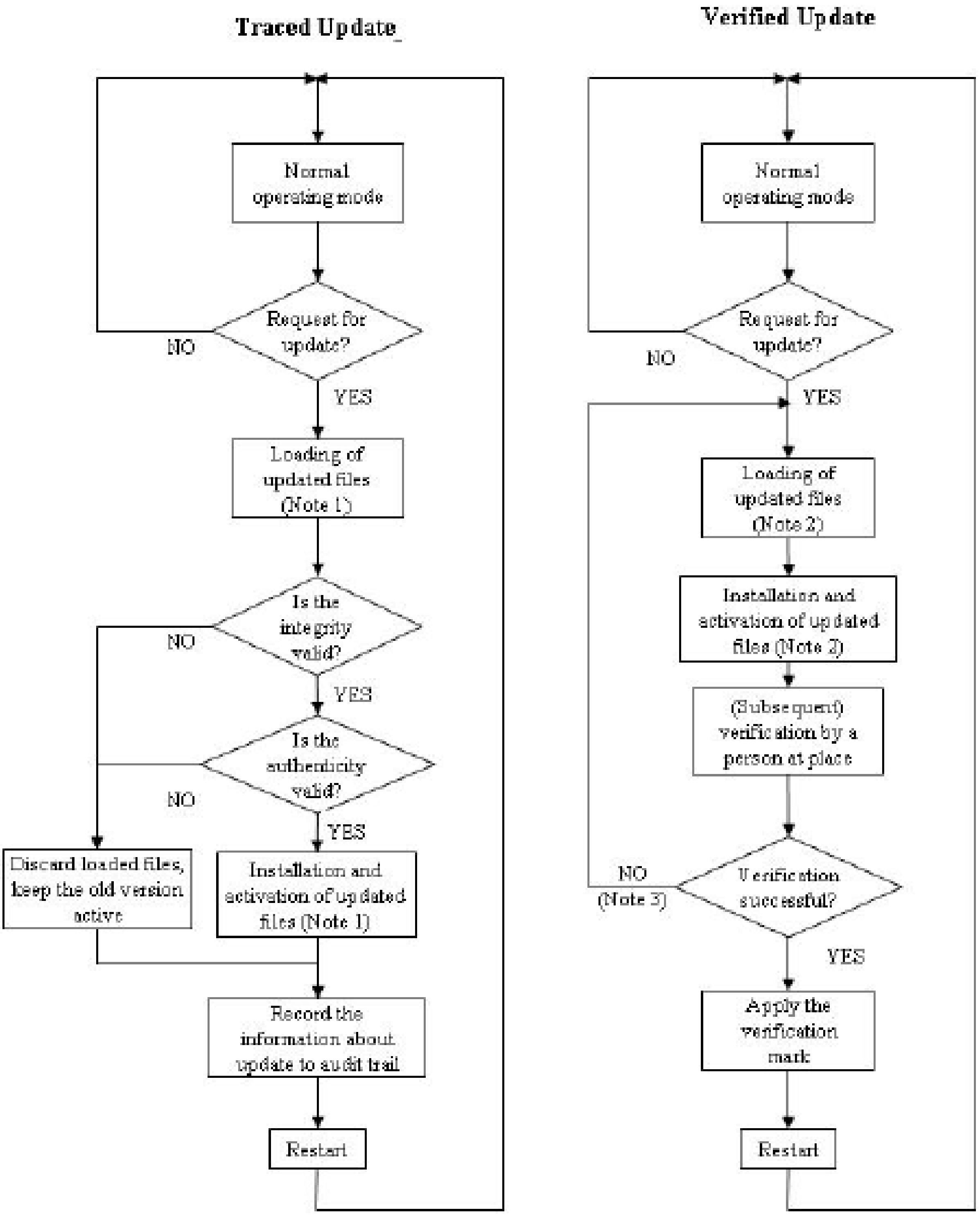

Figure 2 Flowchart of the update procedure

Notes to Figure2:

1) In the case of a *Traced update*, updating is separated into two steps: "loading" and "installing/activating". This implies that the software is temporarily stored after loading without being activated because it must be possible to discard the loaded software and revert back to the old version, if the checks fail.
2) In the case of a *Verified update*, the software may also be loaded and temporarily stored before installation but depending on the technical solution, loading and installation may also be accomplished in one step.
3) Here only failing of the verification because of the software update is considered. Failing because of other reasons doesn't require re-loading and re-installing of the software, symbolised by the NO-branch.

INTERCOMPARISONS

Proficiency testing of laboratories performing verification of measuring instruments

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Abstract

In this paper, the principles of laboratories performing verification of measuring instruments are considered. Measuring instrument verification is required in many cases for transactions and regulatory body surveillance. Verification laboratories are sometimes public institutions but they are more often private entities, and are notified by the authorities. Some measuring instruments such as water meters, heat meters or electrical energy meters are mainly verified, but not calibrated. Taking into account the above, the competence of the verification laboratories shall be ensured. One of the most useful tools for this purpose is proficiency testing.

Proficiency testing may take the form of intercalibrations, but in this case some verification operations are not dealt with. It should be noted that competence in calibration demonstrates only the extent of the technical knowledge of the body concerned without necessarily taking into account the relevant legal requirements.

In this study, the proficiency testing results of interlaboratory comparisons for water meters and watt-/varhour meters organized by Estonian Accreditation Centre in 2003–2004 are analyzed. Participants were laboratories from Estonia, Latvia and Russia.

Conclusions are given which can be used for proficiency testing methods for verifying measuring instruments which do not require calibration, especially concerning the selection of the reference object, documentation, data and object preparation, performance criteria, confidentiality and analysis of results.

Introduction

The reason why this study was carried out was that nowadays there is a need to ensure the results of measuring instrument verification using well known principles of quality assurance. Verification is required for measuring instruments which are used for transactions, to guarantee their accuracy and safety, and for surveillance authorities. In practice, many measuring instruments such as water meters, heat meters and electricity meters are mainly verified but not calibrated.

In Estonia, over 50 % of measuring instruments are verified by private companies, notified by the authorities. To obtain this notification, concrete evidence must be given that the Quality System is suitable and that all the technical requirements are followed in the laboratory.

Some restrictions do exist, and the number of verification laboratories shall be optimal since a high level of competition may damage the quality of the metrological control. Laboratories must have a sound financial structure, thus ensuring that the quality of the verification process is not compromised.

A correct laboratory notification system allows the time required for the development and practical execution processes to be shortened, it ensures optimum conditions for the verification operations, ensures the suitability of those operations destined to ensure quality control of the processes involved, and ensures a higher degree of conformity to the requirements.

Taking the above into account, the validity of the verifications shall be confirmed. For this purpose, interlaboratory comparisons can successfully be used.

As result of this study, guidance documents were produced which led to an improvement in the assurance of the competence of verification laboratories in Estonia, also taking into account MID [3] requirements.

Need for proficiency testing as interlaboratory comparisons

Proficiency testing is the use of interlaboratory comparisons for the purpose of determining the performance of laboratory measurements.

According to ISO/IEC Guide 43-1 [1] interlaboratory comparisons are conducted for various purposes and may be used by participating laboratories and other parties related to measuring instrument verification to:

- determine the performance of a laboratory for specific measurements and to monitor that laboratory's performance on an ongoing basis;

- identify problems in laboratories;
- monitor established methods;
- provide additional confidence to the laboratory's clients and also to the authorities; and
- identify interlaboratory differences.

Participation in proficiency testing provides laboratories with an objective means of assessing and demonstrating the reliability of the results they produce. One of the main uses of proficiency testing is to assess the laboratory's ability to perform tests competently. This may include assessment by other parties such as accreditation or regulatory bodies. Confidence that a verification laboratory consistently obtains reliable results is of major importance to users of laboratory services.

Most bodies assessing the technical competence of laboratories require satisfactory performance in interlaboratory comparisons as significant evidence of a laboratory's ability to produce reliable results. This is particularly important for verification laboratories and it should be underlined that a major distinctions exists between:

- the evaluation of the competence of a laboratory by the assessment of its total operation against predetermined requirements; and
- the examination of the results of a laboratory's participation in proficiency testing which may only be considered as giving information about the technical competence of the testing laboratory at a single point in time under specific conditions of the test involved in a particular proficiency testing scheme.

Interlaboratory comparisons are a mandatory element for the accredited laboratory quality system. So, according to ISO/IEC 17025 [2] the results of interlaboratory comparisons should be used:

- as preventive action. In this case the preventive action is mainly as an analysis of interlaboratory comparison results carried out by the laboratory itself, taking into account specific requirements related to verification;
- as an important management review item. This gives objective and valid bases for the conclusions;
- as a tool for validation of methods; and
- as evidence for an estimation of best measurement capability.

Use of comparison results by verification laboratories

The main values of interlaboratory comparisons for verification laboratories are given below:

- they allow the performance of laboratories to be determined for specific areas, taking into account legal requirements for the measuring instruments;
- they allow the assured accuracy level of measurements to be determined so that error limits are controlled correctly;
- they give higher quality verification results;
- they give evidence for the regulatory bodies and for the clients that verifications are carried out appropriately;
- they give a practical basis for conclusions during internal laboratory audits;
- they are a basis for corrective actions, especially if previous actions did not produce positive results; and
- they give confidence that quality is assured for those methods that are rarely used.

Some points are of great importance for measuring instrument verification laboratories, such as:

- they help the development and validation of in-house methods or methods based on general normative requirements;
- they help in the application of new methods allowing real evidence of the correctness to be put forward. Up to now, there is a lack of internationally standardized verification methods;
- they are useful for the determination of systematic deviations. It is especially recommended that participants in the scheme come from a variety of countries.

Need for measuring instrument verification

In the EU, the scope of initial verification of measuring instruments is harmonized through the MID [3]. Various regulations are valid for the subsequent verification of measuring instruments; the use of verified instruments is rendered mandatory in areas where there may be a risk of harmful effects of using non verified instruments - such as a risk of fraud or injury. Verified measuring instruments shall be used in commercial transactions, in health or in environmental protection or during surveillance of various conditions by authorities.

The need for verification of measuring instruments in Estonia up to February 2005 is illustrated in Table 1 and in Fig. 1, in which the quantity and characteristics of the measuring instruments are given. Expert research shows that in Estonia, some 1–1.2 million measuring instruments fall under metrological control.

The scope of verifications in Estonia involves weighing instruments, fuel dispensers, water meters, gas meters, heat meters, watt-/varhour meters, manometers, thermometers, measurement tanks, volume measures, taximeters and length measuring instruments.

Number of laboratories	Technical personnel	Competence	Type of measuring instrument
19	30–40 persons	Accredited for verifications and for calibrations	Weighing instruments; material measures of volume Gas meters
4	10–15 persons	Accredited only for verification based on EC Directives and documents	Fuel dispensers; watt-/varhour meters; heat meters; water meters; taximeters

Table 1 Principle data concerning verification laboratories in Estonia

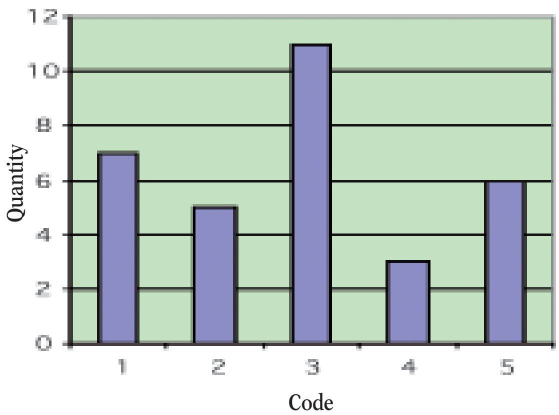

Fig. 1 Number of verification laboratories in Estonia, depending on the area of activity
Area identification codes: 1 – Mass; 2 – Electrical energy; 3 – Volume; 4 – Length; 5 – Others.

Figure 1 shows that the largest number of verification laboratories are for volume measuring instruments, water meters, capacity serving measures, and measurement tanks. One laboratory can work in various areas.

Organization of interlaboratory comparisons

The design and organization process is similar for all interlaboratory comparisons. At the initial stage, the input of technical experts and personnel is required to ensure the success and smooth operation of interlaboratory comparisons. The scheme shall be designed to avoid any confusion about its objectives.

During the organization of the intercomparison, the following shall be taken into consideration:

- quality policy determination and development of the plan to the highest specifications of the provider;
- objective, range, scope, time, operation methods and statistical design principles;
- appointment of competent personnel and staff and subcontracting;
- openness and use of results;
- selection of the test item and adequate equipment, test item preparation, item homogeneity and stability tests;
- design of rules and documents for the participants, documentation and recording, manuals for participants and use of methods;
- determination of reference values and other important parameters, determination of assigned values and performance criteria, clarity and the format in which results shall be presented, report format;
- performance evaluation procedures;
- confidentiality assurance procedures, activity rules for minimizing collusion and falsification of results and ethical considerations;
- safety and environmental considerations;
- costs;
- sending of the invitations to participants, test item management and distribution, results from participants;
- checking and analysis of the received data;
- data estimation, analysis and calculation, data preparation which shall be based on well-known statistics theories;
- data processing and software;
- end report and performance presentation;
- procedure for feedback, communication with participants and feedback results;
- handling of complaints.

It is necessary to have a precise documented timetable which includes all the above points.

The content of the report varies depending on the purpose, but each report shall be clear and comprehensive and include data on the distribution of results from all participants, together with an indication of the performance of individual participants.

Especially, the report shall include:

- the provider and the names of the persons involved in the design and conduct of the intercomparison;
- a clear description of the items and stability testing;
- statistical data and summaries, including graphical displays;
- assigned values details;
- performance criteria; and
- possibilities to improve the scheme.

The duration of the scheme for verification laboratories should not exceed one year.

Problems of interlaboratory comparisons in verification

Depending on the specific moment at which the verification takes place, the organization of an interlaboratory comparison can pose a number of problems which can be grouped as below.

A. Determination of the reference value and its uncertainty

Verification results are estimated taking into account uncertainty parameters and legal requirements. Uncertainty values are prescribed by legal acts, therefore the reference laboratory shall select a measuring instrument which has optimal uncertainty parameters for legal requirements. An uncertainty level of a reference object which is too high is not suitable for prescribed verification equipment (equipment can produce “noise”).

It is useful to know the main statistical data of the reference object, taking into account verification tasks.

B. Calculation of performance statistics

In verification, it is important that the performance measure is meaningful to participants. Measures shall relate to the application needs and be well understood by participants and authorities. Results need to be transformed into performance statistics which aid the interpretation and which allow a comparison with defined goals. The main objective of the verification is to measure the deviation from the reference value in a manner that allows comparison with performance criteria.

The outlier results should be not removed; this aids the performance estimation.

Variability measures can be used for the calculation of additional performance statistics and in summary reports. Additional statistical measures can be:

- general mean of results;
- standard deviation;
- coefficient of variations;
- absolute or relative deviation; and
- in specific cases, also repeatability and reproducibility.

C. Use of the E_n score

The E_n score can be used effectively if the calibration operations involve the use of equation (3). For a comparison of verification laboratories, the statistic based on E_n is difficult to use because the uncertainty is often not evaluated, or is not that important.

Competence of providers of interlaboratory comparisons

The person responsible for providing an intercomparison shall ensure that all the tasks involved in its provision have been competently set up. At the design stage of interlaboratory comparisons, the provider shall determine the aim and the choice of intercomparison type.

The provider shall have:

- implemented a Quality Management System;
- enough staff members to lead the group;
- if needed, suitable subcontractors, especially specialists for specific tasks, for example the estimation of legal requirements.

For the technical part, the provider shall have resources for:

- planning;
- preparing the test item;
- homogeneity and stability testing;
- statistical design;

Interlaboratory comparisons in practice

In Estonia two interlaboratory comparisons were carried out in the verification area: for water meters and for electrical energy (watt-/varhour) meters.

The object of the first intercomparison was a mechanical cold water meter with DN 15 and the most essential metrological parameters were considered for the water meter, taking into account legal requirement prescriptions.

The time period for the intercomparison was 1 April to 1 December 2003. Participants were eight laboratories (including the reference laboratory) from Estonia, two laboratories from Latvia and one from Russia.

The reference laboratory was an accredited calibration laboratory and also had a measuring instruments verification activity. The coordinator of the comparison was the Estonian accreditation body Estonian Accreditation Centre (EAK).

During the comparison, all preparation and maintenance stages were carried out by the reference laboratory. Final reports were presented to the reference laboratory and data analysis was carried out jointly by the reference laboratory and EAK.

The method used was a comparison of transfer cold water meter parameters in the participating laboratory using the participant laboratory's standards and test rig. Transportation of the transfer cold water meter was carried out by the participants.

The stability of the transfer cold water meter was controlled in the reference laboratory after each calibration in the participant laboratory. The transfer cold water meter drift was determined during the period March to October 2003 and the reference values were estimated using water at temperature 18 °C to 19 °C.

The comparison control points were water volume by prescribed flow rates (0.0315; 0.063; 0.125; 1.5 and 2.8) m^3/h and the deviations of volume of the meter were estimated using the laboratory's standards and conditions.

Processing the results took several months. All the results presented by participants were included, and no outliers were found. Also given in the reports was the deviation of the volume of transfer water meter from the laboratory's standard D_i values and the deviation of the combined uncertainty U, with k=2 on the prescribed flows.

The following values were calculated using the results presented by the participants:

- deviation of the laboratory volume values from the reference laboratory volume values Δ_{st}. The deviation Δ_{st} was calculated using equation (1). This deviation allows the laboratory's capability to fulfill the verification limits to be estimated. For cold water meters the measured volumes were 5 % or 2 % (for bigger flows);
- E_n value by use of equation (3);
- the maximum difference between the various laboratories' results by use of the equation $\Delta_{max} = D_{imax} - D_{imin}$. This deviation allows the laboratory's maximum difference (reproducibility) results to be estimated.

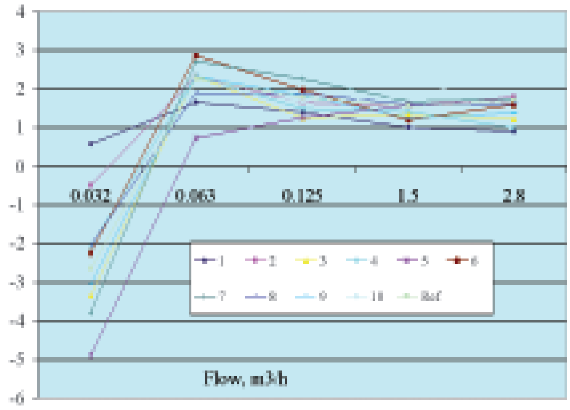

Fig. 2 Results of the intercomparison of the water meter. Laboratory deviations D_i values

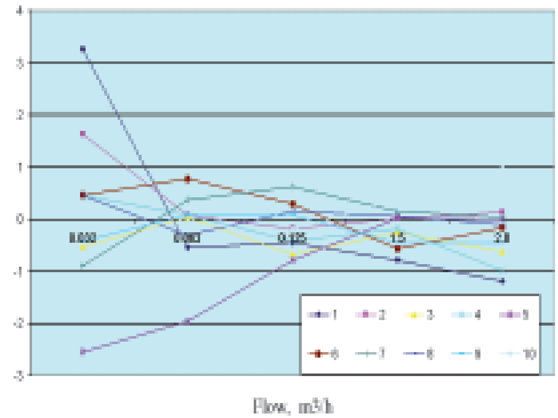

Fig. 3 Results of the intercomparison of the water meter. Laboratory E_n scores

The results of the comparison are illustrated in Figures 2 and 3. The deviation D_i is given for each laboratory for various flows in Fig. 2, and in Fig. 3 the laboratory's E_n value is given.

The conclusions of the water meter comparison were as follows:

- for this intercalibration, the E_n value was greater than 1 in five cases (for laboratories 1 and 2 twice at two flow rates);

- data analysis and records; and
- reports.

Any financial problems shall be discussed and resolved, including a correct listing of the costs involved. At the development stage, the timetable of the various stages shall be accurate and precise.

Interlaboratory comparison performance: mathematical model of the verification scope

The main objective of verification is to measure the deviation from the reference value.

The laboratory's absolute deviation from the standard (reference, assigned) result value can be calculated by equation (1):

$$\Delta_{st} = D_i - D_{ref} \quad (1)$$

where D_i is the laboratory result and D_{ref} is the reference value.

The laboratory's relative deviation from the standard (reference, assigned) result value can be calculated by equation (2):

$$D_{ri} = \frac{D_i - D_{ref}}{100\ D_{ref}}\ \% \quad (2)$$

For the calculation of the calibration performance, the value of the criteria E_n can be used, calculated by the following well-known equation (3):

$$E_n = (D_i - D_{ref}) / \sqrt{U^2_{lab} + U^2_{ref}} \quad (3)$$

The intercalibration result is satisfactory if E_n is less than 1, according to ISO Guide 43-1 [1].

In some rare cases the laboratory *Z*-value can be used for a verification comparison, calculated by equation (4):

$$Z = \frac{D_i - D_a}{s} \quad (4)$$

where D_a is the participant's mean result value and *s* is the standard deviation.

According to ISO Guide 43-1 [1], the participant's result is good if the *Z*-value is less than 1 and satisfactory if the *Z*-value is less than 2.

Optimization of interlaboratory comparisons

For the intercomparison to be successful, it is essential that costs remain reasonable. At the design stage, the provider shall discuss and resolve financial problems, including supplying a correct description of the costs which shall be optimal; to achieve this, the principles below may be used.

The main optimization mathematical expression is in the form of an equation where the object *k* has parameters X_{i1}; … X_{in} which gives the minimal cost *S* of the activity. The cost change ΔS depends on the change in parameter ΔX_i and can be expressed by equation (5):

$$\Delta S = f(\Delta X_i) \quad (5)$$

The general theory states that the mathematical optimization model consists of the determining function and the limit conditions. The determining function is a mathematical description of the situation depending on the aims and concrete optimization object features and time particularities. For optimization, first of all the principles are applicable where the object parameters and the time relationship to the cost have a primary place in the model. The model shall allow the relationship's minimum and maximum values to be found.

For interlaboratory comparisons, the main parameters for optimization are the general cost and the cost for participants. For verification, some costs can be borne by the regulatory body.

Various limitations shall be taken into account for building up the model. These restrictions can be either connections between various parameters, time limitations, resource limitations, environmental limitations, safety requirements (especially emanating from EU Directives and international standards) and also formal limitations which cannot be expressed directly mathematically, such as ethical limitations.

For the above limitations, sensitive coefficients *c* shall be used in the model and those can be determined mainly through experience:

$$M = \sum_{i=1}^{n} cM_i \quad (6)$$

where *M* is the feature parameter.

For verification, object technical parameter limitations and of course resource limitations are more important.

The exact mathematical optimization model is complicated to determine, and as a rule the simplified model can be used but the composed simplified model's validity shall be estimated.

The result can be determined by using a step by step procedure.

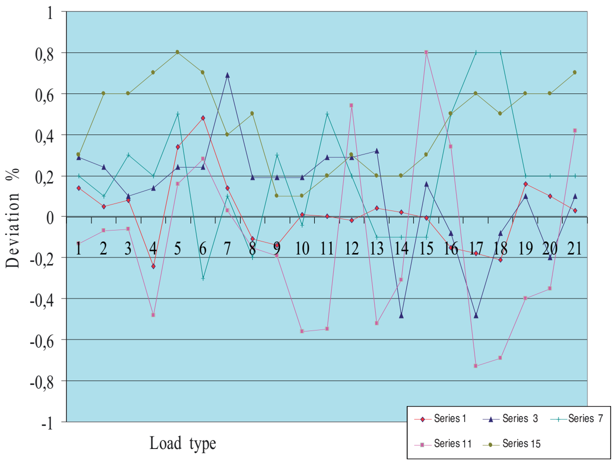

Fig 4 Results of the intercomparison of the watt-hour meter. Laboratory deviation $D_{i\,t}$ values.
Laboratory codes: Series 1 – reference laboratory; series 3 – laboratory 1; series 7 – laboratory 2; series 11 – laboratory 3; series 15 – laboratory 4.

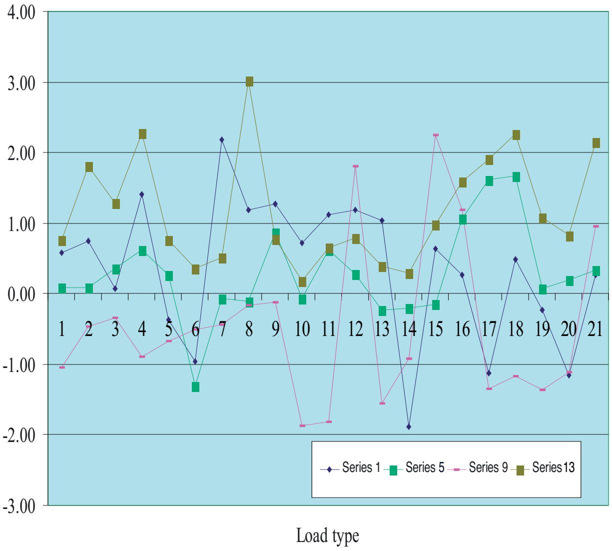

Fig 5 Results of the intercomparison of the watt-hour meter. Laboratory E_n values.
Laboratory codes: series 1 – laboratory 1; series 5 – laboratory 2; series 9 – laboratory 3; series 13 – laboratory 4.

- laboratories 1 and 2 had a big results difference of 5.5 % at a flow rate of 0.032 m^3/h (the verification limit MPE value for a cold water meter is ± 5 %);
- for the medium flow rate, 2.8 m^3/h represents a big difference in results (laboratories 1 and 10 had 1.5 % whereas the verification limit MPE value for a cold water meter is ± 2 %);
- laboratory 5 had a much better uncertainty than the other laboratories.

As a summary, one may conclude that the intercomparison results were more or less satisfactory, taking into account the laboratories' results difference and the verification limits.

The objects of the second intercomparison were a 3-phase alternative current static watt-hour meter for active energy and a var-hour meter for reactive energy. The most essential metrological parameters were considered for the meters, taking into account the legal requirement prescriptions of IEC standards.

The time period for the intercomparison was 1 April 2003 to 25 February 2004. Five laboratories participated, including the reference laboratory, all from Estonia. The reference laboratory was an accredited calibration laboratory, which was also engaged in verification activity. The coordinator was the Estonian accreditation body, the Estonian Accreditation Centre (EAK).

All the preparation and maintenance were carried out by the reference laboratory. The reports on the final results were presented to the reference laboratory and data analysis was carried out jointly by the reference laboratory and by EAK.

The method used was a comparison of transfer watt-hour and var-hour meters in the participating laboratory using the participating laboratory's standards and test rig.

The stability of the transfer watt-hour and var-hour meters was controlled in the reference laboratory after each calibration in the participating laboratory. The comparison object had an accuracy level of 0.5 as specified by the IEC.

The control points were the same as in IEC standards, taking into account Estonian legal requirements. The deviation of the transfer meter parameter from the laboratory standard values was estimated.

The control points were as follows:

1. Polyphase loading with balanced loads and with voltage $100 \cdot \sqrt{3} / 100$ V by $\cos \varphi = 1.0$; loads 0.05 I_b; 0.1 I_b and I_{max}; $\cos \varphi = 0.5$ lagging, loads 0.1 I_b; 0.2 I_b and I_{max} and $\cos \varphi = 0.8$ leading, loads 0.1 I_b; 0.2 I_b and I_{max}.
2. Single-phase loading but on the balanced voltage $100 \cdot \sqrt{3} / 100$ V by $\cos \varphi = 1.0$; loads 0.2 I_b and I_{max} and $\cos \varphi = 0.5$ leading, loads 0.5 I_b and I_b.
3. Polyphase loading with balanced loads and balanced voltage $100 \cdot \sqrt{3} / 100$ V by $\sin \varphi = 1.0$; loads 0.05 I_b; 0.1 I_b and I_{max} and $\sin \varphi = 0.5$, loads 0.2 I_b and I_{max}.
4. Single-phase loading but on the balanced voltage $100 \cdot \sqrt{3} / 100$ V by $\sin \varphi = 1.0$; loads 0.2 I_b and I_b and $\sin \varphi = 0.5$, load I_b.

Each participant used their own working procedures and equipment. The logistics were organized by the participating laboratory.

All the results were included on the summary report as presented by the participants; no outliers were found. The item parameters are given for the deviation from the laboratory's standard D_i values and the combined deviation uncertainty U, with k=2 for each control point.

Using the participants' results, the following were calculated:

- participating laboratory's deviation value from the reference laboratory value as deviation Δ_{st} by equation (1);
- E_n value by equation (3);
- maximum difference between the laboratories' results by equation $\Delta_{max} = D_{imax} - D_{imin}$.

The deviation D_i is presented in Fig. 4, and in Fig. 5 the E_n value is given for each laboratory.

The conclusions of this intercomparison were as follows:

- the E_n value was greater than 1 in many cases;
- the laboratories' results difference was often more than 0.6 %, which is greater than that presumed for the given transfer meter but lower taking into account legal verification prescriptions (1 % or 2 %). The reason for the big differences can be the voltage $100 \cdot \sqrt{3} / 100$ V which is not usual for an ordinary verification laboratory.

As a summary, one may conclude that the inter-comparison results were more or less satisfactory taking into account the verification requirements, but the laboratories should provide more evidence for the limit conditions.

Conclusions

Interlaboratory comparison principles can successfully be applied for measuring instrument verification laboratories as a quality assurance tool. The main task is to achieve suitable estimation bases and properly organize the intercomparison, for which it is essential to ensure reference values taking into account specific verification points which are given by standards and which form the mathematical model for a successful performance estimation. Optimization is essential for the scheme to survive.

To ensure confidence in the data calculation, this should be carried out by a third party. If needed, corrections can be made for the next similar scheme.

The results of this work were used by Estonian verification laboratories to improve their procedures and the quality of their work. ■

References

[1] ISO/IEC Guide 43-1:1997 Development and Operation of Proficiency Testing Schemes

[2] ISO/IEC 17025:2000 General requirements for the competence of testing and calibration laboratories

[3] Measuring Instruments Directive (MID) (2004/22/EC) of the EU

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OIML Certificate System:

Certificates registered 2005.11–2006.01

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

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

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

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

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

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

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

▶ Issuing Authority / *Autorité de délivrance*

Netherlands Measurement Institute (NMi)
Certin B.V., The Netherlands

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

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

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

OIML Recommendation applicable within the System / Year of publication

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

Certified type(s)

Type(s) certifié(s)

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

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

Year of issue

Année de délivrance

Applicant

Demandeur

Système de Certificats OIML:

Certificats enregistrés 2005.11–2006.01

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

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

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

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

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Diaphragm gas meters
Compteurs de gaz à parois déformables

R 31 (1995)

▶ Issuing Authority / *Autorité de délivrance*

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

R031/1995-FR2-2005.01
Diaphragm gaz meter ACTARIS
type GALLUS 2000 - G1,6
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.02
Diaphragm gas meter ACTARIS
type GALLUS 2000 - G1,6
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.03
Diaphragm gas meter ACTARIS
type GALLUS 2000 -G1,6
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.04
Diaphragm gas meter ACTARIS
type GALLUS - G2,5
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.05
Diaphragm gas meter ACTARIS
type GALLUS 2000 - G2,5
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.06
Diaphragm gas meter ACTARIS
type GALLUS 2000 - G2,5
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.07
Diaphragm gas meter ACTARIS
type GALLUS 2000 - G4
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.08
Diaphragm gas meter ACTARIS
type GALLUS 2000 - G4
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.09
Diaphragm gas meter ACTARIS
type GALLUS 2000 - G4
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.10
Diaphram gas meter ACTARIS
type GALLUS 1000 - G1,6
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.11
Diaphragm gas meter ACTARIS
type GALLUS 1000 - G1,6
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

R031/1995-FR2-2005.12
Diaphragm gas meter ACTARIS
type GALLUS 1000 - G1,6
Actaris S.A.S., Rue Chrétien de Troyes,
ZAC Val de Murigny, B.P. 327, F-51061 Reims, France

▶ Issuing Authority / *Autorité de délivrance*

Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R031/1995-NL1-2005.01
Diaphragm gas meter, type G1,6
Daesung Measuring Co. Ltd., 656-216,
2 Dong 1Ga Sung-Su, SungDong-Gu, Seoul, Korea (R.)

R031/1995-NL1-2005.02
Diaphragm gas meter, type G2,5
Daesung Measuring Co. Ltd., 656-216,
2 Dong 1Ga Sung-Su, SungDong-Gu, Seoul, Korea (R.)

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

R 49 (2003)

▶ Issuing Authority / *Autorité de délivrance*

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

R049/2003-FR2-2005.01
Compteur d'eau froide CZ 2000 Classe 2
Contazara S.A., Carretera Castellon km 5.5,
E-50720 Sarragosse, Spain

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

R 51 (1996)

▶ Issuing Authority / *Autorité de délivrance*

Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R051/1996-NL1-2004.05 Rev. 1
Type AC9000plus Temperature range 0 °C / 40 °C
Thermo Electron B.V., Hardwareweg 3,
NL-3821 BL Amersfoort, The Netherlands

▶ Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R051/1996-DE1-1998.01 Rev. 4
Automatic catchweighing instrument - Type EC ... and HC ...
OCS Checkweighers GmbH, Max-Planck-Str. 7,
D-74523 Schwäbisch Hall, Germany

R051/1996-DE1-2003.11 Rev. 1
Automatic Catchweighing Instrument - Type ES 5xyz, ES 6xyz and ES 7xyz
Espera-Werke GmbH, Moltkestr. 17-33,
D-47058 Duisburg, Germany

R051/1996-DE1-2003.13 Rev. 1
Automatic catchweighing Instrument - Type BW B...
Pesa Waagen AG Elektronische Wäge- und Sensortechnik, Witzbergstrasse 25,
CH-8330 Pfäffikon/ZH, Switzerland

R051/1996-DE1-2004.01 Rev. 1
Automatic catchweighing Instrument - Type BW B...
Caljan ApS, Ved Milepaelen 6-8,
DK-8361 Hasselager-Aarhus, Denmark

R051/1996-DE1-2005.05
Automatic catchweighing instrument - Type CW55
Weber-Waagenbau u. Wägeelektronik GmbH,
Boschstraße 7, D-68753 Waghäusel 1, Germany

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*

Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R060/2000-NL1-2005.16
Type 1042, 1042 HF, 1042 Symmetric and 1042 Symmetric HF
Vishay-Transducers, 5 Hazoran Street, New Industrial,
IL-42506 Netanya, Israel

R060/2000-NL1-2005.17 Rev. 1
Type ZSF-A-..... and ZSFY-A-.....
Keli Electric Manufacturing (Ningbo) Co., Ltd., 199
Changxing Road, Jiangbei District, Ningbo City, China

R060/2000-NL1-2005.18
Type MTB
Mettler-Toledo (Changzhou) Precision Instruments Ltd., 5 HuaShanZhong Lu, ChangZhou, JiangSu, China

R060/2000-NL1-2005.19
Type SP4
Hottinger Baldwin Messtechnik GmbH, Im Tiefen See 45, D-64293 Darmstadt, Germany

R060/2000-NL1-2005.20
Type GDplus... or 0782plus
Mettler-Toledo (Changzhou) Precision Instruments Ltd., 5 HuaShanZhong Lu, ChangZhou, JiangSu, China

R060/2000-NL1-2005.21
Type TSA
AEP Technology S.r.l., Via Bottego 33, I-41010 Cognento (Modena), Italy

R060/2000-NL1-2005.23
Type 1004
Vishay Tedea - Huntleigh International Ltd., 5 Hazoran Street, New Industrial, IL-42506, Netanya, Israel

▸ Issuing Authority / *Autorité de délivrance*
OIML Chinese Secretariat,
State General Administration for Quality Supervision and Inspection and Quarantine (AQSIQ), China

R060/2000-CN1-2005.03
Load cell VLC-100
Virtual Measurements & Control Inc. (USA), 1040A N. Dutton Ave, CA 95401 Santa Rosa, United States

R060/2000-CN1-2005.04
Load cell VLC-110
Virtual Measurements & Control Inc. (USA), 1040A N. Dutton Ave, CA 95401 Santa Rosa, United States

R060/2000-CN1-2005.05
Load cell GX
Hangzhou South-Ocean Sensor Co., Ltd., Zhakou, Fuxing Road, 310008 Hangzhou, China

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic gravimetric filling instruments
Doseuses pondérales à fonctionnement automatique

R 61 (1996)

▸ Issuing Authority / *Autorité de délivrance*

Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R061/2004-NL1-2005.01
Type Cxx-x series
Laurijsen Weegautomaten Dongen B.V., De Leest 22, NL-5107 RC Dongen, The Netherlands

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*

Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R076/1992-NL1-2005.26 Rev. 1
Types: WB-100...MA;WB-110...MA;BC-420MA (STMA);DC-320MA (STMA).
Tanita Corporation (Brand names: Tanita, Rhewa, Wunder), 14-2, 1-Chome, Maeno-cho, Itabashi-ku, 147-8630 Tokyo, Japan

R076/1992-NL1-2005.27
Type IPC, IPC-WP, JC or JC-WP
Ishida Co., Ltd., 959-1, Shimomagari, Kurita-Gun, Ritto-cho, 520-3026 Shiga, Japan

R076/1992-NL1-2005.30
Type SM-300...
Teraoka Weigh-System PTE Ltd., 4 Leng Kee Road, #06-01 SIS Building, 159088 Singapore, Singapore

R076/1992-NL1-2005.31
Type SM-100..
Shanghai Teraoka Electronic Co., Ltd., Tinglin Industry Developmental Zone, Jinshan District, Shanghai 201505, China

R076/1992-NL1-2005.32
Type PO-2900
Charder Electronic Co., Ltd., 103, Kuo Chung Road, Dah Li City, Taichung Hsien 412, Chinese Taipei

R076/1992-NL1-2005.33
Type RM-40...
Shanghai Teraoka Electronic Co., Ltd., Tinglin Industry Developmental Zone, Jinshan District, Shanghai 201505, China

R076/1992-NL1-2005.34
Type SM-710
Teraoka Weigh-System PTE Ltd., 4 Leng Kee Road, #06-01 SIS Building, 159088 Singapore, Singapore

R076/1992-NL1-2005.35
Type D-POS : D-POS Scanner
Dibal S.A., c/ Astintze Kalea, 24, Poligono Industrial Neinver, E-48016 Derio (Bilbao-Vizcaya), Spain

R076/1992-NL1-2005.36
Type R - Series
Motex Scales Co. Ltd., 222 - 105, Nae-Dong, Ojung-Gu, Bucheon-City, 421-160 Kyunggi-Do, Korea (R.)

R076/1992-NL1-2005.37
Type BW Series (BWXX..)
Ohaus Corporation, 19A Chapin Road, Pine Brook, 07058 New Jersey, United States

R076/1992-NL1-2005.38
Type XA xxx
Radwag Zaklad Mechaniki, 26-600 Radom, ul. Grudniowa 37/39, Poland

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

Physikalisch-Technische Bundesanstalt (PTB), Germany

R076/1992-DE1-2001.08 Rev. 3
Nonautomatic electromechanical weighing instrument - Type BC BL 100, BD BL 100, BD BL 200, BF BL 500
Sartorius A.G., Weender Landstraße 94-10, D-37075 Göttingen, Germany

R076/1992-DE1-2004.04 Rev. 2
Non-automatic electromechanical weighing instrument with or without lever works. Type XP..., XS...
Mettler-Toledo GmbH, Im Langacher, CH-8606 Greifensee, Switzerland

R076/1992-DE1-2004.07 Rev. 1
Non-automatic electromechanical weighing instrument with or without lever works. Type AV..., AV...-C, AS...-C
Ohaus Corporation, 19A Chapin Road, Pine Brook, 07058 New Jersey, United States

R076/1992-DE1-2005.07
Non-automatic electromechanical weighing instrument for persons without lever system. Type M985x2 (multi-interval instrument)
SECA GmBH & Co. kg., Hammer Steindamm 9-25, D-22089 Hamburg, Germany

R076/1992-DE1-2005.08
Non-automatic electromechanical weighing instrument with or without lever works. Type JL...-C
Mettler-Toledo GmbH, Im Langacher, CH-8606 Greifensee, Switzerland

R076/1992-DE1-2005.09
Non-automatic electromechanical weighing instrument with or without lever works. Type AV...-C, AS...-C
Ohaus Corporation, 19A Chapin Road, Pine Brook, 07058 New Jersey, United States

R076/1992-DE1-2005.10
Non-automatic electromechanical weighing instrument for persons - Types: M704x2 / M764x2
SECA GmBH & Co. kg., Hammer Steindamm 9-25, D-22089 Hamburg, Germany

▶ **Issuing Authority /** ***Autorité de délivrance***
OIML Chinese Secretariat,
State General Administration for Quality Supervision and Inspection and Quarantine (AQSIQ), China

R076/1992-CN1-2005.01
Price computing instrument QTP-30kg
W & P Scales Mfg. (Kunshan) Co., Ltd., No. 99 Shunchang Rd., Jiangsu Province, 215337 Kunshan, China

R076/1992-CN1-2005.02
Weighing Indicator XK3190-D2+
Shanghai Yaohua Weighing System Co., Ltd., No. 4059, Shan Nan Road, 200124 Shanghai, China

R076/1992-CN1-2005.03
Price computing instrument ACS-15-JJ (F902-15)
Changzhou Honsta Electric Manufacturing Co., Ltd., West End of Zhongliangting Flyover Changxi Road, Jiangsu, 213001 Changzhou, China

R076/1992-CN1-2005.04
Weighing computing instrument M10010-15
W & P Scales Mfg. (Kunshan) Co., Ltd., No. 99 Shunchang Rd., Jiangsu Province, 215337 Kunshan, China

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

R076/1992-DK1-2006.01
Non-automatic weighing instrument - Type Load Line-3
Tunaylar Baskül Sanayi ve Ticaret A.S., Beylikdüzü No. 6, 34520 Büyükçekmece, Istanbul, Turkey

R076/1992-DK1-2006.02
Non-automatic weighing instrument - Type Load Line-2
Tunaylar Baskül Sanayi ve Ticaret A.S., Beylikdüzü No. 6, 34520 Büyükçekmece, Istanbul, Turkey

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic level gauges for measuring the level of liquid in fixed storage tanks
Jaugeurs automatiques pour le mesurage des niveaux de liquide dans les réservoirs de stockage fixes

R 85 (1998)

▶ Issuing Authority / *Autorité de délivrance*
Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R085/1998-NL1-2005.11
Automatic level gauge for measuring the level of liquid in storage tanks, model Volutank
Bartec GmbH, Schulstrasse 30, D-94239 Gotteszell, Germany

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*
Czech Metrology Institute (CMI), Czech Republic

R117/1995-CZ1-2005.02
Fuel dispenser for motor vehicles - Type V-line 899x.xxx, V-line 46xx.xxx, V-line 47xx.xxx
Adamov-Systems, a.s., Mirova 2, 679 04 Adamov, Czech Republic

▶ Issuing Authority / *Autorité de délivrance*
Netherlands Measurement Institute (NMi) Certin B.V., The Netherlands

R117/1995-NL1-2005.06
Type DPX-X
Dresser Wayne Pignone, Via Roma 32, I-23018 Talamona (SO), Italy

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Multi-dimensional measuring instruments
Instruments de mesure multidimensionnels

R 129 (2000)

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

R129/2000-DK1-2005.01
Multi-Dimensional Measuring Instrument. Type Freight Volume System M101, Freight Volume System M202
Scaletronic A/S, Rugkaergardsvej 52, DK-2630 Taastrup, Denmark

OIML CERTIFICATE SYSTEM

List of OIML Issuing Authorities (by Country)

The list of OIML Issuing Authorities will now be published in each issue of the OIML Bulletin. For more details, please refer to our web site: www.oiml.org/certificates

AUSTRALIA

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

AUSTRIA

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

BELGIUM

BE1 - Metrology Division	R 76	R 97	R 98

BRAZIL

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

BULGARIA

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

CHINA

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

CZECH REPUBLIC

CZ1 - Czech Metrology Institute	R 76	R 117/118

DENMARK

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

FINLAND

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

FRANCE

FR1 - Bureau de la Métrologie	*All activities and responsibilities were transferred to FR2 in 2003*				
FR2 - Laboratoire National de Métrologie et d'Essais	R 31	R 49	R 50	R 51	R 58
	R 60	R 61	R 76	R 85	R 88
	R 97	R 98	R 102	R 105	R 106
	R 107	R 110	R 114	R 115	R 117/118
	R 126	R 129			

GERMANY

DE1 - Physikalisch-Technische Bundesanstalt (PTB)	R 16	R 31	R 49	R 50	R 51
	R 58	R 60	R 61	R 76	R 88
	R 97	R 98	R 102	R 104	R 105
	R 106	R 107	R 110	R 114	R 115
	R 117/118	R 128	R 129	R 133	

HUNGARY

HU1 - Országos Mérésügyi Hivatal	R 76

JAPAN

JP1 - National Metrology Institute of Japan	R 60	R 76	R 115	R 117/118

KOREA (R.)

KR1 - Korean Agency for Technology and Standards	R 76

THE NETHERLANDS

NL1 - NMi Certin B.V.	R 31	R 49	R 50	R 51	R 60
	R 61	R 76	R 85	R 97	R 105
	R 106	R 107	R 117/118	R 126	R 129
	R 134				

NEW ZEALAND

NZ1 - Ministry of Consumer Affairs, Measurement and Product Safety Service	R 76

NORWAY

NO1 - Norwegian Metrology Service	R 50	R 51	R 61	R 76	R 105
	R 106	R 107	R 117/118	R 129	

POLAND

PL1 - Central Office of Measures	R 76	R 98	R 102

ROMANIA

RO1 - Romanian Bureau of Legal Metrology	R 97	R 98	R 110	R 114	R 115

RUSSIAN FEDERATION

RU1 - Russian Research Institute for Metrological Service	R 31	R 50	R 51	R 58	R 60
	R 61	R 76	R 85	R 88	R 93
	R 97	R 98	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		

SLOVAKIA

SK1 - Slovak Legal Metrology (Banska Bystrica)	R 76	R 117/118

SLOVENIA

SI1 - Metrology Institute of the Republic of Slovenia	R 76

SPAIN

ES1 - Centro Español de Metrología	R 51	R 60	R 61	R 76	R 97
	R 98	R 126			

SWEDEN

SE1 - Swedish National Testing and Research Institute AB	R 50	R 51	R 60	R 61	R 76
	R 85	R 98	R 106	R 107	R 117/118

SWITZERLAND

CH1 - Swiss Federal Office of Metrology and Accreditation	R 16	R 31	R 50	R 51	R 60
	R 61	R 76	R 97	R 98	R 105
	R 106	R 107	R 117/118		

UNITED KINGDOM

GB1 - National Weights and Measures Laboratory	R 49	R 50	R 51	R 60	R 61
	R 76	R 85	R 98	R 105	R 106
	R 107	R 117/118	R 129	R 134	
GB2 - National Physical Laboratory	R 97				

UNITED STATES

US1 - NCWM, Inc.	R 60	R 76

LIAISON NEWS

ILAC ARC Meeting

20–21 February 2006 Tel Aviv, Israel

RÉGINE GAUCHER
MAA Project Leader, BIML

ILAC MRA and ILAC ARC

In order to facilitate the acceptance of tests and measurements performed by accredited laboratories, in 2002 the International Laboratory Accreditation Cooperation (ILAC) draw up a Mutual Recognition Arrangement (MRA), the aim of which is to have test and/or calibration certificates issued by an accredited laboratory accepted internationally.

The ILAC Arrangement Committee (ARC) meets twice a year and is responsible for managing and maintaining this MRA. In particular, it is in charge of harmonizing the accreditation process and is responsible for the application of ISO/IEC 17011 among ILAC MRA signatories.

The ARC is composed of representatives of each National Accreditation Body, signatories of the ILAC MRA. Regional Accreditation Organizations such as the European Accreditation (EA), the Asia Pacific Laboratory Accreditation (APLAC), the Inter American Accreditation Cooperation (IAAC) and the South African Developing Cooperation in Accreditation (SADCA) participate in the ILAC ARC as Observers.

Cooperation between ILAC and the OIML in the implementation of the OIML Mutual Acceptance Arrangement (OIML MAA)

OIML B 10-1 *Framework for a Mutual Acceptance Arrangement on OIML Type Evaluations* requires that all the Testing Laboratories involved in tests and examinations under the MAA be assessed according to the criteria of ISO/IEC 17025 either by accreditation or by peer assessment.

Harmonization between both processes (accreditation and peer assessment) is an important issue to avoid any discrepancy between Testing Laboratories. For that purpose, ILAC and the OIML started discussions several months ago and a draft Memorandum of Understanding (MoU) is currently under discussion to develop closer cooperation in the application of ISO/IEC 17025 to legal metrology and in assessing in the field of legal metrology.

OIML participation in the 3rd ILAC ARC Meeting

Mrs. Orna Dreazen, ILAC ARC Chairwoman, invited the OIML to present its MAA and the intended cooperation with ILAC at its 3rd Committee Meeting on 20–21 February 2006 in Tel Aviv, Israel. Twenty Accreditation Bodies and the four regional observers attended the meeting. The BIML presented an overview of:

- OIML goals and activities;
- The operation of the OIML Certificate System;
- The implementation of the MAA.

Concerning the implementation of the MAA, the following particular issues were developed:

- Conformity assessment of Testing Laboratories, either by accreditation or by peer assessment;
- Competence requested for experts conducting assessments;
- Reference documents used for conducting assessments.

In addition, the draft MoU drawn up by ILAC and the OIML was commented by ILAC ARC participants. In principle, the ILAC ARC is rather in favor of developing such cooperation, even if some operating issues need to be clarified.

Further steps

1 The draft MoU will be submitted for comments to the ILAC Executive Committee during its meeting to be held on 23–24 February 2006. These comments will then be presented to the OIML during the OIML-ILAC meeting planned on 9 March 2006 in Paris.

2 An amended draft MoU will be circulated among CIML Members and ILAC Members for comments in order to prepare the final MoU, for which the signature is expected during the ILAC General Assembly in November 2006.

3 Further to the MoU signature, ILAC and the OIML will prepare a work program in order to define the common actions to be developed. These will include in particular:

- Training for experts who will conduct assessments;
- Procedures for conducting assessments;
- Guidelines for the application of ISO/IEC 17025;
- Requirements applicable to the Accreditation Body. ■

RLMO NEWS

PTB Training courses for experts from COOMET Member Countries

H. Apel, K. Herrmann, W. Sabuga, H-D. Velfe
Physikalisch-Technische Bundesanstalt (PTB),
Braunschweig, Germany

Introduction

The Regional Organization for *European-Asian Cooperation of National Metrology Institutions* (COOMET) presently comprises 14 member countries and is composed of four Technical Committees. Of these, TC 4 deals with *Information and Training* and was established only recently, due to the fact that the globalization of trade and the growing importance of standards also require an increasing transfer of know-how and technologies, whereby the operation of measuring procedures and the interpretation of measurement results are just as important as the technical equipment itself.

The PTB has a special *Technical Cooperation* department to support countries in the establishment of their own metrological systems by means of specific projects; language barriers in the basic and advanced training of metrology experts often still represent a more significant hurdle than scarce financial resources or the availability of qualified national experts ready to be trained abroad.

This is especially the case concerning metrology, which is characterized by its specific technical terminology which sometimes differs from country to country. At the 12th OIML Conference in Berlin in October 2004, several speakers pointed out this fact during the discussions. The COOMET President, Prof. Nikolai Zhagora, emphasized the willingness of COOMET members to harmonize their national regulations in legal metrology with European and international rules and regulations, in particular in order to reduce technical barriers in foreign trade and to improve the export chances of the national enterprises. This aim, however, is often difficult to achieve owing to the fact that among the experts - who are in general well prepared technically - there is still a lack of knowledge of foreign languages. Thus, many newly emerging states (especially those which were formerly part of the Soviet Union) still use Russian as their unique common foreign language. As a response to this situation, the PTB offered to carry out qualifying measures in Russian within the scope of COOMET. The first seminars have now taken place.

1 Seminar on the practice of metrological control of prepackages

At the end of September 2005, the PTB organized a four-day seminar in Minsk (Belarus) on the control of prepackages which also included practical controls in two plants using filling devices. The concept of the seminar was prepared by the head of COOMET TC2 *Legal Metrology,* H. Apel, with the prior consent of all partners involved. The PTB Working Group Q.51 was in charge of the translation of the seminar documents and of the administrative execution of the workshop. The seminar was organized locally by the COOMET Secretariat, which is based at the Belarusian metrology institute BelGIM in Minsk. Two experienced experts from the German verification authorities were engaged as lecturers and trainers contributing not only their knowledge on the theoretical fundamentals, but also their experience on practical tests of prepackage control.

The seminar was considered to have been extremely helpful by the 17 participants coming from five different countries and the information obtained can contribute to strengthening consumer protection in this field in their home countries. Manufacturers also have a direct economic benefit from prepackages which are in full compliance with the legal regulations (avoiding overfilling of prepackages, building up customer confidence and increasing export chances).

This workshop was characterized by a very active participation of the trainees. They were given the opportunity to assess the seminar by means of a questionnaire and to submit proposals for further cooperation. The extensive discussions showed that due to the changing economic and political situation in these countries, there are still many gaps in national legislation which make it difficult to execute an efficient control on prepackages. As a consequence, the participants suggested holding a further seminar on prepackage control which should mainly address political and technical decision-makers and which should focus on the legal bases which already exist or which are under revision (OIML R 79 and R 87, EU Directives on prepackages, Prepackage Ordinance in Germany).

2 Training course on hardness measurement

The PTB Laboratory for *Hardness Measuring Technique* carried out a practice-oriented training course in Braunschweig for young scientists from the countries of the *Commonwealth of Independent States* (CIS) in the field of hardness measurement. The experts came from Belarus, Kazakhstan, Russia, Ukraine and Uzbekistan.

In order to enable an effective training on hardness standard measuring machines and devices, the number of participants in this intensive course was limited to five.

Lectures on the fundamentals of hardness metrology as well as practical exercises on the machines and devices were carried out in the course. The lectures held by the head of the laboratory, K. Herrmann, dealt with the following subjects:

- Standardization of the conventional hardness measuring methods for metals (Rockwell, Vickers, Brinell and Knoop) within the scope of ISO,
- Standardization of hardness measuring methods for rubber and plastics within the scope of ISO,
- Fundamentals of the determination of the measurement uncertainty of the hardness measurement method, in the calibration of hardness testing machines, of hardness reference blocks according to ISO standards and to the guides of the *European Cooperation for Accreditation* (EA),
- Fundamentals of the instrumented indentation test for coated and uncoated samples,
- Introduction to the laser-acoustic measurement method,
- Measurement methods for indenters,
- Measurement principles and status of the standardization of portable hardness testing devices.

In the practical exercises, the participants had the opportunity to calibrate hardness reference blocks - made of different metals - according to the hardness measuring methods Rockwell, Vickers, Brinell and Knoop. Furthermore, they were made familiar with the measurement of the hardness of silicons, rubber and plastics. The indentation test was practiced on a micro and a nano indentation instrument. Generating an indentation on a fused silica sample at a test force of only 100 µN was appreciated by all participants as an interesting example of nano-metrology. By means of a laser-acoustic measuring device it was shown how it is possible to determine Young's modulus of coatings having a thickness of only a few nm. The training included both the conventional hardness measuring methods generally applied in industry as well as the modern measuring procedures for the determination of mechanical properties which have been developed for the nanotechnologies in the past years, e.g. in microelectronics and microsystem technology.

There was enough time for questions and discussions during the whole course and participants asked many questions not only related to their professional practice but also to the development tendencies of hardness metrology. It was also very much appreciated that the course offered the possibility of establishing personal contacts with the PTB experts as well as among the participants themselves.

3 Training seminar on pressure measurement

In November 2005, a 1-week training course on pressure measurement, headed by W. Sabuga, took place at the PTB in Russian for experts from the metrological state institutes of the COOMET countries. The precondition for participating in this course was a sound basic knowledge in the field of pressure metrology and a direct involvement with metrological tasks in the laboratories of their institutes at home. The following seven institutes were each represented by a single participant:

- KSSMRIM (Ukraine),
- CNS UZ (Uzbekistan),
- INSM (Moldova),
- KYRGYZSTANDARD (Kyrgyzstan),
- VNIIM (Russia),
- BelGIM (Belarus),
- KazInMetr (Kazakhstan).

The PTB's program on advanced training covered subjects such as the traceability of the unit of pressure to the SI basic units with the use of pressure balances and liquid manometers, the measurement standards for the realization of the pressure scale from 1 kPa to 1.4 GPa, fundamentals of pressure measurement by means of pressure balances and procedures for their calibration, methods and standards for the calibration of pressure transducers, measurement of absolute pressures with liquid manometers as well as the associated uncertainty calculation. A considerable part of the course consisted in practical exercises with regard to pressure comparison measurement with two hydraulic pressure balances, data collection, evaluation of the results, determination of the effective area and of the pressure distortion coefficient of piston-cylinder assemblies including uncertainty assessment. Examples were presented for the calibration of electrical barometers, for standards for the measurement of small gauge pressures and for small differential pressures at high line pressures.

The participants showed a special interest in the latest generation of pressure measuring devices such as pressure balances with non-rotating piston for the measurement of small gauge pressures and absolute pressures, as well as for advanced measuring techniques and devices for the determination of the influence quantities required for precise pressure measurements.

Many questions were asked with regard to the mutual recognition (BIPM MRA) of calibration measurement capabilities (CMC) and to the regulations for the organization and performance of international comparison measurements. Therefore, examples were given concerning the field of pressure measurements as well as information on accreditation procedures in the EU, on the *German Calibration Service* (DKD) and on the type approval of pressure measuring instruments.

The participants used the opportunity for consultation with regard to their individual problems within their laboratories in the field of pressure measurement and to the selection of suitable pressure standards for their special metrological tasks at home.

The participants considered the course as extremely useful. However, it was generally regretted that the five-day training course had been too short. The commitment of all participants was so intensive that the discussions in the laboratories often lasted until very late in the evening.

4 Preparation of further courses

This success encouraged the PTB to offer further training courses in Russian this year.

Thus, a two-day workshop will take place for participants from COOMET member states on the testing of software in measuring instruments subject to legal control, after the meeting of TC 2 *Legal Metrology* which is held once a year. The aim of this workshop will be to impart knowledge on the technical requirements the PTB has developed within the scope of legal metrology for the testing of software in type approvals and to show how these have been incorporated in the WELMEC guidelines. This subject is increasingly gaining importance with the adoption of the *EU Measuring Instruments Directive* (MID – 2004/22 EC), which demands software tests of different severity levels for various types of measuring instruments. The regulations, however, which are prescribed by the MID, are so general that they require further technical interpretation. WELMEC Guide 7.2 on *General Requirements for Software-controlled Measuring Instruments* which was specially developed for this purpose proved not to be sufficient. The training program of the workshop therefore includes, among other topics, the following modules:

- Content of WELMEC Guide 7.2,
- Software examination according to WELMEC Guide 7.2,
- Test methods,
- Software testing by means of checklists in the case of a simple measuring instrument (e.g. electricity meters),
- Software testing in the case of a complex measuring device (e.g. 3-dimensional measuring system) with software separation, download, long-term storage and data transmission.

The two-day course will be guided by the head of COOMET TC2/SC2, M. Shabanov, BelGIM, and U. Grottker, PTB, and is scheduled for 6-7 July, 2006 at the INSM in Kishenev, Moldavia.

In Sofia, Bulgaria, the follow-up course on prepackaging law will be held from 4-6 October, 2006. This time, the course will address the legislators and executives of the regulating authorities in charge of the international harmonization of the legal regulations in prepackaging law. As a working basis, the lecturers will hand out a model regulation to the participants of the workshop in Russian for the purpose of discussion. This model regulation will be prepared according to the international regulations, and aims at ensuring a high level of consumer protection. Criteria will be developed, and the experience gained with the implementation of West European rules and regulations is to be taken into consideration for reasons of international harmonization. The participants will have the task of elaborating counterdrafts tailored to the target ideas and the specific needs of their countries, which might be used as a potential basis for drawing up their national prepackaging laws.

Anyone interested in the above-mentioned workshops and who fulfills the requirements with regard to language skills and technical knowledge, whether from a COOMET or OIML Member State, is welcome to participate in the training courses as long as space is still available; they should contact the PTB or COOMET. If sufficient funding is provided, all the courses described above can also be organized in other languages for other regional organizations of metrology. ■

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JOINT DECLARATION

BUREAU INTERNATIONAL DES POIDS ET MESURES

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

INTERNATIONAL LABORATORY ACCREDITATION COOPERATION

Common Statement and Declaration by the BIPM, the OIML and ILAC on the Relevance of Various International Agreements on Metrology to Trade, Legislation and Standardization

1 Executive Summary

The International Bureau of Weights and Measures (BIPM), the International Organization of Legal Metrology (OIML) and the International Laboratory Accreditation Cooperation (ILAC) work closely together in order to promote a world-wide metrology system.

This common statement describes the missions of each of the three organizations and their complementary, but mutually supportive, work. It also highlights the importance of their Mutual Recognition Arrangements to underpin the unified world-wide metrology system for industry, commerce and world-wide trade. The statement specifically invites Governments and other Authorities to endorse and commit themselves to use the appropriate Arrangements whenever possible.

2 Preamble

2.1 Trade fuels economic growth in developed as well as developing nations. Measurements play an essential role in developing confidence between trading partners and in demonstrating that goods comply with written specifications and legal requirements; a process which involves making comparable or equivalent measurements in different countries. Any lack of acceptance by regulatory or other trade-related authorities in an importing country of the measurements made in an exporting country can become a technical barrier to trade.

2.2 The organizations named in this document are all involved in various forms of mutual recognition arrangements which seek to facilitate the mutual acceptance of measurements used in, for example, the industrial, environmental, medical and food sectors.

2.3 The International Bureau of Weights and Measures (BIPM) is an intergovernmental organization, financed by Governments from over seventy countries which represent over 90 %[1] of world trade. The BIPM undertakes scientific work which relates to commonly agreed measurement standards (the international system of units, the SI) at the highest level and the traceability of measurements to these standards. This activity is part of what is commonly known as metrology (the science of measurement). The BIPM operates within the Metre Convention, a diplomatic treaty established in 1875 and works with National Metrology Institutes (NMIs) worldwide. These NMIs hold the highest-level measurement standards at a national level and disseminate them, through calibration services, to lower level national users in the scientific, industrial, commercial, and public sectors. The BIPM has established a Mutual Recognition Arrangement (known as the CIPM MRA) within which all signatories agree to recognize each others' national measurement standards and calibration and measurement certificates. The CIPM MRA ensures that, at a national and international level, any differences between the highest level national measurement standards are known and recorded in a database maintained by the BIPM which is openly accessible (kcdb.bipm.org).

2.4 The International Organization of Legal Metrology (OIML) is an intergovernmental organization under an International Convention signed in 1955. Its main responsibilities cover

[1] Source, KPMG consulting, 2001. For the text of the report, see www.bipm.org

mutual information in legal metrology, harmonization of legal metrology regulations, development of mutual confidence and recognitions in this field and support to the development of legal metrology; in particular, in Developing Countries.

OIML Recommendations (model technical regulations) and Documents or Guides (informative documents) are international standards as defined in the WTO TBT Agreement, and are best practice in many industrial and other sectors. They require evidence of traceability to the measurement standards of the SI.

The OIML has set up a voluntary System of Certificates of Conformity for measuring instruments with regard to the OIML Recommendations and is implementing a Mutual Acceptance Arrangement (MAA) within which Declarations of Mutual Confidence (DoMCs) will be signed for different categories of measuring instruments. Test results issued in this Certificate System by signatories of a DoMC which demonstrate conformity with OIML Recommendations will be accepted and utilized by the other signatories.

In addition, the OIML is studying further acceptance and/or recognition systems for the assessment of prepackages content and for results of bulk measurements, thus facilitating international trade.

2.5 The International Laboratory Accreditation Cooperation (ILAC) is an international association of nationally recognized accreditation bodies largely concerned with appropriate harmonization of the work of accreditation bodies who service about 25 000 accredited calibration and testing laboratories, around the globe. The accredited laboratories operate in the commercial sector and public sectors and in most cases, do not require the highest level of measurement accuracy but do require evidence of technical competence and traceability to the SI.

ILAC Full Members and Associates in 58 economies assess and accredit the performance of these laboratories and other organizations to the generic requirements of ISO/IEC 17025 or similar internationally accepted written standards in specific sectors, like ISO 15189 for clinical laboratories. In order to facilitate acceptance internationally of tests and measurements performed in this accredited sector, those members who are signatories to the ILAC Mutual Recognition Arrangement recognize, as equivalent, the test and measurement certificates generated by the laboratories accredited by each signatory.

2.6 The work of the three bodies is complementary. The infrastructure for metrology in a country comprises a National Metrology Institute which maintains and disseminates traceability to the SI through calibrations and other services. The national networks of accredited and other calibration laboratories then make use of the national traceability framework to perform other measurements and calibrations which can then also demonstrate SI traceability. The national Legal Metrology system/infrastructure makes use of this and of legal infrastructures to demonstrate conformity with regulatory requirements. The ILAC signatory (i.e. ILAC Full Member) accreditation bodies use an appropriate written standard to assess the technical and managerial competence of laboratories, e.g. to ISO/IEC 17025.

Metrology, accreditation and legal metrology therefore form three key elements of what is increasingly recognized by many international and intergovernmental bodies as an essential infrastructure for national and international consistency of measurement in relation to agreed written standards and for compliance with the requirements of the World Trade Organization. The BIPM, ILAC and the OIML collaborate closely with the International Standardization Organization (ISO) and the International Electrotechnical Commission (IEC), which are largely responsible for international activity concerned with written or documentary standards and which draw their membership from national standardization bodies

2.7 All three bodies have a common interest in, and responsibility for, its end use by industry, commerce, science and the trade or regulatory communities. To summarize, the world measurement system (WMS) is, in essence, a combination of:

- comparable national standards, demonstrably traceable to the SI and their realization and maintenance at the NMI level and validated through the CIPM MRA;
- effective national traceability and measurement systems in which measurements are traceable to these national standards, at whatever level of accuracy is appropriate to the user. This is generally through a network of technically competent calibration and testing laboratories accredited to ISO/IEC 17025 or other appropriate documents such as ISO Guide 34 for reference material production, by a Nationally recognized Accreditation Body (NAB) which is a signatory to the ILAC Arrangement;
- similar arrangements through organizations responsible for legal metrology at a national level and which largely require national legal metrology laboratories to be accredited as testing laboratories to the appropriate ISO standards; and
- internationally recognized specifications, written standards and regulatory requirements.

3 Basis for this Declaration

3.1 At its 22nd meeting, the General Conference on Weights and Measures (CGPM), voted the Resolution annexed to this document and invited the International Committee for Weights and Measures (CIPM) which has responsibility for the work of the BIPM:

"to prepare a declaration on the importance and application of the CIPM MRA in trade, commerce and regulatory affairs, and to bring it to the attention of the Governments of the Metre Convention with the recommendation that the principles of the CIPM MRA be included in intergovernmental agreements as appropriate."

The CGPM Resolution also noted a range of economic and other benefits which flow from the CIPM MRA and encouraged Governments to promote it.

3.2 At its meeting in October 2004, the CIPM noted the activities of ILAC and the OIML in relation to the CGPM Resolution. It therefore asked the BIPM to collaborate with ILAC and the OIML in the preparation of a declaration on the importance of using all three Mutual Recognition Arrangements by Governments and trade or related bodies. The present document and associated declaration is the result of this collaboration.

3.3 In the following declaration, the three organizations invite Governments, Regulatory Authorities, Regional and International Trade or Economic groups and other bodies, to commit themselves to use the appropriate Arrangements whenever possible.

From a user point of view, the key benefit from such a commitment is the assurance that any measurement made within this system has been made by a body whose technical competence and capabilities have been reviewed, nationally, regionally and internationally, by appropriate technical peers. As a result, these measurements can be accepted with full confidence by the signatories to the Arrangements. No higher technical authority exists. Organizations which use measurements made by signatory bodies can have full confidence in their accuracy and their traceability to the fundamental units of science and engineering in a very wide range of application areas and that they meet the measurement requirements in appropriate written standards and applicable legislation and regulation.

4 Declaration

In accordance with Resolution 6 of the 22nd General Conference of Weights and Measures (CGPM), the International Committee for Weights and Measures (CIPM), the International Organization of Legal Metrology (OIML), and the International Laboratory Accreditation Cooperation (ILAC):

- **invite Governments to endorse, and declare their commitment to use and refer to organizations which are signatories to the CIPM MRA, the OIML MAA and the ILAC Arrangement, wherever measurements are required as evidence of compliance with legislation, regulation or the pursuit of human well-being at a national and international level.**

The three bodies further:

- **invite standardization organizations, regulatory and trade bodies to note the existence and value of the Arrangements set out in this document, and to collaborate with the three organizations so as to develop ways and means of referring to, promoting, and using the Arrangements in their work.**

Annex 1

Extract from the minutes of the 22nd General Conference on Weights and Measures (October 2003)

Resolution 6 On the importance of the CIPM Mutual Recognition Arrangement

The 22nd General Conference,

noting

- the positive social and economic impact, including the lowering of costs in non-tariff barriers to trade that are expected to follow from adoption by regulators and legislators of the CIPM Mutual Recognition Arrangement (CIPM MRA),
- the effect of the CIPM MRA in building mutual confidence between trading partners,
- the interest already created with certain regulatory authorities, trade organizations and national authorities,
- the use of the CIPM MRA, for example, in facilitating the European Union/United States trade agreement,
- that the credibility of the CIPM MRA is based upon a secure technical foundation, namely, the key comparisons, quality systems and other measures to ensure quality,
- that the CIPM MRA has been signed with the approval of the appropriate official authorities in each country,

welcomes the interest shown by these bodies, and

invites

- all Member States to promote the CIPM MRA among their national regulatory, accreditation and standardization bodies as a framework for acceptance of calibration and measurement certificates from national metrology institutes (NMIs) and designated institutes as well as from accredited laboratories that can demonstrate traceability to the International System of Units through standards realized by the signatory NMIs and designated institutes,
- the International Committee to prepare a declaration on the importance and application of the CIPM MRA in trade, commerce and regulatory affairs, and to bring it to the attention of the Governments of the Metre Convention with the recommendation that the principles of the CIPM MRA be included in intergovernmental agreements as appropriate,

encourages the International Committee to take all possible steps to increase the number of signatories of the CIPM MRA representing NMIs and other designated institutes that form part of the metrological infrastructure of the Member States of the Metre Convention and the Associates of the General Conference. ■

Signed in Paris on 23 January 2006 by:

*Professor Andrew Wallard - Director, BIPM * Mr. Daniel Pierre - Chair, ILAC * Mr. Jean-François Magana - Director, BIML*

FAREWELL FROM THE PTB

Retirement of Prof. Dr. Manfred Kochsiek

ROMAN SCHWARTZ, PANAGIOTIS ZERVOS
PTB, Germany

On 5 February 2006 Prof. Dr. Manfred Kochsiek, Vice President of the Physikalisch-Technische Bundesanstalt (PTB), celebrated his 65th birthday. With this, his well-deserved retirement began on 1 March 2006.

Manfred Kochsiek began his career at the PTB some forty years ago as a certified mechanical engineer. After obtaining a doctorate from the Faculty of Engineering at Hanover Technical University with a dissertation on the topic *For determination of the pitch diameter and the partial flat angle at threads* he took over key tasks, successively becoming head of the PTB Mass Unit and Mechanical Scales laboratories. He was then appointed head of the Technical-Scientific Services department from 1985 to 1993. During this time questions concerning the international integration of the PTB in the field of legal metrology, metrological and technical cooperation as well as standardization were the focal points of his work. In 1993 he became a Member of the PTB Presidential Board and in 1998 he became Vice President.

On 7 February 2006, during an official ceremony in the auditorium of the PTB, Prof. Kochsiek officially stepped down as PTB Vice President at the end of an international metrology workshop, the theme of which was "The Road to the Global Measurement System".

His intense national and international commitment, for example as CIML Acting President, was reflected in the lectures given at this international workshop where the development tendencies of European and global metrology were evoked. The impressive list of the speakers was like an extract of the Who's Who of worldwide metrology!

During the event, Andrew Wallard (BIPM Director), Alan Johnston (CIML President), Leo van Biesen (IMEKO President), Seton Bennett (EUROMET Chairman), Corinne Lagauterie (WELMEC Vice-Chair) and Nikolai Zhagora (COOMET President) all gave lectures which clearly expressed the importance of metrology for modern-day economies and societies.

A further highlight of this event - and certainly a personal one for Prof. Kochsiek - was the award of the congressional medal of the VDMA (the German Machinery and Plant Manufacturers' Association), handed over by the chairman of the German Weighing Machine Manufacturers' Association (AWA), Dr. Maaz, and the distinction awarded to him on behalf of COOMET by its President, Dr. Zhagora.

The PTB Vice Presidency will in the future be taken over by Prof. Dr. Manfred Peters, previously head of the PTB Mechanics and Acoustics Department. Prof. Peters is also an expert in German and international metrology.

The day ended with a reception held at the PTB, during which the numerous guests had the occasion to say goodbye to Prof. Kochsiek and to congratulate him on his achievements during his outstanding career.

The BIML, in turn, adds its most sincere thanks to Prof. Kochsiek for his advice, assistance, initiatives and leadership during the many years its Staff have known and worked with him, and wishes him well in his retirement - even though we are sure that Manfred will continue to help and advise whenever possible in his professional, friendly and efficient way for many years to come! ■

Andrew Wallard (BIPM Director) speaking about "The global impact of the CIPM Mutual Recognition Arrangement"

Alan Johnston (CIML President) speaking about the "OIML Mutual Acceptance Arrangement (MAA)"

Prof. Ernst O. Göbel, PTB President, congratulating Prof. Manfred Kochsiek during the formal passing of office

Dr. Maaz, Chairman of the German Weighing Machine Manufacturers' Association (AWA) handing over the congressional medal of the VDMA to Prof. Kochsiek

The OIML is pleased to welcome the following new

CIML Member

- **Bulgaria:**
  Dr. Katerin Katerinov

OIML Meetings

11–12 May 2006 - Hamburg, Germany

TC 8/SC 1 Static volume and mass measurement
- Revision of OIML R 80 and R 85

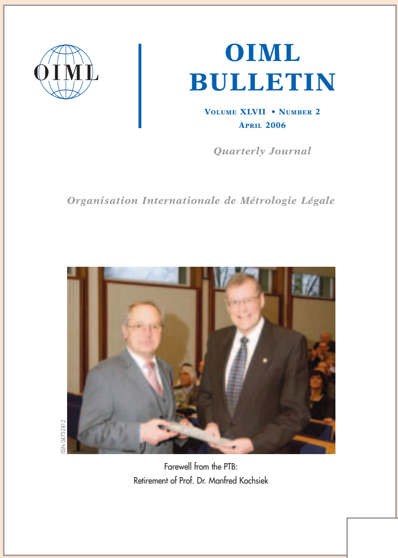
14–20 October 2006 - Sheraton Hotel, Cape Town, South Africa
(Date to be confirmed)

- 41st CIML Meeting
- Working Group on conformity to type
- Seminar on packaging
- Permanent Working Group on Developing Countries
- Presidential Council meeting

Committee Drafts

Received by the BIML, 2005.12 – 2006.02

Surveillance of utility meters in service on the basis of sampling inspections	E	2 CD	TC 3/SC 4	DE
General requirements for software controlled measuring instruments (Pre-draft)	E	1 WD	TC 5/SC 2	DE + FR
Revision R 80: Road and rail tankers. Part 1: Technical and metrological requirements	E	2 CD	TC 8/SC 1	AT
Revision R 85: Automatic level gauges for measuring the level of liquid in fixed storage tanks Part 1: Metrological and technical requirements - Tests Part 2: Metrological control and tests Part 3: Test report format	E	2 CD	TC 8 SC 1	AT
Revision R 71: Fixed storage tanks. General requirements	E	2 CD	TC 8/SC 1	AT



OIML BULLETIN

Volume XLVII • Number 2
April 2006

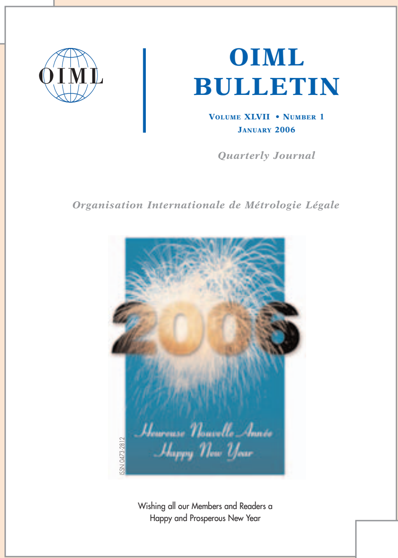
Quarterly Journal

Organisation Internationale de Métrologie Légale

Farewell from the PTB:
Retirement of Prof. Dr. Manfred Kochsiek

Call for papers

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



OIML BULLETIN

Volume XLVII • Number 1
January 2006

Quarterly Journal

Organisation Internationale de Métrologie Légale

Wishing all our Members and Readers a
Happy and Prosperous New Year

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

OIML BULLETIN

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October 2005

Quarterly Journal

Organisation Internationale de Métrologie Légale

OIML celebrates its Fiftieth Anniversary
and holds its Fortieth CIML Meeting in Lyon, France

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.

Papers selected for publication will be remunerated at the rate of 23 € per printed page, provided that they have not already been published in other journals. The Editors reserve the right to edit contributions for style, space and linguistic reasons and author approval is always obtained prior to publication. The Editors decline responsibility for any claims made in articles, which are the sole responsibility of the authors concerned. Please send submissions to:

The Editor, OIML Bulletin
BIML, 11 Rue Turgot, F-75009 Paris, France
(editor@oiml.org)

OIML BULLETIN

Volume XLVI • Number 3
July 2005

Quarterly Journal

Organisation Internationale de Métrologie Légale

Air pollution:
Exhaust-gas analyzers and air quality monitoring