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Editorial

Chris Pulham
Editor/Webmaster, BIML

www.oiml.org revisited

Information technology across the planet has now progressed to the stage where we wonder how we ever managed without it! Gone are the days of interminable deliveries of wads of paper across the oceans, of money wasted on exorbitant international courier services, and of endless hours of packaging up circulars in post-office resistant envelopes.

Now, to ensure Members receive the information they're waiting for, one click of a button and the information is disseminated to hundreds of people in the time it takes to say "that's done" (or sometimes "oops – have to send that one again!").

Following close behind in the wake of this rapid transition, the team at the BIML has also invested time and energy to ensure that we keep up with developments in the information transfer rush.

1) We redesigned our web site menu structure, taking into account the queries we receive, to ensure that the information most asked for is most readily available, with the aim of reducing the time people have to spend hunting around for the publication or information they want before giving up (or sending us a fax...).

2) We published new public web pages giving details of the Memoranda of Understanding the OIML has with other organizations, and information for prospective new member counties explaining what the OIML can offer them.

3) In February we uploaded a comprehensive new Reports page (http://www.oiml.org/download/reports.html) where 15 new PDF documents can be instantly downloaded to provide a full picture of the situation regarding Membership, Publications, the Certificate System, TC/SC structures and projects, and statistics on the number of MAA Issuing Participants and MAA Certificates.

4) Lastly, we created a page to keep Members informed of recent notifications, under Article 10.6 of the WTO TBT Agreement, by WTO Member States of changes to technical legislation related to metrology or which may have implications for legal metrology.

CIML Members and OIML Corresponding Members have access to the Members' area, where all circulars, e-mailings, notifications of contributions and online votes are available; they are now seeing the importance of casting their vote in the direct online approvals and preliminary ballots of draft publications.

As we endeavor to speed up the technical work processes in preparation for the advent of the new *Directives for Technical Work*, we feel sure that Members will continue to participate to the greatest extent possible.

In concluding, again we always welcome and value comments about our web site itself, and about the WorkGroups sub-sites which we have created and expanded for the use of the Technical Committees and Subcommittees. ■

THERMOMETERS

A test procedure for the performance of infrared ear thermometers

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Abstract

The development of infrared (IR) ear thermometers started in the 1990s. Since around 1997 these instruments have been widely used not only in medical institutes but also in the home because they are quick and safe to operate and do not create a risk for the environment since mercury and glass are not used.

On the other hand, this more widespread usage has given rise to an increasing number of consumer complaints relating to the performance quality of IR ear thermometers as measuring instruments.

Therefore, since 1998 industry has been conducting an actual condition survey on these instruments. Based on the results of the research, the report JIS T 4207:2005 (JIS T 4207) was published in 2005. On the basis of this, two characteristic measurement performance tests were carried out: "Temperature indication characteristics" and "Temperature drifts", using IR ear thermometers sold on the Japanese market in 2009.

The result of the assessment showed that only one out of the five types of IR ear thermometers actually met the standard; this type went on sale after JIS T 4207 was published.

In addition, it was recognized that the blackbody system which the National Institute of Advanced Industrial Science and Technology (AIST) developed and designed could be fully utilized for conformity assessment. We evaluated the performance quality during the actual measurement of human body temperature and as a result, the dispersion of the measurement was found to be greater than the measurement error. We assume that the main causes for this dispersion in an actual measurement could arise from usage difficulties and the complexity of the method of operation – for example the shape or location of measurement buttons.

Consequently, it was confirmed that we should analyze the performance quality of IR ear thermometers as measuring instruments for professional use, and establish criteria for their conformity assessment.

1 Introduction

Human body temperature measurement is widely carried out both at medical institutes and also at home as a health indicator. It is therefore necessary for clinical thermometers to have high accuracy and in response to this need the OIML published Recommendations for *Mercury-in-glass clinical thermometers* (OIML R 7:1979), *Clinical electrical thermometers for continuous measurement* (OIML R 114:1995) and *Clinical electrical thermometers with maximum device* (OIML R 115:1995) [1]. The measurement law in each country, under which the quality of measuring instruments is maintained, is based on the technical requirements of these Recommendations.

In early 2003, the outbreak of Severe Acute Respiratory Syndrome (SARS) in Asia drew public attention. To prevent the spread of SARS, immigration control was strengthened at all the SARS-infected area airports. Many travelers were screened to establish whether their body temperature was 38 °C or greater using IR ear thermometers and thermographs which were able to measure temperature in a very short period of time. Especially in China and Taiwan, many people took their temperature daily using IR ear thermometers – in fact, people became quite interested in taking their temperature and IR ear thermometers had a strong impact on society because of the SARS epidemic.

Body temperature measurement in Japan goes back to the 1920s. Initially mercury-in-glass clinical thermometers were used, then in the 1970s electrical thermometers with thermistors came into use not only in medical institutes but also in the home. However, these clinical thermometers had two issues:

(1) measurement takes 5 minutes or longer; and

(2) there is a safety and environmental risk of using glass and mercury.

As a solution to these issues, IR ear thermometers, which could measure thermal radiation in an ear canal and realize a non-contact and fast response (i.e. within 1 s), were developed in the 1990s. In the early stages, their price was high in comparison with conventional clinical thermometers and their size was as large as a desktop computer! For this reason, they were generally only employed in hospitals, mainly in neonatal wards.

Afterwards, the rapid development of infrared technologies allowed better performance, miniaturization, and notably a reduction in cost. Thus, IR ear thermometers, which were once used only in the medical profession, spread into domestic use because of their convenience and lower cost.

The production quantity of clinical thermometers in Japan from 1995 to 2007 is illustrated chronologically in

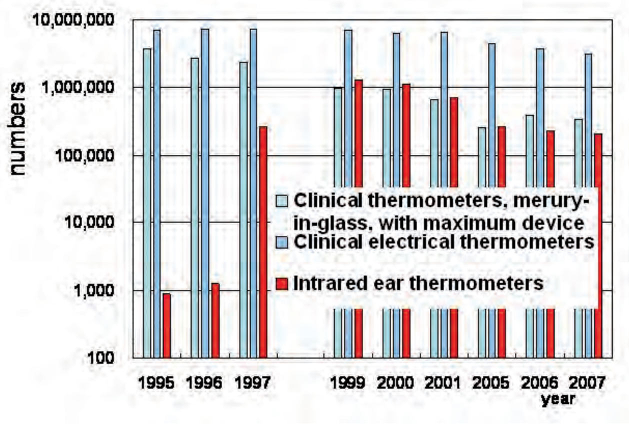


Figure 1 Transition of the production of clinical thermometers in Japan

Figure 1 [7][8]. The vertical scale shows the sum total of domestic production, imported products, and overseas production by Japanese companies.

In terms of legislation, IR ear thermometers are subject to control in Japan by the Pharmaceutical Affairs Act. This Act, passed in 2005, includes regulation to ensure the reliability of the measured values, while the Act issued prior to 2005 focused on safety. Furthermore, the Measurement Act amended in 1993 listed only clinical electrical thermometers with maximum device as specific measuring instruments requiring legal control, because the production and sale of IR ear thermometers were limited to medical use only at that time. However, as shown in Figure 1, these situations gave rise to the necessity to develop standards and test facilities for legal control of IR ear thermometers and to validate the test methods used. Therefore, since 1998 NMIJ has carried out verification of the performance quality of IR ear thermometers, in cooperation with industry and academic experts.

2 Traceability and technical requirements for IR ear thermometers

2.1 Correspondence in Japan for a solution to technical issues

In 1998, the Ministry of Economy, Trade and Industry organized a technical committee for IR ear thermometers, whose secretariat was set up in the Japan Measuring Instruments Federation (JMIF). They conducted a survey on the usage tendencies and technical requirements in the USA and in EU countries along with market studies, analyses and performance evaluations of commercial types.

The committee highlighted the following technical issues:

(1) establishment of a working standard;
(2) development of a transfer blackbody;
(3) design of the blackbody for testing;
(4) the need for a Japanese Industrial Standard (JIS) for IR ear thermometers.

To tackle these challenges, a "JIS preparation committee" for IR ear thermometers was established in 2000, which included consumers and metrological experts. They prepared a JIS draft laying down requirements for the structure of the product and standards for conformity assessment. At the same time, NMIJ was in charge of (1) above and has carried out research using its existing facilities since 1999. Moreover, a three-year plan was drawn up in 2000 in terms of (2) and (3); NMIJ has developed calibration and testing facilities, and designed a blackbody for the evaluation tests required in the JIS draft for the future legal regulation. Consequently, "Infrared ear thermometers JIS T 4207:2005" was published on 25 March, 2005, based on the result of the above-mentioned research [4].

2.2 The trend towards international standards

In the USA, the American Society for Testing and Materials (ASTM) set up E1965-98: "Standard Specification for Infrared Thermometers for Intermittent Determination of Patient Temperature" in 1998 [2]. This standard was one of the earliest in the world for IR ear thermometers.

In Europe, contemporary with E1965-98, the European Committee for Standardization (CEN) drew up EN12470 "Clinical thermometers – Part 5: Performance of infrared ear thermometers", which was implemented in 2003 [3].

The first ISO-IEC kick-off meeting of a joint working group was held in Berlin in December 2005 and gave rise to active international standardization, including consideration of the revision of the relevant OIML Recommendations. For the latest information, ISO/FDIS 80601-2-56 "Medical electrical equipment – Particular requirements for basic safety and essential performance of clinical thermometers for body temperature measurement" was published on October 1, 2009 [9]. The technical standard regarding the measurement of IR ear thermometers has basically same technical requirements as JIS T 4207.

2.3 Traceability

Most IR ear thermometers use simple optics and observe the infrared emission within wide viewing angles. A maximum permissible error of ± 0.2 °C is typically required for the temperature measurement range from 35 °C to 42 °C. Since an IR ear thermometer is an infrared radiation thermometer specially designed for clinical use, the temperature scales of the thermometers should be calibrated with a blackbody radiator with small uncertainties. In the temperature range from 35 °C up to 42 °C in which the clinical thermometers must work without fail, the platinum resistance thermometer (PRT) calibrated at fixed points can realize the temperature scale with a typical uncertainty of less than 10 mK traceable to ITS-90. In the case of "clinical thermometers, mercury-in-glass, with maximum device" or "clinical electrical thermometers with maximum device", the thermometers can be calibrated by direct comparison with the standard PRT sensor using a thermostatic stirred water bath with high stability and uniformity. On the other hand, IR ear thermometers cannot be compared directly with the standard PRT sensor itself. The blackbody radiator mediates between the two kinds of sensors. Taking into account the maximum permissible error of ± 0.2 °C required for clinical thermometers, an uncertainty much smaller than 50 mK is needed for the standard blackbody system [5].

Based on the above-mentioned situation, NMIJ started the calibration service for a blackbody system of IR ear thermometers in the temperature range from 32 °C to 42 °C in 2001. In the same year, comparison of blackbody systems was carried out in Japan by transfer blackbody among domestic manufacturers experimentally. Japanese manufacturers' blackbodies are found to be traceable to national measurement standards and in 2003 a comparison of the NMIJ, NPL, and PTB blackbody cavities for IR ear thermometers was performed for the first time [6].

The NMIJ and the PTB transported their standard blackbodies to the NPL and the radiance temperatures of the blackbodies were directly compared simultaneously using high-resolution IR ear thermometers as comparators. The results of the comparison show that radiance temperatures realized by the NMIJ, NPL, and PTB blackbody cavities agree within ± 0.01 °C, well within their uncertainty levels of around 0.04 °C in the temperature range from 35 °C to 42 °C. In addition, the results demonstrate comparable quality of the blackbody cavities recommended in the JIS and EN standards. As a next step, NMIJ and the relevant calibration service bodies have been discussing the possibility of whether the blackbody system of IR ear thermometers could be calibrated by the Japanese Calibration Service System (JCSS).

Germany has already utilized the service traceable to the national standards through the calibration laboratories accredited by the German Calibration Service (DKD).

2.4 Technical requirements

JIS T 4207 has used the US standard E1965-98: "Standard Specification for Infrared Thermometers for Intermittent Determination of Patient Temperature" since 1998 and the European standard EN12470 "Clinical thermometers - Part5 : Performance of infrared ear thermometers" as references. The existing Japanese standard on clinical electrical thermometers with maximum devices was also referred to for consistency between them.

Furthermore, there is now a universal obligation to provide information on usage for consumers and points relating to safety, since usage problems often occur with the increased domestic use.

3 Performance of IR ear thermometers

3.1 Technical requirements

The technical requirements are as follows:

(1) Temperature indication characteristic;
(2) Probe cover characteristics;
(3) Temperature drift;
(4) Storage characteristics;
(5) Long-term stability;
(6) Mechanical shock resistance;
(7) Cleaning/disinfection characteristics;
(8) Line voltage variations;
(9) Electrostatic discharges;
(10) Radiated electromagnetic fields;
(11) Radiated interference electric field strength.

Test results of (1) and (3) are discussed in the following section, because they are distinctive characteristic of IR ear thermometers from the point of view of infrared radiation thermometric instruments. Actual measure-

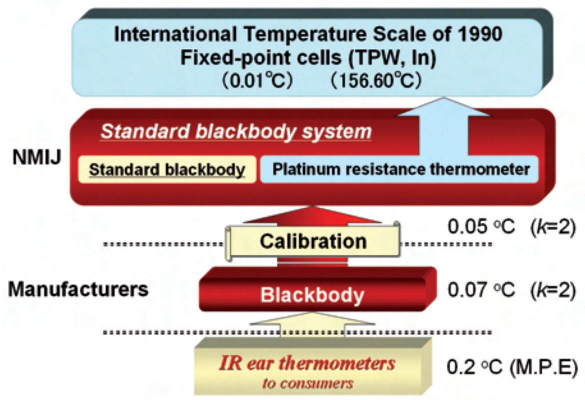


Figure 2 Traceability in Japan

ment of human body temperature by IR ear thermometers was tested as well. Furthermore, we looked at the long term stability using IR ear thermometers sold in 1999 [1]. The results presented in Figures 10 and 11 are given by IR ear thermometers on the Japanese market before 1999, when JIS T 4207 had not been published and traceability in the radiance temperature had not been established.

For conformity assessment of IR ear thermometers this time, we utilized the blackbody systems which belong to the manufacturer's group shown in Figure 2 (hereafter called the working blackbody system) and examined the performance quality of IR ear thermometers and the validity of the blackbody system. In addition, we introduced the results of actual human body temperature measurement by IR ear thermometers.

3.2 Standard blackbody system

NMIJ has developed a standard blackbody system traceable to the International Temperature Scale (ITS-90) in radiance temperature at the infrared wavelength region for calibration of IR ear thermometers. The blackbody system consists of "blackbody cavity", "thermostatic device", and "standard reference thermometers (including indicator and bridge)". The details of the blackbody are described in [5].

Figure 3 illustrates a cross-sectional view of the standard NMIJ blackbody. The blackbody can be operated normally in the temperature range from 30 °C to 50 °C. Figure 3 (1) shows the shape of the cavity, which is identical to that recommended in the JIS annex [4].

The effective emissivity of the cavity is estimated as being higher than 0.9995 for up to a 90° view angle of the IR ear thermometer based on the Monte Carlo calculation. The horizontal cavity made of copper is fully immersed in the temperature-controlled stirred water bath of special design, the volume of which is about 20 liters. The temperature of the water close to the bottom of the cavity is measured by a calibrated PRT sensor. The temperature uniformity around the cavity is better than 5 mK. As shown in Table 1, an expanded uncertainty of around 30 mK has been evaluated in the temperature range from 35 °C to 42 °C in which the IR ear thermometer has to be calibrated.

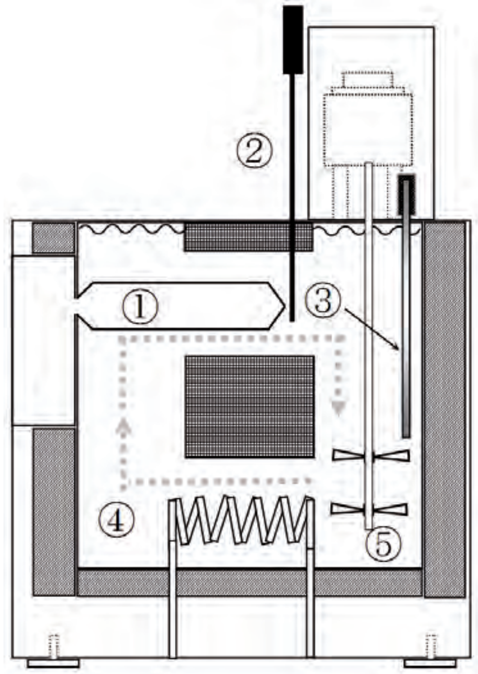


Figure 3 Cross-sectional view graph of the NMIJ blackbody for infrared ear thermometers. (1) blackbody cavity, (2) reference PRT sensor, (3) heater, (4) cooling coil, and (5) stirrer

	32	42	°C
Reference temp. Type B	0.005		K
Reference temp. Type A	0.005		K
T_{cavity} :heat loss	< 0.001		K
$T_{emissivity}$:isothermal ($\theta = 90°$, $T_{ambient} = 23°C$)	0.008	0.016	K
$T_{emissivity}$:non–isothermal	0.002		K
$T_{emissivity}$:ambient temp. ($T_{ambient} = 23 \pm 2°C$)	0.002		K
u_c :total ($k = 1$)	0.011	0.018	K
U :expanded ($k = 2$)	0.022	0.036	K

Table 1 Uncertainty budget of radiance temperature of the NMIJ IR ear thermometer blackbody system [5]

As described in 3.1, we utilized the working blackbody system. Because we had to be able to carry it to a climatic chamber to test it (as in 3.4.2 "Temperature indication characteristics in changing environmental conditions") it was necessary to design it so that it was small.

To make it compact, the cooling coil connected with an external chiller was replaced by a Peltier cooler element, mounted on the rear side of the bath. The blackbody system usually operates in the temperature range from 30 °C to 50 °C. The horizontal cavity is fully immersed in the specially designed temperature-controlled stirred water bath, the volume of which is about 15 L. Therefore the temperature uniformity around the cavity was better than 10 mK, and the stability was within ± 0.01 °C in an hour.

The working blackbody system needs to be traceable to the NMIJ standard blackbody system at radiance temperature. The calibration method is to compare the

Calibration temperature point (°C)	Deviation (K)	Expanded uncertainty (K)
35.5	–0.02	0.06
37.0	–0.02	0.06
41.5	–0.02	0.06

Table 2 Calibration results of the working blackbody system

radiance temperature of the standard NMIJ blackbody with the comparative blackbody system, using IR ear thermometers with high resolution (0.01 °C), and taking deviation values of temperature readings. Table 2 shows the calibration result from the calibration certificate number 093025. In addition, the (2) reference PRT sensor under JCSS calibration has an expanded uncertainty of 35 mK (k = 2) in its indium point and 20 mK (k = 2) in its water triple point.

Table 2 shows that the expanded uncertainty of the working blackbody system is small enough for conformity assessment of IR ear thermometers with a maximum permissible error of ± 0.2 °C. The deviation values are residual errors in the radiance temperature to the reference temperature of the test blackbody. The uncertainty values are calculated from uncertainties of the standard blackbody and the radiance comparison measurement. The expanded uncertainties are estimated for the coverage factor, k = 2.

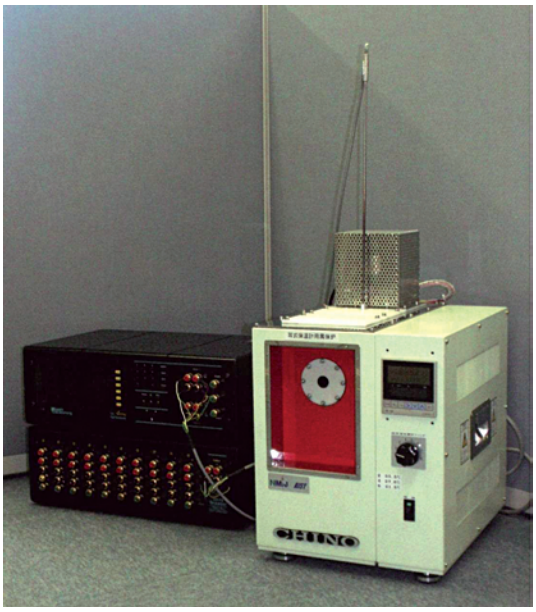


Figure 4 The NMIJ blackbody

3.3 Measurement procedure

The measurement procedure for a blackbody is based on 7.1.3 in JIS T 4207. Additional measurement conditions are as follows:

(1) We prepared the five types of IR ear thermometers (2 units per type).

(2) Repeated measurement cycle was 3 minutes.

(3) Measurements at 35.5 °C, 37.0 °C, and 41.5 °C were repeatedly performed three times a day at each temperature point for four days.

(4) When we measured the radiance temperature of the blackbody, the IR ear thermometer was moved by hand so that the tip of the probe was almost set to the center of the cavity opening.

(5) We handled the IR ear thermometers with a set of double gloves during the measurement to decrease the drift of the output signal of the IR ear thermometer due to warming in the hand.

3.4 Performance results of infrared ear thermometers in the Japanese market in 2009

3.4.1 Temperature indication characteristics at 23 °C ± 3 °C and 50 % R.H.

The test was performed under the following conditions:

(1) Ambient temperature: 23 °C ± 3 °C;

(2) Blackbody temperatures: 35.5 °C, 37 °C and 41.5 °C;

(3) Measurement at each temperature point specified in (2) successively three times by each IR ear thermometer.

As shown in Figure 5, all thermometers of each type had a good repeatability. However, more than half of them had errors over 0.2 °C from the blackbody temperature. It should be pointed out that the type **g** indicated 1 °C higher than the reference temperature because of the corrective mode on the biometric parameters, which is equivalent to the effective emissivity correction of human ear canals. After changing the mode of the type **g** from the corrective mode to the calibration mode, the errors became smaller as shown in Figure 6.

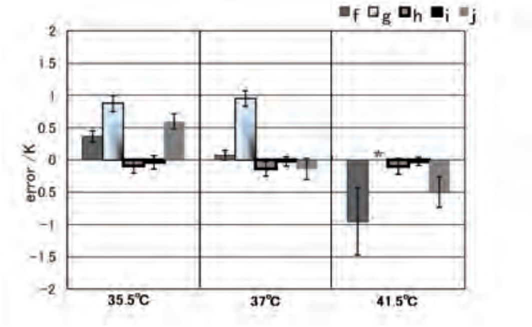


Figure 5 Difference between the indicated temperature and the temperature of the blackbody cavity. The bars indicate the mean error of two thermometer readings of each of the five different types of thermometer. The error bars are the standard deviation of the mean of twelve measurements accumulated by using each of the two [8], where * represents the error on the indicator of the type **g** at 41.5 °C.

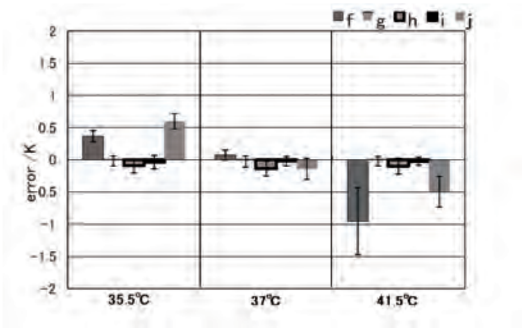


Figure 6 Difference between the indicated temperature and the temperature of the blackbody cavity, in the case that type **g** thermometers are changed to the calibration mode. The bars indicate the mean error of two IR ear thermometer readings of each type. The error bars are the standard deviation of the mean of twelve measurements accumulated by using each of the two [8].

3.4.2 Temperature indication characteristics by changing environmental conditions

Environmental conditions are as follows:

(1) Ambient temperature: 17 °C, Relative humidity: 40 %;
(2) Ambient temperature: 17 °C, Relative humidity: 73 %;
(3) Ambient temperature: 34 °C, Relative humidity: 40 %;
(4) Ambient temperature: 34 °C, Relative humidity: 73 %.

Right: ▶

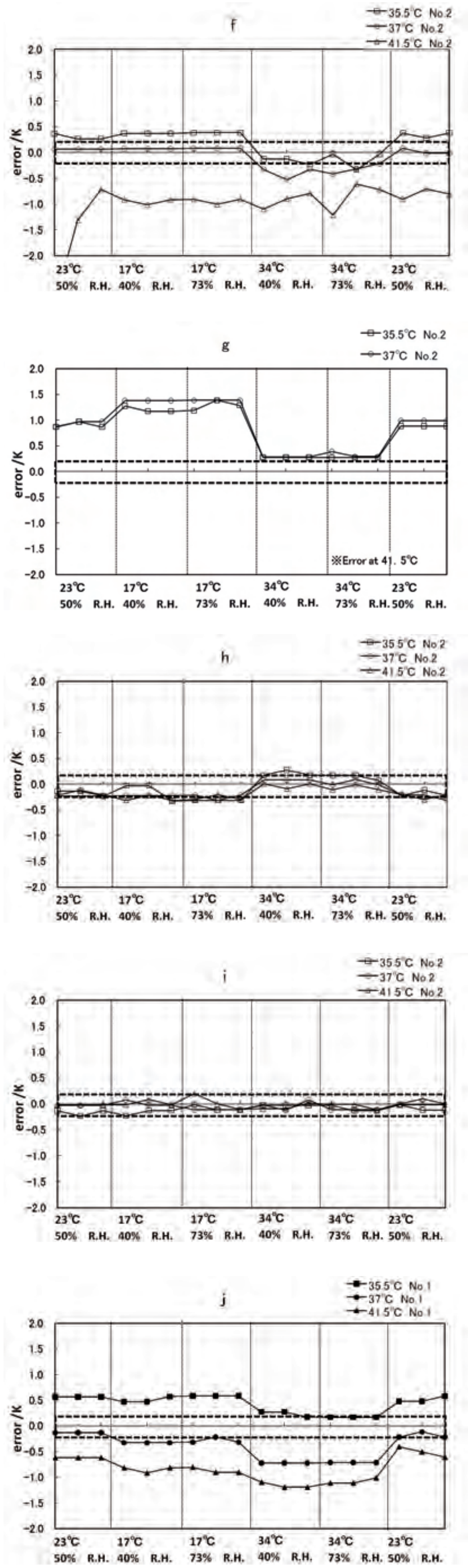


Figure 7 Difference between the indicated temperature and the temperature of the blackbody cavity. The plots indicate the error of the IR ear thermometer readings of each of the five different types (types f to j, top to bottom).

Prior to the measurement, the thermometers, blackbody, and reference PRT sensor were stabilized at each condition (1), (2), (3), and (4) for a minimum of 30 minutes, or longer if so specified by the manufacturer. The inside dimensions of the climatic chamber were 1970 mm × 2100 mm × 1970 mm.

In addition, while monitoring the reference PRT sensor, we placed the temperature measurement system outside of the thermostatic bath since it can not be set under high temperature and humidity. The stability of the blackbody system was within ± 0.01 °C in an hour. Therefore we found the working blackbody system had adequate stability under such an environment.

As shown in Figure 7, more than half of them revealed errors of over 0.2 °C compared to the blackbody temperature. Moreover, we found a tendency that those IR ear thermometers with a difference from the blackbody temperature had more variation of indicated values and showed lower values than the blackbody temperature at ambient temperature 34 °C than at 17 °C. In other words, the variation in the indicated values seems to be smaller at ambient temperature 17 °C. On the other hand, it was found that the change in relative humidity to 70 % did not significantly affect the readings of IR ear thermometers.

3.4.3 Temperature drift

This test was performed to check the stability of IR ear thermometers by changing the ambient temperature and humidity. The following is the testing procedure, according to the EN standard, and referred to in JIS T 4207:

(1) Working blackbody system is set at ambient temperature: 23 ± 5 °C, relative humidity: 50 ± 20 %, and the blackbody temperature is kept at 37 ± 0.5 °C.

(2) After stabilizing the blackbody, take three initial readings in the blackbody at room temperature, calculate the average and use the result as a reference value.

(3) Store the IR ear thermometer inside a climatic chamber, in which the temperature is controlled at (10 ± 0.5) °C above the actual ambient temperature and relative humidity within the range from 30 % to 70 %.

(4) After stabilizing the thermometer for a minimum of 30 min, or longer if so specified by the manufacturer, remove it from the chamber and take readings against the blackbody just after removal, and then take readings again in 1 min, 2 min, 3 min, 4 min, 5 min, 10 min, 20 min and 30 min repeatedly. During the repeated measurements the ear thermometer is left on a table at room temperature.

(5) Repeat the above procedure for a climatic chamber temperature of (10 ± 0.5) °C below the actual ambient temperature.

The importance of the conformity assessment of temperature drift is rather the repeatability of the indicated temperature of IR ear thermometers than their absolute temperature. Therefore, in JIS T 4207 the difference between the indicated temperature and the reference value is ± 0.2 °C. The reference value of each of the five IR ear thermometers is as follows:

Type	Reference value
f	–0.1 °C
g	1.0 °C
h	0.0 °C
i	–0.1 °C
j	–0.2 °C

Table 3 Reference values

Figure 8 shows changes in the temperature readings of the five types of IR ear thermometers (**f, g, h, i** and **j**) as a function of the time elapsed after taking the IR ear thermometer out of the climatic chamber at ambient temperature 34 °C. For the first 5 minutes after the removal, the readings of four out of the five types of IR ear thermometers showed a temperature lower than that of the blackbody cavity. The only type whose difference between the indicated temperatures and the reference value was within ± 0.2 °C was type **i**, although the temperature readings seemed to be affected slightly by changes in environmental conditions.

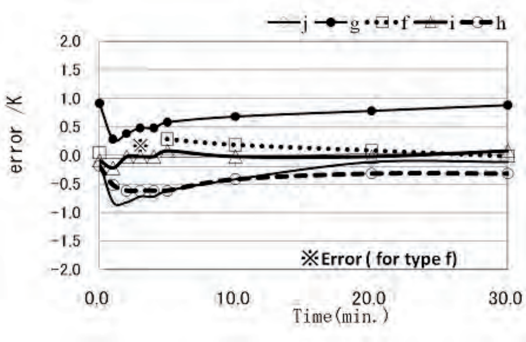


Figure 8 Difference between the indicated temperature and the temperature of the blackbody cavity. The plots indicate the error of each of the five different types of IR ear thermometer readings. Temperature points in the climatic chamber were set at 34 °C.

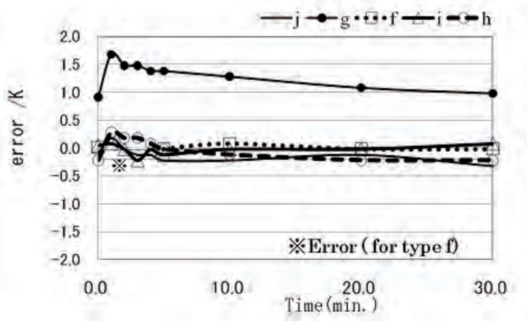


Figure 9 Difference between the indicated temperature and the temperature of the blackbody cavity. The plots indicate the error of each of the five different types of IR ear thermometer readings. Temperature points in the climatic chamber were set at 13 °C.

Figure 9 shows changes in temperature readings of the five types of IR ear thermometers (**f, g, h, i** and **j**) as a function of the time elapsed after taking them out of the climatic chamber at an ambient temperature of 13 °C. The types whose difference between the indicated temperatures and the reference value was within ± 0.2 °C were type **f** and type **i**. For the first 5 minutes after the removal, the readings of four out of the five types showed a temperature higher than that of the blackbody cavity.

When the ambient temperature was higher than 23 °C as described in 3.4.2, it was confirmed that the change in the temperature readings of the IR ear thermometer was large. Since it indicated a sign error until about five minutes had passed, type **f** was unable to measure the blackbody cavity.

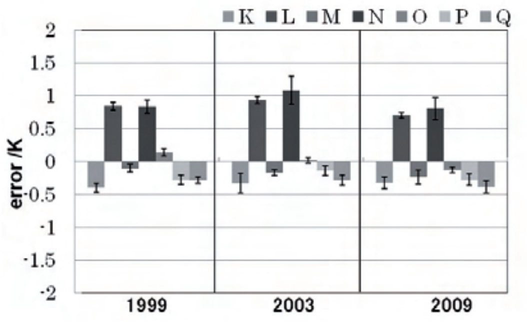


Figure 10 Difference between the indicated temperature and the temperature of the blackbody cavity at 37 °C. The bars indicate the mean error of three thermometer readings of each of seven different types of IR ear thermometers. The error bars are the standard deviation of the mean of thirty measurements accumulated by ten measurements using each of the three.

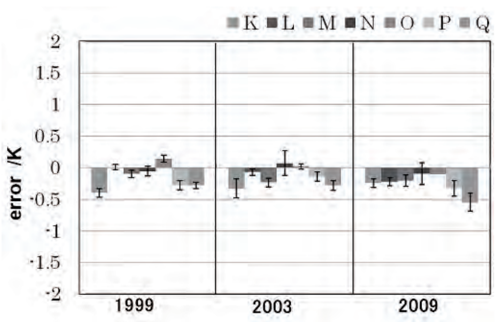


Figure 11 Difference between the indicated temperature and the temperature of the blackbody cavity at 37 °C. When the **L** type and **N** type are changed to the calibration mode, the bars indicate the mean error of the readings of three ear thermometers of each type. The error bars are the standard deviation of the mean of thirty measurements accumulated by ten measurements using each of the three.

3.5 Long-term stability of IR ear thermometers manufactured in 1999

We performed a test to check the long-term stability for about ten years using IR ear thermometers manufactured in 1999. These thermometers were kept in a simple box with desiccants at an ambient temperature of 23 °C and 50 % relative humidity. These thermometers were measured in accordance with the procedures shown in 3.3 in 1999, 2003 and 2009.

As shown in Figures 10 and 11, the temperature readings of almost all of the seven types were lower than that of the blackbody cavity, but almost all the thermometers of each type had good long-term stability. As for the change after 10 years, nothing was identified by appearance; however, we found some thermometers were unable to be switched on and had a reading dispersion of between 1 °C and 3 °C. The change occurred in two out of the seven types, although three of each of the two types were not faulty. Some had problems after 3 years, others after 10 years. The failures were likely caused by the varying quality of the electrical circuits. Additionally, we found battery exhaustion in two out of the five types in which we had found no problems, but these two started working normally after replacing the battery.

4 Results of body temperature

We measured the body temperature measured by the IR ear thermometers sold on the Japanese market in 2009.

4.1 Measurement procedure

(1) We measured the body temperature in the testing room according to 3.4.

(2) Three people acted as test subjects.

(3) Firstly, they measured their body temperature holding the electric thermometers under their arm for 10 minutes or longer until the temperature stabilized.

(4) Then, they did same measurement using IR ear thermometers, three times for each type of thermometer. The measurements were performed at five-minute intervals or longer if so specified by the manufacturer.

(5) Finally, they again measured the body temperature holding the electric thermometer under their arm for 10 minutes or longer until the temperature stabilized.

(6) Whenever the body temperature was measured, the probe cover on the IR ear thermometer was changed to a new one.

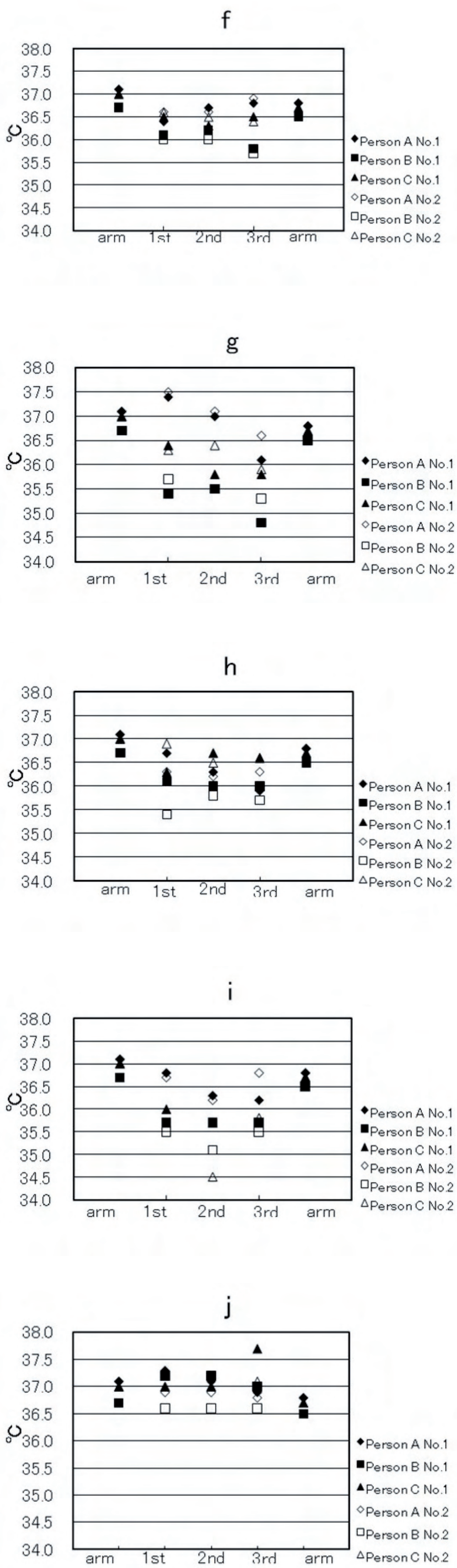
(7) In the case of IR ear thermometers without a probe cover, we cleaned the probe each time before the measurement was made.

(8) The interval between the measurement of (3) and (5) was about 40 minutes.

4.2 Results of measuring the body temperature

The results of the IR ear thermometer readings for human body temperature measurement are shown opposite in the order in which they were measured.

Figure 12 shows that the change in temperature between two measurements by the under arm electric clinical thermometer was 0.2 °C or 0.3 °C for 40 minutes. On the other hand, the temperature range of each test subject was 0.5 °C on average in the repeated measurement by the IR ear thermometers at 15-minute intervals. Furthermore, the highest temperature range was 1.3 °C. We did not identify the characteristic



Right: ▶

Figure 12 The plots indicate the body temperature measured by a clinical electrical thermometer and by IR ear thermometers (types **f, g, h, i,** and **j**). The order of the horizontal axis begins with the reading of the under arm clinical electrical thermometer. Next, the three readings of the IR ear thermometers and the reading of the under arm clinical electrical thermometer follow [8].

features of the temperature range by each manufacturer, nor by each test subject. The thermometers of manufactures **h** and **i** had a wide temperature range in body temperature measurement, although they had good results in measuring in the blackbody cavity [8] according to Figures 5 and 6.

As the results of Figure 12 show, a temperature in ear measurement by the IR ear thermometer showed the same reading as the under arm one by the clinical electrical thermometer or lower.

The following three issues were observed in the test subject during the body temperature measurement:

(1) Difficult usage caused by the structure, such as the form of the IR ear thermometer or the location of the measurement buttons.
(2) Difficult operation method of the IR ear thermometers.
(3) Significant differences in the operation methods between the respective companies.

5 Conclusion

The result in chapter 4 showed that only type **i** satisfied the temperature indication characteristics and drift requirements according to the metrological technical standards of JIS T 4207. We are of the opinion that JIS T 4207 could have contributed to the improvement of technology in metrology. Furthermore, we consider that the revision of the Pharmaceutical Affairs Act in 2005 also had an effect on the development of IR ear thermometers.

In general, prior to 2005 the Pharmaceutical Affairs Act had an approval system by the Ministry of Health and Welfare and there was no obligation to design products based on technical standards, since JIS T 4207 did not exist. Since 2005 the system has changed and approval must be obtained from the approved certification body designated by the state; design must be based on the requirements of JIS T 4207. The change in legislation has introduced differences in product quality.

NMIJ has provided a standard service for blackbody IR ear thermometers since 2001; it is likely that this service has reduced measurement errors, since the errors of indication are within ± 0.2 °C in more than half the types at 37 °C as at 2009, according to Figs. 5 and 6.

Regarding ambient conditions, changes in the environmental temperature increased the variation in the temperature indication of the thermometers, whereas changes in relative humidity did not really affect it. The main reason for this is thought to be the principle of the IR ear thermometers. Since the indicated temperatures are determined by the difference between the environmental temperature and that of the blackbody, they are more likely to be affected if the difference is small. In the case of ambient temperature at 34 °C and the blackbody at 35 °C, it is difficult for IR ear thermometers to decide on the actual indicated temperature.

Based on the above results, we verified that calibration in brightness temperature and conformity assessment could be conducted for the blackbody system with the technologies NMIJ has designed in the past. In particular, one significant result was that we confirmed the high stability of the blackbody system under high temperature and humidity.

As a next step, one important task to accomplish is the administration of the blackbody system to ensure reliability of the indication values of IR ear thermometers. One concrete means of doing this is to carry out thorough periodical calibration for the blackbody system and to adequately control the ambient temperature and humidity during both the usage and storage of the blackbody system so as not to cause severe deterioration or modify the inside of the blackbody cavity. JIS T 4207 does not include reference to the operation method of the blackbody system, though it does to national traceability. A future task would be to discuss including the blackbody control method system in JIS T 4207.

During the assessment, from the standpoint of measuring human body temperature, we found more varieties in usage than in performance quality. Three factors could be broadly identified:

(1) Difficult usage due to the structure (such as the form of the IR ear thermometer or the location of the measurement buttons).
(2) Difficult operating method.
(3) Major differences in the operating method across the different companies.

In comparison with conventional thermometers such as “clinical thermometers, mercury-in-glass, with maximum device” or “clinical electrical thermometers with maximum device”, IR ear thermometers have a variety of usages in each type.

Responding to the current condition, JIS T 4207 includes the requirement for information such as a description in the instruction manual, which should facilitate use. Users are required to learn the application in accordance with each type. If major differences such as (3) cause variations in the measurement result, then discussion of the reasons for this will be necessary when JIS T 4207 is revised in the future.

Acknowledgement

The authors would like to acknowledge and extend their heartfelt gratitude to the following persons who have given insightful comments and suggestions: Mr. Toru Kojima, Director of the Metrology Training Center, Metrology Management Center, Dr. Juntaro Ishii, Researcher at the Temperature and Humidity Division, and Mr. Hiroo Ikegami, Researcher at the Measurement Standard System Division. ■

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WEIGHTS

The mass measurement and uncertainty evaluation of standard weights

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An interlaboratory comparison between INM and sixteen regional laboratories

Abstract

To ascertain the level of competence of Romanian calibration laboratories, an interlaboratory comparison of seven standard weights was performed between the National Institute of Metrology (acting as a pilot laboratory) and sixteen metrology laboratories throughout Romania.

The best measurement capability of each laboratory was tested in calibrating seven standard weights. The comparisons were carried out between April 2007 and December 2008 and the transfer standards used (which belonged to the INM) had nominal values of 10 kg, 1 kg, 500 g, 200 g, 100 g, 20 g and 100 mg. The density and the volume of each weight were furnished by the INM.

Each laboratory's results are presented for each weight, together with the declared uncertainty and the normalized errors (E_n values), with respect to the INM.

1 Introduction

The transfer standards used were carefully selected by the pilot laboratory, LP, and the comparison scheme was selected to minimize the influence of any instability in their mass.

The seventeen participants in the comparison (including the INM) were: Piatra Neamţ, Vaslui, Suceava, Ploieşti, Piteşti, Târgovişte, Craiova, Slatina, Drobeta Turnu Severin, Târgu Jiu, Reşiţa, Baia Mare, Satu Mare, Zalău, Bistriţa and Bucharest.

In line with general intercomparison practice [1], the laboratories were assigned numerical codes from 1 to 17 to ensure confidentiality of the results, LP having the code "1".

2 Circulation scheme

The artifacts were initially calibrated by LP and then circulated among the participating laboratories in two waves. At the end of each wave, the artifacts were returned to LP for re-calibration, before being sent back out to the participating laboratories in the second wave. The 10 kg, 1 kg, 200 g, and 20 g transfer standard weights were made of stainless steel, the 500 g and 100 g weights were made of drawn brass, and the 100 mg weight was made of nickel silver polygonal sheet.

The density of the weights was provided by LP as follows:

- for the 10 kg, 1 kg, 200 g, and 20 g weights:
  7950 kg/m^3, U = 140 kg/m^3
- for the 500 g and 100 g weights:
  8400 kg/m^3, U = 170 kg/m^3
- for the 100 mg weight:
  8600 kg/m^3, U = 170 kg/m^3

3 Measurement instructions

The participants carried out the calibrations without re-determining the density of the weights.

The following information about the transfer standards was given in advance to the participants: nominal masses, densities and their uncertainties, and magnetic proprieties. Instructions were also given on how to handle, store and transport the weights. For each laboratory the measurement time was two weeks, and participants were requested to send their results back to LP within two weeks after the end of the measurements.

No detailed calibration instructions were given to the laboratories.

4 Reference values

The reference values were determined by the LP at the beginning, middle and end of the interlaboratory comparison.

For the weights of 500 g and 100 g, a large drift was recorded during the comparison, so it was necessary to include this in the calculation. Therefore, in order to arrive at a uniform calculation for all the itinerant weights, it was decided to perform the drift corrections also for the other weights, as shown in Table 3, which also contains the reference values corrected for drift in accordance with the date in the first column (it was considered as being a linear drift).

These values were used when analyzing the results and determining the normalized errors.

5 Tasks

It was the participants' task to determine the mass of the standards with an uncertainty corresponding to their capability. The nominal values of the weights were selected such that the weighing instruments and mass standards of the participants could be tested within a wide range. The participants were requested to supply the following information:

- mass and uncertainty of the seven mass standards;
- traceability of the reference standards used;
- physical properties of the reference standards used;
- method used for calibration;
- specifications of the measuring instruments used (weighing instruments, barometers, hygrometers, thermometers);
- ambient atmospheric conditions at the time of each measurement.

The participants were also requested to specify the uncertainty budget in sufficient detail.

6 Results

All the sixteen participants were requested to send a full calibration report with all the measurement results (see Table 1), relevant data and uncertainty estimates to LP.

Each laboratory reported the measured mass value that was assigned to each of the seven artifacts, together with an expanded uncertainty for each weight. For all laboratories, the coverage factor was 2.

All data are reported on the sample as received. The results are presented exactly as sent in by the participants.

One tool that is often used in analyzing the results from interlaboratory comparisons is the normalized error E_n, which takes into account both the result and its uncertainty. The normalized error E_n is given as:

$$E_n = \frac{x_{lab} - x_{ref}}{\sqrt{U_{lab}^2 + U_{ref}^2}}$$

where:

E_n = normalized error;
x_{lab} = result of the measurement carried out by the participating laboratory;
x_{ref} = comparison reference value of LP;
U_{ref} = measurement uncertainty of LP;
U_{lab} = measurement uncertainty reported by the participating laboratory.

Using this formula, an acceptable measurement and reported uncertainty would result in an E_n, value of between –1 and +1, with a desired value close to zero. The E_n data for each laboratory are presented in Table 2.

This computation provides supplemental information concerning the measurement capability of the participating laboratories.

The measurement uncertainty of LP, U_{ref}, contains a component associated with the drift of the weights, during the interlaboratory comparison.

Graph 1 represents a centralization chart for the normalized deviations E_n for all the laboratories and all the weights.

Graphs 2 to 8 present the differences between participants' results and the reference value, and the uncertainty (k = 2) for all the weights. The reference value is represented by a red line and the associated uncertainty by two green lines.

Graphs 2' to 8' give detailed views of graphs 2–8.

Legend:

(red line) Reference value

(green line) Measurement uncertainty U (k = 2) of LP

(red bar) Result of measurement carried out by a participating laboratory

I Measurement uncertainty U (k = 2) reported by a participating laboratory

7 Discussion

- Six participating laboratories (6, 9, 11, 12, 15, 16) obtained results that are compatible with those of LP for all the weights;
- For the 10 kg weight, five participating laboratories (5, 7, 10, 14, 17) differ from the results of LP;
- For the 1 kg weight, three participating laboratories (4, 7, 8) differ from the result of LP;
- For the 500 g weight, two participating laboratories (4, 13) differ from the result of LP;
- For the 200 g weight, four participating laboratories (3, 13, 14, 17) differ from the results of LP;

Laboratory's code	10 kg		1 kg		500 g		200*g		100 g		20* g		100*mg	
	E mg	U mg	E mg	U mg	E mg	U mg	E mg	U mg	E mg	U mg	E mg	U mg	E mg	U mg
1	342,3	2,4	904,20	0,14	1,00	0,07	16,70	0,04	-208,54	0,02	4,802	0,009	0,012	0,002
15	344	5,2	904,16	0,21	0,872	0,199	16,693	0,145	-208,607	0,145	4,814	0,008	0,0168	0,0019
2	341,150	7,105	904,100	4,437	0,947	0,348	16,780	0,224	-208,509	0,162	4,859	0,047	0,018	0,010
12	339,6	7,5	904,161	1,5	0,8	1,2	16,678	0,03	-208,596	0,025	4,788	0,01	0,018	0,004
6	348	16	904,28	0,28	0,74	0,14	16,74	0,10	-208,60	0,12	4,790	0,026	0,016	0,004
7	29,86	139,84	885,40	10,069	1,96	9,090	16,00	1,420	-179,62	1,130	5,14	1,040	0,017	0,016
5	295	16	903,9	1,6	0,6	0,8	16,8	0,3	-208,62	0,16	4,81	0,08	0,019	0,016
14	56	110	906,8	3	2,05	2,5	17,5	0,4	-208,47	0,3	4,73	0,1	-0,008	0,030
10	155	59	907	12	0,3	11	16,9	0,15	-208,6	0,12	4,8	0,11	-0,06	0,11
1	342,6	2,3	904,16	0,25	0,54	0,07	16,76	0,03	-208,64	0,02	4,807	0,013	0,019	0,003
16	334	40	904,2	3,7	1,4	2,5	16,8	0,70	-208,5	0,21	4,82	0,04	0,018	0,006
11	280	150	905	8	0,9	5,7	16,74	0,13	-208,69	0,11	4,836	0,035	0,031	0,011
4	480	166	896,3	1,3	-1,8	1,0	16,8	0,6	-208,92	0,29	4,78	0,08	0,005	0,011
8	391	174	893,020	2,244	0,258	1,345	16,490	0,352	-208,568	0,277	4,529	0,207	0,028	0,027
17	170	55	908,5	5,3	3	2,8	17,15	0,2	-208,4	0,18	4,83	0,17	0,00	0,16
9	335	50,0	903,7	5,0	0,50	2,5	16,76	1,0	-208,66	0,5	4,83	0,2	0,018	0,05
3	300	100	906	8	0	8	10,66	0,68	-208,621	0,8	4,92	0,08	0,04	0,10
13	288,1	61,4	903,8	2,1	1,91	0,84	21,71	0,17	-139,64	0,15	4,797	0,066	0,019	0,062
1	342,2	2,7	904,14	0,26	0,23	0,07	16,74	0,05	-208,70	0,04	4,800	0,01	0,031	0,002

Table 1 Deviation from nominal mass (*E*) and expanded uncertainty (*U*) for the corresponding values

Nominal Value	10 kg	1 kg	500 g	200*g	100 g	20* g	100* mg
U_{ref}	2,8	0,28	0,29	0,07	0,09	0,015	0,008
Laboratory's code	Normalized deviations E_n						
1	0,00	0,00	0,00	0,00	0,00	0,00	0,00
15	0,28	-0,10	-0,21	-0,09	-0,33	0,67	0,46
2	-0,16	-0,02	0,12	0,29	0,29	1,13	0,34
12	-0,35	-0,02	-0,04	-0,57	-0,25	-0,87	0,39
6	0,34	0,25	-0,17	0,11	-0,11	-0,47	0,09
7	-2,24	-1,86	0,13	-0,52	25,57	0,32	0,06
5	-2,92	-0,17	-0,11	0,20	-0,07	0,06	0,13
14	-2,60	0,87	0,56	1,86	0,47	-0,75	-0,82
10	-3,18	0,24	-0,03	0,89	0,20	-0,06	-0,71
1	0,00	0,00	0,00	0,00	0,00	0,00	0,00
16	-0,21	0,01	0,36	0,06	0,65	0,32	-0,22
11	-0,42	0,11	0,08	-0,11	-0,26	0,80	0,67
4	0,83	-5,91	-2,15	0,08	-0,86	-0,30	-1,30
8	0,28	-4,92	-0,10	-0,73	0,34	-1,32	0,13
17	-3,13	0,82	0,94	1,90	1,37	0,16	-0,16
9	-0,15	-0,09	0,07	0,01	0,04	0,14	-0,18
3	-0,42	0,23	-0,04	-8,90	0,08	1,46	0,12
13	-0,88	-0,16	1,85	27,17	399,16	-0,06	-0,17
1	0,00	0,00	0,00	0,00	0,00	0,00	0,00

(red)	$E_n > 1$
(blue)	$E_n < -1$

Table 2 Normalized deviations E_n from the reference values

- For the 100 g weight, three participating laboratories (7, 13, 17) differ from the results of LP;
- For the 20 g weight, three participating laboratories (2, 3, 8) differ from the results of LP;
- For the 100 mg weight, one participating laboratory (4) differs from the results of LP;
- LP asked the participants to review their results for confirmation. All the participating laboratories replied to LP, three of which made some insignificant changes in their calculations.
- Two participating laboratories (5, 11) took into account uncertainty due to eccentricity, even though the balances have a suspended load receptor;
- Eight participating laboratories (2, 4, 8, 10, 14, 15, 16, 17) did not take into account the contribution due to eccentricity in their uncertainty budgets;
- Eight participating laboratories (2, 6, 7, 10, 12, 14, 15, 17) did not use additional weights in the calibration and also did not take into account the contribution due to the difference between the standard and the test object in their uncertainty budgets.
- Five participating laboratories (4, 5, 8, 9, 13) wrongly calculated the uncertainty associated with the reference standard, which is therefore not in accordance with C.6.2.2 of OIML R 111;
- Two participating laboratories did not take into account the air buoyancy effect in their calculation.

LP sent out the summary results in a draft report to all the participants, substituting the code number in place of the laboratory name. Each laboratory could therefore see all the results but could not see which results referred to which laboratory.

8 Conclusions

Analyzing the results of the interlaboratory comparison it can be seen that 17 % of the total results give rise to discrepancies.

Six of the 16 laboratories (6, 9, 11, 12, 15, 16) obtained compatible results with LP. Three laboratories (2, 5, 10) had only one result with an "E_n" number larger than 1 and seven laboratories (3, 4, 7, 8, 13, 14, 17) had two or more results with an "E_n" number larger than 1.

The results obtained can be used to demonstrate the participating laboratories' measurement capabilities. Those participants that obtained results outside the range [–1, +1] should analyze the reasons in order to remedy and correct them.

After analyzing the results, the following corrective measures are proposed:

- It is advisable that some participants review their uncertainty analysis;
- In the case of a big difference between the standard and the test object it is advisable to use additional weights so that this difference is as small as possible. Otherwise, the uncertainty of this component should be increased;
- Further qualification of the personnel in calibrating and estimating uncertainty is desirable. ■

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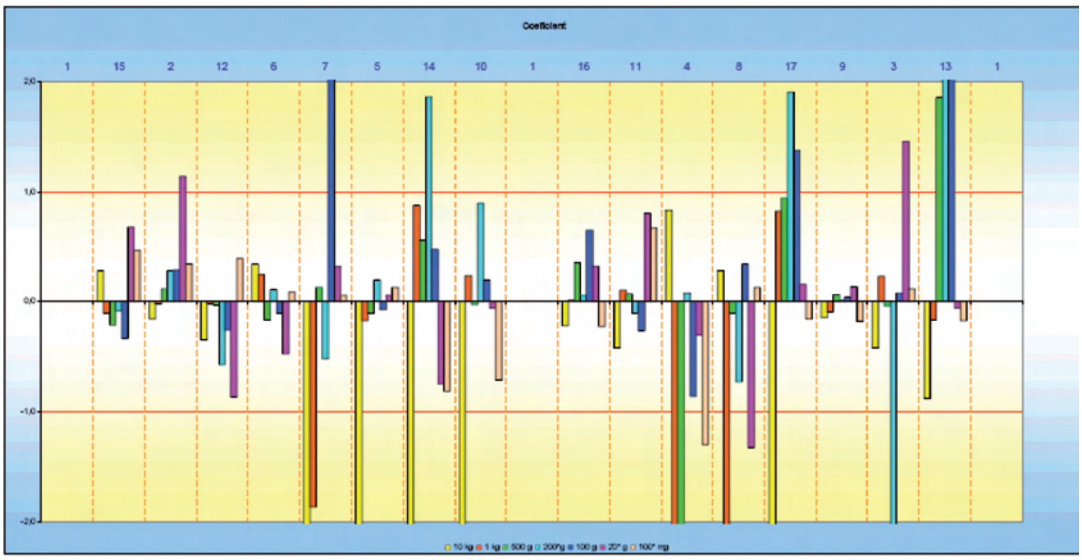
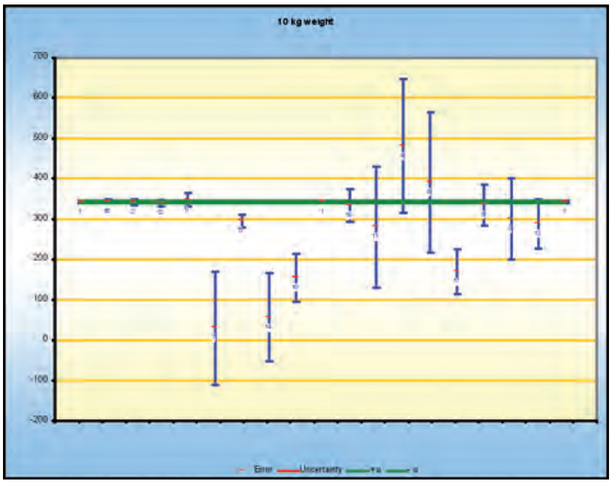
DATE	10 kg	1 kg	500 g	200*g	100 g	20*g	100* mg
16.09.2007	342,300	904,200	0,996	16,700	-208,540	4,802	0,012
02.10.2007	342,333	904,196	0,945	16,707	-208,551	4,803	0,013
18.10.2007	342,367	904,191	0,895	16,713	-208,562	4,803	0,014
03.11.2007	342,400	904,187	0,844	16,720	-208,573	4,804	0,014
19.11.2007	342,433	904,182	0,793	16,727	-208,584	4,804	0,015
05.12.2007	342,467	904,178	0,743	16,733	-208,596	4,805	0,016
21.12.2007	342,500	904,173	0,692	16,740	-208,607	4,805	0,017
06.01.2008	342,533	904,169	0,641	16,747	-208,618	4,806	0,017
22.01.2008	342,567	904,164	0,591	16,753	-208,629	4,806	0,018
07.02.2008	342,600	904,160	0,540	16,760	-208,640	4,807	0,019
23.02.2008	342,556	904,158	0,506	16,758	-208,647	4,806	0,020
10.03.2008	342,511	904,156	0,471	16,756	-208,653	4,805	0,022
26.03.2008	342,467	904,153	0,437	16,753	-208,660	4,805	0,023
11.04.2008	342,422	904,151	0,402	16,751	-208,667	4,804	0,024
27.04.2008	342,378	904,149	0,368	16,749	-208,673	4,803	0,026
13.05.2008	342,333	904,147	0,333	16,747	-208,680	4,802	0,027
29.05.2008	342,289	904,144	0,299	16,744	-208,687	4,802	0,028
14.06.2008	342,244	904,142	0,264	16,742	-208,693	4,801	0,030
30.06.2008	342,200	904,140	0,230	16,740	-208,700	4,800	0,031

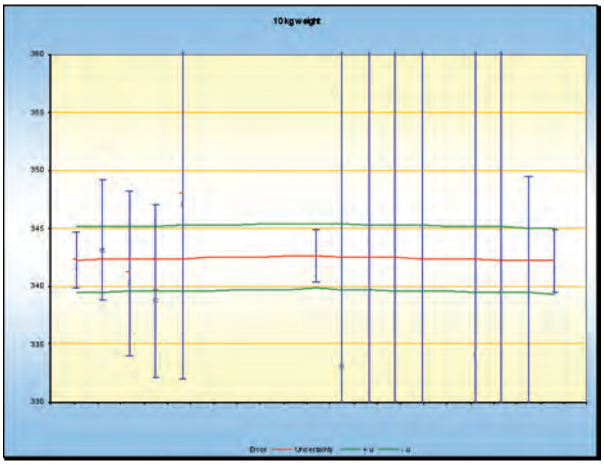
Table 3 Reference values corrected for drift



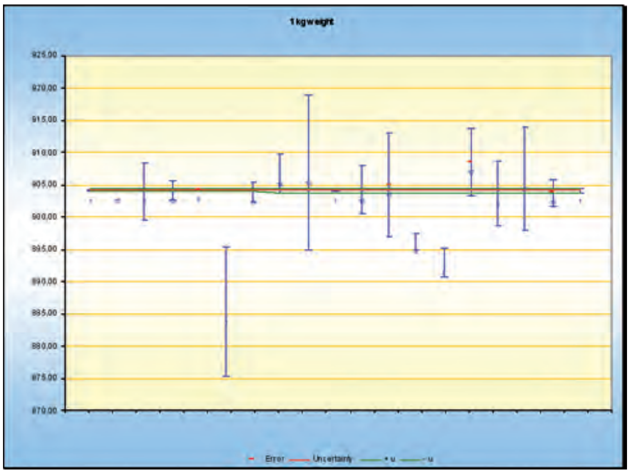
Graph 1 Centralized chart for the normalized deviations E_n for all the laboratories



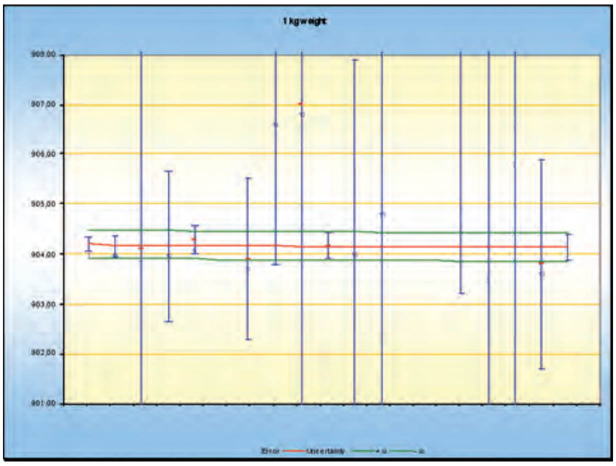
Graph 2 Difference between participants' results and the reference value for 10 kg



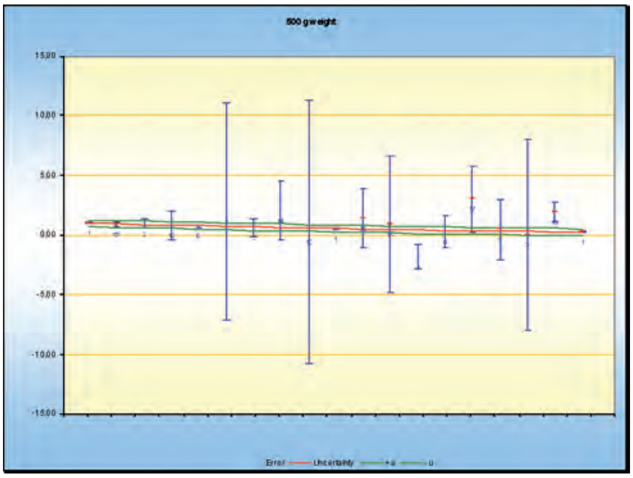
Graph 2' Detailed view of Graph 2



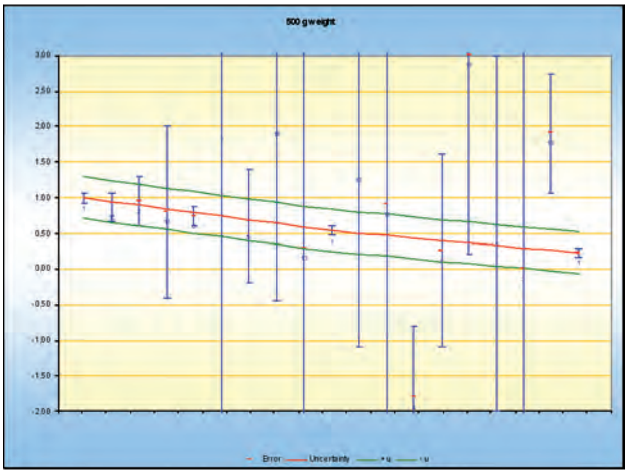
Graph 3 Difference between participants' results and the reference value for 1 kg



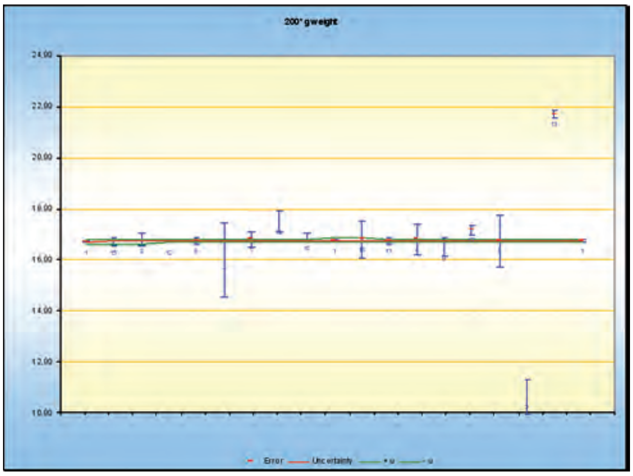
Graph 3' Detailed view of Graph 3



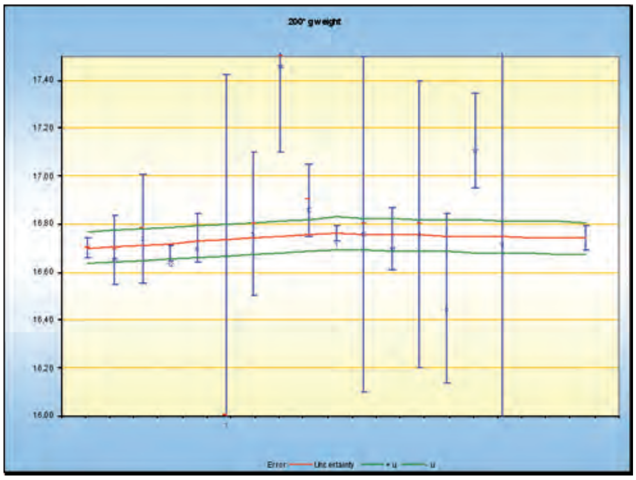
Graph 4 Difference between participants' results and the reference value for 500 g



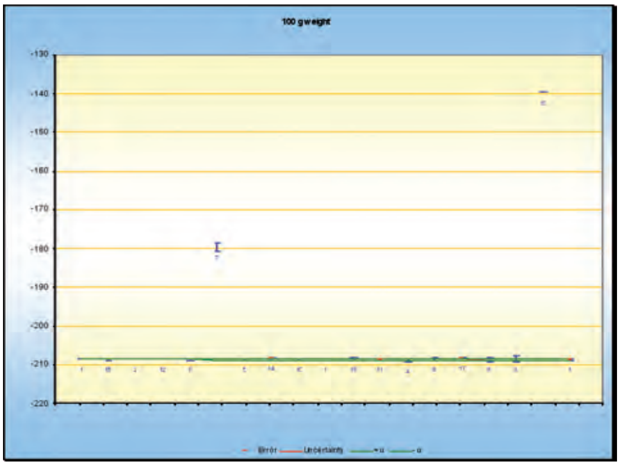
Graph 4' Detailed view of Graph 4



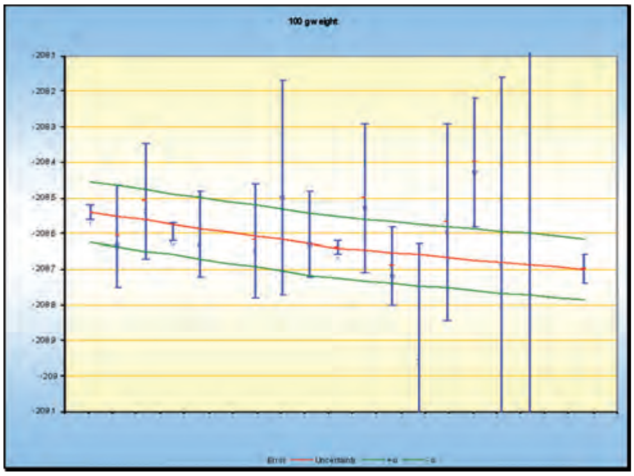
Graph 5 Difference between participants' results and the reference value for 200 g



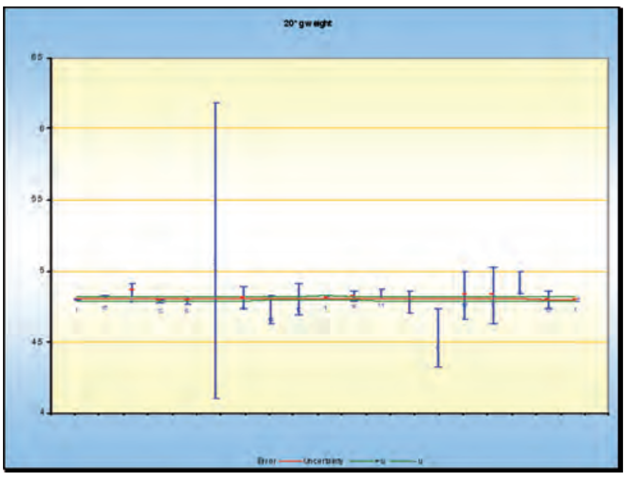
Graph 5' Detailed view of Graph 5



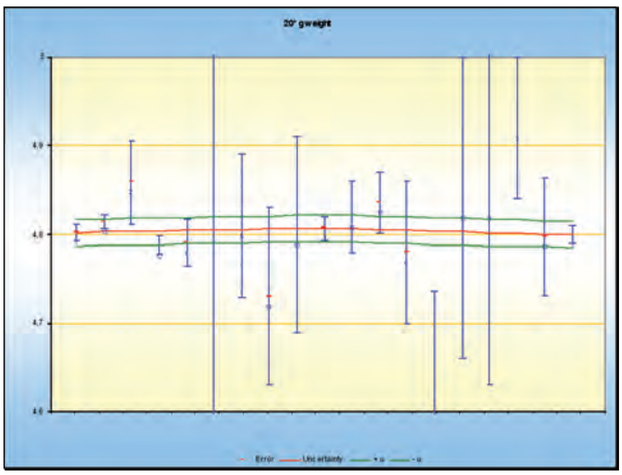
Graph 6 Difference between participants' results and the reference value for 100 g



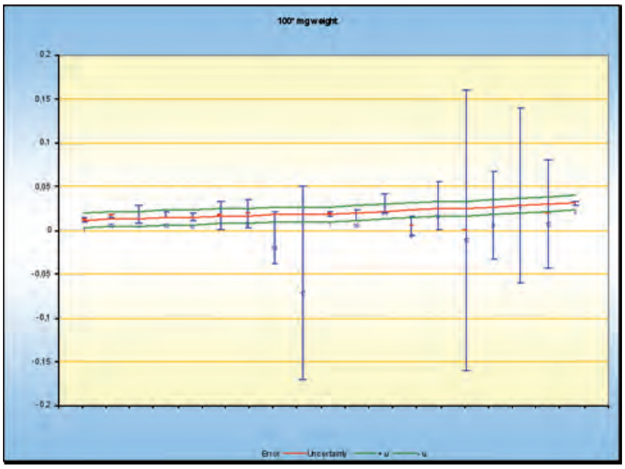
Graph 6' Detailed view of Graph 6



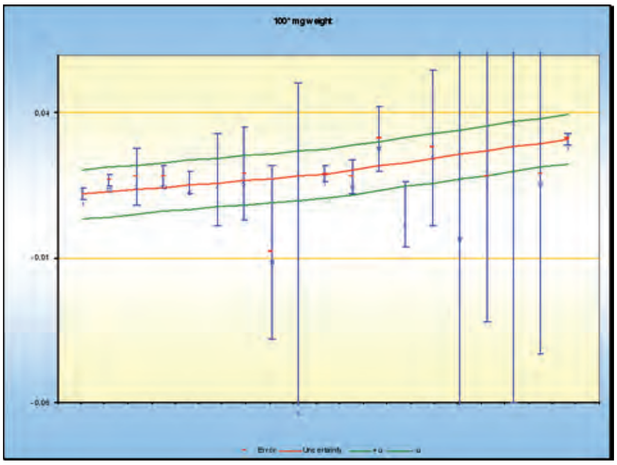
Graph 7 Difference between participants' results and the reference value for 20 g



Graph 7' Detailed view of Graph 7



Graph 8 Difference between participants' results and the reference value for 100 mg



Graph 8' Detailed view of Graph 8

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MID

Implementation of the European Directive on Measuring Instruments in Ukraine

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Abstract

This article describes the modern metrological normative bases used for the implementation of the European Directive on Measuring Instruments (MID) in Ukraine.

Introduction

Mutual exchange of experience and information in legal metrology is very important, and indeed the OIML was created in order to promote the global harmonization of legal metrology procedures. The OIML has developed a worldwide technical structure that provides its Members with metrological guidelines for the elaboration of national and regional requirements concerning the manufacture and use of measuring instruments for legal metrology applications [1].

Normative legal metrology documents are made effective through or on behalf of the National Service of Legal Metrology (NSLM). Legal metrology requirements can be laid down both by national standards and by normative documents developed by various national bodies with international relations. The OIML develops model regulations (International Recommendations and Documents) which provide OIML Members with an internationally agreed-upon basis for the establishment of national legislation on various categories of measuring instruments.

In January 1997 Ukraine became an OIML Corresponding Member and as such was able to receive Documents, Recommendations and other OIML Publications, and was entitled to use them for the harmonization of its national normative bases on metrology. Taking into consideration the high degree of acceptance and the wide application of OIML Recommendations internationally, the priority task for the development of national normative bases on metrology was (and still is) the harmonization of national standards with OIML requirements, which should be carried out taking into account the priorities detailed below.

The principles of technical harmonization in Europe are specified by the decisions of the European Union (EU), but its Directives only set out certain major conditions that are required for the provision of reliable measurements, whereas the relevant technical requirements are based on OIML Recommendations and Documents. The primary objective of harmonization in the EU is to ensure free trade relations, which is why it is important to harmonize type approval procedures for measuring instruments, the order of dissemination of the units from measurement standards to operating measuring instruments, and certain other reasons.

1 Scopes of activity in legal metrology

The legislative basis of the State Metrology Service of Ukraine includes the Law of Ukraine "Metrology and Metrological Activity" No. 113/98 of 11.02.98 and the Law of Ukraine No. 1765-IV of 15.06.2004 (hereafter called "the Law"). The Law on measuring units, standards and measuring instruments is the law on which the present-day activities of the State Metrology Service are based; its main provisions are harmonized with norms and rules on metrology which are generally accepted worldwide [2–4], and with OIML Documents (OIML D 1 *Elements for a Law on Metrology* in particular).

The Law determines the legal and organizational fundamentals for ensuring uniform measurements in Ukraine, as well as regulating relations in metrological activity. It aims to assist the development of science, technology and the national economy, to protect citizens and the economy of Ukraine from the potentially negative consequences of inaccurate measurement results, to create favorable conditions for the development of international relationships and international trade, as well as to establish the basic legal principles of metrological activity at national level.

The Derzhspozyvstandard of Ukraine (DSSU) exercises the state management of the activities on assurance of the uniformity of measurements in Ukraine. The resolutions of the DSSU on metrology which are adopted within its competence are obligatory for ministries, departments, local authorities, enterprises, organizations, business entities and foreign manufacturers importing measuring instruments into Ukraine. If an international agreement with Ukraine stipulates rules which differ from those in Ukraine's legislation on metrology and metrological activity, then the country's international agreement is executed in accordance with existing laws.

Measurement results may be used provided that the corresponding characteristics of measurement errors or uncertainty are known. Measuring instruments must comply with the specified operating conditions as well as with the specified accuracy requirements. Only those measuring instruments that have been successfully verified, calibrated or metrologically certified are authorized for production, repair, sale or hire in Ukraine.

Measuring instruments intended for large-scale production or for importation in batches into Ukraine are subject to state acceptance and inspection tests with the type approval. Types of approved measuring instruments are entered by the DSSU into the State Register of measuring instruments authorized for use in Ukraine.

The normative base of the State Metrological Service of Ukraine includes national standards (DSTU), normative documents and recommendations on metrology (MPU, MRU) which the National Standardization Technical Committees of Ukraine (TC) develop in the field of metrology:

- TC 63 "General norms and rules of the state system of assurance of measurement uniformity";
- TC 90 "Electrical and magnetic measuring instruments";
- TC 122 "Gas, liquid and solid substance analyses";
- TC 156 "Devices for mass, force, deformation measurements and testing of mechanical characteristic of materials".

In Ukraine for the purposes of legal metrology, the following national standards are used [5–7]:

- DSTU 3400 – basic principles, organization, and consideration of the results of state testing (type examination) of measuring instruments;
- DSTU 2708 – organization of and procedures for conducting initial and periodic verification of measuring instruments;
- DSTU 3215 – organization of and procedures for conducting metrological certification of measuring instruments.

2 National standards for the implementation of the MID

Legal metrological control requires conformity with specified performance requirements and should not lead to barriers to the free movement of measuring instruments. Where legal metrological control is prescribed for specified measuring instruments, only those complying with common performance requirements should be used. Legal metrological control means the control of the measurement tasks intended for the field of application of a measuring instrument, for reasons of public interest, public health, public safety, public order, protection of the environment, levying of taxes and duties, protection of consumers and fair trading.

A number of measuring instruments in the field of legal metrological control are covered by a specific Directive 2004/22/EC on measuring instruments (MID) [8], adopted in March 2004. The provisions concerning measuring instruments should be the same in all the EU Member States and proof of conformity accepted through out the EU. Conformity assessment should provide a high level of confidence in those measuring instruments and their sub-assemblies, which should therefore respect the provisions of the MID. If sub-assemblies are traded separately and independently of an instrument, the exercise of conformity assessment should be undertaken independently of the instrument concerned. In 2009 the MID was accepted in Ukraine as the dominant technical regulation on metrology.

In order to ease the task of establishing conformity with the essential requirements and to enable conformity to be assessed, it is desirable to have harmonized standards. Such harmonized standards are drawn up by private bodies and should retain their status as non-mandatory texts. To this end, the European Committee for Standardization (CEN), and the European Committee for Electrotechnical Standardization (CENELEC) are recognized as the competent bodies for the adoption of harmonized standards in accordance with the general guidelines on cooperation between the European Commission and the European Standardization bodies.

For the purposes of the MID the following terms are used: *"harmonized standard"* means a technical specification (EN) adopted by CEN, CENELEC or jointly by both these organizations; *"normative document"* means a document containing technical specifications (D or R) published by the OIML.

The technical and performance specifications of internationally agreed normative documents may also comply, in part or in full, with the essential requirements laid down by the MID. In those cases the use of these internationally agreed normative documents can be an alternative to the use of harmonized European standards and, under specific conditions, give rise to a presumption of conformity. Conformity with the essential requirements laid down by the MID can also be provided by specifications that are not supplied by a European technical standard or an internationally agreed normative document. The use of European technical standards or internationally agreed normative documents should therefore be optional.

A measuring instrument shall provide a high level of metrological protection in order that any party affected can have confidence in the result of measurement, and shall be designed and manufactured to a high level of quality in respect of the measurement technology and security of the measurement data. The requirements that shall be met by measuring instruments are set out below and are supplemented, where appropriate, by specific instrument requirements in Annexes MI-001 to MI-010 of the MID that provide more detail on certain aspects of the general requirements.

The National Services of Legal Metrology of the EU Member States presume conformity with the essential requirements referred to in Annex I of the MID and in the relevant instrument-specific Annexes MI-001–MI 010 of the MID in respect of a measuring instrument that complies with the elements of the national standards or normative documents on metrology implementing the European harmonized standard (EN) and International Documents (D) or Recommendations (R) of the OIML for that measuring instrument that correspond to those elements of this Standard, Document or Recommendation, the references in respect of which are published in the *Official Journal of the European Union* (C series).

Where a measuring instrument complies only in part with the elements of the national standards or normative documents on metrology referred to in the MID, the NSLM presume conformity with the essential requirements corresponding to the elements of the national standards with which the instrument complies. The NSLM shall publish the references to the national standards and normative documents on metrology referred to in the MID.

In 2006–2008 the titles and references of the harmonized standards and normative documents under the MID were published in the EU Commission Communications in the framework of the implementation of the MID [9–12] in the Official Journal of the European Union. Harmonized Ukrainian national standards, European harmonized standards and International harmonized Documents or Recommendations referred to in the MID [13–43] are shown in Table 1.

3 Modules of conformity assessment of measuring instruments for the MID

The state of the art in measurement technology is subject to constant evolution which may lead to changes in the needs for conformity assessments. Therefore, for each category of measuring instruments and, where appropriate, sub-assemblies, there must be an appropriate procedure or a choice between different procedures of equivalent stringency.

The procedures adopted are as required by Council Decision 93/465/EEC concerning the modules for the various phases of the conformity assessment procedures and the rules for the affixing and use of the “CE” marking [44], which are intended to be used in the technical harmonization Directives particularly in the MID. In 1993, Council Decision 93/465/EEC was utilized in Ukraine as the terms of reference on metrology. However, derogations were made in the MID for these modules in order to reflect specific aspects of metrological control.

The conformity assessment of a measuring instrument with the relevant essential requirements is carried out by the application, at the choice of the manufacturer, of one of the conformity assessment procedures listed in the instrument-specific Annexes of the MID. The manufacturer shall provide, where appropriate, technical documentation for specific instruments or groups of instruments as set out in the MID. The conformity assessment modules making up the procedures are described in Annexes A to H1 of the MID, and shown in Table 2 for the MID and the Ukrainian terms of reference for the measuring instruments.

For the purposes of the MID, the following conformity assessment modules are used (see Table 2):

B – type examination (state testing and type approval of measuring instruments by application of national standard DSTU 3400 in Ukraine);

C – declaration of conformity to type based on internal production control (not used in Annexes MI 001–MI 010).

C1 – declaration of conformity to type based on internal production control (not used in Annexes MI 001–MI 010);

D – declaration of conformity to type based on quality assurance of the production process (preceded by module B);

D1 – declaration of conformity based on quality assurance of the production process (without module B);

E – declaration of conformity to type based on quality assurance of final product inspection and testing (preceded by module B);

E1 – declaration of conformity based on quality assurance of final product inspection ant testing (without module B);

F – declaration of conformity to type based on product verification (initial verification for production, as necessary, periodic verification of measuring instru-

Measuring instruments in the MID	MID Annex	International Documents, Recommendations, Standards	Ukrainian National Standards	Comment
Water meters	MI-001	OIML R 49-1...2 EN 14154-1…3	DSTU OIML R 49-1... 2 DSTU EN 14154-1…3	Draft Draft
Gas meters and volume conversion devices	MI-002	EN 1359 EN 12261 EN 12405-1 EN 12480 EN 14236	DSTU EN 1359 DSTU EN 12261 DSTU EN 12405 DSTU EN 12480 –	
Active electrical energy meters	MI-003	EN 50470-1...3	DSTU EN 50470-1...3	Draft
Heat meters	MI-004	OIML R 75-1...2 EN 1434-1...2 EN 1434-4...5	– DSTU EN 1434-1...2 DSTU EN 1434-4...5	
Measuring systems for continuous and dynamic measurement of quantities of liquids other than water (fuel dispensers for motor vehicles, etc.)	MI-005	OIML R 117 OIML D 11	DSTU OIML R 117-1 DSTU OIML D 11	Draft Draft
Automatic weighing instruments (automatic catch weighers, automatic batch weighing machines, automatic rail weighbridges, automatic gravimetric filling instruments, continuous automatic weighing machines (belt weighers), discontinuous and continuous totalizers, etc.)	MI-006	OIML R 50-1 OIML R 51-1 OIML R 61-1 OIML R 106-1 OIML R 107-1	– DSTU OIML R 51-1 DSTU OIML R 61-1 DSTU OIML R 106-1 DSTU OIML R 107-1	– Draft Draft
Taximeters	MI-007	–	–	
Material measures (capacity serving measures, etc.)	MI-008	OIML R 29	–	
Dimensional measuring instruments (length measuring instruments, area measuring instruments, multi dimensional measuring instruments, etc.)	MI-009	OIML R 66 OIML R 129-1 OIML R 136-1	DSTU OIML R 66 – DSTU OIML R 136-1	 Draft
Exhaust gas analyzers	MI-010	OIML R 99/ISO 3930	DSTU ISO 3930	Draft

Table 1 Harmonized Ukrainian national standards, European standards and International Documents or Recommendations referred to in the MID

Measuring instruments in the MID Annexes	MID Annex	Conformity assessment modules for the MID (in the Ukrainian terms of reference on measuring instruments)
Water meters	MI-001	B+F/B+D/H1 (B+F/G+F/G)
Gas meters and volume conversion devices	MI-002	
Active electrical energy meters	MI-003	
Heat meters	MI-004	
Taximeters	MI-007	
Exhaust gas analyzers	MI-010	
Measuring systems for continuous and dynamic measurement of quantities of liquids other than water (with additional module G)	MI-005	
Automatic weighing instruments: - mechanical systems - electromechanical systems - electronic systems or systems with software	MI-006	 B+D/B+E/D1/F1/G/H1 (B+F/G+F/G) B+D/B+E/B+F/G/H1 (B+F/G+F/G) B+D/B+F/G/H1 (B+F/G+F/G)
Material measures: - linear measures - capacity serving measures	MI-008	 F1/D1/B+D/H/G (B+F/G+F/G) A1/F1/D1/E1/B+E/B+D/H (B+F/G+F/G)
Dimensional measuring instruments: - mechanical or electromechanical devices - electronic devices or devices with software	MI-009	 F1/E1/D1/B+F/B+E/B+D/H/H1/G (B+F/G+F/G) B+F/B+D/H1/G (B+F/G+F/G)

Table 2 Conformity assessment modules for measuring instruments for Annexes of the MID and the Ukrainian terms of reference on measuring instruments

ments in application of national standard DSTU 2708 in Ukraine) (preceded by module B);

F1 – declaration of conformity based on product verification (without module B);

G – declaration of conformity based on unit verification (state metrological certification of measuring instruments in application of national standard DSTU 3215 in Ukraine);

H – declaration of conformity based on full quality assurance;

H1 – declaration of conformity based on full quality assurance plus design examination.

In Ukraine the following specific conformity assessment modules are used:

B – for the realization of international agreements between Ukraine and other countries, and after recognition of the results of state testing of measuring instruments and applicable type approval of measuring instruments with inclusion in the State Register of Measuring Instruments of Ukraine in application of national standard DSTU 3400 [5];

F – for the realization of initial verification for production and, as necessary, periodic verification of measuring instruments in application of national standard DSTU 2708 [6];

G – for the realization of state metrological certification of measuring instruments and in order to receive a metrological certificate for each measuring instrument in application of national standard DSTU 3215 [7].

Conformity assessment procedure B+F is used for the realization of state testing and type approval of measuring instruments in application of DSTU 3400, initial verification for production (and, as necessary, periodic verification) of measuring instruments in application of DSTU 2708. For this conformity assessment procedure, the type of measuring instrument must be included in the State Register of Measuring Instruments of Ukraine in application of national standard DSTU 3400, and must have a verification certificate in application of national standard DSTU 2708, and must have a verification mark in application of national standard DSTU 3968 [45].

Conformity assessment procedure G+F is used for the realization of state metrological certification of measuring instruments in application of national standard DSTU 3215, and for periodic verification in application of national standard DSTU 2708. For this conformity assessment procedure each measuring instrument must pass state metrological certification and hence obtain a verification certificate in application of national standard DSTU 2708.

4 Conclusions

Below are the conclusions obtained from this investigation:

1) As a basis for conformity assessment of measuring instruments according to the MID at national level, national standards harmonized with corresponding European standards, and OIML Documents and Recommendations should be used. In Ukraine there is currently a question of harmonization of national standards for some categories of measuring instruments, certain of which are in the Annexes of the MID.

2) Modules for conformity assessment of measuring instruments according to the MID at national level should be used. In Ukraine some specific modules are used for conformity assessment of measuring instruments according to the MID on the basis of national standards on metrology. ■

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INFRASTRUCTURES

Public perception of metrology in the Republic of Cuba

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Abstract

In this paper, the results of research on Cuban society's current perception of metrology are presented, based on case studies conducted in seven companies in Havana. It is demonstrated that there is a real potential to have a positive impact on the Cuban people's knowledge of this topic by means of well-designed actions aimed directly at meeting their previously identified training needs. The methods used and the results of this research work contribute to studies currently being undertaken in Cuba about society's scientific culture and the public perception of science and technology.

Introduction

A new field of knowledge that focuses on the study of the "public perception of science" and society's "scientific culture" has been gaining ground over the last few years.

From the conceptual viewpoint, Polino C., Fazio M.E., and Vaccarezza L. [1], among others, believe that even if both terms are often believed to be synonymous, the former actually refers to the process of social communication and its effects on the formation of knowledge, attitudes and expectations in society, while the latter has a more complex origin and composition. In fact, when defining the term "scientific culture" we should not only think about all the knowledge, attitudes, expectations, abilities and skills of an isolated individual, since we consider the term "culture" as being essentially linked with "society".

Whereas science and technology are part of society in the form of institutions, systems and processes, society in turn defines the branches of science and technology that it is interesting to develop. Therefore, it is always interesting to discuss and appraise whether science, technology and society are sufficiently integrated into each other to help knowledge become the content that society will subsequently put into general practice as an element of its members' common sense.

To this end, a framework must be provided to study and evaluate science's function and performance within society's cultural and productive dynamics. All efforts should then be channeled into the design and implementation of clear-cut, well-structured policies that will make it possible to counter any setbacks and boost the positive outcomes.

Surveys on the perception of scientific culture are regularly carried out in the European Union, Australia, Canada, China, United States, and Japan. Some Spanish-speaking countries (for example Argentina, Brazil, Spain and Uruguay) have carried out qualitative studies and polls centered on people's perception of science and technology. Mexico and Panama have some governmental experience in this kind of measurement. Cuba has just started to work in this field, using research protocols to assess people's levels of perception, scientific culture and participation in science and technology and establish the proper indicators.

Launched in 2005 mainly by a group of researchers from INIMET, this work focused on society's perception of metrology and the level of metrological culture in seven organizations selected according to their economic relevance and social purpose. Three of them are production enterprises involved in the manufacture of doors; prefabricated metallurgical units; construction equipment; fragrances for perfume, soap and cream production; injectable pharmaceuticals; veterinary drugs, and yoghurt. The other four are service organizations, two of which are involved in hotel management and the other two in project development.

Once a preliminary diagnosis had been carried out, specific improvement action was undertaken in order to modify the workers' views of, knowledge about and interest in metrology.

For the purposes of this research, metrological culture was understood as the intellectual level achieved after a learning process about measurements and units of measurement, measuring instruments and methods and other related subjects, with the hopes that we would help people to both assume a more proactive attitude towards the defense of their rights as consumers of goods and services and increase their overall culture.

Development

Since the dawn of civilization, measurements have been paramount to society's scientific-technical development. No technological production, service or research process can exist today without the use of measuring equipment.

Metrology is the scientific basis on which all measurement processes are developed, and plays a major role in every country's daily life and economic progress, regardless of its level of development. However, this fact is hardly in keeping with the Cuban society's perception of metrology.

Faced with this situation, INIMET was charged with the design of an action plan to increase the level of metrological culture in Havana-based enterprises, and the resulting study included middle-sized and large companies involved in production (veterinary drugs, cosmetics and foods) and services (industrial design, housing and social projects, hotel management and food sales).

The methods implemented emphasized three major subjects: interests, knowledge and attitudes of the assessed individuals, supplemented by subsequent interpretations of the results achieved. The inquiry strategy covered three interrelated levels of analysis:

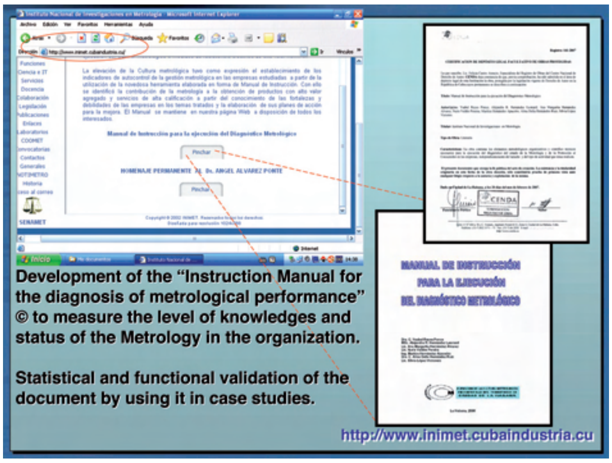
- degree of knowledge among selected workers about metrology and the organization's metrological obligations;
- degree of knowledge among these individuals about their own organization and its metrological processes;
- existing level of metrological culture based on the workers' perception of the role played by metrology in the fulfillment of their goals.

The results of the work allowed, on the one hand, the population sample's perception of metrology to be discussed and assessed, and on the other, actions to be implemented to increase the level of metrological culture in the sample organizations and in Cuban society as a whole.

Given their significance, we list below the benefits derived from our study.

Instruction manual to make a metrological diagnosis [2]

As a first step in our research we made a diagnosis of the situation in the target enterprises. To this end a number of reliable tools were created that provided information about the existing levels of metrological culture and consumer protection. We used these tools to develop a scientific-technical methodological and organizational document called "Instruction manual for the diagnosis of metrological performance" that we registered with CENDA (Cuba's Copyright Center). This manual also made it possible to have all the elements we needed to design actions for improvement in these enterprises using the knowledge about the status of the existing organizational culture regarding metrology.



The following methods were used to develop the manual:

- interviews with key staff in charge of the functions included in the scope of the diagnosis and surveys among managers and technicians to assess their level of awareness of the studied topics and general knowledge about the organization and to identify the prevailing opinion about these subjects;
- analysis of the organization documentation to establish metrology's position in the flow diagram, the level of metrological management pursuant to the process requirements, and whether the relevant regulations were being fulfilled;
- gather evidence on site during the metrological survey to assess the status of the equipment, the use of legal units of measurement and certified reference materials, and the existing needs;
- exchange experience on site with the relevant staff about the measuring process to identify opportunities and weaknesses for improvement in every workstation.

One of the tools included in the manual is a metrological survey that includes 26 variables aimed at obtaining information about the measuring and testing equipment and the reference materials: for instance, their denomination, role within the process, original purpose, brand, model, country, date of manufacture, metrological characteristics, technical condition, and date of the last metrological control. In the case of the reference materials, we stated whether or not they are certified, information about the certifying body, and the needs for measuring and testing equipment and reference materials.

Our survey also gave us information about the units of measurement used to express the results in order to define whether non-legal units were used at any time, and enabled us to make plans to implement the International System of Units (SI).

For the interviews we identified the Director General of each organization as key staff, and they had the chance to express their points of view and affirm their willingness to correct the problems detected.

The survey, which was answered by technicians and managers who were directly involved in measurement, includes three types of questions addressing the following objectives:

- type I, to evaluate their knowledge about these topics;
- type II, to request information; and
- type III, to identify the prevailing opinion about these topics.

Types II and III questions provided the most widespread opinions about the required performance established in the reference documents or by the organization. Thus we found out what the surveyed staff thought about metrology, its importance in the production or service process, and the operation of the organization. The purpose of this information was to correct any deviation.

Statistical and functional validation of the survey

In order to make sure our survey provided reliable, homogeneous information, we made a *statistical validation* using Cronbach's alpha, a very common psychometric coefficient to measure survey reliability (Oviedo and Campos-Arias (2005) [3]). Thus we evaluated an index of internal consistency with values ranging from 0 to 1. Most authors agreed that a value between 0.70 and 0.90 shows a correct degree of internal consistency.

The assessment of all items in Type I questions gave us a Cronbach's alpha value of 0.78, which meets the reliability requirement of the test.

For its *functional validation*, the survey was applied by seven different researchers to a wide cross section of over 100 people in the organizations. The results achieved confirmed the validity of the survey given the low sensitivity to the differences between the survey-takers and the respondents.

As confirmed by both the data and the results about the existing knowledge, one enterprise scored as a *high level* organization, while the others received qualifications ranging from *low level* to *very low level*. None was found to be at a *very high level*. The findings of the diagnosis allowed us to identify opportunities for management improvement, namely:

- to provide training on metrology, metrological assurance and consumer protection;
- to carry out the metrological control of all measuring instruments used in the main production or service processes and to provide internal services in the organization;
- to pay attention to the location and performance of the metrological activity within the structure and organization of the enterprise with a view to facilitating its execution;
- to guarantee the traceability of measurements;
- to design a program for the full implementation of the SI units;
- to recompile the register of all the measuring instruments in the organization so as to include metrology-related and other important data such as: measuring range, class, error, uncertainty, brand name of instruments, model, country and year of manufacture, date of its last calibration or verification, and technical condition;
- to obtain the tools and instruments needed to repair and control measuring instruments in a proper way; and
- to complete the organization's documents with those elements that contribute to an adequate development of metrological management.

Although it was not part of the research, we led all the target organizations to design an action plan to find short-term, medium-term and long-term solutions to the findings of their metrological work. Among the main items in this plan were the funding of metrological obligations and the revision of their organizational structure.

One major result of our project was the identification of training needs among the specialists from the favored enterprises and the design of specific actions to meet them. Once we defined the current level of metrological culture of these individuals we were able to introduce the proper mechanisms to improve it.

Many Cuban organizations have undertaken a process to improve and certify their quality management system to the NC ISO 9001:2008 standard, "General requirements of a quality management system", in which metrology plays a significant role in the provision of products and services of sufficient quality to be competitive in international markets.

In our experience, failure to be thorough in the execution of metrological work has a negative impact on process and product quality and paves the way for poor management of resources and metrological violations linked to a lack of confidence in the quality of measurements made in various economic areas and consumer protection practices, to name but a few consequences.

In this regard, man is at the center of any action designed to assure the proper process quality and performance. Therefore, the staff must have the necessary qualification and skills to increase the level of metrological management in their organization and identify any strength, weakness, opportunity and threat in order to plan for improvement.

Teaching aids to train human resources involved in measurement

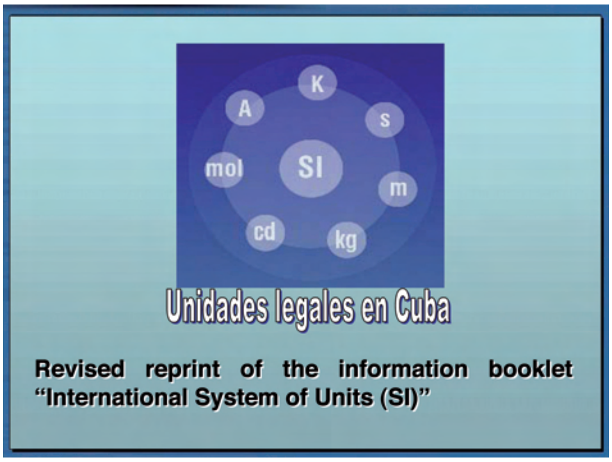
The following topics must be covered:

- metrology: importance and prospects;
- legal metrology and the SI System;
- product testing: a guarantee to consumers;
- laboratory accreditation;
- uncertainty of measurements, the basis of mutual recognition and the elimination of technical barriers to trade;
- industrial metrology and mass quantity metrology;
- volume measurements; and
- consumer protection.

Professionals with experience in both metrology and consumer protection were involved in the process, and the most current documents and bibliography were used.

Revised reprint of the information booklet "International System of Units (SI)"

This booklet was updated to the eighth edition in 2006 of *Le Système International d'Unités*, published by the International Bureau of Weights and Measures (BIPM) and the new ISO 1000 and ISO 80000 standards. All the definitions of the basic units and the rules for writing symbols and quantities were revised and updated with the help of the Metrology Division of the National Bureau of Standards.



Designed to be used in Cuban schools at all levels of education, the booklet is also useful to professionals and citizens in general, as it includes the SI and other units legally applied in Cuba and related information. It was launched at the 7th International Symposium "Metrology 2008", held in Havana.

Training actions in the target organizations

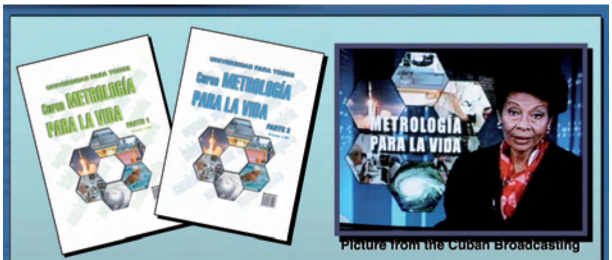
Eight training workshops were organized for 252 specialists from the organizations which benefited from our research and other interested enterprises. We also trained their board members in subjects like metrology and consumer protection, and upgraded the staff's level of metrological culture through exchanges organized during the fieldwork.

Introduction of a new course and redesign of another as part of INIMET's training service program as of 2009

Our experience in workshop organization made it possible to extend our training by redesigning a course on metrological assurance introduced in INIMET's qualification program and provided to specialists from our economy with good results. In reply to requests from several organizations, a new course was added to teach how to use the instruction manual to carry out a metrological diagnosis, also with good results.

Course, tabloid and book "Metrología para la Vida¨ (*Metrology for Life*)© for the scientific dissemination of metrology

The course *Metrology for Life*, offered through the TV program *Universidad para Todos* (Open University) in one-hour, nationwide broadcasts for 16 weeks, together with a two-part 32-page tabloid and a book with the



Course “Metrology for life” was offered through the TV programm University for all in one hour, nationwide broadcasts for 16 weeks, together with a two-part 32-page tabloid © for the scientific dissemination of Metrology.

same title, have been an important resource to disseminate this science and improve the Cuban people’s metrological culture. This course was very popular and extremely useful to bring metrology to the fore, as it took this science to every home and allowed the population to become acquainted with the basic tools to carry out proper measurements. Sold at a very reasonable price at newspaper stands across the country, the tabloid includes part of the content found in the book, namely:

- an overview of metrology;
- consumer protection in Cuba: challenges and prospects;
- product testing: a guarantee for consumers;
- past, present and future of the International System of Units in the Republic of Cuba;
- calibration and traceability;
- an approach to the uncertainty of measurements; and
- metrological assurance of the national economy.

The book *Metrology for Life* was registered with the Cuban Copyright Center.

All the above actions met their goal of making as much information as possible accessible to everyone so that they can have a comprehensive view of metrology and its applications.

Conclusions

The tools employed to make a metrological diagnosis were designed from self-control indicators of metrological management directed toward customer satisfaction and consumer protection, and were useful to obtain reliable information about people’s perception of metrology and their level of metrological culture.

Both the current perception of metrology in the diagnosed organizations, and the positive change that occurred in the mindset of managers and trainees, allow us to assert that it is possible to make a positive difference in society’s knowledge about the above topics by implementing well-designed actions directly aimed at fulfilling previously identified training needs.

The methods we used in our research and technological innovation project “Increasing metrological culture in organizations in the province City of Havana” stand as a major contribution to studies currently underway in Cuba about people’s perception of science and technology and our society’s scientific culture. ■

Acknowledgment

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ROAD SAFETY

Road safety and metrology: What's the binomial?

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Abstract

Efficient traffic enforcement requires regulations in which the role of metrology is very important. It is imperative for both authorities and manufacturers to have a system of measurement traceability within the framework of conformity assessment of those instruments that are placed on the market. There is an increasing interest in the role of metrological decisions in conformity assessment, particularly where measurements are used as the basis for health and safety such as in road traffic.

This paper focuses on the role of the Portuguese Legal Metrology Authority in the field of road safety, emphasizing the relevance of metrological control of certain measuring instruments within the scope of the Strategic Plan of the National Program of Road Safety approved in 2009, as a way to reduce and monitor accidents.

1 Introduction

Worldwide, around a million people die every year as a result of road traffic accidents; 'human catastrophe' is the expression often used to describe this global traffic safety situation.

Several sectors of society are cooperating to share and transfer their knowledge, and to gather evidence based on strategies and countermeasures that will help improve the situation.

All countries are faced with the same road safety problems, namely excessive speed, drink driving, use (and failure) of seat belts, insufficient body protection provided by vehicles, accident black spots, non-compliance with driving and rest times by commercial drivers, poor visibility, etc.

In the EU the Road Safety Action Program (2003–2010) was implemented with the goal of halving the number of people killed on the roads by 2010. The follow-up action plan covers the period 2009–2014 and a mid-term review will take place in 2012 or 2013.

The National Plan for Road Accident Prevention in Portugal is chaired by the Ministry of Internal Affairs, and the starting point was the average for the period 1998–2000.

2 Measuring instruments used in road safety

The contribution of metrology to road safety can be observed in the safety of vehicles, police speed checks, alcohol and drug detection, etc.

The science of measurement has a central role in the technical tools to ensure that the related technologies used are reliable (see Table 1).

For the common user, these metrological tools can be perceived as either relevant or irrelevant, but the advantages offered by metrology to ensure a safer life are omnipresent – a simple example is incorrect tire pressures which can be critical.

Efficient police enforcement requires harmonized procedures; confidence in the results of measurements is an inherent element of this process. For metrology, confidence implies measurements that are traceable to the International System of Units (SI) to a certain confidence level. Many decisions are based on tests or measurements, before the instruments are placed on the market. They must demonstrate that the metrological requirements are met and if the instruments are in use for some time they may be subject to re-verification tests. The instrument will be rejected if it operates outside its metrological limits. According to the scope of the European Measuring Instruments Directive (MID), covered by Decree Law no. 192/2006, the free trade of a number of categories of measuring instruments is regulated, by defining the essential requirements and certification procedures.

The only category of instruments in the field of road safety that is included in the scope of the MID is the category exhaust gas analyzers. For the other instruments, the type approval and verification requirements are based on specific national regulations (see 2.1). Special attention must be paid to all systems with software incorporated, to ensure the integrity, authenticity and privacy of the data. Taking into account the specific national operating conditions, EU Member States should improve networks to support and harmonize the type testing requirements.

The OIML plays an important role in the harmonization of regulations applied to metrological control.

OIML R	Application	Metrological function
R 23 Tire pressure gauges for motor vehicles	Define the metrological characteristics to which pressure gauges intended for the measurement of the inflation pressures in motor vehicle tires must conform.	Measure the direct influence of a mechanical transmission and the elastic deformation of a sensing element.
R 55 Speedometers, mechanical odometers and chrono-tachographs for motor vehicles	Define the metrological regulations for speedometers, odometers and chronotachographs.	Measure the constant k of odometers or chronotachographs, measure the coefficient w of vehicles.
R 76-1 & 2 Non-automatic weighing instruments	Evaluate the metrological and technical characteristics of non-automatic weighing instruments that are subject to official metrological control.	Measure the mass of a body by using the action of gravity on this body, using the intervention of an operator.
R 91 Radar equipment for the measurement of the speed of vehicles	States the conditions that the micro-wave Doppler radar must satisfy when the results of measurements are to be used in legal proceedings applied on roads.	Measure the angle of incidence of the beam.
R 99-1&2&3 Instruments for measuring vehicle exhaust emissions	Inspection and maintenance of in-use motor vehicles with spark ignition engines.	Measure the volume fraction of one or more of the following exhaust gas components: CO, CO_2, O_2, HC (in terms of n-hexane).
R 126 Evidential breath analyzers	Define the performance requirements of EBAs and the means and methods employed in testing them.	Measure accurately and display numerically the breath alcohol mass concentration of persons (drivers, workers, etc.) who may have consumed alcohol.
R 134-1& 2 Automatic instruments for weighing road vehicles in motion and measuring axle loads	Evaluate the metrological and technical requirements of automatic weighing instruments, having a load receptor and aprons, that determine the vehicle mass and axle loads.	Measure the vehicle mass and axle loads and, if applicable, the axle-group loads of a road vehicle while the vehicle is crossing over the load receptor of the weighing instrument.

Table 1 Application of OIML Recommendations for road safety enforcement

Many countries, such as Portugal, have developed national regulations based on OIML Recommendations where metrological control is mandatory for the National Road Code.

The role of metrology is also highlighted in certain International Standards and European Directives. As an example, Directive 92/55/EEC emphasizes measurements of motor vehicle emissions (for which technical support is provided by certain International Standards such as ISO 11614:1999 and ISO 3930:2004). Other examples can be given for instruments that are directly related to road safety such as chronotachographs (Directive 2006/22/EC) and speed limitation devices (Directive 2004/11/EC), both covered by Portuguese laws.

3 Metrological control in Portugal

The Portuguese Metrological System is based on Decree Law no. 291/90 and on a general regulation no. 962/90 that regulates and describes the metrological control requirements for measuring instruments, complemented by specific orders for each category, notably as pertains to instruments related to road safety:

- Regulation no. 625/86, 25 October: Tachographs.
- Law Decree no. 281/94, 11 November and Law no. 46/2005, 23 November: speed limitation devices.
- Regulation no. 797/97, 1 September: Apparatus for measuring the opacity and determining the light absorption coefficient of exhaust gas.
- Regulation no. 389/98, 6 July: Tire pressure gauges for motor vehicles.
- Regulation no. 422/98, 21 July: Pressure gauges.
- Regulation no. 21/2007, 5 January: Instruments for measuring vehicle exhaust emissions.
- Regulation no. 1542/07, 6 December: Radar equipment for vehicles.
- Regulation no. 1556/2007, 10 December: Evidential breath analyzers (EBA).

Any measuring instruments that are not covered by the MID have to be approved by the Portuguese Institute for Quality (IPQ). Before the instrument is used, it is verified by a notified body to ensure its accuracy. During its use the instrument owner is responsible for its maintenance, accuracy and correct use.

IPQ works closely with regional metrology offices and collaborates with manufacturers and suppliers.

According to national regulations (see list above), only breath analyzers and radar equipment for vehicles are verified directly by IPQ; the other instruments are verified by qualified entities after recognition and supervision carried out by IPQ.

3.1 Alcohol and speed control

The major causes of fatal road accidents are related to driving under the influence of alcohol or excessive speed. IPQ plays a major role by improving the traceability of the measurements of the instruments used by the police for driver controls. Furthermore, measuring instruments used for evidential purposes under the Portuguese Highway Code, namely EBA and radar devices, must have Portuguese type approval as well as initial verification and subsequent annual verification.

3.2 Evidential breath analyzers (EBA)

Evidential breath analyzers are instruments that automatically measure the mass concentration of alcohol in exhaled breath. They can be used to measure accurately and display numerically the breath alcohol mass concentration of persons who may have drunk alcohol. Over the years, breath testing has become a widely used method for the qualitative and quantitative determination of the alcohol level of persons suspected for driving under the influence of alcohol.

All over the world, scientists started to look for new non-invasive methods to determine the alcohol concentration in the human body. Depending on the accuracy, specifically alcohol-related, cross sensitivity, long term stability, etc, a number of measuring principles are used for breath alcohol determination: chemical, biochemical (system based on oral fluids), physical (semiconductor cell - surface reaction), electrochemical (fuel cell), infrared spectroscopy, and gas chromatography.

Breath-alcohol testing methods have changed over the years from chemical oxidation and calorimetric procedures to physico-chemical techniques such as gas chromatography, electrochemical oxidation and multiple wavelength infrared spectrophotometers. However, in the field of metrological control and in the scope of Portuguese regulation, an infrared spectometry EBA was adopted.

The emphasis on police enforcement to ensure road safety is related to the estimation that 2 % of all journeys across the EU take place with an illegal blood alcohol concentration (BAC). In Portugal, the legal limit is 0.5 g/L BAC, however, different EU Member States have different legal BAC limits (see Fig. 1).

Regarding these different limits, the various countries have also established different penalties.

g/L	Sanction / Fine
0.5 ≤ BAC ≤ 0.8	Suspension of driving license from one month to one year/fine of € 250 to € 1250
0.8 ≤ BAC ≤ 1.2	Suspension of driving license from two months to two years/fine of € 500 to € 2500
BAC ≥ 1.2	Imprisonment

Table 2 Administrative offence for drivers with excess alcohol (Portuguese Highway Code)

An increase in the blood alcohol concentration causes a number of psychomotor and behavioral patterns to change, directly increasing the risk of accidents (see Table 3).

It is mandatory for all EU Member Sates to carry out breath tests and they are advised to monitor the prevalence of drink driving.

Legal metrology contributes to solving this problem through OIML Recommendation R 126, which defines the performance requirements of EBAs as well as the means and methods employed in testing them.

All evidential breath analyzers are verified by IPQ according to this OIML Recommendation [2].

3.3 Speed control

According to information from the EU, speed is also a key contributory factor for around 30 % of fatal accidents. Relationships have been established between speed and accident risk, such as the relation between a higher speed and the reaction time, consequences of injury, etc.

International Recommendations advise that radar equipment must be used to perform the measurement of traffic speed on roads.

BAC (g/L)	Probability to cause an accident
0.6	2 × as high
0.8	4 × as high
1.0	6 × as high
1.3	12 × as high

Table 3 Alcohol and accident risks (source: [11])

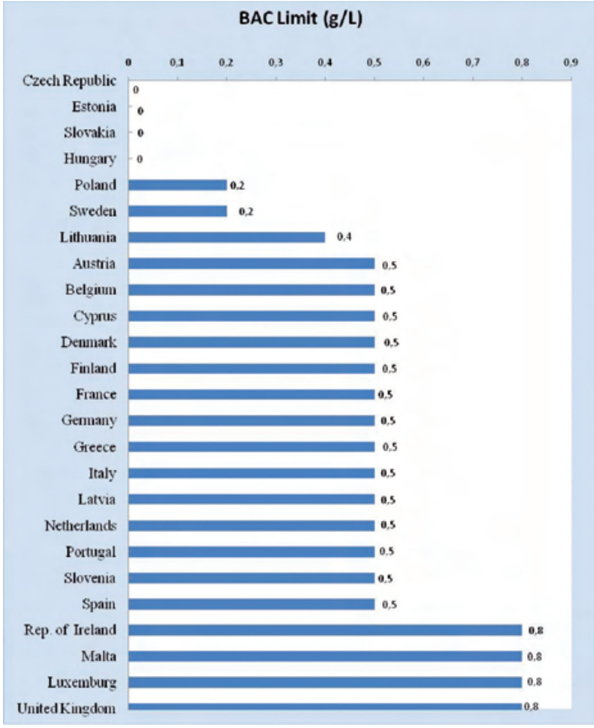

Figure 1 Legal alcohol limits for drivers

In the framework of Portuguese Legislation (according to national regulation no. 1542/07 and OIML R 91), radar instruments are submitted to a metrological control. By this approach, IPQ carries out the type approval and verifications of the microwave Doppler radar [1]. Emphasizing the traceability of measurements, the suitability of these instruments is fully guaranteed, allowing them to be used legally for enforcement purposes (police enforcement and Highway Code).

Speed limits are at the core of any speed management policy, despite the fact that current speed limit policies differ between EU countries. The general speed limit for motorways in EU Member States is in most cases 120 or 130 km/h, for rural roads it is 80 or 90 km/h and for urban roads 30 to 50 km/h (see Table 4).

According to EU Directive 92/24/EEC and its recent adaptation (2004/11/EEC), speed limits are compulsory for heavy goods vehicles (HGVs) of 3 500 kg and more as well as for buses weighing 5 000 kg or more. However, some countries apply lower values for bus speed limits on different road types.

4 Technology improvement

According to EU recommendations aimed at enforcing traffic law [9], the three priority areas for technology

Country	In built-up areas (km/h)	Outside built-up areas (km/h)	Motorways (km/h)
Austria	50	100	130
Belgium	50	90	120
Bulgaria	50	90	130
Cyprus	50	80	100
Czech Republic	50	90	130
Denmark	50	80	110 or 130
Estonia	50	90 or 100 or 110	-
France	50	90 or 110	130
Finland	50	80 or 100	100 or 120
Greece	50	90 or 110	130
Germany	50	100	130 (*)
Hungary	50	90 or 110	130
Italy	50	90 or 110	130
Ireland	50	80 or 100	120
Latvia	60	90	100
Luxembourg	50	90	130
Lithuania	50	90	110 or 130
Netherlands	50	80-100	120
Malta	50	80	100
Poland	50	90-110	130
Portugal	50	90-100	120
Slovenia	50	90	130
Spain	50	90 or 100	120
Sweden	50	70-90	110
United Kingdom	48 (30 mph)	96 or 112 (60 or 70 mph)	112 (70 mph)

Table 4 Speed limits on EU roads (source: *J-P Cauzard, SARTRE 3, 2005)*

improvement are speeding, drink driving and the use of seatbelts. Regarding drink driving, some countries have implemented new devices for alcohol breath testing, linked to locks connected to the vehicle [7]. This type of device prevents the vehicle from being started unless the driver has undergone a breath test. If the system indicates a breath alcohol concentration over the threshold level, it inhibits the vehicle from being driven.

The implementation of this alcohol ignition interlock program is ongoing in some countries with significant progress being made in areas such as commercial transport (school buses) and rehabilitation programs. In Portugal the implementation of interlocks has not had a significant impact on society. These instruments are not covered by national metrological legislation but should rather be submitted to a calibration program in order to provide the traceability of their results to SI units. Furthermore, it covers some advances in road safety technology such as the integration of cameras into the device to identify the person who provided the breath sample.

Concerning speed, the European Commission has proposed an action plan and a European Directive for Intelligent Transport Systems (ITS). Intelligent Speed Adaptation (ISA) is an ITS which gives information to the driver about speed, discourages the driver from speeding, or prevents the driver from exceeding the speed limit [6].

Since the human factor is the major risk factor for road safety, the development of new technology will need to ensure appropriate vehicle safety and to make intelligent human/vehicle interfaces.

The European Action Plan suggests a number of targeted measures and a proposal for a Directive laying down the framework for their implementation. The purpose is to ensure better use of the new active safety systems and advanced driver assistance systems with proven benefits in terms of in-vehicle safety for the vehicle occupants and other road users (including vulnerable road users). The Action Plan covers the period 2009–2014 and a mid-term review will take place in 2012–2013.

5 Conclusions

As the science of measurement, metrology is present in each of our lives, serving the community as a whole in many ways.

In order to improve solutions to detect the risks to (or caused by) drivers, metrology should be seriously engaged where the risk factors are correctly identified, such as alcohol and drug consumption and speeding.

The same approach could be adopted for the reduction of risks caused by environmental conditions. In addition, the direct involvement of metrology may prevent or decrease the driver's errors of judgment, focused on the technology of the on-board computer and automatic cruise control. However, for an efficient enforcement of the binomial metrology/road safety, confidence must be omnipresent, where confidence in this context means the global acceptance of the results. For that, a mutual recognition agreement should be mandatory for the technical aspects and prosecution process, with a global application at the level of the European legal framework.

The relevant organizations should put more effort into improving the engagement of metrology in road safety research projects and other joint commissions.

That is the binomial which plays a fundamental role in technology optimization and certainly, the future must go in that direction. ■

This article is also being published in the April 2010 edition of the International Journal of Metrology and Quality Engineering.

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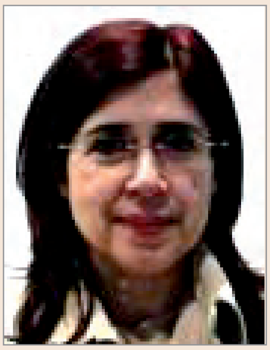
The Authors



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LIAISON NEWS

ISO/CASCO WG 32 First meeting

1–3 February 2010 Geneva (Switzerland)

Régine Gaucher, BIML

Introduction

The OIML is an A liaison in ISO/CASCO and may therefore participate in ISO/CASCO technical work; notably, it may submit comments at the various stages of the development of ISO Standards.

ISO/CASCO Working Group 32 is responsible for the revision of ISO/IEC Guide 67:2004 *Conformity assessment – Fundamentals of product certification*. Product certification is linked to OIML technical work in particular in the following areas:

- OIML TC 3, which is responsible for metrological control;
- OIML TC 3/SC 5, which is responsible for the OIML Certificate System and the Mutual Acceptance Arrangement (which are certification schemes in the sense of ISO Standards and Guides); and
- OIML TC 6, which is setting up a certification scheme for prepackages.

Consequently, similarly for ISO/CASCO WG 29 (which is responsible for the revision of ISO/IEC Guide 65:1996 *General requirements for bodies operating product certification systems*) the OIML has become a member of WG 32, in particular to advise ISO/CASCO on the specificities which may exist in regulatory certification.

It is important to note that the certification body (e.g. the National Type Approval Body) is not always the scheme owner. The National Type Approval Body may be designated by the government and the government itself is the certification scheme owner. This issue has been emphasized and is now clearly defined in ISO Drafts 17065 (revision of Guide 65) and 17067 (revision of Guide 67).

Meeting

ISO/CASCO WG 32 held its first meeting in Geneva on 1–3 February 2010. The objective was to clarify the terms of reference of the project approved by ISO/CASCO to consider the revision of ISO/IEC Guide 67 and to draw up the contents of the draft Standard, the aim of which is to provide guidance for the understanding, development, establishment, maintenance or comparison of certification schemes for products, processes and services.

ISO/CASCO WG 32 is also responsible for incorporating relevant material from:

- ISO/IEC Guide 23:1982 *Methods of indicating conformity with standards for third-party certification systems;*
- ISO/IEC Guide 27:1983 *Guidelines for corrective action to be taken by a certification body in the event of misuse of its mark of conformity;*
- ISO/IEC Guide 28:2004 *Conformity assessment - Guidance on a third-party certification system for products;*
- ISO/IEC Guide 53:2005 *Conformity assessment - Guidance on the use of an organization's quality management system in product certification.*

The following ISO/IEC Guide and Standard will also be taken into account in the future ISO/IEC 17067:

- ISO/IEC Guide 60:2004 *Conformity assessment - Code of good practice*; and
- ISO/IEC 17007:2009 *Conformity assessment - Guidance for drafting normative documents suitable for use for conformity assessment*.

The future ISO/IEC 17067 is intended to be used by product certification bodies, regulators, trade associations, and industry associations in their role as scheme owners whereas requirements applicable to certification bodies are given in the draft Standard 17065.

On the basis of the preliminary discussions during the meeting, a first Working Draft should be available and circulated within ISO/CASCO WG 32 members in June 2010 for comments by the end of August 2010.

The next meeting could be planned in October 2010 to review the comments received on the first Working Draft.

Comments from the OIML on the ISO/IEC drafts

In the same way as for the ISO/IEC CD 17065, once it is available the draft will be posted on the relevant OIML TC/SC workgroups to allow OIML TC/SC Members to provide the BIML with comments which will serve as inputs to the comments sent to ISO/CASCO as OIML comments. ■

MOMBASA 2009

CIML Round Table on Metrological Control

Mombasa, Kenya 28 October 2009

MANFRED KOCHSIEK,
Former Vice-President of the Physikalisch-Technische Bundesanstalt (PTB), Germany

Eighty participants from 55 countries and economies participated in the CIML Round Table on Metrological Control in Mombasa, held in conjunction with the 44th CIML Meeting in October 2009. The main reason for holding it was to reflect developments over previous years, as summarized below:

- Total systems approach to metrological control: should measurements be regulated rather than the measuring instruments themselves? This had already been discussed at the Seminar "Stakes and priorities of legal metrology for trade" - what was important, the result of the measurement or the measuring instrument?
- Metrological control in the future: moving the center of gravity from pre-market to post-market control, and whether the various operations could be carried out independently (for example type evaluation and production evaluation);
- The delegation of certain operations to private bodies versus keeping them in state or state run bodies; discussion of current systems of in-service metrological control; possibilities of accepting first party conformity evaluations, test results and all declarations of conformity by manufacturers, repairers or others; it was very important to discuss this question;
- How to maintain a satisfactory level of knowledge and control over the actual overall quality of instruments and service; and
- The meaning of the maximum permissible errors at different stages of the life of an instrument from the design stage, production stage, before and after the first installation, at inspection, in service, after repair, and the use of uncertainty evaluation in these cases.

Another reason was that a number of OIML publications dealing directly or indirectly with metrological control were being revised. Among these were:

- D 1 *Elements for a law on metrology*;
- D 16 *Principles of assurance of metrological control*;
- D 19 *Pattern evaluation and pattern approval*; and
- D 20 *Initial and subsequent verification of measuring instruments and processes*.

After the introduction by the moderator Prof. Manfred Kochsiek , five presentations were given:

1. *Conformity assessment: a new approach* (Jean-François Magaña);
2. *Metrological control in developing economies within Africa* (Stuart Carstens);
3. *Metrological control today and in the future* (Pavel Klenovský);
4. *The European approach, the expected role of manufacturers, notified bodies and Member States* (Corinne Lagauterie); and
5. *The evolution of legal metrology* (Jean-François Magaña).

The presentations are available at:

http://workgroups.oiml.org/ciml-2009/round-table-on-metrological-control/

1. Conformity assessment: a new approach

Mr. Magaña pointed out that in addition to traditional type approval and initial verification a third new element was necessary for the assessment of instruments: a procedure for conformity to type, which meant it must be ensured that a measuring instrument which would later be put into series production complied with the requirements of the type approval, for example with regard to the components and material, something that cannot be verified during initial verification.

2. Metrological control in developing economies within Africa

Mr. Carstens said he intended to cover the points from the perspective of the developing countries in Africa. He explained their concept of metrological control, total systems approach, the comparison of pre-market versus post-market, state versus private competence, the different MPEs and the advantages of verified procedures to form the basis for the OIML MAA which would give effect to the obligations of the WTO TBT Agreement. In developing countries only two MPEs were needed, for verification and for in-service inspection.

3. Metrological control today and in the future

Mr. Klenovský, responsible for OIML Document D 16 on metrological control, examined different models:

- the German or traditional European model: verification of legally controlled measuring instruments, charged to their users, complemented by in-service surveillance as a form of metrological supervision
- the American model (used in some states of the US) involving subsequent verification of measuring instruments, not charged to the user so that the operation is paid for by the government.

Mr. Klenovský explained the advantages and disadvantages of both models, especially the role of manufacturers, government and authorized bodies. In passing he expressed the wish for more active participation on the part of some of the P-Members of TC 3/SC 2 concerning the finalization of the revision of OIML D 16.

4. The European approach, the expected role of manufacturers, notified bodies and Member States

Mrs. Lagauterie first explained the European approach, especially regarding the essential requirements for the instrument, putting into service and onto the market, and also the duties of manufacturers, notified bodies and Member States.

She explained that WELMEC played an important role in terms of the development of European legal metrology. A general agreement on metrological control in Europe is still under discussion.

5. The evolution of legal metrology

Mr. Magaña pointed out that confidence in measurement results under real working conditions had always been a major challenge. When he had started working in legal metrology some 30 years ago, authorities had had to edict regulations and to carry out all the necessary operations. In the 90s operations were taken over by public or private laboratories. Today, authorities conferred more and more tasks to accreditors and others. Only surveillance of measuring instruments and defining laws and decrees should remain a governmental task, with the risk that the distance between the authorities and the "others" might become too big.

Summary and conclusions

Many of the participants then took the opportunity to comment and ask questions concerning:

- Possible problems if private bodies were to take over too many tasks in legal metrology;
- Measuring systems are increasingly replacing single measuring instruments;
- A services Recommendation or a services Directive (for Europe only);
- An approach based on uncertainty of measurement versus categories of instruments to reach an accurate measurement for the specific application;
- The conformity to type procedure might be necessary in some countries; in Europe this is covered partly by Module D and the CE mark;
- Clearer distinction of terminology in the field of measurement control, e.g. supervision, control, inspection (necessary for OIML Document D 9);
- Changes in legal metrology practices during the last thirty years especially the steps towards a global measurement system;
- Problems of developing countries not having the facilities to operate a system of metrological control.

In summarizing it can be stated that there is a strong need to include the following issues in the OIML system:

- Conformity to type;
- Need for clarification of terminology in OIML Document D 9;
- Market surveillance;
- Reflection of the Round Table discussions for the revision of OIML D 1, D 16, D 19 and D 20. ■

NEW BOOK

The history of metrology

MULTILINGUAL ILLUSTRATED BOOK PUBLISHED

The Portuguese Institute for Quality (IPQ), which also accommodates the national institute for metrology, has published a richly pictorial, illustrated book with the title ***Weights and Measures in Portugal***. The author is António Cruz, the director of the Metrology Department of this Institute. Contrary to what the title implies, not only is the history of the development of metrology in Portugal described, but this history is in fact embedded in the universal history of metrology. It begins with well-founded assumptions about ancient times and leads up to the networks of international cooperation, as it represents itself today under the sign of globalization.

Andrew Wallard (Director of the BIPM) characterizes the history of metrology in his Foreword as fascinating, since it is closely interwoven with the evolution of society, with religion, with trade and - not least - with science.

Thus, metrology deals with the realization and the comparison of standards and measuring instruments; it is the result of the worldwide efforts of many participants.

Ernst Göbel, President of the PTB, focuses in his Foreword on the observation that each society needs reliable measures, and that all civilisations developed their own systems of units, which made conversion necessary. In individual cases, the measures were disseminated worldwide even without a conversion, as, e.g. the Cologne Mark - a unit of weight, which at times reached into the most distant corners of the globe via the trade relations of the Portuguese trading posts and colonies overseas.

The book is written in three languages: Portuguese, English, and German, and is illustrated throughout.

The photos - many of which originate from the PTB - are qualitatively exceptional and contain not only illustrations of measurement standards and measuring instruments from all eras of human history, but also depict documents and historically important illustrations of side issues of metrology.

The reader is introduced in a generally understandable language to the history of metrology, with a focus on the more than 800-year history of Portugal which, as is common for most early civilisations, is driven by legal metrology.

The book, with its 245 pages of high-gloss paper, can be ordered from the IPQ by sending a message to metrologia@mail.ipq.pt, at a cost of 40 euros including taxes, postage and handling (the package weighs about 2 kg!).

Hartmut Apel

OIML Systems

Basic and MAA Certificates registered 2009.12–2010.02

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

The OIML Basic Certificate System

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

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

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

Other information on the System, particularly concerning the rules and conditions for the application, issue, and use of OIML Certificates, may be found in OIML Publication B 3 *OIML Certificate System for Measuring Instruments* (Edition 2003, ex. P 1) and its *Amendment* (2006) which may be downloaded from the Publications page. ■

The OIML MAA

In addition to the Basic System, the OIML has developed a *Mutual Acceptance Arrangement* (MAA) which is related to OIML Type Evaluations. This Arrangement - and its framework - are defined in OIML B 10-1 (Edition 2004) and its Amendment (2006), and B 10-2 (2004).

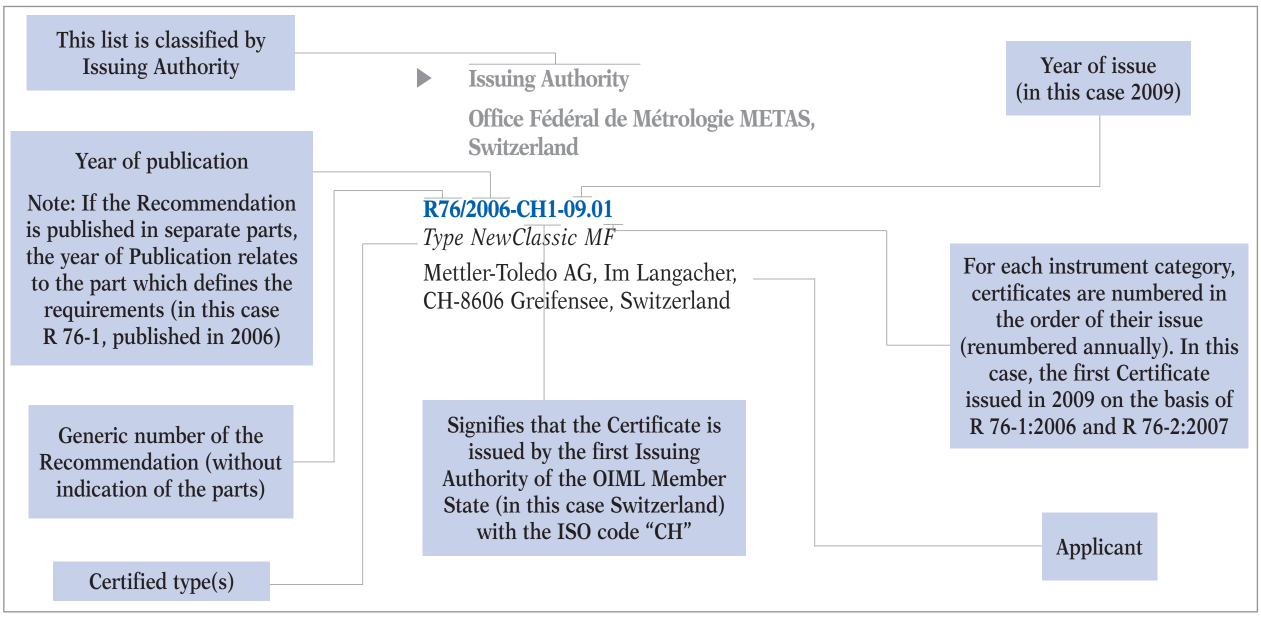
The OIML MAA is an additional tool to the OIML Basic Certificate System in particular to increase the existing mutual confidence through the System. It is still a voluntary system but with the following specific aspects:

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

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

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

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



INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Water meters intended for the metering of cold potable water

R 49 (2006)

▶ Issuing Authority / *Autorité de délivrance*

National Weights and Measures Laboratory (NWML), United Kingdom

R049/2006-GB1-2008.01 Rev. 1 (MAA)
Family of cold-water meters utilising a common, volumetric measuring element, with a nominal capacity of 13.2 revs/litre and having a rated permanent flowrate Q_3 of 6.3 m^3/h.
Elster Metering Ltd., 130 Camford Way, Sundon Park, Luton LU3 3AN, Bedfordshire, United Kingdom

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

R049/2006-GB1-2009.01 Rev. 1 (MAA)
Family of cold-water meters utilising a common, volumetric measuring element, with a nominal capacity of 16.5 revs/litre and having a rated permanent flowrate Q_3 of 2.5 m^3/h (R250) or 4.0 m^3/h (R400)
Elster Metering Ltd., 130 Camford Way, Sundon Park, Luton LU3 3AN, Bedfordshire, United Kingdom

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Metrological regulation for load cells (applicable to analog and/or digital load cells)

R 60 (2000)

▶ Issuing Authority / *Autorité de délivrance*

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

R060/2000-JP1-2010.01 (MAA)
DCC21-20T, DCC21-24T, DCC21-36T
Yamato Scale Co., Ltd., 5-22 Saenba-cho, JP-673-8688 Akashi, Japan

In this Bulletin:
28 Certificates in total in the categories covered by a DoMC, of which 19 (68 %) are MAA Certificates

▶ Issuing Authority / *Autorité de délivrance*

National Weights and Measures Laboratory (NWML), United Kingdom

R060/2000-GB1-2009.08 (MAA)
Digital high tension alloy steel load cell
Avery Weigh-Tronix Ltd., Foundry Lane, Smethwick, West Midlands B66 2LP, United Kingdom

R060/2000-GB1-2009.10 (MAA)
Strain gauge compression load cell Type T302x
Avery Weigh-Tronix Ltd., Foundry Lane, Smethwick, West Midlands B66 2LP, United Kingdom

R060/2000-GB1-2009.11
Stainless steel shear beam load cell
Fotiadis Panagiotis, Industrial Area Sindos, P. Box. 1217, GR-57022 Thessaloniki, Greece

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V., The Netherlands

R060/2000-NL1-2008.10 Rev. 1 (MAA)
A double ended shear beam load cell - Type: QSB...
Keli Electric Manufacturing (Ningbo) Co. Ltd., No. 199 Changxing Road, Jiangbei District, CN-315033 Ningbo, P.R. China

R060/2000-NL1-2009.11 Rev. 1 (MAA)
Single point bending beam load cell - Type: C2X1-....
Minebea Co. Ltd., Measuring Components Business Unit, 1-1-1 Katase Fujisawa-shi, JP-251-8531 Kanagawa-ken, Japan

R060/2000-NL1-2009.12 (MAA)
A shear beam load cell - Type: SBZ... and SBU...
Dini Argeo Srl, Via Della Fisica, 20, IT-41042 Spezzano di Fiorano (MO), Italy

R060/2000-NL1-2009.13 (MAA)
A shear beam load cell - Type: SSH
Mettler-Toledo (Changzhou) Precision Instruments Ltd., 5, Middle HuaShan Road, Xinbei District, CN-213022 ChangZhou, Jiangsu, P.R. China

R060/2000-NL1-2009.15 (MAA)
A single point load cell - Type: AMIB .... and AMIBK
Keli Electric Manufacturing (Ningbo) Co. Ltd., No. 199 Changxing Road, Jiangbei District, CN-315033 Ningbo, P.R. China

▶ Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R060/2000-DE1-2008.05 Rev. 1
Strain gauge single point load cell - Type: HLCA...; HLCB...; HLCF...
Hottinger Baldwin Messtechnik GmbH, Im Tiefen See 45, DE-64293 Darmstadt, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Nonautomatic weighing instruments

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

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

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

R076/1992-JP1-2004.01 Rev. 1
Non-automatic weighing instruments - Electronic Balance AUW-D/AUW/AUX/AUY series
Shimadzu Corporation, 1, Nishinokyo-Kuwabara-cho, Nakagyo-ku, JP-604-8511 Kyoto, Japan

R076/1992-JP1-2009.02 (MAA)
Non-automatic weighing instruments - Type: ITX-..., ITB-..., ATX-..., ATB-... series
Ishida Co. Ltd., 44, Sanno-cho, Shogoin, Sakyo-ku, JP-606-8392 Kyoto, Japan

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

National Weights and Measures Laboratory (NWML), United Kingdom

R076/1992-GB1-2009.10 Rev. 1 (MAA)
Angel Series, AP+ Model, non-automatic weighing instrument
CAS Corporation, #19, Ganap-ri, Gwangjuk-Myoun, Yangju-Si, KR-482-841 Gyeonggi-Do, Korea (R.)

R076/1992-GB1-2010.02 (MAA)
Charder MS-4400 Baby Hoist Scale
Charder Electronic Co. Ltd., 103, Kuo Chung Road, Dah Li City, TW-Taichung Hsien 41262, Chinese Taipei

R076/1992-GB1-2010.03 (MAA)
CASTON Series non-automatic weighing instruments
CAS Corporation, #19, Ganap-ri, Gwangjuk-Myoun, Yangju-Si, KR-482-841 Gyeonggi-Do, Korea (R.)

R076/1992-GB1-2010.04 (MAA)
SW Series non-automatic weighing instruments
CAS Corporation, #19, Ganap-ri, Gwangjuk-Myoun, Yangju-Si, KR-482-841 Gyeonggi-Do, Korea (R.)

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

NMi Certin B.V., The Netherlands

R076/1992-NL1-2007.38 Rev. 1
Non-automatic weighing instrument - Type: DS-673(SS)
Shanghai Teraoka Electronic Co. Ltd., Tinglin Industry Developmental Zone, Jinshan District, CN-201505 Shanghai, P.R. China

R076/1992-NL1-2008.22 Rev. 1
Non-automatic weighing instrument - Type: ASP / ATP / AHW / AHC / QSP / QTP / QHW / QHC
Taiwan Scale Mfg. Co. Ltd., 282, Sec. 3, Hoping W. Road, TW-Taipei, Chinese Taipei

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

Physikalisch-Technische Bundesanstalt (PTB), Germany

R076/1992-DE1-2002.05 Rev. 1
Non-automatic electromechanical weighing instrument without lever system - Types: M963, M959, M958, M958x1, M957, MLC956x2, M955
Seca GmbH & Co. kg., Hammer Steindamm 9-25, DE-22089 Hamburg, Germany

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

Swedish National Testing and Research Institute AB, Sweden

R076/1992-SE1-2009.01
Graduated, self-indicating, electronic, multi-interval non-automatic weighing instrument
Ishida Co., Ltd., 44, Sanno-cho, Shogoin, Sakyo-ku, JP-606-8392 Kyoto, Japan

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

DANAK The Danish Accreditation and Metrology Fund, Denmark

R076/1992-DK1-2009.05
Non-automatic weighing instrument - Type: T28
Taiwan Scale Mfg. Co. Ltd., 282, Sec. 3, Hoping W. Road, TW-Taipei, Chinese Taipei

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Non-automatic weighing instruments
R 76-1 (2006), R 76-2 (2007)

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

Office Fédéral de Métrologie METAS, Switzerland

R076/2006-CH1-2009.01 (MAA)
Non-automatic weighing instrument - Type: NewClassic MF
Mettler-Toledo AG, Im Langacher, CH-8606 Greifensee, Switzerland

▶▶

R076/2006-CH1-2009.02 (MAA)
Non-automatic electromechanical weighing instrument - Type: NewClassic SG
Mettler-Toledo AG, Im Langacher, CH-8606 Greifensee, Switzerland

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

R076/2006-GB1-2009.04 (MAA)
Weighing indicator, as part of a non-automatic weighing instrument, designated the 1080
Avery Weigh-Tronix Ltd., Foundry Lane, Smethwick, West Midlands B66 2LP, United Kingdom

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

R076/2006-DE1-2009.02
Non-automatic electromechanical weighing instrument with or without lever system - Type: WM...
Bizerba GmbH & Co. KG, Wilhelm-Kraut-Strasse 65, DE-72336 Balingen, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Automatic level gauges for measuring the level of liquid in fixed storage tanks

R 85 (1998)

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

R085/1998-NL1-2009.02
Automatic level gauge for measuring the level of liquid in storage tanks, model N753X with antennas type N7530 DN 150; type N7530 DN 200; type N7530 DN 250; type N7531 Teflon 1,5 (Rod); type N7533 DN 450 (Parabolic); type N7532 DN 150; type N7532 DN 200; type N7532 DN 250; type N7532 DN 300*
Varec Inc., 5834 Peachtree Corners East, Norcross GA 30092, United States

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Fuel dispensers for motor vehicles

R 117 (1995) + R 118 (1995)

▶ Issuing Authority / *Autorité de délivrance*
International Metrology Cooperation Office, National Metrology Institute of Japan (NMIJ) National Institute of Advanced Industrial Science and Technology (AIST), Japan

R117/1995-JP1-2009.01
Fuel dispenser for motor vehicles, Tatsuno SUNNY-G II series
Tatsuno Corporation, 2-12-13, Shibaura Minato-ku, JP-108-8520 Tokyo, Japan

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

R117/1995-NL1-2009.01 Rev. 1
Fuel dispenser for motor vehicles - Type: Quantium XXXX
Tokheim Group S.A.S., Paris-Nord 2, 5 rue des Chardonnerets, BP 67040, Tremblay en France, FR-95971 Roissy Charles de Gaulle Cedex, France

R117/1995-NL1-2009.02
Fuel dispenser for motor vehicles - Type: Quantium XXXX
Tokheim, BP 268, FR-14013 Caen Cedex, France

R117/1995-NL1-2009.02 Rev. 1
Fuel dispenser for motor vehicles - Type: Quantium XXXX
Tokheim Group S.A.S., Paris-Nord 2, 5 rue des Chardonnerets, BP 67040, Tremblay en France, FR-95971 Roissy Charles de Gaulle Cedex, France

R117/1995-NL1-2009.03
Fuel dispenser for motor vehicles - Type: Quantium XXXX
Tokheim, BP 268, FR-14013 Caen Cedex, France

R117/1995-NL1-2009.03 Rev. 1
Fuel dispenser for motor vehicles - Type: Quantium XXXX
Tokheim Group S.A.S., Paris-Nord 2, 5 rue des Chardonnerets, BP 67040, Tremblay en France, FR-95971 Roissy Charles de Gaulle Cedex, France

OIML CERTIFICATE SYSTEM

List of OIML Issuing Authorities (by Country)

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

AUSTRALIA

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

AUSTRIA

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

BELGIUM

BE1 - Metrology Division	R 76	R 97	R 98

BRAZIL

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

BULGARIA

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

CHINA

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

CZECH REPUBLIC

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

DENMARK

DK1 - The Danish Accreditation and Metrology Fund	R 50	R 51	R 60	R 61	R 76	R 98
	R 105	R 106	R 107	R 117/118	R 129	R 134
DK2 - FORCE Technology, FORCE-Dantest CERT	R 49					
DK3 - DELTA	**R 50**	**R 51**	**R 60**	**R 61**	**R 76**	**R 106**
	R 107	**R 129**	**R 134**			

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 85
R 88	R 97	R 98	R 99	R 102
R 104	R 105	R 106	R 107	R 110
R 114	R 115	R 117/118	R 126	R 128
R 129	R 133	R 136		

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 21	R 31	R 49	R 50	R 51
R 60	R 61	R 76	R 81	R 85
R 97	**R 99**	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 49**	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	R 134

SLOVAKIA

SK1 - Slovak Legal Metrology (Banska Bystrica)	R 49	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 - Federal Office of Metrology METAS	R 16	R 31	R 49	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

VIETNAM

VN1 - Directorate for Standards and Quality (STAMEQ)	R 76

The OIML is pleased to welcome the following new

CIML Members

- **Islamic Republic of Iran:**
  Mr. Hossein Azareshi
- **Italy:**
  Mr. Paolo Francisci
- **Turkey:**
  Mr. Bayram Tek

OIML Meetings

OIML TC 8/SC 7 Gas metering

Meeting scheduled for 30 June–2 July 2010 - Verispect (Delft, The Netherlands)

45th CIML Meeting

21–24 September 2010 - Orlando (Florida, USA))

TC 1 Terminology

Meeting scheduled for 29–30 September 2010 - GUM (Warsaw, Poland)

TC 3/SC 5 Conformity assessment

Meeting scheduled for October 2010 (Dates and venue to be confirmed shortly)

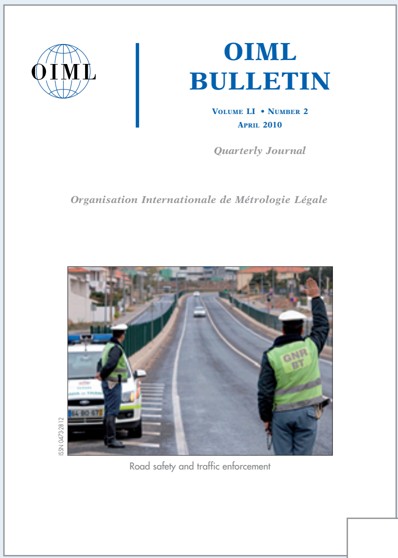
Committee Drafts

Received by the BIML, 2010.01 – 2010.02

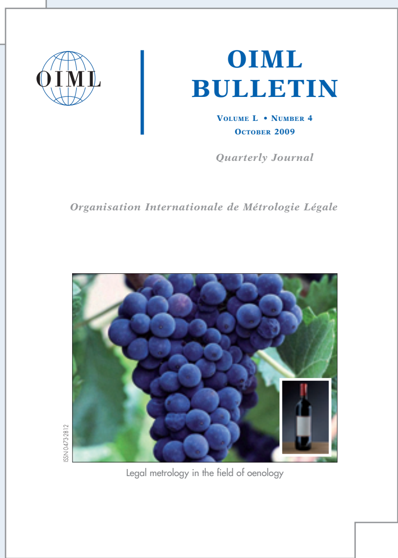
None

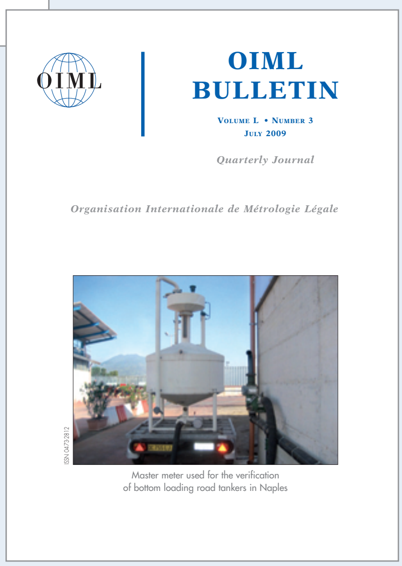
Call for papers

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



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





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

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

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