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Mr. Zhi Shuping, Minister of AQSIQ
and Mr. Stephen Patoray, BIML Director
open the first OIML Pilot Training Center in P.R. China

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■ Contents

OIML
BULLETIN
VOLUME LVII • NUMBER 4
OCTOBER 2016

■ technique

■ evolutions

■ update

FIRST OIML PILOT TRAINING CENTER IN P.R. CHINA

SEE EDITORIAL AND PAGES 22-25

■ Editorial

Stephen Patoray
BIML Director

OIML Pilot Training Center events in P.R. China

It was a great honor for me to participate in both the first and the second OIML Pilot Training Center (OPTC) Sessions in China this summer.

The OPTC is the realization and continuation of a vision that was first suggested by the CEEMS Advisory Group, chaired by Mr. Pu Changcheng. As this Training Center has now become a reality, it is a very significant step towards enabling the OIML and the Advisory Group to fulfill several of the major objectives contained in the Resolution on CEEMS which was passed at the 50th CIML meeting in Arcachon in 2015.

Legal metrology is nearly as old as civilization but the equipment and the technology involved are constantly changing. One item that is always discussed at all Regional Legal Metrology Organization (RLMO) meetings and also with nearly all OIML Members is training. It is not only CEEMS but all OIML Members that need to maintain a well-trained staff, which is why this type of Training Center is so important.

The topic of the first OPTC session was training on NAWIs (see report on page 22). The importance of this topic can easily be seen by the large number of participants from all over the globe who participated in these events.

The topic of the second OPTC session was *Legal Metrology Management System* (see report on page 24), which primarily focused on the content of OIML D 1 *Considerations for a Law on Metrology.* While this OIML Document is only one of over thirty International Documents published by the OIML, it does provide several fundamental examples of the value of metrology:

- Metrology facilitates fair trade
- Metrology drives innovation
- Metrology supports regulation
- Metrology advances the protection of citizens
- Metrology helps meet societal goals

All of these examples and many more are tied to a national quality infrastructure (QI) which refers to all aspects of metrology – standardization, testing, and quality management including certification and accreditation. This involves both public and private institutions and the regulatory framework within which they operate.

With the opening of this OIML Pilot Training Center in China, it is my hope that this will be a model for other OIML Member States who will now follow in the footsteps of the OIML Advisory Group, the AQSIQ and NIM to set up similar Pilot Training Centers in other parts of the world. ■

VEHICLE WEIGHING

High speed WIM system for highway vehicle weighing

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Abstract

Dynamic weighing devices are designed to measure the weight of a vehicle while it is moving over a scale at different speeds. So unlike static scales, there is no need to stop the vehicle for accurate weighing; this makes the weighing process more efficient. One such dynamic weighing system is Weigh-In-Motion (WIM) vehicle scales, which estimate vehicle axle loads without affecting the flow of traffic. WIM technologies allow trucks to be weighed in the traffic flow, without any disruption to operations.

WIM scales are used in two categories: high speed and slow speed weighing systems. Slow speed WIM scales are used in law enforcement to screen trucks entering a weigh station; legally loaded vehicles are allowed back onto the road while over-weight trucks are directed to the static scales.

WIM scales are also used in virtual weighing stations to monitor traffic, identifying those vehicles with weight violations and sending their image and weight information wirelessly to an officer located downstream of the scale site. Still other in-motion vehicle scales are used to weigh bulk commodities where real-time information on the flow of material is required.

1 Introduction

Good roads are important for the socio-economic development of any country and funds to construct and maintain roads to good standards are very limited. Therefore, preservation of this investment is critical. It is estimated that more than 30 % of heavy vehicles that use the Iranian road network are overloaded. Overloading relative to legal load limits is known to be fairly widespread and is responsible for the significant increase in pavement (road) deterioration. Overloading has resulted in a very serious and costly maintenance problem (see Figure 1).

Trucks exceeding the legal weight limits increase the risk of traffic accidents and damage to the infrastructure (pavements and bridges). They also result in unfair competition between transport modes and companies. It is therefore important to ensure truck compliance with weight regulations. New WIM technologies are being developed for more efficient overload screening and enforcement. Much progress has been made recently to improve and implement WIM systems, which can contribute to the safer and more efficient operation of trucks [12].

Pavements are engineered structures placed on natural soils and designed to withstand traffic loading and climate changes with minimal deterioration and in the most economical way [1]. The majority of modern pavement structures may be classified as flexible or rigid pavement structures:

- a flexible pavement consists of a surface layer constructed of flexible ingredients (typically asphalt/concrete) over a granular base and sub-base layers placed on the existing, natural soil; and
- a rigid pavement is a pavement structure that deflects very little under loading because of the high stiffness of the cement/concrete used in the construction of the surface layer. Rigid pavements can be further categorized depending on the types of joints used and the use of steel reinforcement [2].

Each of these pavement types has specific failure mechanisms and each failure mechanism is caused by specific factors. Examples of such failure mechanisms include fatigue damage and roughness of rigid and flexible pavements, and rutting of flexible pavements. These failure mechanisms are caused by heavy vehicle loads, climate change, material properties, and inadequate layer thicknesses [1]. Among these factors, heavy vehicle loads are the major cause of damage. The size and configuration of vehicle loads together with the environment have a significant effect on induced tensile stresses within flexible pavements [3]. Heavy vehicle loads subject the pavement to high stress, which causes damage. However, not all trucks have the same damaging effects; the damage to the road depends on the speed of the vehicle, wheel loads, number and location of axles, load distributions, type of suspension, number of wheels, tire types, inflation pressure and other factors [2].

A correct estimation of truck-induced damage is important for regulators since the fees and penalties applied to truck operators for using the roads are related to the damage caused to the roads. Regulators need to attribute costs to vehicle operators in accordance with truck-induced damage. Correct evaluation of truck damage also helps highway engineers to optimize road design and maintenance activities [4].

In recent years, several studies have estimated truck damage by computing the responses (stresses, strains and deflections) of road surfaces under heavy vehicle loads using mechanical approaches [5]. One of the concepts introduced for measuring road damage from axle loads is ESAL, which is the acronym for Equivalent Single Axle Load. ESAL is a concept developed from data collected at the American Association of State Highway Officials (AASHO) Road Test to establish a damage relationship for comparing the effects of axles carrying different loads. The reference axle load is an 18 000 lb. (8 164 kg) single axle with dual tires.

ESALs is a cumulative traffic load summary statistic. The statistic represents a mixed stream of traffic of different axle loads and axle configurations predicted over the design or analysis period and then converted into an equivalent number of 18 000 lb. single axle loads summed over that period. ESAL is an illustration of the effects of overloading on road surface damage. According to Tomas Winnerholt of the Swedish Road Administration, it was clarified that the fourth power rule has been used:

$$ESAL = \sum_{n=1}^{i} \left(\frac{W_i}{10}\right)^4 . k_i \quad (1)$$

where

i = number of axles or axle groups
W_i = axle (group) weight for axle (group) i (ton)
k_i = effect reduction factor for axle (group) i
k = 1 for single axle
$k = (10/18)^4 = 0.0952$ for tandem axle
$k = (10/24)^4 = 0.0302$ for tri-axle

Therefore, by using WIM systems, the load of each axle, the vehicle gross weight, and also the ESAL for each vehicle are measured very accurately.

2 High speed WIM system designed for highway vehicle weighing

A range of high speed weighing in motion scales utilizing load cells and piezoelectric technologies is available; these scales meet or exceed ASTM E1318-02 performance requirements and can be used with a variety of peripherals such as over-height detectors, off-scale sensors, image capture cameras for number plate recognition, and other peripherals. High speed WIM means that sensors installed in one or more traffic lanes measure axle and vehicle loads while these vehicles are traveling at their normal speed in the highway traffic flow. HS-WIM allows the weighing of almost all trucks traveling along a road section, and enables either individual measurements or statistics to be recorded [9].

The system presented in this article is composed of two platforms that provide an accurate dynamic weight estimation (the per-axle weight and gross weight of vehicles while they are travelling at highway speed), and speed calculation. It detects axle-spacing so that vehicles can be identified by class.

Each platform is mounted in a prefabricated concrete foundation which is installed in a vault flush with the road surface. Each platform is equipped with four load cells and the system is completely waterproof and functions in all weather and operating conditions, including all cables and drain access. Because of its specific design, there is no need to modify road surfaces; it aligns with road inclinations (see Figure 2).

Some other key features of this system are:

- long term stability (IP68 rating load cells);
- speed range 5 to 200 km/h (3 to 124 mph);
- working temperature range –30 °C to +80 °C;
- using very stable load cells with 23 kHz natural frequencies makes it possible to weigh in very low or high speed situations;

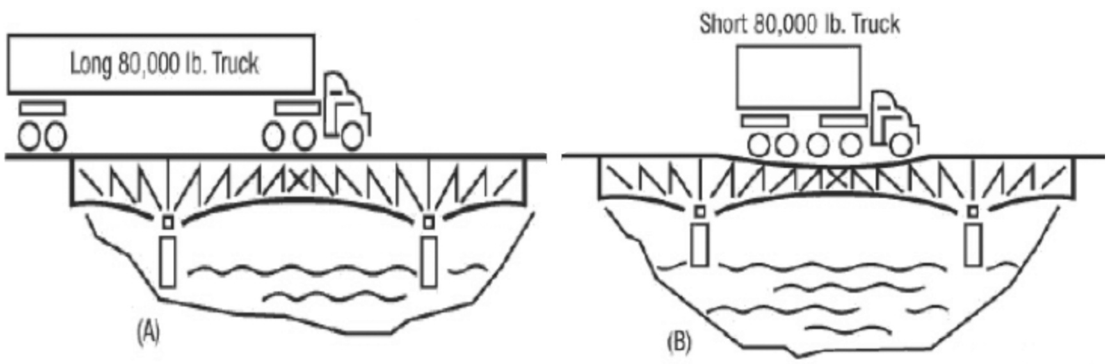

Figure 1: Effect of vehicle overloading on our roads

Figure 2: The WIM technology is composed of two platforms

- requires little maintenance; servicing is fast and easy. Its structure is designed in a uniform block that can be serviced from the roadside with hand tools;
- using two platforms for each lane makes it possible to weigh with less than 3 % error for gross vehicle weight (and speed);
- combining this system with a stereo vision camera provides greater accuracy for speed estimation;
- image capturing with LPR (License Plate Reader) and USDOT number readers using OCR (Optical Character Recognition) technology;
- in-motion vehicle dimensioning;
- designed to comply with ASTM E1318 requirements [11].

3 Data analysis and weight estimation methods

The very high sampling rate (2.5 mega samples per second) of this system provides more than enough data even for 240 km/h vehicle speed. Data for each platform at every single second is:

$2.5 \times 10^6 \times 24$ bit = 6 Mbit/s (mega bit data per second).

For four platforms simultaneously:

$4 \times 6 = 24$ Mbit/sec

Figure 3 shows sample data from a two-axle vehicle travelling at 195 km/h after removing high frequency noise from the main signal.

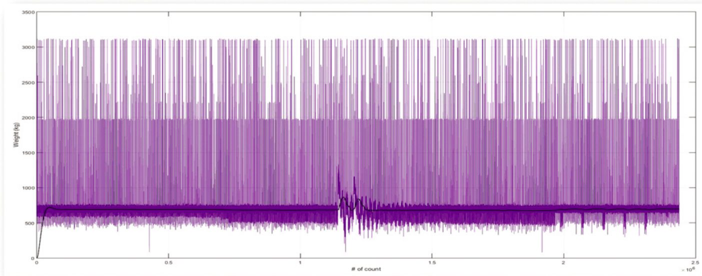

Figure 3: Sample data from a two-axle vehicle

One sample data from TEC-WIM system for a five-axle heavy vehicle (1-2-2) is shown in Figure 4.

For an accurate weighing estimation in the WIM system, the empirical mode decomposition (EMD) approach is used. Hilbert-Huang transform is widely used in signal analysis. However, due to its inadequacy in estimating both the maximum and the minimum values of the signals at both ends of the range, traditional HHT is likely to produce boundary errors in the empirical mode decomposition (EMD) process [6, 7].

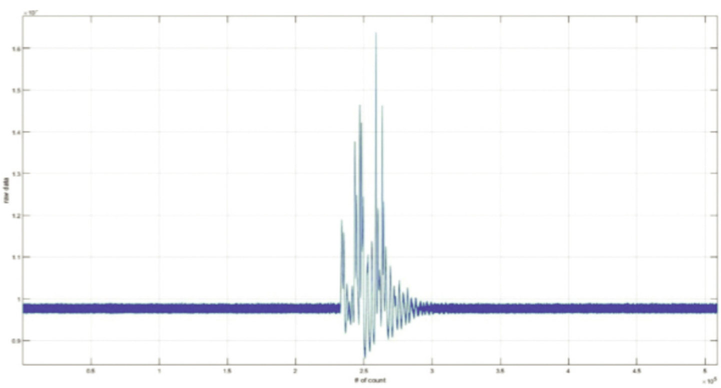

Figure 4: Sample data from the TEC-WIM system for a five-axle heavy vehicle

To overcome this deficiency, an enhanced empirical mode decomposition algorithm was proposed for processing complex signals. A technique was developed to obtain the extreme points of raw data from the WIM system by introducing the linear extrapolation into the EMD. HHT is useful to analyze nonstationary signals, and EMD is the core of HHT, which directly affects the final analysis; however, there are some problems (such as end effect, envelope fitting) that need to be solved in EMD.

The main idea of empirical mode decomposition is an iterative sifting process that decomposes a given signal into a set of intrinsic mode functions (IMFs), which are simple oscillatory functions with varying amplitude and frequency and hence have the following properties:

(a) Throughout the whole length of a single IMF, the number of extrema and the number of zero crossings must either be equal or differ at most by one (although these numbers could differ significantly from the original data set).

(b) At any data location, the mean value of the envelope defined by the local maxima and the envelope defined by the local minima are zero.

Given these two properties of an IMF, the sifting process for extracting an IMF from a given signal (*t*) is described as follows:

(1) Identify all the local extrema (the combination of both maxima and minima) and connect all these local maxima (x_{max}) and minima (x_{min}) with a cubic spline as the upper (lower) envelope.

(2) The mean of the two envelopes is subtracted from the data to obtain their difference:

$$h(t) = x(t) - \frac{x_{max} - x_{min}}{2} \tag{2}$$

Taking $h(t)$ as the new input data, repeat steps 1 and 2 iteratively until the envelopes are symmetric with respect to zero mean under certain criteria. The final $h(t)$ is designated as $c(t)$, and the first IMF satisfies the criteria of an intrinsic mode function.

The residue $r(t) = x(t) - c(t)$ is then treated as the new data subject of the sifting process as described above, yielding the second IMF from $r(t)$: the procedure continues until either the recovered IMF or the residual data are small enough, which means the integrals of their absolute values or the residual data have no turning points. Once all of the wavelike IMFs are subtracted from the data, the final residual component represents the overall trend of the data. At the end of this process, the signal (*t*) can be expressed as follows:

$$x(t) = \sum_{i=1}^{N} c_i(t) + r_N(t) \tag{3}$$

Then we use B-spline curve fitting for polynomial estimation (see Figure 5).

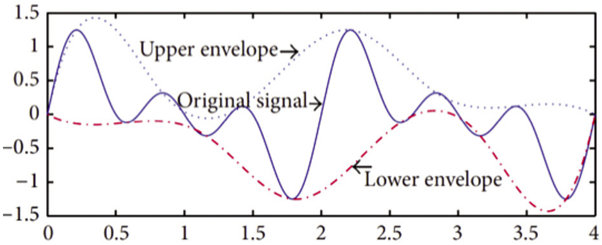

Figure 5: B-spline curve fitting for polynomial estimation

4 Cubic spline curve fitting on data

When a vehicle travels on a WIM system, the force its tires exert on the ground is equal to the static axle weight (which is regarded as the real axle weight in practice). When the vehicle moves, the tire force exerted on the ground contains dynamic forces in addition to the static axle weight. The dynamic forces form the interference to the real axle weight. The road surface roughness, the load of the vehicle and its mass distribution, and the properties of the suspensions and tires contribute to the dynamic forces [10]. The maximum magnitude of the dynamic forces can reach 30 % of the real axle weight. The lowest frequency of the dynamic forces can reach 1.5 Hz. The magnitudes and frequencies of the dynamic forces vary with the vehicle speed, road surface roughness, vehicle suspension, and tire pressure. Assuming that the dynamic force signals are sinusoidal, the force exerted on the weighing platform can be described as:

$$f(t) = w + \sum_{i=1}^{n} A_i \sin(2\pi f_i\, t + \emptyset_i) \tag{4}$$

where

t is the sampling time,
w is the static axle weight,
n is the number of dynamic forces, and
A_i, f_i, and ϕ_i are the amplitude, frequency and initial phase of the i-th dynamic force.

The estimation of the static axle weight can be calculated from:

Weight = Residue × Const

where Const is a constant (axle weight/signal voltage, in kg/mV) proportionality coefficient for the WIM system.

5 TEC-WIM software output

The WIM software automates the entire weighing process. It is capable of identifying:

- vehicle class;
- gross vehicle weight;
- each axle weight;
- ESAL;
- axle distances;
- vehicle speed;
- date and time of pass; and
- it also provides detailed data to produce a full array of reports for record keeping and data analysis. Measured weights can be compared to legal limits for enforcement purposes, as well as generating tickets on site.

6 Discussion and conclusion

The results have shown that the dynamic impact load of wheels can be used to estimate the static weight of vehicles very accurately. In this system there is no need to stop vehicles and disrupt the flow of traffic. Adaptive signal processing is used to eliminate high frequency noises and environment noises. Then accurate weight values are extracted from the raw data. This system showed that the average error for gross vehicle weight was less than 3 % tested on most sites. ■

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SPHERICAL TANKS

Evaluation of the uncertainties of the geometrical parameters and capacity of spherical tanks

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1 Introduction

The calibration of spherical tanks by means of the electro-optical distance-ranging (geodetic) measuring method using laser scanners and electronic scanning total stations is unequalled in terms of speed, accuracy and cost [8]. But this method will only be effective enough if we have mathematically strict and objective methods for the evaluation of the tanks' geometrical parameters and capacity as well as their uncertainty (for spherical tanks described in [7]).

OIML R 71 [1] specifies that the maximum permissible uncertainty for the capacity of spherical tanks calculated according to the GUM [3] for k = 2, shall be equal to 0.5 %. The correct evaluation of the uncertainty of their capacity is very important when performing the verification. References [4, 1965] and [5, 1992] do not contain any information about this method. The new version of [4, 2012] is not available and [5, 1992] was withdrawn. Therefore, the goal of this article is to eliminate this shortcoming and to apply the most efficient mathematical method for solving such problems - evaluation by the least square method (LSM).

The general principles for solving these problems by LSM using all types of tanks (using vertical tanks as an example) were set out by the authors of this publication in [8, 2015].

In [7, 2013] the processing method of the geometrical tank parameters by points coordinates on the spherical tank's wall surface is described. Also, we are talking about the evaluation of their uncertainty based on statistical measurement data.

The uncertainty of the liquid volume in the spherical tanks depends on the measurement uncertainty of the liquid level by an automatic level gauge (ALG). The systematic bias graduation table of the tank relative to the ALG measurement liquid level is of great importance to the decision. References [1, 2, 4, 5 and 6] do not contain a method of decision of the systematic bias. The solution to this problem is described in [7] (process of spherical tank calibration) and in this article.

2 Evaluation of a spherical tank's geometrical parameters not using the covariance matrix of the point coordinates at the tank wall surface

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

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

For spherical tanks:

$$R = \sqrt{(x_i - x_o)^2 + (y_i - y_o)^2 + (z_i - z_o)^2}$$

where:

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

$\tau_1 ... \tau_k$ are the defined geometrical parameters – R, x_o, y_o, z_o for the spherical tank surface – the mid-internal radius and coordinates center of the tank;

$k = 4$ is the quantity of the determined geometrical parameters of the spherical tank;

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

For spherical tanks the absolute height is the vertical distance from any horizontal flatness to the point with number i.

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

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

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

where:

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

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

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

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

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

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

where:

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

V is the correction matrix to the measured coordinate points;

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

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

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

l is the constant terms vector of the correction equation.

Then, equations (2) for spherical tanks are given by:

$$\vartheta_i^{(g)} = b_{i1} \cdot \delta R^{(g)} + b_{i2} \cdot \delta x_o^{(g)} + b_{i3} \cdot y_o^{(g)} + b_{i4} \cdot z_o^{(g)} + l_i^{(g)} \qquad (4)$$

where:

$$b_{i1} = 1; \quad a_{i1} = b_{i2} = -\frac{x_j - x_o^{(g)}}{R^{(g)}}; \qquad (5)$$

$$a_{i2} = b_{i3} = -\frac{y_i - y_o^{(g)}}{R^{(g)}}; \quad a_{i3} = b_{i4} = -\frac{z_i - z_o^{(g)}}{R^{(g)}};$$

$$l_i^{(g)} = R^{(g)} - \sqrt{\left(x_i - x_o^{(g)}\right)^2 + \left(y_i - y_o^{(g)}\right)^2 + \left(z_i - z_o^{(g)}\right)^2}.$$

where:

$R^{(g)}, x_o^{(g)}, y_o^{(g)}, z_o^{(g)}$ are the initial values of the defined geometrical parameters of the spherical tank;

g is the number of approximation.

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

$$\sum_{i=1}^{n} P_i \cdot \vartheta_i^2 = min \qquad (6)$$

where P_i are the weights of the radial deviations.

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

$$\frac{1}{P_i} = Q_i = \left| a_{i1} a_{i2} a_{i3} \right| \cdot \begin{vmatrix} q_{x_i} K_{x_i y_i} K_{x_i z_i} \\ K_{y_i x_i} q_{y_i} K_{y_i z_i} \\ K_{z_i x_i} K_{z_i y_i} q_{z_i} \end{vmatrix} \cdot \begin{vmatrix} a_{i1} \\ a_{i2} \\ a_{i3} \end{vmatrix}^T \qquad (7)$$

$$P_i = \frac{1}{Q_i} = (A_i q_{xyz}^i A)^{-1} \qquad (8)$$

where:

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

$K_{x_i y_i}$, $K_{x_i z_i}$, $K_{y_i x_i}$, $K_{y_i z_i}$, $K_{z_i x_i}$, $K_{z_i y_i}$ are the covariance (correlation) moments;

q_{xyz}^i is the covariance (correlation) coordinate matrix which is calculated using formula (12) [8];

$A_i = \left| a_{i1} a_{i2} a_{i3} \right|$ is the partial derivative matrix of equation (1) [8] by the measured coordinates (see equations (2) and (3) [8]).

Scanning geodetic instruments create a coordinate file without saving the results of the direct measurement of the length and angle (the standard deviation of the coordinates in the manufacturer's specification is, for example, 2 mm, but is not defined for the length and angle). Therefore, this gives:

$$q_{x_i} = q_{y_i} = q_{z_i} = 1;$$

$$K_{x_i y_i} = K_{x_i z_i} = K_{y_i x_i} = K_{y_i z_i} = K_{z_i x_i} = K_{z_i y_i} = 0$$

If in theory for spherical surfers $P_i = 1$, in practical for spherical tanks this is not exact, but this fact may be ignored.

For another surface, for example a cone or ellipsoid, calculation of the weight using formulas (7) and (8) is necessary.

Taking into account that the parametric equations of corrections (2) (for spherical tanks (4)) are much greater than the determined geometrical parameters, one may build a normal equation system, which in the matrix, taking into account that $B^T \cdot \vartheta = 0$, gives:

$$B^T \cdot B \cdot \delta\tau + B^T \cdot l = 0 \text{ or } N \cdot \delta\tau + L = 0 \quad (9)$$

Corrections to the initial values of the geometrical parameters determined in the matrix are obtained by solving the system of linear equation (9) by the formula:

$$\delta\tau = -N^{-1} \cdot L = -Q \cdot L \quad (10)$$

where:

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

When inserted in formula (2) (for spherical tanks (4)), the radial deviations fit into the main principles of LSM:

$$\sum_{i=1}^{n} \vartheta_i^2 = min \quad (11)$$

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

$$\sigma_\vartheta = \sqrt{\frac{\sum_{i=1}^{n} \vartheta_i^2}{n-k}} \quad (12)$$

The defined parameters, their covariance matrix and the standard deviation of the main defined tank geometrical parameter – mid internal radius and center coordinates – are:

$$R^{(g+1)} = R^{(g)} + \delta R^{(g)}; \quad x_o^{(g+1)} = x_o^{(g)} + \delta x_o^{(g)}; \ (13)$$

$$y_o^{(g+1)} = y_o^{(g)} + \delta y_o^{(g)}; \quad z_o^{(g+1)} = z_o^{(g)} + \delta z_o^{(g)}; \ (14)$$

$$K_{\delta\tau} = \sigma_\vartheta^2 \cdot Q;$$

$$u_A(R) = \sigma_R = \sigma_\vartheta \sqrt{Q_{11}}; \ u_A(z_o) = \sigma_{z_o} = \sigma_\vartheta \sqrt{Q_{44}} \quad (15)$$

where:

Q_{11} and Q_{44} are the first and fourth diagonal components of the inverse matrix to the normal equation matrix.

The standard radial deviation σ_ϑ, calculated by formula (12), comprises not only geodetic measurement uncertainties. It also comprises real surface deviations from the mathematically correct shape. They appear when the tank is manufactured and due to deformations caused by its use. Based on their experience in calibration, the authors wish to state that the second component exceeds the first by 5–10 times.

3 Measurement model for the spherical tank total and interval capacities

The measurement model of the total and interval capacities of the spherical tank is:

$$V_{H_f} = \psi_V(\tau_1 ... \tau_k, H_f) = \pi \cdot H_f^2 \cdot (\bar{R} - H_f/3) \quad (16)$$

where:

H_f is the *dip height* (3.19 [2]) – the height of the liquid in the tank relative to the *dipping datum point* (3.16 [2]) – the bottom point of the approximation spherical surface;

$\bar{R}$ is the adjusted radius of the spherical tank;

f is current number for which the interval capacity is calculated;

$\pi = 3.1415926…$.

For spherical tanks almost all corrections may be entered for capacities and volume through the adjusted radius of the tank by the formula:

$$\overline{R} = R + \Delta R_t + \Delta R_P - \Delta R_w - \Delta R_c + \Delta R_D + \Delta R_A \quad (17)$$

where:

R is the radius of the tank which is calculated using formula (13);

$\Delta R_t = \lambda \cdot (t_o - t) \cdot R$ is the correction for the temperature of the tank wall at the calibration;

$\Delta R_P = \frac{(P_o - P) \cdot R^2}{E \cdot \Delta R_w}$ is the correction for the internal pressure in the tank at the calibration;

ΔR_w and ΔR_c are the thickness of the tank wall and their coating respectively if measurements were performed externally;

λ is the linear thermal expansion coefficient of the material (for steel – $12.5 \cdot 10^{-6}$ K^{-1});

t_o is the temperature in operation (for example, 15 °C or 20 °C);

t is the average temperature of the tank wall at the calibration;

P_o is the pressure in the tank at the temperature in operation (for example, 15 °C or 20 °C);

P is the mid pressure in the tank at the calibration;

E is the modulus elasticity of the material (for steel – $2.1 \cdot 10^{11}$ H/m^2);

ΔR_D is the constant correction of the geodetic instrument to the measuring distances (this correction may be equal to 0, but its uncertainty is not equal to 0);

ΔR_A is the atmospheric correction to the measuring distances due to the temperature, pressure and humidity of the air (in extreme cases this correction is not better than 0.003 % per measuring distance).

The dip of the liquid in the tank's relative dipping datum point – the bottom point of the approximation spherical surface is calculated by formulas (18):

$$H_f = H_T - L_f; \quad H_T = (z_T - z_o) + \Delta z_t + \Delta z_P + \overline{R} \quad (18)$$

where:

H_T is the height of the *upping reference point* (3.17 [2]) – the height of the *reference flange* [6] for *automatic level gauge (*ALG*)* (3.1 [2]) or (3.11 [1]) relative bottom point of the approximation spherical surface;

z_T is the measured absolute height of the flange for ALG;

z_o is the absolute height center of the approximation spherical surface calculated by formulas (14);

L_f is the *ullage* (3.20 [2]) – in this case the specified vertical distance from the reference flange for the ALG to the level of the liquid;

$\Delta z_t = \lambda \cdot (t_o - t) \cdot (z_T - z_o) \approx \Delta R_t$ is the correction for the temperature of the tank wall at the calibration;

$\Delta z_P \approx \Delta R_P$ is the correction for the internal pressure in the tank at the calibration, because the reference flange is not far from the surface and the vertical axis of the spherical tank.

If we denote $\overline{T} = (z_T - z_o) + \Delta R_t + \Delta R_P$, we obtain $H_f = \overline{T} - L_f + \overline{R}$ and according to formula (16) the adjusted spherical tank's interval capacity below height H_f is:

$$\overline{V}_{H_f} = V_{H_f} + \Delta V_{H_f};$$

$$\overline{V}_{H_f} = \pi \cdot ((\overline{T} - L_f)^2 \cdot \overline{R} + ((\overline{T} - L_f) + \overline{R})^3 / 3) + \Delta V_{H_f} \quad (19)$$

where:

$\overline{T}$ is the adjusted vertical distance between the reference flange and the center of the spherical tank;

ΔV_{H_f} is the terrain corrections below height H_f.

Taking into account a large number of points whose coordinates are determined by the method of laser scanning on the tank surface, it is proposed to calculate the terrain corrections ΔV_{H_f} using formulas (20) and (21):

$$\overline{\vartheta}_{H_f} = \frac{\sum_{i=1}^{n_{H_f}} \vartheta_i}{n_{H_f}}; \quad \Delta V_{H_f} = S_{H_f} \cdot \overline{\vartheta}_{H_f}; \quad (20)$$

$$S_{H_f} = \psi_S(\tau_1 ... \tau_k, H_f) = 2 \cdot \pi \cdot \overline{R} \cdot H_f \quad (21)$$

where:

S_{H_f} is the tank's surface area below height H_f;

$\overline{\vartheta}_{H_f}$ is the mid radial deviation of the tank's wall below height H_f (ϑ_i is calculated by (4));

n_{H_f} is the number of points on the tank's surface below height H_f, the coordinates of which were determined.

Theoretically the range for calculation of the spherical tank's interval capacity is calculated by formula (22):

$$H_{\substack{\max \\ \min}} = \overline{R} \pm \sqrt{\overline{R}^2 - (x_T - x_o)^2 - (y_T - y_o)^2} \quad (22)$$

where:

x_T, y_T are horizontal coordinates of the reference flange from the geodetic observation;

x_o, y_o are the horizontal coordinates of the spherical tank's center calculated by formulas (13) and (14).

The total capacity is necessary to calculate the gas phase volume:

$$\overline{V}_{tot} = 4 \cdot \pi \cdot \overline{R}^3 / 3 \quad (23)$$

4 Evaluation of the uncertainty of the spherical tank total and interval capacities

The evaluation of the standard deviation (A-type standard uncertainty) unimproved by the spherical tank interval capacity below height H_f is calculated considering correlation by formula (24):

$$u_A^2(V_{H_f}) = \sigma_{V_{H_f}}^2 = F_{V_{H_f}} \cdot K_{\delta\tau} \cdot F_{V_{H_f}}^T = \sigma_\vartheta^2 \cdot F_{V_{H_f}} \cdot Q \cdot F_{V_{H_f}}^T \quad (24)$$

where:

$$F_{V_{H_f}} = \left| \frac{\partial \psi_V}{\partial R} \; \frac{\partial \psi_V}{\partial x_o} \; \frac{\partial \psi_V}{\partial y_o} \; \frac{\partial \psi_V}{\partial z_o} \right| = \left| \pi H_f^2 \quad 0 \quad 0 \quad \pi H_f (2R - H_f) \right| \quad (25)$$

is the partial derivatives vector from function (16) by the tank's geometrical parameters R and z_o.

Formula (24) excludes correlation:

$$u_A(V_{H_f}) = \pi \sqrt{H_f^4 u_A^2(R) + H_f^2 (2R - H_f)^2 u_A^2(z_o)} \quad (26)$$

The evaluation of the standard deviation (A-type standard uncertainty) of the spherical tank's surface area below height H_f is calculated considering correlation by formula (27):

$$u_A^2(S_{H_f}) = \sigma_{S_{H_f}}^2 = F_{S_{H_f}} \cdot K_{\delta\tau} \cdot F_{S_{H_f}}^T = \sigma_\vartheta^2 \cdot F_{S_{H_f}} \cdot Q \cdot F_{S_{H_f}}^T \quad (27)$$

where:

$$F_{S_{H_f}} = \left| \frac{\partial \psi_S}{\partial R} \; \frac{\partial \psi_S}{\partial x_o} \; \frac{\partial \psi_S}{\partial y_o} \; \frac{\partial \psi_S}{\partial z_o} \right| = \left| 2\pi H_f \quad 0 \quad 0 \quad 2\pi R \right| \quad (28)$$

is the partial derivatives vector from function (21) by the tank's geometrical parameters R and z_o.

Formula (27) excluding correlation gives:

$$u_A(S_{H_f}) = \pi \sqrt{(2H_f)^2 u_A^2(R) + (2R)^2 u_A^2(z_o)} \quad (29)$$

The standard deviation of the mid radial deviation of the tank's wall below height H_f, which is given in formulas (20), is calculated by formula (30):

$$u_A(\overline{\vartheta}_{H_f}) = \sigma_{\overline{\vartheta}_{H_f}} = \sqrt{\frac{\sum_{i=1}^{n_{H_f}} (\vartheta_i - \overline{\vartheta}_{H_f})^2}{n_{H_f} \cdot (n_{H_f} - 1)}} \quad (30)$$

The standard deviation (A-type uncertainty) of the terrain correction ΔV_{H_f} is calculated by formula (31):

$$u_A(\Delta V_{H_f}) = \sqrt{\overline{\vartheta}_{H_f}^2 \cdot u_A^2(S_{H_f}) + S_{H_f}^2 \cdot u_A^2(\overline{\vartheta}_{H_f})} \quad (31)$$

The A-type uncertainty of the adjusted tank interval capacity below height H_f is calculated using formula (32):

$$u_A(\overline{V}_{H_f}) = \sqrt{u_A^2(V_{H_f}) + u_A^2(\Delta V_{H_f})} \quad (32)$$

The B-type and combined uncertainty of the spheres mid radius and distance $\overline{T}$ are calculated by formulas (33) – (36):

$$u_B(\overline{R}) = \sqrt{u^2(\Delta R_t) + u^2(\Delta R_P) + u^2(\Delta R_w) + u^2(\Delta R_c)}\,; \quad (33)$$

$$u_B(\overline{T}) = \sqrt{u^2(z_T) + u^2(\Delta R_t) + u^2(\Delta R_P)}\,; \quad (34)$$

$$u_c(\overline{R}) = \sqrt{u_A^2(R) + u_B^2(\overline{R})}\,; \quad (35)$$

$$u_c(\overline{T}) = \sqrt{u_A^2(z_o) + u_B^2(\overline{T})} \quad (36)$$

Evaluation of the total and interval capacities of the spherical tank and its B-type uncertainty due to important corrections such as corrections for tank deformations due to the working pressure in the tank, corrections for tank deformation due to temperature variations and others have been included.

$$u(\Delta R_t) = \lambda \cdot R \cdot u(t_o - t)\,; \quad (37)$$

$$\frac{u(\Delta R_P)}{\Delta R_P} = \sqrt{\left(\frac{u(P)}{P}\right)^2 + \left(\frac{u(E)}{E}\right)^2 + \left(\frac{u(\Delta R_w)}{\Delta R_w}\right)^2 + \left(\frac{2 \cdot u(R)}{R}\right)^2} \quad (38)$$

Evaluation of the combined uncertainty of the spherical tank's adjusted interval capacity below height H_f is calculated by formulas (39) or (40):

$$u_c(\overline{V}_{H_f}) = \sqrt{u_A^2(\overline{V}_{H_f}) + u_B^2(\overline{V}_{H_f})}\,; \quad (39)$$

$$u_c(\overline{V}_{H_f}) = \pi \cdot \sqrt{C_{1f}^2 \cdot u_c^2(\overline{R}) + C_{2f}^2 \cdot u_c^2(\overline{T})} \quad (40)$$

where:

$C_{1f} = -\overline{R} \cdot (2 \cdot (\overline{T} - L_f) + \overline{R})$ and

$C_{2f} = -((\overline{T} - L_f)^2 + \overline{R}^2)$ are the sensitivity coefficients.

The expanded uncertainty of the spherical tank's adjusted interval capacity below height H_f is calculated by formula (41):

$$U_f^{\text{int}} = k \cdot u_c(\overline{V}_{H_f}) \quad (41)$$

The combined and expanded uncertainties of the total capacity are necessary for calculation of the gas phase volume uncertainty:

$$u_c(\overline{V}_{tot}) = 4 \cdot \pi \cdot \overline{R}^2 \cdot u_c(\overline{R})\,; \quad (42)$$

$$U_{tot} = k \cdot u_c(\overline{V}_{tot}) \quad (43)$$

5 Evaluation of the liquid volume in the spherical tank and its uncertainty

To calculate the liquid volume in the spherical tank it is necessary to measure the level and temperature of the liquid and internal pressure in the tank. The mathematical model of the volume calculation is the following:

$$\widetilde{V}_{H_i} = \pi \cdot ((\overline{T}_i - L_i)^2 \cdot R_i + ((\overline{T}_i - L_i) + R_i)^3 / 3) + \Delta V_{H_i} \quad (44)$$

$$\overline{R}_i = \overline{R} + \Delta R_{ti} + \Delta R_{Pi}\,; \quad (45)$$

$$\overline{T}_i = \overline{T} + \Delta R_{ti} + \Delta R_{Pi} \quad (46)$$

where:

L_i is the measured distance from the reference flange for the ALG to the liquid surface;

$\Delta R_{ti} = \lambda \cdot (t_i - t_o) \cdot \overline{R}$ is the correction for the temperature of the tank wall at the measuring of the liquid level;

$\Delta R_{Pi} = \dfrac{(P_i - P_o) \cdot \overline{R}^2}{E \cdot \Delta R_w}$ is the correction for the internal pressure in the tank at the measuring of the liquid level;

t_i is the mid temperature of the tank wall at the measuring of the liquid level (approximately equal temperature of the liquid);

P_i is the mid pressure in the tank at the measuring of the liquid level (when temperature is t_i);

ΔV_{H_i} is the terrain corrections below height H_i;

i is the current number, for which the liquid volume is calculated.

The combined uncertainty of the spheres mid radius at the measuring of the liquid level and distance $\overline{T}$ are calculated by formulas (47) and (48):

$$u_c(\overline{R}_i) = \sqrt{u_c^2(\overline{R}) + u^2(\Delta R_{ti}) + u^2(\Delta R_{Pi})} \quad (47)$$

$$u_c(\overline{T}_i) = \sqrt{u_c^2(\overline{T}) + u^2(\Delta R_{ti}) + u^2(\Delta R_{Pi})} \quad (48)$$

where:

$u_c(\overline{R})$ is the combined uncertainty of the radius evaluated by formula (35);

$u_c(\overline{T})$ is the combined uncertainty of the distance $\overline{T}$ evaluated by formula (36);

$u(\Delta R_{ti})$ and $u(\Delta R_{Pi})$ are the uncertainties of the corrections for the temperature of the tank wall and the internal pressure in the tank, at the measuring of the liquid level. They are evaluated by formulas (37) and (38);

The combined and expanded uncertainties of the liquid volume measured by the spherical tank below height H_i shell be estimated by formulas (49):

$$u_c(\widetilde{V}_{H_i}) = \pi \cdot \sqrt{C_{1i}^2 \cdot u_c^2(\overline{R}_i) + C_{2i}^2 \cdot (u_c^2(\overline{T}_i) + u_c^2(L_i)) + u_A^2(\Delta V_{H_i})} ;$$

$$U_i^{vol} = k \cdot u_c(\widetilde{V}_{H_i}) \quad (49)$$

where:

$u(L_i)$ is the uncertainty of the measuring distance from the reference flange for the ALG to the surface of the liquid;

$C_{1i} = -\overline{R}_i \cdot (2 \cdot (\overline{T}_i - L_i) + \overline{R}_i)$ and $C_{2i} = -((\overline{T}_i - L_i)^2 + \overline{R}_i^2)$ are the sensitivity coefficients.

6 Summary

1) A general theoretical method for the evaluation of spherical tank interval capacity and its uncertainty has been developed. It provides adequate comparable results regardless of the tank shape dimensions, its surface deformations, geodetic measurement accuracy, and also the location and number of tanks points whose coordinates were determined on the surfaces.

2) For spherical tanks their capacity and volume have been calculated and the structure of their uncertainty has been analyzed more efficiently by using the tank's mid internal radius and its corrections and uncertainties.

3) The uncertainty of the spherical tank interval capacity and the liquid volume in it depends on the uncertainties of the mid radius and coordinates of the center of the sphere, the uncertainties of the reference flange coordinates, the uncertainty of the terrain corrections to the capacity and volume, the uncertainty of the tank wall temperature and the internal pressure measurement, etc. All the above-mentioned factors have been considered in this article.

4) Using the laser scanning method and the method of measurement results processing proposed in this article we can obtain a reduction in the spherical tank capacity uncertainty from 0.5 % to 0.1 % – 0.2 %.

5) The proposed method can be used as a mathematical background for developing International Recommendations for evaluating the spherical tank's geometrical parameters, its capacities, liquid volume, and its uncertainty.

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MEASURING

Measurement(s) in question

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Introduction

I was introduced to metrology by Dr. Pierre Giacomo who was Director of the International Bureau of Weights and Measures (BIPM) from 1978 to 1988, and by my colleagues in a number of scientific, legal and industrial metrology laboratories. I defended my doctoral thesis "Metrology and education" in 2003[1].

I was originally a professional trainer and project leader in education and social work for over 20 years, and have interacted with groups of trainees, people in difficulty, young people and adults who organize and define their knowledge and skills. Together we have carried out an in-depth examination of questions of meaning, common sense, measurement and values that are of benefit to collective intelligence and benevolence.

With a group of metrologists, we founded the Métrodiff[2] Association in 2000, whose aim is to disseminate metrological culture to as many people as possible. Metrologists and scientists are often asked questions about metrology and its historical, social, philosophical and spiritual meanings; beyond that, we also put such questions to members of society, in which individuals and groups organize themselves to deal with the growing disorientation of value systems and develop new solutions to solve new problems that are arising in the present and which will arise in the future.

The birth of universal metrology

The equitable sharing of measurement concepts and values remains central to all civilized societies. Over long periods, documented historical evidence shows a recurring fact: *excess* generates *measurement* and curiously enough, this returns to the front of the stage when it comes to social unity and the redistribution of resources.

Measurements are part of our daily activities and have become so familiar that we forget to think about them, even though they structure decision-making in our societies. For thousands of years, metrology has earned its stripes of operational language with a universal vocation for science, technology and many elementary acts performed in our societies.

The word "metrology" was first coined in 1780. It is the science of measurement and its applications. The term now encompasses scientific, industrial and legal metrologies in their entirety, and has gradually replaced "Weights, Measures and Currencies", inherited from our Ancestors.

The decimal metric and decimal division measurement systems in France were born at the time of the *Declaration of the Rights of Man and of Citizens*. The decree of the Convention of the 18th of Germinal year 3[3] (7 April 1795) stated that metric law had to be implemented in France. From that point on everyone, from the most powerful to the most humble, would use the same measurement system and would have be able to manage their own affairs and avoid metrological traps and fraud.

The Enlightenment project is universal. The claim of universalism, in the case of metrology, is not that this activity would naturally be imposed like universal gravitation on all humans, but that this timeless activity, ideally based on shared common values and references, would be intended for use by all humans beyond their political, cultural and religious affiliations.

The choice to share a common metric, later adopted by the world community in 1875, does not abandon identity, but rather opens a door to others for the benefit of all.

The Sanskrit root of the word measure is said to be *māa* – hence *maya*, illusion and magic. The first part *mé* in Indo-European is the word stem *med* – hence doctor, medical, meditate, etc. The same stem is seen in *met, mens, ment, mod* – cure, govern, think, reflect, weigh, judge, meditate, imagine, invent, evaluate, estimate, balance, etc. All of these action verbs are meaningful and relevant in the field of measurement.

Metrological pact, trust pact, recognition pact

The longevity of the Pharaonic civilization in Egypt has been based from the outset in the concept of "*maât*", which expresses at the same time *measure, trust, order*

[1] http://mac.quartier-rural.org/these/these2.html (2003)

[2] http://www.metrodiff.org/

[3] http://www.metrodiff.org/cmsms/index.php/histoire/18_germinal_an_3.html

and fairness. To make *"maât"* intelligible and effective for everyone, the concept was deified and grew into a powerful symbolic organization that lasted for more than three millennia. The Great Goddess Maât, a pretty young lady depicted wearing an ostrich feather, energizes and personifies measure, fairness, order, solidarity, benevolence and overall prosperity. Each and all referred to her. During psychostasia or the weighing of the soul ceremony, Maât officiated with Thoth, the Grand Surveyor. Weighing one's actions during life and being held accountable for these actions during the transition from life to death seems to be a universal funeral ritual.

Balance is the symbol of divine justice and of human justice

The metrological pact is based on agreement of a mutual trust contract. A pacified cultural context across the globe would recognize that all civilizations of the world for millennia have contributed, are contributing (and will continue to contribute) and helping to build this universal common language in order to agree on values and the ways to protect them.

What is this *International System*[4] inherited from the work of our Ancestors, dedicated "at all times, to all people"? Only the market serves as an instrument of measurement; while it does not possess the necessary qualities in the face of instability and excess in today's world, we must return to genuine measurements.

Evolution of the need for measurement

The English physicist Lord Kelvin (1824–1907), renowned for his work in thermodynamics, is known to have said that a change of measurement system is not without consequences for systems of thought, unless it is rather the evolution of ideas that leads to an upheaval of measurement units.[5]

For thousands of years humans have been measuring the world around them with what is most readily available, their body. The foot, the hand, the palm, the capacity of one's arms, the day's work and the time it takes to walk are very useful references in everyday life. Today, the evolution of metrology unites with the senses, the singular.

We seek more and more to measure and assign a value to perception and feelings such as human development, territorial welfare or personal happiness, and even quantify our carbon footprint[6]. We increasingly use measuring instruments to continuously monitor our physical and energetic state, to establish our performance using indicators (the daily number of steps we take, our heartbeat, blood pressure, etc.) and when appropriate, decide to change our behavior.

"Personal Metrology", of which I depicted the initial outline[7], is a simple method: it is a vital function of human beings who learn to recognize and acknowledge themselves and their environment to survive, live and evolve.

"Collective metrology" allows one to organize one's co-responsibility in the world and to go beyond the power-based relations that overwhelm the social fabric with their excesses and their egotism. The action-research work in which I participate shows that the exercise of co-construction of participatory evaluation systems has positive effects on the individual and collective well-being. These support measures, where *all* the stakeholders co-produce solutions, improve the moral and physical health of the participants and reflect back a positive image to the actors in the field.

The experience of social action campaigns in areas with fragile (or not) populations clearly shows that the co-construction of a common space where measurement tools (indicators) are rigorously and benevolently developed and transmitted also has the effect of articulating a political policy based on mutual and reciprocal trust around common practices.

This change in perspective reflects a cultural change: social action and personal care services become a recognition of others through the sharing of common values of solidarity and citizenship and the ability to equip themselves to co-act. This is a way of reconnecting with a type of metrology that not only serves the technical, scientific or economic powers, but feeds into the social space of relations of trust and goodwill.

Among numerous studies, impact measures, data quality and assessment schemes, the co-construction of indicators and new social values of governance are put into question. Agreeing on common values requires harmonization of methods and measuring processes in areas as diverse as social and solidarity-based economy (SSE), services, territorial social action, the metrological quality of performance indicators, etc.

4 http://www.bipm.org/fr/measurement-units/

5 Vedelago S. Isotopes, Mesure et démesure, no. 13, December 1995, p.38

6 See the book *Terre 2100* and the article by D. Bretelle Desmazières (2009)

7 M.A. Cotteret "Mesurez-vous ! De la métrologie à l'autonomie" (2008)

Conclusion

Certain traditional metrology procedures are probably transposable to feelings and subjectivity. They allow us to agree on what is a reliable measurement result. A prerequisite is indispensable: to acquire basic rules about metrological culture and the principles underlying "good" and accurate measurement.

Measurement operators, whoever they may be and whatever they measure, must be rigorous, honest, attentive, careful, methodical and patient. They must use methods and procedures that are validated and reproducible. They must check their measurement operations, repeatedly if necessary. They must assess uncertainty (an integral part of the result) and include it in the final results. They must record and report their data and how they obtained it. A measurement is not taken, it is given.

Finally, measurement sets a path of truth, as understood in the context of "maât", and establishes a path of lucidity.

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References

Marie-Ange Cotteret is currently a trainer and head of many educational and social projects. She holds a PhD in education. She is President of the Métrodiff Association[2], whose goal is to share and disseminate a base culture of measurement understanding. She is a member of the *Conseil Scientifique de Alliance pour l'innovation relationnelle* AIR Fund[8] and is a Research Associate with Laboratoire DICEN[9], Paris. Lastly, she is Entrepreneur Associate in the Business and Employment Co-operative Ozon[10] and Author of "Mesurez vous ! De la métrologie à l'autonomie", 2008[11].

[8] http://www.air-fund.net
[9] http://www.dicen-idf.org/equipe/
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Photo: https://www.panamo.eu/

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métrodiff

HISTORY OF SCALES

Weights, scales and weighing in the course of time up to digital measurement – International information on metrology and legal metrology

Part 20: Time to say goodbye!

Wolfgang Euler, Hennef (Sieg), Germany

Ladies and Gentlemen,

Esteemed readers,

To all of those who have accompanied us on the path of international legal metrology,

Around five years ago in December of 2011, the city of Detmold bore happy witness to a coming-together (via divergent paths) of several minds who were actively working in international metrology. It quickly became apparent that we shared a common goal – to pass on our knowledge to members of all generations, young and old. We had long since recognized that general education needed more and better support, but particularly so in the fields of national and international metrology.

For many, metrology today has become a common resource, for which reason it is not particularly noticed, despite the fact that it is precisely these areas that have accompanied human beings on this planet ever since they abandoned nomadic life for sedentism. Since this took place around 10,000 years ago, life without measurement has become inconceivable – in trade and commerce just as much as in healthcare and many other areas of daily life.

With this in mind, our team spontaneously decided to produce a series of articles (on a voluntary basis) in English and German. In the OIML Bulletin the series was entitled ***A History of Scales***. In *Mühle + Mischfutter,* these articles were entitled ***Weights, Scales and Weighing in the Course of Time – From the Beginning to the Modern Digital Age – and International Legal Metrology***.

The goal of our contributions to weighing technology was quite simply to provide readers with as much realistic and beneficial knowledge to complement their lives as possible. In doing so, we wanted to reach young people in particular, with enhancement of general education being our main concern, as reflected in our motto: *To continually join together the dynamism of young people with the wisdom of their elders.*

To date, 19 articles have been created with the considerable and special support of the ***Verlag Moritz Schäfer*** in Detmold and the ***Physikalisch-Technische Bundesanstalt (PTB)*** in Braunschweig; these articles were produced by the ***Organisation Internationale de Métrologie Légal (OIML)*** in Paris and published at regular intervals in around 130 countries.

Our entire team would now like to bid farewell to all of you with this, our ***"Article No. 20 – Time to Say Goodbye"***. It is our sincere hope that you have enjoyed this series of articles and that we have been able to impart to you some things that you have found worth knowing. We would be very glad to receive your responses and/or feedback.

Below is a summary of the main subjects in our series of articles:

- Antiquity and the modern era;
- Weights and scales;
- Non-automatic weighing instruments (NAWIs) and automatic weighing instruments (AWIs from 1883 on);
- Checkweighers;
- Mass;
- Consumer protection with and for fair competition; and
- The era (from around 1955 on) of load cells in conjunction with force measurements in the digital era. We should all devote special attention to this newest technology, as it not only offers advantages but also causes difficulties and problems now and then. This is simply how things are – and how they will remain, for the time being, in the digital world.

Time to say goodbye!

On behalf of the entire editorial team and all of the authors and contributors, thank you for your interest in our work.

Wolfgang Euler
18 September 2016
D-53773 Hennef/Sieg (Cologne/Bonn)
Germany

Technology moving into the future:
Evolutions in mechanical and electronic
non-automatic and automatic scales

OIML PILOT TRAINING CENTER

Report on the first OIML NAWI training course

17–21 July 2016 Beijing, P.R. China

Su Guo
OIML Advisory Group Secretary

The OIML Pilot Training Center (OPTC), located on the Changping Campus of the National Institute of Metrology, China, was officially opened on 18 July 2016. This is the first ever such OIML Training Center in the world.

Over 50 participants from Cambodia, China, Colombia, Egypt, Germany, Greece, India, Indonesia, Iran, Jordan, Kazakhstan, Kenya, Rep. Korea, Malaysia, Mongolia, the Philippines, Singapore, Chinese Taipei, Thailand, Viet Nam and the BIML participated in the first *OIML Training Course on Non-Automatic Weighing Instruments*.

The fact that the OIML chose to set up its first OPTC in China, the world's largest developing country, is not only an acknowledgement of China's considerable work in the field of metrology, but also the opportunity for China to engage in a historic mission. In the future, the OPTC will become a global model for international metrology training as well as a home for metrological talents, thus enhancing both managerial and technical capacities in countries and economies with emerging metrology systems (CEEMS).

The first training course focused on the test methods and procedures in OIML R 76 *Non-automatic weighing instruments* (NAWIs). This Recommendation was chosen because these instruments are widely used throughout the world, and OIML R 76 is also the basis for other international Recommendations. Additionally, it is one of the most comprehensive Recommendations in existence and is widely recognized and acknowledged as being authoritative and complete. NAWIs were also the first measuring instruments to become applicable under the framework of the OIML MAA, with the signing of the R 76 Declaration of Mutual Confidence (DoMC). This training course will continue to reinforce the global understanding of OIML R 76, strengthen the influence of OIML type evaluations, and also promote the development of the "one test, one certificate, global mutual recognition" concept.

The NAWI training course comprised thematic lectures, on-site training and group discussions, and was led by invited experts from Germany, China and the BIML as co-trainers. Participants also visited the Changping Campus of the NMI and a Sartorius manufacturing plant.

All the participants openly discussed many aspects of legal metrology, talked about key (and especially difficult) problems facing the field of NAWIs, exchanged experiences, and proposed new ideas for international training methods. Finally, each participant noted down

Opening speech by Mr. Pu

Delegates attending the first OIML OPTC NAWI training course

their comments and experience of legal metrology training policies and mechanisms as well as issues relating to NAWIs according to their own roles. The Advisory Group will evaluate the assessment and will report back during the 51st CIML Meeting in October.

Generally, the participants responded that they appreciated this NAWI training course because it had a modular curriculum design and because the content was good, rich and diverse. In particular, it invited senior experts to give concrete guidelines. Because all the participants came from well-known research institutes and enterprises, the course offered them both a global vision as well as a combination of specific tangible work practice, so they found it very rewarding. Secondly, participants found the training effective as it succeeded in building a high-level international platform of metrology cooperation, it addressed key issues during the discussions and it allowed those present to exchange experiences, each participant describing the situation in their own country. Participants agreed that through this training they were able to further deepen their understanding of legal metrology, of the OIML, and notably of OIML R 76.

Finally, participants agreed that the Training Center is very important, especially for the CEEMS community. China, as Chair of the OIML Advisory Group, will follow the needs of everyone involved, not only to promote training on NAWIs but also to promote other legal measuring instruments. The organizers hope that the OPTC will be a model that will rapidly be used as the basis for establishing more centers as a network in the world.

OIML OPTC NAWI training course group photo

OIML PILOT TRAINING CENTER

Report on the OIML *Legal Metrology Management System* Seminar

9–11 August 2016, Guangzhou, P.R. China

Su Guo
OIML Advisory Group Secretary

An international *Legal Metrology Management System* Seminar, jointly organized by AQSIQ and the OIML, was held on 9–11 August 2016 in Guangzhou, P.R. China. It was attended by over 100 participants from 16 economies.

Metrology, as an important part of the national quality infrastructure (QI), has a unique role in promoting scientific and technological progress, serving innovation, and promoting industrial restructuring. It also plays a unique role in promoting a more ecologically balanced world and in achieving global sustainable development. There is, especially, an urgent need to establish an effective global metrology management system in line with the requirements of current global trends.

Building a sound and efficient international metrology system requires wisdom and creativity on the part of all the concerned parties, and calls for close international cooperation between the OIML, BIPM, IAF, IEC, ILAC, IMEKO, ISO, ITC, ITU, UNECE, UNIDO and other international metrology organizations at a high level, in good faith, to deal with the large number of common interests that are at stake.

In order to promote metrology in *Countries and Economies with Emerging Metrology Systems* (CEEMS), the OIML has adapted its actions to specifically cater for the needs of its CEEMS Members, thus fully reflecting its awareness of its huge responsibility in this field.

As a key OIML Member State, China attaches great importance to international cooperation in the field of metrology, and has actively been fulfilling its respective rights and obligations for many years.

As an international and regional metrology organization member, AQSIQ joined forces with the OIML to organize this Seminar in order to build a platform to facilitate the exchange of legal metrology cooperation between OIML Members, with the intention of sharing its long-standing experience in the field of legal metrology, and in doing so to engage in joint efforts to constantly improve the infrastructure of the OIML community.

The OIML has published over 30 International Documents, the most important of which for CEEMS is without doubt OIML D 1 *Considerations for a Law on Metrology*. The key themes developed in OIML D 1 are mainly the promotion of fair trade, the promotion of innovation and support of metrological supervision, and the protection of citizens' rights; all these areas are closely related to the concept of the national quality infrastructure.

Panel during the opening session of the Seminar

Delegates attending the first OIML OPTC Seminar

The Seminar was organized over three days:

- on day 1, the invited guests from Germany, China and New Zealand delivered keynote speeches – each economy then presented a report on the overall situation concerning its national metrology system;
- on day 2, the participants were divided into six groups, each of which discussed the following topics:
  - "How to optimize the legal metrology management system in OIML D 1";
  - "How to raise the awareness of metrology"; and
  - "How to improve capacity building in your organization".

  Each group then nominated one representative to speak on its behalf on stage.
- On day three all the participants were taken on a technical visit to laboratories in Dongguan, Guangdong Province Institute of Metrology.

In conclusion, this Seminar has served to further promote substantive cooperation among OIML Members in areas of common concern and interest. Many experts have contributed comments and strategies to promote the role of metrology which can support the foundation of sustainable growth for economic and social development. ■

Delegates attending the first OIML OPTC Seminar

SAARC
SOUTH ASIAN ASSOCIATION FOR REGIONAL COOPERATION

Workshop on Best Practice in Metrology Law Development

30–31 March 2016 Kathmandu, Nepal

Manfred Kochsiek
Former CIML Acting President / PTB Consultant
Hans-Dieter Velfe
PTB Consultant

Introduction to SAARC

The **South Asian Association for regional Cooperation (SAARC)** is a regional intergovernmental organization and geopolitical union in South Asia. Its member states include Afghanistan, Bangladesh, Bhutan, India, Nepal, the Maldives, Pakistan and Sri Lanka. SAARC comprises 3 % of the world's area, 21 % of the world's population (1.6 billion inhabitants) and 9.12 % of the global economy, as of 2015.

SAARC was founded in Dhaka in 1985. Its secretariat is based in Kathmandu, Nepal. The organization promotes the development of economic and regional integration. It launched the South Asian Free Trade Area in 2006. SAARC maintains permanent diplomatic relations at the UN as an observer and has developed links with multilateral entities, including the EU.

South Asian Free Trade Area (SAFTA)

SAFTA was envisaged primarily as the first step towards transition to a South Asian Free Trade Area, leading subsequently towards a Customs Union, Common Market and Economic Union. In 1995, the Sixteenth session of the Council of Ministers (New Delhi, 18–19 December 1995) agreed on the need to strive for the realization of SAFTA and to this end an Inter-Governmental Expert Group (IGEG) was set up in 1996 to identify the necessary steps for progressing to a free trade area.

SAARC Workshop

The two-day SAARC workshop was organized by the NBSM (Nepal Bureau of Standards & Metrology) in Kathmandu from 30 to 31 March 2016. It was facilitated by Prof. Manfred Kochsiek, former CIML Acting President and Vice-president of the PTB, Dr. V.T. Chitnis, India, and Dr. G.M.S. De Silva, Sri Lanka, PTB Experts.

Country	Population (Million)	GDP (Nominal)	GDP per Capita (PPP)
Afghanistan (AF)	32.007	$21.3 bn	$1.976
Bangladesh (BD)	159.857	$205.3 bn	$3.581
Bhutan (BT)	0.779	$2.2 bn	$8.158
India (IN)	1,276.2	$2308.0 bn	$6.266
Maldives (MAL)	0.38	$3.0 bn	$14.980
Nepal (NEP)	28.4	$21.6 bn	$2.488
Pakistan (PAK)	190.4	$250 bn	$4.886
Sri Lanka (SL)	21.7	$80.4 bn	$11.068

Fig. 1 SAARC members

Fig. 2 Delegates attending the Workshop

The main objective was to develop a better understanding of best practice for developing legislation for metrology. Topics discussed at the workshop were, among others:

- What needs to be regulated?
- How should legal metrology organizations (LMO) be set up?
- Who should be the enforcement body?
- Who is the lawmaker, and who is the verifier?

The workshop gave a first insight into existing national legislation and its implementation in the SAARC member countries. This information was proposed to be used for representing a precondition to avoid technical barriers to trade (TBT) of measurement instruments. Further, the workshop provided a platform to trigger closer collaboration and information exchange in the region among national legal metrology organizations.

A follow-up one-day workshop on legal metrology activities was also discussed and prioritized.

Opening of the meeting

As per standard SAARC procedure, the meeting was opened by the SAARC Secretariat Ms. L. Savithri, Director (EFT). In her opening remarks she highlighted the key points about SARSO's (South Asian Regional Standards Organization) establishment with full responsibilities for coordination of standardization, metrology, accreditation and conformity assessment activities in the SAARC region.

Ms. Savithri informed delegates that during the SAARC Ministerial meeting held in March 2016 the meeting appreciated the contribution of the PTB in assisting the SAARC process by building the capacity of Member States and hoped for continuous support. She highlighted the proposed establishment of a South Asian Economic Union for better results in economic integration. Ms. Savithri concluded on the positive note that SAARC was improving in so many areas concerning economic integration and positive growth. Finally, she expressed her best wishes and looked forward to a successful session.

Mr. Tashi Wagchuk, the representative from the SARSO Secretariat and Mr. Daniel Böhme, PTB Project Coordinator, welcomed participants. They expressed regrets that India and Bangladesh were unable to participate. PTB Experts Dr. V.T. Chitnis, Dr. G.M.S. Silva and Prof. Manfred Kochsiek were introduced.

Mr. Böhme and Mr. Pudasaini, Director General of NBSM, stated that the workshop would provide a good platform for sharing information and planning activities. They also stated that legal metrology is an important aspect in technical barriers to trade and is important for export/import and for the benefit of consumers.

Seminar

Fig. 3 SAARC logo

Delegates from the Member States gave brief reports on the status of laws and legal metrology enforcement mechanisms available in their respective Member States:

- **ANSA, Afghanistan**

  The Standards law is in place. The legal metrology law is at initial draft stage.

- **BSB, Bhutan**

  There is no legal metrology law in particular but weights and measures are covered under the Consumer Protection Act.

- **Maldives**

  The weights and measures rules and regulations are covered under the Consumer Protection law. The legal provisions and fee structure are also covered in the regulations. Metrology is under the responsibility of the Maldives Polytechnic and legal metrology is enforced by five Metrology cells under the Ministry of Economic Development. Two more cells were yet to be established.

- **Nepal**

  The Legal Metrology law is in place and implemented through nine satellite offices.

- **Pakistan**

  Legal metrology (weights and measures) is enforced and monitored by the provinces and each province has its own law. The National Physical and Standards Laboratory (NPSL), Pakistan is the custodian of traceability and maintaining standards in Pakistan.

- **Sri Lanka**

  The Measurement Units Standards and Services Department (MUSSD) is a government institute responsible for scientific, industrial and legal metrology in Sri Lanka. It maintains the National Standards and is responsible for the dissemination of traceability. The weights and measures law is being implemented by sixty-five inspectors at district level of legal verification. The MUSSD is involved in the verification of weights, scales, fuel pumps, weighing bridges, volumetric, prepackaging, etc.

During the two-day workshop, the experts gave presentations on “Quality infrastructure” (Dr. V.T. Chitnis and Dr. G.M.S. Dec Silva). Prof. Manfred Kochsiek gave presentations on “Metrological infrastructure of a country based on international best practice - legal metrology as an important part”, “Benchmarking the Metrology laws of the 10 ASEAN countries”, and “Benchmarking the Metrology laws in SAARC Member countries”. Brief discussions were also held on the status of laws in the SAARC region and delegates from Member States gave updates on the legal metrology status.

Case studies were presented by two countries: Nepal and Pakistan. Prof. Kochsiek gave an overview of the benchmarking of the legal metrology legislation in the eight member countries against international best practice, especially OIML D 1:2012 *Considerations for a Law on Metrology*. The outcome was that some countries have acceptable legislation and others have just started to develop legislation from scratch.

Workshop

As a follow-up to benchmarking metrology legislations in SAARC Member States, the meeting decided that detailed feedback on the legislation would be circulated during the first week of May 2016 by the PTB. The Member States were requested to comment and send feedback to the PTB by 15 June 2016. The meeting recommended using the feedback from the Member States as a basis for all future activities; it also decided to circulate the report of the workshop to the Metrology Coordination Meeting.

Prof. Kochsiek delivered a presentation on the OIML Certificate Systems. He explained the benefits of the Certificate System and the OIML Mutual Acceptance Arrangement (OIML MAA), the requirements, and recent developments. A question and answer session was held to clarify the presentation.

Priority	Field	Type of assistance required	Member States
Short term priorities			
1	Legislation	Consultancy	AF/BT/NEP/PAK/SL
2	Fuel dispensers (electro mechanical) and volume	Training	MAL/NEP
3	Pre packages	Consultancy, training and harmonization of regulations	PAK/SL
Long term priorities			
1	Electricity meters		BT/MAL/NEP/PAK
2	Water meters		PAK
3	AWI	Training and consultancy	PAK
4	Flow meters other than water		PAK

Fig. 4: Outcome of the discussion on defining Legal Metrology Activities Priorities

Planning session and further steps

A one-day Legal Metrology Activity Planning workshop was held on 1 April 2016; this was a roadmap workshop to discuss potential activities and develop an action plan that can be implemented within the next few months.

The Member States discussed and prioritized those legal metrology activities that were intended to be implemented within the PTB project duration. Unfortunately, these actions had to be cancelled because of finances running short. The activities – short and long term – listed in Figure 4 are planned to be realized in a new project.

Conclusion

The workshop showed the big differences in the legislation and organization of legal metrology in the SAARC countries. Some countries already have well developed legislation; others have to start from scratch. The implementation of the best practice in legal metrology is a great challenge and needs further support from international experts and donor organizations. The participants agreed on the necessity that in all their countries consultancy and training are the most important next steps. ■

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AFRIMETS

AFRIMETS General Assembly and associated meetings

25–28 July 2016 Giza, Egypt

Wynand Louw, AFRIMETS Secretariat

Introduction

The AFRIMETS General Assembly and associated meetings were held from 25 to 28 July in Giza, Egypt.

From Monday 25 July the Technical Committee meetings took place, including TC-Legal. An AFRIMETS Sustainability Workshop was coordinated by UNIDO during which strategies were discussed on how to ensure the future sustainability of the organisation. It was concluded that the organisation is sustainable at present, but that NMIs and Legal Metrology Organisations should support staff to attend meetings and a larger number of NMIs should pilot benchmarking exercises. For the time being the Secretariat will be hosted by one of the larger NMIs. Membership fees will be considered in future, but not before a comprehensive study has been performed on the pros and cons and the administrative issues have been dealt with.

NMISA experts chaired four of the Technical Committee meetings and NIS experts chaired two, where comparison results and calibration and measurement capability claims (and the review process) were discussed, and new comparisons were planned. The TC-Quality System discussed the applications from six SADC NMIs for the approval of their QS as fit-for-purpose for the CIPM MRA. The approval of the QS of the Namibian Standards Institute is imminent, pending the submission of a few final documents, and the process to approve the others is well advanced.

The Executive Committee (EXCO) discussed the Sustainability Plan, approved new Ordinary Members (The Gambia and Liberia) and endorsed the EXCO members until July 2017. An open session of the GA followed on Wednesday that was attended by Prof. Dr. Hazem Monsour, Assistant Minister of Higher Education & Scientific Research.

Resolutions

The AFRIMETS GA Resolutions below are of particular interest.

Resolution 8/2016

The AFRIMETS GA confirms the following EXCOM members for 2016–2017 and resolves that they will serve until the next GA in July 2017:

Chair:	Mr Dennis Moturi from EAMET
Vice-Chairs:	Mr Wondwosen Fisseha from NEWMET as Vice-Chair, Scientific and Mr Jaco Marneweck from SADCMET/MEL as Vice-Chair, Legal.

The following individuals as SRMO representatives:

	Scientific	Legal
CEMACMET:	Mr Aristide Gabin Nguedeu	Dr Silla Semballa
EAMET:	Mr Eric Karamuzi	Mr John-Paul Musimami
MAGMET:	Mr Dyane Salah	Mr Samir Drissi
NEWMET:	Dr Mohamed Amer	Mr Paul Date
SADCMET/MEL:	Mr Donald Masuku	Mr Jaco Marneweck
SOAMET:	Mr KY Oumarou	Mr Salifou Issoufou

Resolution 9/2016

The AFRIMETS GA acknowledges the election of Chairs and Vice-Chairs by its TCs and reconfirms its decision that Chairs of the scientific TCs must be from NMI members or at least observers of the relevant CC or CC-WG, and decides that Chairs elected by a TC that do not fulfil this condition will be Vice-Chairs until the NMI obtains at least the status of observer of the relevant CC or CC-WG.

AFRIMETS
Intra-Africa Metrology System
Système Intra-Africain de Métrologie

The following TC-Chairs and Vice-Chairs will serve in 2016–2018:

TC/SC	Chair	Vice-Chair(s)
TC-QS:	Dr Noha Khaled	Mr Peter Kahihia (QS review - English) Dr Wynand Louw (CMC Submission and Review) Colonel Abene Lassaad (CMC and QS Review - French)
TC-M & RQ: Sub-WG Mass Sub-WG Pressure Sub-WG Viscosity Sub-WG Force Sub-WG Fluid flow	Dr Alaa Eltaweel Thomas Mautjana Brian Yalisi Dr Mostafa Mikawy Dr Seif Osman TBC	Mr Dominic Ondoro TBC TBC TBC TBC Ali Zahran
TC-Length:	Oelof Kruger	Dr Osama Terra
TC-EM:	Alexander Matlejoane	Dr Mohammed Abd El-Raouf
TC-T:	Dr Efrem Ejigu	Victor Mundembe Victor Mwazi Richard Odak Dr. Mohamed Gamal Ahmed
TC-RI:	Me Zakithi Msimang	Markos Fikreab (Dosimetry Radiation Protection) Dr Noha Khaled (Dosimetry Radiation Therapy) Martin van Staden (Radioactivity Measurements) Dr Ahmed El Sersy (Neutron dosimetry)

Resolution 11/2016

The AFRIMETS GA accepts with appreciation the offer from South Africa to host the GA 2017 in conjunction with its 10 year (NMISA) and 70 year (metrology in South Africa) celebrations and encourages members to attend the celebrations and GA.

Left to right: Dr Wynand Louw, Mr Dennis Moturi and Mr Wondwosen Fisseha

OIML CERTIFICATE SYSTEM

List of OIML Issuing Authorities

The list of OIML Issuing Authorities is published in each issue of the OIML Bulletin. For more details, please refer to our web site: www.oiml.org
The change since the last issue of the Bulletin is marked in red.

		R 16	R 21	R 31	R 35	R 46	R 49	R 50	R 51	R 58	R 60	R 61	R 75	R 76	R 81	R 85	R 88	R 93	R 97	R 98	R 99	R 102	R 104	R 105	R 106	R 107	R 110	R 112	R 113	R 114	R 115	R 117/118	R 122	R 126	R 128	R 129	R 133	R 134	R 136	R 137	R 139
AT1	Bundesamt für Eich- und Vermessungswesen (BEV)							■	■	■		■		■		■	■		■	■		■	■		■	■	■			■	■	■									
AU1	National Measurement Institute (NMI)						■	■	■		■			■		■									■	■						■		■		■					
BE1	SPF Economie, PME, Classes Moyennes et Energie													■					■	■																					
BG1	State Agency for Metrology and Technical Surveillance (SAMTS)													■						■																					
BR1	Instituto Nacional de Metrologia, Normalização e Qualidade Industrial (INMETRO)													■																											
CH1	Institut fédéral de métrologie METAS	■		■			■	■	■		■	■		■					■	■				■	■	■						■						■			
CN1	General Administration of Quality Supervision, Inspection and Quarantine of P. R. China (AQSIQ)			■		■		■	■		■	■		■					■	■						■						■						■			
CZ1	Czech Metrology Institute (CMI)						■							■	■	■								■								■						■			■
DE1	Physikalisch-Technische Bundesanstalt (PTB)			■	■		■	■	■	■	■	■		■		■	■		■	■	■	■	■	■	■	■	■			■	■	■		■	■	■	■		■	■ (red)	
DK1	The Danish Accreditation and Metrology Fund (DANAK)							■	■		■	■		■						■				■	■	■						■				■		■			
DK2	FORCE Certification A/S						■																																		
DK3	Dansk Elektronik, Lys & Akustik (DELTA)							■	■		■	■		■											■	■										■		■			
ES1	Centro Español de Metrología (CEM)						■		■		■	■		■					■	■														■							
FI1	Inspecta Oy							■	■		■	■		■		■									■	■						■									
FR1	Ministère de l'Economie, de l'Industrie et de l'Emploi (MEIE)	*All activities and responsibilities were transferred to FR2 in 2003*																																							
FR2	Laboratoire National de Métrologie et d'Essais (LNE)		■	■			■	■	■	■	■	■		■	■	■	■		■	■	■	■		■	■	■	■			■	■	■		■		■		■		■	
GB1	NMRO Certification Services (NMRO)		■		■		■	■	■		■	■	■	■		■				■				■	■	■						■				■		■			
HU1	Hungarian Trade Licensing Office (MKEH)													■																											
IT1	Ministero dello sviluppo economico - Direzione generale mercato, concorrenza, consumatori, vigilanza e normativa tecnica						■																																		
JP1	National Metrology Institute of Japan / National Institute of Advanced Industrial Science and Technology (NMIJ / AIST)						■				■			■																	■	■									
KR1	Metrology and Measurement Division (KATS)													■																											
NL1	NMi Certin B.V.		■	■		■	■	■	■		■	■		■	■	■			■		■			■	■	■						■		■	■	■		■		■	
NL2	KIWA Nederland B.V.						■																																		
NO1	Norwegian Metrology Service (Justervesenet)							■	■			■		■										■	■	■						■				■					
NZ1	Measurement and Product Safety Service (MAPSS Wellington)													■																											
PL1	Central Office of Measures (GUM)													■						■		■																			
RO1	Bureau Roumain de Métrologie Légale (B.R.M.L.)																		■	■							■			■	■										
RU1	Russian Research Institute for Metrological Service (VNIIMS)			■			■	■	■	■	■	■		■		■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	
SE1	Swedish National Testing and Research Institute AB (S.P.)							■	■		■	■		■		■				■					■	■						■									
SI1	Metrology Institute of the Republic of Slovenia (MIRS)													■																											
SK1	Slovak Legal Metrology						■							■																		■									
US1	NCWM, Inc.										■			■																											
VN1	Directorate for Standards and Quality (STAMEQ)													■																											

OIML Systems

Basic and MAA Certificates registered 2016.06–2016.08

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

The OIML Basic Certificate System

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

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

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

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

The OIML MAA

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

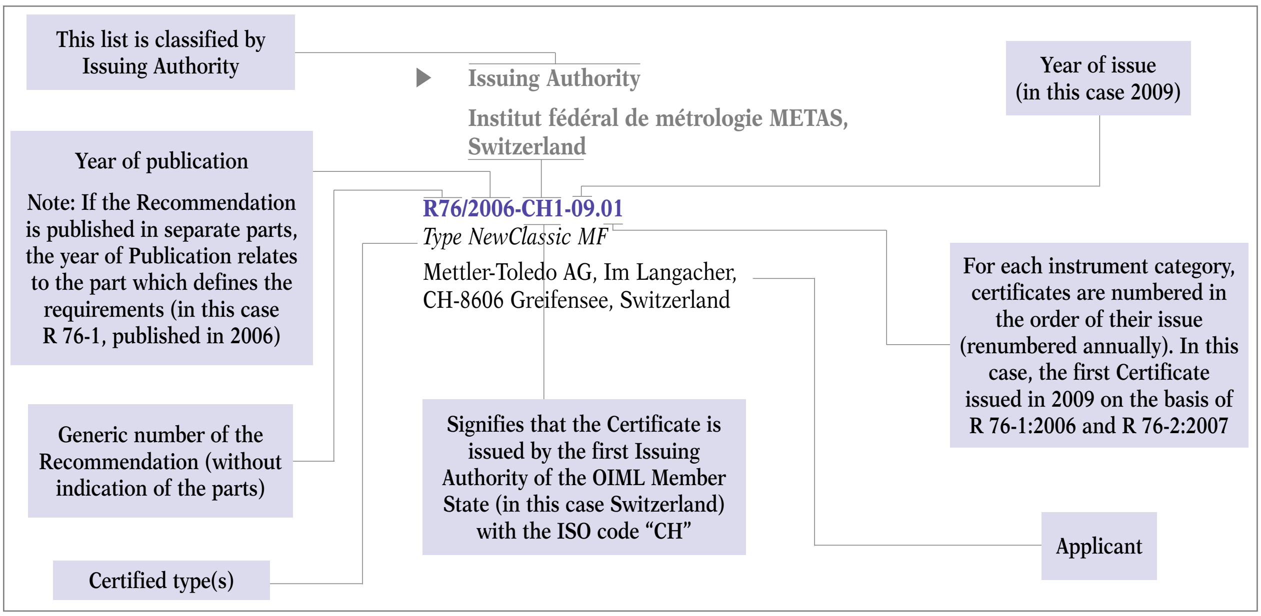
The OIML MAA is an additional tool to the OIML Basic Certificate System in particular to increase the existing mutual confidence through the System. It is still a voluntary system but with the following specific aspects:

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

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

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

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



INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Taximeters
Taximètres

R 21 (2007)

▶ Issuing Authority / *Autorité de délivrance*
NMRO Certification Services (NMRO), United Kingdom

R021/2007-GB1-2016.01
Type: MDT 900A
UCAST Pte Ltd., 1091 Lower Delta Road #04-02, 169202 Singapore

R021/2007-GB1-2016.02
Type: M1 Plus
Italtax S.r.l., Via dell'Industria, 16, IT-62017 Porto Recanati (MC), Italy

R021/2007-GB1-2016.03
Type: MDT900A
ST Electronics (Info-Comm Systems) Pte Ltd., 100 Jurong East Street 21, ST Electronics Jurong East Building, 609602, Singapore

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

R 49 (2006)

▶ Issuing Authority / *Autorité de délivrance*
Laboratoire National de Métrologie et d'Essais, Certification Instruments de Mesure, France

R049/2006-FR2-2014.03 Rev. 2
Water meter ITRON - Type: NEVOS / VCI
Itron France, 9 rue Ampère, FR-71031 Macon, France

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

R049/2006-NL1-2012.01 Rev. 8
Water meter - Type: WATERFLUX 3070
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, Netherlands

R049/2006-NL1-2012.01 Rev. 9
Water meter - Type: WATERFLUX 3070
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, Netherlands

R049/2006-NL1-2013.01 Rev. 7
Water meter intended for metering of cold potable water, model "OPTIFLUX x300C; OPTIFLUX x000F + IFC300y", class 1 and 2
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, Netherlands

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Water meters for cold potable water and hot water
Compteurs d'eau potable froide et d'eau chaude

R 49 (2013)

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

R049/2013-CZ1-2016.01
Water meter - Type: MUT2200EL/MC608A
Euromag International S.r.l., Via Torino 3, IT-35035 Mestrino (PD), Italy

R049/2013-CZ1-2016.02
Water meter - Type: ISOFLO
Itron France, 11, Boulevard Pasteur, FR-67500 Haguenau, France

R049/2013-CZ1-2016.03
Water meter - Type: MAGB1
Arkon Flow Systems, s.r.o., Berkova 534/92, CZ-612 00 Brno, Czech Republic

▶ Issuing Authority / *Autorité de délivrance*
Laboratoire National de Métrologie et d'Essais, Certification Instruments de Mesure, France

R049/2013-FR2-2014.03 Rev. 2
Water meter ITRON - Type: NEVOS / VCI
Itron France, 9 rue Ampère, FR-71031 Macon, France

R049/2013-FR2-2015.01 Rev. 1
Water meter ITRON - Type: WOLTEX (WE)
Itron France, 11, Boulevard Pasteur, FR-67500 Haguenau, France

R049/2013-FR2-2015.02
Water meter ITRON - Type: P290+
Itron France, 11, Boulevard Pasteur, FR-67500 Haguenau, France

R049/2013-FR2-2016.03
Water meter ITRON - Type: X 61
Itron France, 9 rue Ampère, FR-71031 Macon, France

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

R049/2013-DE1-2016.03
Water meter intended for the metering of cold potable water and hot water. Rotary piston meter with mechanical indicating device 8R MD or 7R MD - Type: RTKD
Zenner International GmbH & Co. KG, Römerstadt 4, DE-66121 Saarbrücken, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

R 51 (2006)

▶ **Issuing Authority / *Autorité de délivrance***
NMRO Certification Services (NMRO), United Kingdom

R051/2006-GB1-2013.01 Rev. 3
Type: L-Series 2180
Trimble Loadrite Auckland Ltd., 45 Patiki Road, Avondale, Auckland, New Zealand

R051/2006-GB1-2014.04 Rev. 2
DACS-G-S015 and DACS-G-S060 Series
Ishida Europe Ltd., 11 Kettles Wood Drive, Woodgate Business Park, Birmingham B32 3DB, United Kingdom

▶ **Issuing Authority / *Autorité de délivrance***
SP Technical Research Institute of Sweden, Sweden

R051/2006-SE1-2016.01
Graduated, self-indicating, electronic, automatic weighing instrument - Type: Load Sensing System version 1
Cargotec CHS PTE LTD Bromma, 15, Tukang Innovation Drive, 618299 Singapore

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

R 60 (2000)

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

R060/2000-NL1-2016.01 (MAA)
Bending beam load cell, with strain gauges - Type: 280 and 380W
Vishay Precision Group - Transducers, 26 Harokmim St., 5885849 Holon, Israel

R060/2000-NL1-2016.05 (MAA)
Single point load cell - Type: BX6
TScale Electronics Mfg (Kunshan). Co. Ltd., No. 99 Shunchang Road, Zhoushi Town, Kunshan City, CN-215300 Suzhou Jiangsu Province, P.R. China

R060/2000-NL1-2016.07 (MAA)
Single point load cell, with strain gauges, equipped with electronics - Type: PW15 AHI, PW15IA
Hottinger Baldwin Messtechnik GmbH, Im Tiefen See 45, DE-64293 Darmstadt, Germany

R060/2000-NL1-2016.08 (MAA)
Bending beam load cell, with strain gauges, equipped with electronics - Type: FIT/5. . .,FIT5
Hottinger Baldwin Messtechnik GmbH, Im Tiefen See 45, DE-64293 Darmstadt, Germany

R060/2000-NL1-2016.14 Rev. 1 (MAA)
Compression load cell, with strain gauges, equipped with electronics - Type: SLC820 . . .
Mettler-Toledo (Changzhou) Precision Instruments Ltd., 5, Middle HuaShan Road, Xinbei District, CN-213022 ChangZhou, Jiangsu, P.R. China

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R060/2000-NL1-2016.15 (MAA)
Compression load cell, with strain gauges - Type: IN-ZS
Ningbo ETDZ AIEN Electronics Co. Ltd., No. 66, Xian Tan road, LandXia Street, 315480 YuYao City, Ningbo, P.R. China

R060/2000-NL1-2016.16 (MAA)
Tension load cell, with strain gauges - Type: SLS520
Mettler-Toledo (Changzhou) Precision Instruments Ltd., 5, Middle HuaShan Road, Xinbei District, CN-213022 ChangZhou, Jiangsu, P.R. China

R060/2000-NL1-2016.18 (MAA)
Compression load cell, with strain gauges, equipped with electronics - Type: RPWB
Curiotec Co. Ltd., 79 Myeong-bong-san-ro, 352, beon-gil, Goantang-mueon, 413-855, Paju-si, Gyeongii-do, Korea (R.)

R060/2000-NL1-2016.19 (MAA)
Bending beam load cell, with strain gauges - Type: DEBB-220 or DEBB-300
Shekel Scales Ltd., Kibbutz Beit Keshet, M.P. Lower Galilee, 1524700 Afula, Israel

R060/2000-NL1-2016.20 (MAA)
Compression load cell, with strain gauges - Type: CPX
Dini Argeo Srl, Via Della Fisica, 20, IT-41042 Spezzano di Fiorano (MO), Italy

R060/2000-NL1-2016.21 (MAA)
Single point load cell, with strain gauges - Type: PC6H
Flintec UK Ltd., W4/5 Capital Point, Capital Business Park, Wentloog Avenue, Cardiff CF3 2PW, United Kingdom

R060/2000-NL1-2016.22 (MAA)
Bending beam load cell, with strain gauges - Type: CZL638
Guangdong South China Sea Electronic Measuring Technology Co. Ltd., Dasheng Industrial Park, Machong, Dongguan, 523136 Guangdong Province, P.R. China

▶ **Issuing Authority / *Autorité de délivrance***
NMRO Certification Services (NMRO), United Kingdom

R060/2000-GB1-2016.05
Type: T66
Thames Side Sensors Ltd., Unit 10 - io Trade Center, Deacon Way, Reading RG30 6AZ, United Kingdom

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

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

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

R076/2006-CZ1-2016.01
Indicator, tested as a part of a weighing instrument (for non-automatic weighing instrument) - Type: PUE HY10
Radwag Wagi Elektroniczne Witold Lewandowski, ul. Bracka 28, 26-600 Radom, Poland

▶ **Issuing Authority / *Autorité de délivrance***
Dansk Elektronik, Lys & Akustik (DELTA), Denmark

R076/2006-DK3-2016.07
Non-automatic price computing weighing instrument - Type: LWN / LWNT / AIPI-SS / AIPI-SS2 / LCN - LCNT - HWN - HWNT - LHW-SZ / LHWT-SZ
GSS Scale (Suzhou) Co. Ltd., No.1, Jinrui Road, Taiping Industrial Park, Xiangcheng District, Suzhou, P.R. China

▶ **Issuing Authority / *Autorité de délivrance***
Institut fédéral de métrologie METAS, Switzerland

R076/2006-CH1-2016.01 (MAA)
Non-automatic analytical precision weighing instrument - Type: ME. . . T
Mettler-Toledo GmbH, Im Langacher 44, CH-8606 Greifensee, Switzerland

R076/2006-CH1-2016.01 Rev. 1 (MAA)
Non-automatic analytical precision weighing instrument
Mettler-Toledo AG, Im Langacher 44, CH-8606 Greifensee, Switzerland

R076/2006-CH1-2016.02 (MAA)
Non-automatic weighing instrument - Type: XPR. . .
Mettler-Toledo AG, Im Langacher 44, CH-8606 Greifensee, Switzerland

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

NMi Certin B.V., The Netherlands

R076/2006-NL1-2016.10 (MAA)
Non-automatic weighing instrument - Type: FreshBase or FB . . .
Mettler-Toledo GmbH, Im Langacher 44, CH-8606 Greifensee, Switzerland

R076/2006-NL1-2016.24 (MAA)
Indicator - Type: AD-4401A
A&D Instruments Ltd., 24 Blacklands Way, Abingdon Business Park, Abingdon OX14 1DY, United Kingdom

R076/2006-NL1-2016.27 (MAA)
Non-automatic weighing instrument - Type bCom
Mettler-Toledo (Changzhou) Measurement Technology Ltd., N° 111, West TaiHu Road, ChangZhou XinBei District, CN-213125 Jiangsu, P.R. China

R076/2006-NL1-2016.34 (MAA)
Non-automatic weighing instrument - Type: bPlus
Mettler-Toledo GmbH, Im Langacher 44, CH-8606 Greifensee, Switzerland

R076/2006-NL1-2016.35 (MAA)
Analog data processing device (ADPD) - Type: PAD-400xA
Hottinger Baldwin Messtechnik GmbH, Im Tiefen See 45, DE-64293 Darmstadt, Germany

R076/2006-NL1-2016.36 (MAA)
Non-automatic weighing instrument - Type: Hill-Rom 900 series hospital beds
Hill-Rom S.A.S., ZI de Talhouet, FR-56330 Pluvigner, France

R076/2006-NL1-2016.37 (MAA)
Non-automatic weighing instrument - Type: RU-series
Ohaus Corporation, 7, Campus Drive, Suite 310, 07054 Parsippany - NJ, United States

R076/2006-NL1-2016.39 (MAA)
Non-automatic weighing instrument - Type: SM-5600
Teraoka Weigh-System PTE Ltd., 4 Leng Kee Road, #05-03/04/05 & 11, SIS Building, SG-159088 Singapore

R076/2006-NL1-2016.41 (MAA)
Non-automatic weighing instrument - Type: PFD series
Mettler-Toledo (Changzhou) Measurement Technology Ltd., N° 111, West TaiHu Road, ChangZhou XinBei District, CN-213125 Jiangsu, P.R. China

R076/2006-NL1-2016.43 (MAA)
Indicator - Type: IND570
Mettler-Toledo (Changzhou) Measurement Technology Ltd., N° 111, West TaiHu Road, ChangZhou XinBei District, CN-213125 Jiangsu, P.R. China

R076/2006-NL1-2016.44 (MAA)
Non-automatic weighing instrument - Type: DPS-560
Teraoka Seiko Co. Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku, JP-146-8580 Tokyo, Japan

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

NMRO Certification Services (NMRO), United Kingdom

R076/2006-GB1-2015.06 Rev. 1 (MAA)
Checkmaster and Linemaster V
Ian Fellows Ltd., 3D/E Centurion Way, Crusader Park, Warminster BA12 8BT, United Kingdom

R076/2006-GB1-2015.09 (MAA)
Type: MS-xxxx Series
Charder Electronic Co. Ltd., No. 103, Guozhong Road, Dali Dist, 412 Taichung, Chinese Taipei

R076/2006-GB1-2016.01 (MAA)
Type: MATAS PB
Kemek Engineering, Mokslininku str, 62, Vilnius, LT-08412 Lithuania

R076/2006-GB1-2016.03 (MAA)
Type: ZM510-SD4
Avery Weigh-Tronix, Foundry Lane, Smethwick B66 2LP, United Kingdom

R076/2006-GB1-2016.04 (MAA)
Type: MS-6110
Charder Electronic Co. Ltd., No. 103, Guozhong Road, Dali Dist, 412 Taichung, Chinese Taipei

R076/2006-GB1-2016.07 Rev. 1
Type: Xti or XTs family of instruments
Avery Berkel, Foundry Lane, Smethwick B66 2LP, United Kingdom

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

Physikalisch-Technische Bundesanstalt (PTB), Germany

R076/2006-DE1-2009.02 Rev. 1
Non-automatic electromechanical weighing instrument with or without lever system - Type: WM . . .
Bizerba GmbH & Co. KG, Wilhelm-Kraut-Strasse 65, DE-72336 Balingen, Germany

▶▶

R076/2006-DE1-2012.03 Rev. 4
Non-automatic electromechanical weighing instrument - Type: SQP . . .
Sartorius Lab Instruments GmbH & Co. KG, Weender Landstr. 94-108, DE-37075 Gottingen, Germany

R076/2006-DE1-2015.03 Rev. 1
Non-automatic electromechanical weighing instrument without lever works - Type: SARTOCOWAT
Sartorius Industrial Scales GmbH & Co. KG, Leinetal 2, DE-37120 Bovenden, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

R 117 (1995) + R 118 (1995)

▶ **Issuing Authority / *Autorité de délivrance***
Russian Research Institute for Metrological Service (VNIIMS)

R117/1995-RU1-2016.01 Rev. 1
MIDCO Fuel Dispensing Units SureFill/AccueFill Series Suction type and Remote type
Midco Ltd., Metro Estate, Vidyanagari Marg, Kalina, IN-400 098 Mumbai, India

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

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

R 117 (2007) + R 118 (1995)

▶ **Issuing Authority / *Autorité de délivrance***
Russian Research Institute for Metrological Service (VNIIMS)

R117/2007-RU1-2016.02
Fuel Dispensers Advantage Series
Gilbarco-China, Binhe Industrial Zone, No. 15 Jianshe Jie Road West Binhe, Pinggu District, CN-101200 Beijing, P.R. China

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

R117/2007-NL1-2015.01 Rev. 2
Density sensor (a sensor as a part of a densitometer) - Type : CDM100M, CDM 100P
Emerson Process Management Micro Motion Inc., 7070 Winchester Circle, CO 80301 Boulder, Colorado, United States

R117/2007-NL1-2016.01
Fuel dispenser - Type: Quantium XXXX
Tokheim Sofitam Applications S.A.S., Immeuble Le Cezanne, Paris Nord 31-35, Allee des Impressionnistes, BP 45027 Villepinte, FR-95912 Roissy Ch de Gaulle Cedex, France

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Gas meters
Compteurs de gaz

R 137 (2012)

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

R137/2012-NL1-2016.06
Diaphragm Gas Meter - Type: RS/ 2001 LA, RS/ 2001 AL, RS/ 2,4, RSV/ 2001 LA, RSV/ 2,4, RSE/ 2001 LA, RSE/ 2,4
Pietro Fiorentini S.p.A., Via E. Fermi 8/10,
IT-36057 Arcugnano (VI), Italy

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Gas measuring systems
Ensembles de mesurage de gaz

R 139 (2014)

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

R139/2014-CZ1-2016.01
Dispenser for compressed natural gas type OCEAN BMO 40xx.Oxx/CNG
Tatsuno Europe a.s., VAT No. CZ26221454,
Prazska 2325/68, CZ-67801 Blansko, Czech Republic

info

The OIML is pleased to welcome the following new

Corresponding Member readmissions

- Sudan
- Syrian Arab Republic

CIML Members

- Australia:
  Mr. Bill Loizides
- Norway:
  Mr. Hans Arne Frøystein
- Poland:
  Mr. Maciej Dobieszewski
- Spain:
  Mr. Jose Manuel Bernabe Sanchez

OIML meeting

October 2016

15th International Conference,
51st CIML Meeting and associated events

Week of 17 October 2016

Strasbourg, France

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www.worldmetrologyday.org
World Metrology Day Website

Committee Draft

Received by the BIML, 2016.06 – 2016.08

Revision of OIML R 61 Automatic gravimetric filling instruments	5 CD	TC 9/SC 2/p 8	UK	2016-07-01

Call for papers

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

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

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

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- 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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