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Contents

OIML BULLETIN

VOLUME LVI • NUMBER 1
JANUARY 2015

technique

evolutions

update

DELEGATES ATTENDING THE 49TH CIML MEETING

Sommaire

BULLETIN
OIML
Volume LVI • Numéro 1
janvier 2015

technique

évolutions

informations

■ Editorial

Peter Mason
CIML President

Happy New Year 2015

As we enter 2015 I ask myself what will be different in the world of the OIML. And the answer that comes most clearly is that we can expect to transform the way in which we carry out most of our work as a result of the new functions available on the OIML website. For an organisation such as the OIML, a website is more than just the window we show to the rest of the world. Increasingly, it will become central to the way in which we communicate with each other and, crucially, carry out the technical work which is our key role as a standards-making body.

Offering Members the opportunity to update their own information and designate participation in the technical work will ensure that the information needed to carry out our work is distributed more quickly and accurately so that it reaches those who are directly involved in such work. Extending electronic voting to project groups will mean that we are able to make decisions much more quickly. And looking forward, having a standard way of developing, commenting on and amending drafts means that more colleagues across the world of legal metrology will be able to make a contribution.

Making the most of this new set of tools will, however, require some effort on the part of all of us. My personal "New Year's Resolution" is to improve my understanding of everything the new website can do and to make a determined attempt to use it to its full capacity. My experiences so far have confirmed that the new functions are easy to understand and use.

Nevertheless, improved information technology and communications can only take us so far. We also need to ensure that we adapt the way in which we work. The OIML Convention remains the basis of what we do as an organisation, but how we work has changed significantly over the past four years and will continue to do so. At the 49th CIML Meeting a new approach to planning our activities was proposed and I believe this will be very valuable as we continue to develop both the OIML's technical work procedures and the OIML Certificate System.

So there remains much to be done – and much to look forward to.

Wishing you a very successful 2015... ■

Bonne Année 2015

En ce début d'année 2015, alors que je m'interroge sur ce qui va changer dans le monde de l'OIML, la réponse m'apparaît de façon très claire : nous pouvons espérer transformer notre manière d'effectuer la plus grande partie de nos travaux grâce aux nouvelles fonctions du site Internet de l'OIML. Pour une organisation comme l'OIML, un site Internet est bien plus que la vitrine que nous présentons au reste du monde. Il prendra une place de plus en plus centrale dans notre façon de communiquer et, surtout, de conduire les travaux techniques, rôle clé d'un organisme de normalisation comme le nôtre.

Donner aux Membres les moyens de mettre à jour leurs propres données et d'indiquer leur participation aux travaux techniques garantira une diffusion plus rapide et plus fiable des informations requises pour réaliser nos travaux afin d'atteindre ceux qui sont directement impliqués dans ces travaux. Étendre le vote électronique aux groupes de projet favorisera une prise de décisions accélérée. Et s'agissant des perspectives à terme, disposer d'une méthode normalisée pour élaborer, commenter et amender des projets permettra à un plus grand nombre de collègues de la communauté de la métrologie légale d'apporter leur contribution.

Mais, pour tirer pleinement parti de cette nouvelle panoplie d'outils, chacun de nous doit faire des efforts. Pour ma part, voici ma « résolution du Nouvel an » : mieux connaître toutes les possibilités qu'offre le nouveau site Internet et tenter résolument de l'exploiter à sa pleine capacité. Si j'en crois mon expérience à ce jour, ses nouvelles fonctions sont simples à comprendre et à utiliser.

Améliorer la technologie informatique et la communication n'est cependant qu'un début. Nous devons aussi adapter nos méthodes de travail. Si la Convention de l'OIML demeure le fondement de notre activité en tant qu'organisation, notre manière de travailler a, quant à elle, beaucoup changé ces quatre dernières années et continuera de changer. À sa 49ème réunion, le CIML a proposé une nouvelle stratégie de planification de nos activités qui sera, à mon avis, très utile alors que nous poursuivons le développement des procédures relatives aux travaux techniques de l'OIML et du Système de Certificats OIML.

Il reste donc beaucoup de choses à faire, mais aussi beaucoup de perspectives positives à venir.

Je vous souhaite à tous de grandes réussites pour l'année 2015... ■

FREQUENCY

Testing of exponential sweep signals with the aid of Hilbert transform

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Abstract

Exponential sweep signals are used for various measurements whenever a broadband excitation is required for supplying constant energy in frequency bands of constant relative bandwidth. A method is described which enables the detection of inaccurate exponential frequency increase with time by submitting the test signal to a Hilbert transform. This mathematical procedure furnishes the time dependence of amplitude as well as the instantaneous frequency. The capability of this method is demonstrated on a 1/3 octave filter bank which should be tested by an exponential swept sine according to the standard IEC 61260. Due to the detected stepwise linearized exponential frequency increase of the generator under test, by using this generator, a correct filter bank erroneously indicates level differences of several dBs in adjacent bands.

Introduction

For the spectral analysis of acoustic or vibration signals, for example on sound level meters, filter banks with constant relative bandwidth are used. These are, typically, octave and third octave band filters. For checking the time invariance of such filters, the standard IEC 61260 [1] recommends a sweeping sinusoidal sound signal with an exact exponential frequency increase as a test signal. With constant amplitude, this signal subsequently provides the same energy to all individual filters of the filter bank, and, therefore, all filters should indicate the same level value. This is the case if no input data are lost during signal processing (time invariant operation) and if the frequency of the test signal increases exponentially with a constant sweep rate and amplitude. A method for checking the required properties of the test signal is described below.

Swept sine signal

The sweep starts at time T_{start} with frequency f_{start} and ends with frequency f_{end} at time T_{end}. The frequency will therefore be:

$$f(t) = f_{start} \cdot \exp(r(t - T_{start})) \qquad (1)$$

Thus, at the end of the sweep:

$$f_{end} = f_{start} \cdot \exp(r(T_{end} - T_{start})) \qquad (2)$$

The exponential sweep rate r, assumed to be a constant, is therefore:

$$r = \frac{\ln\left(\frac{f_{end}}{f_{start}}\right)}{T_{end} - T_{start}} \qquad (3)$$

For the ideal exponential swept sine signal:

$$x(t) = A \sin\left[\frac{2\pi}{r}(f(t) - f_{start})\right] \qquad (4)$$

where $f(t)$ is given by eq. (1) and plotted in Figure 1 for a signal of 10 s duration.

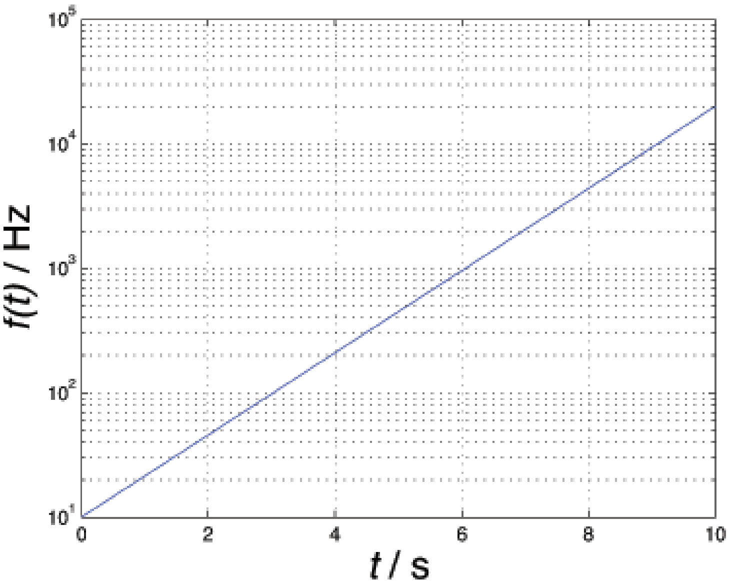

Figure 1 Logarithmic representation of the instantaneous frequency (10 Hz ... 20 kHz) with respect to time of an exponential sweep signal (eq.(1))

Applying such a signal to the input of the filter bank should display a constant level for all filters after an averaging process including the complete calculation time which, especially for very low frequency bands (< 10 Hz), is necessary because here the averaging requires much more time than the excitation.

A prerequisite for the validity of such a filter check is that the applied exponential sweep signal fulfills the following requirements:

- the amplitude of the signal has to be constant over the whole measured frequency range;
- the sweep rate r (eq.(3)) should also be constant for all frequencies.

Only if both conditions are met, the energy of the signal within each fractional-octave-filter band will be constant. To check these conditions, the properties of the Hilbert transform proved to be an appropriate means.

Hilbert transform

First, the test signal has to be digitized by an AD converter. The digital time signal will be submitted to a Hilbert transform [3]–[6]. This mathematical procedure is based on the Fast Fourier transform (FFT) and provides a complex time function for the signal under test, the real part of which is the input signal $x(t)$. Together with the calculated imaginary part of the Hilbert transform $x'(t)$, an envelope and, thus, a time-related amplitude signal $|z(t)|$ (magnitude) can be generated. The complex signal $z(t)$ is called the *analytical signal*:

$$z(t) = x(t) + \mathrm{j}\, x'(t) = |z(t)| \exp(\phi(t)) \qquad (5)$$

The envelope $|z(t)|$ is given by:

$$|z(t)| = \sqrt{x^2(t) + x'^2(t)} \qquad (6)$$

The instantaneous phase is defined as:

$$\phi(t) = \arctan(x'(t)/x(t)) \qquad (7)$$

The instantaneous frequency $f_{\mathrm{inst}}(t)$ can be calculated from (7) as a function of time using:

$$f_{\mathrm{inst}}(t) = \frac{1}{2\pi}\frac{\mathrm{d}\phi}{\mathrm{d}t} \;. \qquad (8)$$

Equations (6) and (8) provide the required time-dependent quantities magnitude $|z(t)|$ and instantaneous frequency $f_{\mathrm{inst}}(t)$.

When applying the Hilbert transform to the signal $x(t)$ (eq.(4)) some minor artifacts occur due to the start and stop process of the sweep in the Fourier transform which are discussed in [2] in more detail. In the following, an example is given of how a deviation from these requirements can be detected and to which extent the application of an inaccurate exponential swept sine $x(t)$ can lead to a wrong judgement of a correct working filter bank.

Check of a generator sweep

In practice, signal generators are still in use which generate the exponential sweep by piecewise linear approximation. Figure 2 shows the result of calculation of the instantaneous frequency of such a generator signal (generator: HP3325A). For a better identification of the linear sections, the frequency axis here is linear scaled.

To show the influence of the test signal, a comparison was made by applying different exponential swept sine signals to a correct time invariant 1/3 octave filter bank in a sound level meter (Norsonic NOR131). Applying a pure exponential swept sine with constant input amplitude corresponding to sound pressure level of 106 dB, a constant filter output level should be indicated. For the first generator (B&K 1051) the result is shown in Figure 3. The level displayed on the sound level meter only varies within the limits of the display resolution between 105.9 dB and 106 dB. This is the expected result for a correct exponential sweep. In contrast, using the generator with linearized exponential sweep (HP3325A), the same filter bank shows significant deviations from the expected constant values as shown in Figure 4. The use of such an inaccurate test signal inevitably leads to an incorrect assessment of a filter bank.

Discussion

Although the use of exponential swept sine test signals is very common today, for example in room acoustics or electroacoustics, until now no method has been presented for verifying the validity of such measurements. The given example shows that the error in the final result is significant, when fractional octave band filters are used in connection with erroneous exponential swept sine signals. Also for other measurements using linearized exponential sweep signals for excitation, it is obvious that the energy is not equally

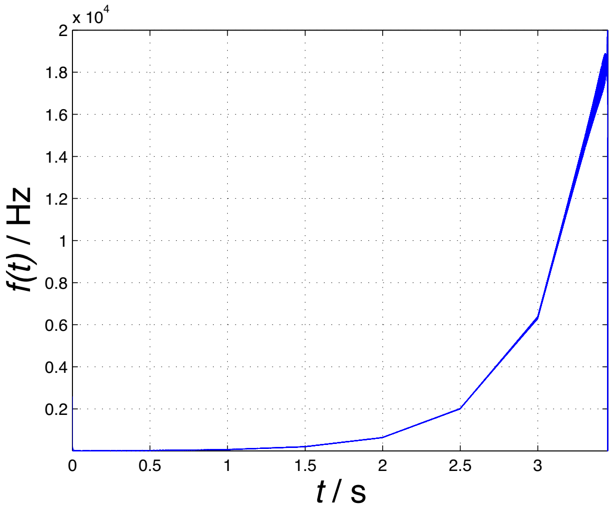

Figure 2 Measured instantaneous frequency of a piecewise linearized exponential sweep, plotted on a linear frequency scale

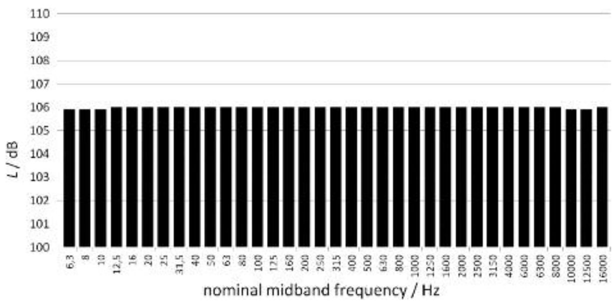

Figure 3 Correct result of a filter bank in a sound level meter excited with a pure exponential sweep signal (generator B&K 1051)

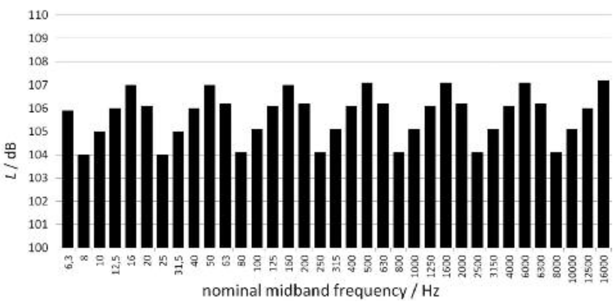

Figure 4 Incorrect result of the same filter as in Figure 3 by using a linearized exponential sweep signal (generator HP 3325A)

distributed on a logarithmic frequency scale, which for example is necessary for evaluations in fractional octave band filters.

In modern FFT analyzers or signal processing systems the Hilbert transform is often implemented but unfortunately, the properties of the instantaneous frequency are hardly exploited. If the imaginary part $x'(t)$ of the analytic signal (eq. (5)) is available, it is possible to calculate the instantaneous frequency applying equations (7) and (8). See [6] for applications in musical acoustics.

Conclusion

The Hilbert transform algorithm is able to calculate the instantaneous frequency of exponential sweep signals for fractional octave band filters and can detect inaccurate exponential characteristics of generators. Further, the simultaneous calculation of the magnitude (envelope) vs. time enables a precise check to be made of the required properties of swept sine test signals. The example presented shows that a check of exponential swept sine test signals to be used should be mandatory. This text is an excerpt from a recently published paper [2]. ■

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WEIGHING IN MOTION

Analysis of weigh-in-motion tank vehicles transporting liquid cargo on highways

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Abstract

In order to avoid accidents and limit damage to the road surface it is important to prevent the presence of overweight trucks. The traffic regulations stipulate the Gross Vehicle Weight (GVW) and the vehicle axle load. This paper analyzes the dynamic behavior of the force exerted on the ground by the axles of a tanker vehicle carrying liquid during weigh-in-motion and the application of weight surveillance using OIML R 134. Field measurements were carried out using various types of vehicles and liquid loads on different types of roads and weighing instruments up to 6 km/h. Laboratory experiments were developed to study the behavior of vehicles with six axles both with baffles (internal partitions) and without baffles. Dynamic models and digital simulations were developed to study the influence of a senoidal force applied to the tank to generate a sloshing effect.

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1 Introduction

Recently, there has been growing concern in Brazil over the need to reduce damage to highway road surfaces. The service life of the road surface is proportional to the weight of the vehicles using it [1], which has led to the introduction of weight controls.

National law [2,3,4] sets the excess weight limit for vehicles at 5 % for GVW and 10 % for axles. The traffic authority uses scales to control truck weight, which may be static [5] or weigh-in-motion systems (WIM) [6] where the metrological maximum permissible error (mpe) for type approval and initial verification is 0.5 % for GVW and 1.5 % for axles. Particularly in the case of liquid transport, measurement by axles is prohibited. Currently, the process of measuring the weight of vehicles in motion is carried out at low speed. It is believed that the measurement accuracy decreases when the velocity increases.

However, the number of vehicles on the roadways is increasing and the process of weight control needs to be faster. New studies intend to increase the velocity of the weight measurement using weigh-in-motion (WIM) [7]. Weigh-in-motion at high speed is used for direct application in the surveillance of the weight of vehicles, using as a criterion a mix of the relevant OIML Recommendations and a draft European Standard (Fiwi) [8]. The use of sensors installed on bridges to estimate the weight of vehicles for monitoring the use of bridges has been studied [9,10,11,12,13]. The speed and roughness significantly influence the impact during the measurement of axle load at a speed of 17 m/s [14]. Determining the best location(s) for installing weigh-in-motion equipment is therefore important [15]. The use of fiber optic based dynamic pressure sensors for WIM system is considered [16].

A field study using weigh-in-motion with trucks carrying liquid is being developed [17]. Weigh-in-motion experiments in the field with different types of trucks with water at three different levels have been conducted [18]. However, the accuracy of WIM systems is still of some concern. International standards use different ways to classify WIM measuring instruments [19,20,21]. The sloshing effect is also important for dynamic analysis in liquid transport [22,23,24].

2 Methods and results

Field measurements of GVW and weight per axle weighing of moving vehicles up to 6 km/h were performed on two highways. In order to reduce the influence of the characteristics of the installation of weighing instruments in the field, a reduced scale experiment was prepared in a similar installation in a laboratory. Similar load sensors to those used in weighing instruments were used to evaluate the applied force per axle. The vehicle weight was also registered in a static balance for reference purposes. A multi-body system based on the mass-spring-damper model was used to represent the sloshing effect and to estimate the axle forces and GVW.

2.1 Field measurements

A preliminary analysis was performed of field measurements made in weigh-in-motion facilities commonly used in weight monitoring and control of excess load trucks on the roads. A representative sample of the types of trucks in the Brazilian fleet of tank trucks carrying liquid was used, considering the different diameters of the tanks, load configurations and density of product transported, according to meetings at the National Transportation Agency (ANTT) and class associations. The portable dynamic scale shown in Figure 1 was used on the Imigrantes highway in São Paulo.

The results are shown in Table 1 for 10 measurements at each of the speeds 2 km/h, 4 km/h and 6 km/h. Vehicles with liquid cargo exhibit higher errors than vehicles with dry cargo:

- the maximum value of the GVW mean error was 0.63 % for the six-axle vehicle with an LPG load;
- the maximum error per axle was 4.84 % for a six-axle truck loaded with caustic soda;
- the maximum error for the GVW was 3.01 % for a tank container vehicle.

These two vehicles do not use baffles. It was possible to compare the two types of vehicles used for different products. Figure 2 shows an 3S3 type of vehicle: the last three axles work in conjunction using a tandem system. Figures 3 and 4 show a 3I3 type of vehicle, where the last three axles are independent. Figure 5 shows the mass axles distribution in 3S3 vehicles. Figure 6 show the mass axles distribution in 3I3, where the last three axles are more balanced. The combined uncertainty U was estimated, considering a coverage factor $k = 2$, the uncertainty related to the repeatability factor u_1, the uncertainty related to the standard used u_2 and the uncertainty regarding the reading u_3, according to Table 2 and equation 1, considering type A from a sequence of measurements and B direct.

$$U = k\sqrt{u^2{}_1 + u^2{}_2 + u^2{}_3} \tag{1}$$

Additionally, an inspection was undertaken to record the conditions of vehicle safety, in order to check the conditions of the tyres and chassis on vehicle stability.

Figure 1 Portable dynamic scale

Figure 2 Vehicle type 3S3 with acrylate

A fixing problem in the chassis of the vehicle with five axles and tank container was identified.

Subsequently, a specific operational structure was developed on the Presidente Dutra highway in Queluz city in São Paulo, Brazil, to measure vehicle weight. The vehicles passed by a sequence of weighing in motion devices, first a fixed WIM shown in Figure 7 and then onto a portable dynamic scale shown in Figure 8, installed in the same path occupying two points as indicated in Figure 9. This layout allowed the direct comparison between the two weighing instruments. A comparison of the results obtained at this stage between the fixed WIM and the portable WIM is shown in Tables 2 and 3, considering 10 measurements at each speed 2 km/h, 4 km/h and 6 km/h for relative max axle error, max GVW error and standard deviation in the GVW of the mean values.

The seven-axle vehicle with alcohol showed a maximum mean error of –1.8 % on the fixed WIM and 1.4 % on the portable WIM. On the other hand, the maximum error per axle load was –4.73 % for the vehicle with biodiesel on the fixed WIM and the maximum error

Table 1 Comparative values of weight measurement in motion

Type of vehicle and number of axles	Products transported	Max error per axle	Max error (GVW)	Average error (GVW)	Standard deviation in (GVW)	Uncertainty
3 axles	Mass reference	–1.22 %	–0.76 %	–0.11 %	0.34 %	0.14 %
3 axle	Glycol	– 1.95 %	– 1.6 %	–0.17 %	0.47 %	0.18 %
3 axles	Glycol	– 2.76 %	–1.15 %	–0.52 %	0.4 %	0.19 %
5 axles tank container	Polyisobutylene	4.64 %	3.01 %	0.55 %	0.73 %	0.29 %
5 axles	Alcohol	–1.72 %	–0.9 %	–0.33 %	0.4 %	0.15 %
6 axles 3S3	LPG	2.14 %	1.78 %	0.63 %	0.6 %	0.17 %
6 axles 3S3	Catalyst	–2.24 %	1.27 %	0.18 %	0.35 %	0.13 %
6 axles 3S3	Acrylate	2.89 %	1.9 %	0.61 %	0.57 %	0.21 %
6 axles 3S3	Gasoline	–2.08 %	–1.36 %	–0.18 %	0.5 %	0.19 %
6 axles 3S3	LPG	3.52 %	1.68 %	0.23 %	0.46 %	0.22 %
6 axles 3I3	Hypochlorite	2.85 %	0.36 %	0.08 %	0.17 %	0.18 %
6 axles 3I3	Ammonia	3.27 %	0.79 %	0.58 %	0.2 %	0.08 %
6 axles 3I3	Caustic soda	4.84 %	–1.46 %	0.23 %	0.38 %	0.15 %
7 axles	Alcohol	–3.23 %	–1.29 %	–0.44 %	0.55 %	0.19 %
6 axles 3S3	Sugar	–2.19 %	–1.02 %	–0.51 %	0.27 %	0.1 %
9 axles	Soybean	–2.92 %	1.00 %	0.26 %	0.37 %	0.13 %

Uncertainty factors considered

Uncertainty	Resolution	Type	Distribution
Repeatability	-	A	normal
Standard	10 kg	B	rectangular
Reading	10 kg	B	rectangular

per total weight was –3.06 % for the seven-axle vehicle with alcohol. On the portable WIM the maximum error per axle was 7.79 % and the maximum error per GVW was 4.72 % for the seven-axle vehicle with alcohol. The largest errors during the measurements were related primarily to the effects of vibration due to vehicle maintenance. The vibration in the case of the portable instrument was larger because it was not fixed to the base installation.

2.2 Laboratory experiment

A laboratory experiment was developed to avoid the effect of vibration caused by road surface roughness and slope, and so that the repeatability of measurements and vehicle acceleration could be controlled. In the COPPE-UFRJ Acoustics and Vibration Laboratory an experimental lane, a reduced size model of a WIM vehicle weighing system and a six-axle vehicle made of aluminum, shown in Figure 10, were used.

To observe the movement of the liquid, two acrylic cargo tanks were built, one with internal baffles (shown in Figure 11) and the other without baffles, shown in Figure 12, similar to cargo tanks for liquid transportation. The objective of using baffles was to prevent excessive movement of the load, but they are not used for the shipment of certain products, in line with current

Figure 3 Vehicle type 3I3 with asphalt

Figure 4 Vehicle type 3I3 with LPG

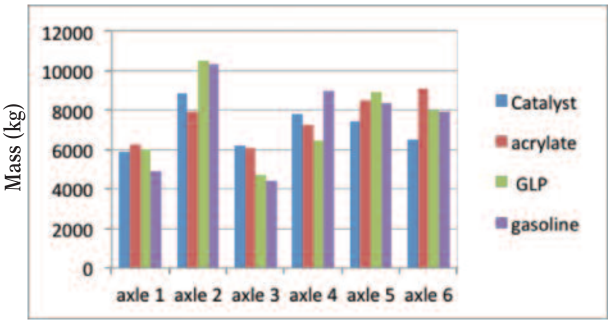

Figure 5 Mass distribution for axles in 3S3 vehicles

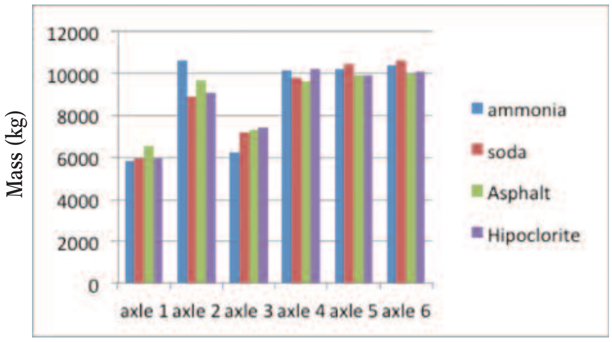

Figure 6 Mass distribution for axles in 3I3 vehicles

Figure 7 Detail of fixed scales in the weighing station

Figure 8 Detail of the installation of a portable scale sequencing

Figure 9 Provision of a fixed scale and a portable scale sequencing

Table 2 Individual weighings on the fixed scales

Type of vehicle and number of axles	Products transported	Fixed WIM				
		Max axle error	Max error (GVW)	Average error (GVW)	Standard deviation in (GVW)	Uncertainty (GVW)
6 axles 3S3	Butadiene	1.88 %	2.41 %	0.09 %	0.41 %	0.15 %
6 axles 3S3	Estileno	–3.49 %	–0.57 %	–0.11 %	0.19 %	0.2 %
6 axles 3I3	Biodiesel	–4.73 %	–1.62 %	–0.79 %	0.28 %	0.14 %
7 axles Bitrem	Alcohol	–4.44 %	–3.06 %	–1.80 %	0.59 %	0.51 %

Table 3 Different weighings using the portable scale

Type of vehicle and number of axles	Products transported	Portable WIM				
		Max axle error	Max error (GVW)	Average error (GVW)	Standard deviation in (GVW)	Uncertainty (GVW)
6 axles 3S3	Butadiene	1.72 %	0.78 %	0.09 %	0.41 %	0.15 %
6 axles 3S3	Estileno	–2.33 %	1.51 %	0.29 %	0.56 %	0.07 %
6 axles 3I3	Biodiesel	–4.05 %	–1.58 %	1 %	0.38 %	0.1 %
7 axles Bitrem	Alcohol	7.79 %	4.72 %	1.40 %	1.06 %	0.51 %

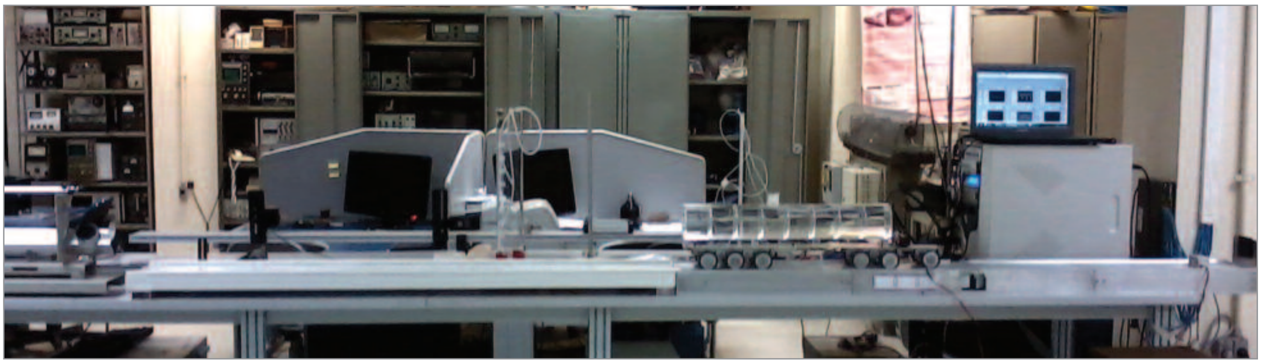

Figure 10 Experimental track weighing

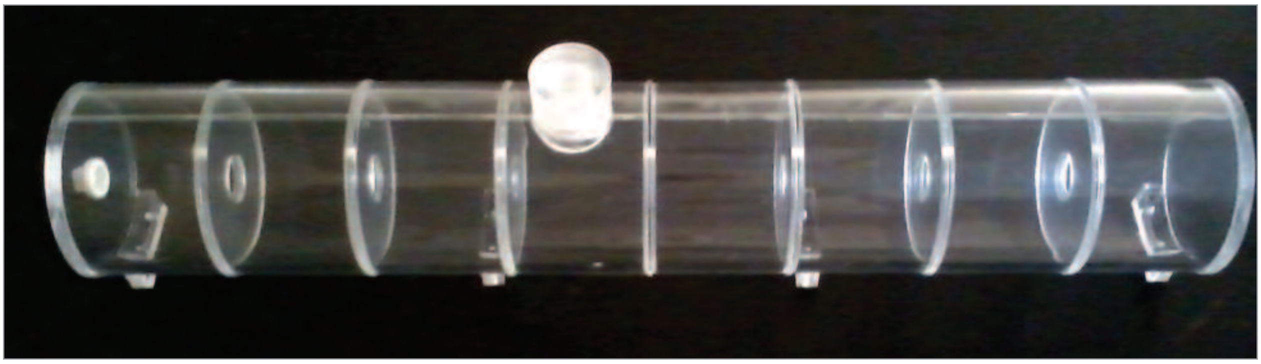

Figure 11 Tank with baffles

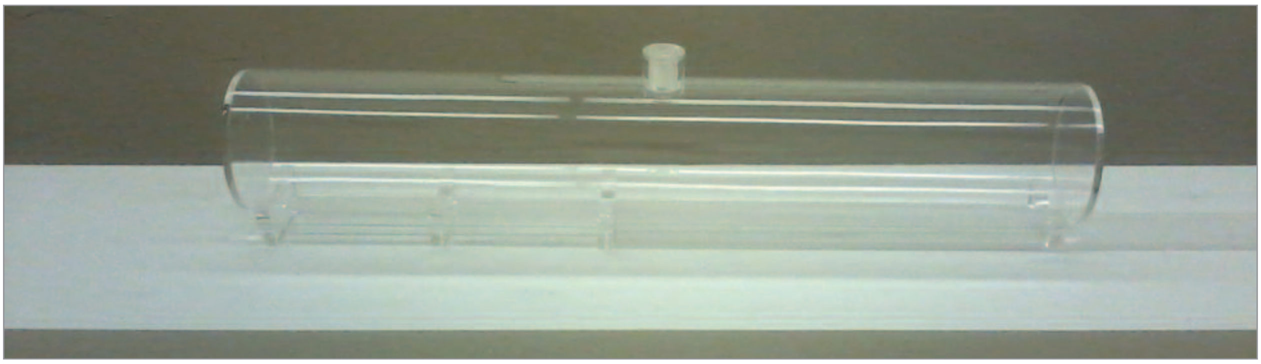

Figure 12 Tank without baffles

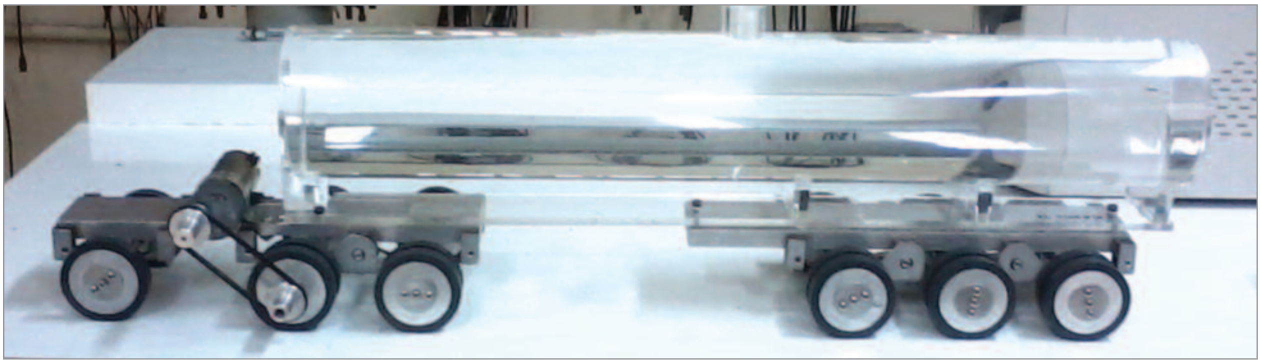

Figure 13 Prototype truck with tank without baffles

legislation. The two tanks were built with the same dimensions, but the tank with baffles has a lower transport capacity due to the space taken up by the internal partitions. The tanks were installed on a prototype similar to the six-axle vehicle, as shown in Figure 13, for axle weight measurements under different conditions.

A Labview interface was developed for signal acquisition. The electrical signals of four load cells were processed and added to allow the resultant forces applied by the prototype axles to be evaluated. Measurements were performed at three different speeds, where (s1) represents the low speed 0.1 m/s, (s2) the intermediate speed 0.2 m/s and (s3) the high speed 0.3 m/s. The prototypes with the two types of tanks were compared to the reference values obtained from a static balance. The results for the total weight are shown in Figure 14 for the tank without baffles and in Figure 15 for the tank with baffles. The dynamically measured values are higher than the static mass. The vehicle is accelerated from its rest position, passing over the sensors before the fluid has time to settle down, so the fluid is still being accelerated.

The laboratory measurements show the dynamic effect of the liquid load during the measurement of force in the WIM system. The difference between the reference values of the GVW and the dynamically measured values corresponds to the effect of impacts

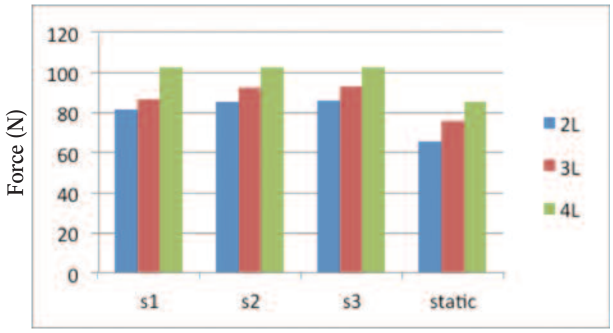

Figure 14 Measurements of the GVW of the prototype truck with tank without baffles

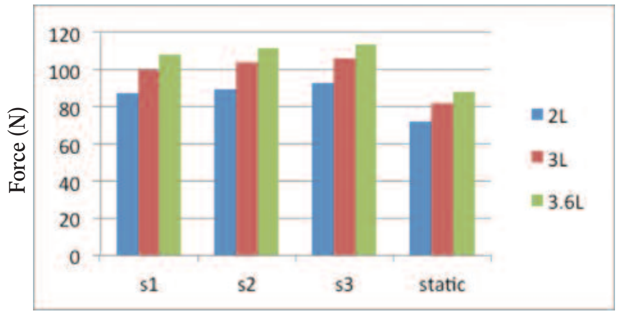

Figure 15 Measurements of the GVW of the prototype truck with tank with baffles

and transients on the load sensors. Regarding the laboratory measurements, Figure 16 shows the dynamic effect for the tank without baffles and Figure 17 shows the effect for the tank with baffles. The dynamic factor varies between 1.1 and 1.3, considering the dynamic effect of the vehicle load *D*, the static effect of the vehicle load *S* according to equation 2, the dynamic factor *IM* and the maximum dynamic and static value $R_d(x)$ $R_s(x)$ according to equations 2 and 3 [16].

$$D = (1 + IM) * S \tag{2}$$

$$IM = \frac{R_d(x) - R_s(x)}{R_s(x)} \tag{3}$$

The variation of the dynamic factor in the tank with baffles is more a function of the speed than of the load. However, the variation of the dynamic factor in the tank without baffles is more a function of the load than of the speed.

2.3 Computer modelling

Computer models were developed for the vehicles used in the laboratory. Tanks both with and without baffles were considered. For each model a system of nonlinear equations of 19 variables was developed, considering the concepts of Newtonian dynamics with the determination of the equations of motion according to the methodology proposed in [25,26]. The model developed used the concepts of multi-degrees of freedom [27], according to equation 4. The relationship of the displacement variables *q(i)* is shown in the schematic drawings in Figures 18 and 20.

The displacement force *F* depends on the mass matrix $\bar{M}$, the matrix damping $\bar{C}$, and the elasticity coefficient matrix $\bar{K}$.

$$\bar{M}\ddot{q}(t) + \bar{C}\dot{q}(t) + \bar{K}\, q(t) = F(t) \tag{4}$$

Damping and spring effects are used for the modelling of the liquid displacement, using constants obtained in the laboratory experiments. Sequences of measurements for each loading condition and type of tank, using the constant of elasticity and the natural frequency were performed. The ratio of mass values (m) and natural frequency (f), according to equation 5, was measured by counting the variations in the load position after a short lateral excitation in the tank, provided that the spring constant (K) and the time to establish the load was used to estimate the damping coefficient (C). (K) and (C) are presented in Table 4.

$$f \approx \frac{1}{2\pi}\sqrt{\frac{k}{m}} \tag{5}$$

The axle forces were obtained considering the effects of the mass-spring-damper, and F according to equation 6. For the GVW the relative error Er% was estimated according to equation 7. The model for the tank with baffles is represented in Figure 18 and the result is presented in Figure 19 and Table 5. For the tank without baffles the model is presented in Figure 20 and the result is presented in Figure 21 and Table 6. A harmonic force *F* was applied in time, considering the amplitude Fm and the period Tp. The time to pass each axle over the weighing station was estimated for Fm = 4N and Tp = 2s. Measurements were performed at the same three different speeds as during the laboratory experiment, where (s1) represents the low speed 0.1 m/s, (s2) the intermediate speed 0.2 m/s and (s3) the high speed 0.3 m/s.

$$F = Fm*\sin(2*Pi*t/Tp) \tag{6}$$

$$Er\% = \left(\frac{Rd(x) - Rs(x)}{Rs(x)}\right) * 100 \tag{7}$$

The results considering the same Fm = 4N but Tp = 4s are presented in Tables 7 and 8. The results considering *F* = 4N constant are presented in Table 9 for the tank with baffles and in Table 10 for the tank without baffles.

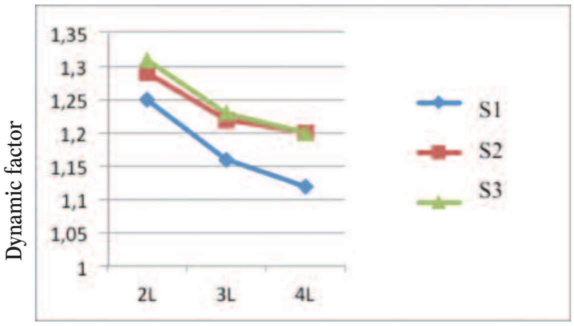

Figure 16 Dynamic effect of measurements in the laboratory – Tank without baffles

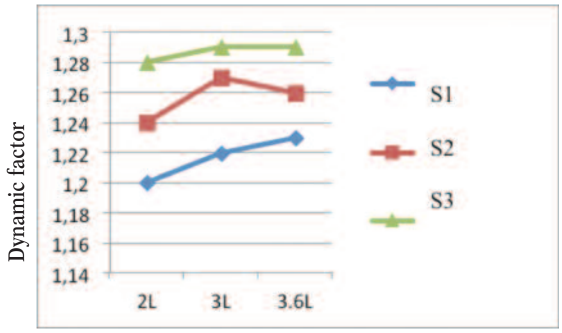

Figure 17 Dynamic effect of measurements in the laboratory – Tank with baffles

Table 4 Spring constant and damping coefficient values

	With baffles			**Without baffles**		
Load	2 L	3 L	4 L	2 L	3 L	3.6 L
K [N/m]	90	136	2000	55	472	2000
C [m/s]	0.2	0.02	2000	10	100	2000

Table 5 Gross vehicle weight for the six vehicle axles for the tank with baffles *F* harmonic

Relative % error - Tank with baffles Fm = 4 and Tp = 2			
	Speed		
Load	s1	s2	s3
2 L	–0.13	–0.24	0.016
3 L	–0.14	–0.31	0.043
4 L	–0.15	–0.27	–0.0016

Table 6 Gross vehicle weight for the six vehicle axles for the tank without baffles *F* harmonic

Relative % error - Tank without baffles Fm = 4 and Tp = 2			
	Speed		
Load	s1	s2	s3
2 L	–0.52	–0.68	–0.39
3 L	-0,10	-0,13	-0,076
4 L	–0.016	–0.01	–0.0079

Table 7 Gross vehicle weight for the six vehicle axles for the tank with baffles Tp = 4s

Relative % error - Tank with baffles Fm = 4 and Tp = 4			
	Speed		
Load	s1	s2	s3
2 L	–0.31	–0.45	–0.03
3 L	–0.26	–0.56	–0.30
4 L	–0.28	–0.54	–0.37

Table 8 Gross vehicle weight for the six vehicle axles for the tank without baffles Tp = 4s

Relative % error - Tank without baffles Fm = 4 and Tp = 4			
	Speed		
Load	s1	s2	s3
2 L	–0.76	–1.50	–0.63
3 L	–0.16	–0.32	–0.11
4 L	–0.031	–0.056	0.030

Table 9 Gross vehicle weight for the six vehicle axles for the tank with baffles *F* constant

Relative % error - Tank with baffles *F* = 4 constant			
	Speed		
Load	s1	s2	s3
2L	–0.08	0.043	–0.030
3L	–0.28	0.018	0.25
4L	0.0036	0.014	0.026

Table 10 Gross vehicle weight for the six vehicle axles for the tank without baffles *F* constant

Relative % error - Tank without baffles *F* = 4 constant			
	Speed		
Load	s1	s2	s3
2 L	0.00021	0.0062	0.0570
3 L	0.0021	0.018	0.042
4 L	0.020	0.043	0.059

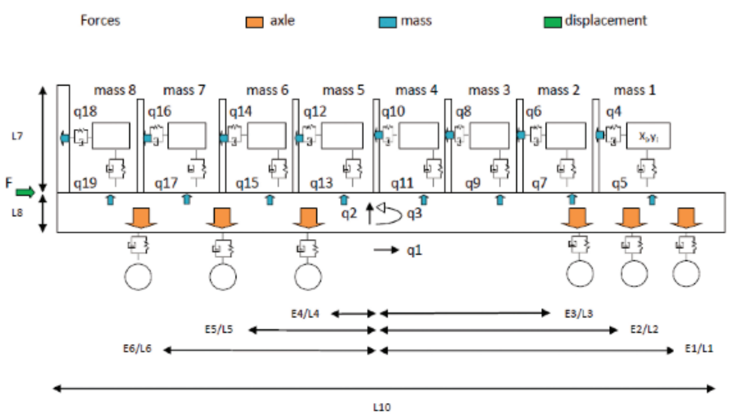

Figure 18 Dynamic model for the six vehicle axles for the tank with baffles

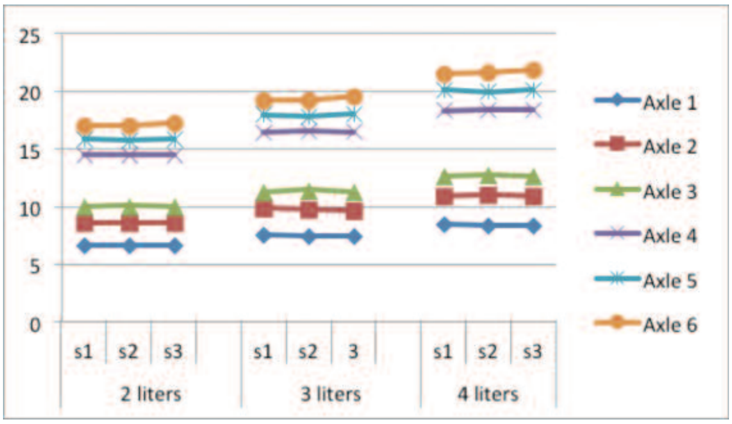

Figure 19 Axle forces for the six vehicle axles for the tank with baffles *F* harmonic

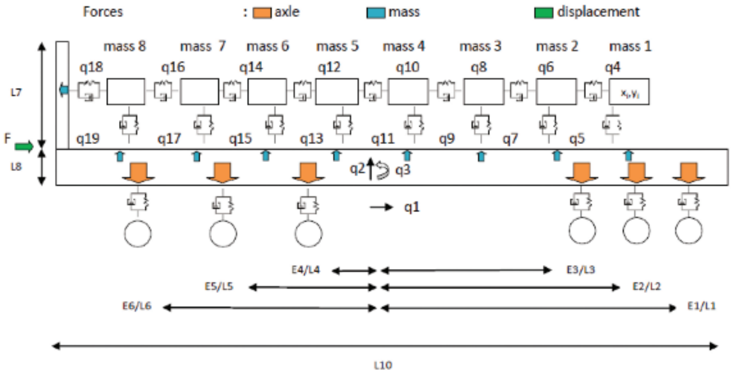

Figure 20 Dynamic model for the six vehicle axles for the tank without baffles

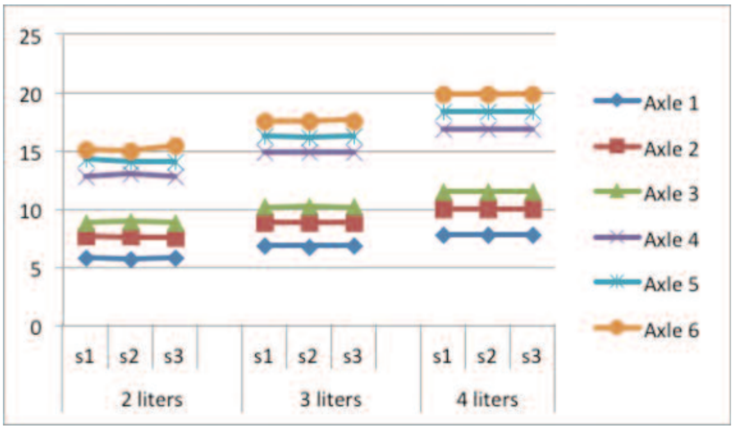

Figure 21 Axle forces for the six vehicle axles for the tank without baffles *F* harmonic

The influence of the harmonic force could be verified. With constant *F* the accuracy is better than when *F* is harmonic.

The influence of acceleration is presented considering the example of 3 liters varying Tp at F = 27N. The results are presented in Table 11 and in Figure 22 considering axle1 = E1, axle2 = E2, axle3 = E3, axle4 = E4, axle5 = E5 and axle6 = E6. For constant velocity 16 m/s the results are presented in Table 12 and Figure 23 for the tank without baffles, and in Table 13 and Figure 24 for the tank with baffles.

Table 11 Gross vehicle weight for the six vehicle axles for the tank with baffles - Tp varying

3 liters with baffles Fm = 27 N velocity 16 m/s			
	Tp = 2s	Tp = 4s	Tp = 8s
Er%	–0.90	–0.49	–0.57

Table 12 Gross vehicle weight for the six vehicle axles for the tank without baffles - *F* varying

3 liters without baffles Fm = 27 N velocity 16 m/s			
	Tp = 2s		Tp = 8s
Er%	–0.11	Er%	–0.030

Table 13 Gross vehicle weight for the six vehicle axles for the tank with baffles - *F* varying

3 liters with baffles constant velocity 16 m/s		
	F = 0	F = 27 N
Er%	–0.485	–0.488

3 Discussion

Studies [28,29,30] show the importance of the use of different types of vehicles to analyze the accuracy of WIM systems in application for monitoring the truck weight. The results presented for field measurements were obtained with loads of different products, and many types of vehicles and tanks. The axle force distribution in different kinds of vehicle was demonstrated. The maximum errors in the field study are similar to [28]. Vehicle weights can be influenced by vibration related to the suspension of the vehicle and the road surface.

In [28] the dynamic effect is considered of the relation between the standard deviation of the dynamic measurements and the static tyre pressure to qualify the dynamic load. In [16] the relation *D* was considered. In this study the laboratory experiments show the dynamic effect that varies between 1.1 to 1.3 for the GVW. The same vehicle with six axles was used to compare the use of the tank both with and without baffles. The difficulty for the software to obtain the weight of the vehicle from the dynamic value could be demonstrated. According to [22,23,24] it is important to consider the slosh effect when the movement is laminar or turbulent. The effect of sloshing is more significant when it is turbulent.

The dynamic computer model showed the influence of the harmonic force applied at the vehicle and velocity. The axle influence of the force was presented on tanks both with and without baffles. For the metrological approach it is important to emphasize the analysis of acceleration during measurements. The variation of the

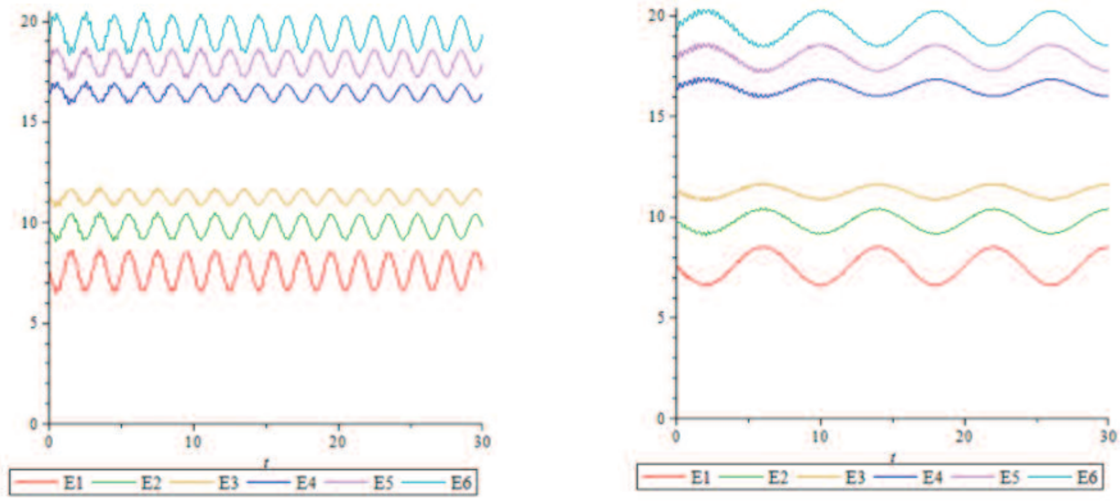

Figure 22 Tank with baffles at Fm = 27 N Tp = 2s and Tp = 8s and velocity=16 m/s

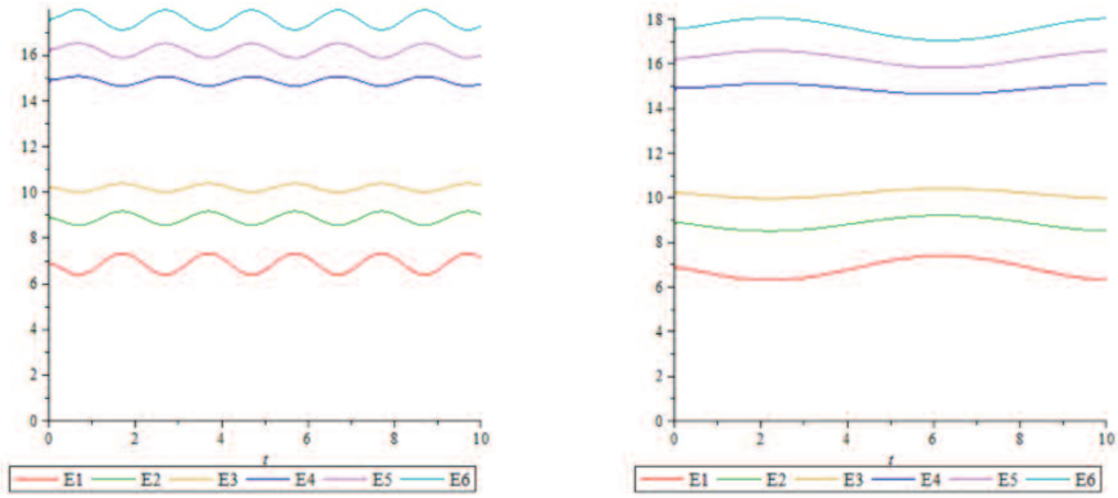

Figure 23 Tank without baffles at Fm = 27 N Tp = 2s and Tp = 8s and velocity = 16 m/s

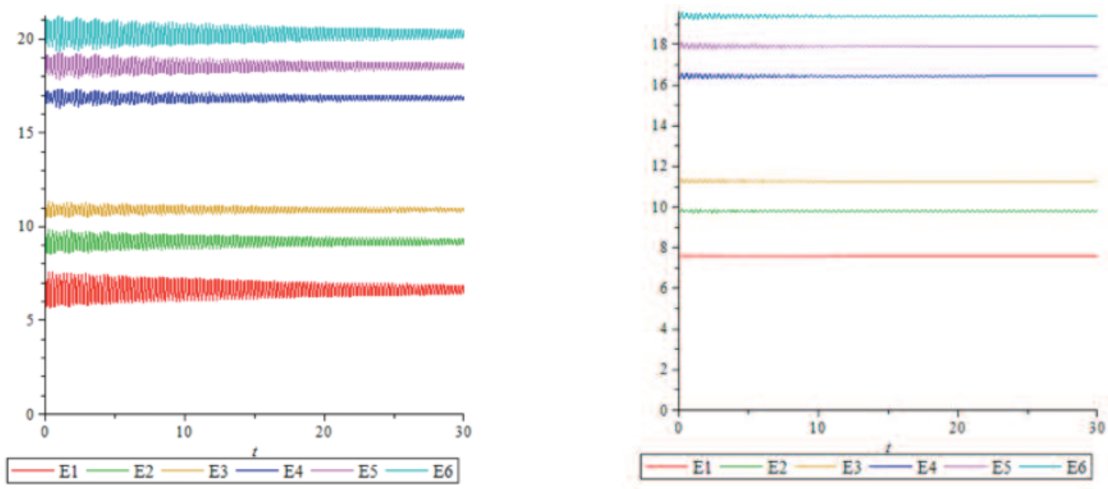

Figure 24 Tank with baffles at F = 27 N F = 0 N and velocity = 16 m/s

acceleration can be recorded to be related to the force measured on the sensors in order to reduce measurement uncertainties. The acceleration control during weighing is indicated to improve the WIM accuracy. There is a limit of 0.6 m/s^2 considered in [20]. The speed of the data processing is fundamental for real application.

Vehicles carrying liquid loads or other products that that may be subjected to fluctuations in their center of gravity when the vehicle moves, shall be used as reference vehicles only if the WIM instrument is applied subsequently for determining the mass, or the loads of single-axles and/or axle-groups of such vehicles. If the WIM instrument is not intended for this use, it shall bear the marking “not to be used to weigh vehicles carrying liquids or other products that may be subjected to fluctuations in their center of gravity by vehicle movement” [19]. OIML R 134 [19] classifies the maximum error and 100 % of values as a determining factor in the classification for considering the tolerance limit.

Moreover, ASTM-1318 [20] and COST [21] highlight the average of the measurements as being a determining factor in the classification of instruments and 95 % of reliability. But in this case the standard deviation of the mean is important for the influence of the dynamic effect. No tyre load measurement shall be taken until the oscillations induced by inertial forces (for example, via a load of undulating liquid) of the vehicle have subsided to a point that the indicated tyre load changes less than three scale divisions in 3 s. If more than 6 s are required to reach this stable condition when making any tyre load measurement after the brakes on the vehicle being weighed are fully released, the vehicle shall be eliminated from the test unit for type approval test loading [20].

4 Conclusion

The field accuracy in the fixed instrument is better than in the portable scales. For the fixed WIM the maximum GVW errors were –3.06 %, 2.41 % and for the axle –4.73 %, 1.88 %. For the portable WIM the max GVW error was 4.72 % and for the axle it was 7.79 %. The uncertainties obtained were 0.08 % up to 0.51 %.

For national application the difference between the maximum error and the limit of overload tolerance is important. Considering the field results and [19] on initial verification it would be required to adopt classes 10 for the GVW and F for the axle. The maximum permissible error for the vehicle mass determined by in-motion weighing as a percentage of the conventional value of the vehicle mass in class 10 is 5 % on initial verification and 10 % on in-service inspection. F is 8 % on initial verification and 16 % on in-service inspection [19]. The current Brazilian national metrological mpe is 0.5 % for GVW and 1.5 % for axles in type approval. The use of WIM in a liquid load is currently prohibited for use in weight control. Nevertheless, WIM could still be suggested for use in selective traffic monitoring. Only overweight vehicles, as indicated by WIM, would be further evaluated in a static condition, on fixed scales, thus allowing for load stabilization. This more precise measurement would confirm or negate the WIM indication and would be used to eventually establish penalties.

In the laboratory the difficulty could be demonstrated in estimating the dynamic effect of tank vehicles both with and without baffles. It is important to consider the varying load, the speed of the vehicle and the data processing aspect. In the tank with baffles the dynamic effect is more a function of speed than the load; in the tank without baffles it is more a function of load than the speed.

The computer model using multi-degrees of freedom and a mass spring damper would demonstrate the effect of a laminar movement considering F constant, considering an F harmonic and velocity 16 m/s. This effect could explain the axle force variation measurement in the tank transporting the liquid. When the speed of the vehicle passing over the WIM system is faster than the movement of liquid the effect of the movement of the liquid does not have too much influence. In this case the speed of data processing is fundamental for measuring the instantaneous force. ■

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PERFORMANCE OF "TUNING FORK" LOAD CELLS

Development of modularizing technology and its application

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Shinko Denshi Co. Ltd.

Keywords:

Double ended tuning fork sensor, tuning fork scale, tuning fork load cell, OIML R 76 [1], OIML R 60 [2], load cell [1,2], module[1], digital load cell, legal metrology

1 Abstract

Sensors currently used in electronic weighing instruments are mainly electromagnetic force balances, strain gauges, and tuning forks. Among them, double ended tuning fork sensors (DETF sensors) have been put into practical use by Shinko Denshi Co. Ltd.

DETF sensors have superior long-term stability, and their resolution and repeatability are equivalent to those of electromagnetic force balance sensors. The sensors are also as suitable for measuring relatively heavy loads as strain gauge load cells (SG load cells) are. Tuning fork scales share the above-mentioned advantages of both sensors, and are widely used in places where strict quality control is required such as in the pharmaceutical and automotive industries as well as chemical plants and precious metal processing plants.

This paper describes how the authors confirmed the sensor's conformity to accuracy class B 50 in OIML R 60:2000 [2], whose requirements are difficult to achieve even for conventional SG load cells, while detailing its verification outcomes. Fundamental principles and modularizing technology of DETF sensors are also introduced as well as examples of their application.

2 Introduction

DETF sensor development originated when Yuzuru Nishiguchi[2] studied scales with a vibrating wire sensor, and began designing and developing resonators in 1973. A couple of years later, a pressure sensor with tuning fork, designed and developed by a Japanese manufacturer, led to full scale development of the DETF sensor, with the objective of applying this technology to scales. A basic patent was filed in 1983 and the first vibrating tuning fork scale was made into a product. At the time its structure consisted of a Roberval mechanism in which a DETF sensor was embedded.

Table 1 shows the basic structures of mass-detecting DETF sensor units according to the maximum capacities of tuning fork scales.

Table 1 Structures of DETF sensor units

Maximum capacity	Structure of DETF sensor unit
≤ 30 kg	DETF sensor + Roberval mechanism
> 30 kg	DETF sensor + Roberval mechanism with an integrated lever
	(For expanded weighing pan) Multi-point support with DETF sensor + Roberval mechanism with an integrated lever

Later on, the assembly type with a Roberval mechanism (see Figure 1) was further developed into a mono-block structure, illustrated in Figure 2; both were chosen according to the intended use.

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[1] **OIML R 76:2006 [1] T.2.2 Module**

Identifiable part of an instrument that performs a specific function or functions, and that can be separately evaluated according to specific metrological and technical performance requirements in the relevant Recommendation. The modules of a weighing instrument are subject to specified partial error limits.

Note: Typical modules of a weighing instrument are: load cell, indicator, analog or digital data processing device, weighing module, terminal, primary display.

[2] The founder of Shinko Denshi Co. Ltd.

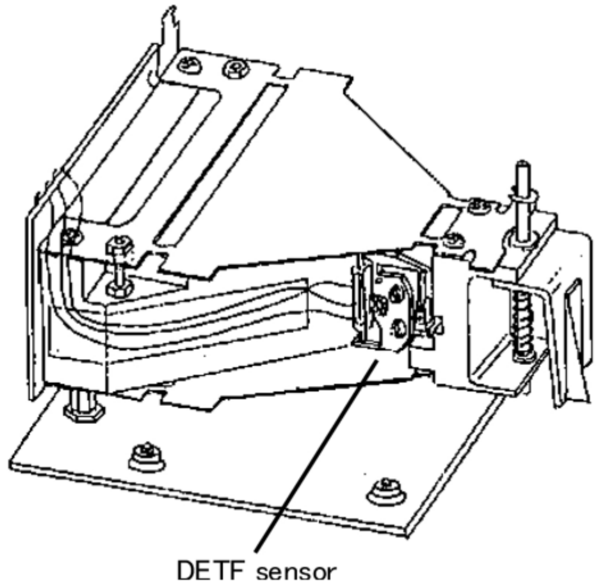

Figure 1 DETF sensor unit (Assembly type)

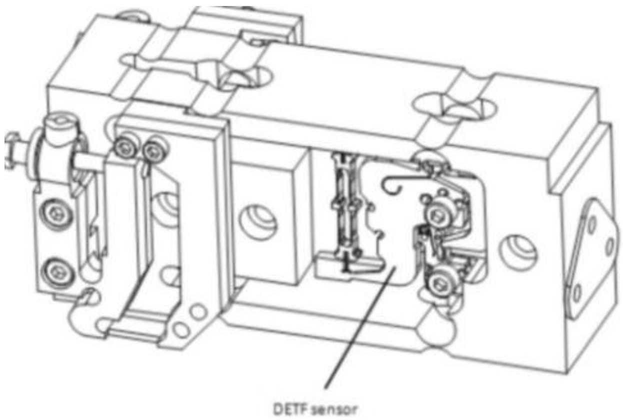

Figure 2 DETF sensor unit (Mono-block type)

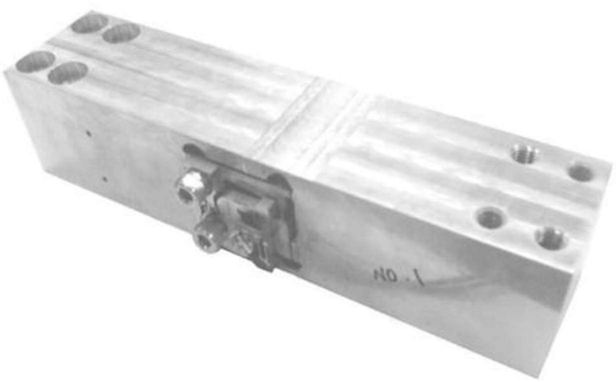

Photo 1 Outline of a DETF sensor unit (with integrated lever)

Integrating a lever with a Roberval mechanism (see Photo 1) enabled the unit to be employed in a tuning fork scale with a maximum capacity of 30 kg and above. Utilizing a plurality of these units also contributed to the expansion of the weighing pans.

Recently, both the pharmaceutical and the automotive industries have demanded weighing systems suited for measuring objects according to the amount or attributes in respect of higher reliability and appropriate quality control. However, it is not practical for a complete instrument to be incorporated into a weighing system. To address this issue, it was necessary to develop a modular sensor.

Tuning fork scales employing these units achieve a specification with a maximum capacity of 300 kg, an actual scale interval of 1 g and a verification scale interval of 10 g.

The National Metrology Institute of Japan, National Institute of Advanced Industrial Science and Technology (NMIJ/AIST) [3] has verified, confirmed and reported the results of the DETF sensor units' characteristics of temperature, repeatability and long-term stability. Regarding the legal metrological performance of tuning fork scales, NMIJ/AIST has already granted Japanese type approvals.

In light of the above, it is planned to apply for OIML certificates of conformity for the sensors according to OIML R 60:2000 [2]. Prior to this application, all the performance tests in OIML R 60:2000 [2] were conducted.

The DETF sensor's performance has served to reduce the gravitational distortion that affects the focus of the world's largest and most accurate optical-infrared telescope (the Subaru Telescope, operated by Japan's national astronomical observatory, located at the summit of Mauna Kea, Hawaii, USA).

3 Design and development of the tuning fork load cell

3.1 Principle and structure of DETF sensor

The basic principle of a DETF sensor is that it utilizes a physical phenomenon where the resonant frequency (f) of a double ended tuning fork resonator changes as tension (T) changes.

Practically, the tension (T) and the resonant frequency (f) of a vibrating wire are represented by formula (1), so that the tension (T) can be determined by measuring the frequency (f).

$$f = \frac{1}{2l}\sqrt{\frac{T}{\rho}} \qquad (1)$$

l = String length
ρ = Density

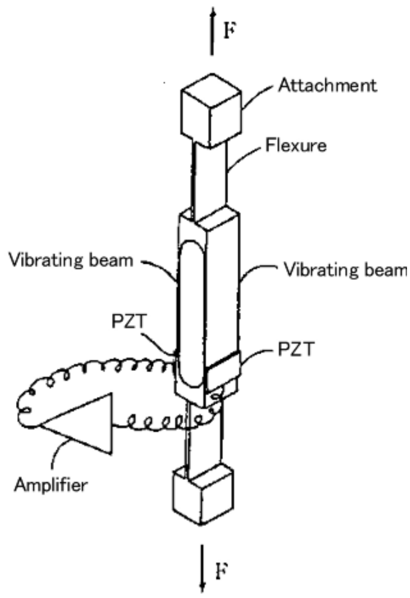

Figure 3 DETF resonator

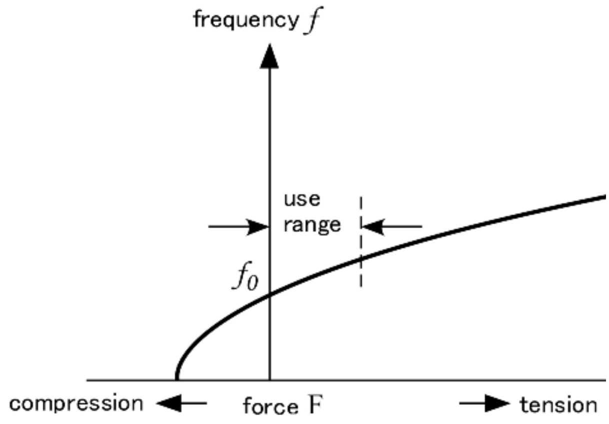

Figure 4 Relation between force (F) and frequency (*f*)

Figure 3 shows a diagram of a double-ended tuning fork resonator whose shape resembles two common tuning forks joined at each end.

One of the DETF resonator's distinguishing characteristics is its stable vibration at a high value of Q, due to the fact that opposite reactions and moments mutually cancel each other out by two vibrating beams moving symmetrically, resulting in a confinement of the oscillation energy. Also, flexures attached to both ends of the vibrating beams mitigate unfavorable effects that might be caused by a state of the assembly or from the outside.

Two piezo-ceramic elements (exciting and sensing), attached to the lower ends of the vibrating beams and connected to an amplifier, cause continuous vibrations. The relation between the frequency (*f*) and the force (F) is described in formula (2) while the characteristic curve is presented in Figure 4 [4].

$$f = f_0\sqrt{1 + KF} \tag{2}$$

where $f_0 = C\frac{t}{L^2}\sqrt{\frac{E}{\rho}}$

L = Length of a vibrating beam
t = Thickness of a vibrating beam
E = Young's modulus (N/mm^2)
ρ = Density
K and C are constants

By counting the clock pulses per cycle, the frequency (f) can be converted into digital values. A microprocessor performs compensation and linearization accordingly.

DETF sensors fall into a category of force sensors that convert the vibration frequency (f) into a weight value. As illustrated in Figure 5, the basic structure of the DETF sensor is an integration of a double-ended tuning fork and a lever. The leverage ratio and thickness of the body have a variation according to the maximum capacities of the sensors.

As formula (2) explains, the resonant frequency (f) of a DETF sensor varies according to temperature changes on Young's modulus, therefore the temperature variation needs to be small. Given this situation, a constant modulus alloy having a small temperature coefficient of Young's modulus was adopted as the DETF sensor material.

Generally, a constant-modulus alloy is widely used in spring scales as well as hairsprings in watches [5]. The thermal coefficient of Young's modulus of the constant-modulus alloy currently used for the DETF sensor is about one-hundredth that of stainless steel. The alloy used for the sensor also has tensile and yield strengths equal to or better than that of spring steel, resulting in better creep and durability performance.

A DETF sensor is cut out from a constant-modulus alloy plate with a wire electrical discharged machine with a precision of 10 µm (see Photo 2).

3.2 Design and development of the tuning fork scale

Recent electronic weighing instruments are classified into the categories of force balance, electrical resistance and resonant sensors according to their mass-detecting functions. Figure 6 shows a relation between maximum capacities and scale intervals (e) that pertain to each category of electric weighing instruments. Electrical resistance sensors are used to measure greater masses, whereas force balance sensors are for smaller masses.

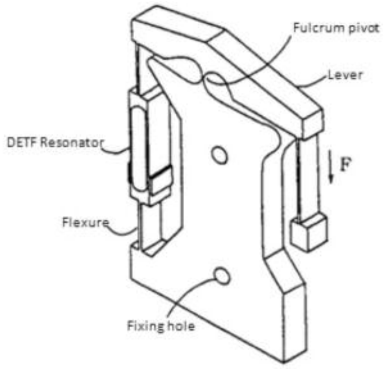

Figure 5 Basic structure of a DETF sensor

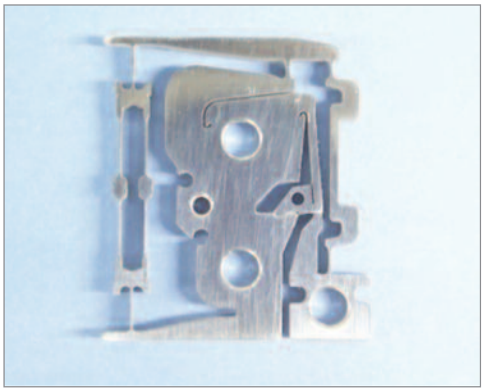

Photo 2 Outline of a DETF sensor

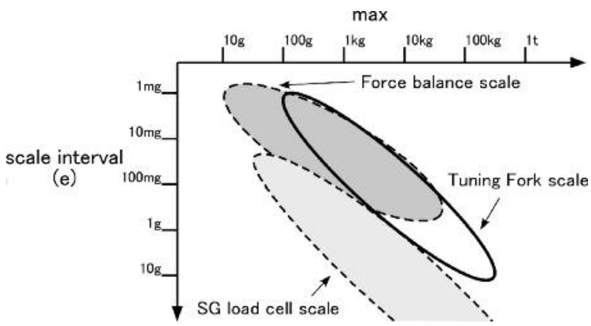

Figure 6 Relation between maximum capacities and scale intervals (e)

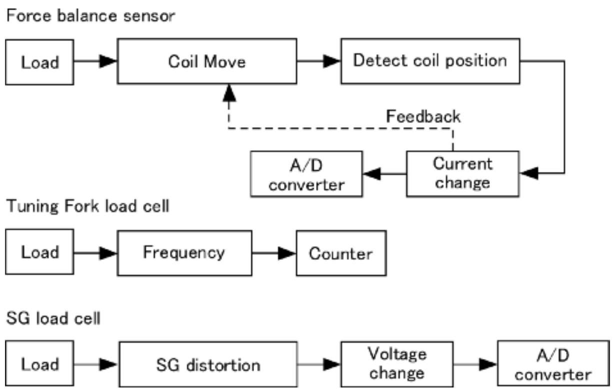

Figure 7 Load conversion flowcharts for each sensor

Two types of resonant sensors are incorporated into scales; one is with a wire and the other is with a DETF resonator. In the 1970s, scales with wire resonators were produced for practical use in Western countries, but today, tuning fork scales are widely used. Major features of the tuning fork scales are as follows:

- fewer breakdowns are expected thanks to their simple structure (using fewer components), compared to scales with force balance sensors;
- tuning fork scales do not need A/D converters as shown in Figure 7 due to direct conversion of frequency into mass value; and
- temperature error and time-dependent changes attributed to electronic circuits are very limited as A/D converters and amplifiers are not required.

Also, tuning fork scales have excellent temperature characteristics with extremely small temperature coefficients of span with $\pm 0.5 \cdot 10^{-6}$/°C and of zero indication with $\pm 2 \cdot 10^{-6}$/°C [6].

A further advantage of tuning fork scales is that the scales can be explosion-proof since very little electricity (of the order of μW) is required to power them. In particular, they easily conform to the standards for explosive atmospheres (IEC60079: Ex ia IIB T4) [7], which are hard to follow for scales with electrical resistance or force balance sensors in the category of accuracy class II (OIML R 76:2006) or higher standards. Explosion-proof tuning fork scales with high accuracy have been made into products [5, 6].

The temperature increase by self-heating in a DETF sensor is negligibly small so that the sensor has a shorter warm-up time and can be used within one minute after switching on the electrical power, which is of benefit on site.

As of September 2014, tuning fork scales have obtained more than 30 approvals of types according to OIML R 76:2000, EC Directives and the Measurement Act of Japan. Among them, Japanese type approvals of Class I (number of verification scale intervals 220 000) and Class II (80 000) were granted.

To meet the demands of various industries, the current product lineup includes analytical balances with a maximum capacity of 220 g and the smallest scale interval of 0.1 mg, high accuracy weighing platforms with a maximum capacity of 300 kg and the smallest scale interval of 1 g, as well as high accuracy explosion-proof scales.

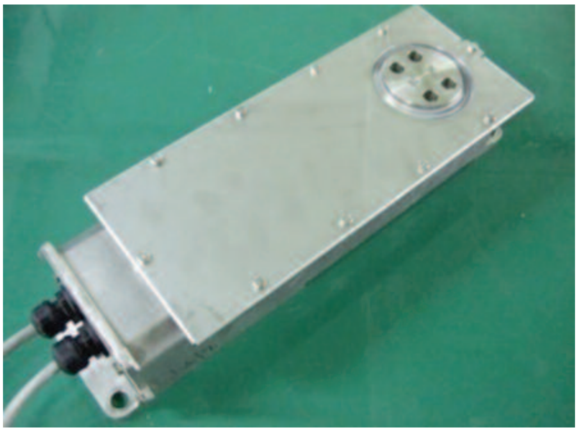

Photo 3 Outline of a tuning fork load cell

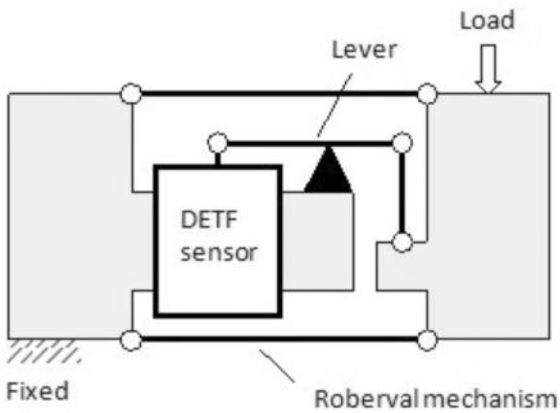

Figure 8 Diagram of a DETF sensor unit

3.3 Development of tuning fork load cells

3.3.1 Structure of tuning fork load cells

A recently developed tuning fork load cell comprises a DETF sensor unit (see Photo 1) and an electric circuit; both are enclosed in an airtight and dustproof stainless steel case, which leads to high durability and makes them corrosion-resistant. The outline is shown in Photo 3.

The structure of a DETF sensor unit has a strain body consisting of a lever and a Roverbal mechanism integrally cut out from a metallic block. Additionally, a DETF sensor is incorporated within it. Its diagram is shown in Figure 8.

A load applied on the strain body is diminished by the lever mechanism then transmitted to the DETF sensor. The leverage ratio is 10:1, and the maximum capacity of 110 kg is thus diminished to a tenth of the capacity. Therefore, a load of 11 kg is to be transmitted to the DETF sensor.

When the maximum capacity is applied, the frequency of the DETF sensor changes by $\Delta f / f \approx 10$ %, whereas the resistance change rate of a SG load cell is $\Delta R / R \approx 0.2$ %. This explains why the output signal variation rate of the DETF sensor is 50 times greater than that of a SG load cell, resulting in higher repeatability.

To ensure its metrological properties remain intact while maintaining water and dustproof performance high, the DETF sensor unit and the case are attached with a diaphragm made of silicon rubber. Also, a breathable and water and dustproof sheet is installed at the bottom of the case to eliminate the internal and external pressure differences of the case. The water and dustproof performance conforms to IP65 (IEC/EN60529)[8].

The signal of the applied load is processed in a built-in electronic circuit to output digital signal.

The maximum capacity of a tuning fork load cell varies within the range 30 kg–300 kg. DETF sensors, DETF sensor units and tuning fork load cells have been granted patents in Japan and abroad.

3.3.2 Test condition and evaluation points

To verify the accuracy of a tuning fork load cell, performance tests were conducted according to OIML R 60:2000 with the specifications below:

Maximum capacity	E_{max} = 110 kg
Minimum verification scale interval	v_{min} = 0.5 g
Maximum number of load cell verification scale intervals	n_{max} = 50 000
Test temperature =	20 °C, 40 °C, –10 °C, 20 °C
Minimum load cell output =	0.1 g
PLC =	0.8

The test items evaluated are shown in Table 2.

Each test item was performed in the order shown in Figure 9. By adding or removing linkage deadweights according to the order, required data at each test temperature were collected and processed.

3.3.3 Test equipment

Performance tests on a tuning fork load cell were conducted on the load cell mounted on a force standard machine situated in a temperature-controlled chamber. As shown in Figure 10, the machine comprised suspended linkage dead-weights and an elevating device under the weights.

A loading jig of the machine was set at a point on the tuning fork load cell to prevent any force except that applied vertically. The mass of the jig was about 1.4 kg. The machine applied loads of the deadweights on the load cell by lowering the elevating device.

Table 2 Test items evaluated

Test item	Clause in R 60:2000
Load cell errors	5.1.1, 5.5.1
Repeatability errors	5.4, 5.5.1
Creep	5.3.1
Minimum dead load output return (DR)	5.3.2
Temperature effect on DR	5.5.1.3

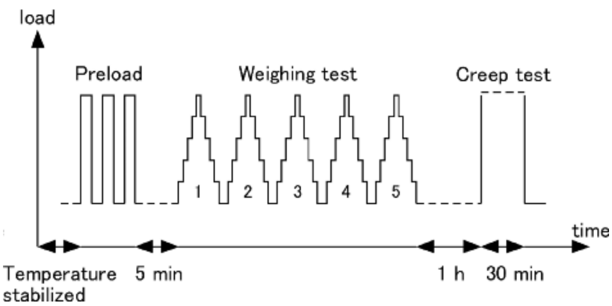

Figure 9 Order of test items

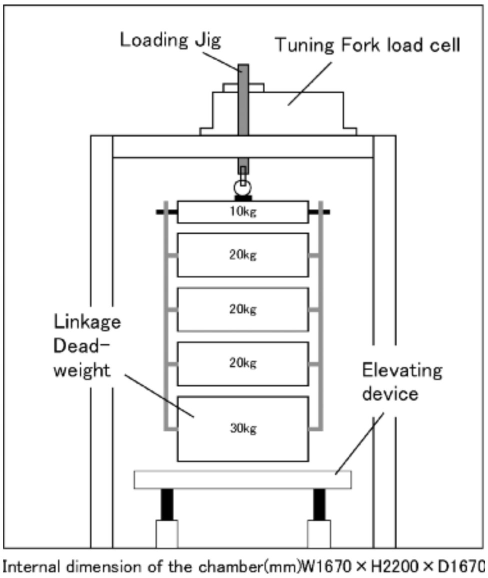

Figure 10 Diagram of test equipment in the temperature-controlled chamber

During the test, air was circulated in the temperature-controlled chamber to keep the temperature constant.

A wind protection sheet enveloped the deadweights to prevent them from swinging, which would cause dispersion in the measured values.

The deadweights were calibrated using weights of class E_2. Loads were applied to the tuning fork load cell by adding weights in the order of 10 kg, 20 kg, 20 kg, 20 kg and 30 kg.

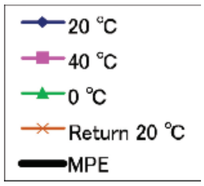

Figure 11 Keys

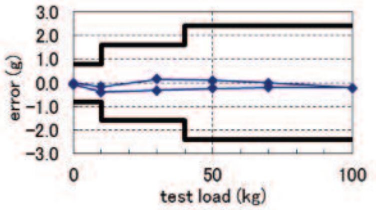

Figure 12 Load cell error (at 20 °C)

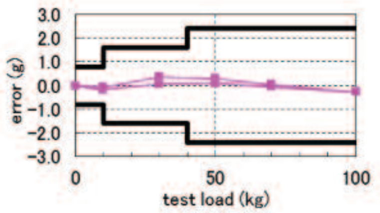

Figure 13 Load cell error (at 40 °C)

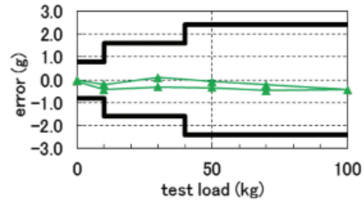

Figure 14 Load cell error (at –10 °C)

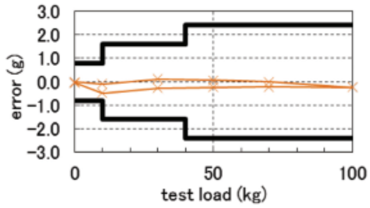

Figure 15 Load cell error (at return 20 °C)

3.3.4 Test result

Figures 12 to 15 show the determined errors of the load cell. Figure 11 shows keys of all the graphs. It was confirmed that each maximum error was below one third of the maximum permissible error (MPE) at each test temperature. A small hysteresis of –0.5 g was found

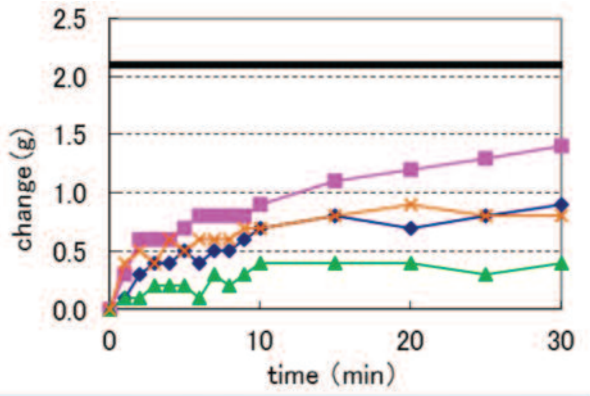

Figure 16 Creep

Table 3 Repeatability error

Test load (kg)	Error (g)				MPE (g)
	20 °C	40 °C	–10 °C	Return 20 °C	
0	0.1	0.1	0.3	0.2	0.8
10	0.2	0.1	0.3	0.2	0.8
30	0.3	0.2	0.2	0.1	1.6
50	0.2	0.2	0.1	0.1	2.4
70	0.2	0.3	0.1	0.2	2.4
100	0.2	0.1	0.2	0.1	2.4
70	0.2	0.4	0.0	0.2	2.4
50	0.1	0.2	0.1	0.3	2.4
30	0.2	0.2	0.1	0.1	1.6
10	0.2	0.1	0.0	0.6	0.8
0	0.0	0.0	0.1	0.1	0.8

Table 4 Minimum dead load output return (DR)

Temperature (°C)	DR (g)	MPE (g)
20	–0.2	1.0
40	0.2	1.0
–10	–0.3	1.0
Return 20	–0.3	1.0

Table 5 Temperature effect on DR

Temperature (°C)	Change (g/5°C)	MPC (g/5°C)
20 → 40	0.33	0.4
40 → –10	0.11	0.4
–10 → 20	–0.32	0.4

at every temperature. Temperature effects on span, linearity and hysteresis, whose characteristics depend on temperature changes, varied at a negligible level on the basis of the standards.

Table 3 shows the repeatability errors determined in the test. It was also confirmed that each maximum error was below one third of the maximum permissible error (MPE) at each test temperature. The maximum errors did not vary by temperature or load. In this test, large errors were found while testing with a load of 70 kg at 40 °C and with a load of 10 kg at a temperature returned to 20 °C, respectively. A cause of the errors could be a condition under which the deadweights swung along with the loading jig that was blown by the air in the chamber. The errors would be smaller if the swing could be suppressed.

Figure 16 and Table 4 show the results of creep and minimum dead load output return (DR), respectively. The maximum rates of creep change at each temperature tend to be greater according to the temperature rise. Likewise, differences in DRs and in 30 - 20 minute creeps became greater as the test temperatures were increased. However, the maximum change rates of both test items at each test temperature were confirmed to be below the MPEs. The increasing creep rate at a higher temperature can be attributed to the metal form of the DETF sensor unit, especially the Roberval mechanism with an integrated lever, whose characteristic of creep is affected by high temperature.

As for temperature effects on minimum dead load output return described in Table 5, it was confirmed that all the variations of the results in each test temperature ranges of 20 °C to 40 °C, 40 °C to –10 °C, and –10°C to 20 °C were within the MPEs.

Therefore, the above results prove the tuning fork load cell's conformity to the requirements of accuracy class B 50 in OIML R 60:2000.

4 Summary and future issues

The authors introduced the basic principles and modularizing technology of a DETF sensor as well as examples of its application.

The test results proved that the performance of the tuning fork load cell conformed to Accuracy Class B 50 in OIML R 60:2000, whose requirements are difficult to achieve for conventional SG load cells. It is planned to apply for OIML MAA certificates of conformity for tuning fork load cells.

Currently, 15 organizations are registered as issuing authorities regarding OIML R 60:2000. Among them, seven organizations, including Germany and Japan, are appointed as issuing authorities for OIML MAA certificates. The scope of testing and issuing OIML certificates for each organization is listed on the OIML website. As stated in 3.3.1, the tuning fork load cells evaluated are categorized as class B 50, hence the number of testing organizations will be limited. As of the end of September 2014, the number of OIML certificates of conformity according to OIML R 60:2000 is about 750; 450 are for OIML Basic certificates and 300 for OIML MAA certificates, respectively. Since all the certificates issued so far are for SG load cells, the world's first OIML certificate for a tuning fork load cell would be issued if accepted.

In this report, a tuning fork load cell was examined with a maximum capacity of 110 kg. However, the capacity will be extended up to 300 kg or greater. Even non-automatic weighing instruments with such high capacities can be available by multiple applications of tuning fork load cells with the assistance of wider weighing pans.

Meanwhile, the authors are focusing on the design and development of weighing systems in which the tuning fork load cells' longer stability and other characteristics are utilized.

5 Acknowledgments

The authors would like to thank Mr. Kazuo Neda of the International Metrology Cooperation Office, Metrology Management Center in NMIJ/AIST, for his considerable technical support and suitable guidance.

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ROAD TRAFFIC

Average speed control

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Abstract

Average speed control (ASC) was introduced in Switzerland by the competent traffic authority, the Federal Roads Office (FEDRO), for a test phase at the beginning of 2010. As the competent partner for verification of technical aspects involved in speed measurement for type approvals as well as the responsible organization for periodic checks, the traffic laboratory at METAS became involved in this project at an early stage. Currently, fixed as well as mobile versions of this type of instrument have been approved and are subject to annual verifications, as are all other types of speed measuring devices.

1 Birth of the system

Average speed control (ASC), which is also known as "section control" or "point-to-point control", is a system which measures the average speed of vehicles between two points located a fixed distance apart. The entry gate identifies each passing vehicle so that the average speed can be subsequently calculated when the vehicle passes through the exit gate. If the driver exceeds a set speed limit (see Figure 1, red car), information about the vehicle is saved and photos are taken at a third gate where the vehicle is flashed. Then, the violation information is transmitted to the police. Otherwise (see Figure 1, green car), the data is immediately deleted to ensure compliance with data protection laws.

European countries that have implemented ASC (I, A, NL, GB) have already recorded a marked reduction in the number of accidents and speeding violations. Their experience has also shown that this new system leads to improved traffic flow and regularity compared to classic systems. The ASC system prevents the "accordion effect" – a dangerous phenomenon observed around fixed radar systems due to drivers adjusting their behavior because of the radar.

At the start of the test phase in 2010, the Federal Roads Office launched a major study with the aim of evaluating the impact of ASC on the behavior of drivers and overall traffic safety in Switzerland. Two sites were chosen for these tests: a fixed version with a length of 1.7 km on the A2 highway near the Arisdorf tunnel (Canton of Basel Landschaft) and a mobile version with a length of 7.4 km on the A9 between Aigle and Bex (Canton of Vaud). Based on these results, the decision was made to approve this system in Switzerland in 2011. For its part, METAS issued type approval certificates for the fixed version on 16 December 2011 and the mobile version on 8 May 2012. Interim approval was granted for the first year. As no problems were detected during the initial period, final approval was granted. Thanks to their METAS approval, these instruments may be used for official speed measurements.

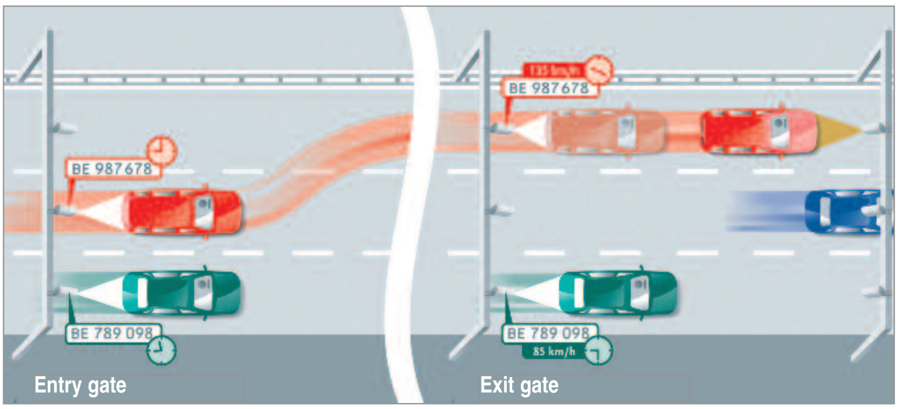

Figure 1 The time it takes to travel from the entry gate to the exit gate divided by the distance (here: 45 km) is equal to the vehicle's average speed. The third gate is used to flash the speeding vehicles (here: red vehicle).

2 Basic principle of the speed measurement

The speed measurement is based on a simple principle: the distance travelled by the vehicle is divided by the time required to travel the distance, yielding the average speed. The distance between the two gates is either measured directly by METAS (fixed version) or by means of GPS units arranged in each gate (mobile version). The time measurement is handled on a common basis between the two gates for the fixed version. For the mobile version, there is a time server in each gate which is synchronized using GPS.

Figure 2 ASC gate on the A2 highway at the entrance to the Arisdorf tunnel

3 Critical measurement issues in the approval process

In the fixed version, the distance represents a set parameter that is measured by METAS. Here, the time base is the same in any installation. In comparison, the mobile version is more challenging since each gate is individually responsible for determining its own position and timing information. In both cases, there are uncertainties that apply to the distance as well as the time.

At each gate (see Figure 2), the vehicle's position is detected in order to take a picture that can be used to identify the vehicle with a timestamp. In the fixed version, a lane-based system is used while the mobile version simultaneously monitors all of the lanes. The detection point thus introduces another uncertainty which must be taken into account.

As with all official speed measurements in Switzerland, a safety margin is respected in the ASC system to ensure that drivers cannot be cited due to measurement errors. Along with other margins, this safety margin is defined in an Ordinance of the Federal Roads Office [1]. The values of the safety margin are as follows:

- 5 km/h for measured speeds up to 100 km/h;
- 6 km/h from 101 km/h to 150 km/h; and
- 7 km/h starting at 151 km/h.

4 Measurement and verification of the distance

The traffic laboratory at METAS has several types of references that can be used to verify the distance measurement. The highest precision involves measurement with a Global Navigation Satellite System (GNSS). Positions can be determined with a measurement uncertainty of ± 2 cm (k = 2).

For measurements that involve long distances, such as on highways, or if numerous bridges or tunnels prevent continuous reception of the satellite signals, another type of reference must be used. For example, this is the case with the fixed system at the Arisdorf tunnel since nearly the entire section is in the tunnel. In this case, the chosen reference instrument is an optical correlator from the company Corrsys [2]. This instrument enables measurement of the distance based on the perceived movement of the road surface (see Figure 3). Calibrated by METAS, it has a measurement uncertainty of better than ± 0.2 % (k = 2) for distances greater than 200 m.

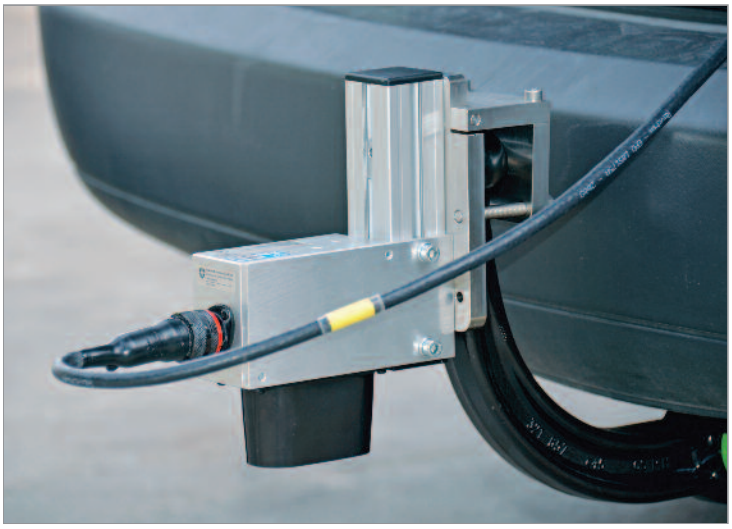

Figure 3 Optical correlator mounted on the METAS vehicle

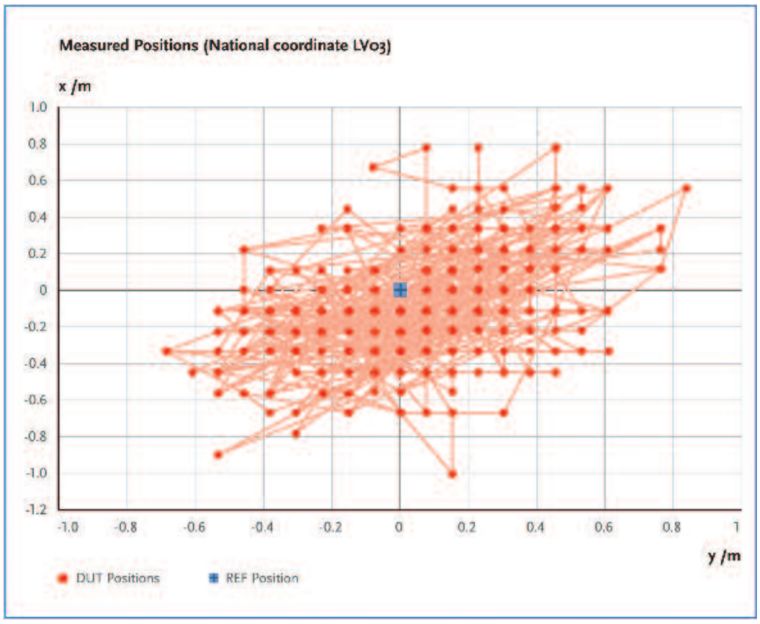

Figure 4 Example of a measurement with 9 satellites, an HDOP of 0.8 and EGNOS. The blue point in the centre corresponds to the METAS reference while the cloud of red points at different positions were generated by the gate's GPS as a function of its uncertainty. The instrument's uncertainty under these conditions is ± 0.9 m (k = 3).

In the case of the fixed version of the ASC system, the distance is measured with the optical correlator and the measured value is then configured in the speed measurement system. In this manner, the distance represents a constant value that is stipulated directly by METAS and cannot be modified by the user.

In the mobile version, the distance is calculated automatically by the gates based on the satellite position data. Since the precision of the position data is highly dependent on the reception quality, a number of tests were carried out during type approval by METAS with the aid of tools such as its GNSS measuring system [3]. This made it possible to control the reception parameters so as to ensure defined quality for the distance calculation. In particular, these parameters involve the number of satellites, the dilution of precision (HDOP), the DGPS correction (in our case with EGNOS [4]) and the measurement time for calculation of the average value of the received positions. This makes it possible to ensure a maximum deviation for the position of ± 2.5 m (k = 3, without averaging of the position) per gate, and thus ± 5 m for the total distance (see Figure 4). Obviously, if the gates are moved or if the GPS reception deteriorates past the limits stipulated by METAS, the instrument will halt the speed measurements until proper operation has been restored. Faulty system states of this sort were the subject of specific tests during the type approval process.

5 Measurement and verification of the timing information

The time measurement is dependent primarily on the internal clock (in case the GPS synchronization is lost), the timing delay for transmission of information through the system, and the delay to snap a photo once the trigger signal is received.

In order to take into account all of the possible deviations, the timing information is verified using the METAS test vehicle which is photographed by the gates. The vehicle is equipped with an infrared digital reference chronometer (resolution 0.1 ms, time base ± 10 ppm) to allow direct time read-out from the photos. This approach accounts for the various delays associated with the instrument. For control purposes, the time between the two gates specified by the ASC system is compared to the time output by the METAS chronometer.

6 Measurement and verification of the speed

In order to verify that the speed calculation process is handled correctly, a speed measurement is performed.

Figure 5 Photo of the METAS vehicle taken by a gate with zoom of the chronometer

The METAS test vehicle constantly measures and records its own speed between the two gates. The average speed (see Figure 6) is then compared with the speed reported by the ASC system.

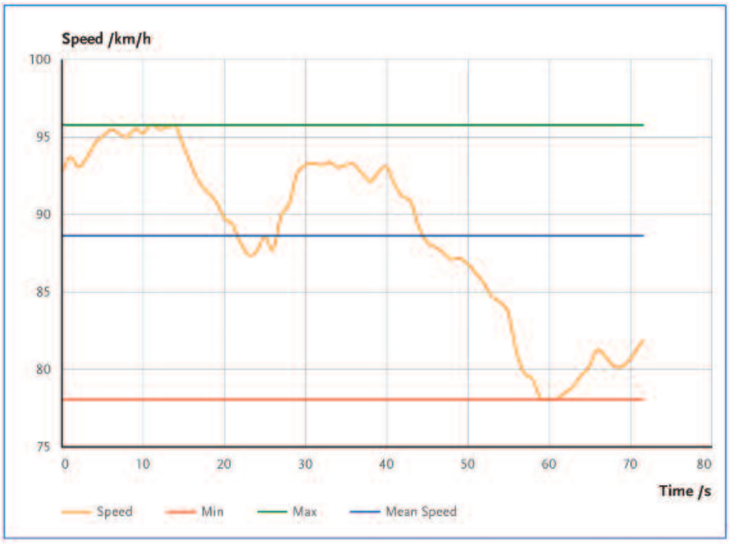

Figure 6 Plot of the reference speed of the METAS vehicle between the gates

7 Other checks made during the verification

These various measurements represent only part of the verification process. All of the system components as well as the associated programs are checked to ensure they have not been exchanged or modified and that the versions approved by METAS are used. The photographic documentation is also inspected. For example, at the Arisdorf site the traffic signs are photographed at the time of each violation. Similarly, the digital signature of the photographs and the encryption of the violation data are checked.

8 Guaranteeing the quality of the speed measurement

Thanks to the many tests carried out during the type approval process along with monitoring of all instruments during annual verifications, the speed measurement results produced by the ASC instruments as well as the vehicle attribution for the speeding infractions are guaranteed to be correct.

The vast experience of the METAS traffic laboratory in the domain of verification of all types of speed measuring instruments, combined with its world unique measurement capabilities, means that manufacturers, clients and drivers can trust that speeding infractions issued on the basis of these instruments are correct.

References

[1] Ordinance of the Federal Roads Office of 22 May 2008 to the Road Traffic Controls Ordinance (RTCO-FEDRO), Classified Compilation of Federal Legislation 741.013.1; Article 8, Item f.

[2] www.corrsys-datron.com

[3] Damien Lachat: Étalonnage des récepteurs de mesures par satellites, METinfo, vol. 17, no. 1, pp. 26-29, 2010

[4] www.egnos-portal.eu

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CORN AND BREAD AND THE FAIR DISTRIBUTION OF THE PRODUCE OF THIS EARTH

Ideas, guidelines, and aspects on the series "The History of Weights and Scales"

Wolfgang Euler, Hennef/Sieg – Cologne/Bonn

The series of articles "The History of Weights and Scales" published in the OIML Bulletin is characterized by two specific aspects.

Firstly, for thousands of years, time and length measurements and quantity determination have been integral elements of human coexistence; they have even been essential for survival. Measuring has been, so to speak, the most important companion of the human race since it gave up nomadic life and became sedentary. During the entire development of weighing technology, from the beam balance to state-of-the art weighing systems, rulers (and later governments) have issued laws and regulations to protect weaker trading partners from unfair mass determinations and fraud. Thus, the OIML set itself the goal of harmonizing this discipline.

The editorial team wanted to support this task by contributing the series of articles on the history of scales and work towards the goal that, in the future, every single country will be a member of the OIML.

The team is convinced that as a result the world might become a more balanced, fairer, and more peaceful place. For instance, there is an Association of Friends and Sponsors of the Chronos Scales of 1883 in Hennef/Sieg, in the Cologne/Bonn area. At its next meeting at the beginning of 2015, it will be discussed, among other topics, how and where the Association can support the OIML in a material way beyond the series of articles. It would also be possible to train specialists of future new OIML Member States directly on site or to invite interested parties to Germany for one or two-week training courses, for example to the PTB in Braunschweig or to the automatic scales center in Hennef, where an exhibition shows and explains the history of former measuring instruments. This ensures a good early historical representation of metrology that can be transferred to the current age.

Secondly, as in the past, weights and scales still influence the international flow of money and goods to a large extent. Without scales, a well-regulated economic cycle would not be possible today. This is why, with its series of articles, the editorial team would like to pass on its knowledge of metrology and of weights and scales to young people who are currently in education and who will be taking on responsibility in our society in the future.

For this reason, the authors will also work without remuneration and donate a portion of their fees to the Carl Reuther Vocational School in Hennef/Sieg and the German Milling School in Braunschweig. This way, the authors promote the education of young people in the fields of engineering and foods. As far as the latter is concerned, the basic foodstuffs - corn, flour and bread - have historically played an important role.

A personal greeting with a review of the series on the history of scales

A few years ago, the first reports on the topic were published at www.hennef.de/index.php?id=1298, which a few employees of Bizerba had gratefully prepared with me. The articles were about the "History of Scales – Weighing and Scales Through Changing Times." The articles appeared simultaneously in four languages: German, English, French and Polish. Following this, it was then by a particular stroke of luck that I got to know the publishers Moritz Schäfer at the Detmold conference for milling technology of the AGF (Corn Research Committee) in September 2011. Still on the same day, both parties agreed to initiate a series with the title "Weights, Scales and Weighing Through Changing Times – from Prehistoric Times to the Present" in the trade journal "Mühle + Mischfutter". No sooner said than done. Already on December 20, 2011, i.e. almost exactly four years ago, the first report appeared in "Mühle" Number 24/2011. Also the former President of the CIML and Vice-President of the PTB in Braunschweig and Berlin, Prof. Dr. Manfred Kochsiek, enjoyed this series. With much dedication, he succeeded in having the articles that had been published in the trade journal translated into English at the PTB and then, from there, sent to the BIML in Paris for further processing.

The first joint team report on the series "History of Scales" appeared in the OIML Bulletin Number 3, July 2012. With this, our articles embarked on a journey through many countries across the world. The first ten essays were produced and put into circulation in a German-English special edition – without any copyright – on 31 October 2013 in Hennef/Sieg (City of Wolfgang

Euler), in Balingen (Bizerba), in Detmold ("Mühle + Mischfutter"), in Braunschweig as well as in Paris (BIML). Details about this can be found on the Internet:

www.vms-detmold.de/index.php/informationen-vorschauarchiv/2-uncategorised/76-geschichte-der-waage

or

www.hennef.de/uploads/media/Geschichte-der-Waage_M-M.pdf

In the thousands of years of the history of weights and scales, there have been three revolutionary changes so far which have increasingly captured my interest for this subject area – especially for (statutory) metrology - and inspired me over time.

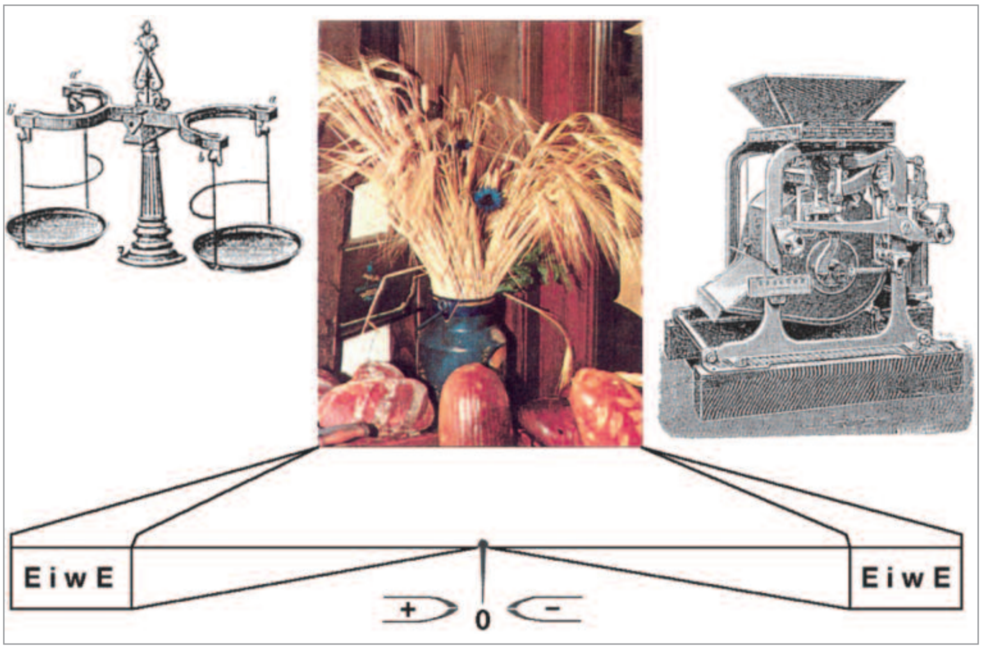
Firstly, manual weighing was carried out – and is still carried out – either using old-fashioned bench scales, with decimal scales or, more recently, fully electronically. Such scales are also called "not self-operated scales" or "NAWI" ("non-automatic weighing instruments"), i.e. weighing requires the active intervention of an operator.

A simple example is that of a vendor who places a piece of meat on the scale which in turn determines the weight and calculates the price and the sales tax. Traditional bench scales are still often used today, particularly in agriculture. They are metrologically very simple, verifiable with high precision, and are still extensively used on trading markets that work on a "mass basis". Modern fully electronic weighing is by no means any better, but it is faster which is of course particularly advantageous for supermarkets. For the consumer, however, this procedure is often less reliable, because it is not based on mass, but force measurement. Additionally, customers are often distracted by pop-up advertising in large characters; by contrast, weight and price are displayed in relatively small characters.

Secondly, the automatic age started in 1883 in Hennef with the Chronos Scales. An interesting point in this regard is that the many thousand year old equal-arm beam scales also form the core of the Chronos Scales. For automatic weighing, no additional and/or own energy is necessary. Such "self-operated" and/or "automatic scales" execute the weighing process without the intervention of operating staff. The weighing sequence is continually initiated automatically; thus, it still does not have anything to do with electronics, computer technology or pneumatics.

Thirdly, in 1955, the triumphant advance of electronic scales and digital weighing systems began, whereby force measurement through weighing cells was used instead of mass determination. My own physical knowledge may be good, yet not exceedingly proounced. However, I have been working for a long time to ensure that metrology is realistic. There is no doubt that we of course also need research. However, in my opinion, statutory measurement guidelines that are plausible, simple and honest, and not increasingly complicated, are more necessary. Transparency is a basic condition for a "balanced" world in the true sense of the word, in which the treasures of our earth are fairly distributed among its inhabitants. This committed goal will also drive me and all other authors of this series of articles in the future.

The whole editorial team, the publishers Moritz Schäfer in Detmold with their trade journal "Mühle + Mischfutter", and the Editors of the OIML Bulletin, would like to thank all readers for their loyalty in 2014 and wish them a good "balance" of health, happiness and success for 2015. Readers can look forward to new articles on automatic scales for weighing – SWA (bagging in small containers, e.g. 5 kg, 10 kg, 25 kg or 50 kg, up to 1000 kg – big bags), check weighers, and prepackaging regulations in the coming year.



A modest man was once asked: "What looks more beautiful – a field of corn swaying in the summer wind or nourishing and healthy bread?" His answer was: "Both are equally very impressive – corn is a great wonder of nature and bread shows the ingenuity of man."

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
There are no changes since the last issue of the Bulletin.

		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
AT1	Bundesamt für Eich- und Vermessungswesen (BEV)							■	■	■		■		■		■	■		■	■	
AU1	National Measurement Institute (NMI)						■	■	■		■			■		■					
BE1	SPF Economie, PME, Classes Moyennes et Energie													■					■	■	
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CN1	General Administration of Quality Supervision, Inspection and Quarantine of P. R. China (AQSIQ)			■		■		■	■		■	■		■					■	■	
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DE1	Physikalisch-Technische Bundesanstalt (PTB)			■	■		■	■	■	■	■	■		■		■	■		■	■	■
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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	National Measurement Office (NMO) - Formerly NWML		■		■		■	■	■		■	■	■	■		■				■	
GB2	National Physical Laboratory (NPL)																		■		
HU1	Hungarian Trade Licensing Office (MKEH)													■							
IT1	Ministero dello sviluppo economico - Direzione generale mercato, concorrenza, consumatori, vigilanza e normativa tecnica						■														
JP1	National Metrology Institute of Japan / National Institute of Advanced Industrial Science and Technology (NMIJ / AIST)						■				■			■							
KR1	Metrology and Measurement Division (KATS)													■							
NL1	NMi Certin B.V.		■	■		■	■	■	■		■	■		■	■	■			■		■
NL2	KIWA Nederland B.V.						■														
NO1	Norwegian Metrology Service (Justervesenet)							■	■			■		■							
NZ1	Measurement and Product Safety Service (MAPSS Wellington)													■							
PL1	Central Office of Measures (GUM)													■						■	
RO1	Bureau Roumain de Métrologie Légale (B.R.M.L.)																		■	■	
RU1	Russian Research Institute for Metrological Service (VNIIMS)			■			■	■	■	■	■	■		■		■	■	■	■	■	
SE1	Swedish National Testing and Research Institute AB (S.P.)							■	■		■	■		■		■				■	
SI1	Metrology Institute of the Republic of Slovenia (MIRS)													■							
SK1	Slovak Legal Metrology						■							■							
US1	NCWM, Inc.										■			■							
VN1	Directorate for Standards and Quality (STAMEQ)													■							

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AU1	National Measurement Institute (NMI)				■	■						■		■		■				
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OIML Systems

Basic and MAA Certificates registered 2014.09–2014.11

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*.

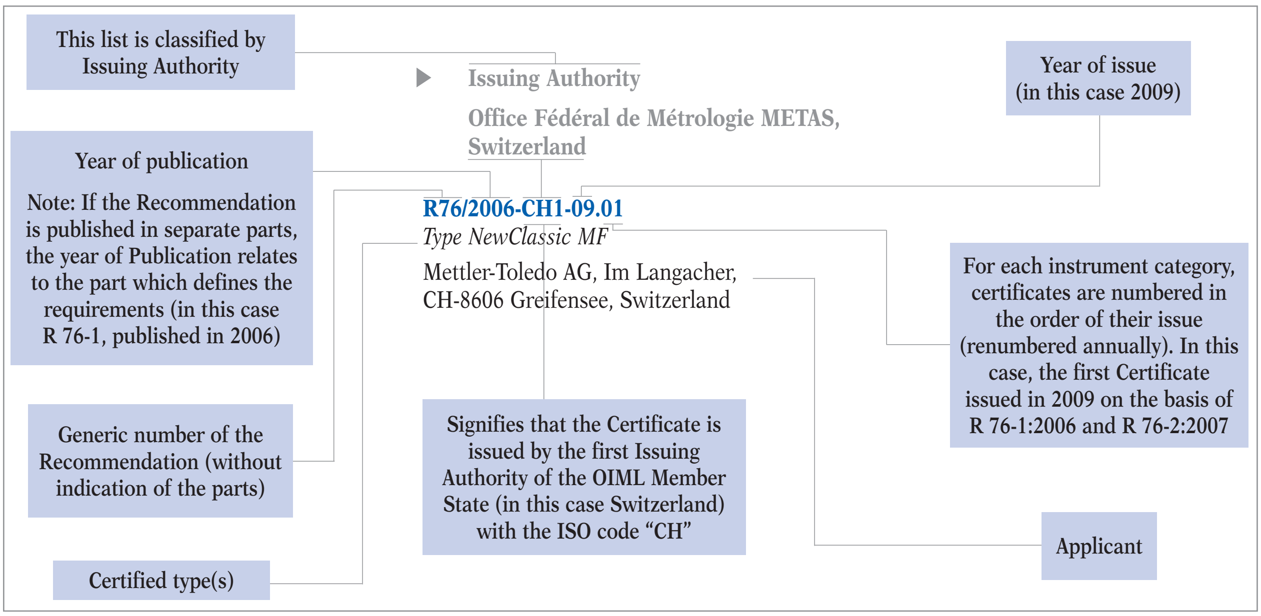
The OIML MAA is an additional tool to the OIML Basic Certificate System in particular to increase the existing mutual confidence through the System. It is still a voluntary system but with the following specific aspects:

- 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

Water meters intended for the metering of cold potable water and hot water
Compteurs d'eau destinés au 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
Water meter ITRON - Type: NEVOS/VCI
ITRON France, 9 rue Ampère, FR-71031 Macon, France

▶ Issuing Authority / *Autorité de délivrance*

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

R049/2006-JP1-2014.01
Electromagnetic water meter - Type: SU
Dalian Aichi Tokei Technology Co., Ltd., No.IA-23-4 Free Zone, Dalian - Liaoning, P.R. China

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V., The Netherlands

R049/2006-NL1-2012.01 Rev. 3
Water meter - Type: WATERFLUX 3070
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, The Netherlands

R049/2006-NL1-2013.01 Rev. 1
Water meter - Type: OPTIFLUX x300C; OPTIFLUX x000F + IFC300 y
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, The Netherlands

R049/2006-NL1-2013.01 Rev. 3
Water meter - Type: OPTIFLUX x300C; OPTIFLUX x000F + IFC300 y
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, The Netherlands

R049/2006-NL1-2013.01 Rev. 4
Water meter - Type: OPTIFLUX x300C; OPTIFLUX x000F + IFC300 y
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, The Netherlands

R049/2006-NL1-2013.01 Rev. 5
Water meter intended for the metering of cold potable water, model OPTIFLUX x300C; OPTIFLUX x000F + IFC300y, class 1 and 2
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, The Netherlands

R049/2006-NL1-2013.01 Rev. 6
Water meter intended for the metering of cold potable water, model OPTIFLUX x300C; OPTIFLUX x000F + IFC300y, class 1 and 2
Krohne Altometer, Kerkeplaat 12, NL-3313 LC Dordrecht, The Netherlands

▶ Issuing Authority / *Autorité de délivrance*

National Measurement Office (NMO), United Kingdom

R049/2006-GB1-2014.02
Family of cold-water meters, designated MeiStream Plus MV, having a rated permanent flowrate Q_3 between 25 m^3/h and 250 m^3/h, utilizing an electronic register which is equipped with AMR via Wi-Fi communication.
Madey Vered Ltd., Ashlegan 8, Kiryat Gat 82021, Israel

▶ Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R049/2006-DE1-2008.02 Rev. 9
Water meter intended for the metering of cold potable water - Type: Q200 Q^3=1.6 (E, P, M), Q200 Q^3=2.5 (E, P, M), SM250 (E, P, M), SM700 (E, P, M), SM800 (E, P, M)
Elster Metering Ltd., 130 Camford Way, Sundon Park, Luton LU3 3AN, United Kingdom

R049/2006-DE1-2013.02 Rev. 1
Water meter with mechanical indicating device or electronic indicating device - Type: WESAN WP, WESAN WP E
Hydrometer GmbH, Industriestrasse 13, DE-91522 Ansbach, Germany

R049/2006-DE1-2014.01
Water meter with mechanical indicating device - Type: ET1, ET2, ET3, ET4
Diehl Metering GmbH, Industristrasse 13, DE-91522 Ansbach, 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*

National Measurement Office (NMO), United Kingdom

R051/2006-GB1-2008.01 Rev. 0
CW3 Checkweigher
Loma Systems Group and ITW Group, Southwood, Farnborough GU14 0NY, United Kingdom

R051/2006-GB1-2009.04 Rev. 1
VersaWeigh, VersaGP, Versa RxC and Versa RxM Checkweighers
Thermo Ramsey Italia S.R.L., Strada Rivoltana km 6/7, IT-20090 Rodano (MI), Italy

R051/2006-GB1-2014.03
Loadmaster Alpha 100
RDS Technology Ltd., Cirencester Road, Minchinhampton, Stroud GL6 9BH, United Kingdom

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

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-NL1-2012.02 Rev. 1 (MAA)
Shear beam load cell, with strain gauges - Type: SB210
SEWHACNM Co., Ltd., 302-504,397, Seockcheon-Ro, Ojeong-Gu, 421-808 Bucheon-Si, Gyenonggi-Do, Korea (R.)

R060/2000-NL1-2012.44 Rev. 1 (MAA)
Tension load cell, with strain gauges - Type: SS300
SEWHACNM Co., Ltd., 302-504,397, Seockcheon-Ro, Ojeong-Gu, 421-808 Bucheon-Si, Gyenonggi-Do, Korea (R.)

R060/2000-NL1-2014.11 (MAA)
Compression load cell, with strain gauges, equipped with electronics - Type: YC14
5.9 Care Weighting System, Via Ischia 2, IT-40017 S. Matteo della Decima, Italy

R060/2000-NL1-2014.14 (MAA)
Shear beam load cell, with strain gauges - Type: 563YHxx or 563YSxx
Anyload Transducer Co. Ltd., 6994 Greenwood Street, Unit 102, V5A 1X8 Burnaby, BC, Canada

R060/2000-NL1-2014.15 (MAA)
Tension load cell, with strain gauges - Type: MS-6
Zhejiang South-Ocean Sensor Manufacturing Co., Ltd., N° 58 Nanyang Road, Qianyuan Town, Deqing County, CN-313216 Huzhou City, Zhejiang Province, P.R. China

R060/2000-NL1-2014.16 (MAA)
Compression load cell, with strain gauges - Type: CP-2
Zhejiang South-Ocean Sensor Manufacturing Co., Ltd., N° 58 Nanyang Road, Qianyuan Town, Deqing County, CN-313216 Huzhou City, Zhejiang Province, P.R. China

R060/2000-NL1-2014.17 (MAA)
Double ended shear beam load cell, with strain gauges - Type: GF-4
Zhejiang South-Ocean Sensor Manufacturing Co., Ltd., N° 58 Nanyang Road, Qianyuan Town, Deqing County, CN-313216 Huzhou City, Zhejiang Province, P.R. China

R060/2000-NL1-2014.18 (MAA)
Double ended shear beam load cell, with strain gauges - Type: GF-5
Zhejiang South-Ocean Sensor Manufacturing Co., Ltd, N° 58, Nanyang Road, Qianyuan Town, Deqing County, CN-313216, Huzhou City, Zhejiang Province, P.R. China

R060/2000-NL1-2014.19 (MAA)
Single point load cell, with strain gauges - Type: PE-5
Zhejiang South-Ocean Sensor Manufacturing Co., Ltd., N° 58 Nanyang Road, Qianyuan Town, Deqing County, CN-313216 Huzhou City, Zhejiang Province, P.R. China

R060/2000-NL1-2014.20 (MAA)
Bending beam load cell, with strain gauges - Type: PE-7
Zhejiang South-Ocean Sensor Manufacturing Co., Ltd., N° 58 Nanyang Road, Qianyuan Town, Deqing County, CN-313216 Huzhou City, Zhejiang Province, P.R. China

R060/2000-NL1-2014.21 (MAA)
Compression load cell, with strain gauges - Type: GY-7
Zhejiang South-Ocean Sensor Manufacturing Co., Ltd., N° 58 Nanyang Road, Qianyuan Town, Deqing County, CN-313216 Huzhou City, Zhejiang Province, P.R. China

R060/2000-NL1-2014.22 (MAA)
Compression load cell, with strain gauges - Type: CP-15
Zhejiang South-Ocean Sensor Manufacturing Co., Ltd., N° 58 Nanyang Road, Qianyuan Town, Deqing County, CN-313216 Huzhou City, Zhejiang Province, P.R. China

R060/2000-NL1-2014.23 (MAA)
Shear beam load cell, with strain gauges - Type: L-BS-xx-ST
Jinan Jinzhong Electronic Scale Co., Ltd., N° 147 Yingxiongshan Road, Jinan, CN-250002 Shandong, P.R. China

R060/2000-NL1-2014.24
Bending beam load cell, with strain gauges - Type: SLP530, SLP532 and SLP533
Mettler-Toledo (Changzhou) Precision Instruments Ltd., 5, Middle HuaShan Road, Xinbei District, CN-213022 ChangZhou, Jiangsu, P.R. China

Issuing Authority / *Autorité de délivrance*

National Measurement Office (NMO), United Kingdom

R060/2000-GB1-2014.02
Type: CS compression load cell
Sensocar S.A., Carrer Géminis 77, ES-08228 Terrasa - Barcelona, Spain

R060/2000-GB1-2014.03
BESLO compression load cell
LOADTECH, S.L., Portal Nou 46, Terrasa, Barcelona, Spain

Issuing Authority / *Autorité de délivrance*

Physikalisch-Technische Bundesanstalt (PTB), Germany

R060/2000-DE1-2002.01 Rev. 2
Strain-gauge compression load cell for self-centering pendulum application - Type: C16
Hottinger Baldwin Messtechnik GmbH, Im Tiefen See 45, DE-64293 Darmstadt, Germany

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Nonautomatic weighing instruments
Instruments de pesage à fonctionnement non automatique

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

Issuing Authority / *Autorité de délivrance*

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

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

▶ Issuing Authority / *Autorité de délivrance*

NMi Certin B.V.,
The Netherlands

R076/1992-NL1-2014.52 (MAA)
Non-automatic weighing instrument - Type: DPS-560
Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku, JP-146-8580 Tokyo, Japan

R076/1992-NL1-2014.52 Rev. 1 (MAA)
Non-automatic weighing instrument - Type: DPS-560
Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku, JP-146-8580 Tokyo, Japan

R076/1992-NL1-2014.56 (MAA)
Non-automatic weighing instrument - Type: RN20/VIVA
Mettler-Toledo (Changzhou) Measurement Technology Ltd., N° 111 West TaiHu Road, ChangZhou XinBei District, CN-213125 Jiangsu, P.R. China

▶ Issuing Authority / *Autorité de délivrance*

National Measurement Office (NMO),
United Kingdom

R076/1992-GB1-2012.01 Rev. 3 (MAA)
CT100 Series
CAS Corporation, #262 Geurugogae-ro, Gwangjeok-myeon, Yangju-si, Gyenonggi-do, Korea (R.)

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*

Dansk Elektronik, Lys & Akustik (DELTA),
Denmark

R076/2006-DK3-2014.06
Non-automatic weighing instrument - Type: ACS-C / ACS-L2 / ACS-L5 / BL-CN / ACS-R / BL-GN / ACS-A1 / ACS-268 / ACS-568 / ACS-668A / ACS-668B / ACS-768 / ACS-868
Kaifeng Group Co., Ltd., No 6-8, Sifang Middle Road, Gushan Town, Yongkang City, Zhejiang, CN-321307, P.R. China

R076/2006-DK3-2014.09
Non-automatic weighing instrument - Type: BX 21
BAYKON Endustriel Kontrol Sistemleri San ve Tic A.S., Tuzla Kimya Sanayicileri OSB, Organic Caddessi 31, Tepeoren, Tuzla, 34956 Istanbul, Turkey

R076/2006-DK3-2014.10
Non-automatic weighing instrument - Type: BCS21
BAYKON Endustriel Kontrol Sistemleri San ve Tic A.S., Tuzla Kimya Sanayicileri OSB, Organic Caddessi 31, Tepeoren, Tuzla, 34956 Istanbul, Turkey

R076/2006-DK3-2014.11
Non-automatic weighing instrument - Type: SFE / KFE
Kern & Sohn GmbH, Ziegelei 1, D-72336 Balingen, Germany

▶ Issuing Authority / *Autorité de délivrance*
Office Fédéral de Métrologie METAS,
Switzerland

R076/2006-CH1-2013.01 Rev. 1 (MAA)
Non-automatic electro-mechanic infantile weighing instrument - Type: BIS04
Seca Meß- und Wiegetechnik or Vogel & Halke GmbH & Co., Hammer Steindamm 9–25, DE-22089 Hamburg, Germany

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

R076/2006-NL1-2014.11 (MAA)
Indicator or a Digital Data Processing Device - Type: EDI-2200
Yamato Scale Co., Ltd., 5-22 Saenba-cho, JP-673-8688 Akashi, Hyogo, Japan

R076/2006-NL1-2014.11 Rev. 1 (MAA)
Indicator or Digital Data Processing Device - Type: EDI-2200..
Yamato Scale Co., Ltd., 5-22 Saenba-cho, JP-673-8688 Akashi, Hyogo, Japan

R076/2006-NL1-2014.20 (MAA)
Non-automatic weighing instrument - Type: Adventurer AX series
Ohaus Corporation, 7, Campus Drive, Suite 310, NJ 07054 Parsippany, United States

R076/2006-NL1-2014.37
Non-automatic weighing instrument - Type: Isolette 8000/C2000
Drager Medical Systems Inc., 3135 Quarry Road, Telford, PA 18969 Pennsylvania, United States

▶▶

R076/2006-NL1-2014.44 (MAA)
Non-automatic weighing instrument - Type: RM-5800
Shanghai Teraoka Electronic Co., Ltd., Tinglin Industry Developmental Zone, Jin Shan District, CN-201505 Shanghai, P.R. China

R076/2006-NL1-2014.53 (MAA)
Indicator - Type: X3ARM, X3RM, X3WRM, X5RM, X1RM, X3AGM, X3GM. X3WGM, X5GM, X1GM
Hiweigh Technologies Limited, No. 1 Haiqiao Road, Huina Town, Pudong Distric, CN-201301 Shanghai, P.R. China

R076/2006-NL1-2014.55 (MAA)
Non-automatic weighing instrument - Type: bMobile, bDrive.
Mettler-Toledo (Changzhou) Measurement Technology Ltd., N° 111 West TaiHu Road, ChangZhou XinBei District, CN-213125 Jiangsu, P.R. China

R076/2006-NL1-2014.57 (MAA)
Non-automatic weighing instrument - Type: HE…Moisture Analyzer
Mettler-Toledo GmbH, Im Langacher 44, CH-8606 Greifensee, Switzerland

R076/2006-NL1-2014.58 (MAA)
Non-automatic weighing instrument - Type: BC Series
Mettler-Toledo Inc., 1150 Dearborn Drive, Ohio 43085, Worthington, United States

R076/2006-NL1-2014.59
Non-automatic weighing instrument - Type: FG. . .
A&D Instruments Ltd., 24 Blacklands Way, Abingdon Business Park, Abingdon OX14 1DY, United Kingdom

R076/2006-NL1-2014.60 (MAA)
Indicator - Type: DPS-5600i and DPS-5600Mi
Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku, JP-146-8580 Tokyo, Japan

R076/2006-NL1-2014.61 (MAA)
Non-automatic weighing instrument - Type: S51 series, S71 series.
Ohaus Corporation, 7, Campus Drive, Suite 310, NJ 07054 Parsippany, United States

▶ **Issuing Authority / *Autorité de délivrance***
National Measurement Office (NMO), United Kingdom

R076/2006-GB1-2014.05 Rev. 1 (MAA)
CI-600A Series and CI-600D Series
CAS Corporation, #262, Geurugogae-ro, Gwangjeok-myeon, Yangju-si, Gyenonggi-do, Korea (R.)

R076/2006-GB1-2014.09 (MAA)
NCR 7879-2XXX and 7879-5XXX
NCR Corporation, 2651 Satellite Blvd, 30096 Duluth, Georgia, United States

R076/2006-GB1-2014.11 (MAA)
OP-960+ Baggage Scale
Mechanica Sistemi srl, Via G. Dalla Chiesa 74/76, IT-20037 Paderno Dugnano (MI), Italy

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

R076/2006-DE1-2014.02
Non-automatic electromechanical weighing instrument without lever system - Type: SLSC2/SLSC2MR
Hottinger Baldwin Messtechnik GmbH, Im Tiefen See 45, DE-64293 Darmstadt, 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***
International Metrology Cooperation Office, National Metrology Institute of Japan (NMIJ) National Institute of Advanced Industrial Science and Technology (AIST), Japan

R117/1995-JP1-2011.01 Rev. 3
Fuel dispenser for motor vehicles, A series
Tokico Technology Ltd., 3-9-27 Tsurumi Chuo, Tsurumi-ku, Yokohama City, Kanagawa, Japan

R117/1995-JP1-2014.01
Fuel dispenser for motor vehicles, Tatsuno Sunny-XB Series
TATSUNO CORPORATION, 3-2-6, Mita, Minato-ku, 108-8520 Tokyo, Japan

49th Meeting of the International Committee of Legal Metrology

Auckland, New Zealand 4–6 November 2014

Opening speeches

Matua Matt Maihi, Kaumatua from the Komiti Marae, Auckland

Good morning, good morning; I want to say good morning in Maori. Ladies and gentlemen, can I ask you to be upstanding as we call on our representatives.

[Maori song and words in Maori]

I am pleased to open the Conference. We are not an old country, we are going to celebrate a hundred and seventy five years of the establishment of Auckland, so that is not long ago, when I see the nationalities that are here. Next year, Auckland will celebrate its founding a hundred and seventy five years ago. For us, Tamatufinua, the people who were here first, we have been here a thousand years, as long as a lot of you in your own country. But anyway, I just want to say, our National Anthem was initially a hymn, so when you hear "all the gods" in our national anthem, well, that's what it is. I am just going to read it, because there are five verses and we only sang the first verse. I want to read the second verse, because it includes all of us. And this is our prayer, as we stand:

Men of every created race,
Gathered here before thy face,
Asking thee to bless this place,
God defend our free land,
From dissension and hate
And corruption, guard our state.
Make our country good and great:
God defend New Zealand.

Can I just pray:

Father, we bow in reverence before your holy, friendly face. We come humbly as people from all nationalities and countries. We ask indeed that you will bless this conference, as those who have come to these shores to discuss and deliberate the business relating to their measurements and weights, and so undertake for us, our God, in this Conference, we ask [Maori words]. Please be seated. [Maori chant]

As I look around this room, and I am engulfed by a nation of people of the world, can I say to you all, welcome, welcome, welcome. Welcome to New Zealand. Welcome to Autilwa. Welcome in relationship to the work that you do for the benefit of all peoples, to ensure that the roles of our people in every country are treated equally in relationship to weights and measures. While you have come from afar, while you have loved ones at home, I invite you, under the mantle of humanistic love and Autilwa Foeso, that you make us your family while you are here. And with that, we open our doors, we open our hearts, we open our minds to you all.

Picture: Ian Dunmill, BIML

Auckland region scenery

OIML Awards

During the 49th CIML Meeting, OIML medals were awarded to Dr. Grahame Harvey (Former CIML Vice-President), Mr. Stuart Carstens (CIML Member for South Africa) and Ms. Veronika Martens (CECIP) for their outstanding contributions to international legal metrology.

The Sixth OIML Award for Excellent Contributions in Legal Metrology in Developing Countries was made to the Serbian National Metrology Institute, the DMGM, which had very successfully managed the reform of legal metrology structures in Serbia.

Pictures: Patricia Saint-Germain, BIML

This is a special day for us, as New Zealanders, to have the opportunity to express many countries that are here today of the world, and I say to you all: Welcome, welcome, welcome. And while we have your President here to be representation for you all, and unfortunately I cannot speak all the languages round here that I see that are sitting here today, but I do know one thing: that we, as people, really enjoy the company of each other by opening our doors, opening our minds, opening our hearts. Love and peace and harmony and unity. And so I say to you all once again, through the medium of your representatives here today, Hairu mai, welcome, Hairu mai, welcome, Hairu mai. [Words in Maori]. I give love from my heart and I give love from my people of New Zealand to you all, and say to you, welcome, welcome, welcome.

Picture: Ian Dunmill, BIML

[Maori singing]

That was a lament of one of our ancestors some six hundred years ago. He had a dream. He had a vision that one day there would come a wind blowing in from the north west, and that wind would make a change to the way we live. And of course, today, gone are the grass skirts, and today we are here speaking a totally different language; the wind of change sent upon our people, and we have here today an international group of people representing the world, and that is a great change for us to be able to say to you once again [Words in Maori).

Peter Mason, CIML President

Mr. Mason began by saying that on behalf of all his colleagues representing all of the countries and all legal metrologists across the world, he also wished to say three times, thank you, thank you, thank you.

He also recognized the fact that, while English was their working language, the official language of the Organization continued to be French, and therefore he would also say, merci, merci, merci.

Mr. Mason confirmed that what delegates had heard that day was undoubtedly the warmest and most memorable welcome that he had ever experienced in his years with the Organization. It was something that they would carry away with them as a memory; it would also, he thought, be an inspiration for the work that they were going to do over the next three days, so once again he said thank you, thank you, thank you for the warmth that had been expressed, and for the description that Mr. Matua Matt Maihi had given of his beautiful country. New Zealand was a country which many of those present had already had an opportunity to see, and which he knew some of them would be taking more time to see since they had travelled this long distance in order to be there. Thank you, thank you, thank you, he repeated.

This was followed by a Waiata (or song) sung by a group representing the CIML:

Te aroha - Love
Te whakapono - Faith
Me te rangimarie - Peace
Tatou tatou e - For us all

Mr. Mason then told delegates that it was his very great pleasure to introduce, and to invite to address the CIML, the honorable Paul Goldsmith, newly appointed Minister of Commerce. He knew that CIML Members were doubly honored to have Mr. Goldsmith with them that day: this would be one of his first official engagements in his new role, and he had also had to miss some important meetings in the Capital in order to attend the CIML meeting. Members should be extremely grateful that he had been able to address them.

Looking at Mr. Goldsmith's CV, Mr. Mason said that he also saw what would be called in his own country "a local lad", and that he was therefore probably better placed than most to give Members a welcome to the city of Auckland and the vibrant commercial heart of the country. Without any further ado, therefore, he would invite Minister Goldsmith address the meeting.

The Honorable Paul Goldsmith, Minister of Commerce and Consumer Affairs

In English and in Maori, Mr. Goldsmith greeted Mr. Mason, Members of the CIML and guests. He said that he very much appreciated the opportunity to speak to them all and to open this, the 49th CIML Meeting.

As those present knew, the Organization had begun with the signing of the Treaty in Paris in 1955. It had taken 59 years, but he was pleased to open this meeting on the historic occasion of the Organization's first visit to New Zealand. He therefore offered a welcome to New Zealand, and to Auckland. In addition to having an interesting and productive meeting, he hoped Members would take the opportunity to enjoy a little of the New Zealand scenery and hospitality while they were there. Indeed, they might like to test the volume of some of the wine bottled over on Waikiki later in the week!

All consumers, Mr. Goldsmith pointed out, needed accurate measurements in all facets of life. The work of bodies such as the OIML lay behind so much of what was taken for granted by consumers. An effective legal metrology system underpinned the economy. Every day, consumers, traders, government regulators and industry made decisions based on measurement results, and a well-functioning society relied on confidence in the accuracy and transparency of all measurements used in daily life. It was his view that the most important thing a government could do was to provide stability and predictability. Where there were those conditions, this led to confidence; where there was confidence in the business and consumer spheres, that led to investment, and it was investment that led ultimately to jobs and to the higher living standards to which all aspired.

And so, politicians, officials, regulators, all play their part, and, of course, CIML Members played a very important role, underpinning all those details that were relied on in a well-functioning economy. As international trade expanded, so did the importance of the CIML's efforts to extend the reach of mutually compatible and internationally recognized measurements.

In many instances, Mr. Goldsmith continued, accurate measurements saved lives. Taking the area of road safety, the World Health Organization had reported in 2013 that each year 1.25 million people died on the world's roads – an enormous cost in both finance and human suffering was involved, and so the reduction in road safety crashes was a key social goal for all governments, and, as Members knew, a need for effective regulation in this area was the enforcement agencies' ability to accurately measure a vehicle's speed and weight and a driver's alcohol consumption.

Similarly, global protection and monitoring of the environment was currently a widespread expectation. Monitoring the effects of pollution in water and the atmosphere involved critical measurements, which would have a direct impact on how life was lived in the future. Decisions made by governments around the world which affected people's health and the environment were meaningless without the support of accurate measurement. In New Zealand, the government had four key priorities for the next three years:

1 To responsibly manage government finances. Mr. Goldsmith was pleased to announce that New Zealand was now back in surplus;
2 To build a more competitive and productive economy;
3 To deliver better public services; and
4 To rebuild the city of Christchurch, which, as many of those present would know, had been badly damaged by an earthquake in 2011.

The successful implementation of these policies relied on support from effective standards and conformance infrastructures and the ability to evaluate the effectiveness of what was done. Limited resources needed to be focused on where they could be most effectively utilized, and return best value for the investment made.

So this OIML meeting was called, Mr. Goldsmith said, for a variety of experts from around the world, presenting a unique opportunity for Members to share international best practice and to consider and set the future direction of the important work of the OIML.

Mr. Goldsmith expressed pleasure in opening the 49th Committee Meeting and in wishing delegates well in their discussions and deliberations. He hoped that they would enjoy their time in Auckland and in New Zealand and thanked Members for coming. ■

LIAISONS

Renewal of the OIML-ILAC-IAF Memorandum of Understanding

Willem Kool, BIML

The OIML maintains liaisons with a large number of organizations. These organizations are very diverse. They may be

- intergovernmental bodies and development organizations,
- regional (legal) metrology organizations,
- international standards setting organizations,
- international accreditation organizations,
- international federations representing stakeholders, or
- other international or regional organizations with an interest in metrology.

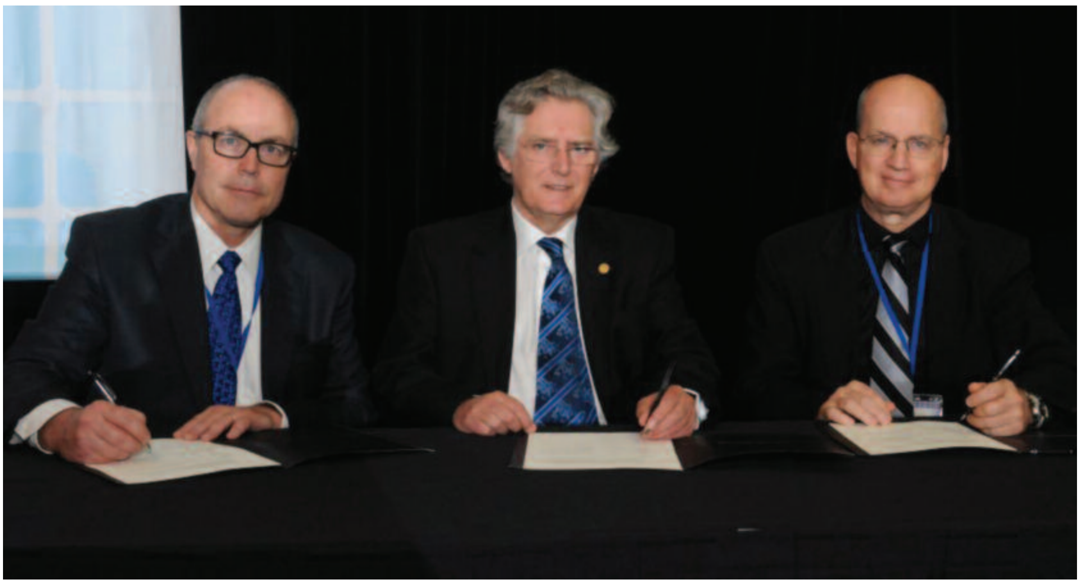
In most cases, these liaisons are at the level of technical committees and subcommittees and are a mechanism to exchange information about each other's work programs and, if appropriate, to contribute to each other's technical work.

In cases where the cooperation is considered to be of a more strategic nature the OIML strives to formalize the liaison by means of a Memorandum of Understanding (MoU), which describes in some detail the mechanisms of cooperation between the organizations that have signed the MoU.

The CIML President addressing the IAF-ILAC Joint General Assembly, Vancouver, Canada, 16 October 2014

To support the Mutual Acceptance Arrangement (MAA) on type evaluations of measuring instruments, the OIML has concluded an MoU with the International Laboratory Accreditation Cooperation (ILAC) and the International Accreditation Forum (IAF). This MoU was first signed in 2007 and renewed (and slightly modified) in 2010. The MoU has recently been reviewed, which has led to a number of editorial changes, such as updated references to standards. The only substantial change was to extend the review period from three to five years.

The revised MoU was signed by the CIML President, Mr. Peter Mason, the Chair of ILAC, Mr. Peter Unger and the Chair of the IAF, Mr. Randy Dougherty, on 16 October 2014 at the occasion of the IAF-ILAC Joint General Assembly in Vancouver, Canada. The revised MoU is reproduced hereafter. ■



Signing the MoU: left to right: Mr. Randy Dougherty, IAF Chair, Mr. Peter Mason, CIML President, Mr. Peter Unger, ILAC Chair

MEMORANDUM OF UNDERSTANDING (MOU)
BETWEEN
THE INTERNATIONAL LABORATORY ACCREDITATION COOPERATION (ILAC),
THE INTERNATIONAL ACCREDITATION FORUM (IAF)
AND
THE INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY (OIML)

The Chair of the International Laboratory Accreditation Cooperation (ILAC),
The Chair of the International Accreditation Forum (IAF), and
The President of the International Committee of Legal Metrology (CIML),

have agreed to cooperate through this Memorandum of Understanding (MoU) considering that:

- measurement plays an essential role in developing confidence between trading partners and in demonstrating that goods and services comply with written specifications and legal requirements;
- accreditation and legal metrology are key elements of an essential infrastructure for national and international consistency of measurements;
- the use of competent product certification, quality management system certification, testing, calibration and inspection in legal metrology controls must be encouraged;
- the existence of a Mutual Recognition Arrangement (MRA) between ILAC members has already led to the acceptance of laboratory and inspection results delivered by an accredited body from another country by a number of national regulatory bodies
- the existence of a Multilateral Recognition Arrangement (MLA) between IAF members has already led to the acceptance of certifications delivered by an accredited certification body from another country;
- the importance of the International Organization of Legal Metrology (OIML) Mutual Acceptance Arrangement (MAA), the ILAC MRA and the IAF MLA to underpin a unified worldwide metrology system for consumer protection, industry, commerce and world-wide trade; and
- the complementary nature of OIML, ILAC and IAF work and the benefits of working together for the development of an international, global metrology system.

1. Areas of Cooperation

The Parties agree to:

1.1 maintain an active ILAC-IAF-OIML liaison by:

- i) facilitating common approaches in the interpretation and implementation of ISO/IEC 17025, ISO/IEC 17020, ISO/IEC 17065, ISO/IEC 17021 and other relevant standards and/or technical criteria, and
- ii) harmonizing assessment procedures;

1.2 share interpretations of common issues of relevance to laboratories, inspection bodies and/or certification bodies by:

- i) exchanging information,
- ii) jointly developing publications and, where practicable, conducting joint work on the development of technical guides, standards, procedures and policies relevant to the affected laboratories, inspection bodies and/or certification bodies, and
- iii) cooperating in the development of joint training courses for technical assessors and conformity assessment experts operating in the field of legal metrology;

1.3 establish lists of technical and metrological experts and technical assessors trained by OIML and ILAC MRA signatories and IAF MLA signatories;

1.4 request ILAC MRA signatories and IAF MLA signatories to use technical and metrological experts and technical assessors from the above-mentioned lists whenever legal metrology activities are included in the scope of the accreditation;

1.5 request IAF Members to promote, to the certification bodies, the use of technical and metrological experts validated by the OIML when legal metrology enters into the scope of the certification;

1.6 request the OIML to use technical assessors from ILAC MRA signatories, that are trained by the OIML for OIML peer assessments;

1.7 request the OIML to recognize accreditations delivered under the conditions defined in this MoU;

1.8 promote and develop the consistency and complementarity of the ILAC Mutual Recognition Arrangement, the IAF Multilateral Recognition Arrangement and the OIML Mutual Acceptance Arrangement;

1.9 promote and develop inter-laboratory comparisons and, in particular, proficiency testing; and

1.10 invite representatives of each Organization to participate as liaisons in agreed meetings of the other Organizations.

2. Implementation

2.1 This Memorandum of Understanding shall come into force upon its signature by the ILAC Chair, the IAF Chair and the CIML President, and will remain in force until terminated in accordance with the provisions hereafter defined.

2.2 This Memorandum of Understanding will be reviewed every five years.

2.3 Relevant work programs to implement the Memorandum of Understanding will be agreed upon by the Parties from time to time.

2.4 The appropriate ILAC bodies, IAF bodies and the International Bureau of Legal Metrology (BIML) will be responsible for implementing such work programs and for reporting on them at the ILAC General Assembly, at the IAF General Assembly and at the CIML Meeting as relevant.

3. Amendments

This Memorandum of Understanding, which supersedes the one signed between ILAC, IAF and OIML on 28 October 2010, may be amended at any time by a written agreement between the parties.

4. Termination

This Memorandum of Understanding may be terminated by either party upon three months written notice.

Peter S Unger
Chair
International Laboratory Accreditation Cooperation (ILAC)

Randy Dougherty
Chair
International Accreditation Forum (IAF)

Peter Mason
President
International Committee of Legal Metrology (for the OIML)

Signed on: 16th October 2014

TRAINING

AFRIMETS Legal Metrology School

Hammamet, Tunisia 8–17 October 2014

SONILA LIKSKENDAJ, UNIDO
IAN DUNMILL, BIML

1 Introduction

Building on the first AFRIMETS Metrology School held in Nairobi in 2012, which aimed to create and strengthen technical competence in metrology in Africa, the second Metrology School, focussing on Legal Metrology, was held in Hammamet, Tunisia from 8 to 17 October 2014.

The event was organized by the intra-African Metrology System (AFRIMETS) and the United Nations Industrial Development Organization (UNIDO) in cooperation with the ACP-EU Technical Barriers to Trade Programme (ACP-EU TBT Programme), the National Metrology Agency of Tunisia (ANM), the OIML and the PTB. The institutional strengthening of the Intra-Africa Metrology System (AFRIMETS) Project is funded by the Norwegian Agency for Development Cooperation (Norad) and the United Nations Industrial Development Organization (UNIDO).

The 10-day training was delivered by experts from well-known metrology institutes in France, the UK, South Africa, Benin, Republic of Congo, Zimbabwe and Tunisia and gave participants extensive knowledge of legal metrology, both in theory and in practice. It was an excellent opportunity and valuable learning occasion for all those who participated. The school added value not only to the professional career of the young metrologists, but also to their institutions and countries.

AFRIMETS

The lack of adequate measurement infrastructures in African countries has put them at a disadvantage in accessing international markets. Many are unable to manufacture to international specifications, to ensure the integrity of their export commodities, to apply quality control to their fresh produce exports and to monitor public health and environmental conditions. And when they do have basic metrology infrastructures, there is often a lack of competence and skilled metrologists.

Recognising the importance of improving the capacity of national metrology institutes, and of harmonizing legal metrology issues, the nations and sub-regions of Africa came together in 2007 to establish an intra-African Metrology System (AFRIMETS). AFRIMETS's primary aim is to harmonize activities associated with scientific, industrial and legal metrology. By enabling African countries to meet the challenge of technical barriers to trade, AFRIMETS will make a critical contribution to the fostering of trade between African countries and the rest of the world.

AFRIMETS' mission statement is: "Promote metrology and related activities in Africa with the aim of facilitating intra–African and international trade and to ensure the safety, health, and consumer and environmental protection of its citizens".

AFRIMETS's long-term objectives are:

- establishing all the organizational structures within AFRIMETS that are needed to fulfill its aims as set out in the founding MoU;
- becoming financially independent of sources outside Africa for its administration, thereby ensuring its ongoing existence;
- elevating its status so that it is fully accepted within the African Union;
- leveraging national and donor funding to realize its goals;
- establishing legal metrology and basic scientific and industrial metrology structures in all its member states;
- using these structures to improve measurement capabilities and harmonize administrative and technical regulations in these countries in order to facilitate intra-Africa and international trade.

Currently 44 countries are members of AFRIMETS. Metrology activities have been structured into six sub-regions of the continent to ensure the success of regional development. (See map on page 50.)

UNIDO and AFRIMETS

In 2009 UNIDO, Norwegian Agency for Development Cooperation (Norad) and AFRIMETS partnered to implement a project to strengthen the capacity of AFRIMETS so that it could contribute to lowering the

export rejection rates of African products caused by the non-equivalence of African and international metrology. The project (2009-2011) successfully completed its outputs, and contributed to bring AFRIMETS as the leading continental quality infrastructure organization in Africa. A key output of this project was the elaboration of a Strategic Roadmap 2012-2016, which provided a snapshot of the scientific, industrial and legal metrology in Africa. This initiative allowed the identification and analysis of the existence gaps in the measurements standards and legal metrology, including a number of recommendations proposed for the development of a continental and sustainable metrology infrastructure.

This snapshot of the status of metrology in Africa indicated that the way forward for the continent is to improve the capacity of national metrology institutes, and indeed to harmonize the legal metrology issues, to provide traceability and to support accredited testing facilities.

Nevertheless, measurement in Africa still requires support and guidance to overcome technical and organizational difficulties to catch up with its peers around the world in order to provide quality measurement services and support to industry and consumers. The project was extended, and the second phase (2014-2015) builds on the achievements of the first phase and is expected to:

- strengthen capacities of National Legal Metrology Organizations (LMO);
- strengthen capacities of National (industrial/ scientific) Metrology Organizations (NMO);
- ensure sustainability of AFRIMETS.

2 Defining training needs

Many African countries have long been at a disadvantage in international markets, not only due to their lack of accredited metrology infrastructure, but particularly due to the lack of skilled metrologists. With this in mind, the organization of specialized training in legal metrology was defined in the AFRIMETS Strategic roadmap 2012–2016 as an essential activity which would significantly contribute to improving the capacity of national metrology institutes, and in particular of legal metrology in the region.

The Legal Metrology School included the key areas identified in the roadmap. These are expected to satisfy the priority continental needs in legal metrology such as measurement uncertainty, traceability of measurements, mass, volume and pre-packaged goods, by delivering national and regional benefits.

3 Designing and planning the training

Application: The Legal Metrology School was specially designed for the needs of African countries and primarily for the members of AFRIMETS. The detailed planning started a year prior to the School.

Applicants were asked to submit an application form to the event's Organizing Committee. The form included information on the institution, qualifications, their academic and professional background, and current responsibilities. Applicants were also asked to submit a letter of recommendation from their institution, a motivation letter and a copy of their CV. They were also asked about their area of specialization.

Strict screening of applicants: All application forms were evaluated against a predetermined set of requirements to ensure that they were in the target audience of early-stage metrology. The participants who demonstrated the highest potential to become agents of change in their own countries were selected to participate. By encouraging the participation of women in this event, high importance was given to gender issues in the selection process.

Distribution and fair participation: 110 applications were received from 38 African countries, including two applications from outside Africa (Haiti). The committee carefully reviewed all applications and selected 97 applicants to attend the training. Considering the limited funding and in order to maintain a balanced geographical distribution, the Organizing Committee agreed to accept at least two participants per country. Where more than two applications were successfully evaluated for a given country, they were offered the chance to attend the event under the condition that travel costs were covered by their institutions.

Programme content: The Legal Metrology School was designed to provide participants with both theoretical and practical knowledge in a number of key technical fields, according to questionnaires completed by AFRIMETS members in the early planning stages of the school.

PS: Setting the background		
Basics	Measurements	Measurement uncertainty
PS: Plenary session legal metrology		
Legal system	Metrology legislation	OIML
TC: Quality Aspects of Legal Metrology		
Volume	Mass	Pre-packages
PT: Technical visits to industry		
Group assignments		
Practical training in industry		

Plenary sessions (PS): Plenary sessions included the basics of metrology and the concepts of measurement and measurement uncertainties. They also provided an extensive overview of the legal system, metrology-related legislation and quality aspects of legal metrology and OIML standards. English/French interpretation was provided:

- Concepts of measurement: Metrology, the science of measurement; The National Measurement System (Andy Henson, BIPM);
- Basics: Quantity mathematics and physics with technical applicability in metrology; statistics (Lassaad Abene, Tunisia);
- Measurement uncertainties and measurement errors: Guide to the expression of Uncertainty in Measurement (GUM). Statistical distributions (discrete, Poisson, continuous probability, uniform, exponential, Gaussian, Student's) (George Bonnier, France);
- The legal system and metrology: Constitution, law, acts, legislations, regulations and standards. Examples from European and developing countries (Peter Mason, UK);
- Legal metrology and the OIML: Structure, members, functions. Introduction to OIML Recommendations. OIML certificate system and MAA (Luis Mussio, BIML; Peter Mason, UK);
- Metrology related infrastructure and legislation and OIML D 1: Metrology infrastructure, metrology legislation, national metrology regulations and their alignment with regional requirements and obligations in terms of the WTO TBT agreement (Brian Beard, South Africa);
- Legal metrology regulatory functions and practices: Responsibilities of the state; type approval of measuring instruments; initial and subsequent verification of measuring instruments; metrological supervision and the application of sanctions; supervision of private bodies that carry out a legal function (Brian Beard, South Africa);
- Conformity assessment: Presumption of conformity; harmonized standards; OIML normative documents; accreditation procedure (Loukoumanou Osseni, Benin);
- Quality aspects of legal metrology 1: ISO 9000: Quality management; Meeting customers' requirements and improving product quality. ISO 17020: Conformity assessment; Requirements for the operation of various types of bodies performing inspection (Kanama Viki Mbuya, Democratic Republic of Congo);
- Quality aspects of legal metrology 2: ISO 17025: General requirements for the competence of testing and calibration laboratories; QMS of the verification institution (Kanama Viki Mbuya, Democratic Republic of Congo);
- Training and qualification of legal metrology personnel: OIML D 14 and its interaction with ISO/IEC 17024 (Mourad Ben Hassine, Tunisia);
- Trends and applications of legal metrology: Energy, environment, health, security (Ian Dunmill, BIML);
- Benefits of legal metrology for industry and for consumers (Samia Khadhri, Tunisia).

Technical courses (TC): These were based on the main needs which had been identified, and focussed on volume, mass and pre-packaged goods.

The participants were divided into two main groups (mass and volume) based on the technical areas indicated in their application forms. Participants coming from the same country were trained in both fields. All participants attended the pre-packaged goods course. All technical courses were given in English and French, and the programme content in both languages was harmonized.

The English version of these courses were delivered by Brian Beard (South Africa), Jaco Marneweck (South

Africa) and Victor Mundembe (Namibia). The French versions were delivered by Hichem Ben Hadj Brahim (Tunisia), Mouadh Madani (Tunisia), Seifeddine Souahlia (Tunisia).

Practical training (PT): The field visits that participants made to eight Tunisian companies were an important component of the programme. Each visit helped participants recognize the serious impact a plant or process failure or an instrument malfunction caused by wrongly calibrated equipment would have on the end product or on the consumer. This clearly highlighted the importance of the metrologist and the national metrology institute. Participants were required to give feedback presentations on the industrial visits.

At each company, participants were prompted to identify:

- the major measurement units that affect the various stages of a process;
- the measurements that are critical for the final products: volume, mass and pre-packages etc.
- the quality assurance requirements and quality control points throughout the process;
- the measurement infrastructure support for the quality assurance and quality control of products: What systems are in place? What standards and/or certification accreditation are applicable?
- the importance of measurement tolerances during the production process;
- health and safety requirements and their implementation for the protection of consumers.

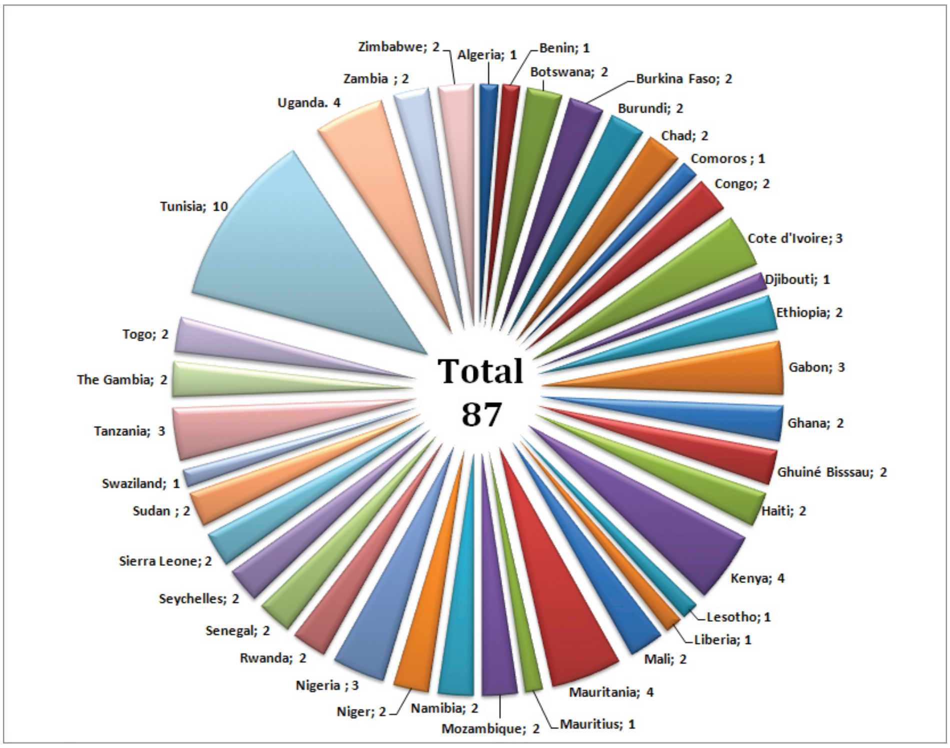
Presenters: 15 experts with an extensive knowledge and experience in the field were selected to match the training needs. To decrease the cost of the event, high priority was given to selecting experts from the region, who were more familiar with the needs of African countries at both national and regional levels.

Sponsorship: Most of the costs were covered by the ACP-EU TBT programme which paid for 59 participants including two from Haiti, and by UNIDO which covered the cost of the rest of participants as well as the expenses of some presenters and the organizational and logistical cost of the entire event.

Evaluating training outcomes: To assess the benefits of this learning opportunity and to improve the effective implementation of future initiatives, a voluntary evaluation questionnaire was handed to the participants at the end of the event.

Feedback was evaluated and an evaluation report was prepared. Based on the results of the 62 questionnaires analyzed, the majority of the participants were very satisfied. Nevertheless, in order to improve future training, a number of comments and suggestions were made by the participants:

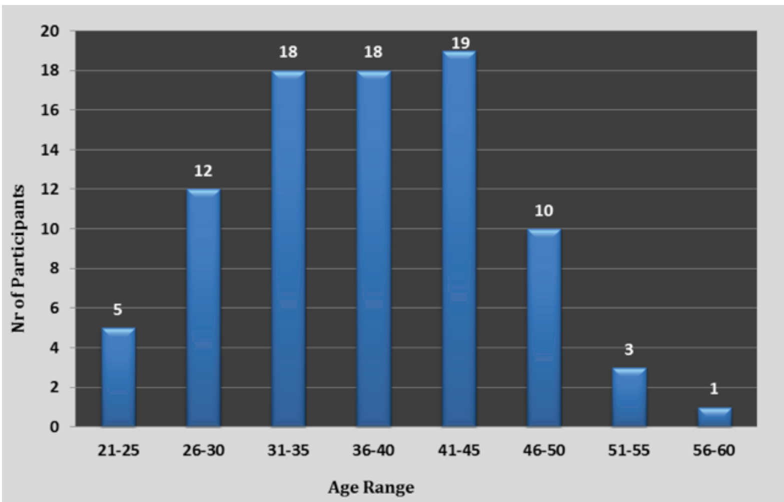
1) *The duration of the Legal Metrology School should be extended*: 10 days were found to be insufficient. Almost all the participants indicated that the short length of the courses made it difficult for them to assimilate the material;



2) *Include more practical training in the overall programme:* The participants found the practical training and technical visits to industry a very interesting component. However, many pointed out that the event included more theoretical than practical training;
3) *Pre-packaged goods course should be presented into more detail*: The course was found to be useful. However, a number of participants indicated that it was given in very general terms due to the short time available;
4) *Include other additional courses in the programme*: It was recommended by a few participants to include courses on electricity meters, gas meters, and petrol dispensers.

4 The participants

86 participants from 38 countries, including 15 women and 10 participants from Tunisia, attended the Legal Metrology School. Most were at an early stage in their professional career. A significant number of participants were between 31 and 45 years old, with some knowledge and experience already acquired to better assimilate the training material.



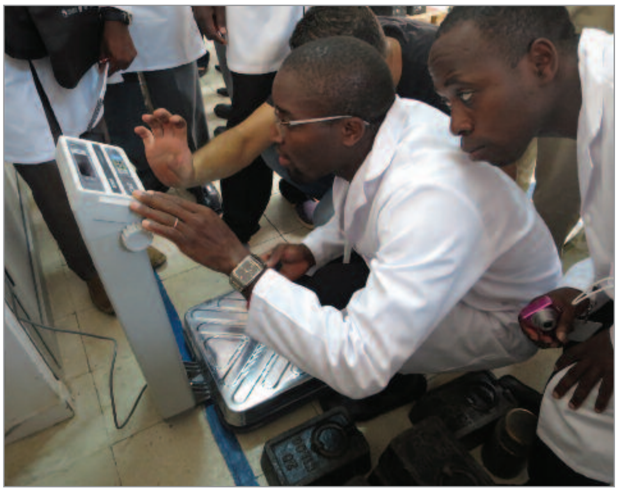
5 Key achievements

The 2014 AFRIMETS Metrology School was a great success. It gave participants both a good grounding in theory and hands-on experience of practical legal metrology. The industrial visits engaged participants in actually applying what they had learnt.

Participants were able to engage with experts from well-known metrology institutes in question-and-answer sessions during the technical presentations and core technical training sessions, and to participate in other interactive activities (industry visits and group assignments) as well as preparing a written report on the industry visits.

They returned to their countries with a sound understanding of the role and importance of having in place an effective national legal metrology infrastructure and a solid grounding in its practice.

They are prepared to become agents of change in crucial areas, by supporting the development of their countries' capacity to produce goods that meet the demanding requirements of global markets, and to thereby make a significant contribution to economic growth and poverty reduction. ■



Participants attending the AFRIMETS Legal Metrology School

Hammamet, Tunisia
8–17 October 2014

The OIML is pleased to welcome the following new

CIML Members

Algeria:
Mr. Rabah Messili

Egypt:
Eng. Ahmed Yousef Hussein Abo Taleb

Tunisia:
Mr. Cherif Fekiri

Corresponding Member

Azerbaijan

OIML meetings

February 2015

TC 17/SC 7 Software validation working group (R 126)
25 February, BIML, Paris, France

June 2015

TC 17/SC 7/p 3 Evidential breath analyzers (R 126)
30 June - 1 July, VSL, Delft, The Netherlands

October 2015

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

Committee Drafts

Received by the BIML, 2014.10 – 2014.12

Revision R 59: Moisture meters for cereal grains and oilseeds	E	7 CD	TC 17/SC 1/p 1	CN+US
OIML Dxx:201x: Conformity to type (CTT) – Pre-market conformity assessment of measuring instruments. Scope for pre-market surveillance activities focused on the conformity assessment of measuring instruments to give assurance that the manufactured (or production) instruments meet their approved type	E	2 CD	TC 3/SC 6/p 1	NZ
OIML R 139-3: Compressed gaseous fuel measuring systems for vehicles. Part 3: OIML Report format for type evaluation	E	2 CD	TC 8/SC 7/p 4	NL

Call for papers

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

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

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

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

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

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

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