

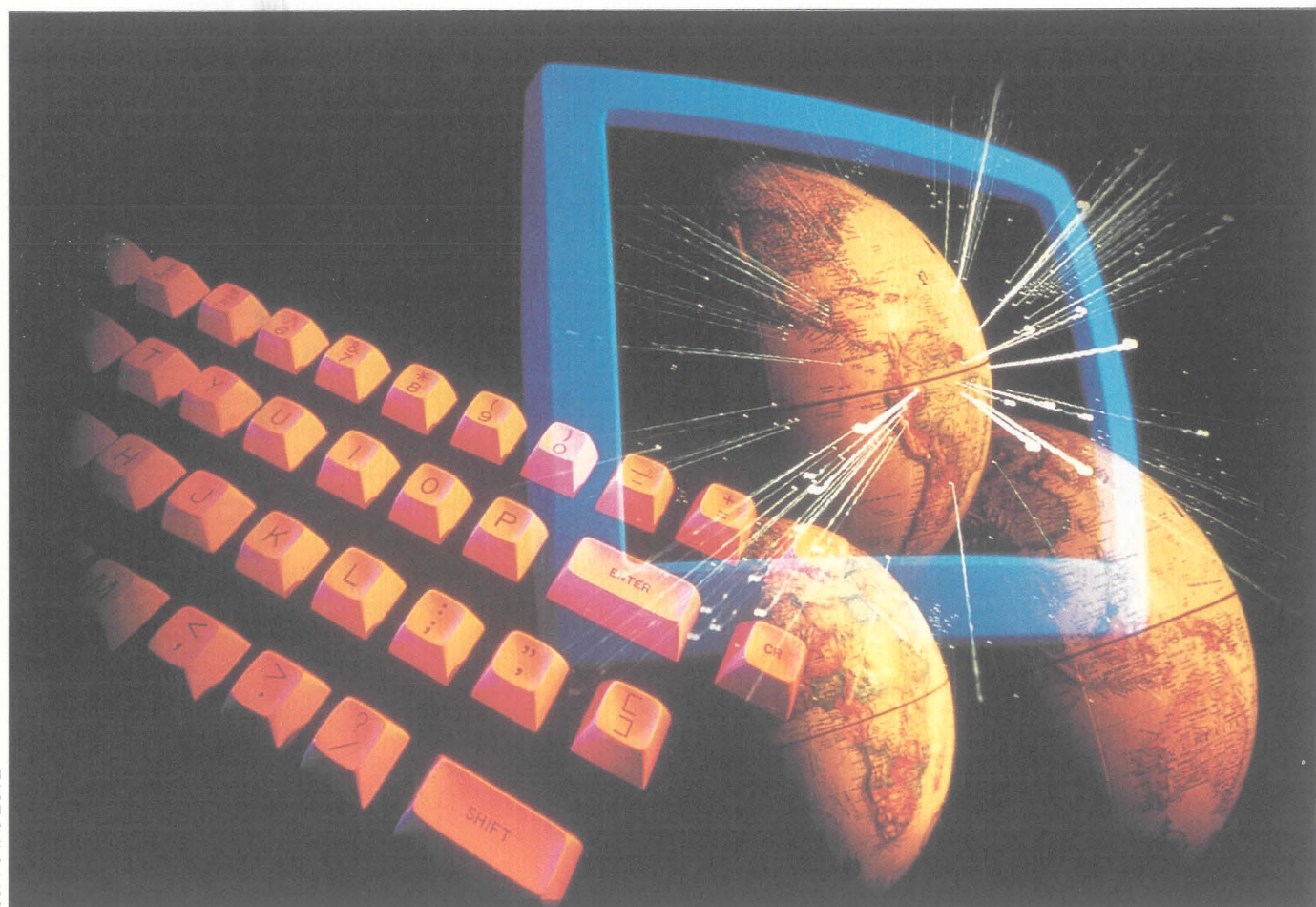


OIML BULLETIN

VOLUME XXXVIII • NUMBER 2 • APRIL 1997

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

QUARTERLY JOURNAL



ISSN 0473-2812

OIML on the Internet

THE OIML BULLETIN IS THE QUARTERLY
JOURNAL OF THE ORGANISATION
INTERNATIONALE DE MÉTROLOGIE LÉGALE.

The Organisation Internationale de Métrologie Légale (OIML), established 12 October 1955, is an inter-governmental organization whose principal aim is to harmonize the regulations and metrological controls applied by the national metrology services of its Members.

OIML SECRETARIAT

BUREAU INTERNATIONAL DE
MÉTROLOGIE LÉGALE (BIML)

11 RUE TURGOT, 75009 PARIS, FRANCE
TEL: 33 (0)1 48 78 12 82 OR 42 85 27 11
FAX: 33 (0)1 42 82 17 27

EDITOR-IN-CHIEF

Bernard Athané

EDITORS

Philippe Degavre
Chris Pulham

1997 SUBSCRIPTION RATES

EUROPE: 400 FRF
OUTSIDE EUROPE: 450 FRF

OIML PRESIDENCY AND PRESIDENTIAL COUNCIL

PRESIDENT

Gérard J. Faber (NETHERLANDS)

VICE PRESIDENTS

Samuel E. Chappell (USA)
Manfred Kochsiek (GERMANY)

MEMBERS

Seton J. Bennett (UNITED KINGDOM)
John Birch (AUSTRALIA)
Lev K. Issaev (RUSSIAN FEDERATION)
Yoshiharu Kurita (JAPAN)
Li Chuanqing (P.R. OF CHINA)
Jean-François Magana (FRANCE)
Bernard Athané (DIRECTOR OF BIML)

BIML TECHNICAL AGENTS

DIRECTOR

Bernard Athané

ASSISTANT DIRECTORS

Alexandre Vichenkov
Philippe Degavre

ENGINEER

Edouard Weber

EDITOR

Chris Pulham

ADMINISTRATOR

Philippe Leclercq

ISSN 0473-2812

DEPOT LEGAL NO 9155

PRINTED IN FRANCE

GRANDE IMPRIMERIE DE TROYES
130, RUE GÉNÉRAL DE GAULLE
10000 TROYES

OIML

MEMBER STATES

ALGERIA	KENYA
AUSTRALIA	DEM. P. REP. OF KOREA
AUSTRIA	REP. OF KOREA
BELARUS	MONACO
BELGIUM	MOROCCO
BRAZIL	NETHERLANDS
BULGARIA	NORWAY
CAMEROON	PAKISTAN
CANADA	POLAND
P. REP. OF CHINA	PORTUGAL
CUBA	ROMANIA
CYPRUS	RUSSIAN FEDERATION
CZECH REPUBLIC	SAUDI ARABIA
DENMARK	SLOVAKIA
EGYPT	SLOVENIA
ETHIOPIA	SPAIN
FINLAND	SRI LANKA
FRANCE	SWEDEN
GERMANY	SWITZERLAND
GREECE	TANZANIA
HUNGARY	THE FORMER YUGOSLAVÉ REPUBLIC OF MACEDONIA
INDIA	TUNISIA
INDONESIA	UNITED KINGDOM
IRAN, ISLAMIC REPUBLIC OF	UNITED STATES OF AMERICA
IRELAND	YUGOSLAVIA
ISRAEL	ZAMBIA
ITALY	
JAPAN	
KAZAKHSTAN	

CORRESPONDING MEMBERS

ALBANIA	MAURITIUS
BAHRAIN	MEXICO
BANGLADESH	MOLDAVIA
BARBADOS	MONGOLIA
BENIN	MOZAMBIQUE
BOTSWANA	NEPAL
BURKINA FASO	NEW ZEALAND
COLOMBIA	OMAN
COSTA RICA	PANAMA
CROATIA	PAPUA NEW GUINEA
ECUADOR	PERU
FIJI	PHILIPPINES
GHANA	SEYCHELLES
HONG KONG	SINGAPORE
ICELAND	SYRIA
JORDAN	THAILAND
KUWAIT	TRINIDAD AND TOBAGO
LATVIA	TURKEY
LITHUANIA	UKRAINE
LUXEMBURG	URUGUAY
MALAWI	VIETNAM
MALAYSIA	

technique

- 5 Automatic control of 20 kg and 50 kg weights in large numbers
A. Helms
- 8 Calibration of weights and surface roughness
T. Myklebust, H. Källgren, P. Lau, L. Nielsen, K. Riski
- 18 Accurate weighing in motion of vehicles at low speed
L. Brulant, A. Liegeois
- 25 Calibration of flexible tapes to ppm accuracy level
C. B. Rosenberg, C. S. C. Munteanu, R. A. Ferguson
- 30 Optimum traceability type hierarchies
D. Kisets

evolutions

- 37 The development of metrology in Mauritius
K. Ramful
- 40 InterAmerican Accreditation Cooperation (IAAC) - Communiqué
- 41 The verification and test laboratory accreditation system of the Republic of Belarus
N. Kusakin, N. Zhagora
- 43 The establishment of a regional metrology network in South Africa
M. Kochsiek

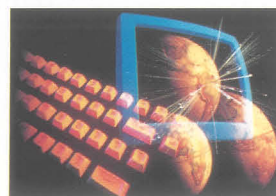
update

- 45 Report on OIML technical activities 1996–1997
- 53 Reports on OIML meetings: Presidential Council and TC 17/SC 7
- 57 OIML Certificate system
- 61 11th WELMEC committee meeting
- 62 New publications – General information

OIML ON THE INTERNET

SEE EDITORIAL AND PAGE 63

Photo: Stephen Marks, The Image Bank



technique

- 5 Contrôle automatique des poids de 20 kg et de 50 kg en grand nombre
A. Helms
- 8 Étalonnage des poids et rugosité de leur surface
T. Myklebust, H. Källgren, P. Lau, L. Nielsen, K. Riski
- 18 Pesage de précision, en mouvement, des véhicules routiers à faible vitesse
L. Brulant, A. Liegeois
- 25 Étalonnage des mesures de longueur souples en ruban au niveau d'exactitude du ppm
C. B. Rosenberg, C. S. C. Munteanu, R. A. Ferguson
- 30 Optimisation des hiérarchies de traçabilité
D. Kisets

évolutions

- 37 Le développement de la metrologie à l'île Maurice
K. Ramful
- 40 InterAmerican Accreditation Cooperation (IAAC) - Communiqué
- 41 Le système d'accréditation des laboratoires de vérifications et d'essais en République de Belarus
N. Kusakin, N. Zhagora
- 43 La mise en place d'un réseau régional de métrologie en Afrique du Sud
M. Kochsieck

informations

- 45 Rapport sur les activités techniques de l'OIML 1996-1997
- 53 Rapports de réunions OIML: Conseil de Présidence et TC 17/SC 7
- 57 Système de Certificats OIML
- 61 11^{ème} réunion du comité de WELMEC
- 62 Nouvelles publications et informations générales



Editorial

OIML on the Internet

During the month of February 1997, OIML launched its new WEB page. This project does not stem merely from a desire to keep up with current trends; our objective is more to set up a system which enables us to better deal with the growing number of requests for information on our activities, just as other international organizations are also doing.

The culmination of both the increasing use which is made of our publications by measuring instrument manufacturers and test laboratories, the development of our certificates of conformity and also the references made to OIML in numerous national, regional and international provisions all serve to spread the name - and the fame - of the OIML across the world. But this also generates a large number of inquiries, which obliges our office staff to devote an ever increasing amount of time to providing the information required.

For the time being, the content of OIML documents on the WEB will be limited to a description of our activities and of what legal metrology is, a list of our Members (including the addresses of the national legal

metrology services of almost 100 countries) and our publications, presented in a format similar to that used in the separate listing which accompanies the Bulletin.

At a later date, information about our technical activities (meetings, state of progress of work) as well as information on our development aid activities and delivery of certificates, etc. will also be included in these OIML pages.

Lastly, we are starting to consider the possibility of making the texts of International Recommendations and other OIML publications available to interested parties. But before this comes into operation, a serious market survey will be carried out, and the experience of other organisms in this matter will be called upon.

We hope that Internet users who discover us either by our URL (Internet address) or by key words such as "OIML" or "LEGAL METROLOGY", which are now included in a number of search engines, keep us informed of their impressions after exploring the contents of our site, and let us know also their proposals for rendering the information contained therein even more user-friendly and practical. ■

<http://www.oiml.org>



CALIBRATION OF WEIGHTS

PRACTICAL TEST PROCEDURES
FOR CLASSES E₁ TO M₃ WEIGHTS

2 - 4 OCTOBER 1996 - BORÅS, SWEDEN

Automatic control of 20 kg and 50 kg weights in large numbers

A. HELMS, MSES GmbH, Germany

Introduction

In connection with the calibration of high capacity weighing instruments and especially with the traceable control of the "calibration weights" used for their adjustment, larger quantities of 20 kg or 50 kg weights are required as reference objects. The weights are packed together so that the summation of their nominal mass values is identical to the nominal mass value of the individual "calibration weight".

For that reason there is a big demand on calibration or verification of such objects in large numbers. Refer to References [1] and [2].

A system has been designed to facilitate the calibration of a series of 20 kg or 50 kg weights comprising up to 50 objects. The whole system works fully automatically regarding the handling of the objects, the weighing procedure and the documentation of the results.

The weighing cell used is either a regular 30 kg or a 50 kg mass comparator. In order to increase the speed of comparative weighing, the mass comparator is tuned up with an integrated working standard. The function principle of this system will be discussed in this paper.

1 Weight calibrator

The MC50002 calibrator (as the main component of the automatic calibration system) is designed on the basis of a Sartorius CC30001 or CC50001 weighing cell with a readability of 5 mg or 10 mg respectively. In order to ensure a small standard deviation, there is a centering pan on top of the platform. The calibrator is equipped with an internal working standard which is used as a reference weight in connection with differential substitution weighing. The objects to be calibrated have to be positioned on the calibrator pan and an automatic switching mechanism subsequently loads the weighing

cell with the working standard and the test object in accordance with the double substitution pattern.

However, the user does not need to realize this substitution mechanism during daily calibration work. For the user, it is essential that both the mass or the conventional mass and the measurement uncertainty are determined by the calibrator, regardless of what happens internally in the calibrator. After the calibration has been carried out, the mass m or the conventional mass m_c of the object and the measurement uncertainty U are shown on the computer screen, which is used as a display.

The function principle of the weight calibrator is shown in Fig. 1.

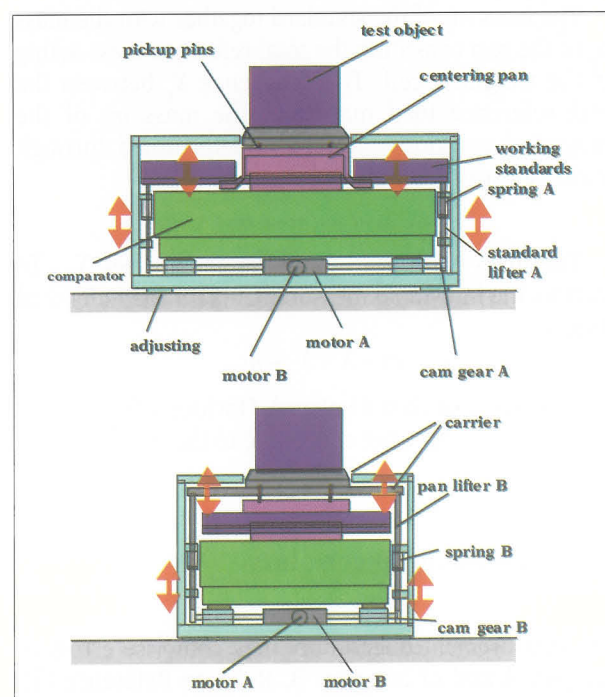


Fig. 1 Function principle of the MC50002 weight calibrator

As the mass m of the object plus the mass m_p of the weighing pan is on the same level with the mass m_s of

the integrated working standard, the mass difference

$$X = m + m_p - m_s$$

may be determined through double substitution weighing.

It will be shown hereafter that the mass value of the pan will be eliminated.

2 Calibration of the working standard

The integrated working standard of the weight calibrator needs to be calibrated prior to its serial application to the measured objects. Both its mass value and its uncertainty have to be known before it is used as a measurement standard. The results of the calibration are memorized in the computer and are used for the evaluation of the individual calibration processes.

For the calibration of the calibrator's working standard, a reference standard of appropriate accuracy is to be used.

The calibration procedure of the working standard is very similar to the calibration procedure of the measurement objects. However instead of the object, the external reference standard has to be positioned on the calibrator pan. Again, double substitution weighing will be carried out. Here the integrated working standard plays the role of the test object, whereas the "object" on the pan plays the role of the reference standard.

The mass m_r of the standard together with the mass m_p of the pan constitute the total reference mass acting on the weighing cell. The difference X_c between the total reference load mass and the mass m_s of the integrated working standard is determined through double substitution weighing:

$$X_c = m_s - (m_r + m_p)$$

The mass calibrator computer memorizes X_c . To evaluate the individual measurements for the individual objects:

$$m = X + X_c + m_r$$

is calculated and then displayed. Obviously the mass of the pan system does not contribute to the result.

3 Measurement uncertainty

The measurement uncertainty may comprise errors of category A and of category B. Refer to Reference [3]. For the uncertainty calculation, the calibration of the integrated standard has to be considered first.

The mass value

$$m_s = X_c + m_r + m_p$$

of the integrated standard comprises the following uncertainties:

- Uncertainty u_c of the calibration procedure (category A)
- Uncertainty u_r of the reference standard (category B). The mass value of the reference standard and its uncertainty are stated in its certificate.
- Uncertainty u_p of the weighing pan (category B). This uncertainty has to be estimated and confirmed through separate long-term measurements. Compared to the mass of the object, the mass of the pan is relatively small. For this reason, the uncertainty contribution from the pan can be assumed to be small too.

The combined uncertainty of the integrated standard contains these uncertainties as discussed:

$$u_s = \sqrt{u_c^2 + u_r^2 + u_p^2}$$

The measurement uncertainty of the mass to be calibrated is calculated by:

$$m = X + m_s - m_p$$

It comprises the following uncertainties:

- Uncertainty u_w from the substitution weighing (category A)
- Uncertainty u_s from then integrated standard (combined)
- Uncertainty u_p of the weighing pan (category B).

So the combined uncertainty of the test object is:

$$u = \sqrt{u_w^2 + u_s^2 + u_p^2}$$

$$u = \sqrt{u_w^2 + u_c^2 + u_r^2 + 2u_p^2}$$

After expansion by the coverage factor k , the value of this uncertainty will be displayed together with the mass value of the object.

4 Uncertainty budget

As an example, the uncertainty budget for a 50 kg application of the weight calibrator is considered here.

By repeating the substitution process, it may be shown that the standard uncertainty of the weighing would not exceed:

$$u_w = 10 \text{ mg.}$$

For the calibration of the integrated working standard, the substitution process may be conducted n times. For this reason, the uncertainty of the working standard calibration may be:

$$u_c = t_r \times u_w / \sqrt{n}$$

So the category A uncertainties are:

$$\sqrt{u_w^2 + u_c^2} = u_w \sqrt{1 + (t_r^2 / n)}$$

For δm (the maximum permissible error of the object) the expanded uncertainty for its mass value at $k = 2$ should not exceed:

$$U = 2u = \delta m / 3$$

The standard uncertainty of the reference standard fulfills similar conditions but with a smaller maximum permissible error:

$$U_r = 2u_r = \delta m / 10$$

The mass of the pan may be assumed to be less than one tenth of the mass of the object. For this reason, the following condition may be met by the mass of the pan: its change in time between the calibration of the integrated standard and the calibration of the object may be estimated by an uncertainty that is equal to the uncertainty of a weight with the same nominal mass value:

$$U_p = 2u_p = (1/3) \cdot (1/10) \delta m$$

This condition may be controlled separately by another mass calibrator for smaller nominal values.

The present consideration (for $n = 10$) leads to a maximum permissible standard uncertainty of the weight calibration process being $0.147 \delta m$. So if the condition

$$u_w \leq (4/30) \delta m$$

is set, the requirement on the weighing process will be fulfilled in any case. For class E_2 calibration with $\delta m = 75$ mg, the maximum permissible standard uncertainty of the weighing process would be 10 mg.

This requirement is exactly met by the MC50002 weight calibrator.

5 Automatic feeding system

For a larger number of objects, the weight calibrator can easily be combined with a system of conveyers. This system automatically feeds the calibrator with the measurement objects one after the other. Of course, in most cases for greater numbers of objects the required accuracy is relatively low.

The feeding system together with the mass calibrator are shown in Fig. 2; it can calibrate up to 50 objects without human interference. The conveyers are lined up in lanes on both the provision side and the

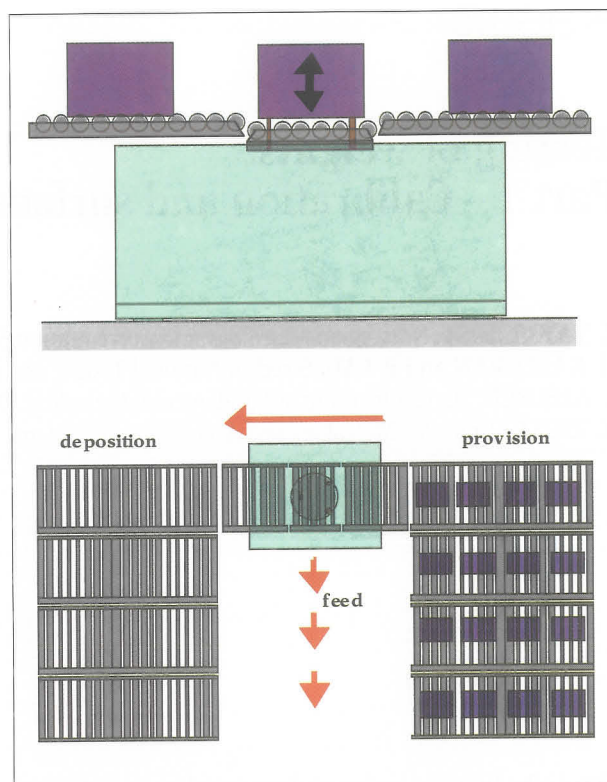


Fig. 2 Automatic system MCA50002

deposition side, and the weight calibrator is moved from one lane to the next. In every position the objects on the provision lane are shifted onto the calibrator by a feeding system, one after the other. Further on after calibration, the object is shifted to the corresponding lane on the deposition side.

Of course all calibrations are accompanied by a protocol containing the mass value and the measurement uncertainty.

In case of 50 kg or 20 kg weights as test objects, a simultaneous adjustment is possible. After the determination of the mass value using an automated feeding device for every sample, a computer controls the provision of its adjustment cavity by an appropriate quantity of adjustment material. ■

References

- [1] Helms, A.: Rückführbare Massebestimmungen über 50 kg - Anforderungen an Waagen und Massenormale, wägen + dosieren 4/1995;
- [2] Helms, A.: Traceable Mass Determination at Capacities Higher than 50 kg - Balance and Mass Standard Requirements, OIML - Seminar "Weighing Towards the Year 2000", Sept. 1995;
- [3] OIML R 111, edition 1994.

Testing of weights: Part 1 - Calibration and surface roughness

T. MYKLEBUST, Norwegian Metrology and Accreditation Service, Norway

H. KÄLLGREN and P. LAU, Swedish National Testing and Research Institute (SP), Sweden

L. NIELSEN, Danish Institute of Fundamental Metrology, Denmark

K. RISKI, Center for Metrology and Accreditation, Finland

1 Introduction

This is the first of a series of three articles about testing of weights. To ensure that the requirements of OIML R 111 [1] are fulfilled and to unify test procedures and pattern evaluation reports for weights, the OIML Nordic Task Force Group was formed, consisting of four national institutes from Denmark, Finland, Norway and Sweden. The aim of the group was to develop test methods and to prepare a proposal for test procedures and pattern evaluation reports for weights of OIML classes E₁ - M₃. The documentation will be similar to that in use for nonautomatic weighing instruments (OIML R 76-1 and OIML R 76-2 [2]).

While preparing the documentation, new problems were encountered (e.g. measurement of magnetic properties) that required investigation. We have emphasized that all tests and evaluations should be of a practical nature and have therefore performed tests with weights of different accuracy classes using various methods.

In this article only calibration and surface roughness are concerned. The calibration is especially applicable to high accuracy classes, which are the most demanding and which also require the most important procedure. Whilst the uncertainty of calibration is treated in great detail, the derivation of many formulae has often been omitted; they can be found in various literature.

In this paper, the calibration of a test weight is always performed by comparisons against reference weights. In these comparisons the weighing instrument is used as a comparator for weights of the same nominal masses. The traceability for mass comes from the reference weight.

In this context, the calibration of a weight is the procedure used to establish its conventional mass value; this is the only part of the whole verification procedure. According to international vocabularies of metrology, the terms "calibration" and "verification" are defined as follows:

Calibration:

"Set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards" (VIM 6.11).

Verification:

"All the operations carried out by an organ of the national service of legal metrology (or other legally authorized organization) having the object of ascertaining and confirming that the instrument entirely satisfies the requirements of the regulations for verification. Verification includes both examination and stamping" (VIM 2.4).

2 True mass and conventional mass

2.1 True mass

The operation of a weighing instrument is usually based on the measurement of the gravitational force F_g with which the weight is attracted by the earth:

$$F_g = m \cdot g - V \cdot \rho_a \cdot g \quad (1)$$

where m is the true mass of the weight, g is the local acceleration of gravity, V is the volume of the weight (mass m divided by density ρ), and ρ_a is the density of air at the position of the weight.

$m \cdot g$ represents the force due to the mass of the weight, and $V \cdot \rho_a \cdot g$ is the force due to air buoyancy. If all other forces (such as electric or magnetic interaction forces) between the weight and the weighing instrument can be neglected, then the indication of the weighing instrument is proportional to F_g .

Usually it is assumed that the acceleration of gravity is constant during the weight calibration and that force contributions other than those in (1) can be neglected. Nevertheless, if weights of different shapes are compared to a high accuracy level, the vertical gradient of g has to be considered.

If two weights (i.e. a test weight and a reference weight) are compared with an ideal weighing instrument, the mass difference between the weights is:

$$m_t - m_r = (\rho_{at} V_t - \rho_{ar} V_r) + k(I_t - I_r) \quad (2)$$

where r and t refer to the reference and test weights respectively and k is the scale factor which converts the indication values into true mass values. The indications difference $I_t - I_r$ is assumed to be so small that the corresponding air buoyancy correction can be neglected.

2.2 Conventional mass

The conventional value of the result of weighing in air (conventional mass) m_c is defined by the equation [1]:

$$m \left[1 - \frac{\rho_0}{\rho(20^\circ\text{C})} \right] = m_c \left[1 - \frac{\rho_0}{\rho_{\text{ref}}} \right] \quad (3)$$

where $\rho_0 = 1.2 \text{ kg/m}^3$ is the reference value for the density of air, $\rho_{\text{ref}} = 8000 \text{ kg/m}^3$ is the reference value for the density of the weight, and $\rho(20^\circ\text{C})$ is the density of the weight at a temperature of 20°C .

If two weights (the reference weight and the test weight) with conventional masses m_{cr} and m_{ct} and volumes V_r and V_t are compared, then the conventional mass difference $\Delta m_c = m_{\text{ct}} - m_{\text{cr}}$ is approximately:

$$\Delta m_c = f \cdot (I_t - I_r) + \frac{[\rho_a \Delta V_1 - \rho_0 \Delta V_2]}{1 - \frac{\rho_0}{\rho_{\text{ref}}}} \quad (4)$$

where

$$\rho_a \Delta V_1 = \rho_a [V_t(t) - V_r(t)]$$

$$\rho_a \Delta V_2 = \rho_0 [V_t(20^\circ\text{C}) - V_r(20^\circ\text{C})] \quad \text{and}$$

$$f = \frac{m_s}{\Delta I_s} \quad (5)$$

where f is the scale factor of the weighing instrument, I_r and I_t are the indications of the weighing instrument loaded with the reference weight and with the test weight, and ρ_a is the average air density.

The scale factor f is the ratio of the (conventional) mass of a sensitivity weight m_s to the indication difference ΔI_s obtained when loading the weighing instrument with the sensitivity weight. It is assumed that the scale factor is constant.

By assuming in (4) that the volume difference $V_t - V_r$ is independent of temperature and that $1 - (\rho_0/\rho_{\text{ref}}) = 1$, the formula can be further simplified to:

$$\Delta m_c = f \cdot (I_t - I_r) + \left[\frac{m_r}{\rho_r} - \frac{m_t}{\rho_t} \right] \cdot (\rho_a - \rho_0) \quad (6)$$

Here the volumes have been expressed in terms of mass and density. The formula can be applied if the weights have the same nominal mass and if the second component is of the same order of magnitude as the required uncertainty. These requirements are normally fulfilled if the weights are made from the same material. However, if class E weights are to be calibrated to the highest accuracy level, then formula (2) is recommended.

3 Requirements for calibration

3.1 Environmental conditions during calibration

Calibration of weights should be performed in steady ambient conditions under normal atmospheric pressure and at a temperature close to room temperature. If the temperature inside the mass comparator differs from the temperature in the laboratory, both the reference and test weights should (if possible) be placed inside the mass comparator some time before calibration is started.

Environmental conditions should also be within the specifications of the weighing instrument; for weights of classes E_1 and E_2 the temperature should be close to 20°C .

Table 1 Summary of the environmental conditions required

Class	Maximum temperature change during calibration	Relative air humidity should be in the range (% RH)
E ₁	0.5 °C / hour	35 ... 70
E ₂	1 °C / hour	35 ... 70
F ₁ and F ₂	2 °C / hour	35 ... 70
M ₁ , M ₂ and M ₃	3 °C / hour	No condensation

If the relative humidity is lower than 40 %, forces due to static electricity can lead to erroneous weighing results. If the relative humidity is higher than 60 % for a long period of time, there is a possibility of corrosion for certain weights.

3.2 Cleaning the weights

The weights should be handled and stored in such a way that they stay clean. Before calibration, dust and any foreign particles should be removed using for example a gas flow (clean gas, not compressed air) or a soft brush. Care should be taken not to change the surface properties of the weight e.g. by scratching.

If a weight contains significant amounts of dirt which can not be removed by the above methods, the weight or some parts of it can be washed with clean alcohol, distilled water or other solvents. A weight with an internal cavity should not normally be immersed in the solvent if there is a possibility that the latter will penetrate into the cavity. If there is a need to monitor the stability of a weight in use, the mass of the weight should also be determined before cleaning.

Cleaning should not remove any significant amount of material. After cleaning with solvent, enough time should be allowed for the mass of the weight to stabilize. Typical stabilization time after cleaning with alcohol is 5 days for class E₁ weights, 3 days for class E₂ weights and 1 day for class F₁ weights.

3.3 Thermal stabilization

The weight should be allowed to reach the ambient condition of the laboratory. The temperature especially of classes E₁, E₂ and F₁ weights should be close to the temperature inside the mass comparator.

3.4 Weighing instrument

The performance of the weighing instrument to be used should be known from earlier measurements. Its resolution, repeatability and eccentricity should especially be such that the required uncertainty can be reached.

3.5 Reference weights

The reference weight should generally be of a higher accuracy class than the weight to be calibrated. For calibration of classes E₁, E₂ or F₁ weights, the reference weight should possess metrological characteristics (magnetic properties, density, surface roughness) similar to or better than those of the weight to be calibrated, and should also have a calibration certificate.

4 Weighing procedures

4.1 Direct comparison

Normally the mass of the test weight should be calibrated by comparison against a reference weight or a sum of reference weights with the same nominal mass as the test weight.

4.2 Subdivision

A whole set of weights can be calibrated against one (or more) reference weights. This method requires several comparisons within each decade in the set. For more details see [5]. In these weighings, different combinations of weights of equal total nominal mass are compared and the weighing schemes of (7) and (8) can be applied. This method is mainly used to calibrate sets of E₁ weights when the highest accuracy is required. It is especially useful for weights with nominal masses below 1 g.

Advantages of the method:

- improved accuracy;
- the need for only one or two reference weights;
- often it is possible to include a checkweight of known mass as one of the test weights.

Disadvantages of the method:

- usually more comparisons are needed;
- several weights have to be placed on the weighing pan simultaneously;
- more advanced mathematics is involved.

5 Weighing schemes for comparison measurements

Three different weighing schemes are given below. Schemes (7) and (8) are used when calibrating weights of classes E and F while (9) is used when calibrating class M weights.

5.1 Comparison of one test weight with the reference weight

Various weighing schemes can be utilized; for two weights the following schemes (best known as ABBA and ABA schemes) are possible. These schemes eliminate linear drift.

$$I_{r1}, I_{t1}, I_{t2}, I_{r2}, (I_{r2n-1}, I_{t2n-1}, I_{t2n}, I_{r2n}) \quad (7)$$

$$I_{r1}, I_{t1}, \dots, (I_{rn}, I_{tn}), I_{rn+1} \quad (8)$$

where I is the indication of the weighing instrument and r and t denote respectively the reference weight and the test weight.

In (7) and (8) the sequence of I values denotes the order in which the weights should be placed on the weighing pan. The time interval between weighings should be kept constant. The sequence is repeated n times ($n \geq 1$).

5.2 Comparison of several test weights of the same nominal mass with one reference weight

If several test weights $t(k)$ ($k = 1, 2, \dots, K$) with the same nominal mass are to be calibrated, the weighing scheme can be modified to the following scheme:

$$(I_r, I_{t(1)}, I_{t(2)}, \dots, I_{t(K)}), \dots, I_r \quad (9)$$

This scheme is recommended only if the drift with time is negligible compared with the required uncertainty. The number of weights should normally not be more than 5, i.e. $K \leq 5$.

5.3 Number of measurements

The number of measurements n depends both on the required uncertainty as compared with the repeatability, and the reproducibility of the measurement.

A suggestion for the minimum number of times the test weight should be placed on the weighing instrument is given in Table 2.

Table 2 Minimum number of times the test weight should be placed on the weighing instrument

Class	E ₁	E ₂	F ₁	F ₂	M ₁ - M ₃
n	≥ 6	6	3	2	1

If n is much larger than 10 it is often better to divide the weighing sequence into shorter sequences, each of about 10 measurements. These sequences can be measured during an extended period of time. If $n < 5$ then the repeatability of the weighing instrument (e.g. the pooled estimate of standard deviation) should be stable and known.

6 Weighing results

6.1 Average mass difference for one test weight

The conventional mass difference Δm_i between the test weight and the reference weight can be calculated from the formula:

$$\Delta m_i = f \cdot \Delta I_i + m_0 C_i \quad (10)$$

where

$$C_i = (\rho_{ai} - \rho_0) \left[\frac{1}{\rho_t} - \frac{1}{\rho_r} \right]$$

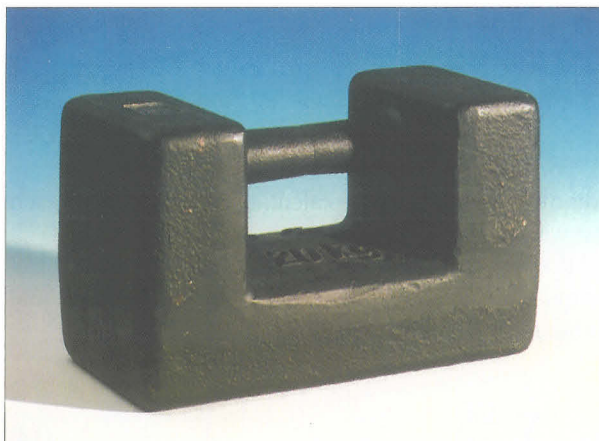


Fig. 1 20 kg OIML class M₁ rectangular bar weight (type 2)

where m_0C_i is the air buoyancy correction, m_0 is the nominal mass of the weights and ΔI_i is the observed indication difference.

For scheme (7) the indication difference ΔI_i is:

$$\Delta I_i = (I_{t2i-1} + I_{t2i} - I_{r2i-1} - I_{r2i}) / 2 \quad (11)$$

($i = 1, 2, \dots, n$)

and for scheme (2) it is:

$$\Delta I_i = I_{ti}(I_{ri} - I_{ri+1}) / 2 \quad (12)$$

($i = 1, 2, \dots, n$)

In the C_i coefficient, ρ_r (ρ_t) is the density of the reference (test) weight, ρ_{ai} is the average air density during measurement (i), and ρ_0 is the reference air density (1.2 kg/m^3). If the density of a weight is not known but its value is known to be within the allowed limits, the reference value 8000 kg/m^3 should be used. If the air density is not determined, then either the reference value or the average air density in the laboratory should be used.

In cases where air buoyancy correction is known or can be assumed to be negligible the second component in (10) can be omitted. If there is only one value (e.g. average value) for the air buoyancy correction it can also be applied after averaging.

Formula (10) can be applied if the weights have the same nominal mass and if the second component is of the same order of magnitude as the required uncertainty. These requirements are normally fulfilled if the test procedures described here are followed. However, if class E weights are to be calibrated to the highest level of accuracy, exact formulae using true masses are recommended.

The average mass difference between the test weight and the reference weight $\Delta \bar{m}$ can be obtained from the formula:

$$\Delta \bar{m} = \sum_{i=1}^n \frac{\Delta m_i}{n} \quad (13)$$

For several test weights, formula (12) for the indication difference should be calculated separately for each test weight.

If there are several (J) identical series of measurements with average values Δm_j and with about equal standard deviations, the average mass difference is:

$$\Delta \bar{m} = \sum_{j=1}^J \frac{\Delta \bar{m}_j}{J} \quad (14)$$

Several series of measurements are usually performed only in the calibration of class E weights when the reproducibility of weighings has to be investigated.

6.2 The conventional mass of the test weight

The conventional mass of the test weight m_t is

$$m_t = m_r + \Delta \bar{m} \quad (15)$$

In verification, the mass of the reference weight is not always known; in this case its nominal value should be used. In such cases the reference weight must always be of a higher accuracy class than the test weight.

7 Uncertainty of mass determination

Uncertainty calculations are based on Annex B of OIML R 111 [3] and on the ISO *Guide to the Expression of Uncertainty in Measurement* [6]. In the following, the most important uncertainty components are treated separately.

7.1 Uncertainty of weighing process u_w

7.1.1 Low accuracy classes

For classes F_2 , M_1 , M_2 and M_3 usually only a few measurements are made. If at least 3 measurements ($n = 3$) are performed the standard uncertainty of the weighing process can be estimated by:

$$u_w(\Delta \bar{m}) = [\max(\Delta m_i) - \min(\Delta m_i)] / (2\sqrt{3}) \quad (16)$$

u_w is half of the observed variation width divided by $\sqrt{3}$. If only one or two measurements are made, the variation width must be known from earlier measurements. Usually u_w should not be larger than 1/10 of the maximum permissible error.

7.1.2 Other classes

For classes E_1 , E_2 and F_1 , usually several measurements are made and uncertainty can be estimated by statistical methods. The variance of the mass difference Δm_i is:

$$s^2(\Delta m_i) = \frac{1}{n-1} \sum_{i=1}^n (\Delta m_i - \Delta \bar{m})^2 \quad (17)$$

For weighing scheme (7) $s(\Delta m_i)$ is approximately equal to the standard deviation of the balance measured with a single weight. For scheme (8) it is approximately $\sqrt{3}/\sqrt{2}$ times the standard deviation.

The standard uncertainty of the mean $\Delta \bar{m}$ is:

$$s(\Delta \bar{m}) = \frac{s(\Delta m_i)}{\sqrt{n}} \quad (\text{scheme 7}) \quad (18)$$

or:

$$s(\Delta \bar{m}) = \frac{\sqrt{(4n-1)} \cdot s(\Delta m_i)}{\sqrt{(3n-1)n}} \quad (\text{scheme 8}) \quad (19)$$

both with $n-1$ degrees of freedom. If only a few measurements are made the estimate of $s(\Delta \bar{m})$ is unreliable. Then its value should be taken from earlier measurements made under similar conditions (pooled estimate).

If there are several identical series of measurements the variance $s^2(\Delta \bar{m})$ can be calculated from the following formula:

$$s^2(\Delta \bar{m}) = \frac{1}{J(J-1)} \sum_{j=1}^J (\Delta \bar{m}_j - \Delta \bar{m})^2 \quad (20 \text{ a})$$

or

$$s^2(\Delta \bar{m}) = \frac{1}{J} \sum_{j=1}^J s_j^2(\Delta \bar{m}_j) \quad (20 \text{ b})$$

where the contribution of (20 a) is the variation of the mean mass difference $\Delta \bar{m}$ and (20 b) is the pooled variance of the mean mass difference $\Delta \bar{m}_j$ for a single series of measurements. The formula which gives the largest contribution should be used.

The standard uncertainty of the mass difference between the test weight and the reference weight is:

$$u_w(\Delta \bar{m}) = s(\Delta \bar{m}) \quad (21)$$

with $n-1$ or $J-1$ degrees of freedom. The latter choice should be used if several series of measurements have been performed and (20 a) is dominating.

7.2 Uncertainty of the reference weight $u(m_r)$

The standard uncertainty $u(m_r)$ of the mass of the reference weight can be calculated from the calibration certificate of the reference weight by dividing the quoted expanded uncertainty U , by the coverage factor k (usually $k=2$)

$$u(m_r) = \frac{U}{k} \quad (22)$$

If the reference weight has been calibrated several times, the stability of the weight can be estimated. If the change of mass is significant compared with the stated uncertainty, $u(m_r)$ should be increased.

In some cases a verified weight of F_1 or lower accuracy class is used as a reference weight. If such a weight has a certificate of compliance which does not state its mass value, the uncertainty can be estimated from the maximum permissible error (mpe) of that specific class:

$$u(m_r) = \frac{\text{mpe}}{\sqrt{3}} \quad (23)$$

If several reference weights $m_{r(i)}$ ($i=1, 2, \dots, R$) are combined and their covariances are not known, then a correlation coefficient of 1 can be assumed. This will lead to the linear summation of uncertainties:

$$u(m_r) = \sum_i u(m_{r(i)}) \quad (24)$$

where $u(m_{r(i)})$ is the standard uncertainty of reference weight i . This is an upper limit for the uncertainty.

7.3 Uncertainty of air buoyancy correction $u_b(\Delta \bar{m})$

The uncertainty of air buoyancy correction can be calculated from the formula:

$$u_b(\Delta \bar{m}) = m_0^2 \left[\left(\frac{1}{\rho_t} - \frac{1}{\rho_r} \right)^2 u^2(\rho_a) + \{(\rho_a - \rho_0)^2 + u^2(\rho_a)\} \right. \\ \left. \times \left\{ \frac{u^2(\rho_t)}{\rho_t^4} + \frac{u^2(\rho_r)}{\rho_r^4} \right\} \right] \quad (25)$$

where $u(\rho_a)$ is the uncertainty of air density determination and $u(\rho_r)$ is the uncertainty of the density of the reference weight. Equation (25) contains a second order

component which contains products of uncertainties. The second order component is significant if the densities of the weights can be assumed to be equal and if the air density is close to its reference value.

For weights of classes M_1 , M_2 and M_3 the uncertainty due to air buoyancy correction is negligible and can usually be omitted.

7.3.1 Uncertainty of air density

If the air density is not determined the following uncertainty for the air density shall be applied:

$$u(\rho_a) = \frac{0.12}{\sqrt{3}} \text{ kg/m}^3 \quad (26)$$

In the calibration of weights of classes E_1 and E_2 the air density should be determined. Its uncertainty is usually estimated from the uncertainties of temperature, pressure and humidity. For the calculation of air density the CIPM formula (1981/91) should be used [7].

7.3.2 Uncertainty of the density of weights

The densities of weights belonging to classes E_2 , F_1 and F_2 are not always known. Often the range within which the density lies is known or can be estimated from the composition of the material. In such a case, either the average value of the range or the value 8000 kg/m³ should be used. From the density range, the uncertainty of the density can be estimated. For the standard uncertainty the range of values divided by $2\sqrt{3}$ can be used. The range must however not be wider than the allowed density limits given in R 111. For austenitic stainless steel a density of $(7920 \pm 150) \text{ kg/m}^3$ ($k = 2$) can be assumed.

If a class E_1 weight is used as a reference weight, its density and the corresponding uncertainty should be known from the calibration certificate. If a class E_1 weight is to be calibrated, its density must usually be determined in a separate measurement.

7.4 Uncertainty due to the weighing instrument

7.4.1 Tests of the weighing instrument

The best approach is to test the balances and mass comparators and use the results from the test in the uncertainty calculations. Especially when calibrating E_1

weights it is important to have records of several measurements to ensure that there is enough information about the performance of the instrument.

7.4.2 Sensitivity of the weighing instrument

If the balance is calibrated with a sensitivity weight (or weights) of mass m_s and standard uncertainty $u(m_s)$, the uncertainty due to sensitivity is deduced from:

$$u_s^2(\Delta\bar{m}) = (\Delta\bar{m})^2 \left[\frac{u^2(m_s)}{m_s^2} + \frac{u^2(\Delta I_s)}{\Delta I_s^2} \right] \quad (27)$$

where ΔI_s is the difference of indication when the sensitivity weight is applied and $u(\Delta I_s)$ is the uncertainty of ΔI_s , $\Delta\bar{m}$ is the average mass difference of balance readings between the test weight and the reference weight. If the sensitivity is not constant with time, temperature or load, its variation must be included in the uncertainty.

7.4.3 Resolution of the weighing instrument

For a digital balance with scale interval d the uncertainty due to resolution is:

$$u_d(\Delta m) = \left[\frac{d/2}{\sqrt{3}} \right] \sqrt{2} \quad (28)$$

where the factor $\sqrt{2}$ comes from the fact that there are two readings: one with the reference weight and one with the test weight.

7.4.4 Eccentric loading

If this contribution is known to be significant, the magnitude must be estimated and if necessary the contribution must be included in the uncertainty budget. A possible formula for the uncertainty due to eccentricity is:

$$u_E(\Delta\bar{m}) = \frac{\frac{d_1}{d_2} D}{2\sqrt{3}} \quad (29)$$

where D = maximum value – minimum value from the eccentric test performed according to OIML R 76-2, d_1 is the estimated distance between the centers of the

weights and d_2 is the distance from the center of the load receptor to the center of one of the corners.

7.4.5 Magnetism

If the weights satisfy the requirements in OIML R 111, the uncertainty contribution due to magnetism $u_m(\Delta\bar{m})$ may be assumed to be zero. If a weight is known to have a high susceptibility or is magnetized, a non magnetic spacer can be placed between the weight and the load receptor to reduce the magnetic forces.

7.4.6 Combined standard uncertainty for the balance

The uncertainty components are added quadratically:

$$u_{ba}(\Delta\bar{m}) = \sqrt{[u_s^2(\Delta\bar{m}) + u_d^2(\Delta\bar{m}) + u_E^2(\Delta\bar{m}) + u_{ma}^2(\Delta\bar{m})]} \quad (30)$$

7.5 Combined standard uncertainty

The combined standard uncertainty of the conventional mass of the test weight $u(m_t)$ is:

$$u_c = \sqrt{[u_w^2(\Delta\bar{m}) + u_r^2(m_r) + u_b^2(\Delta\bar{m}) + u_{ba}^2(\Delta\bar{m})]} \quad (31)$$

The summation contains all the contributions described above.

7.6 Expanded uncertainty

The expanded uncertainty of the conventional mass of the test weight is:

$$U = k u_c(m_t) \quad (32)$$

Usually the coverage factor $k = 2$ should be used. If the number of measurements is less than 10 and the uncertainty u_w is a dominant component in the uncertainty analysis ($u_w > u_c(m_t)/2$) the coverage factor k should be calculated from the effective degrees of freedom v_{eff} and the t distribution assuming 95.45 % confidence. For more details see [6].

8 Surface roughness

8.1 Introduction

The stability of the mass of a weight is highly dependent on its surface structure. A smooth surface has a smaller effective area and collects less "dirt" than a rough surface. Once the surface has become contaminated, the smooth surface is easier to clean. A weight with a smooth surface is therefore expected to be more stable than a weight with a rough surface, other things being equal.

This is the reason why OIML R 111 specifies the maximum surface roughness R_z (ISO) allowed for weights of accuracy classes E_1 to F_2 .

Two complementary methods are proposed for assessing surface roughness:

- 1) Visual comparison with a roughness comparison specimen, and
- 2) Roughness measurement using stylus instruments.

8.2 Assessment of scratches

The surface of a new weight, except for the bottom surface, shall in principle be free of scratches. However, a few fine scratches may be accepted, if by professional judgment they can be considered not to significantly influence the stability of the weight.

A weight which has been in use for many years will normally have scratches on the surface. For such weights the surface may be accepted, if the scratches appear to have been generated by normal use of the weight. In the assessment of the surface roughness of such a weight, scratches and other defects shall not be taken into account. If there are so many scratches that this is not possible, the weight shall not be accepted.

8.3 Visual comparison

For weights of class E_1 , E_2 , F_1 , F_2 , larger than or equal to 1 g, the roughness of the surface may be compared visually against roughness comparison specimens certified according to ISO 2632-2. The certification shall include the roughness parameter R_z , defined in ISO 4287-1. The surface of the comparison specimen shall have a similar lay and shall have been produced by similar machining methods as the surface of the weights. Since the weights have plane as well as cylindrical surfaces, two comparison specimens shall be used: one with plane surfaces and one with cylindrical surfaces.

If the visual assessment clearly indicates that the roughness R_z of the weight surface is smaller than the maximum value specified in section 8.2.3 of OIML R 111 (see Table 3 below), no further measurements of the roughness are necessary. In case of doubt as to compliance, the roughness R_z shall be measured as described in the following section. Figures 2 and 3 show the comparison method.

Table 3 Maximum values of surface roughness

Class	E ₁	E ₂	F ₁	F ₂
$R_z^*(\mu\text{m})$	0.5	1	2	5

* R_z represents the average peak to valley height as defined by ISO



Fig. 2 An example of a surface roughness comparison scale; scales are available for different machining methods, e.g. surface grinding, cylindrical grinding and turning, etc.



Fig. 3 Surface roughness - visual comparison of an OIML class E₂ weight against a specimen certified according to ISO 2632-2

8.4 Roughness measurement

If the visual comparison does not give a conclusive result, the surface roughness R_z of the weight should be measured using a stylus instrument as defined in ISO 3274. Before use, the stylus instrument shall be properly calibrated by use of calibration specimens certified according to ISO 5436. Other instruments may be used only if traceability to the unit of lengths has been documented.

The surface roughness shall be measured in accordance with ISO 4288. At least 6 measurements shall be made: two on the plane top surface and four on the cylindrical surface. Care shall be taken not to include scratches or other surface defects in the traced profiles.

The weight is accepted only if all the measured values of the surface roughness R_z are smaller than the maximum value specified in Table 3.

8.5 Uncertainty

The uncertainty when performing visual examination is hard to calculate but is estimated to be about 10 % ($k = 2$).

9 Summary

Test procedures for calibrating weights of different accuracy classes have been described; they correspond to the classical ABBA and ABA schemes and the mathematics required to derive the mass of the test weight have been kept to a minimum. Especially statistical monitoring methods are not discussed, and some formulae are approximations. It should be remembered that most formulae are given for the conventional mass and are only valid in applications where the densities of the weights do not deviate too much from the requirements of OIML R 111.

The uncertainty budget contains most of the components which are important in everyday calibrations. Some components such as magnetism and stability are difficult to express conclusively. In some cases they can be dominating uncertainties.

A practical method for determining surface roughness has been given. ■

References

- [1] OIML R 47 *Standard weights for testing of high capacity weighing machines*, 1976
- [2] OIML R 76-1 and OIML R 76-2
- [3] OIML R 111 *Weights of classes E_1 , E_2 , F_1 , F_2 , M_1 , M_2 , M_3* , 1994
- [4] Draft Annex to OIML R 111 *Test procedures* (only available at this stage to TC 9/SC 3 working group)
- [5] Chapman G. D. *Orthogonal designs for the calibration of kilogram submultiples* NRCC25819, 27 April 1995, Canada
- [6] *Guide to the expression of uncertainty in measurement* - ISO. First edition 1993
- [7] Giacomo P., *Metrologia* 18, 33 (1982), Davies R. S., *Metrologia* 29, 67 (1992)

Editor's note:

Parts 2 (Density) and 3 (Magnetism and convection) of this series of papers will be published in future editions of the OIML Bulletin.



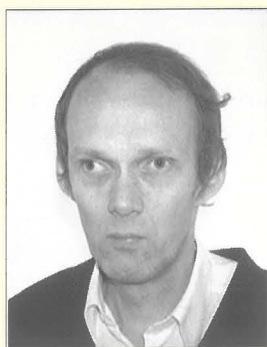
Thor Myklebust
Norwegian Metrology and
Accreditation Service,
Norway



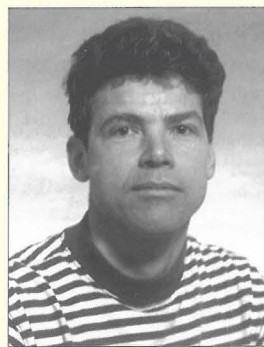
Håkan Källgren
Swedish National Testing and
Research Institute,
Sweden



Peter Lau
Swedish National Testing and
Research Institute,
Sweden



Kari Riski
Center for Metrology and
Accreditation,
Finland



Lars Nielsen
Danish Institute of
Fundamental Metrology,
Denmark

AUTOMATIC WEIGHING

Accurate weighing in motion of vehicles at low speed

L. BRULANT and A. LIEGEOIS, Captels S.A. and L.I.R.M.M., France

Abstract

It is easier and faster to weigh vehicles in motion than to weigh them statically. That was the reason why Captels, a French industrial weighing company, decided to develop a low speed weighing in motion system, called the type LS WIM TRN 30 system. This paper describes how the system addresses mechanical behavioral effects (which appear during weighing in motion and which usually cause a decrease in measurement accuracy), and also the results of different test campaigns. Key expressions used are "vehicle weighing in motion"; "axle weighing signal"; "dynamic overload"; "weighing accuracy".

1 Introduction

Vehicles are notably weighed to ensure road safety, since the more a vehicle is loaded, the more the road is damaged and the greater is the braking distance. Vehicles are also weighed in industrial applications, e.g. for controlling incoming and outgoing bulk products. The vehicle weighing in motion operating procedure is



LS WIM Portable system for industrial weighing

easier and faster than the static procedure, and this is the reason why an axle weigher which is able to weigh both a static vehicle and one in motion has been developed.

Development was based on specialist experience in the weighing field, and concentrated on three different areas:

- firstly on physical product development (mechanical, electronic and computer products),
- secondly on the study of the phenomena which cause measurement disturbance (especially dynamic vehicle mechanical behavior)
- thirdly on test campaigns, which were carried out in order both to quantify the weighing accuracy and improve weighing system performance.

2 A low speed weighing in motion device

The low speed weighing in motion system, shown in Fig. 1, is an axle-by-axle weighing device.

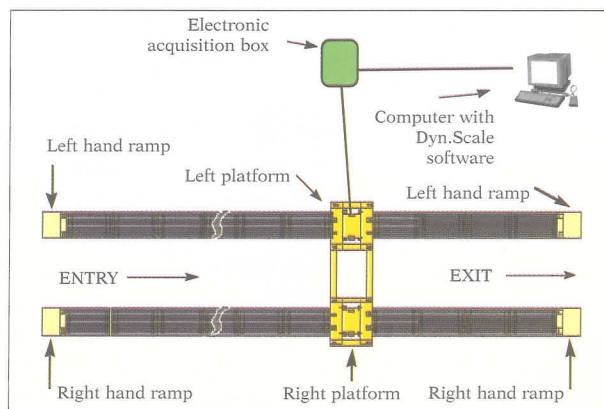


Fig. 1 Weighing in motion system

Three main components constitute the system:

i) 2 weighing platforms complete with load-cells

Load cells, based on resistance strain gauges, translate a mechanical stress, due to axle force, into a variable electrical signal. The variation and the mechanical deformation are proportional and this technology guarantees an accuracy of better than 1/1000 over a full temperature range of -10 to $+40$ °C.

With the strain gauge load-cells, the axle weighing device is traceable to the Bureau International de Métrologie Légale (BIML) - indeed, the system is calibrated with a standard mass during manufacture. Once the device is set up, it is immediately operational.

ii) An electronic data acquisition unit

This unit receives the signals from the platforms which it then samples and digitizes. With the TRN 30 LS WIM unit, 1000 measurements are made per second. Such an acquisition frequency, according to the Shannon theorem, allows frequencies of up to 500 Hz to be detected.

Moreover, this electronic unit guarantees an accuracy of 1/1000 of the platform's total capacity. This accuracy is consistent with that of the platforms.

iii) A computer with Dyn.Scale software

Dyn.Scale is a weighing software program for both weighing mode procedures, i.e. static and weighing in motion modes. With this software, the system conforms to the weighing metrology classification of an Automatic Weighing Instrument, because it has the following properties:

- it functions without the intervention of an operator;
- weighing is continuous;
- zero is automatically set;
- data is memorized;
- weighing measurements can be easily be made.

Three optional parts can be included in the system:

a) mechanical components (approach ramps)

Without ramps, platforms must be mounted in shallow pits in the road surface; the system is then a pit-mounted device. With ramps, platforms are laid on the surface and the vehicle is lifted to the level of the platforms by the ramps. This system is referred to as a portable axle weigher, and takes less than half an hour to set up.

b) a printer

Weigh tickets can be produced for customers by connecting a printer.

c) an induction loop and optical barrier

Without the addition of these parts, the weigher can only automatically detect an axle. This means that weighing is completed when the maximum defined number of axles are weighed, or if an operator intervenes. With an induction loop and optical barrier, the system detects the vehicle when the front bumper enters the weighing area, and weighing is completed when the rear bumper leaves the area. In this way the weighing is completed at the end of the vehicle, whatever the number of axles, without operator intervention.

Two versions of the axle weigher exist. One is used for heavy vehicle weighing, the other for light vehicles.

3 Weighing signal description

3.1 Global shape of the curve

When a vehicle is weighed, an output signal (which has two vectors) is received from the platforms: one is the load or force measurement, the other is time. As a vehicle is weighed axle by axle, the curve shows each axle shape. For example, Fig. 2 represents the weighing of a traction unit with an articulated trailer having a tridem axle arrangement.

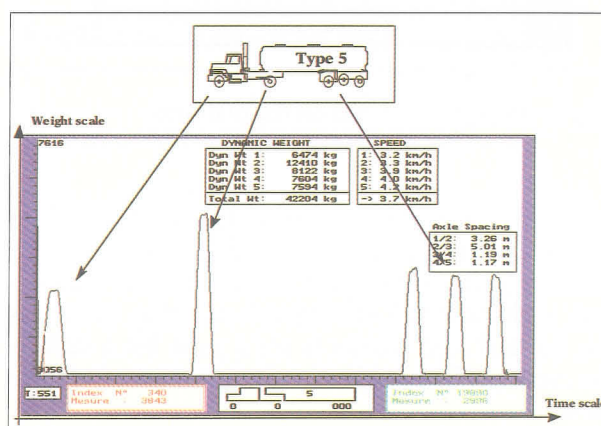


Fig. 2 The signal received during truck weighing

With this data, the following parameters can be calculated or determined:

- vehicle class;
- weight of each axle;
- total weight of the vehicle;
- maximum legal weights;
- overloads of the vehicle;
- speed of each axle;
- average speed of the vehicle;
- acceleration of the vehicle.

Erroneous weighings are automatically detected: an error message appears if the vehicle speed or acceleration is out of range, or if an axle is weighed when it is half on the road and half on the scales (called "off scales" weighing).

3.2 Axle weighing signal

Figure 3 represents the measured points registered by the data acquisition system during the passage of a vehicle axle.

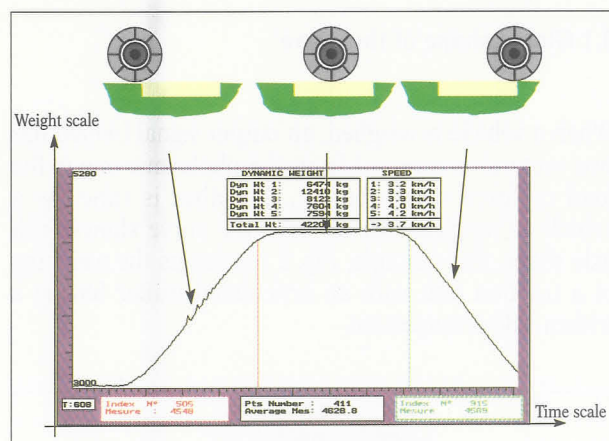


Fig. 3 Passage of an axle on the platform

All the points are crude measurements without digital processing (i.e. without filtering or interpretation etc.). The signal shape, which looks like a trapezium, is characteristic of every axle weighing. Indeed, as the tyre and road contact is not a point but a surface, the curve can be considered as being composed of three parts:

- an up slope when the axle encroaches on the weigh platforms;
- a plateau when tyres are completely on the platforms;
- a down slope when the axle leaves the platforms.

Up and down slopes and plateau duration depend on axle load and vehicle speed during the weighing, but they also depend on tyre pressure and tyre print. If we consider a model with a deformable wheel on a hard road with a rectangular contact area and a parabolic pressure distribution, then the slopes are:

$$p = 4 \times w \times P_{\max} \times [\delta - \delta^2] \times V$$

- where:
- δ is the ratio between wheel print on the platform and the total wheel print;
 - w = the width of the wheel print;
 - V is the vehicle speed;
 - P_{\max} is the tyre's maximum pressure value (see Fig. 4).

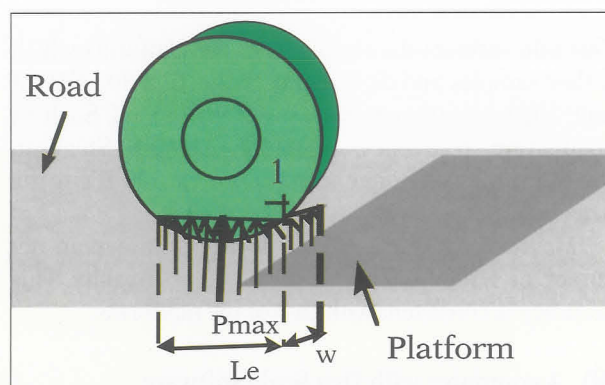


Fig. 4 Wheel load distribution

4 Measured force

As the device weighs axles successively, the oscillations of the vehicle and changes in the center of gravity cause disturbances to the weighing. Moreover, a platform output signal is proportional to the vertical forces applied on it but the force due to an axle weighing in motion has two components:

- the gravitational force which is the axle static weight, and which depends on the distribution of loads on the vehicle's axles;
- a dynamic load (or impact factor) due to the vertical acceleration of the vehicle mass.

Because the required force is the static weight, the dynamic load detracts from the measurement accuracy. So the mechanical phenomenon was accounted for during the mechanical and software development of the weighing systems. In this way the adverse influence on the weighing is decreased and measurement accuracy is improved.

4.1 Axle load distribution

Vehicle axles are weighed at different points in time, so axle weight distribution can change between two consecutive axle weighings. For example, the weight of axle i is P_i during the first axle weighing. When it is weighed at time t_i , its weight is $P_i + \Delta P_i$. For a vehicle with N axles, P_m (the measured weight) is as follows:

$$P_m = \text{Axle}_1 \text{ Load}(t_1) + \text{Axle}_2 \text{ Load}(t_2) + \text{Axle}_3 \text{ Load}(t_3) + \dots + \text{Axle}_N \text{ Load}(t_N)$$

$$= P_1 + P_2 + \Delta P_2 + P_3 + \Delta P_3 + \dots + P_N + \Delta P_N$$

so the vehicle is weighed with an error whose value is:

$$E = \frac{\Delta P_2 + \Delta P_3 + \dots + \Delta P_N}{P_1 + P_2 + P_3 + \dots + P_N} \times 100 \%$$

Axle load distribution at a given time depends on the vertical position of the chassis. Therefore it depends on spring and shock absorber values and on the center of gravity of the frame. When a vehicle is moving, the chassis position is also a function of the vehicle's acceleration.

This error could distort axle-by-axle weighing in both the static or weighing in motion modes. However, during weighing in motion on a portable system, axle load distribution changes are more significant because the chassis position is modified when an axle goes up or down a ramp. Moreover, multi-axle vehicles have a compensating system which changes the load distribution on coupled axles.

4.2 Dynamic load

This force is due to the vertical acceleration of the masses. A vehicle includes some flexible mechanical parts such as springs, shock absorbers, tyre characteristics, etc. Figure 5 shows a quarter car model which illustrates vertical axle and wheel forces. It takes into account the sprung mass (M_s) which is the chassis load carried by the axle, spring (K), shock absorber (C) and tyre. The tyre is symbolized by its mass (M_u), vertical stiffness (K_u) and vertical damping coefficient (C_u).

Wheel forces on the road are calculated using the Newton-Euler equations. Then, dynamic load is related to the vertical acceleration of the masses:

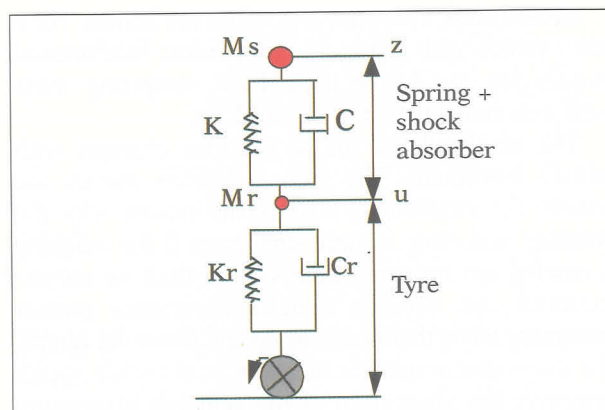


Fig. 5 Quarter car vehicle model

$$\text{Dynamic load} = M_s \frac{d^2 z}{dt^2} + M_r \frac{d^2 u}{dt^2}$$

$$M_s \frac{d^2 z}{dt^2} = -M_s g - C \left[\frac{dz}{dt} - \frac{du}{dt} \right] - K(z - u)$$

$$M_u \frac{d^2 z}{dt^2} = -M_u g - C_u \left[\frac{du}{dt} - V \frac{dz_s}{dx} \right] - K_u(u - z_s)$$

$$+ C \left[\frac{dz}{dt} - \frac{du}{dt} \right] - K(z - u)$$

- where:
- u is the vertical center of gravity of the wheel;
 - z is the vertical center of gravity of the chassis;
 - g is acceleration due to gravity.

Two dominant frequencies are in evidence in the dynamic load signal. The first is due to sprung mass oscillations, the second is due to unsprung mass movement. The numeric values of the frequencies depend on stiffness parameters. For the quarter car model these frequencies are:

$$F_{\text{sprung mass}} = \frac{1}{2\pi} \times \sqrt{\frac{K_u + K}{M_u}}$$

$$F_{\text{sprung mass}} = \frac{1}{2\pi} \times \sqrt{\frac{K}{M}}$$

Nevertheless, characteristic values are known. For a heavy vehicle with leaf spring suspension, fundamental frequencies are lower than 1 Hz; unsprung mass oscillation frequencies are about 12 Hz.

The amplitude of the oscillations changes with vehicle movement. The more a vehicle moves, the greater the amplitude. That is the reason why the dynamic load error is more significant if the weighing is carried out on a portable system than on a pit-mounted one, because vehicles experience greater movement when their axles go up and down the ramps. The movement amplitude increases with vehicle speed; moreover the absorption of the vehicle's suspension before axle weighing decreases with vehicle speed, so dynamic loading can increase.

5 Test campaigns

Weighing system qualities relate to measurement accuracy and reliability. The low speed weighing in motion system performances were studied during some test campaigns which were carried out for different configurations of the axle weigher (light or heavy vehicle weighing, pit-mounted or portable system). In all cases, the error measured during low speed weighing is calculated with reference to static weight.

$$\text{Error} = \frac{\text{Low speed measured weight} - \text{Static measured weight}}{\text{Static measured weight}} \times 100 \%$$

The static weight could be measured on the system in the static mode or on another weigher. At the end of a test campaign, some modifications were made to the system to improve its performances; these are based on weighing observations and statistical studies.

We have selected four of the test campaigns carried out to present the LS WIM TRN 30 performances. This sample has been chosen to show performances for

different configurations of the weighing system. Please refer to Table 1.

5.1 Test campaign 1: one vehicle is weighed with a portable system

Test 1 A

This campaign took place on the "N 10" road in France during June 1996 under the direction of the French Transport Ministry and the Department of Roads and Bridges (L.C.P.C). One standard vehicle (with a two-axle traction unit and an articulate trailer with a tridem axle arrangement, similar to the truck drawn in Fig. 2) was weighed several times at a variety of low speeds. Its axle weights were as follows:

- Axle 1: 5920 kg;
- Axle 2: 9750 kg;
- Axle 3: 8170 kg;
- Axle 4: 7910 kg;
- Axle 5: 7850 kg.

In total, 32 weighings were carried out at speeds varying from 5 to 15.5 km/h. All weighings were accepted (no violations were detected).

Test 1 B

Within the framework of the National Traffic Data Acquisition Conference (Hartford, Connecticut, USA, 18-22 September 1994), a demonstration was given under the control of officials of the Connecticut Department of Transportation. The demonstration consisted of a vehicle made to pass over the weigher 72 times at speeds varying between 5 km/h to 16 km/h (3 mph to 10 mph). Within these weighings, two were "off scales" weighings.

Table 1 Results of weighing in motion system test campaigns

	Number of weighings				Error	
	Total	With error < 3 %	With error > 3 %	With error > 5 %	Average (%)	Standard deviation (%)
Test 1A	32	32	0	0	1.04	0.75
Test 1B	72	65	7 (with 2 "off-scales" weighings)	0	0.47	1.73
Test 2	57	52	5	2	0.60	1.78
Test 3	82	82	0	0	-0.08	0.37

5.2 Test campaign 2: heavy vehicles chosen at random were weighed on the portable system

This test was carried out at Saint Arnould (France) in September 1995 with the collaboration of the L.C.P.C. The aim was to determine the specification of the low speed weighing in motion system under overload enforcement conditions. To do this, police officers stopped trucks at the motorway toll area and they were weighed both in static mode and in low speed in motion modes. Because of the length of time taken to weigh a vehicle in static mode, some vehicles were only weighed in motion.

On 8th September 1995, 149 weighings in motion were carried out. Among these vehicles, 56 were weighed in the static mode, 3 weighings were refused (they were "off scales" weighings). The speed of the weighings varied from 3 to 9 km/h.

5.3 Test campaign 3: light vehicle weighing on a pit-mounted weighing system

This campaign was undertaken under the direction of U.S. customs and took place in Hertford (USA) in November 1994. The aim of the test was to detect the

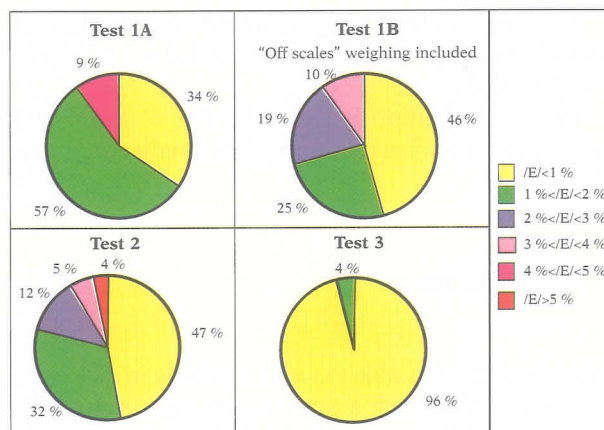


Fig. 6 Error distributions of test campaigns

location of the center of gravity of vehicles and comprised three stages:

- vehicle weighing. Only US customs officers were on the weighing site;
- vehicle classes, vehicle loads and the position of the center of gravity of loads were determined off line in Captels' office using stored weighing files from the first stage.
- US customs officers provided exact vehicle dimensions and load data. Statistics on weighing accuracy were computed.

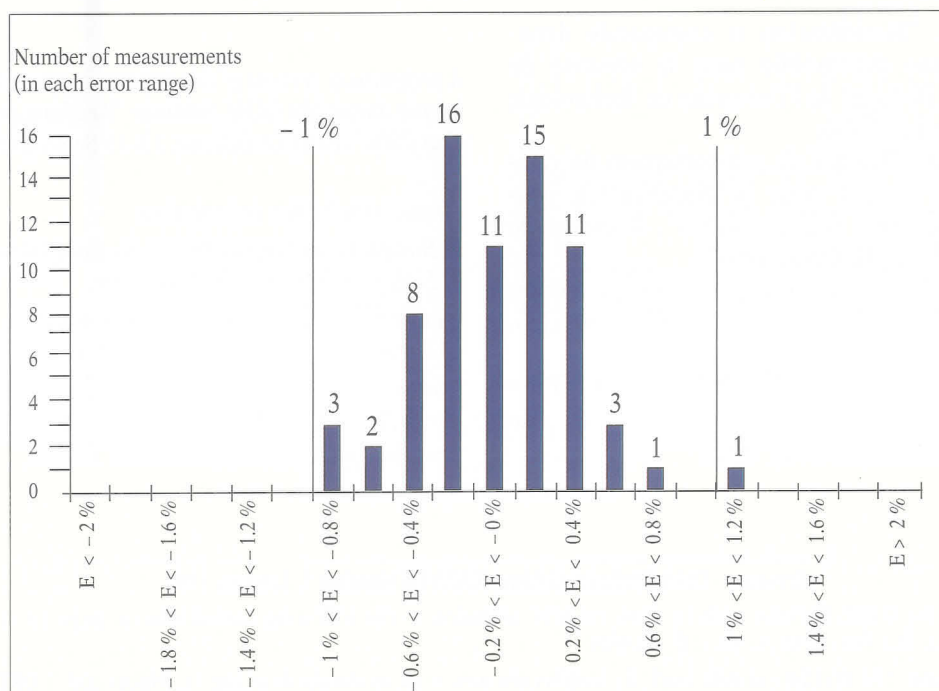


Fig. 7 Test n° 3: error distribution diagram

Two vehicles were weighed, both with 4 different loads. In total, 82 weighings were carried out at speeds from 6 to 15.5 km/h.

Error distribution is shown in Fig. 6, and Fig. 7 shows the error distribution with a smaller step between classes.

6 Conclusions

This axle weigher is able to weigh a vehicle in motion at low speed. With such a system, the measurement is influenced by the mechanical behavior of the vehicle (load position changes, dynamic overload). Under these circumstances, weighing accuracy depends on vehicle movement and on the version of the weighing instrument (pit-mounted or portable system). Research is continually being undertaken to improve weighing accuracy, as follows :

- study of the speed of response and immunity to torque on the weigh platforms;
- improvement of the vehicle model;
- analysis of the frequency spectrum of the weighing;
- application of artificial intelligence to improve measurement performance. ■

References

- [1] A. Alloum, "Modélisation et commande dynamique d'une automobile pour la sécurité de conduite", Doctorat de l'Université de Technologie de Compiègne (1994).
- [2] F. Ben Amar, "Modèle de comportement de véhicules tout terrain pour la planification géométrico-physique de trajectoires", Doctorat de l'université P. et M. Curie (1994).
- [3] P. Arfos & P. Monteil, "Low speed weigh-in motion system using a portable axle weigher", Cost 323, Zurich, 1995.
- [4] T. Emmanuel, "Planification robuste et navigation de robots mobiles tout terrain", Doctorat de l'Université Montpellier II, 1995.

- [5] T. D. Gillespie, "Truck factor affecting dynamic loads and road damage", proceedings of the third international symposium on heavy vehicles weight and dimensions, Cambridge, UK, July 1992.
- [6] L. F. Gorman, "Slow speed weigh in motion how it has involved and why", OIML Seminar *Weighing Towards the Year 2000*, Paris, 13-15 Sept. 1995. (See OIML Bulletin n° 4, Oct. 1996, pages 36-44).
- [7] L. Gyenes & C. G. B. Mitchell, "The spatial repeatability of dynamic pavement loads caused by heavy goods vehicles", proceedings of the third international symposium on heavy vehicles weight and dimensions, Cambridge, UK, July 1992.
- [8] L. Le Letty, "Parameter estimation in Analytical Models of Automotive vehicles and fault diagnosis", 1995 American Control Conference, Seattle, USA, June 1995.
- [9] S. Lhermitte, "Surcharges dynamiques: pneus", compte rendu d'activité du laboratoire des Ponts et Chaussées, 1983.
- [10] S. Lhermitte, "Surcharges dynamiques: suspensions", compte rendu d'activité du laboratoire des Ponts et Chaussées, 1983.
- [11] V. Misun, "Loads on lorries' driving systems due to road unevenness", proceedings of the third international symposium on heavy vehicles weight and dimensions, Cambridge, UK, July 1992.
- [12] A. Znidaric, R. E. Snyder, J. Znidaric, F. Moses, "Bridge weigh in motion testing of vehicle gross weights in Slovenia", Cost 323, Zurich (1995).

A preliminary version of this paper was presented as a lecture during the OIML Seminar "Weighing towards the Year 2000" (Paris La Défense, 13-15 September 1995).

Contacts for further information:

L. Brulant is involved with both the Companies below;

A. Liegeois solely with the Laboratory.

*Captels S.A., 1 rue du Mazet, Z.A. les Avants,
34270 Saint Mathieu de Tréviers, France.*

*Laboratoire d'Informatique, de Robotique et de
Micro-électronique de Montpellier (L.I.R.M.M.),
1 rue Ada, 34392 Montpellier Cedex, France.*

Erratum - OIML Bulletin Volume XXXVIII Number 1, January 1997

The Editors of the OIML Bulletin wish to draw readers' attention to the following corrections on page 18 of Mr. Günter Missuweit's article *Test Procedures for Class E₁ Weights*:

Right hand column, the first line should read "E₁ weights are now used as standards at the 16 Offices and 5 DKD calibration laboratories."

Right hand column, line 6 should read "Many years of experience in realizing the mass scale were good prerequisites ..."

LENGTH METROLOGY

Calibration of flexible tapes to ppm accuracy level

C. B. ROSENBERG, C. S. C. MUNTEANU, R. A. FERGUSON, National Weights and Measures Laboratory, Teddington, UK

Summary

Flexible line standards (measuring tapes) still form a major component in the traceability chain for length metrology in the range 2 m to 50 m. Other laser, electronic or acoustic devices exist but are either significantly more expensive than traditional tapes or cannot yet produce the same performance.

This paper describes the tapebench facility at the National Weights and Measures Laboratory in the UK and the experimental technique used to calibrate the highest quality tapes.

1 Introduction

The calibration or verification of flexible line measures (tapes) ranging from OIML Class III (trade measures) up to Class I and above is generally carried out by a direct comparison method. In essence this means stretching the tapes out side by side and performing a determination of one tape in terms of the other. Given that tapes can be up to 50 m in length (or occasionally 100 m) this is clearly a difficult procedure.



General view of the bench facility
Reproduced by permission of the Controller of HMSO

The tapes are normally quoted as standard at a specified temperature and tension. For an experiment with such large spatial extent it is evidently difficult to control the temperature, and similarly the effect of friction over such distances will be a major influence on the strain realised under load.

Further up the traceability hierarchy where the accuracy levels rise and smaller uncertainties are necessary, these and other experimental deficiencies become increasingly significant and place considerable demands on the environment, equipment and experimental technique.

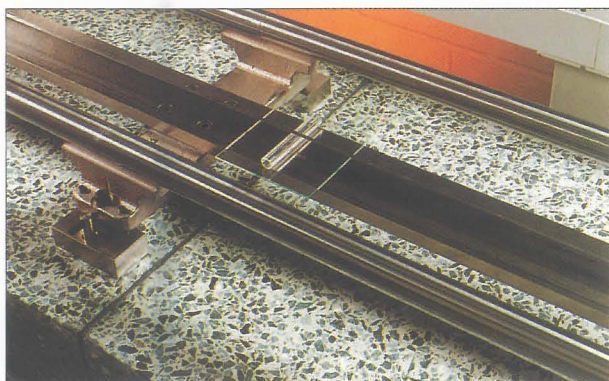
At the NWML, the calibration of the highest level standard tapes is carried out in a laboratory situated in the basement.

2 NWML bench facility

The tapebench is housed in a purpose-built corridor laboratory located in the basement, and has its own air conditioning system independent of the rest of the building. The temperature specification is $20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ with a maximum time rate of change of $0.1\text{ }^{\circ}\text{C}$ per hour and maximum spatial variation along the bench of $\pm 0.5\text{ }^{\circ}\text{C}$.

The base of the bench is made from concrete lintels each 3 m long and of cross section 300 mm wide \times 225 mm high. These are supported on 53 brick piers each of cross section 560 mm \times 330 mm and spaced about 1 m apart. The top surface of the lintels is screeded to fill the gaps and provide a good surface, onto which 50 mm thick synthetic marble tiles are mounted. The tiles are fitted to the top of the bench using epoxy cement.

The rails are made from 2-metre lengths of centreless ground stainless steel rod about 25 mm in diameter. They are spaced 190 mm apart and are supported in saddles positioned every 700 mm which are adjustable laterally, in height and for lateral tilt.



Close-up view
Reproduced by permission of the Controller of HMSO

The height of the rail system above the laboratory floor is approximately 1200 mm. Between the rails there is a flat surface running the length of the bench and made from 60 mm wide, 12 mm thick steel on which tapes can be stretched. The straightness of the system is such that a point fixed on a carriage stays within a volume defined by a right cylinder of diameter 1 mm when that carriage is moved over the entire length of the bench.

There are two carriages which carry microscopes, spirit levels and the optics associated with the interferometer. The carriages are of split design such that the base can be locked in position and the moving parts translated by micrometer (along the direction of the bench axis) and tilted. There is a remote-controlled variable speed drive by means of a metal band running parallel to the bench, so that one carriage can be driven if required. The length of the bench is such that a full 50 metres of working space is available.

The interferometer used is a standard Hewlett-Packard type 5518A laser head, 5508A display, interferometer block type 10766A and retroreflector type 10767A.

3 Scope

The NWML tapebench can be and is used for the calibration of all classes of tape. The procedures and techniques used for the classes fall into three bands: a low level (Class II and below), a medium level (Class I) and a high level (national standard level). Only the last procedure will be considered here.

This procedure can only be applied to tapes that are of adequate quality. In practical terms this means that the graduation lines are sufficiently well defined and that the construction material is suitable. Of particular importance is the linear thermal expansion coefficient which must be known to fall within a very narrow band, or itself be very small. Generally this would mean construction from invar (an iron, nickel, manganese and carbon alloy) which has a very low expansion coefficient (of order 1×10^{-6} per $^{\circ}\text{C}$).

4 Principles of measurement

The basic principle of the calibration is that the movement of a single carriage fitted with a microscope and retro-reflector is measured in terms of a laser wavelength. The positions of the carriage along the bench are made to correspond with the graduations on the tape by observation of coincidence between a graticule line and the defining point on the graduation line of interest.

The result required is the distance between the defining points when the tape is laid flat on a very low (ideally zero) friction surface. This is subject to its stated tension and at its reference temperature. To achieve the low friction condition, and hence uniform stress throughout the tape, the technique used is to place the tape over a series of rollers. The profile taken up by the tape in this condition will be a series of catenaries. For simplicity the rollers are uniformly spaced and arranged so that every line to be checked is situated above a roller. By using a second series of catenaries at spans of twice those used in the first determination, it is possible to deduce the catenary correction (shortening) and hence correct the measured results for the flat condition.

The use of uniformly spaced rollers is largely a matter of convenience as is the choice of two spans related by a factor of two; in principle the method can be used for non-uniform spans, provided that sufficient data is acquired to determine the catenary corrections.

5 Theory

The catenary is the shape taken by a heavy chain suspended between two points and is a particular form of a hyperbolic cosine (cosh) function (see Fig. 1):

$$y = a \cosh(x/a), \text{ where } a = T_0/\sigma g.$$

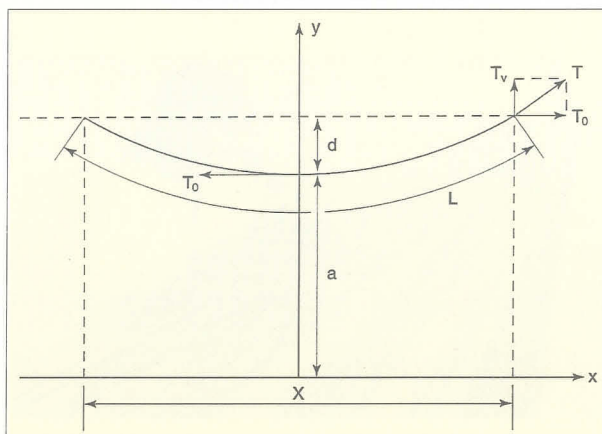


Fig. 1 Hyperbolic cosine function

The parameter "a" is characteristic of the particular catenary. T_0 is the tension at the lowest point and σ is the mass per unit length.

Generally the ratio of the tensioning force to the weight of a tape is large, hence the sag at the centre of a span is small. The argument of the cosh function is therefore small and there is negligible loss in accuracy by using only the first two terms in a Maclaurin expansion to determine the shortening.

For a single span as shown the relevant formulae are:

$$\text{the shortening } (L - X) = \frac{X^3}{24a^2}$$

$$\text{the sag } d = \frac{X^2}{8a}$$

If the tape is hung in N equal length spans, the overall shortening is given by:

$$\text{shortening} = \frac{X^3}{24a^2} \frac{1}{N^2}$$

where X now refers to the overall length (see Fig. 2).

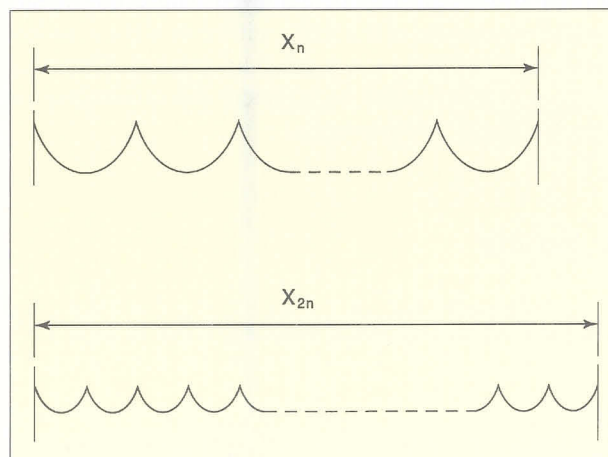


Fig. 2 Two series of spans are used, corresponding to $N = n$ and $N = 2n$

If two series of spans are used, corresponding to $N = n$ and $N = 2n$, then the total shortening for the latter case can be shown to be:

$$\text{shortening } s_{2n} = (X_{2n} - X_n) / 3$$

and the shortening per span = $s_{2n} / 2n$.

The difference $X_{2n} - X_n$ can be determined experimentally and the additive correction s_{2n} applied to the straight line distance measured between the graduations.

6 Experimental details and precautions

At the ppm level of accuracy, attention to detail is vital to ensure successful calibration. Acclimatisation and settling of the tape in the thermal and mechanical environment in which it is tested and careful alignment are essential.

Typically a tape of overall length 50 m would be set up with spans of 2.5 m ($N = 20$) and for the determination of the correction every second roller would be removed giving spans of 5 m ($N = 10$). The rollers would be 10 mm in diameter and be placed upon plane glass slides.

• Tensioning

One end of the tape is securely anchored while the other end is connected to a hanging weight by a wire. The wire used must be thin and of sufficient strength to withstand the tension. This wire passes over a large diameter (approximately 30 cm) pulley wheel. The wheel must have low friction bearings so that its effect on the tensioning force is small. It must also be adjustable in position so that the force is applied to the tape at a slight downward slope to maintain the tape firmly on the first roller. The connections to the tape at both ends incorporate swivel joints which can be adjusted to minimise the torque transmitted to the tape via the wires.

• Alignment

The method of alignment involves adjusting the tape in a lateral plane to ensure the graduation points lie on a line closely parallel to the axis of the measurement system. Also the rollers must be positioned immediately under the graduations - this is achieved by adjustment of the rollers while viewing through the microscope. It is possible to judge when a roller is positioned correctly by the symmetry of the line and the light reflected from the roller.

• Temperature measurement

To determine the temperature distribution along the tape, a multi-head platinum resistance thermometer system is used. The sensors are placed very close to (but not actually touching) the tape at intervals of about 5 m along its length. Temperature corrections can be applied using the readings associated with each interval being calibrated.

• Refractive index determination

The correction for refractive index (usually referred to as a velocity of light correction) requires that the

refractive index be determined at the time of measurement. This is done by computing the refractive index using the air temperature, atmospheric pressure and relative humidity using a modified Edlén formula. The result is then fed directly into the laser control unit for incorporation in the displayed results.

• Method of observation

To guard against loss of laser counts and to counteract linear drift, a measurement scheme is used which is symmetrical in time. The carriage is set over the zero graduation line at the beginning, then sequentially at each line up to the maximum. The carriage is then displaced and returned to the maximum graduation, after which the sequence is repeated in reverse order ending on the zero mark. This whole procedure is carried out twice with the tape having been disturbed longitudinally and allowed to settle in between.

A final determination of the overall length is made with every second roller removed. Again, a time symmetrical sequence is used.

7 Traceability and uncertainties

Traceability of the measurement of length is based upon verification of the frequency of the laser - this is carried out by the National Physical Laboratory in the UK. The displacement of the carriage is measured in terms of counts of interference fringes, so it is necessary to know the wavelength at the time of measurement. The environmental sensors are a vibrating-cylinder barometer, a hygroscopic electrolyte hygrometer and a platinum resistance thermometer. All instruments used to make subsidiary measurements are calibrated and have traceability to national standards.

The contributions to the total uncertainty can be classified into environmental/thermal, mechanical and other. They can further be identified as Type A or Type B and length-dependent or length-independent. The combined uncertainty can be written in the form:

$$\pm (X + YL) \mu\text{m}$$

where L is the length to be determined and expressed in metres. The target uncertainty level for this work was $X = 10$ and $Y = 0.6$.

Work at this level demands a very detailed and comprehensive analysis of the uncertainties. 24 contributions were identified and for some of these, subsidiary experiments were carried out to determine their quantitative effect; for others, worst case figures were used.

While it is not intended to reproduce all the details here, it is worth recording the principal components.

A major contribution is the repeatability of the system which is classified as Type A. This (and the Type B contribution due to carriage tilt) combine to form most of the X component. The former component is primarily due to the repeatability of setting the coincidence between the graticule and the defining line. This alone represents a standard uncertainty of $5 \mu\text{m}$. The latter contribution was held within limits by levelling the carriage at each measuring station. By levelling to within ± 5 seconds of arc ($1/2$ a division on the spirit level used) it was possible to put bounds of $\pm 1.2 \mu\text{m}$ on this factor for any one interval.

The major length-dependent contributions arise from the standard (effectively the laser wavelength) and the correction to the tape under test due to its offset from its standardising temperature and non-uniform distribution. In both cases, the key to low uncertainties is a stable and uniform thermal environment brought about by effective air-conditioning with a temperature as close as possible to that at which the tape is to be certificated. The sensitivity of the wavelength to the environmental parameters is 1 in 10^6 per $^{\circ}\text{C}$, 3.5 in 10^7 per mmHg and 1 in 10^8 per %RH. The uncertainties quoted above can only be achieved where the linear thermal expansion coefficient is either small (e.g. as for invar) or is known to a very small uncertainty. Since the latter is seldom found in practice, this procedure is invariably used for invar tapes.

8 Results

The parameters of a typical tape are shown in Table 1.

Table 1

Parameter	Details
Length:	30 m overall, subdivided at 5 m intervals
Material:	Invar
Cross section:	6 mm \times 0.5 mm
Density:	7900 kg/m ³ giving a weight per metre length of 23.7 g
Tensioning weight:	9 kg
Young's Modulus of elasticity:	144 GN/m ²
Linear thermal expansion coefficient:	1.1×10^{-6}
Characteristic parameter "a":	380 m
Sag (5 m spans):	8 mm
Sag (2.5 m spans):	2 mm

The tape was calibrated with 2.5 m spans ($N = 12$) and every second roller was removed ($N = 6$) to determine S_{2n} .

$X_{2n} - X_n$ was found to be $160 \mu\text{m}$ and the catenary correction to each 5 m interval was found to be $9 \mu\text{m}$. Table 2 shows the results.

Table 2

Interval (m)	Error (μm) *	Uncertainty ($\pm \mu\text{m}$) **
0 - 5	+ 59	13
0 - 10	+ 108	16
0 - 15	+ 127	19
0 - 20	+ 231	22
0 - 25	+ 273	25
0 - 30	+ 286	28

* Corrected to 20 °C and standard gravity $g = 9.80665 \text{ m/s}^2$
 ** At approximately 95 % confidence level based on a coverage factor $k = 2$.

9 Discussion

During development of the multiple catenary method, two checks were made to investigate the magnitude of systematic uncertainties. The first was carried out by NPL and involved measurements made with several spans and a check to see that the plot of overall shortening vs $(1/N^2)$ gave a straight line with a slope and intercept as predicted by the theory.

The other check was made by comparison of the results obtained historically by NPL with those obtained recently by NWML on a particular tape. The results of 6 calibrations over 10 years gave a 2σ /(RSS of uncertainties) of 0.37.

10 Conclusions

As with all metrology at very high accuracy levels, care in setting up the testpiece and noting the results is essential and invariably time-consuming. The method is therefore by no means appropriate for production line work. However, in its context which is for one-off calibrations of tapes at the highest possible level, it has been shown to give excellent results. ■

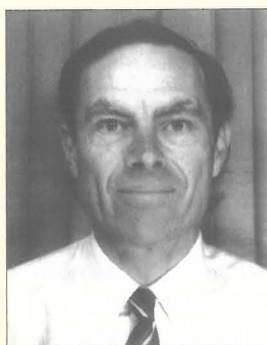
11 References and acknowledgements

The expansion for the cosh function can be found in sourcebooks of formulae such as "Handbook of Mathematical Tables and Formulas" by R. Burington.

Other data from "Physical and Chemical Constants" by Kaye and Laby.

"The Refractive Index of Air" by B. Edlén in Metrologia Vol. 2 No. 2 1966 pp. 71 - 80.

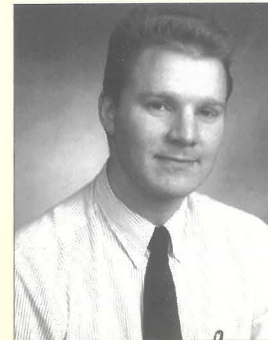
Acknowledgement is given to Dr. D. C. Williams of the National Physical Laboratory (UK) for his help and guidance throughout the development of the NWML facility and this experimental method.



C. B. Rosenberg, BSc (Hons),
MSc, CEng, MIEE



C. S. C. Munteanu



R. A. Ferguson



TRACEABILITY

Optimum traceability type hierarchies

DR. D. KISETS, National Physical Laboratory, Jerusalem, Israel

Abstract

The significant function of any traceability-type system such as classes of accuracy, hierarchy of measuring instruments, etc. is to ensure quality of measurement (or other) information about the object⁽¹⁾ that the system is intended for. To this end the exact values of the characteristics on which a hierarchy system is based, are to be rigorously well-founded.

This paper⁽²⁾ presents optimum values of the characteristics, namely accuracy coefficients, traceability factors and levels of confidence in evaluating measurement uncertainty. The unified system of accuracy classification is developed on the basis of these characteristics.

The theses of this paper are based on Qualimetry and Theory of Information. Mathematical expressions and data which can be used in practice are suggested.

The author believes that this paper may be of interest to both the OIML and all those concerned with metrology and standardization.

1 Introduction

Measurements in economy, including calibration and testing activity, are a part of the comprehensive system of quality assurance of any object. Whilst meeting with the philosophy of ISO 9000 standards, its practical realization does present a problem, which stems from the lack of well-founded methods for:

- (a) creating optimum traceability type hierarchies (TTH) such as accuracy classes, hierarchies of measuring instruments, etc., and
- (b) quantitative estimating of the existing TTH and to what extent they are close to optimum.

One of the reasons for the lack of methods lies in the rather varied requirements and recommendations which exist (if any) with regard to the so-called accuracy coefficient (ρ) and level of confidence (C) in evaluating the measurement uncertainty (U). The accuracy coefficient ($0 \leq \rho \leq 1$) may represent the ratio of certified uncertainties belonging to adjacent levels of the hierarchy, or the reciprocal of the so-called test uncertainty ratio (TUR), etc.

Hierarchy schemes of measuring instruments [1]⁽³⁾ are developed so that the ratio between the uncertainties of the standards of the two levels concerned can vary between 2 and 10, i.e. $\rho = 0.5 - 0.1$. According to the joint requirements of the American National Standards Institute and the National Conference of Standards Laboratories [2], the expanded uncertainty of measurement standards shall not exceed 25 % (i.e. $\rho = 0.25$) of the acceptable tolerance, as specified by the manufacturer.

The value of the level of confidence was unified by the EAL [3] as being $C = 95\%$. However a common approach has not been achieved, simply because this value is the result of consent, rather than rigorous substantiation.

Without further discussing existing optimality and unification approaches, the problem in question is to find the best values of the characteristics, in order to ensure optimum quality of measurement information obtained for the hierarchy levels of the system.

The criterion based on Qualimetry and Theory of Information (IQ-criterion) [4] was used to solve the problem. The general concept of determining the best values of ρ and C , applicable to products and processes, is explained in [4]. This paper aims to outline the results of further research carried out specifically for applied metrology.

Editor's notes:

(1) "Object" in the context of this paper means a process, product or service.

(2) This paper only represents the author's views on a matter certain aspects of which are presently being discussed within the CIML.

(3) Numbers in square brackets refer to the References section.

The "information cycle" principle was discovered in the course of the research, and forms the basis of the following achievements illustrated in the paper:

- the optimum accuracy coefficient (ρ_0) and the optimum level of confidence (C_0) were evaluated;
- the traceability factor (F_t) was proposed, whereby the quantitative estimation of TTH quality was available;
- the unified scale of accuracy classification was created.

2 Quality of measurement

Whilst considering the subject of applied metrology, it is necessary to emphasize that the quality of measurement carried out is a particularly systematic concept which has a bearing on accuracy classification and traceability. In order to be properly integrated into the framework of ISO 9000 standards, calibration and testing on the one hand and *objects* on the other hand should be compatible as regards the quality of measurement information. Broadly speaking, compatibility tasks should ensure that:

- the traceability of all measurements which can affect *object* quality is realized in such a way that any normal use of the *object* cannot lead to a decrease in the quality of measurement information;
- uncertainties of measurement (or other accuracy characteristics) are known at every level of traceability, and that their values (especially depending on how critical a particular measurement is) are specified based on the same principle.

Therefore as far as measurement is concerned, quality may be defined as the ability to carry out measurements on a separate hierarchy level with the accuracy characteristics that satisfy the following requirements:

- (a) they are in line with the accuracy characteristics of other hierarchy levels of the system, and
- (b) they should not be superior to those required to obtain necessary and sufficient measurement information.

This particularly means that considering the systematic approach, accuracy characteristics must be optimized. The quality of a TTH is to be built up both vertically (hierarchy levels), and horizontally (characteristic values at each level). Also of specific note is the quality estimation of the traceability itself.

Two problems need to be solved in order to achieve the required end result:

- 1) the technical problem of providing optimum measurement information, and

- 2) the economic problem of selecting those optimum technical solutions which use this information to the best advantage. In the author's opinion, solving the first problem is the most fundamental subject of unification in terms of constancy - this is the problem addressed in this paper.

3 Optimum accuracy coefficient and confidence

Apart from the distinguishing feature between TTH and a parameters-based system, i.e. the quality characteristics of any *object*, both systems are similar in terms of IQ-criterion. The similarity lies in the following: the *weights*⁽⁴⁾ of the parameters as well as the *weights* (K_j) of the TTH elements can be represented in the form of probabilities, where $j = 1, 2, \dots, n$ (n = the number of elements).

The *weights* involve a complete group of probabilities related to independent events, i.e. a coexistence of the system elements. Therefore, for metrological purposes the *weights* in question are determined by accuracy characteristics as follows:

$$K_j = (1/A_j) / \sum_{j=1}^n (1/A_j) \quad (1)$$

where A_j = the relative accuracy characteristic, associated with tolerances, permissible errors or measurement uncertainties, as the case may be.

The description of a system through *weights* can be graphically expressed as a step function, called a *diagram of weights*. The values of *weights* in such a diagram are arranged as $K_1 \geq K_2 \geq \dots \geq K_n$, and their sum = 1. The effectiveness and reliability of such a system depend on the degree of its redundancy of information (R).

The analysis performed with the IQ-criterion has shown:

- the suitability of considering the optimum system as being one for which the linear *diagram of weights* is characteristic when $\Delta K = K_j - K_{j+1} = \text{constant}$.
- the possibility of determining the optimum accuracy coefficient and confidences for system elements as

Editor's note:

- (4) "Weight" in the context of this paper means ponderousness or relative significance.

$\rho_{jo} = K_{\varphi_0}/K_1$ and $C_{jo} = 1 - 0.5 \rho_{jo}$ respectively. At this point K_{φ_0} is the optimum lower limit of *weights*, complying with the optimum number φ_0 of *weight* elements of the system ($\varphi_0 = n - R_0$), where R_0 = the optimum redundancy of information;

- the existence of the information cycle as $n = 2\pi R_0$ inherent in such a system for its hierarchical sequence, so that the following expressions are practically true for determining the optimum accuracy coefficient (ρ_0) and optimum confidence (C_0):

$$\rho_0 = R_0/n = K_{\varphi_0}/K_1 = 1/2\pi \quad (2)$$

$$C_0 = 1 - 0.5 \rho_0 = 1 - 1/4\pi = 0.92 \quad (3)$$

The proof of the existence of the information cycle is briefly dealt with in the Appendix. The peculiarity of the redundancy structure inherent in the optimum hierarchy was taken as one of the considerations for this proof. The redundancy consists of:

- the part for which a positive redundancy of information is true when $0 \leq C_j \leq 0.5$, i.e. $0.5 K_{\varphi} \leq K_j \leq K_{\varphi}$ and
- the part for which a negative redundancy of information (in fact "dis-information") is true when $C_j < 0$; $K_n \leq K_j \leq 0.5 K_{\varphi}$.

The following permissible ranges are true due to the redundancy structure under consideration:

- for the accuracy coefficient:
from $(1/2\pi) = 0.159$ to $(1/4\pi) = 0.080$
- for the confidence:
from $(1 - 1/4\pi) = 0.92$ to $(1 - 1/8\pi) = 0.96$.

It is of note that the generally accepted level of confidence ($C = 0.95$) is within the limits above.

The increase of the accuracy coefficient beyond the value $\rho_0 = 1/2\pi$ leads to both loss of measurement information and to excess hierarchy levels. The decrease of the accuracy coefficient to less than the value $\rho_0 < 1/4\pi$ leads to an unwarranted increase in accuracy when calibrating measuring instruments.

4 Traceability factor

The number of levels (H_0) in an optimum hierarchy is equal to the redundancy R_0 chosen from the series of integers. Respective integers of the system's elements (n) are the rounded off values obtained from the series $2\pi, 4\pi, 6\pi$, etc.

As far as measurement traceability is defined as an unbroken chain of comparisons [5], it is imperative for estimating the quality of traceability itself to take into account all the hierarchy levels preceding the one being

considered. However, the absence of a well-founded way of summarizing the quality components, accuracy coefficients ad hoc, renders this difficult.

The difficulty can be successfully overcome by using the levels of confidence as alternatives to accuracy coefficients, rendered possible due to C and ρ interdependence.

In fact this is the transition to estimation using probabilities, for which the technique of summarizing the components to obtain a complex estimation is rigorously substantiated. The product of confidences appears to hold in this case.

According to the principles of Qualimetry [6] the complex estimation of quality ought to be carried out using the values of quality components taken in relation to their best values. The optimum level of confidence (C_0) is the best value in question in this instance. That is the same for each (i) level as the reference to the respective confidence (C_i). Therefore, the traceability factor (F_t) as the complex quality estimation of a TTH traceability may be calculated as follows:

$$\begin{aligned} F_t &= (1/C_0)^{H-1} \times \prod_{i=1}^{H-1} C_i \\ &= (1 - 1/4\pi)^{1-H} \times \prod_{i=1}^{H-1} (1 - 0.5 \rho_i) \end{aligned} \quad (4)$$

where H = the number of hierarchy levels of TTH.

It is clear that for the optimum hierarchies, when $\rho_i = \rho_0$, $C_i = C_0$ and $H = H_0$, the optimum traceability factor always is $F_{t0} = 1$. As for existing hierarchies, a traceability factor can be used for the comparative estimations and regulations directed to improve the quality. By way of example, the hierarchy recommended by the OIML in the field of mass measurement [7] may be considered. In this case $H = 7$, $\rho_i = 1/3$ for all hierarchy levels, and therefore, calculation by (4) results in $F_t = 0.55$, i.e. the traceability factor is far from optimum. Thus to summarize, the hierarchy of accuracy classes of weights [7] is largely redundant since its quality of measurement traceability appears to be too low.

5 Unified scale of accuracy classification

It stands to reason that the idea of unified optimum accuracy coefficients may be used to develop the rational TTH system.

It should be noted that rather different approaches may be practiced for creating a model of accuracy classification depending on A_{\min} and A_{\max} , the absolute values of minimum and maximum accuracy characteristics regarding the type of system under consideration.

Table 1 The USAC data

Groups (Gi)	Relative values for elements (Ej)							Multiplying factor
	E1	E2	E3	E4	E5	E6	E7	
G20	6.8	6.0	5.2	4.4	3.5	2.7	1.9	1.1 $\times 10^{-16}$
G19	43	38	33	27	22	17	12	$\times 10^{-16}$
G18	27	24	20	17	14	11	7.5	$\times 10^{-15}$
G17	17	15	13	11	8.8	6.7	4.7	$\times 10^{-14}$
G16	11	9.7	8.3	7.0	5.7	4.4	3.0	$\times 10^{-13}$
G15	6.7	5.9	5.1	4.3	3.5	2.7	1.9	$\times 10^{-12}$
G14	42	37	32	27	22	17	12	$\times 10^{-12}$
G13	26	23	20	17	13	10	7.2	$\times 10^{-11}$
G12	17	15	13	11	8.8	6.7	4.3	$\times 10^{-10}$
G11	10	8.8	7.6	6.4	5.3	4.1	2.9	$\times 10^{-9}$
G10	6.5	5.7	4.9	4.1	3.4	2.6	1.8	$\times 10^{-8}$
G9	41	36	31	26	21	16	11	$\times 10^{-8}$
G8	26	23	20	17	13	10	7.2	$\times 10^{-7}$
G7	16	14	12	10	8.3	6.4	4.5	$\times 10^{-6}$
G6	10	8.8	7.6	6.4	5.2	4.0	2.8	$\times 10^{-5}$
G5	64	56	49	41	33	25	18	$\times 10^{-5}$
G4	40	35	30	26	21	16	11	$\times 10^{-4}$
G3	25	22	19	16	13	10	7.0	$\times 10^{-3}$
G2	16	14	12	10	8.3	6.4	4.4	$\times 10^{-2}$
G1	10	8.8	7.6	6.4	5.2	4.0	2.8	$\times 10^{-1}$

Apparently the best way was to develop such a model that might be suitable in general cases. That is why the use of relative values (when $A_{\max} = 1$) is an appropriate basis for the Unified Scale of Accuracy Classification (USAC) for all fields of measurement:

$$A_{\min} / A_{\max} = \rho_o^{H_o} = \rho_o^{R_o} \quad (5)$$

Mathematically the USAC (as a completely unified system) might be represented as an infinite number of hierarchy levels. However, it is well known that a fundamental physical restriction to measurements exists because of the Heisenberg uncertainty [8]. According to this principle, the product of uncertainties of position (ΔX) and quantity of motion (ΔP) is equal to $h/4\pi$, where $h = 6.754 \times 10^{-32}$ g.m.sec (Planck's constant).

Taking into account this principle as well as expression (5), the following equation is true for determining the limit (R_{om}) of the USAC hierarchy levels:

$$(1/2\pi)^{R_{om}} = h_r/4\pi \quad (6)$$

where $h_r = h/(1\text{g. m.sec})$, the relative value of h .

Eventually R_{om} is determined as:

$$R_{om} = \ln(h_r/4\pi) / \ln(1/2\pi) = (2\pi)^2 \quad (7)$$

The error of this equation is roughly equivalent to the error of rounding off the exact result of both R_o and $(2\pi)^2$ up to 40. Incidentally, this result illustrates the coordination between the information cycle and the fundamental physical constant.

We shall define the USAC elements as the intervals of values in which the accuracy characteristics under consideration are permissible.

The USAC is the set of dimensionless base-line numerical values (see Table 1) plotted as system elements (E_j) and system groups (G_i). These data were calculated on the basis of the proposed conception of the optimum accuracy coefficient.

In so doing, the complete number of elements in a group is determined as the rounded-off value of 2π up to 7. The intervals (Δij) for element values ($GiEj$) are determined as:

$\Delta ij = (GiE1 - GiE7)/7$. The group relations are determined as:

$$GiE7 = (1/2\pi) \times GiE1 = G(i + 1)E1.$$

The complete optimum classification is attainable by the following ratio between $GiEj(e)$ for accuracy classes, and $GiEj(u)$ for uncertainties:

$$GiEj(u) = (1/2\pi) \times GiEj(e) = G(i + 1)Ej(e) \quad (8)$$

The restriction regarding the number of groups (classes) placed in Table 1 is conditional and in line with practice. Going beyond 20 serves no purpose, since the best accuracy which can be achieved in the fields of physical measurements corresponds to the value of 10^{-15} relative uncertainty (measurement of time and frequency).

The assumption about uniting the USAC groups as an informative series of hierarchy levels also appears to be true. Because ρ_0 is a fraction, such a series cannot consist of a whole number of groups; about 2π groups are united in each of these series. It is supposed that each series represents the specific limits of practical application in respect of the measurement field under consideration. While the limits are rather conventional (e.g. measurement of time), the G1-G7 and G2-G8 series involve respectively the complete range of relative tolerance (up to 2.6×10^{-6}) and relative uncertainty (up to 4.1×10^{-7}) for routine application clocks. Starting from G8, the classification is for use exclusively in the highest accuracy technical spheres of this measurement field.

6 USAC practical application

The use of these proposed principles does not present any difficulty for either an existing or newly developed TTH. Any relative accuracy characteristic may be identified by the class and element of classification to which it belongs within the framework of USAC.

It is impossible in this paper to give detailed examples of the USAC application even for one of the existing systems. This is necessarily restricted to a brief study of OIML accuracy classes of weights [7] as a follow-up to the point discussed in section 4. Each of these classes, being transformed into the form of rel-

ative values, may be identified in terms of USAC. For example, the generalized results of the full conversion for the OIML classes of weights are given in Table 2.

Table 2 Conversion of OIML R 111 system into USAC system

Nominal values	Classes (from - to) and number of levels (H)	
	R 111	USAC
50 kg - 50 g	$E_1 - M_3$ (H = 7)	G8 - G5 (H = 4)
20 g - 10 g	$E_1 - M_3$ (H = 7)	G8 - G4 (H = 5)
5 g	$E_1 - M_3$ (H = 7)	G7 - G4 (H = 4)
2 g - 1 g	$E_1 - M_3$ (H = 7)	G7 - G3 (H = 5)
500 mg - 100 mg	$E_1 - M_2$ (H = 6)	G6 - G3 (H = 4)
50 mg	$E_1 - M_1$ (H = 5)	G6 - G3 (H = 4)
20 mg - 5 mg	$E_1 - M_1$ (H = 5)	G5 - G3 (H = 3)
2 mg - 1 mg	$E_1 - M_1$ (H = 5)	G4 - G2 (H = 3)

Table 3 illustrates the difference between this existing system and its optimum conversion in respect to only one of the nominal values of weights, i.e. 1 kg.

It stands to reason when comparing the data of these Tables that the USAC Table is the materially more economical hierarchy in respect to the number of hierarchical levels.

Unlike the existing system, the newly developed one can be created as a fully optimum system. Firstly, this means maintaining the equality between the ratio of maximum permissible errors belonging to adjacent accuracy classes (hierarchy levels) and the value of the optimum accuracy coefficient. Secondly (the solution to the economic problem mentioned in section 2), this should also result in selecting the proper elements of classification. The selection is to be the optimum one for the existing conditions at the moment of developing the system and with due regard for long-term goals.

Table 3 Maximum permissible errors (δ_m) for 1 kg nominal value

R 111 classes:	E_1	E_2	F_1	F_2	M_1	M_2	M_3
$\pm \delta_m$ in mg:	0.5	1.5	5	15	50	150	500
USAC classes:	G8	G7	G6	G5	G4		
$\pm \delta_m$ in mg:	0.5	3	20	125	800		

7 Follow-up discussion

The linear approximation of the ranged *weights* of accuracy characteristic is not ideal in terms of determination accuracy. However, the occurrence of a certain determination inaccuracy does not question the information cycle principle developed here. Thus while the improvement of the approximation model is of theoretical interest, it cannot affect the proposed conception regarding optimum measurement hierarchies, or markedly affect obtained data.

As to the concept, it is of interest to compare the generally accepted principles of current hierarchy schemes for measuring instruments [1] with those developed in this paper. Table 4 illustrates the difference in the interpretation of the four core subjects in question.

The availability of different philosophies is the major inference drawn from this comparison. Acknowledging the practical significance of the OIML Document, attention may also be paid to improvement of the Document according to these statements.

8 Conclusions

To meet the requirements of international quality standards it is essential to ensure a high quality of measurement traceability and a unified approach in creating TTH.

The quality of traceability depends on the extent to which the TTH is close to optimum which, in turn, is to be based upon and determined by the optimum accuracy characteristics.

The criterion based on Qualimetry and Theory of Information as well as the principle of the information cycle serve as grounds for determining the optimum characteristics and creating the optimum TTH.

The following results were obtained by using the principles proposed in this paper:

- The unified best accuracy characteristics, namely accuracy coefficient and level of confidence, are substantiated herein.

Table 4 Comparison of general principles

"A" = Defined by OIML International Document D 5

"B" = Deduced by the paper (essentially worded in terms of [1])

1 Reason for the existence of hierarchy schemes

A The quest for a better quality of ordinary measurement is the very reason for the existence of hierarchy schemes (Para 1.4).

B The achievement of such a quality of measurements that meets the optimum measurement information about the quality of the *object* undergoing test.

2 Objective of all hierarchy schemes

A To reduce as much as possible the measurement errors and to derive maximum confidence in all measurements, including the most ordinary ones (Para 1.5).

B To achieve as far as possible the optimum accuracy of measurements and to ensure evidence that all measurements are carried out properly in respect of quality of measurement information.

3 Uniformity of hierarchy schemes

A The hierarchy schemes presented are constructed with a certain degree of uniformity (Para 1.4).

B The hierarchy schemes developed are constructed based on the fully unified classification system.

4 Unification of accuracy coefficient

A It does not appear realistic to attempt to fix the ratio between the inaccuracies of the standards of the two levels concerned (Section 3).

B The ratio in question (accuracy coefficient) must be chosen within the limits ensuring the optimum quality of measurement traceability.

- The method for estimating the quality of measurement traceability with the traceability factor is also developed.
- The Unified Scale of Accuracy Classification is created and the main ways of its practical application are also defined.

Appendix: Determination of the information cycle

The existence of the information cycle can be proved in two different ways. The first is based on the analytical determination of that value of ρ_o for which the relative maximum quality loss (L_{qm}) is equal to the relative error of optimization - the optimization loss (L_o). The second way is based on the direct calculation of ρ_o with the entropy function, both ways are developed below:

1) The relative quality loss (L_q) of a system, considered as the function of the redundancy of its elements, ought only to be estimated within the range of the positive redundancy. Thus, in general the quality loss may be determined as follows:

$$L_q = k_f (K_\phi + K_{\phi+1} + \dots + K_{\phi_m})$$

$$= (1/nK_1) (K_\phi + K_{\phi+1} + \dots + K_{\phi_m})$$

where ϕ_m = the number of informative elements of the system corresponding to $0.5 K_\phi$.

$$k_f = (1/n) \sum_{j=1}^n (K_j/K_1) = 1/nK_1 \text{ = the form-factor of the diagram of weights.}$$

For the linear diagram, when $\phi = \phi_o$; $\phi_m = \phi_o + 0.5 R$; $(K_\phi/K_1) = R/n = \rho_o$, the quality loss (L_{lq}) as well as its maximum value (L_{lqm} when $n = 2$) results in:

$$L_{lq} = 0.25\rho_o \times (1.5\rho_o + 1/n); \quad L_{lqm} = 0.25\rho_o \times (1.5\rho_o + 0.5)$$

The redundancy of the conventional subsystem, consisting of redundant $(n - \phi)$ components, gives rise to the optimization loss (L_o). This loss may be expressed for the linear diagram (L_{lo}) as follows:

$$L_{lo} = \Delta\phi_o/\phi_o = (n - \phi_o) \rho_o / n(1 - \rho_o) = \rho_o^2 / (1 - \rho_o)$$

The equality $L_{lo} = L_{lqm}$ is true for determining the value of ρ_o . Thus the calculation results in $\rho_o = 0.155$. The relative difference between this obtained value of ρ_o and $1/2\pi$ - the characteristic of the information cycle, is less than 3 %. In respect of the number of informative elements (ϕ) the corresponding error is less than 0.5 %.

2) As for the second way, the following general expressions exist according to [4]:

$$\rho_o = (R/n) = 1 - (\phi/n)$$

$$\phi = \exp \left[- \sum_{j=1}^n (K_j \ln K_j) \right]$$

where for the linear diagram of weights:

$$K_j = n(n+1-j) / n(n+1).$$

The data of relative difference $\delta_r = 1 - (\phi/\phi_o)$ between ϕ and $\phi_o = n_r [1 - (1/2\pi)]$, calculated with the last expressions are entered in Table 5, where also n_r = the rounded-off $2\pi R$ value.

Table 5

R	n_r	δ_r
$1/\pi$	2	-0.12
1	7	-0.04
2	13	-0.01
3	19	0.00
4	26	0.00
5	32	0.00
2π	40	+0.01
3π	60	+0.01
4π	79	+0.01
...
∞	∞	+0.02

The occurrence of the information cycle may be considered as proved, due to the minute value of δ_r . Table 5 also demonstrates that the estimation error is always less than $1/2\pi$ by absolute value.

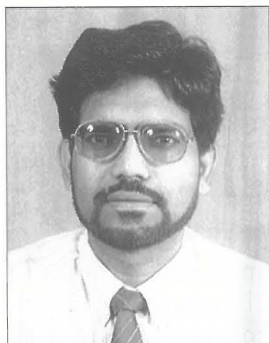
Here are the main conclusions of this consideration:

- The complete close information cycle $n = 2\pi R$ is characteristic for the optimum TTH type system.
- The linear diagram of weights is quite an appropriate model for the optimum system in question.
- The sound connection between the two approaches, based on the conceptions of quality and information, is revealed through the information cycle. ■

References

- [1] OIML International Document D 5: Principles for the Establishment of Hierarchy Schemes for Measuring Instruments. 1st ed. 1982, p. 7.
- [2] ANSI/NCSL Z 540-1-1994: Calibration Laboratories and Measuring and Test Equipment - General Requirements.
- [3] WECC Doc. 19-1990: Guidelines for Expression of the Uncertainty of Measurement in Calibration.
- [4] D Kisets. On Completeness of Measurement Information about the Quality of Object. Proceedings - ISQA 9th International Conference - 1992, p.p. 134 - 139.
- [5] International Vocabulary of Basic and General Terms in Metrology. 2nd edition, ISO, 1993, p. 47.
- [6] G. G. Azgaldov, E.P. Raihman. On Qualimetry. Izdatelstvo Standartov. Moscow - 1973, p. 35.
- [7] OIML R 111: Weights of classes $E_1, E_2, F_1, F_2, M_1, M_2, M_3$, ed. 1994 (E).
- [8] V. A. Patrighny, A. S. Sire. The Word Trends in Developing the Methods of Measurement and Measuring Instruments. Moscow. Izdatelstvo Standartov, 1994, p. 23.

Contact information: Dr. D. Kisets, National Physical Laboratory, Danciger Bldg. A, Jerusalem 91904, Israel.
Tel. (972) 2 658 5724 - Fax (972) 2 652 0797



METROLOGICAL INFRASTRUCTURES

The development of metrology in Mauritius

K. RAMFUL, Ministry of Trade and Shipping, Mauritius

1 Introduction

The island state of Mauritius lies south of the Equator, at longitude 58 °E and latitude 20 °S. It has a land area of almost 2000 km² and a population of approximately 1.2 million people.

In Mauritius there are two bodies responsible for metrology activities, namely the Mauritius Standards Bureau (MSB) and the Legal Metrology Division (LMD) of the Ministry of Trade and Shipping. The MSB is responsible for scientific metrology and the LMD is responsible for legal metrology. The responsibilities for industrial metrology are shared between the two organizations.

The international system of units (SI) has been legalized in the country since 1984 by an Act of Parliament, the SI Act 1984.

2 Legal metrology in Mauritius

2.1 The coming into operation of the LMD

Until 1 July 1990, the police department was responsible for Legal Metrology within the ambit of the Weights and Measures Ordinance of 1878. It was felt in the early 1980's that the administration of

weights and measures should be the responsibility of a technical body, with personnel suitably trained in the technological aspects of the work. The Legal Metrology Act was passed in the then Legislative Assembly in 1985, and proclaimed to be effective as from 1 July 1990, when the new Legal Metrology Division, created under the aegis of the Ministry of Trade and Shipping, took over the administration of weights and measures from the police department.

The Division is housed in a new building located at Bell-Village, on the outskirts of the capital Port-Louis. The building comprises a workshop, a verification room, a dry laboratory (for length and mass calibrations), a wet laboratory (for volumetric calibrations), several offices and a library (for documentation purposes).

The main objective of the Legal Metrology Act is the control of weighing and measuring instruments used in trade and the protection of the public in relation to the sale of goods by weight or measure. To implement the Legal Metrology Act, the Division is focusing its work on three main responsibilities:

- maintenance of measurement standards which are traceable to International Standards via the Mauritius Standards Bureau;
- control of weighing and measuring instruments used in trade;
- control of goods.

2.2 Maintenance of measurement standards

The maintenance of measurement standards which are traceable to international standards is vital in that it ensures standardization and harmonization of trade not only locally, but on an international level. This definitely helps our country to compete in international trade.

The national standards which have traceability to international standards are maintained by the Mauritius Standards Bureau and are used for the verification of the secondary standards which are kept and maintained at the Legal Metrology Division. The secondary standards are used for the verification of the working standards, and the latter are used for the verification of trade weighing and measuring instruments.

2.3 Control of weighing and measuring instruments

(a) Pattern approval

The pattern and design of weighing instruments in trade use are controlled by the certificate of suitability (Section 6 of the Legal Metrology Act, according to which no person can import or manufacture a weighing instrument unless he holds a certificate of suitability in

respect to the pattern or design of the instrument). The patterns of petrol pumps are also controlled since only models approved under the regulations are accepted for verification.

(b) Verification

Before an instrument can be put into use for trade, it has to be duly verified by the LMD. In Mauritius, new trade instruments have to be verified and stamped before being offered for sale to traders. As from 1994 periodical verification has become mandatory; the period prescribed depends on the type of instrument, as shown below:

Type	Period
Spring balance	at least once a year
Length measures	at least once every 5 years
Other instruments ^(*)	at least once every 2 years

^(*)(e.g. electronic weighing machines, petrol pumps, weighbridges, capacity measures, etc.)

(c) Supervision of the use of instruments in trade

This is done by carrying out inspection visits to trade premises to ensure that traders are using correct and verified scales.

In Mauritius, three departments are responsible for the supervision of the use of instruments in trade. These departments are the LMD, the police department, and the market inspectorates of the local authorities. A committee, chaired by the Controller of Weights and Measures and comprising of representatives from the various departments, has been set up to coordinate the enforcement of the Legal Metrology Act. The secretariat of the coordinating committee

is ensured by the LMD. In cases of dispute a technical report (issued by the LMD) is considered to be *prima facie* evidence in legal proceedings.

2.4 Control of goods

The Legal Metrology (Prepacked Commodities) Regulations (GN 125 of 1994) prescribe three requirements for prepacked goods:

- correct labeling;
- standardization of pack sizes for certain mass-consumption items;
- accuracy of net contents.

In addition, it is stipulated in the regulations that every packer shall verify (or cause to be verified by a duly certified instrument) the net quantity of his prepacked commodities on the packing line at regular intervals every day, and he shall also maintain a record of such verifications. The labeling and accuracy requirements stipulated in the regulations are in line with OIML Recommendations.

The control of prepacked goods is a relatively new activity, which only started on a regular basis since 1994.

2.5 LMD staff

The technical staff of the LMD comprises a Director (Controller of Weights & Measures), two Legal Metrologists, two Senior Technical Officers and eight Technical Officers, three of whom were recently recruited following the recent increase in work load due to new activities being taken on.

2.6 New activities and future projects

The following new activities were started recently:

- verification of bulk meters for the measurement of petroleum products;
- calibration of road-axle weigher.

The future projects of LMD are:

- (a) calibration of road tankers;
- (b) setting up of new facilities to improve the accuracy of the calibration of one-tonne weights used in the verification of road weighbridges;
- (c) setting up additional facilities for carrying out the pattern approval tests for nonautomatic weighing machines;
- (d) decentralization of the verification service so that traders can benefit from a service nearer to their place of activity;
- (e) improvement on the present method of calibration of fixed storage tanks.

3 Industrial and scientific metrology

3.1 The present status of metrology at the Mauritius Standards Bureau (MSB)

The MSB was established in 1975 by the Standards Act (1975) as a technical advisory body under the then Ministry of Commerce & Industry. Since July 1993, the MSB has become a parastatal body which is responsible for:

- the promotion and encouragement of standardization in industry and trade;
- the preparation and modification of standards;
- quality control tests on commodities;
- control of the use of the MSB certification mark;
- metrology and calibration services;

- a technical documentation center on standardization;
- applied research to promote technological development in industry;
- the administration of the national quality system certification scheme.

Regarding metrology, MSB has a Division which is entrusted to carry out:

- maintenance of national measurement standards;
- calibration of secondary measurement standards;
- calibration of measuring instruments used by public and private institutions;
- calibration of instruments used in product testing and the certificate marking scheme at MSB.

It has been agreed between the MSB and the LMD that all the industrial calibrations in the fields of mass, length and volume needing an accuracy of the same level as that required by the Legal Metrology Act would be performed by the LMD, while those of higher accuracy would go to the MSB. This arrangement was felt necessary to avoid duplication of calibration

facilities and hence optimize investments.

The Metrology Division of MSB also offers calibration services for the parameters of force, pressure, temperature and DC-AC electrical measurements.

The technical staff of the Metrology Division of MSB comprises a Divisional Standards Officer, a Standards Officer and two Technical Officers.

3.2 The Metrology Standards Committee

The Metrology Standards Committee was set up at the MSB in 1992 and comprises members from both governmental or semi-governmental bodies and the private sector, which are concerned by metrology. The responsibility of the committee is to draft appropriate metrology standards in line with international standards and to approve calibration procedures at the MSB.

3.3 New projects

The Mauritius Standards Bureau (which is located at Reduit) will be

moving to Moka in a new building comprising of modern, sophisticated and more spacious laboratories. The Metrology Division of the MSB is at present working on a project to increase the calibration capacities in the fields of electrical measurements and thermometry. New equipment in these two fields is being purchased.

4 Conclusion

With the ISO 9000 Quality System certification scheme in Mauritius, the need for metrology services has increased considerably. Further, we have to ensure that the calibration and test reports are unanimously accepted, hence the imminent project of the Laboratory Accreditation Scheme in Mauritius.

The goal established by the GATT, in particular the removal of technical barriers to trade, makes it necessary not only to consolidate our metrology activities but also to accelerate the harmonization of our legal metrology requirements with those of International Standards. ■

InterAmerican Accreditation Cooperation (IAAC) – Communiqué

The second meeting of the Inter-American Accreditation Cooperation (IAAC) took place from 20–22 November 1996 in Montevideo (Uruguay) with the participation of forty-five delegates representing seventeen countries. The IAAC is a cooperation between accreditation bodies whose objective is to facilitate trade between countries in the Americas.

Certification bodies, registration bodies, testing and calibration laboratories and other interested parties also participate. The aim of the IAAC is to promote international recognition of the accreditations granted by participating accreditation bodies, and the acceptance of certificates of conformity and test results issued by conformity assessment organizations and laboratories accredited by them.

In this meeting the terms of reference for the IAAC were agreed upon through the signing of a memorandum of understanding, according to which its signatories will work towards multilateral recognition of their equivalence and acceptance of one another's results, based on adherence to international principles and practices for accreditation activities.

The memorandum was signed by the following accreditation organizations:

- Argentine Accreditation Body (OAA), Argentina;
- National Institute of Metrology, Standardization and Industrial Quality (INMETRO), Brazil;
- National Institute of Standardization (INN), Chile;
- Ministry of Industry and Trade (SIC), Colombia;
- National Institute for the Defense of Competition and the Protect-

ion of Intellectual Property (INDECOPI), Peru;

- American National Standards Institute (ANSI), United States;
- American Association for Laboratory Accreditation (A2LA), United States;
- Autonomous Service, Standardization Directorate and Quality Certification (SENORCA), Venezuela.

Representatives of other accreditation organizations present expressed their interest in signing the memorandum, pending final authorization from their organization.

The signatory organizations established goals for IAAC similar to those of the International Accreditation Forum (IAF) and the International Laboratory Accreditation Cooperation (ILAC) and will coordinate closely with them and regionally with COPANT, the Pan American Standards Commission, and the Organization for American States in achieving these goals for the Americas.

The IAAC selected Reinaldo Balbino Figueiredo of INMETRO as its first Chairman and decided its next meeting will be held on November 19–21 1997 at a venue in Colombia.

IAAC - Working Group Tasks

Working Group 1: Guidance and general documentation.

- To develop, publish and maintain IAAC Guidance documents on the application of ISO/IEC Standards and Guides which relate to management system certification/registration, product certification, personnel certification and accreditation. IAAC documents will be based on IAF and ILAC documents as far as possible.

Working Group 2: Conformity assessment - technical assistance and training.

- To undertake studies relating to all aspects of technical assistance and training in conformity assessment and provide training and technical assistance to IAAC members in the field of conformity assessment.

Working Group 3: Multilateral agreement.

- To develop and manage criteria and operational procedures for the entry of members into the IAA MLA, including criteria and procedures for peer evaluation of accreditation bodies, and criteria and procedures for the suspension or withdrawal of membership in the IAAC MLA.

IAAC documents will be based on ISO/IEC and IAF/ILAC documents as far as possible.

Working Group 4: Public relations and promotional activities.

- To identify the need for and to develop all IAAC publicity material. To draft and update general IAAC information documents and other public relations material.

Working Group 5: Calibration and testing activities.

- To study the needs for IAAC interlaboratory comparisons and proficiency testing programs, especially in new fields of accreditation of calibration and testing laboratories. ■

Contact for further information:

Reinaldo Balbino Figueiredo
President of IAAC
Tel: (55) 021 502-1009 - ext. 212/213
Fax: (55) 021 502-6542
email - Serai@inmetro.gov.br

NATIONAL STRUCTURES FOR ACCREDITATION

The verification and test laboratory accreditation system of the Republic of Belarus

N. KUSAKIN and N. ZHAGORA, Belstandart, Belarus

The Republic of Belarus operates a National Accreditation System (NAS) for verification and test laboratories which has been harmonized with the 45000 series of European standards. The verification laboratory covers all the functions of a conventional calibration laboratory and the system is fully documented.

The six standards of the *Verification and Test Laboratory Accreditation System* are as follows:

STB 941.0-93

Basic statements;

STB 941.1-93

General requirements for verification and test laboratory accreditation bodies;

STB 941.2-93

General requirements for accreditation of verification and test laboratories;

STB 941.3-93

General requirements for assessment of verification and test laboratories;

STB 941.4-93

Register;

STB 941.5-95

Verification and test laboratory assessors: general requirements.

Prime objectives of NAS

- to provide traceability of measurements;
- to harmonize the rules and procedures of NAS according to recommendations of international organizations and national systems of other countries;
- to facilitate mutual acceptance of and assure confidence in verification and test results.

The NAS is available to any laboratory which accepts its rules and procedures, and which sets itself the objective of receiving official acceptance.

Tasks undertaken by NAS

- authorization of accreditation bodies;
- laboratory accreditation;
- establishment of general requirements and criteria for evaluation of laboratory technical competence;
- carrying out surveillance of the activities of accreditation bodies and accredited laboratories;
- creation of a central database of the accreditation bodies and accredited laboratories, including the scope of their activities and their technical capabilities;
- acceptance of calibration and test laboratory accreditation performed by national bodies of other countries;

- training of assessors and auditors and their evaluation on the basis of generally accepted European criteria;
- defining harmonized accreditation rules and procedures;
- assistance in European and international accreditation systems cooperation.

Organization of the accreditation system

- **National Accreditation Body (Belstandart)**
- **Accreditation Council**

and also:

- Accreditation bodies for verification laboratories;
- Accreditation bodies for test laboratories;
- Accredited verification laboratories;
- Accredited test laboratories.

National Accreditation Body (Belstandart)

The Belstandart is the central body of the Accreditation System in the Republic of Belarus and is responsible for accreditation body authorization; this procedure requires the Belstandart to form a commission of leading experts, who perform the assessment according to STB 941.1.

Note: The Belstandart is the Committee for Standardization, Metrology and Certification of the Republic of Belarus.

In line with the results of the assessment, the Belstandart decides whether to grant (or refuse) accreditation body status, and specifies the scope of accreditation body activities. To summarize its activities, the Belstandart:

- establishes the basic principles of NAS;
- legalizes normative and procedural documents of NAS and monitors their implementation and reviewing;
- forms the assessment commission for potential accreditation bodies;
- validates the status of the accreditation body;
- validates certificates issued by accreditation bodies and accredited laboratories and grants the appropriate authority to the laboratory accreditation bodies;
- considers and makes decisions upon accreditation appeals;
- organizes training programs for laboratory assessors and surveillance inspectors; evaluates their general suitability and competence;
- maintains a register of accreditation bodies, accredited laboratories and assessors;

- interacts with international, state and public organizations acting in the field of accreditation of bodies and laboratories;
- makes decisions upon acceptance of a laboratory accreditation performed by other countries' national bodies;
- takes part in accreditation of verification and test laboratories;
- publishes the register of bodies, verification and test laboratories accredited in the Republic of Belarus as well as laboratories for which accreditation has been accepted;
- represents the Republic of Belarus in national, regional and international accreditation organizations.

Accreditation Council

The Accreditation Council acts on the basis of its status, determines general policy and coordinates the functioning of NAS together with Belstandart. The Council is represented by delegates from Ministries and Departments of the Republic of Belarus, accreditation bodies and laboratories.

Up to the present time, the following have been accredited:

- 7 accreditation bodies;
- 250 test laboratories;
- 12 verification laboratories (amongst which three are affiliated with Western European firms such as Schlumberger, Clorius, Endris and Houzer).

Note:

One of the leading accreditation bodies is the Minsk Center for Standardization and Metrology, which operates a documented quality system providing traceability to every stage of the accreditation process as well as inspection of verification and test laboratories. 194 laboratories have already taken advantage of its services.

Information about accredited laboratories is constantly being published in the "Belstandart Bulletin".

An agreement for mutual acceptance of accreditation results has been signed by CIS countries (the former USSR) and is referred to as "Rules for interstate accreditation" PMG 08-94. ■



METROLOGICAL INFRASTRUCTURES

Establishment of a regional metrology network in Southern Africa

M. KOCHSIEK, CIML Vice President

1 Background

The South African Development Community (SADC) was established in 1992 with the aim of being the means by which member countries could move towards economic integration as a trading block.

It came into existence following the transformation of the South African Development Community Conference (SADCC), the origins of which go back to 1980, into the SADC. The SADC presently consists of twelve member countries: Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

This area comprises some 140 million inhabitants covering 6.85 million km² and accounting for 170 billion US \$ in gross national product.

SADC is in the process of simultaneously implementing the two basic models for regionalism - sectorial cooperation and trade integration.

SADC had previously given consideration to a 1994 study entitled *Report on a study for a program on the SADC metrology system* by the consultant G. B. Makando, and had approved the recommendation contained in that report to establish a SADC metrology network.

2 Preparing the metrological network

At the invitation of the South African National Metrology Laboratory (NML), an SADC planning workshop took place in Pretoria on 7-11 October 1996; it consisted of:

i) a two-day training seminar/conference

This dealt with various metrology topics, and was presented by both technical and systems experts.

After Mr. Kochsiek's lecture on *The importance of regional metrology networks for competitiveness, mutual confidence and trade between trading blocks*, the following items were addressed:

- the regional metrology networks in the Asia Pacific, in North America and in Europe;
- the role of NMIs;
- accreditation and certification in the regional metrology infrastructure;
- development of metrology in SADC countries; and
- special branches of metrology laboratories in South Africa.

ii) a one-day plenary workshop

During this workshop, the floor was opened up to encourage feedback concerning the topics listed

above, which had been discussed earlier in the conference. This also served to provide inputs for the two-day planning session; the main points were the SADC requirements for trade metrology, accreditation of calibration and testing laboratories and for measurement traceability.

iii) a two-day planning session

This session for the preparation of a regional strategy and plan of action was restricted to three representatives per SADC member country. The outcome was a proposal for a regional metrological SADC infrastructure, described below.

3 The new regional metrology infrastructure

It was decided at the planning session to create three regional umbrella organizations to represent the National Metrology Institutes, Accreditation Bodies and Legal Metrology Organizations in the SADC region in international forums and interactions with similar groupings in other trading blocks.

All three regional organizations consist of a governing body, in which all SADC member countries are represented.

The SADC Industry and Trade Coordinating Division (SITCD) in Dar-es-Salaam will also be represented by a Board member and will act as the interface to the official SADC structures. The regional coordinator will be entitled to attend meetings of the governing body, and the chair of each governing body will rotate amongst member countries.

The executive portion of the regional umbrella bodies is a secretariat headed by a regional coordinator. The secretariat carries out the day to day running of the organization concerned, and is staffed and financed by one of the national member organizations. It is responsible for the progress of the approved working program, for which it also has access to the support of Technical Committees.

All three secretariats were instructed to draft constitutions for their organizations. The guidelines compiled by the working groups at the October 1996 planning session and the constitutions of similar organizations will be the basis for this work.

The National Metrology Laboratory (NML) of South Africa agreed to make information on the new SADC metrology infrastructure available on the Internet. Its World Wide Web (WWW) homepage is at

<http://aeroweb.aero.scir.co.za/programmes/metrology/>

More background information about the SADC can be found at the SADC WWW homepage at

<http://business.kent.edu/sabos/sadc.html>

3.1 SADC MET

SADC MET is the umbrella organization of the National Metrology Institutes (NMI's) within the SADC. Its objectives include the achievement of international traceability for all NMI's in the region, consult-

ancy on the establishment of NMI's, support of the objectives of the SADC, conclusion of Mutual Recognition Agreements, organization of intercomparisons and involvement in training programs.

Zimbabwe is nominating the first chairperson of the governing body, and South Africa accepted to run the secretariat and to appoint a regional coordinator (Dr. Hengstberger, NML).

Postal address:

The Regional Coordinator
SADC MET
c/o National Metrology Laboratory
AEROTEK/CSIR
Pretoria 0001, South Africa.

3.2 SARAC

SARAC is an acronym for the Southern African Regional Accreditation Cooperation. The objective of this body is the creation of a pool of accredited calibration and testing laboratories and of accredited certification bodies.

Mr. A. C. Hurdoyal (Mauritius) was elected to chair the governing body and South Africa agreed to provide the secretariat with Mr. M. Peet as the regional coordinator.

3.3 SALMEC

SALMEC stands for SADC Legal Metrology Cooperation. Its aims are:

- the harmonization of trade metrology legislation;
- the harmonization of verification and calibration techniques (including certification);
- regional standardization of packaging sizes;
- compliance with OIML activities and recommendations;
- regional uniformity of pattern approvals;
- organization of a training program;
- exchange of metrology related information;
- intercomparisons and the identification of equipment to be covered by legal metrology regulations.

South Africa was asked to nominate the chairperson (Brian Beard, SABS) for the governing body and Zimbabwe accepted responsibility for the secretariat. ■



Workshop attendees of the SADC Metrology Conference, Pretoria, South Africa, 7-10 October 1996



OIML technical activities

1996 Review
1997 Forecasts

The information given on pp. 46–52 is based on 1996 annual reports submitted by OIML secretariats. Work projects are listed for each **active** technical committee and subcommittee, together with the state of progress at the end of 1996 and projections for 1997, where appropriate.

Activités techniques de l'OIML

Rapport 1996
Prévisions 1997

Les informations données en pages 46–52 sont basées sur les rapports annuels de 1996, fournis par les secrétariats OIML. Les thèmes de travail sont donnés pour chaque comité technique ou sous-comité **actif** avec l'état d'avancement à la fin de 1996 et les prévisions pour 1997, si approprié.

KEY TO ABBREVIATIONS USED

WD	Working draft (Preparatory stage) <i>Projet de travail (Stade de préparation)</i>
CD	Committee draft (Committee stage) <i>Projet de comité (Stade de comité)</i>
DR/DD	Draft Recommendation/Document (Approval stage) <i>Projet de Recommandation/Document (Stade d'approbation)</i>
Vote	CIML postal vote on the draft <i>Vote postal CIML sur le projet</i>
Appr.	Approval or submission to CIML/Conference for approval <i>Approbation ou présentation pour approbation par CIML/Conférence</i>
R/D	International Recommendation/Document (Publication stage) For availability: see list of publications <i>Recommandation/Document International (Stade de publication)</i> <i>Pour disponibilité: voir liste des publications</i>

OIML TECHNICAL ACTIVITIES		1996	1997
TC 1 Terminology			
• Revision V 1: Vocabulary of legal metrology		2 CD	3 CD
TC 2 Units of measurement			
• Revision D 2: Legal units of measurement		Vote / Appr.	D
TC 3/SC 1 Pattern approval and verification			
• Initial verification of measuring instruments utilizing the manufacturer's quality system		2 CD	DD
• Revision D 3: Legal qualification of measuring instruments and inclusion in its text the existing D 19 and D 20		–	I CD
TC 3/SC 2 Metrological supervision			
• Revision D 9: Principles of metrological supervision		I CD	2 CD
TC 4 Measurement standards and calibration and verification devices			
• Principles for the selection and expression of metrological characteristics of standards and devices used for calibration and verification		WD	I CD
• Revision D 5: Principles for the establishment of hierarchy schemes for measuring instruments		WD	I CD
• Revision D 10: Recalibration intervals of measurement standards and calibration devices		WD	WD
• Revision D 6 and D 8: Measurement standards. Requirements and documentation		WD	I CD
TC 3 Metrological control – TC 4 Measurement standards and calibration and verification devices			
• Uncertainty in legal metrology measurements		WD	I CD
TC 6 Prepackaged products			
• Revision R 79: Information on package labels		Appr.	R
• Revision R 87: Net content in packages		–	I CD
TC 7/SC 1 Measuring instruments for length			
• Revision R 30: End standards of length (gauge blocks)		WD	I CD

OIML TECHNICAL ACTIVITIES

TC 7/SC 3 Measurement of areas

Instruments for measuring the areas of leather

1996

5 CD

1997

5 CD

TC 7/SC 4 Measuring instruments for road traffic

- Electronic taximeters
- Revision R 55: Speedometers, mechanical odometers and chronotachographs for motor vehicles. Metrological regulations

WD

3 CD

WD

DR

TC 7/SC 5 Dimensional measuring instruments

- Multi-dimensional measuring instruments
- Test report format for the evaluation of multi-dimensional measuring instruments

2 CD

2 CD

3 CD

3 CD

TC 8 Measurement of quantities of fluids

- Standard capacity measures for testing measuring systems for liquids other than water - R 120
- Pipe provers for testing measuring systems for liquids other than water - R 119
- Vortex meters used in measuring systems for fluids- D 25
- Laboratory volume measures - Automatic pipettes - D 26

R

-

R

-

D

-

D

D

TC 8/SC 1 Static volume measurement

- Revision R 85: Automatic level gauges for measuring the level of liquid in fixed storage tanks

DR

Vote / Appr.

TC 8/SC 2 Static mass measurement

- Measuring systems for the mass of liquids in tanks

DR

Vote / Appr.

TC 8/SC 5 Water meters

- Revision R 49: Water meters intended for the metering of cold water

DR

DR

TC 8/SC 6 Measurement of cryogenic liquids

- Revision R 81: Measuring devices and measuring systems for cryogenic liquids (including tables of density for liquid argon, helium, hydrogen, nitrogen and oxygen) and including development of Annex: Test report format

3 CD

3 CD

OIML TECHNICAL ACTIVITIES		1996	1997
TC 8/SC 7 Gas metering			
• Metering systems for fuel gas		WD	WD
TC 8/SC 8 Gas meters			
• Revision R 6: General provisions for gas volume meters		WD	I CD
• Revision R 32: Rotary piston gas meters and turbine gas meters		WD	WD
TC 9 Instruments for measuring mass and density			
• Revision R 60: Metrological regulation for load cells		I CD	2 CD
TC 9/SC 1 Nonautomatic weighing instruments			
• Revision R 76-1: Nonautomatic weighing instruments		—	I CD
TC 9/SC 2 Automatic weighing instruments			
• Annex to R 50: Test procedures and test report format for the evaluation of continuous totalizing automatic weighing instruments		Appr.	R
• Revision R 51: Automatic catchweighing instruments (including test procedures and test report format)		R	—
• Revision R 61: Automatic gravimetric filling instruments (including test procedures and test report format)		R	—
• Annex to R 106: Test procedures and test report format for the evaluation of automatic rail-weighbridges		R	R
• Annex to R 107: Test procedures and test report format for the evaluation of discontinuous totalizing automatic weighing instruments		R	R
• Automatic instruments for weighing road vehicles in motion		2 CD	2 CD
TC 9/SC 3 Weights			
• Annex to R 111: Test procedures and test report format for the evaluation of weights of classes E ₁ , E ₂ , F ₁ , F ₂ , M ₁ , M ₂ , M ₃		WD	I CD
TC 10/SC 1 Pressure balances			
• Pressure transducers with uniform output signal		WD	I CD

OIML TECHNICAL ACTIVITIES

TC 10/SC 2 Pressure gauges with elastic sensing elements

- Pressure transmitters with elastic sensing elements
- Annex to R 101: Test procedures and test report format for the evaluation of indicating and recording pressure gauges, vacuum gauges and pressure vacuum gauges with elastic sensing elements (ordinary instruments)
- Annex to R 109: Test procedures and test report format for the evaluation of pressure gauges and vacuum gauges with elastic sensing elements (standard instruments)

1996

—

CD

CD

1997

WD

DR

DR

TC 10/SC 4 Material testing machines

- Requirements for force measuring instruments for verifying materials testing machines
- Force measuring systems of materials testing machines (Revision R 64: General requirements for materials testing machines and Revision R 65: Requirements for machines for tension and compression testing of materials)

WD

3 CD

1 CD

3 CD

TC 10/SC 5 Hardness standardized blocks and hardness testing machines

- International intercomparison of hardness blocks (Rockwell hardness blocks)

—

Plan for
inter-
comparison**TC 10/SC 6 Strain gauges**

- Revision R 62: Performance characteristics of metallic resistance strain gauges

—

WD

TC 11 Instruments for measuring temperature and associated quantities

- Revision R 75: Heat meters

—

WD

TC 11/SC 1 Resistance thermometers

- Revision R 84: Resistance-thermometer sensors made of platinum, copper or nickel (for industrial and commercial use) and inclusion of metallic electrical platinum, copper and nickel resistance thermometers with extended range

WD

1 CD

TC 11/SC 2 Contact thermometers

- Standardized thermocouples
- Liquid-in-glass thermometers

WD

2 CD

1 CD

2 CD

OIML TECHNICAL ACTIVITIES		1996	1997
TC 11/SC 3 Radiation thermometers			
• Revision R 18: Visual disappearing filament pyrometers		WD	DR
• Revision R 48: Tungsten ribbon lamps for calibration of optical pyrometers		WD	DR
TC 12 Instruments for measuring electrical quantities			
• Revision R 46: Active electrical energy meters for direct connection of class 2		–	WD
• Verification of watthour meters		–	WD
TC 13 Measuring instruments for acoustics and vibration			
• Revision R 58 including development of Annex: Test report format for the evaluation of sound level meters		Appr.	R
• Revision R 88 including development of Annex: Test report format for the evaluation of integrating-averaging sound level meters		Appr.	R
• Revision R 102: Sound calibrators		–	WD
• Annex to R 104: Test report format for the evaluation of pure-tone audiometers		R	R
• Annexes to R 122: Test procedures and test report format for the evaluation of equipment for speech audiometry		WD	WD
• Octave-band and fractional octave-band filters		2 CD	3 CD
TC 14 Measuring instruments used for optics			
• Annex to R 93: Test report format for focimeters		DR	Vote / Appr.
TC 15 Measuring instruments for ionizing radiations			
• Radiochromic film dosimetry system for measuring absorbed dose in products from gamma and electron radiation		3 CD	3 CD
TC 16/SC 1 Air pollution			
• Revision R 99 including development of Annex: Test report format for the evaluation of instruments for measuring vehicle exhaust emissions		2 CD	DR
TC 16/SC 2 Water pollution			
• Revision R 83: Gas chromatograph - mass spectrometer		WD	1 CD
• Revision R 100: Atomic absorption spectrometers for measuring metal pollutants in water		WD	1 CD

OIML TECHNICAL ACTIVITIES

TC 16/SC 3 Pesticides and other pollutant toxic substances

- Revision R 82: Gas chromatographs for measuring pollution from pesticides and other toxic substances

1996

WD

1997

I CD

TC 16/SC 4 Field measurements of hazardous (toxic) pollutants

- Portable and transportable X-ray fluorescence spectrometers for field measurement of hazardous elemental pollutants - R 123
- Air sampling devices for toxic chemical pollutants at hazardous waste sites
- Fourier transform infrared spectrometers for measurement of hazardous chemical products

R

R

WD

I CD

WD

I CD

TC 17/SC 1 Humidity

- The scale of relative humidity of air certified against saturated salt solutions - R 121

R

-

TC 17/SC 2 Saccharimetry

- Refractometers for measuring the sugar content of grape must - R 124

Appr.

R

TC 17/SC 3 pH-metry

- Revision R 54: pH-scale for aqueous solutions
- Method of carrying out pH-measurements. Certification methods of solutions for verification of pH-meters

DR

Postponed

I CD

Postponed

TC 17/SC 4 Conductometry

- Methods of measurement of the conductivity of electrolytic solutions
- Hierarchy scheme for instruments measuring the electrolytic conductivity

I CD

I CD

WD

I CD

TC 17/SC 5 Viscometry

- Newtonian viscosity standard specimens for the calibration and verification of viscometers
- Procedure for the kinematic viscosity measurements by means of standard viscometers

CD

DR

2 CD

DR

TC 17/SC 6 Gas analysis

- Revision R 73: Requirements concerning pure gases CO, CO₂, CH₄, H₂, O₂, N₂ and Ar intended for the preparation of reference gas mixtures

WD

I CD

OIML TECHNICAL ACTIVITIES

TC 17/SC 7 Breath analyzers

- Evidential breath analyzers

TC 18 Medical measuring instruments

- Ergometers for foot crank work: definitions, requirements, tests

TC 18/SC 1 Blood pressure instruments

- Revision R 16: Manometers for instruments for measuring blood pressure (sphygmomanometers)

1996

DR

1 CD

4 CD

1997

DR / Vote

2 CD

DR

Committee drafts received by BIML*December 1996–February 1997*

Stage of development	Title	TC/SC	Secretariat
2 CD	Automatic instruments for weighing road vehicles in motion	TC 9/SC 2	UK
2 CD	Octave-band and fractional octave-band filters	TC 13	Germany
5 CD	Instruments measuring the area of leathers	TC 7/SC 3	Hungary
1 CD	Revision of OIML D 9: Principles of metrological supervision	TC 3/SC 2	Czech Republic
1 CD	Pressure transducers with unified (4–20) mA or (10–50) mA output signal	TC 10/SC 1	Czech Republic
1 CD	Methods of measurement of the conductivity of electrolytic solutions	TC 17/SC 4	Russia

MEETINGS



REUNIONS

PRESIDENTIAL
COUNCIL MEETING

Mr. G. J. Faber, CIML President, convened a meeting of its Council at the BIML on 17th and 18th February 1997. Prior to the meeting, Mr. Faber had extended the constitution of the Council by requesting the presence of Messrs. Li Chuanqing* (China), Kurita (Japan) and Magana (France) in addition to the two Vice Presidents Messrs. Chappell (USA) and Kochsiek (Germany), and Messrs. Birch (Australia), Bennett (United Kingdom) and Issaev (Russia).

The Director of the BIML acted as secretary to the meeting, part of which was also attended by members of the Bureau's technical staff.

Lastly, Mr. Faber requested the immediate past President, Mr. Birkeland, to represent OIML at the National Metrology Institutes Directors' meeting (held at the BIPM on the same dates) and then to meet up with him during the afternoon of Tuesday 18th, in order to inform Council Members of the results of this meeting and participate in the discussions concerning the rapprochement with the BIPM.

After being given information about the OIML's general and financial situation, its technical activities, the launch of an Internet

site and the state of preparations for the forthcoming CIML meeting, the Council examined in more detail a number of questions which are of importance for the future of the Organization.

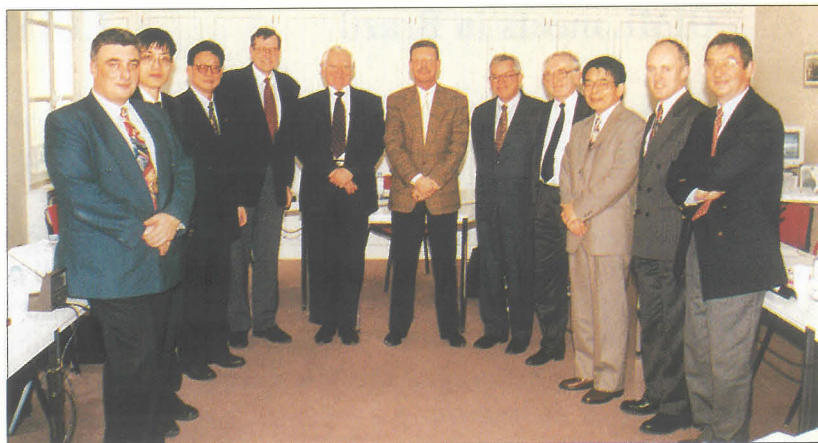
As far as accreditation was concerned, Mr. Faber instructed Mr. Chappell to form and manage a small working group (consisting of Messrs. Bennett, Birch and Athané) with the task of developing the views put forward during the November 1996 round table discussions and those of the Council meeting, especially Mr. Magana's proposal concerning accreditation in the context of the OIML Certificate System.

The subject of activity at regional level was discussed in some depth, with the conclusion that OIML must support regional legal metrology organisms and play a coordinating role, but also that regional cooperation between countries must not prevent the latter from carrying out their duties as OIML Members, particularly as far as the implementation of OIML

Recommendations is concerned. Mr. Faber will shortly be sending a letter on this topic to all OIML Members.

In addition, OIML action in favor of the development of legal metrology was discussed in depth, including the possibility of increased cooperation with IMEKO (and its TC 11 committee) and with the BIPM. As a first step, a detailed analysis of the metrological needs of developing countries - as well as those countries in transition towards a market economy - must be carried out and used as a basis for this future cooperation.

Finally, the Members of the Council made their views about the rapprochement with the BIPM known to Mr. Faber, in order that he may best participate in discussions of the joint BIPM/OIML group which met on 19th February. (If it is deemed appropriate, information about the conclusions of the third BIPM/OIML meeting will be given in a future issue of the OIML Bulletin). ■



Members of the Presidential Council, photographed at BIML

* Mr. Li Chuanqing was unable to attend this meeting and was represented by Messrs. Dong Zheng and Han Jianping, from BEST.

REUNION DU CONSEIL DE PRESIDENCE

M. G. J. Faber, Président du CIML, a réuni son Conseil les 17 et 18 février 1997, au BIML. Il en avait auparavant élargi la composition en demandant à MM. Li Chuanqing* (Chine), Kurita (Japon) et Magana (France) de se joindre aux deux Vice-Présidents Chappell (USA) et Kochsiek (Allemagne) et à MM. Birch (Australie), Bennett (Royaume-Uni) et Issaev (Russie).

Le Directeur du BIML a assuré le secrétariat de la réunion à laquelle les agents techniques du Bureau ont partiellement assisté.

Enfin, M. Faber a demandé au Président sortant, M. Birkeland, de représenter l'OIML à la réunion des Directeurs des Instituts Nationaux de Métrologie, organisée au BIPM aux mêmes dates, puis de le rejoindre le mardi 18 après-midi, pour informer les membres du

* Dans l'impossibilité de participer à la réunion, M. Li Chuanqing s'est fait représenter par MM. Dong Zheng et Han Jianping, du BEST.

Conseil des résultats de cette réunion et participer aux discussions sur le rapprochement avec le BIPM.

Après avoir pris connaissance d'informations sur la situation générale et financière de l'OIML, ses activités techniques, l'ouverture d'un site sur Internet, et les préparatifs pour la prochaine réunion du CIML, le Conseil a examiné plus en détail un certain nombre de questions d'importance pour le futur de l'Organisation.

En ce qui concerne les questions d'accréditation, M. Faber a chargé M. Chappell d'animer un petit groupe de travail (MM. Bennett, Birch et Athané) chargé de développer les vues présentées lors de la table ronde de Novembre 1996 et lors de la réunion du Conseil, en particulier une proposition de M. Magana sur l'accréditation dans le cadre du Système de Certificats OIML.

L'activité au niveau régional a fait l'objet d'une discussion approfondie, concluant sur le soutien que l'OIML se doit d'apporter aux organismes régionaux de métrologie légale, sur son rôle coordinateur, mais aussi sur le fait que la coopération régionale ne doit pas

empêcher les pays de satisfaire à leurs obligations de Membres de l'OIML, en ce qui concerne en particulier la mise en application des Recommandations OIML. Une lettre à ce sujet sera prochainement adressée par M. Faber à tous les membres de l'OIML.

L'action de l'OIML en faveur du développement de la métrologie légale a par ailleurs été longuement discutée, en liaison avec la possibilité d'une coopération accrue avec l'IMEKO (et son comité TC 11) et avec le BIPM. Dans un premier temps, une analyse détaillée des besoins en matière de métrologie des pays en développement, mais aussi des pays en transition vers une économie de marché, doit être effectuée pour servir de base à cette future coopération.

Enfin, les Membres du Conseil ont fait part à M. Faber de leurs vues sur le rapprochement avec le BIPM, afin de lui permettre de mener au mieux les discussions du groupe conjoint BIPM/OIML, qui s'est réuni le 19 février (si approprié, des informations sur les conclusions de la troisième réunion BIPM/OIML seront données dans un prochain numéro du Bulletin OIML). ■

OIML meets in Brazil

The 32nd CIML meeting will be held in Rio on 29-31 October 1997. It will be preceded by a meeting of the OIML Development Council and by a seminar, the aim of which is to reinforce cooperation between OIML and legal metrology organisms in the South and Central American countries. There will also be a meeting of the *Sistema Interamericano de Metrologia*.

L'OIML se réunit au Brésil

La 32^{ème} réunion du CIML aura lieu à Rio du 29 au 31 octobre 1997. Elle sera précédée d'une réunion du Conseil de Développement de l'OIML, d'un séminaire destiné en particulier à renforcer la coopération entre l'OIML et les organismes de métrologie légale des pays d'Amérique du Sud et Centrale, ainsi que d'une réunion du *Sistema Interamericano de Metrologia*.

TC 17/SC 7

Drink-drivers, watch out!

OIML is adding the final touch to the regulations on breath analyzers

Thirty-five people representing thirteen countries (Australia, Austria, France, Germany, Hungary, Macedonia, Netherlands, Norway, Poland, Russia, United Kingdom, USA and Yugoslavia) and the BIML met in Paris on 20th and 21st February 1997 to endeavor to conclude OIML work on evidential breath analyzers. It is of note that a wide range of organisms are involved with this work, amongst which legal metrology services, police forces, forensic laboratories, test laboratories and instrument manufacturers.

At the beginning of 1996, a draft Recommendation which had been developed over the previous four or five years had in fact been rejected during a postal inquiry carried out amongst all Member States; this was due to the still quite widespread differences in certain countries' national legislations.

It must be said that the problem of breath analyzers is not that simple. Besides the purely metrological aspects (which are now more or less resolved), a number of legal aspects also arise, such as:

- how can the reliability of instruments be increased in order to ensure that drivers are not wrongly convicted;
- how should the numerous substances which interfere with the ethanol measurement be taken into account;
- to what degree does the driver's body temperature influence the reading (since nothing stops one from driving with a temperature); or
- how can one differentiate between a driver who is over the limit and one who has just drunk a glass of wine or beer and therefore still has traces of alcohol in his or her mouth.

Moreover in many countries, drink-driving regulations are based on a blood test (which reveals the amount of ethanol in the blood), whereas breath analyzers measure the amount of ethanol in the breath.

The ratio between these two amounts is about 2000, although it varies in line with a number of factors.

These issues have been discussed in various articles - see OIML Bulletins numbers 1 and 3 (1995).

The working group was able to examine all the comments put forward on the most recent draft and indeed find solutions, sometimes leaving national authorities free to fix their own special requirements when consensus could not be reached.

The TC 17/SC 7 Secretariat (France) is now in possession of all the elements necessary to prepare a text - with a view to its approval by the CIML next October - which will at least serve to prevent the development of fundamental differences in national regulations. However, it is anticipated that a revision will rapidly be needed in order to include subjects in the Recommendation such as conversion devices (particularly for temperature) and test procedures for breath analyzers used in the open air.

The application of the OIML Certificate System to these instruments should be possible soon after the publication of the Recommendation in 1998. ■



Participants attending the TC 17/SC 7 meeting in Paris

Conducteurs en état d'ébriété, attention!

L'OIML met un point final à la réglementation des éthylomètres

Trente-cinq personnes représentant treize pays (Allemagne, Australie, Autriche, France, Hongrie, Macédoine, Norvège, Pays-Bas, Pologne, Royaume-Uni, Russie, USA et Yougoslavie) et le BIML se sont réunies à Paris les 20 et 21 février 1997 pour s'efforcer de mettre un point final aux travaux de l'OIML sur les éthylomètres. Il est à remarquer la grande diversité des organismes intéressés par ces travaux, parmi lesquels les services de métrologie légale, l'administration de la police, les laboratoires médico-légaux, les laboratoires d'essai et les constructeurs d'instruments.

Un projet de Recommandation, développé au cours des quatre ou cinq dernières années, avait en effet été refusé lors de l'enquête par correspondance faite, au début de 1996, auprès de tous les États Membres en raison de divergences encore profondes entre certaines législations nationales.

Il faut dire que le problème des éthylomètres n'est pas simple: outre les aspects purement métrologiques qui sont maintenant à peu près résolus, de nombreux aspects juridiques interviennent, tels que:

- comment accroître la fiabilité des instruments afin d'être sûr de ne pas condamner un conducteur à tort;
- comment tenir compte des nombreuses substances qui interfèrent avec la mesure d'éthanol;
- quelle peut être l'influence de la température interne du conducteur (puisque rien n'interdit de conduire si on a de la fièvre); ou encore
- comment différencier le fait qu'un conducteur a trop bu, ou qu'il vient juste de boire un verre de vin ou de bière et a donc encore de l'alcool dans la bouche.

Par ailleurs, dans beaucoup de pays, les réglementations sur la conduite en état d'ivresse se réfèrent au taux d'éthanol dans le sang (mesurable par analyse sanguine) alors que l'éthylomètre mesure la teneur d'éthanol dans d'air exhalé (le rapport entre ces deux quantités est d'environ 2000, mais varie selon beaucoup de facteurs).

Toutes ces considérations ont d'ailleurs fait l'objet de six articles dans les Bulletins OIML Nos. 1 et 3 en 1995.

Le groupe de travail a pu examiner tous les commentaires présentés sur le dernier projet en date et trouver des solutions, parfois en laissant libres les autorités nationales de fixer des exigences particulières lorsqu'un consensus ne pouvait être atteint.

Le secrétariat du TC 17/SC 7 (France) a maintenant tous les éléments pour préparer, en vue de son approbation par le CIML en octobre prochain, un texte qui aura au moins le mérite d'empêcher le développement de divergences fondamentales dans les réglementations nationales. Il est à prévoir cependant qu'une révision devra être entreprise rapidement pour compléter la Recommandation sur des sujets tels que les dispositifs de conversion (en particulier pour la température) et les procédures d'essai des éthylomètres utilisés en plein air.

L'application du Système de Certificats OIML à ces instruments devrait être possible rapidement après la publication de la Recommandation, en 1998. ■



De droite à gauche: M. J-F. Magana (Membre du CIML, France), M. B. Athané (présidant la réunion), M. G. Lagauterie (Secrétaire), et la délégation française



REGISTERED OIML CERTIFICATES – CERTIFICATS OIML ENREGISTRÉS

1996.12 – 1997.02

This list is classified by issuing authority; updated information on these authorities may be obtained from BIML.

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

OIML Recommendation applicable within the System / Year of publication

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

► Issuing authority / Autorité de délivrance

Physikalisch-Technische Bundesanstalt (PTB), Germany

R 76/1992 - DE - 93.01

Sartorius AG
Weender Landstraße 94-108, D-37075 Göttingen, Germany
BA BA 200, BA BB 200, ...

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

Pour chaque Etat Membre, les certificats sont numérotés par ordre de délivrance (cette numérotation est annuelle).

Year of issue
Année de délivrance

The code (ISO) of the Member State in which the certificate was issued.

Le code (ISO) indicatif de l'Etat Membre ayant délivré le certificat.

Manufacturer / Fabricant
Certified pattern(s) / Modèle(s) certifié(s)

INSTRUMENT CATEGORY CATÉGORIE D'INSTRUMENT

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

R 51 (1996)

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

R51/1996-DE-96.02
Bizerba GmbH & Co. KG, Wilhelm-Kraut-Straße 65, D-72336 Balingen, Germany

Type GS, $e \geq 1$ g, $n \leq 6000$ (Classes X(1) and Y(a))

R51/1996-DE-96.03

Bizerba GmbH & Co. KG, Wilhelm-Kraut-Straße 65, D-72336 Balingen, Germany

Type GV, $e \geq 1$ g, $n \leq 6000$ (Classes X(1) and Y(a))

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

R51/1996-NL-96.01
Sipi S.p.a., Via Lazzaretto 10, 21103 Gallarate (VA), Italy
SE 41.PA (Class Y(a))

R51/1996-NL-96.02
Anritsu Corp, 5-10-27 Miamiazabu, Minato-ku, Tokyo, Japan
KW64.. (Class X(1))

R51/1996-NL-96.03

GEC Avery Ltd., Foundry Lane, Smethwick, Warley,
West Midlands, B66 2LP, Great Britain

B806 and B901 (Class Y(a))

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT
Load cells

Cellules de pesée

R 60 (1991), Annex A (1993)

► **Issuing Authority / Autorité de délivrance**

**National Weights and Measures Laboratory (NWML),
United Kingdom**

R60/1991-GB-96.05

Tedea Huntleigh Europe Ltd., 37 Portmanmoor Road,
Cardiff CF2 2HB, Great Britain

Load Cell Model 620 (Class C)

R60/1991-GB-96.06

Sensy S.A., Chaussée de Charleroi 97, 6060 Gilly, Belgium

Load Cell Model No KOE 5593 (Class C)

► **Issuing Authority / Autorité de délivrance**

**Netherlands Measurement Institute (NMI) Certin B.V.,
The Netherlands**

R60/1991-NL-95.09 Rev. 3

Tedea Huntleigh Europe Ltd., 37 Portmanmoor Road,
Cardiff CF2 2HB, Great Britain

220/230 (Classes C and D)

R60/1991-NL-96.06

Epel Industrial S.A., Ctra. Sta. Cruz de Calafell, 35 km.
9,400, 08830 Sant Boi de Llobregat, Barcelona, Spain

LC, $P_i = 0.7$ (Class C)

R60/1991-NL-96.07

MASTER-K, 38, avenue des Frères Montgolfier,
69680 Chassieu Cedex, France

FLX, $P_i = 0.7$ (Class C)

R60/1991-NL-96.08

Mettler-Toledo Inc., 1150 Dearborn Drive, Worthington,
OH 43085-6712, USA

0725, $P_i = 0.7$ (Class C)

R60/1991-NL-96.09 Rev. 1

TesT GmbH, Heinrich-Hertz-Straße, 40699 Erkrath, Germany

308, $P_i = 0.7$ (Class C)

R60/1991-NL-96.10

NBC Elettronica Srl., via Bersagilo 20,
122015 Gravedona (CO), Italy

FX, $P_i = 0.7$ (Class C)

R60/1991-NL-96.11

19 Kanap-ri Kwangjeok-myon, Yangju-kun Kyungki-do,
South Korea

SBA (Class C)

R60/1991-NL-96.12

Hottinger Baldwin Messtechnik GmbH, Im Tiefen See 45,
D-64293 Darmstadt, Germany

PW4FC3 (Class C)

R60/1991-NL-96.13

Balea, 8 avenue du Grand Chêne, Z.A. Les Avants,
34270 Saint-Mathieu de Tréviers, France

SWRC-301.T (Class C)

R60/1991-NL-96.14

Thames Side Scientific Company Ltd., 17 Stadium Way,
Tilehurst, Reading, Berkshire RG30 6BX, Great Britain

T63-501 (Class C)

R60/1991-NL-96.15

Shekel Electronics Scales, Kibbutz Beit Keshet, M.P. Lower
Galilee, 15247, Israël

SH600, temperature limits: 0 °C / 40 °C (Class C)

R60/1991-NL-96.16

Shekel Electronics Scales, Kibbutz Beit Keshet,
M.P. Lower Galilee, 15247, Israël

SH600 (Class C)

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**

**Physikalisch-Technische Bundesanstalt (PTB),
Germany**

R76/1992-DE-93.05 Rev. 2

PAG Oerlikon A.G., Moosmattstraße 32,
CH 8953 Dietikon, Switzerland

Series 300 S and 310 SCS (Class II)

R76/1992-DE-95.03 Rev. 1

Sartorius A.G., Weender Landstraße 94-108,
D-37075 Göttingen, Germany

*BB BD 523, HA BD 523 (Classes II and III)
and DK BD 323 (Class III)*

R76/1992-DE-96.01

Sartorius A.G., Weender Landstraße 94-108,
D-37075 Göttingen, Germany

*MD BF 100 (Class I), MA BF 200 (Class II), BA BF 500
(Classes II and III)*

► **Issuing Authority / Autorité de délivrance**

**Danish Agency for Development of Trade and
Industry, Denmark**

R76/1992-DK-96.01

Leon Engineering S.A., P.O. Box 14118, 115 10 Athens, Greece

D2500 AN2 (Class III)

► **Issuing Authority / Autorité de délivrance**

**National Weights and Measures Laboratory (NWML),
United Kingdom**

R76/1992-GB-96.02

Trevor Deakin Consultants Ltd., Ascot Court, White Horse
Business Park, Trowbridge, Wiltshire, BA14 OXA, Great Britain

Freeweigh portable axle weighbridge (Classe IIII)

► **Issuing Authority / Autorité de délivrance**

**Netherlands Measurement Institute (NMI) Certin B.V.,
The Netherlands**

R76/1992-NL-95.16 Rev. 1

Mettler-Toledo A.G., Im Langacher, 8606 Greifensee, Switzerland

*PR and PG line, Max ≤ 8100 g, e ≥ 0.1 g, e = d or e = 10 d,
n ≤ 81 000 e, Temperature limit: +10 °C / +30 °C (Classes I and II)*

R76/1992-NL-95.22 Rev. 1

Ishida Co., Ltd., 959-1, Shimomagari, Ritto-cho, Kurita-Gun,
Shiga 520-30, Japan

*AC-3000 series, Max ≤ 15 kg, e ≥ 2 g, n ≤ 3000 divisions (per partial
weighing range), maximum of two partial weighing ranges,
operating temperature is 5 °C / +40 °C (Class III)*

R76/1992-NL-95.28 Rev. 2

A&D Instruments Ltd., Abingdon Science Park, Abingdon,
Oxford OX14 3YS, Great Britain

HF and HF-G (Class II)

R76/1992-NL-95.30 Rev. 2

A&D Instruments Ltd., Abingdon Science Park, Abingdon,
Oxford OX14 3YS, Great Britain

HR-EC (Class I)

R76/1992-NL-96.08 Rev. 1

Ishida Co., Ltd., 44, Sanno-cho, Shogoin, Sakayo-ku,
Kyoto 606, Japan

*MTX series, 15 kg ≤ Max ≤ 150 kg, e ≥ 5 g, n ≤ 3000 divisions
(per weighing range), maximum of two weighing ranges, operating
temperature 5 °C / +40 °C (Class III)*

R76/1992-NL-96.14

Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku,
Tokyo 146, Japan

DS685.. (Class III)

R76/1992-NL-96.15 Rev. 1

Yamato Scale Co., Ltd., 5-22 Saenba-cho, Akashi 673, Japan

UDS-1100 (Class III)

R76/1992-NL-96.16

Mettler-Toledo Inc., 1150 Dearborn Drive, Worthington,
OH 43085-6712, USA

Mentor (Class III)

R76/1992-NL-96.17

Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku,
Tokyo 146, Japan

DS-515 (Class III)

R76/1992-NL-96.18

Balea, 8 avenue du Grand Chêne, Z.A. Les Avants,
34270 Saint-Mathieu de Trévières, France

SCAL'UP (Class III)

R76/1992-NL-96.19

Tanita Corporation (Brand names: Tanita, Rhewa),
14-2, 1-Chome, Maeno-cho, Itabashi-ku, Tokyo 174, Japan

TBF-401A (Class III)

R76/1992-NL-96.20

Mettler-Toledo Inc., 1150 Dearborn Drive, Worthington,
OH 43085-6712, USA

PS60 (Classes III and IIII)

R76/1992-NL-96.21 Rev. 1

A&D Instruments Ltd., Abingdon Science Park, Abingdon,
Oxford, OX14 3YS, Great Britain

HM (Class I)

R76/1992-NL-96.22

Tokyo Electric Co., Ltd., 6-78, Minami-cho, Mishima-shi,
Shizuoka-ken 411, Japan

SL 9000 (Class III)

R76/1992-NL-96.23

Mettler-Toledo A.G., Im Langacher, 8606 Greifensee, Switzerland

Spider (Classes III and IIII)

R76/1992-NL-96.24

Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku,
Tokyo 146, Japan

SM-8500.. (Class III)

R76/1992-NL-96.25

Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku,
Tokyo 146, Japan

DPS-3600 (Class III)

R76/1992-NL-96.26

Mettler-Toledo A.G., Im Langacher, 8606 Greifensee, Switzerland

GL and PS (Classes II and III)

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**

**National Weights and Measures Laboratory (NWML),
United Kingdom**

R117/1995-GB-96.01

Schlumberger Electronic Transactions RPS Div., Unit 3,
Baker Road, Pitkerro Industrial Estate, Dundee DD5 3RT,
United Kingdom

*Fuel dispenser for motor vehicles, model PRIMA series
(Class 0.5)*

► **Issuing Authority / Autorité de délivrance**

**Netherlands Measurement Institute (NMI) Certin B.V.,
The Netherlands**

R117/1995-NL-96.01

Schlumberger Technologies LTD, Tulla, Co. Clarc, Ireland

CoCa 1.1 (Class 0.5)

R117/1995-NL-96.02

Schlumberger RPS, Brunel Road, Wester Gourdie, Dundee
DD24TG, Scotland, United Kingdom

SM80 (Class 0.5)

11th WELMEC committee meeting - Brussels, 16-17 January 1997

During this meeting, 29 participants from Full or Associate European WELMEC Member countries together with representatives from the European Commission and the BIML discussed a number of important issues concerning legal metrology in Europe.

Of particular note, as WELMEC Chairman Seton Bennett observed, was the draft Directive on measuring instruments, which the Commission plans to send to the Council of Ministers before the end of 1997.

This very important Directive will fix the foundations of legal metrology in Europe for decades to come. In its Resolution, the WELMEC committee congratulated WG 8 and its Chairman Mr. J-F. Magana on their drafting of proposals for essential requirements for many categories of measuring instruments; the Commission has undertaken to take into account the views of WG 8 in order to reach early agreement on the draft Directive.

The committee decided that all Associate Members should be invited to participate in WELMEC's seven working groups, and agreed to add APLMF, FACOGAZ and MARCOGAZ to the list of Corresponding Organizations.

An overview on the activities of some of the working groups is presented below.

WG 2 *Nonautomatic weighing instruments Directive*

As agreed at the 10th committee meeting, WG 2 also considers aspects of automatic weighing instruments as far as is necessary in support of the *Type Approval Agreement*, and is working to provide a definition on the classification of AWIs and NAWIs. In addition, two new draft Guides are being prepared on the testing of load cells and on the modular approach for type approval.

WG 4 *Quality assurance standards in legal metrology*

A revised Guide for the assessment and operation of notified bodies performing conformity assessment according to Directive 90/384/EEC is in preparation. WG 4 will meet in April 1997 in order to complete this draft, which should be submitted at the next WELMEC committee meeting.

WG 5 *Legal metrology enforcement in Europe*

Preparation of:

- a supplement to the WELMEC European Legal Metrology Directory;
- a Conference on Legal Metrology Enforcement, possibly in the autumn of 1997.

WG 6 *Regulation of packaged goods*

The committee approved the following documents for publication:

- WELMEC 8.1
Terms and Definitions, and
- WELMEC 8.2
Translation of terms (prepackages).

WG 6 will meet in Berlin on 22-23 May 1997 in order to prepare four new draft Guides.

WG 7 *Software*

In order to harmonize type approval practice with respect to the software of measuring instruments, WG 7 will develop a Guide which will include the following:

- terminology (definitions);
- software/firmware requirements, documentation, examination;
- test certificates, reports, checklist.

WG 7 will meet in September 1997.

EMeTAS

The EMeTAS Supervisory Group continues its tasks, in particular the supervision of the financial situation; it will meet in Teddington on 5th June 1997. Special attention will be paid to the development of new products (e.g. a web site). ■



Participants attending the 11th WELMEC committee meeting in Brussels

New publications

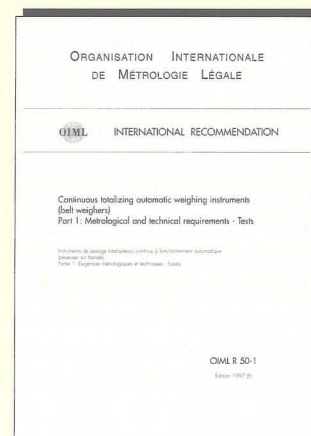
OIML Recommendation

R 50-1 Continuous totalizing automatic weighing instruments (belt weighers)

Part 1: Metrological and technical requirements - Tests

Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande)

Partie 1: Exigences métrologiques et techniques - Essais



Massebestimmung

Book by M. Kochsiek and M. Gläser, PTB Germany

This book, written in the German language and edited by scientists of the Physikalisch-Technische Bundesanstalt, offers an overview of the whole field of mass determination.

It covers the fundamentals of physics including current topics, for example redefinition of the kilogram, the SI system and practically all weighing techniques up to scientific experiments or observations.

The book is aimed at both the expert and everyone concerned with this theme in basic research, technical application, standardization and teaching, since mass determination is of fundamental importance in science, technology and the economy.

Devices and procedures dealt with range from the micro-balance to weighing systems of goods wagons, and from the mass spectrometer to the determination of the masses of celestial bodies.

■ ISBN 3-527-29352-3 Price: DM 298 / FF 265 ■

Determination of mass

Report by R. Balhorn, D. Buer, M. Kochsiek, M. Gläser

When mass is determined, a number of influence quantities are still not taken into consideration. Therefore in this report, the present method of realization and dissemination of the SI unit of "mass kilogram" is described, the uncertainties that can be achieved during mass determination are given and the differences between mass, weight value and conventional weight are also explained.

Methods of mass determination, requirements to be met and test rooms which are needed for relative uncertainties up to 2×10^{-7} or class E_1 are described. In this connection substitution methods, buoyancy of air corrections and estimation of uncertainties are also reported on.

Requirements such as density, magnetic susceptibility, surface roughness and other weight characteristics as well as equipment, environmental conditions and use of the appropriate test rooms are dealt with.

■ PTB report MA-24e: *Determination of mass - Part 1: Dissemination of the unit of mass - balances, weights and test rooms*. ISBN 3-89429-756-5. Price: DM 23.50 + p&p. Available from: Wirtschaftsverlag NW, Verlag für neue Wissenschaft GmbH, Am Alten Hafen 113-115, D-27568 Bremerhaven, Germany ■

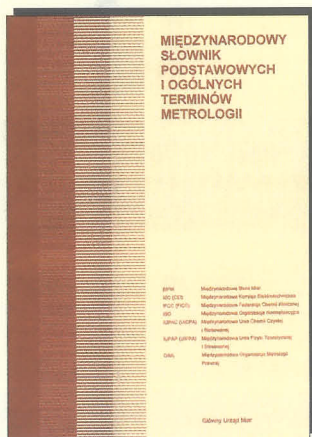


NEWSLETTER

Readers will be interested to know that ILAC publishes a regular complimentary newsletter. In the January 1997 issue, topics addressed include a report on the ILAC '96 Conference in Amsterdam, a summary of work ahead for the new ILAC Committees (which are listed in detail) and other information of general interest.

Please also note ILAC's new address:

Mrs Ann-Margret Gilmour, ILAC Secretariat,
7 Leeds Street, Rhodes 2138, Australia



Polish Vocabulary of Metrology

The *International Vocabulary of Basic and General Terms in Metrology* (1993 edition) has been published in the Polish language (1996) and is available from the Central Office of Measures in Warsaw. ■



Hungarian Guide to the Expression of the Uncertainty in Measurement

The *Guide to the Expression of the Uncertainty in Measurement* (1995 edition) has been published in the Hungarian language (1995) and is available from the Országos Méréügyi Hivatal in Budapest. ■

General Information

To all **INTERNET** users

We will be publishing a list of **INTERNET** contact addresses in future editions of the OIML Bulletin.

If you would like your Organization to be featured in this listing, please send us your full Internet address. To be included in the July 1997 Bulletin, please reply by the end of May.

<http://www.oiml.org>



European Quality Week

"Quality in Europe - at the service of society"

European Quality Week 1997 will take place from Monday November 10 to Sunday November 16 1997. The Week is financially supported by the European Commission and organized by the European Quality Platform, which is a joint venture of the European Organization for Quality (AOQ) and the European Foundation for Quality Management (EFQM).

The *European Quality Week 1997* slogan embodies the philosophy that quality is not just an "exercise", but that it should serve in a practical way to enhance the general quality of life at work - for example the well-being of employees, or the protection of the environment.

Quality Week 1997 promises to be as successful as last year's event, and those who register will receive an information kit compiled based on reports written on last year's Week. Further information may be obtained from Mr. Conrad at the European Organization for Quality in Switzerland:

Tel. +41 31 320 6166 / Fax +41 31 320 6828



October 1997

10	TC 13 Measuring instruments for acoustics and vibration	JAPAN
27	Seminar on legal metrology	RIO, BRAZIL
29	OIML Development Council meeting (morning)	
29-31	32 nd OIML meeting (starting in the afternoon of 29 th October)	

Note: A meeting of the Sistema Interamericano de Metrologia (SIM) will be held on 28th October.



April 1997

9-10	TC 30/SC 12 Measurement of fluid flow in closed conduits Mass flowrate methods	Boulder, USA
28-30	REMCO Committee on Reference Materials	Antwerp, BELGIUM

The OIML is pleased to welcome the following new Corresponding Member:

Ukraine



i n f o



Training course

**19-23 May 1997
Glasgow, UK**

Basic principles and practice of flow measurement

This 5-day NEL course has been designed for those engineers who wish to gain a sound basic knowledge of flow measurement methods, including how to choose the best flowmeters for particular needs.

A series of 19 lectures will cover the following subjects, amongst others:

- Elements of pipe flow and basic metering concepts;
- Different types of meters;
- Mass flow measurement;
- Calibration;
- Density, pressure, temperature and viscosity;
- Data processing;
- Uncertainty in calibration.

The training course will also include practical laboratory demonstrations and informal group discussions.

For further information, please contact Mr. Stewart or Mrs. Campbell, Reynolds Admin. Office, NEL.

Tel. (44) 1355 272361
Fax (44) 1355 272536

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE



SECRETARIAT

BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE

11, RUE TURGOT, 75009 PARIS, FRANCE

TEL: 33 (0)1 48 78 12 82 OR 33 (0)1 42 85 27 11

FAX: 33 (0)1 42 82 17 27

CONTACT INFORMATION

Member States – Members of the International Committee of Legal Metrology

Corresponding Members – National metrology services

PUBLICATIONS

classified by subject and number

International Recommendations

International Documents

Other publications

MEMBER STATES

ALGERIA

Le Directeur
Office National de Métrologie Légale
1, rue Kaddour Rahim
BP 415, 16040 Hussein Dey
Alger
Tel.: 213-2-77 77 37
Telex 65 599

AUSTRALIA

Mr J. Birch
Executive Director
National Standards Commission
P.O. Box 282
North Ryde, N.S.W. 2113
Tel.: 61-2-888 39 22
Fax: 61-2-888 30 33
Telex OTCD AA 100200
(Mail Box 6007: NSC001)

AUSTRIA

Mr R. Galle
Director of the Metrology Service
Gruppe Eichwesen
Bundesamt für Eich- und Vermessungswesen
Postfach 20
Arlgasse 35
A-1163 Wien
Tel.: 43-1-49 11 01
Fax: 43-1-49 20 875

BELARUS

Mr N. A. Kusakin
Chief of the Metrology Department
Standardization, Metrology and
Certification Committee (Belstandart)
93 Starovilensky Trakt
Minsk, 220053
Tel.: 375-172-37 52 13
Fax: 375-172-37 25 88

BELGIUM

Mr H. Voorhof
Conseiller Général
Service de la Métrologie
Ministère des Affaires Economiques
Administration de la Qualité et de la Sécurité
NG III, Bd E. Jacqmain 154
B-1000 Bruxelles
Tel.: 32-2-206 47 35
Fax: 32-2-206 57 45

BRAZIL

Mr R. Luiz de Lima Guimarães
Director of Legal Metrology
Instituto Nacional de Metrologia,
Normalização e Qualidade Industrial
(INMETRO)
Avenida N. S. das Graças, No. 50
Xerém, Duque de Caxias
25250-020 Rio de Janeiro RJ
Tel.: 55-21-679-1407
Fax: 55-21-679-1761

BULGARIA

Mr Krassimir Zhelev
Chef de la Division
Organes nationaux et territoriaux
Comité de Normalisation et de Métrologie
21, rue du 6 Septembre
Sofia 1000
Tel.: 359-2-8591
Fax: 359-2-801402
Telex 22 570 DKS BG

CAMEROON

Le Sous-Directeur des Poids et Mesures
Direction des Prix et de la Protection
du Consommateur
Ministère de l'Economie et des Finances
BP 14 473
Yaoundé
Tel.: 237-22 31 16
Fax: 237-22 35 69
Telex 82-68 à Yaoundé

CANADA

Mr A. E. Johnston
President
Measurement Canada
Industry Canada
Holland Avenue
Ottawa, Ontario K1A 0C9
Tel.: 1-613-952 06 55
Fax: 1-613-957 12 65
Telex 053 3694

CHINA

Mr Li Chuangqing
Director General
State Bureau of Technical Supervision
4, Zhi Chun Lu, Hai Dian
Beijing 100088
Tel.: 86-10-6 203 24 24
Fax: 86-10-6 203 10 10
Telex 210209 SBTSCN
Telegram 1918 Beijing

CUBA

Mr Martin Antunez Ramirez
Director of Metrology
c/o Eng. Alberto Marrero Terrero
Director, International Relations
National Bureau of Standards
Calle E No. 261 entre 11 y 13
Vedado, La Habana 10400
Ciudad de la Habana
Tel.: 53-7-30 00 22
Fax: 53-7-33 80 48
Telex 512245

CYPRUS

Mr G. Tsiartzazis
Controller of Weights and Measures
Ministry of Commerce and Industry
Nicosia
Tel.: 357-2-40 34 41
Fax: 357-2-37 51 20
Telex 2283 MIN COMIND
Telegram Mincommind Nicosia

CZECH REPUBLIC

Mr Pavel Klenovsky
Director General
Czech Metrological Institute
Okružní 31
63800 Brno
Tel.: 420-5-45 22 27 27
Fax: 420-5-45 22 27 28

DENMARK

Mr P. C. Johansen
Assistant Head
Secretariat for Metrology
Danish Agency for Development of Trade and Industry
Tagensvej 135
DK-2200 Copenhagen N
Tel.: 45-35-86-86-86
Fax: 45-35-86-86-87
Telex 15768 INDTRA DK

EGYPT

Mr A. B. El Sebai
President
Egyptian Organization for Standardization
and Quality Control
2 Latin America Street, Garden City
Cairo
Tel.: 20-2-354 97 20
Fax: 20-2-355 78 41
Telex 93 296 EOS UN
Telegram TAWHID

ETHIOPIA

Mr Berhanu Werede
Head of Metrology Department
Ethiopian Authority for Standardization
P.O. Box 2310
Addis Ababa
Tel.: 251-1-61 01 11
Fax: 251-1-61 31 77
Telex 21725 ETHSA ETH

FINLAND

Mrs Marja Leena Junttila
Director, Legal Metrology and
Articles of Precious Metals
Turvateknikan Keskus
Safety Technology Authority
P.O. Box 123 (Lönnrotinkatu 37)
FIN-00181 Helsinki
Tel.: 358-9-40 580 3161
Fax: 358-9 605 474

FRANCE

Mr J. F. Magana
Sous-Directeur de la Métrologie
Ministère de l'Industrie, de la Poste et des
Télécommunications
22, rue Monge
75005 Paris
Tel.: 33-(0)1-43 19 51 40
Fax: 33-(0)1-43 19 51 36

GERMANY

Mr M. Kochsieck
Member of the Presidential Board
Physikalisch-Technische Bundesanstalt
Postfach 3345
D-38023 Braunschweig
Tel.: 49-531-592 30 00
Fax: 49-531-592 30 02
Telex 9-52 822 PTB d
Telegram Bundesphysik Braunschweig

GREECE

Mr A. Dessis
Technical Officer
Directorate of Weights and Measures
Ministry of Commerce
Canning Sq.
10181 Athens
Tel.: 30-1-381 41 68
Fax: 30-1-384 26 42
Telex 21 67 35 DRAG GR
and 21 52 82 YPEM GR

HUNGARY

Mr P. Páky
President
Országos Mérésügyi Hivatal
P.O. Box 919
H-1535 Budapest
Tel.: 36-1-1567 722
Fax: 36-1-1550 598
Telegram HUNGMEETER Budapest

INDIA

Mr P. A. Krishnamoorthy
Director, Weights & Measures
Ministry of Civil Supplies, Consumer Affairs
and Public Distribution
Weights and Measures Unit
12-A, Jam Nagar House, Shahjahan Road
New Delhi 110 011
Tel.: 91-11-338 94 89
Fax: 91-11-338 83 02

INDONESIA

The Director of Metrology
Directorate of Metrology
Directorate General of Domestic Trade
Departemen Perdagangan
Jalan Pasteur 27
40171 Bandung
Tel.: 62-22-44 35 97 and 43 06 09
Fax: 62-22-420 70 35
Telex 28 176 BD

IRAN, ISLAMIC REPUBLIC OF

The Director
Public and International Relations
Institute of Standards and Industrial
Research of Iran
P.O. Box 31585-163
Karaj

IRELAND

Mr S. Murray
Principal Officer
Department of Enterprise and Employment
Frederick Building, Setanta Centre
South Frederick Street,
Dublin 2
Tel.: 353-1-661 44 44
Fax: 353-1-671 74 57
Telex 93478

ISRAEL

Mr A. Ronen
Controller of Weights, Measures
and Standards
Ministry of Industry and Trade
P.O. Box 299
Jerusalem 91002
Tel.: 972-2-75 01 11
Fax: 972-2-24 51 10

ITALY

Mr G. Visconti
Direttore Generale del Commercio Interno
e dei Consumi Industriali
c/o Ufficio Centrale Metrico
Via Antonio Bosio, 15
I-00161 Roma
Tel.: 39-6-841 68 25
Fax: 39-6-841 41 94

JAPAN

Mr Y. Kurita
Director General
National Research Laboratory of Metrology
1-4, Umezono 1-Chome, Tsukuba
Ibaraki 305
Tel.: 81-298-54 41 49
Fax: 81-298-54 41 35
Telex 03652570 AIST
Telegram KEIRYOKEN TSUCHIURA

KAZAKHSTAN

Mr A. Sadikov
Director, Centre
Alma-Ata Standardization and
Metrology Centre
83 Altinsarin Avenue
Alma-Ata 480035
Tel.: 7-327-221 69 72

KENYA

Mr A. E. Ndegwa
Director of Weights and Measures
Weights and Measures Department
Ministry of Commerce and Industry
P.O. Box 41071
Nairobi
Tel.: 254-2-50 46 65/4
Fax: 254-2-50 46 33
Telegram ASSIZERS, Nairobi

DEM. P. REP. OF KOREA

Mr Ho Chang Guk
Vice-President
Committee for Standardization
of the D.P.R. of Korea
Zung Gu Yok Sungli-street
Pyongyang

REP. OF KOREA

Mr Yoon Kyo-Won
Director, International Cooperation
and Metrology Division
Standards and Metrology Department
National Institute of Technology and Quality
1599 Kwanyang-dong, Tong-an-gu
Anyang-shi
Kyunggi-do 431-060
Tel.: 82-343 84 1861
Fax: 82-343.84 6077

MONACO

Mr A. Veglia
Ingénieur au Centre Scientifique de Monaco
16, Boulevard de Suisse
MC-98000 Monte Carlo
Tel.: 33-93-30 33 71

MOROCCO

Mr Abdellah Nejjar
Directeur de la Normalisation et
de la Promotion de la Qualité
Ministère du Commerce et de l'Industrie
Quartier administratif
Rabat-Challah
Tel.: 212-7-76 37 33
Fax: 212-7-76 62 96

NETHERLANDS

Mr G. J. Faber
Director General
Nederlands Meetinstituut nv
Hugo de Grootplein 1
3314 EG Dordrecht
Tel.: 31-78-633 23 32
Fax: 31-78-633 23 09
Telex 38 373 IJKWZ NL

NORWAY

Mr H. Kildal
General Director
Norwegian Metrology
and Accreditation Service
Justervesenet
Fetvæn 99
2007 Kjeller
Tel.: 47-64-84 84 84
Fax: 47-64-84 84 85

PAKISTAN

Mr M. Asad Hasan
Director
Pakistan Standards Institution
39-Garden Road, Saddar
Karachi-74400
Tel.: 92-21-772 95 27
Fax: 92-21-772 81 24
Telegram PEYASAI

POLAND

Mr Krzysztof Mordziński
President
Central Office of Measures
ul. Elekoralna 2
P.O. Box P-10
PL 00-950 Warszawa
Tel.: 48-22-620 07 47
Fax: 48-22-620 83 78

PORTUGAL

Mr J. N. Cartaxo Reis
Director Serviço de Metrologia Legal
Instituto Português da Qualidade
Rua C à Avenida dos Três Vales
2825 Monte da Caparica
Tel.: 351-1-294 81 96
Fax: 351-1-294 81 88

ROMANIA

Mr D. Stoichitoiu
Directeur Général
Bureau Roumain de Métrologie Légale
21, Boulevard Nicolae Balcescu, sector 1
70112 Bucarest
Tel.: 40-1-613 16 54
Fax: 40-1-312 05 01

RUSSIAN FEDERATION

Mr L. K. Issaev
Vice-President
Gosstandart of Russia
Leninsky Prospekt 9
117049 Moscow
Tel.: 7-095-236 40 44
Fax: 7-095 237 60 32
Telex 411 378 GOST
Telegram Moskva-Standart

SAUDI ARABIA

Mr Khaled Y. Al-Khalaf
Director General
Saudi Arabian Standards Organization
P.O. Box 3437
11471 Riyadh
Tel.: 966-1-452 00 00
Fax: 966-1-452 00 86
Telex 40 16 10 saso sj

SLOVAKIA

Mr Lubomir Sutek
President
Úrad pre Normalizáciu
Metrológiu a Skúšobníctvo SR
Štefanovičova 3
814 39 Bratislava
Tel.: 421-7-391 085
Fax: 421-7-391 050

SLOVENIA

Mr Vasja Hrovat
Deputy Director of SMIS
Ministrstvo za znanost in tehnologijo
Urad za standardizacijo in meroslovje
Kotnikova 6
61000 Ljubljana
Tel.: 386-61-178 30 00
Fax: 386-61-178 31 96

SPAIN

The Director
Centro Español de Metrologia
c/ del alfar 2
28760 Tres Cantos (Madrid)
Tel.: 34-1-807 47 00
Fax: 34-1-807 48 07
Telex 47254 CEME E

SRI LANKA

Mr H. L. R. W. Madanayake
Deputy Commissioner of Internal Trade
Measurement Standards
and Services Division
Department of Internal Trade
101, Park Road
Colombo 5
Tel.: 94-1-83 261
Telex 21908 COMECE CF

SWEDEN

Mrs A. Ebbesson
Technical Officer
Section for General Technology
SWEDAC
Box 878
S-501 15 Borås
Tel.: 46-33-17 77 00
Fax: 46-33-10 13 92

SWITZERLAND

Mr B. Vaucher
Vice-Directeur
Office Fédéral de Métrologie
Lindenweg 50
CH-3084 Wabern
Tel.: 41-31-323 32 05
Fax: 41-31-323 32 10
Telegram OFMET

TANZANIA

Mr A. H. M. Tukai
Commissioner for Weights and Measures
Weights and Measures Bureau
Ministry of Industries and Trade
P.O. Box 313
Dar es Salaam
Tel.: 864046/864808
Telex 41 689 INDTRA

**THE FORMER YUGOSLAVE REPUBLIC
OF MACEDONIA**

Mr Grkov Zoran
Assistant to the Minister
Bureau of Standardization and Metrology
Ministry of Economy
Samoilova 10
91000 Skopje
Tel.: 389-91-13 11 02
Fax: 389-91-11 02 63

TUNISIA

Mrs Ghaïet El-Mouna Annabi
 Directeur de la Qualité et de la Protection
 du Consommateur
 Direction Générale de la Concurrence et du
 Commerce Intérieur
 Ministère du Commerce
 6 Rue Venezuela
 1002 Tunis
 Tel.: 216-1-78 08 15
 Fax: 216-1-78 18 47

UNITED KINGDOM

Mr S. Bennett
 Chief Executive
 National Weights and Measures Laboratory
 Stanton Avenue
 Teddington, Middlesex TW 11 OJZ
 Tel.: 44-181-943 72 72
 Fax: 44-181-943 72 70
 Telex 9312131043 (WM G)

UNITED STATES OF AMERICA

Mr S. E. Chappell
 Chief, Standards Management Program, 212
 Office of Standards Services
 National Institute of Standards
 and Technology
 Building 820, Room 162
 Gaithersburg, Maryland 20899
 Tel.: 1-301-975 40 24
 Fax: 1-301-963 28 71
 Telex 197674 NBS UT

ZAMBIA

Mr L. N. Kakumba
 Superintendent Assizer
 Assize Department
 Weights and Measures Office
 Ministry of Commerce and Industry
 P.O. Box 30 989
 Lusaka
 Tel.: 260-1-21 60 62
 Fax: 260-1-22 67 27
 Telegram Assize, LUSAKA
 Telex 45630 COMIND ZA

YUGOSLAVIA

Mr Z. M. Markovic
 Deputy Director
 Federal Bureau of Measures
 and Precious Metals
 Mike Alasa 14
 11000 Beograd
 Tel.: 381-11-328 27 36
 Fax: 381-11-18 16 68
 Telex 11 020 YUZMBG

CIML HONORARY MEMBERS

Mr K. Birkeland (Norway), Immediate Past President of CIML
 Mr V. Ermakov (Russian Federation), former CIML Vice-President
 Mr A. Perlstain (Switzerland), former member of the Presidential Council
 Mr W. Mühe (Germany), former CIML Vice-President
 Mr H. W. Liers (Germany), former member of the Presidential Council

C O R R E S P O N D I N G M E M B E R S

ALBANIA

The Director
 National Directorate
 Drejtoria Kombëtare e Metrologjisë
 dhe e Kalibrimit (DKMK)
 Rruga "Sami Frashëri", Nr.33
 Tirana

BARBADOS

The Director
 Barbados National Standards Institution
 Culloden Road
 St. Michael
 Barbados W.I.

BURKINA FASO

Direction Générale des Prix
 Ministère du Commerce
 et de l'Approvisionnement du Peuple
 BP 19
 Ouagadougou

BAHRAIN

The Responsible of Metrology
 Standards and Metrology Section
 Ministry of Commerce and Agriculture
 P.O. Box 5479
 Manama

BENIN

Direction de la Qualité
 et des Instruments de Mesure
 Ministère du Commerce et du Tourisme
 Cotonou

COLOMBIA

Superintendencia de Industria y Comercio
 Carrera 13 No. 27-00
 Piso 10
 Santafé de Bogotá, D.C.

BANGLADESH

The Director General
 Bangladesh Standards
 and Testing Institution
 116-A Tejgaon Industrial Area
 Dhaka 1208

BOTSWANA

The Permanent Secretary
 Division of Weights and Measures
 Department of Commerce
 and Consumer Affairs
 Private Bag 48
 Gaborone

COSTA RICA

Oficina Nacional de Normas y Unidades
 de Medida
 Ministerio de Economía y Comercio
 Apartado 10 216
 San Jose

CROATIA

Director General
State Office for Standardization
and Metrology
Avenija Vukovar 78
41000 Zagreb

ECUADOR

The General Director
Instituto Ecuatoriano de Normalizacion
Baquerizo Moreno No. 454 y Almagro
Casilla 17-01-3999
Quito

FIJI

The Chief Inspector of Weights and Measures
Ministry of Economic Development, Planning
and Tourism
Government Buildings
P.O. Box 2118
Suva

GHANA

The Director
Ghana Standards Board
P.O. Box M. 245
Accra

HONG KONG

Commissioner of Customs and Excise
Customs and Excise Department
Trade Department Tower
16/F
700 Nathan Road
Kowloon

ICELAND

The Director
Icelandic Bureau of Legal Metrology
Löggildingarstofan
Sidumula 13
108 Reykjavik

JORDAN

Jordanian Institution for Standardization
and Metrology
P.O. Box 941287
Amman 11194

KUWAIT

The Under Secretary
Ministry of Commerce and Industry
Department of Standards and Metrology
Post Box No 2944
Kuwait

LATVIA

Latvian National Centre of Standardization
and Metrology
157, Kr. Valdemara St.
LV-1013 Riga

LITHUANIA

The Director
Lithuanian Standards Board
T. Kosciuskos g.30
2600 Vilnius

LUXEMBURG

Le Préposé du Service de Métrologie
Administration des Contributions
Zone commerciale et artisanale
Cellule A2
rue J.F. Kennedy
L-7327 Steinsel

MALAWI

The Trade Metrology Manager
Malawi Bureau of Standards
Trade Metrology Division
P.O. Box 156
Lilongwe

MALAYSIA

The Director of Standards
Standards and Industrial Research
Institute of Malaysia
P.O. Box 7035
40911 Shah Alam
Selangor Darul Ehsan

MAURITIUS

The Permanent Secretary
Ministry of Trade and Shipping
(Division of Weights and Measures)
New Government Centre
Port Louis

MEXICO

Direccion General de Normas
Secretaria de Comercio y Fomento Industrial
Sistema Nacional de Calibracion
Ave. Puente de Tecamachalco no. 6
Planta Baja
Lomas de Tecamachalco, Seccion Fuentes
53950 Naucalpan de Juarez

MOLDAVIA

The Director General
Departamentul Standarde, Metrologie
si supraveghere tehnica
al Republicii Moldova
str. S. Lazo, 48
277004, or. Chisinau

MONGOLIA

The Director General
Mongolian National Institute
for Standardization and Metrology
Peace Str.
Ulaanbaatar 51

MOZAMBIQUE

Mrs G. Rebello da Silva
Director
Instituto Nacional de Normalizacao e
Qualidade
Av. 25 de Setembro n° 1179, 2° andar
Maputo

NEPAL

The Chief Inspector
Nepal Bureau of Standards and Metrology
P.B. 985, Sundhara
Kathmandu

NEW ZEALAND

The Manager
Trade Measurement Unit
Ministry of Consumer Affairs
P.O. Box 1473, Wellington

OMAN

The General Director
for Specifications and Measurements
Ministry of Commerce and Industry
P.O. Box 550, Muscat

PANAMA

The Director
Comision Panamena de Normas Industriales
y Tecnicas
Ministerio de Comercio e Industrias
Apartado 9658, Panama 4

PAPUA NEW GUINEA

The Director General
National Institute of Standards
and Industrial Technology
P.O. Box 3042, Boroko

PERU

The Director General
INDECOPI
Instituto Nacional de Defensa de la
Competencia y de la Proteccion de la
Propiedad Intelectual
Prolong. Guardia Civil No.400
Esq. con Av. Canada, San Borja
Lima 41

PHILIPPINES

Bureau of Product Standards
Department of Trade and Industry
3rd floor DTI Building
361 Sen. Gil J. Puyat Avenue
Makati, Metro Manila
Philippines 3117

SEYCHELLES

The Director
Seychelles Bureau of Standards
P.O. Box 648
Victoria

SINGAPORE

Weights and Measures Office
Ministry of Trade and Industry
6 Bright Hill Drive
Singapore 57 95 98

SYRIA

The General Director
The Syrian Arab Organization
for Standardization and Metrology
P.O. Box 11836
Damascus

THAILAND

The Director General
Department of Commercial Registration
Ministry of Commerce
Maharaj Road
Bangkok 10200

TRINIDAD AND TOBAGO

The Director
Trinidad and Tobago Bureau of Standards
Century Drive, Trincity Industrial Estate
P.O. Box 467
Macoya, Tunapuna, Trinidad, W.I

TURKEY

The General Director
Sanayi ve Ticaret Bakanlığı
Ölçüler ve Standardlar Genel
Müdürlüğü
06100 Tandoğan
Ankara

UKRAINE

The President
Derjstandard of Ukraine
vul. Gorkogo 174
252650 KIEV-6
Ukraine

URUGUAY

Director Nacional
Direccion Nacional de Metrologia Legal
Ministerio de Industria, Energia y Minería
Buenos Aires 495
Montevideo

S. R. VIETNAM

General Department for Standardization
Metrology and Quality Control
70 Tran Hung Dao St.
Hanoi

PUBLICATIONS

Below are lists of OIML publications classified by subject and number. The following abbreviations are used: International Recommendation (R), International Document (D), vocabulary (V), miscellaneous publication (P). Publications are available in French and English in the form of separate leaflets, unless otherwise indicated. Prices are given in French-francs and do not include postage. "NC" indicates "no charge".

To order publications, please contact the OIML Secretariat by letter or fax:

BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE
11, RUE TURGOT, 75009 PARIS, FRANCE
TEL: 33 (0)1 48 78 12 82 OR 33 (0)1 42 85 27 11
FAX: 33 (0)1 42 82 17 27

On trouvera ci-dessous une liste des publications OIML classées par sujets et par numéros. Les abréviations suivantes sont utilisées: Recommandation Internationale (R), Document International (D), vocabulaire (V) et autre publication (P). Ces publications sont disponibles en français et en anglais sous forme de fascicules séparés sauf indication contraire. Les prix sont donnés en francs-français et ne comprennent pas les frais d'expédition. "NC" signifie "gratuit".

Ces publications peuvent être commandées par lettre ou fax au BIML (voir adresse plus haut).

General Généralités

R 34 (1979-1974)

Accuracy classes of measuring instruments
Classes de précision des instruments de mesurage

60 FRF

R 42 (1981-1977)

Metal stamps for verification officers
Poinçons de métal pour Agents de vérification

50 FRF

D 1 (1975)

Law on metrology
Loi de métrologie

50 FRF

D 2 (being printed - en cours de publication)

Legal units of measurement
Unités de mesure légales

D 3 (1979)

Legal qualification of measuring instruments
Qualification légale des instruments de mesurage

60 FRF

D 5 (1982)

Principles for the establishment of hierarchy schemes for measuring instruments
Principes pour l'établissement des schémas de hiérarchie des instruments de mesure

60 FRF

D 9 (1984)

Principles of metrological supervision
Principes de la surveillance métrologique

60 FRF

D 12 (1986)

Fields of use of measuring instruments subject to verification
Domaines d'utilisation des instruments de mesure assujettis à la vérification

50 FRF

D 13 (1986)

Guidelines for bi- or multilateral arrangements on the recognition of: test results - pattern approvals - verifications
Conseils pour les arrangements bi- ou multilatéraux de reconnaissance des: résultats d'essais - approbations de modèles - vérifications

50 FRF

D 14 (1989)

Training of legal metrology personnel - Qualification - Training programmes
Formation du personnel en métrologie légale - Qualification - Programmes d'étude

60 FRF

D 15 (1986)

Principles of selection of characteristics for the examination of measuring instruments
Principes du choix des caractéristiques pour l'examen des instruments de mesure usuels

80 FRF

D 16 (1986)

Principles of assurance of metrological control
Principes d'assurance du contrôle métrologique

80 FRF

D 19 (1988)

Pattern evaluation and pattern approval
Essai de modèle et approbation de modèle

80 FRF

D 20 (1988)	80 FRF	D 23 (1993)	80 FRF
Initial and subsequent verification of measuring instruments and processes <i>Vérifications primitive et ultérieure des instruments et processus de mesure</i>		Principles of metrological control of equipment used for verification <i>Principes du contrôle métrologique des équipements utilisés pour la vérification</i>	
V 1 (1978)	100 FRF	P 4 (1986-1987)	100 FRF
Vocabulary of legal metrology (bilingual French-English) <i>Vocabulaire de métrologie légale (bilingue français-anglais)</i>		Verification equipment for National Metrology Services <i>Équipement d'un Service national de métrologie</i>	
V 2 (1993)	200 FRF	P 6 (1987)	100 FRF
International vocabulary of basic and general terms in metrology (bilingual French-English) <i>Vocabulaire international des termes fondamentaux et généraux de métrologie (bilingue français-anglais)</i>		Suppliers of verification equipment (bilingual French-English) <i>Fournisseurs d'équipement de vérification (bilingue français-anglais)</i>	
P 1 (1991)	60 FRF	P 7 (1989)	100 FRF
OIML Certificate System for Measuring Instruments <i>Système de Certificats OIML pour les Instruments de Mesure</i>		Planning of metrology and testing laboratories <i>Planification de laboratoires de métrologie et d'essais</i>	
P 2 (1987)	100 FRF	P 15 (1989)	100 FRF
Metrology training - Synthesis and bibliography (bilingual French-English) <i>Formation en métrologie - Synthèse et bibliographie (bilingue français-anglais)</i>		Guide to calibration	
P 3-1 (1996)	400 FRF	Mass and density <i>Masses et masses volumiques</i>	
Legal metrology in OIML Member States <i>Métrologie légale dans les Etats Membres de l'OIML</i>		R 15 (1974-1970)	80 FRF
P 3-2 (1996)	300 FRF	Instruments for measuring the hectolitre mass of cereals <i>Instruments de mesure de la masse à l'hectolitre des céréales</i>	
Legal metrology in OIML Corresponding Members <i>Métrologie légale dans les Membres Correspondants de l'OIML</i>		R 22 (1975)	150 FRF
P 9 (1992)	100 FRF	International alcoholometric tables (trilingual French-English-Spanish version) <i>Tables alcoométriques internationales (version trilingue français-anglais-espagnol)</i>	
Guidelines for the establishment of simplified metrology regulations		R 33 (1979-1973)	50 FRF
P 17 (1995)	300 FRF	Conventional value of the result of weighing in air <i>Valeur conventionnelle du résultat des pesées dans l'air</i>	
Guide to the expression of uncertainty in measurement <i>Guide pour l'expression de l'incertitude de mesure</i>		R 44 (1985)	50 FRF
Measurement standards and verification equipment <i>Étalons et équipement de vérification</i>		Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry <i>Alcoomètres et aréomètres pour alcool et thermomètres utilisés en alcoométrie</i>	
D 6 (1983)	60 FRF	R 47 (1979-1978)	60 FRF
Documentation for measurement standards and calibration devices <i>Documentation pour les étalons et les dispositifs d'étalonnage</i>		Standard weights for testing of high capacity weighing machines <i>Poids étalons pour le contrôle des instruments de pesage de portée élevée</i>	
D 8 (1984)	60 FRF	R 50-1 (1997)	150 FRF
Principles concerning choice, official recognition, use and conservation of measurement standards <i>Principes concernant le choix, la reconnaissance officielle, l'utilisation et la conservation des étalons</i>		Continuous totalizing automatic weighing instruments (Belt weighers). Part 1: Metrological and technical requirements - Tests <i>Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande) Partie 1: Exigences métrologiques et techniques - Essais</i>	
D 10 (1984)	50 FRF	R 50-2 (being printed - en cours de publication)	
Guidelines for the determination of recalibration intervals of measuring equipment used in testing laboratories <i>Conseils pour la détermination des intervalles de réétalonnage des équipements de mesure utilisés dans les laboratoires d'essais</i>		Continuous totalizing automatic weighing instruments (Belt weighers). Part 2: Test report format <i>Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande) Partie 2: Format du rapport d'essai</i>	
D 18 (1987)	50 FRF		
General principles of the use of certified reference materials in measurements <i>Principes généraux d'utilisation des matériaux de référence certifiés dans les mesurages</i>			

R 51-1 (1996)	100 FRF	R 107 (1993)	100 FRF
Automatic catchweighing instruments. Part 1: Metrological and technical requirements - Tests <i>Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais</i>		Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers) <i>Instruments de pesage totalisateurs discontinus à fonction- nement automatique (peseuses totalisatrices à trémie)</i>	
R 51-2 (1996)	300 FRF	Annex (being printed - <i>en cours de publication</i>) Test procedures and test report format <i>Procédures d'essai et format du rapport d'essai</i>	
Automatic catchweighing instruments. Part 2: Test report format <i>Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique. Partie 2: Format du rapport d'essai</i>		R 111 (1994)	80 FRF
R 52 (1980)	50 FRF	Weights of classes $E_1, E_2, F_1, F_2, M_1, M_2, M_3$ <i>Poids des classes $E_1, E_2, F_1, F_2, M_1, M_2, M_3$</i>	
Hexagonal weights, ordinary accuracy class from 100 g to 50 kg <i>Poids hexagonaux de classe de précision ordinaire, de 100 g à 50 kg</i>		P 5 (1992)	100 FRF
R 60 (1991)	80 FRF	Mobile equipment for the verification of road weigh- bridges (bilingual French-English) <i>Équipement mobile pour la vérification des ponts- bascules routiers (bilingue français-anglais)</i>	
Metrological regulation for load cells <i>Réglementation métrologique des cellules de pesée</i>		P 8 (1987)	100 FRF
Annex (1993) Test report format for the evaluation of load cells <i>Format du rapport d'essai des cellules de pesée</i>	80 FRF	Density measurement <i>Mesure de la masse volumique</i>	
R 61-1 (1996)	150 FRF	Length and speed Longueurs et vitesses	
Automatic gravimetric filling instruments. Part 1: Metrological and technical requirements - Tests <i>Doseuses pondérales à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais</i>		R 21 (1975-1973)	60 FRF
R 61-2 (1996)	250 FRF	Taximeters <i>Taximètres</i>	
Automatic gravimetric filling instruments. Part 2: Test report format <i>Doseuses pondérales à fonctionnement automatique. Partie 2: Format du rapport d'essai</i>		R 24 (1975-1973)	50 FRF
R 74 (1993)	80 FRF	Standard one metre bar for verification officers <i>Mètre étalon rigide pour Agents de vérification</i>	
Electronic weighing instruments <i>Instruments de pesage électroniques</i>		R 30 (1981)	60 FRF
R 76-1 (1992)	300 FRF	End standards of length (gauge blocks) <i>Mesures de longueur à bouts plans (cales étalons)</i>	
Nonautomatic weighing instruments Part 1: Metrological and technical requirements - Tests <i>Instruments de pesage à fonctionnement non automatique Partie 1: Exigences métrologiques et techniques - Essais</i>	NC	R 35 (1985)	80 FRF
Amendment No. 1 (1994)		Material measures of length for general use <i>Mesures matérialisées de longueur pour usages généraux</i>	
R 76-2 (1993)	200 FRF	R 55 (1981)	50 FRF
Nonautomatic weighing instruments Part 2: Pattern evaluation report <i>Instruments de pesage à fonctionnement non automatique Partie 2: Rapport d'essai de modèle</i>		Speedometers, mechanical odometers and chrono- tachographs for motor vehicles. Metrological regulations <i>Compteurs de vitesse, compteurs mécaniques de distance et chronotachygraphes des véhicules automobiles. Réglementation métrologique</i>	
Amendment No. 1 (1995)	NC	R 66 (1985)	80 FRF
R 106 (1993)	100 FRF	Length measuring instruments <i>Instruments mesureurs de longueurs</i>	
Automatic rail-weighbridges <i>Ponts-bascules ferroviaires à fonctionnement automatique</i>		R 91 (1990)	60 FRF
Annex (being printed - <i>en cours de publication</i>) Test procedures and test report format <i>Procédures d'essai et format du rapport d'essai</i>		Radar equipment for the measurement of the speed of vehicles <i>Cinémomètres radar pour la mesure de la vitesse des véhicules</i>	
		R 98 (1991)	60 FRF
		High-precision line measures of length <i>Mesures matérialisées de longueur à traits de haute précision</i>	

Liquid measurement Mesurage des liquides

R 4 (1972-1970)	50 FRF	R 86 (1989)	50 FRF
Volumetric flasks (one mark) in glass <i>Fioles jaugées à un trait en verre</i>		Drum meters for alcohol and their supplementary devices <i>Compteurs à tambour pour alcool et leurs dispositifs complémentaires</i>	
R 29 (1979-1973)	50 FRF	R 95 (1990)	60 FRF
Capacity serving measures <i>Mesures de capacité de service</i>		Ships' tanks - General requirements <i>Bateaux-citernes - Prescriptions générales</i>	
R 40 (1981-1977)	60 FRF	R 96 (1990)	50 FRF
Standard graduated pipettes for verification officers <i>Pipettes graduées étalons pour Agents de vérification</i>		Measuring container bottles <i>Bouteilles récipients-mesures</i>	
R 41 (1981-1977)	60 FRF	R 105 (1993)	100 FRF
Standard burettes for verification officers <i>Burettes étalons pour Agents de vérification</i>		Direct mass flow measuring systems for quantities of liquids <i>Ensembles de mesurage massiques directs de quantités de liquides</i>	
R 43 (1981-1977)	60 FRF	Annex (1995)	80 FRF
Standard graduated glass flasks for verification officers <i>Fioles étalons graduées en verre pour Agents de vérification</i>		Test report format <i>Format du rapport d'essai</i>	
R 45 (1980-1977)	50 FRF	R 117 (1995)	400 FRF
Casks and barrels <i>Tonneaux et fûts</i>		Measuring systems for liquids other than water <i>Ensembles de mesurage de liquides autres que l'eau</i>	
R 49 (in revision - en cours de révision)		R 118 (1995)	100 FRF
Water meters intended for the metering of cold water <i>Compteurs d'eau destinés au mesurage de l'eau froide</i>		Testing procedures and test report format for pattern evaluation of fuel dispensers for motor vehicles <i>Procédures d'essai et format du rapport d'essai des modèles de distributeurs de carburant pour véhicules à moteur</i>	
R 63 (1994)	50 FRF	R 119 (1996)	80 FRF
Petroleum measurement tables <i>Tables de mesure du pétrole</i>		Pipe provers for testing measuring systems for liquids other than water <i>Tubes étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau</i>	
R 71 (1985)	80 FRF	R 120 (1996)	100 FRF
Fixed storage tanks. General requirements <i>Réservoirs de stockage fixes. Prescriptions générales</i>		Standard capacity measures for testing measuring systems for liquids other than water <i>Mesures de capacité étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau</i>	
R 72 (1985)	60 FRF	D 4 (1981)	50 FRF
Hot water meters <i>Compteurs d'eau destinés au mesurage de l'eau chaude</i>		Installation and storage conditions for cold water meters <i>Conditions d'installation et de stockage des compteurs d'eau froide</i>	
R 80 (1989)	100 FRF	D 7 (1984)	80 FRF
Road and rail tankers <i>Camions et wagons-citernes</i>		The evaluation of flow standards and facilities used for testing water meters <i>Évaluation des étalons de débitmétrie et des dispositifs utilisés pour l'essai des compteurs d'eau</i>	
R 81 (1989)	80 FRF	D 25 (1996)	60 FRF
Measuring devices and measuring systems for cryogenic liquids (including tables of density for liquid argon, helium, hydrogen, nitrogen and oxygen) <i>Dispositifs et systèmes de mesure de liquides cryogéniques (comprend tables de masse volumique pour argon, hélium, hydrogène, azote et oxygène liquides)</i>		Vortex meters used in measuring systems for fluids <i>Compteurs à vortex utilisés dans les ensembles de mesurage de fluides</i>	
R 85 (1989)	80 FRF	D 26 (being printed - en cours de publication)	
Automatic level gauges for measuring the level of liquid in fixed storage tanks <i>Jaugeurs automatiques pour le mesurage des niveaux de liquide dans les réservoirs de stockage fixes</i>		Glass delivery measures - Automatic pipettes <i>Mesures en verre à délivrer - Pipettes automatiques</i>	

Gas measurement *Mesurage des gaz* ⁽¹⁾

R 6 (1989) 80 FRF
General provisions for gas volume meters
Dispositions générales pour les compteurs de volume de gaz

R 31 (1995) 80 FRF
Diaphragm gas meters
Compteurs de gaz à parois déformables

R 32 (1989) 60 FRF
Rotary piston gas meters and turbine gas meters
Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine

Pressure *Pressions* ⁽²⁾

R 23 (1975-1973) 60 FRF
Tyre pressure gauges for motor vehicles
Manomètres pour pneumatiques de véhicules automobiles

R 53 (1982) 60 FRF
Metrological characteristics of elastic sensing elements used for measurement of pressure.
Determination methods
Caractéristiques métrologiques des éléments récepteurs élastiques utilisés pour le mesurage de la pression. Méthodes de leur détermination

R 97 (1990) 60 FRF
Barometers
Baromètres

R 101 (1991) 80 FRF
Indicating and recording pressure gauges, vacuum gauges and pressure vacuum gauges with elastic sensing elements (ordinary instruments)
Manomètres, vacuomètres et manovacuumètres indicateurs et enregistreurs à élément récepteur élastique (instruments usuels)

R 109 (1993) 60 FRF
Pressure gauges and vacuum gauges with elastic sensing elements (standard instruments)
Manomètres et vacuomètres à élément récepteur élastique (instruments étalons)

R 110 (1994) 80 FRF
Pressure balances
Manomètres à piston

Temperature *Températures* ⁽²⁾

R 18 (1989) 60 FRF
Visual disappearing filament pyrometers
Pyromètres optiques à filament disparaissant

R 48 (1980-1978) 50 FRF
Tungsten ribbon lamps for calibration of optical pyrometers
Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques

R 75 (1988) 60 FRF
Heat meters
Compteurs d'énergie thermique

R 84 (1989) 60 FRF
Resistance-thermometer sensors made of platinum, copper or nickel (for industrial and commercial use)
Capteurs à résistance thermométrique de platine, de cuivre ou de nickel (à usages techniques et commerciaux)

D 24 (1996) 60 FRF
Total radiation pyrometers
Pyromètres à radiation totale

P 16 (1991) 100 FRF
Guide to practical temperature measurements

Electricity *Électricité*

R 46 (1980-1978) 80 FRF
Active electrical energy meters for direct connection of class 2
Compteurs d'énergie électrique active à branchement direct de la classe 2

D 11 (1994) 80 FRF
General requirements for electronic measuring instruments
Exigences générales pour les instruments de mesure électroniques

Acoustics and vibration *Acoustique et vibrations* ⁽¹⁾

R 58 (being printed - en cours de publication)
Sound level meters
Sonomètres

R 88 (being printed - en cours de publication)
Integrating-averaging sound level meters
Sonomètres intégrateurs-moyenmeurs

R 102 (1992) 50 FRF
Sound calibrators
Calibreurs acoustiques

Annex (1995) 80 FRF
Test methods for pattern evaluation and test report format
Méthodes d'essai de modèle et format du rapport d'essai

⁽¹⁾ See also "Liquid measurement" D 25 - Voir aussi "Mesurage des liquides" D 25

⁽²⁾ See also "Medical instruments" - Voir aussi "Instruments médicaux"

R 103 (1992)
Measuring instrumentation for human response to vibration
Appareillage de mesure pour la réponse des individus aux vibrations

R 104 (1993)
Pure-tone audiometers
Audiomètres à sons purs

Annex (being printed - *en cours de publication*)
Test report format
Format du rapport d'essai

Environment Environnement

R 82 (1989)
Gas chromatographs for measuring pollution from pesticides and other toxic substances
Chromatographes en phase gazeuse équipé d'un spectromètre de masse et d'un système de traitement de données pour l'analyse des polluants organiques dans l'eau

R 83 (1990)
Gas chromatograph/mass spectrometer/data system for analysis of organic pollutants in water
Chromatographe de masse et d'un système de traitement de données pour l'analyse des polluants organiques dans l'eau

R 99 (1991)
Instruments for measuring vehicle exhaust emissions
Instruments de mesure des gaz d'échappement des véhicules

R 100 (1991)
Atomic absorption spectrometers for measuring metal pollutants in water
Spectromètres d'absorption atomique pour la mesure des polluants métalliques dans l'eau

R 112 (1994)
High performance liquid chromatographs for measurement of pesticides and other toxic substances
Chromatographes en phase liquide de haute performance pour la mesure des pesticides et autres substances toxiques

R 113 (1994)
Portable gas chromatographs for field measurements of hazardous chemical pollutants
Chromatographes en phase gazeuse portatifs pour la mesure sur site des polluants chimiques dangereux

R 116 (1995)
Inductively coupled plasma atomic emission spectrometers for measurement of metal pollutants in water
Spectromètres à émission atomique de plasma couplé inductivement pour le mesurage des polluants métalliques dans l'eau

R 123 (being printed - *en cours de publication*)
Portable and transportable X-ray fluorescence spectrometers for field measurement of hazardous elemental pollutants
Spectromètres à fluorescence de rayons X portatifs et déplaçables pour la mesure sur le terrain d'éléments polluants dangereux

D 22 (1991)
Guide to portable instruments for assessing airborne pollutants arising from hazardous wastes
Guide sur les instruments portatifs pour l'évaluation des polluants contenus dans l'air en provenance des sites de décharge de déchets dangereux

Physico-chemical measurements Mesures physico-chimiques

R 14 (1995)
Polarimetric saccharimeters
Saccharimètres polarimétriques

R 54 (in revision - *en cours de révision*)
pH scale for aqueous solutions
Echelle de pH des solutions aqueuses

R 56 (1981)
Standard solutions reproducing the conductivity of electrolytes
Solutions-étalons reproduisant la conductivité des électrolytes

R 59 (1984)
Moisture meters for cereal grains and oilseeds
Humidimètres pour grains de céréales et graines oléagineuses

R 68 (1985)
Calibration method for conductivity cells
Méthode d'étalonnage des cellules de conductivité

R 69 (1985)
Glass capillary viscometers for the measurement of kinematic viscosity. Verification method
Viscosimètres à capillaire, en verre, pour la mesure de la viscosité cinématique. Méthode de vérification

R 70 (1985)
Determination of intrinsic and hysteresis errors of gas analysers
Détermination des erreurs de base et d'hystérésis des analyseurs de gaz

R 73 (1985)
Requirements concerning pure gases CO, CO₂, CH₄, H₂, O₂, N₂ and Ar intended for the preparation of reference gas mixtures
Prescriptions pour les gaz purs CO, CO₂, CH₄, H₂, O₂, N₂ et Ar destinés à la préparation des mélanges de gaz de référence

R 92 (1989)
Wood-moisture meters - Verification methods and equipment: general provisions
Humidimètres pour le bois - Méthodes et moyens de vérification: exigences générales

R 108 (1993)	60 FRF	R 114 (1995)	80 FRF
Refractometers for the measurement of the sugar content of fruit juices <i>Réfractomètres pour la mesure de la teneur en sucre des jus de fruits</i>		Clinical electrical thermometers for continuous measurement <i>Thermomètres électriques médicaux pour mesurage en continu</i>	
R 121 (1996)	60 FRF	R 115 (1995)	80 FRF
The scale of relative humidity of air certified against saturated salt solutions <i>Échelle d'humidité relative de l'air certifiée par rapport à des solutions saturées de sels</i>		Clinical electrical thermometers with maximum device <i>Thermomètres électriques médicaux avec dispositif à maximum</i>	
R 124 (being printed - <i>en cours de publication</i>)		R 122 (1996)	60 FRF
Refractometers for the measurement of the sugar content of grape musts <i>Réfractomètres pour la mesure de la teneur en sucre des moûts de raisin</i>		Equipment for speech audiometry <i>Appareils pour l'audiométrie vocale</i>	
D 17 (1987)	30 FRF	D 21 (1990)	80 FRF
Hierarchy scheme for instruments measuring the viscosity of liquids <i>Schéma de hiérarchie des instruments de mesure de la viscosité des liquides</i>		Secondary standard dosimetry laboratories for the calibration of dosimeters used in radiotherapy <i>Laboratoires secondaires d'étalonnage en dosimétrie pour l'étalonnage des dosimètres utilisés en radiothérapie</i>	
Medical instruments Instruments médicaux		Testing of materials Essais des matériaux	
R 7 (1979-1978)	60 FRF	R 9 (1972-1970)	60 FRF
Clinical thermometers, mercury-in-glass with maximum device <i>Thermomètres médicaux à mercure, en verre, avec dispositif à maximum</i>		Verification and calibration of Brinell hardness standardized blocks <i>Vérification et étalonnage des blocs de référence de dureté Brinell</i>	
R 16 (1973-1970)	30 FRF	R 10 (1974-1970)	60 FRF
Manometers for instruments for measuring blood pressure (sphygmomanometers) <i>Manomètres des instruments de mesure de la tension artérielle (sphygmomanomètres)</i>		Verification and calibration of Vickers hardness standardized blocks <i>Vérification et étalonnage des blocs de référence de dureté Vickers</i>	
R 26 (1978-1973)	30 FRF	R 11 (1974-1970)	60 FRF
Medical syringes <i>Seringues médicales</i>		Verification and calibration of Rockwell B hardness standardized blocks <i>Vérification et étalonnage des blocs de référence de dureté Rockwell B</i>	
R 78 (1989)	30 FRF	R 12 (1974-1970)	60 FRF
Westergren tubes for measurement of erythrocyte sedimentation rate <i>Pipettes Westergren pour la mesure de la vitesse de sédimentation des hématies</i>		Verification and calibration of Rockwell C hardness standardized blocks <i>Vérification et étalonnage des blocs de référence de dureté Rockwell C</i>	
R 89 (1990)	80 FRF	R 36 (1980-1977)	60 FRF
Electroencephalographs - Metrological characteristics - Methods and equipment for verification <i>Electroencéphalographes - Caractéristiques métrologiques - Méthodes et moyens de vérification</i>		Verification of indenters for hardness testing machines <i>Vérification des pénétrateurs des machines d'essai de dureté</i>	
R 90 (1990)	80 FRF	R 37 (1981-1977)	60 FRF
Electrocardiographs - Metrological characteristics - Methods and equipment for verification <i>Electrocardiographes - Caractéristiques métrologiques - Méthodes et moyens de vérification</i>		Verification of hardness testing machines (Brinell system) <i>Vérification des machines d'essai de dureté (système Brinell)</i>	
R 93 (1990)	60 FRF	R 38 (1981-1977)	60 FRF
Focimeters <i>Frontofocomètres</i>		Verification of hardness testing machines (Vickers system) <i>Vérification des machines d'essai de dureté (système Vickers)</i>	
		R 39 (1981-1977)	60 FRF
		Verification of hardness testing machines (Rockwell systems B,F,T - C,A,N) <i>Vérification des machines d'essai de dureté (systèmes Rockwell B,F,T - C,A,N)</i>	

R 62 (1985)	80 FRF	P 11 (1983)	100 FRF
Performance characteristics of metallic resistance strain gauges <i>Caractéristiques de performance des extensomètres métalliques à résistance</i>		Factors influencing hardness measurement	
R 64 (1985)	50 FRF	P 12 (1984)	100 FRF
General requirements for materials testing machines <i>Exigences générales pour les machines d'essai des matériaux</i>		Hardness test blocks and indenters	
R 65 (1985)	60 FRF	P 13 (1989)	100 FRF
Requirements for machines for tension and compression testing of materials <i>Exigences pour les machines d'essai des matériaux en traction et en compression</i>		Hardness standard equipment	
V 3 (1991)	80 FRF	P 14 (1991)	100 FRF
Hardness testing dictionary (quadrilingual French-English-German-Russian) <i>Dictionnaire des essais de dureté (quadrilingue français-anglais-allemand-russe)</i>		The unification of hardness measurement	
P 10 (1981)	50 FRF		
The metrology of hardness scales - Bibliography			
		Prepackaging Préemballages	
		R 79 (being printed - <i>en cours de publication</i>)	
		Information on package labels <i>Etiquetage des préemballages</i>	
		R 87 (1989)	50 FRF
		Net content in packages <i>Contenu net des préemballages</i>	

OIML publications classified by number
Publications OIML classées par numéros

INTERNATIONAL RECOMMENDATIONS
RECOMMANDATIONS INTERNATIONALES

R 4 (1970-1972) Volumetric flasks (one mark) in glass <i>Fioles jaugées à un trait en verre</i>	50 FRF	R 22 (1975-1973) International alcoholometric tables (trilingual French-English-Spanish) <i>Tables alcoométriques internationales (trilingue français-anglais-espagnol)</i>	150 FRF
R 6 (1989) General provisions for gas volume meters <i>Dispositions générales pour les compteurs de volume de gaz</i>	80 FRF	R 23 (1975-1973) Tyre pressure gauges for motor vehicles <i>Manomètres pour pneumatiques de véhicules automobiles</i>	60 FRF
R 7 (1979-1978) Clinical thermometers, mercury-in-glass with maximum device <i>Thermomètres médicaux à mercure, en verre, avec dispositif à maximum</i>	60 FRF	R 24 (1975-1973) Standard one metre bar for verification officers <i>Mètre étalon rigide pour agents de vérification</i>	50 FRF
R 9 (1972-1970) Verification and calibration of Brinell hardness standardized blocks <i>Vérification et étalonnage des blocs de référence de dureté Brinell</i>	60 FRF	R 26 (1978-1973) Medical syringes <i>Seringues médicales</i>	50 FRF
R 10 (1974-1970) Verification and calibration of Vickers hardness standardized blocks <i>Vérification et étalonnage des blocs de référence de dureté Vickers</i>	60 FRF	R 29 (1979-1973) Capacity serving measures <i>Mesures de capacité de service</i>	50 FRF
R 11 (1974-1970) Verification and calibration of Rockwell B hardness standardized blocks <i>Vérification et étalonnage des blocs de référence de dureté Rockwell B</i>	60 FRF	R 30 (1981) End standards of length (gauge blocks) <i>Mesures de longueur à bouts plans (cales étalons)</i>	60 FRF
R 12 (1974-1970) Verification and calibration of Rockwell C hardness standardized blocks <i>Vérification et étalonnage des blocs de référence de dureté Rockwell C</i>	60 FRF	R 31 (1995) Diaphragm gas meters <i>Compteurs de gaz à parois déformables</i>	80 FRF
R 14 (1995) Polarimetric saccharimeters <i>Saccharimètres polarimétriques</i>	60 FRF	R 32 (1989) Rotary piston gas meters and turbine gas meters <i>Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine</i>	60 FRF
R 15 (1974-1970) Instruments for measuring the hectolitre mass of cereals <i>Instruments de mesure de la masse à l'hectolitre des céréales</i>	80 FRF	R 33 (1979-1973) Conventional value of the result of weighing in air <i>Valeur conventionnelle du résultat des pesées dans l'air</i>	50 FRF
R 16 (1973-1970) Manometers for instruments for measuring blood pressure (sphygmomanometers) <i>Manomètres des instruments de mesure de la tension artérielle (sphygmomanomètres)</i>	50 FRF	R 34 (1979-1974) Accuracy classes of measuring instruments <i>Classes de précision des instruments de mesurage</i>	60 FRF
R 18 (1989) Visual disappearing filament pyrometers <i>Pyromètres optiques à filament disparaissant</i>	60 FRF	R 35 (1985) Material measures of length for general use <i>Mesures matérialisées de longueur pour usages généraux</i>	80 FRF
R 21 (1975-1973) Taximeters <i>Taximètres</i>	60 FRF	R 36 (1980-1977) Verification of indenters for hardness testing machines <i>Vérification des pénétrateurs des machines d'essai de dureté</i>	60 FRF
		R 37 (1981-1977) Verification of hardness testing machines (Brinell system) <i>Vérification des machines d'essai de dureté (système Brinell)</i>	60 FRF
		R 38 (1981-1977) Verification of hardness testing machines (Vickers system) <i>Vérification des machines d'essai de dureté (système Vickers)</i>	60 FRF
		R 39 (1981-1977) Verification of hardness testing machines (Rockwell systems B,F,T-C,A,N) <i>Vérification des machines d'essai de dureté (systèmes Rockwell B,F,T-C,A,N)</i>	60 FRF


R 40 (1981-1977) Standard graduated pipettes for verification officers <i>Pipettes graduées étalons pour agents de vérification</i>	60 FRF	R 51-2 (1996) Automatic catchweighing instruments. Part 2: Test report format <i>Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique. Partie 2: Format du rapport d'essai</i>	300 FRF
R 41 (1981-1977) Standard burettes for verification officers <i>Burettes étalons pour agents de vérification</i>	60 FRF	R 52 (1980) Hexagonal weights, ordinary accuracy class from 100 g to 50 kg <i>Poids hexagonaux de classe de précision ordinaire, de 100 g à 50 kg</i>	50 FRF
R 42 (1981-1977) Metal stamps for verification officers <i>Poinçons de métal pour agents de vérification</i>	50 FRF	R 53 (1982) Metrological characteristics of elastic sensing elements used for measurement of pressure. Determination methods <i>Caractéristiques métrologiques des éléments récepteurs élastiques utilisés pour le mesurage de la pression. Méthodes de leur détermination</i>	60 FRF
R 43 (1981-1977) Standard graduated glass flasks for verification officers <i>Fioles étalons graduées en verre pour agents de vérification</i>	60 FRF	R 54 (in revision - en cours de révision) pH scale for aqueous solutions <i>Echelle de pH des solutions aqueuses</i>	
R 44 (1985) Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry <i>Alcoomètres et aréomètres pour alcool et thermomètres utilisés en alcoométrie</i>	50 FRF	R 55 (1981) Speedometers, mechanical odometers and chronotachographs for motor vehicles. Metrological regulations <i>Compteurs de vitesse, compteurs mécaniques de distance et chronotachygraphes des véhicules automobiles. Réglementation métrologique</i>	50 FRF
R 45 (1980-1977) Casks and barrels <i>Tonneaux et fûts</i>	50 FRF	R 56 (1981) Standard solutions reproducing the conductivity of electrolytes <i>Solutions-étalons reproduisant la conductivité des électrolytes</i>	50 FRF
R 46 (1980-1978) Active electrical energy meters for direct connection of class 2 <i>Compteurs d'énergie électrique active à branchement direct de la classe 2</i>	80 FRF	R 58 (being printed - en cours de publication) Sound level meters <i>Sonomètres</i>	
R 47 (1979-1978) Standard weights for testing of high capacity weighing machines <i>Poids étalons pour le contrôle des instruments de pesage de portée élevée</i>	60 FRF	R 59 (1984) Moisture meters for cereal grains and oilseeds <i>Humidimètres pour grains de céréales et graines oléagineuses</i>	80 FRF
R 48 (1980-1978) Tungsten ribbon lamps for calibration of optical pyrometers <i>Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques</i>	50 FRF	R 60 (1991) Metrological regulation for load cells <i>Réglementation métrologique des cellules de pesée</i>	80 FRF
R 49 (in revision - en cours de révision) Water meters intended for the metering of cold water <i>Compteurs d'eau destinés au mesurage de l'eau froide</i>		Annex (1993) Test report format for the evaluation of load cells <i>Format du rapport d'essai des cellules de pesée</i>	80 FRF
R 50-1 (1997) Continuous totalizing automatic weighing instruments (Belt weighers). Part 1: Metrological and technical requirements - Tests <i>Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande). Partie 1: Exigences métrologiques et techniques - Essais</i>	150 FRF	R 61-1 (1996) Automatic gravimetric filling instruments. Part 1: Metrological and test requirements - Tests <i>Doseuses pondérales à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais</i>	150 FRF
R 50-2 (being printed - en cours de publication) Continuous totalizing automatic weighing instruments (Belt weighers). Part 2: Test report format <i>Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande). Partie 2: Format du rapport d'essai</i>		R 61-2 (1996) Automatic gravimetric filling instruments. Part 2: Test report format <i>Doseuses pondérales à fonctionnement automatique. Partie 2: Format du rapport d'essai</i>	250 FRF
R 51-1 (1996) Automatic catchweighing instruments. Part 1: Metrological and technical requirements - Tests <i>Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais</i>	100 FRF	R 62 (1985) Performance characteristics of metallic resistance strain gauges <i>Caractéristiques de performance des extensomètres métalliques à résistance</i>	80 FRF
		R 63 (1994) Petroleum measurement tables <i>Tables de mesure du pétrole</i>	50 FRF

R 64 (1985) General requirements for materials testing machines <i>Exigences générales pour les machines d'essai des matériaux</i>	50 FRF	R 79 (being printed - en cours de publication) Information on package labels <i>Etiquetage des préemballages</i>	
R 65 (1985) Requirements for machines for tension and compression testing of materials <i>Exigences pour les machines d'essai des matériaux en traction et en compression</i>	60 FRF	R 80 (1989) Road and rail tankers <i>Camions et wagons-citernes</i>	100 FRF
R 66 (1985) Length measuring instruments <i>Instruments mesureurs de longueurs</i>	60 FRF	R 81 (1989) Measuring devices and measuring systems for cryogenic liquids (including tables of density for liquid argon, helium, hydrogen, nitrogen and oxygen) <i>Dispositifs et systèmes de mesure de liquides cryogéniques (comprend tables de masse volumique pour argon, hélium, hydrogène, azote et oxygène liquides)</i>	80 FRF
R 68 (1985) Calibration method for conductivity cells <i>Méthode d'étalonnage des cellules de conductivité</i>	50 FRF	R 82 (1989) Gas chromatographs for measuring pollution from pesticides and other toxic substances <i>Chromatographes en phase gazeuse pour la mesure des pollutions par pesticides et autres substances toxiques</i>	80 FRF
R 69 (1985) Glass capillary viscometers for the measurement of kinematic viscosity. Verification method <i>Viscosimètres à capillaire, en verre, pour la mesure de la viscosité cinématique. Méthode de vérification</i>	50 FRF	R 83 (1990) Gas chromatograph/mass spectrometer/data system for analysis of organic pollutants in water <i>Chromatographe en phase gazeuse équipé d'un spectromètre de masse et d'un système de traitement de données pour l'analyse des polluants organiques dans l'eau</i>	80 FRF
R 70 (1985) Determination of intrinsic and hysteresis errors of gas analysers <i>Détermination des erreurs de base et d'hystérésis des analyseurs de gaz</i>	50 FRF	R 84 (1989) Resistance-thermometer sensors made of platinum, copper or nickel (for industrial and commercial use) <i>Capteurs à résistance thermométrique de platine, de cuivre ou de nickel (à usages techniques et commerciaux)</i>	60 FRF
R 71 (1985) Fixed storage tanks. General requirements <i>Réservoirs de stockage fixes. Prescriptions générales</i>	80 FRF	R 85 (1989) Automatic level gauges for measuring the level of liquid in fixed storage tanks <i>Jaugeurs automatiques pour le mesurage des niveaux de liquide dans les réservoirs de stockage fixes</i>	80 FRF
R 72 (1985) Hot water meters <i>Compteurs d'eau destinés au mesurage de l'eau chaude</i>	60 FRF	R 86 (1989) Drum meters for alcohol and their supplementary devices <i>Compteurs à tambour pour alcool et leurs dispositifs complémentaires</i>	50 FRF
R 73 (1985) Requirements concerning pure gases CO, CO ₂ , CH ₄ , H ₂ , O ₂ , N ₂ and Ar intended for the preparation of reference gas mixtures <i>Prescriptions pour les gaz purs CO, CO₂, CH₄, H₂, O₂, N₂ et Ar destinés à la préparation des mélanges de gaz de référence</i>	50 FRF	R 87 (1989) Net content in packages <i>Contenu net des préemballages</i>	50 FRF
R 74 (1993) Electronic weighing instruments <i>Instruments de pesage électroniques</i>	80 FRF	R 88 (being printed - en cours de publication) Integrating-averaging sound level meters <i>Sonomètres intégrateurs-moyenneurs</i>	
R 75 (1988) Heat meters <i>Compteurs d'énergie thermique</i>	60 FRF	R 89 (1990) Electroencephalographs - Metrological characteristics - Methods and equipment for verification <i>Electroencéphalographes - Caractéristiques métrologiques - Méthodes et moyens de vérification</i>	80 FRF
R 76-1 (1992) Nonautomatic weighing instruments. Part 1: Metrological and technical requirements - Tests <i>Instruments de pesage à fonctionnement non automatique. Partie 1: Exigences métrologiques et techniques - Essais</i> Amendment No. 1 (1994)	300 FRF NC	R 90 (1990) Electrocardiographs - Metrological characteristics - Methods and equipment for verification <i>Electrocardiographes - Caractéristiques métrologiques - Méthodes et moyens de vérification</i>	80 FRF
R 76-2 (1993) Nonautomatic weighing instruments. Part 2: Pattern evaluation report <i>Instruments de pesage à fonctionnement non automatique. Partie 2: Rapport d'essai de modèle</i> Amendment No. 1 (1995)	200 FRF NC	R 91 (1990) Radar equipment for the measurement of the speed of vehicles <i>Cinémomètres radar pour la mesure de la vitesse des véhicules</i>	60 FRF
R 78 (1989) Westergren tubes for measurement of erythrocyte sedimentation rate <i>Pipettes Westergren pour la mesure de la vitesse de sédimentation des hématies</i>	50 FRF		

R 92 (1989) Wood-moisture meters - Verification methods and equipment: general provisions <i>Humidimètres pour le bois - Méthodes et moyens de vérification: exigences générales</i>	60 FRF	R 106 (1993) Automatic rail-weighbridges <i>Ponts-bascules ferroviaires à fonctionnement automatique</i>	100 FRF
R 93 (1990) Focimeters <i>Frontofocomètres</i>	60 FRF	Annex (being printed - en cours de publication) Test procedures and test report format <i>Procédures d'essai et format du rapport d'essai</i>	
R 95 (1990) Ships' tanks - General requirements <i>Bateaux-citernes - Prescriptions générales</i>	60 FRF	R 107 (1993) Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers) <i>Instruments de pesage totalisateurs discontinus à fonctionnement automatique (peseuses totalisatrices à trémie)</i>	100 FRF
R 96 (1990) Measuring container bottles <i>Bouteilles récepteurs-mesures</i>	50 FRF	Annex (being printed - en cours de publication) Test procedures and test report format <i>Procédures d'essai et format du rapport d'essai</i>	
R 97 (1990) Barometers <i>Baromètres</i>	60 FRF	R 108 (1993) Refractometers for the measurement of the sugar content of fruit juices <i>Réfractomètres pour la mesure de la teneur en sucre des jus de fruits</i>	60 FRF
R 98 (1991) High-precision line measures of length <i>Mesures matérialisées de longueur à traits de haute précision</i>	60 FRF	R 109 (1993) Pressure gauges and vacuum gauges with elastic sensing elements (standard instruments) <i>Manomètres et vacuomètres à élément récepteur élastique (instruments étalons)</i>	60 FRF
R 99 (1991) Instruments for measuring vehicle exhaust emissions <i>Instruments de mesure des gaz d'échappement des véhicules</i>	100 FRF	R 110 (1994) Pressure balances <i>Manomètres à piston</i>	80 FRF
R 100 (1991) Atomic absorption spectrometers for measuring metal pollutants in water <i>Spectromètres d'absorption atomique pour la mesure des polluants métalliques dans l'eau</i>	80 FRF	R 111 (1994) Weights of classes $E_1, E_2, F_1, F_2, M_1, M_2, M_3$ <i>Poids des classes $E_1, E_2, F_1, F_2, M_1, M_2, M_3$</i>	80 FRF
R 101 (1991) Indicating and recording pressure gauges, vacuum gauges and pressure vacuum gauges with elastic sensing elements (ordinary instruments) <i>Manomètres, vacuomètres et manovacuumètres indicateurs et enregistreurs à élément récepteur élastique (instruments usuels)</i>	80 FRF	R 112 (1994) High performance liquid chromatographs for measurement of pesticides and other toxic substances <i>Chromatographes en phase liquide de haute performance pour la mesure des pesticides et autres substances toxiques</i>	80 FRF
R 102 (1992) Sound calibrators <i>Calibreurs acoustiques</i>	50 FRF	R 113 (1994) Portable gas chromatographs for field measurements of hazardous chemical pollutants <i>Chromatographes en phase gazeuse portatifs pour la mesure sur site des polluants chimiques dangereux</i>	80 FRF
Annex (1995) Test methods for pattern evaluation and test report format <i>Méthodes d'essai de modèle et format du rapport d'essai</i>	80 FRF	R 114 (1995) Clinical electrical thermometers for continuous measurement <i>Thermomètres électriques médicaux pour mesurage en continu</i>	80 FRF
R 103 (1992) Measuring instrumentation for human response to vibration <i>Appareillage de mesure pour la réponse des individus aux vibrations</i>	60 FRF	R 115 (1995) Clinical electrical thermometers with maximum device <i>Thermomètres électriques médicaux avec dispositif à maximum</i>	80 FRF
R 104 (1993) Pure-tone audiometers <i>Audiomètres à sons purs</i>	60 FRF	R 116 (1995) Inductively coupled plasma atomic emission spectrometers for measurement of metal pollutants in water <i>Spectromètres à émission atomique de plasma couplé inductivement pour le mesurage des polluants métalliques dans l'eau</i>	80 FRF
Annex (being printed - en cours de publication) Test report format <i>Format du rapport d'essai</i>		R 117 (1995) Measuring systems for liquids other than water <i>Ensembles de mesurage de liquides autres que l'eau</i>	400 FRF
R 105 (1993) Direct mass flow measuring systems for quantities of liquids <i>Ensembles de mesurage massiques directs de quantités de liquides</i>	100 FRF		
Annex (1995) Test report format <i>Format du rapport d'essai</i>	80 FRF		

R 118 (1995)	100 FRF	D 6 (1983)	60 FRF
Testing procedures and test report format for pattern evaluation of fuel dispensers for motor vehicles <i>Procédures d'essai et format du rapport d'essai des modèles de distributeurs de carburant pour véhicules à moteur</i>		Documentation for measurement standards and calibration devices <i>Documentation pour les étalons et les dispositifs d'étalonnage</i>	
R 119 (1996)	80 FRF	D 7 (1984)	80 FRF
Pipe provers for testing measuring systems for liquids other than water <i>Tubes étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau</i>		The evaluation of flow standards and facilities used for testing water meters <i>Évaluation des étalons de débitmétrie et des dispositifs utilisés pour l'essai des compteurs d'eau</i>	
R 120 (1996)	100 FRF	D 8 (1984)	60 FRF
Standard capacity measures for testing measuring systems for liquids other than water <i>Mesures de capacité étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau</i>		Principles concerning choice, official recognition, use and conservation of measurement standards <i>Principes concernant le choix, la reconnaissance officielle, l'utilisation et la conservation des étalons</i>	
R 121 (1996)	60 FRF	D 9 (1984)	60 FRF
The scale of relative humidity of air certified against saturated salt solutions <i>Échelle d'humidité relative de l'air certifiée par rapport à des solutions saturées de sels</i>		Principles of metrological supervision <i>Principes de la surveillance métrologique</i>	
R 122 (1996)	60 FRF	D 10 (1984)	50 FRF
Equipment for speech audiometry <i>Appareils pour l'audiométrie vocale</i>		Guidelines for the determination of recalibration intervals of measuring equipment used in testing laboratories <i>Conseils pour la détermination des intervalles de réétalonnage des équipements de mesure utilisés dans les laboratoires d'essais</i>	
R 123 (being printed - en cours de publication)		D 11 (1994)	80 FRF
Portable and transportable X-ray fluorescence spectrometers for field measurement of hazardous elemental pollutants <i>Spectromètres à fluorescence de rayons X portatifs et déplaçables pour la mesure sur le terrain d'éléments polluants dangereux</i>		General requirements for electronic measuring instruments <i>Exigences générales pour les instruments de mesure électroniques</i>	
R 124 (being printed - en cours de publication)		D 12 (1986)	50 FRF
Refractometers for the measurement of the sugar content of grape musts <i>Réfractomètres pour la mesure de la teneur en sucre des moûts de raisin</i>		Fields of use of measuring instruments subject to verification <i>Domaines d'utilisation des instruments de mesure assujettis à la vérification</i>	
INTERNATIONAL DOCUMENTS DOCUMENTS INTERNATIONAUX		D 13 (1986)	50 FRF
D 1 (1975)	50 FRF	Guidelines for bi- or multilateral arrangements on the recognition of test results - pattern approvals - verifications <i>Conseils pour les arrangements bi- ou multilatéraux de reconnaissance des résultats d'essais - approbations de modèles - vérifications</i>	
Law on metrology <i>Loi de métrologie</i>		D 14 (1989)	60 FRF
D 2 (being printed - en cours de publication)		Training of legal metrology personnel - Qualification - Training programs <i>Formation du personnel en métrologie légale - Qualification - Programmes d'étude</i>	
Legal units of measurement <i>Unités de mesure légales</i>		D 15 (1986)	80 FRF
D 3 (1979)	60 FRF	Principles of selection of characteristics for the examination of measuring instruments <i>Principes du choix des caractéristiques pour l'examen des instruments de mesure usuels</i>	
Legal qualification of measuring instruments <i>Qualification légale des instruments de mesurage</i>		D 16 (1986)	80 FRF
D 4 (1981)	50 FRF	Principles of assurance of metrological control <i>Principes d'assurance du contrôle métrologique</i>	
Installation and storage conditions for cold water meters <i>Conditions d'installation et de stockage des compteurs d'eau froide</i>		D 17 (1987)	50 FRF
D 5 (1982)	60 FRF	Hierarchy scheme for instruments measuring the viscosity of liquids <i>Schéma de hiérarchie des instruments de mesure de la viscosité des liquides</i>	
Principles for the establishment of hierarchy schemes for measuring instruments <i>Principes pour l'établissement des schémas de hiérarchie des instruments de mesure</i>		D 18 (1987)	50 FRF
		General principles of the use of certified reference materials in measurements <i>Principes généraux d'utilisation des matériaux de référence certifiés dans les mesurages</i>	

D 19 (1988) Pattern evaluation and pattern approval <i>Essai de modèle et approbation de modèle</i>	80 FRF	P 2 (1987) Metrology training - Synthesis and bibliography (bilingual French-English) <i>Formation en métrologie - Synthèse et bibliographie (bilingue français-anglais)</i>	100 FRF
D 20 (1988) Initial and subsequent verification of measuring instruments and processes <i>Vérifications primitive et ultérieure des instruments et processus de mesure</i>	80 FRF	P 3-1 (1996) Legal metrology in OIML Member States <i>Métrologie légale dans les Etats Membres de l'OIML</i>	400 FRF
D 21 (1990) Secondary standard dosimetry laboratories for the calibration of dosimeters used in radiotherapy <i>Laboratoires secondaires d'étalonnage en dosimétrie pour l'étalonnage des dosimètres utilisés en radiothérapie</i>	80 FRF	P 3-2 (1996) Legal metrology in OIML Corresponding Members <i>Métrologie légale dans les Membres Correspondants de l'OIML</i>	300 FRF
D 22 (1991) Guide to portable instruments for assessing airborne pollutants arising from hazardous wastes <i>Guide sur les instruments portatifs pour l'évaluation des polluants contenus dans l'air en provenance des sites de décharge de déchets dangereux</i>	80 FRF	P 4 (1986-1987) Verification equipment for National Metrology Services <i>Equipement d'un Service national de métrologie</i>	100 FRF
D 23 (1993) Principles of metrological control of equipment used for verification <i>Principes du contrôle métrologique des équipements utilisés pour la vérification</i>	80 FRF	P 5 (1992) Mobile equipment for the verification of road weighbridges (bilingual French-English) <i>Equipement mobile pour la vérification des ponts-bascules routiers (bilingue français-anglais)</i>	100 FRF
D 24 (1996) Total radiation pyrometers <i>Pyromètres à radiation totale</i>	60 FRF	P 6 (1987) Suppliers of verification equipment (bilingual French-English) <i>Fournisseurs d'équipement de vérification (bilingue français-anglais)</i>	100 FRF
D 25 (1996) Vortex meters used in measuring systems for fluids <i>Compteurs à vortex utilisés dans les ensembles de mesurage de fluides</i>	60 FRF	P 7 (1989) Planning of metrology and testing laboratories <i>Planification de laboratoires de métrologie et d'essais</i>	100 FRF
D 26 (being printed - en cours de publication) Glass delivery measures - Automatic pipettes <i>Mesures en verre à délivrer - Pipettes automatiques</i>		P 8 (1987) Density measurement <i>Mesure de la masse volumique</i>	100 FRF
VOCABULARIES VOCABULAIRES		P 9 (1992) Guidelines for the establishment of simplified metrology regulations	100 FRF
V 1 (1978) Vocabulary of legal metrology (bilingual French-English) <i>Vocabulaire de métrologie légale (bilingue français-anglais)</i>	100 FRF	P 10 (1981) The metrology of hardness scales - Bibliography	50 FRF
V 2 (1993) International vocabulary of basic and general terms in metrology (bilingual French-English) <i>Vocabulaire international des termes fondamentaux et généraux de métrologie (bilingue français-anglais)</i>	200 FRF	P 11 (1983) Factors influencing hardness measurement	100 FRF
V 3 (1991) Hardness testing dictionary (quadrilingual French-English-German-Russian) <i>Dictionnaire des essais de dureté (quadrilingue français-anglais-allemand-russe)</i>	80 FRF	P 12 (1984) Hardness test blocks and indenters	100 FRF
OTHER PUBLICATIONS AUTRES PUBLICATIONS		P 13 (1989) Hardness standard equipment	100 FRF
P 1 (1991) OIML Certificate System for Measuring Instruments <i>Système de Certificats OIML pour les Instruments de Mesure</i>	60 FRF	P 14 (1991) The unification of hardness measurement	100 FRF
		P 15 (1989) Guide to calibration	100 FRF
		P 16 (1991) Guide to practical temperature measurements	100 FRF
		P 17 (1995) Guide to the expression of uncertainty in measurement <i>Guide pour l'expression de l'incertitude de mesure</i>	300 FRF



OIML BULLETIN

CALL FOR PAPERS

The **OIML Bulletin** is a forum for the publication of technical papers and diverse articles addressing metrological advances in trade, health, 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 metrology and related fields, evaluation procedures, accreditation and certification, and measuring techniques and instrumentation.

Authors are requested to submit a double-spaced, titled manuscript and accompanying visual materials (photos, illustrations, slides, etc.), together with a disk copy in one of the following formats: WordPerfect 5.1, ASCII MS-DOS, Word 6.0 (or previous versions for PC), or Quark XPress for Macintosh. Authors are also requested to send a passport-size, black and white identity photo for publication. Papers selected for publication will be remunerated at the rate of 150 FRF per printed page, provided that they have not already been published in other journals. The Editors reserve the right to edit contributions for style and space restrictions.

Please send submissions to:

Bureau International de Métrologie Légale
11, rue Turgot - F-75009 Paris - France

