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Belt weighers used for resource control in the Norwegian fishing industry

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AN ORIGINAL APPLICATION FOR BELT WEIGHERS

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Editorial

Metrology in the Twenty-First Century

Metrology, which is at the same time a basic science and a fundamental set of activities, is of ever growing importance.

Metrology is not a purpose in itself ("l'art pour l'art"): it is intended to serve the world in realizing essential goals connected with free trade, public health, protection of the environment, safety, industrial and agricultural development, space research, etc.

To fulfill this role we metrologists must supply the world with all the help metrology can possibly bring. We have to demonstrate that our support – by creating measurement standards, by testing instruments, by developing and enforcing regulations etc. – cannot be by-passed if progress is to be made.

But are we really able to convince people that we are the partners they so badly need?

I believe we are, provided that we can present our work in a transparent and coherent way. What we therefore need is a clear description of the different aspects of our activities, and the way in which they are inter-related. Scientific metrology, traceability, type testing, verification, certification, accreditation, etc., are not just independent components of metrology, they interconnect as parts of one global tool to improve the quality of goods and services, and indeed life itself.

At the beginning of this year, and as a result of many discussions within the CIML and the Presidential Council, I asked Knut Birkeland, immediate past President of the CIML, to come up with a document in which metrology is described in this way. I am very grateful that he accepted this responsibility, knowing of course that this task would take quite some time: analyzing the situation, interviewing people both within and outside the field of metrology, collecting information, filtering it and using it when adequate.

I am looking forward to seeing the first results of his work, and we will certainly be discussing this theme during the CIML meeting in Rio de Janeiro.

The final document will be very important for two main reasons.

Firstly the Birkeland study will help our Organization to define its strategy for the next century as precisely as possible.

Secondly, it is expected to be a promising stimulus for the ongoing discussions with our colleagues in the BIPM concerning further rapprochement. In fact, this rapprochement should not primarily be based on financial or organizational grounds, but rather on a joint fundamental view of the contribution metrology can pay to society as a whole. ■

G. J. Faber,
President of the International Committee of Legal Metrology

WEIGHTS

PRACTICAL TEST PROCEDURES
FOR CLASSES E_1 TO M_3 WEIGHTS
2 - 4 OCTOBER 1996 - BORÅS, SWEDEN

Testing of weights: Part 3 – Magnetism and convection

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Abstract

When evaluating magnetic problems it should be borne in mind that it is the magnetic interaction between the weight and the weighing instrument that is important. Many class M weights are made of cast iron or simple steel alloys, and as opposed to class E and F weights they more often present large relative errors as a result of this magnetic interaction.

1 Introduction

In this paper, the authors provide a suggestion as to how to interpret the requirement in OIML R 111 [16] that "*Class E, F and M weights should be practically non-magnetic*"; a proposal for a requirement for nonautomatic weighing instruments (NAWI) is also given. Many methods and instruments exist for determining the magnetic properties of weights. In this project the authors primarily used a hall sensor, a fluxgate magnetometer, an instrument based on the attracting method and a susceptometer described in [4, 10 & 11].

Most of the authors' experience is based on the interaction between electronic weighing instruments and weights, but reference [6] states that magnetism is also a problem when using mechanical balances. Temperature gradients must be considered in the calibration of weights as well as in the calibration of balances, as these can cause buoyancy changes, water adsorption or desorption on the weight surface and generate air convection. All of these factors affect the apparent mass of a weight.

Scientists involved in the fields of force, pressure, hardness, torque and volume measurements may also find information in this article to be of interest.

2 Magnetism

2.1 Terminology and units

Magnetic susceptibility, for which certain limits are given in R 111, is the ratio between the magnetization, M, and the induction B_0 which produces it. Below are the SI units for different quantities given.

- Permeability in a vacuum: $\mu_0 = 4\pi \cdot 10^{-7}$ H·m^{-1}
- Induction in free space: $B_0 = \mu_0 \cdot H$ (T)
- Magnetic field: H (A/m) or $\mu_0 \cdot H$ (T)
- Earth's magnetic field: H_E (A/m)
- Magnetic force gradient: $\delta H/\delta Z$ (A/m^2) or $\delta B/\delta Z$ (T/m)
- Magnetization per unit volume: M (A/m)
- Induction in a medium: $B = \mu_0 \cdot (H + M)$ (T)
  This is the Sommerfeld convention, adopted by the Union of Pure and Applied Physics (IUPAP) [1, 2]. In the Kennely system, traditionally favored by electrical engineers, $B = \mu_0 \cdot H + J$ where J is the magnetic polarization.
- Volume magnetic susceptibility (assumed to be a scalar): $\kappa = M/H$
- Volume magnetic susceptibility in air: $\kappa_A = 3.6 \cdot 10^{-7}$
- Vertical magnetic force between a mass comparator and a weight: F_Z (N)
- Volume of the weight: V (m^3)
- Area of the base of the weight or parts of the weighing instrument: A (m^2)
- Acceleration of gravity: g (m/s^2)
- Relative permeability: $\mu_r = \mu/\mu_0 = 1 + \kappa$
- Magnetic moment: $\mathcal{M}$ (A·m^2)
- Induction from the weighing instrument: $B_1 = \mu_0 \cdot H$
- Magnetic induction at the base of the weight; by assumption: $B_2 = \mu_0 \cdot \mathcal{M}$
- Tolerance, T, is the mpe given in Table 1 of OIML R 111.

2.2 Requirements

This section is split into two parts: Part 1 (see 2.2.1) is mainly an extrapolation of the theory on which R 111 is based (for class E and F weights) and Part 2 (see 2.2.2) was developed during this project.

2.2.1 Theory used for R 111 (class E and F weights)

The requirements with regard to magnetism for class E_1–F_2 weights in R 111 are based on the formula below [7]:

$$F_Z = \Delta m \cdot g = (\kappa - \kappa_0) \cdot \mu_0 \cdot V \cdot H \cdot \frac{\delta H}{\delta Z} \quad (1)$$

In article [7] the following assumptions were made:

- $H = 1\ \text{A·cm}^{-1}$; $\mu_0 = 1.256 \cdot 10^{-6}\ \text{H·m}^{-1}$;
- $\delta H / \delta Z = 0.5\ \text{A·cm}^{-2}$;
- class E and F weights are not magnetized (though in the authors' experience they are).

The authors assume that the effect of permanent magnetization, M, of the weight can be added to the susceptibility term. The force acting on a magnetizable object situated in a non-uniform magnetic field may be calculated from the variation of its free energy with its position. When the magnetization is uniform (weights are normally not uniform, but the authors accept that this is not a perfect description of the forces involved) throughout the specimen and the field varies with position, the force is given by [5]:

$$F_Z = [(\kappa - \kappa_0) \cdot \mu_0 \cdot V \cdot H \frac{\delta H}{\delta Z}] + [V \cdot \mu_0 \cdot M \cdot \frac{\delta H}{\delta Z}] \quad (2)$$

The values in Table 1 are such that the contributions from κ and M are equal. The requirements for the susceptibility and magnetization of weights are then:

Table 1 Requirements for different accuracy classes

	E_1	E_2	F_1	F_2
κ	0.01	0.03	0.05	0.05
μ	1.01	1.03	1.05	1.05
$\mu_0 M$ (μT)	1.3	3.8	6.3	6.3

2.2.2 Theory developed during this project

Another expression that appears to the authors to be as suitable as equation (2) above for less accurate weights that are magnetized is given in (3).

$$\Delta m = \frac{F}{g} = \frac{B_1 \cdot B_2 \cdot A}{2 \cdot g \cdot \mu_0} \leq 0.1T \quad (3)$$

B_1 should be less than B_2 since one may weigh weights and objects with a higher magnetization $\mu_0 M$.

The authors therefore suggest that B_1 should not be greater than approximately 30 % of B_2.

In the calculations in Table 2 it is assumed that the magnetic interaction effect should not represent more than 10 % of the absolute value of the tolerance, B, assuming that $B_1 = \mu_0 \cdot B = 100\ \mu$T and that $A = 255\ \text{mm}^2$. This is the worst case for the area of the base, A [11]. The high uncertainty of this formula is one of the reasons for using the worst case.

The requirements for M_1 weights are split into two parts: one for M_1 weights of mass ≤ 10 kg and one for M_1 weights with a conventional mass > 10 kg.

Table 2 Requirements for class M weights

	M_1 (≤ 10 kg)	M_1 (> 10 kg)	M_2	M_3
$\mu_0 M$ (μT)	300	500	900	290

The values in Table 2 are maximum values. As can be seen for example in Fig. 1 the magnetic fields of weights are normally not uniform.

The requirement that M_1 weights should have a magnetization less than 300 μT seems very strict as it excludes most cast iron weights. But M_1 weights of 10 kg and below (according to R 111) shall be made of brass or of another material whose quality is similar to or better than that of brass.

The requirement that M_1 weights should have a magnetization less than 500 μT could be used on rectangular 20 kg and 50 kg weights. This higher value may be qualified due to the smaller area compared to the tolerance [10].

Example for a 50 g class M_1 weight

This is the OIML-shaped weight with the largest area of the base compared to the tolerance [10]. $B_1 = 100\ \mu$T [9, 11] ([7] assumed 126 μT), $B_2 = 300\ \mu$T and $A = 255\ \text{mm}^2$. According to (3), $\Delta m = 0.3$ mg (tolerance $T = 3.0$ mg). These weights are normally not made of cast iron.

2.4 Methods for determining magnetic properties

2.4.1 E_1–F_2 weights (see clauses 6.2 and 6.3 in R 111)

The attracting method

Measure the magnetic permeability, μ_r. This method may be used on 20 g weights [3] and upwards and for

E_2–F_2 weights [12] and M weights with $\mu_r < 2.5$. On some weights it has been seen that the magnetization of the weight has increased each time the instrument was used.

Procedure

Insert a suitable reference material with known magnetic permeability in the instrument. Move the weight towards the instrument (bar magnet with the known reference material) until it touches the instrument. Then remove the weight very gently from the instrument. This measurement should be performed at three different places on a flat surface, both at the top and bottom of the weight.

If the weight is removed from the bar magnet, the relative permeability is less than the reference material. If it is not, it is higher than the relative permeability of the reference material. Normally the instrument includes a set of inserts (reference materials) that may be used.

Part 2: Susceptometer

This method may be used on 1 g–10 kg weights and normally for E_1–F_2 weights.

The instrument consists of a weighing instrument, a table on which the weight is placed, a cylinder (to place the magnets on), magnets and gauge blocks.

The method is based on the assumptions below, of which the last two are the most unwarranted:

- there is a vertical magnetic force;
- the mass standards have an isotropic volume magnetic susceptibility;
- the magnitude of the volume magnetic susceptibility is much less than one;
- the field H is the field before the sample is introduced. This approximation is good to the first order in the susceptibility;
- the alloy is linear, i.e. its susceptibility is independent of the applied magnetic field for strength less than about 6 kA/m;
- the effect of permanent magnetization M can be added as a term separate from the induced magnetization;
- the linear and isotropic susceptibility is also homogenous throughout the artifact;
- M is constant in magnitude and direction throughout the artifact; and
- M is independent of H at low field strengths.

Procedure

- Set the instrument to zero;
- Measure the various parameters [4, 17];
- Place the weight on the table directly above the magnets;
- Note the mass change (F_1/g) on the mass comparator;
- Calculate the magnetic susceptibility.

$$F_{\text{measured}} = F_{\max} \cdot I_a + \frac{\mu_0}{4 \cdot \pi} \cdot \frac{m}{Z_0} \cdot M \cdot I_b \qquad (4)$$

where

$$F_{\max} = (\kappa - \kappa_A) \cdot \frac{3 \cdot \mu_0 \cdot m^2}{64 \cdot \pi \cdot Z_0^4} \qquad (5)$$

I_a and I_b are correction factors due to the shape of the weight.

If it is assumed that the magnetization M is zero then the magnetic susceptibility may de determined using the following equation:

$$\kappa = \frac{F_{\text{measured}} \cdot 64 \cdot \pi \cdot Z_0^4}{3 \cdot \mu_0 \cdot m^2 \cdot I_a} - \kappa_A \qquad (6)$$

If the weight is magnetized, which it normally is, one may continue the measurements by turning the magnet and then noting the mass change (F_2/g) on the mass comparator. The force due to the magnetic susceptibility is then given by:

$$F_\kappa = \frac{F_1 + F_2}{2} \qquad (7)$$

and the force due to the magnetization of the weight is given by:

$$F_M = \frac{F_1 - F_2}{2} \qquad (8)$$

For more information see [4].

Note: This instrument was not commercially available when this article was written.

2.4.2 M_1–M_3 weights (clause 6.6 in OIML R 111)

Part 1: Magnetization

Measure the magnetism with, for example, a fluxgate magnetometer or a Hall probe at the surface of the weight. The measurement should preferably be taken in the direction where the magnetic earth is close to zero.

This test shall be performed at different places at the top and bottom of the weight.

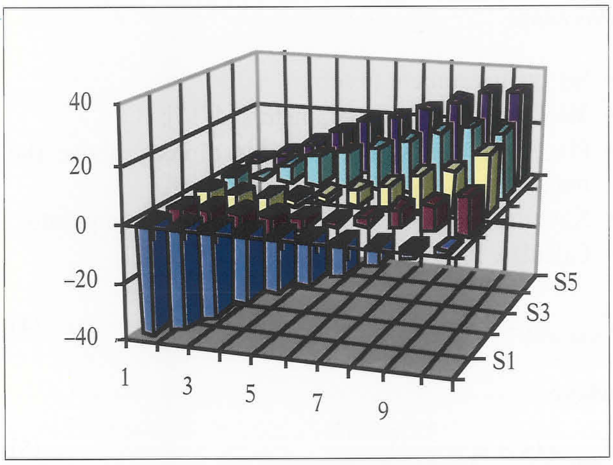

Fig. 1 Typical magnetization distribution at the base of a 20 kg M_2 cast iron weight. The values were measured using a fluxgate magnetometer. The distance from the probe to the sensor is 2.79 cm and the field was measured at 50 different places.

3 Air convection

3.1 Introduction

Temperature gradients must be considered during the calibration of weights as well as during the calibration of balances, as these can cause buoyancy changes, water ad- or desorption on the weight surface and can generate air convection, all of which affect the apparent mass of a weight.

Experimentally it has been shown that if the temperature of a weight is lower than that of the surrounding air, the mass value indicated on a balance is too high (and vice versa). As a general rule, differences in temperature do exist and perfect thermal equilibrium conditions do not, which leads to noticeable measurement errors in balance calibration in the field. For example, the reference weights used may have been stored in a car over a cold night or during a hot day and may have not been given enough time to stabilize.

Similarly in the calibration laboratory the air temperature in the mass comparator nomally exceeds that of the weight by about 0.5 K or more. If no precautions are taken, non negligible deviations from the correct mass value can be expected.

3.2 Cold weights

The air closest to the weight becomes colder than the air further away. As a result its density increases and it will sink along the mantle of the weight, pushing aside the warmer air. This kinetic movement induces a force in the same direction as gravity, via friction between the air molecules and the surface of the weight. The air movement will also affect the top of the weight and the pan, depending on their shape and size. These additional forces result in a higher balance reading compared to the thermal equilibrium between the weight and the air. This situation is depicted on the right hand side of Fig. 2.

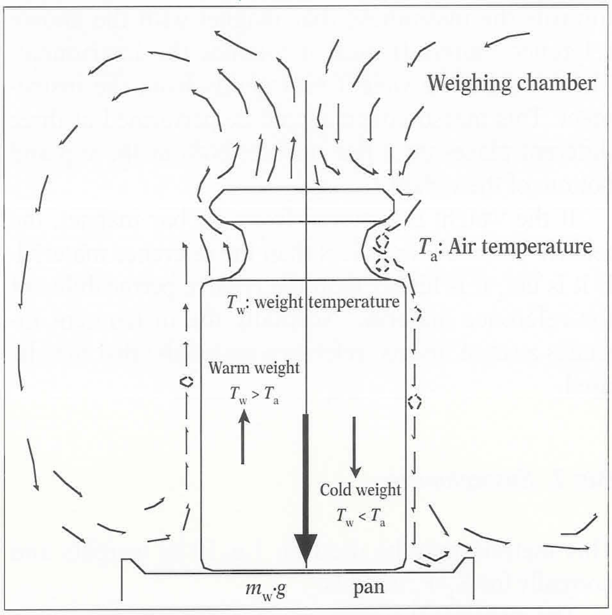

Fig. 2 Convection effect due to temperature differences between the weight and the surrounding air

3.3 Warm weights

The air around and above the weight becomes warmer, its density decreases and it rises, thus creating small whirlpools. The rising air creates an under-pressure above the weight and on the pan which will be filled with colder air and the whirlpool can be extended to the whole of the balance chamber. The convection-induced friction builds up a force opposite to gravity, leading to a lower reading than at thermal equilibrium. As with the cold weight, this effect disappears as the temperature equalizes.

3.4 Theory

Concerning the geometry of the weight, the relation between its mass and volume, the size of the weighing chamber, the area of the balance pan etc., the effect can only be modeled quite roughly, for example using a simple cylinder form. However, it can be shown that the error reading due to this effect decreases exponentially with time as a function of the temperature difference between the weight and its surroundings:

$$\Delta m(t) = m_0 \cdot e^{-\frac{t}{\tau_0}} \qquad (9)$$

where:

$\Delta m(t)$ = error reading at time t
m_0 = initial deviation (t = 0)
τ_0 = time constant

The initial effect m_0 is assumed to be a function of the temperature difference and the area of friction. The time constant τ_0 can be set proportional to the ratio of mass and surface of the weight, giving the following expression:

$$\tau_0 = \frac{m \cdot c}{\alpha \cdot A} \qquad (10)$$

where:

m = mass of the weight
A = surface area (not only the mantel)
c = heat capacity = 460 J/(kg·K) (stainless steel)
α = heat transfer coefficient ≈ 5 W/(m^2·K) (indoor, calm)

The above model predicts the initial effects m_0 and warming up/cooling down times τ_0 which can be used to calculate the time necessary for thermal stabilization. Table 3 below lists such recommended waiting times, calculated for an initial temperature difference of 2 °C. The criterion used is the time for $\Delta m(t)$ to fall below 1/10 of the maximum permissible error (mpe). The results are given for two weight classes E_1 and E_2.

Table 3 Recommended minimum times for temperature stabilization during calibration of class E_1 and E_2 weights and air temperature difference of ± 2 °C

Mass g	Initial effect mg	Class E_1 Time (hours)	Class E_2 Time (hours)
5000	1.08	6.0	1.5
2000	0.53	5.1	1.7
1000	0.31	4.5	1.8
500	0.19	3.9	1.8
200	0.09	3.2	1.6
100	0.06	2.7	1.5
50	0.03	2.2	1.1
20	0.02	1.3	0.5
10	0.01	0.8	0.3

3.5 Experience gained from practical tests

The aim of these tests was to verify the changes in apparent mass and compare them with results predicted by the above model. Figure 3 shows the deviation $\Delta m(t)$ for two cold weights of different shapes. The cylinder model coincides quite well with the OIML-shape, though for a 100 g weight the coincidence is not as good. The shape of the weight and a form factor describing the relation between the vertical mantle area and the mass seem to affect the stabilization time. Furthermore, the moisture balance (especially the formation of a water film, if the weight temperature is below the dew point) is not considered in the simple equation (9), but will have a large contribution to the weighing error during the first 30 to 60 minutes (Fig. 3).

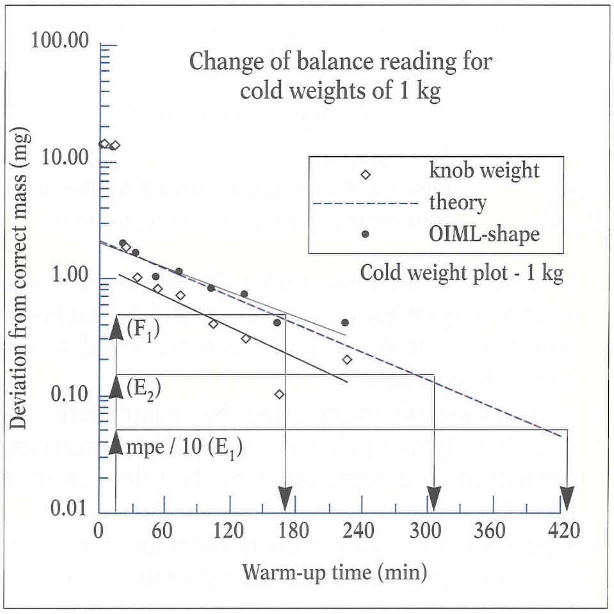

Fig. 3 Measurement error due to a temperature difference of 10 °C. Time for warming up, i.e. until the error $\Delta m(t)$ is below 1/10 mpe of the tested weight class.

The thermodynamically expected symmetry between weights that are ΔT colder or warmer than the surrounding air is not found in reality. On the contrary, cold weights seem to warm up faster than warm weights cool down, which might indicate a more effective convection process. The results from the tests confirmed, however, that the theory is applicable to predict reasonable minimum times for temperature stabilization [2].

3.6 Comparison of effects

Several other effects connected to temperature differences such as water ad-/desorption, volume expansion and changes in air density may also influence the mass determination. For comparison, the orders of magnitude are collected in Table 4 for a temperature difference of 2 °C.

Table 4 Estimated temperature effects

$\Delta m/\Delta T$ (mg/2 °C)	Effect on a 1 kg weight
0.310 mg	air convection
0.055 mg	air density change
0.036 mg	adsorbed moisture
0.015 mg	volume change

4 Conclusion

Below are the authors' suggestions to be used for instruments when classifying the given weights:

Weights	Recommended method
E_1	Susceptometer
E_2–F_2	Susceptometer and/or attracting method
M_1–M_3	Hall sensor or fluxgate magnetometer

- A suggestion for interpreting the requirements as regards magnetization for class E and F weights in clauses 6.2 and 6.3 in R 111 is represented by the values given in Table 5.
- A suggestion for interpreting the requirements for class M weights in clause 6.6 in R 111 concerning magnetization is represented by the values given in Table 5.
- Suggestion for requirements in the future for weighing instruments used to calibrate weights:

Table 5

Accuracy class	Magnetic field (μT)	Magnetic field gradient (A/cm^2)
E_1–F_2	50	0.25
M_1–M_3	100	0.5

If these values are used the values for class E and F weights may be higher, as for the time being they are based on the same values as for weighing instruments used to calibrate class M weights. The requirements in Table 5 are easy to check and should be included in R 76 [15] since it is important to ensure that there are no errors due to the magnetic interaction between the weight (or other objects) and the weighing instrument.

R 47 [14], R 76 and R 111 should include more specific requirements as regards magnetism. Both R 47 and R 111 should be revised and compiled into one Recommendation.

The authors have also confirmed that there are problems due to magnetization of class M weights made of cast iron.

Convection is a problem when calibrating weights. In this article and in the draft [17] the authors have presented practical solutions to this problem. ■

References

[1] Crangle John: Solid State Magnetism. Edward Arnold (1991).

[2] Crangle J. and Gibbs M.: Units and unity in magnetism: a call for consistency. Physics World (Nov. 1994).

[3] ASTM Designation A 342 - 84 (Reapproved 1988). Standard Test Methods for Permeability of Feebly Magnetic Materials.

[4] Davies R. S.: Determining the Magnetic Properties of 1 kg Mass Standards. J. Res. National Institute of Standards and Technology (1995).

[5] W. J. Duffin: Electricity and magnetism. McGraw Hill (4th edition 1990).

[6] Gould F. A.: Tests on Highly Non-magnetic Stainless Steels for use in the Construction of Weights. J. Sci. Instrum. 23, 124-127 (1946).

[7] Kochsiek M.: Anforderungen an Massenormale und Gewichtstücke für höchste Genauigheitansprüche. Wägen + dosieren (n° 1, 1978).

[8] Malcolm McCaig and Alan G. Clegg: Permanent magnets, in theory and practice. 2nd edition. Pentech Press (1987).

[9] Myklebust T.: Methods to determine magnetic properties of weights and magnetic field and field gradients of weights. Justervesenet (Feb. 1995).

[10] Myklebust T.: Measurement of the magnetic permeability, using the attracting method - to be published.

[11] Myklebust T.: Magnetic fields, magnetic field gradients, magnetic susceptibility and magnetic interaction between mass comparators and weights. Justervesenet report - to be published.

[12] Myklebust T. and Börjesson L.: Comparison of two instruments based on the attracting method. JV (June 1995).

[13] Myklebust T.: Magnetic interaction between mass comparators and weights. 14th IMEKO Conference, Warszawa (1995).

[14] OIML R 47: Standard weights for testing of high capacity weighing machines (1976).

[15] OIML R 76-1 & 2: Nonautomatic weighing instr.

[16] OIML R 111: Weights of classes E_1...M_3 (1994).

[17] R 111 draft annexes *Test procedures* and *Test report format* currently being developed by OIML TC 9/SC 3.

TRACEABILITY

Improvement of traceable measurements

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Abstract

The significant problem encountered in achieving traceable measurements is to ensure their integrity regarding various factors, such as procedures for metrological validation of measuring methods and verification of measuring equipment by optimizing the completeness of characteristics and accuracy of their measurement, etc. To this end the informative components of uncertainty are to be rigorously well-founded.

As a development of the author's paper "Optimum Traceability Type Hierarchies", published in the April 1997 issue of the OIML Bulletin, this second paper presents the method for selecting uncertainty components and calculating optimum accuracy coefficients and levels of confidence in evaluating uncertainties for validation and verification, a method considered as the subject of variety control in the framework of legal metrology. The conception of intrinsic accuracy characteristics is proposed on this basis. The improvement of ways for eliminating rough errors in measurement and interlaboratory comparisons, as being the subject of the integrity, is also presented.

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.

1 Introduction

A systematic approach to specifying the accuracy of measuring methods and equipment (MME) is the essential achievement of legal metrology. This approach is realized by means of accuracy classification and hierarchies of measuring instruments [1] ensuring measurement traceability. Nevertheless, it is clear for many professionals engaged in applied metrology that the problem of traceable measurements does not resolve itself only into a comparison of measuring standards and equipment according to legalized (or otherwise adopted) hierarchy schemes of measuring instruments. To be properly related to stated references through a traceability chain, measurement results and associated uncertainties are to be adequately interpreted and evaluated in order to ensure the integrity of traceable measurements.

The effectiveness of the above systematic approach depends on the optimality of the system structure, namely accuracy coefficients (ρ) that represent tolerance uncertainty ratios, however named, and levels of confidence (C) in evaluating measurement uncertainties. The problem of optimizing these characteristics is important both for hierarchy systems and for each measuring method, instrument, or measuring system.

This problem is of great importance not only for exclusively metrological structures, but also for the economy as a whole. Measuring a process without improving it leads to increased costs and lower product quality. According to [2], 46 % of all new product development costs are due to failures because measurements are not monitored and effective solutions are not planned.

The principle of *information cyclicity* was proposed quite recently to solve the problem for traceability hierarchies [3]. According to this principle the variety control of accuracy coefficients and confidences may result in their optimum values:

$\rho_0 = 1/2\pi \approx 0.16$

$C_0 = 1 - 1/4\pi \approx 0.92$

The unified scale of accuracy classification (USAC) was also developed and defined in the above publication.

Thus, the intrinsic uncertainty (U_{in}), which is in fact the out-of-system optimum expanded uncertainty of a particular MME (in terms of accuracy classes), may be calculated as follows:

$$U_{in} = k_o (u_1^2 + u_2^2 + ... + u_\varphi^2)^{0.5} \quad (7)$$

where:

$$k_o = (k_{o1}u_1 + k_{o2}u_2 + ... + k_{o\varphi}u_\varphi)(u_1 + u_2 + ... + u_\varphi)^{-1} \quad (8)$$

k_{oj} = the coverage factor of uncertainty component j.

The characteristics obtained serve a useful purpose due to the following:

- since $\rho_{oj} \geq \rho_o$, $C_{oj} \leq C_o$, the calibration and verification concerning uncertainty sources of MME, different from those for which $K_j = K_1$, may be carried out with uncertainties greater than those when using the same value which would be suitable for the MME as a whole;
- since $U_{in} \leq U$, $k_o \leq k$ (U, k = respectively the expanded uncertainty and coverage factor of its estimation [6]), the averaged permissible accuracy of calibration/verification may be reduced. The effect of such a reduction can be expressed as the relative value k/k_o.

Table 1 illustrates this relation for some confidences applicable for a normal distribution.

Table 1 Relation k/k_o

C_I/k_o	k/k_o			
	C = 0.997 (k = 3.0)	C = 0.994 (k = 2.75)	C = 0.95 (k = 2.0)	C = 0.92 (k = 1.75)
0.5/0.68	4.41	4.04	2.94	2.57
0.78/1.22	2.46	2.25	1.64	1.43
0.92/1.75	1.71	1.57	1.14	1.00

It is of great significance that the advantage of such an approach leads to optimum accuracy characteristics, i.e. without a decrease in the quality of measurement information.

4 Rough errors detection

It is known that rough errors are detected in the measurement process; this is aimed at rejecting those readings having an adverse effect on the measurement result. The detection criterion is expressed by the following condition [7]:

$$(|x_i - m_x| / S_x) > \nu \quad (9)$$

where:

x_i = the "i" reading obtained on measurement;
m_x = the arithmetic mean of readings;
S_x = the experimental standard deviation of the readings;
ν = the specific value dependent on the confidence level (usually 0.9, 0.95, or 0.99) and the number of readings (τ). This value is tabulated for the normal distribution [7] and varies approximately from 1.4 (for $\tau = 3$) to 3.5 (for $\tau = 50$).

Lack of optimality of estimation and the difficulty of application are the main faults of this criterion, as the distribution of readings is different to the normal distribution. This is a clear-cut example of the dubious application of a criterion intended for a statistical model estimation towards the quality of measurement information.

The following equations between statistical experimental dispersion (D) and its permissible limitation (D_{lim}) are true according to the principle of information cyclicity:

(a) for the measuring instrument:

$(1/D_x) = 2\pi (1/D_{x\,lim})$, where $D_x = S_x^2$; $D_{x\,lim} = S_{x\,lim}^2$

(b) for the instrument being part of a measuring system:

$(1/D_j) = (1/\rho_{oj})(1/D_{j\,lim})$, where $D_j = S_j^2$; $D_{j\,lim} = S_{j\,lim}^2$

Therefore, irrespective of the distribution of readings, the unified conditions for detecting rough errors may be respectively presented as follows:

$$(|x_i - m_x| / S_x) > 2.51 \quad (10)$$

$$(|x_{ij} - m_{jx}| / S_j) > (1/\rho_{oj})^{0.5} \quad (11)$$

Clearly $|x_{ij} - m_{jx}|/S_j$ is within the values from 1 (when max $\rho_{oj} = 1$) to 2.51. Thus when ρ_{oj} is increased, the detection requirement is intensified in a similar manner as for the existing method (9) when the number of readings is reduced.

Correct application of the proposed principle of detecting rough errors demands that the number of readings (τ) is to be *à priori* determined to achieve a rather stable result. One of the ways used [7] is the criterion of maximum information of the determination: $1 - (1 - p)^\tau = (1 - p)^\tau$, where p = the probability of absence of rough errors for each measurement. The drawback of this equation is that it does not meet the significant condition of unshifted estimate, i.e. $\tau \geq 1$ within the limits $0 \leq p \leq 1$. The correction is to be applied by substituting ($\tau - 1$) for τ. Thus, the number of readings may be calculated as below:

$\tau = 1 + \ln 0.5/\ln (1 - p)$. If, for example, p = 0.15, then $\tau = 1 + \ln 0.5/\ln 0.85 = 5.27$. Therefore for the objective of reliability the result may be accepted as $\tau = 6$.

5 Characteristics of inter-laboratory comparisons

The judging of quality of measurement results (JQMR) obtained in inter-laboratory comparisons (IC) is carried out by calculating the error E_n when estimating the difference between a laboratory result (x_{lab}) and a reference result (x_{ref}). At first this error (E_{n1}) was normalized with respect to the stated uncertainty U_{lab} [8]. For the laboratory participating in the IC, as a rule this uncertainty is its best measurement capability (BMC). More recently [9] the error (E_{n2}) was normalized also with respect to U_{ref} - the stated uncertainty of a reference laboratory (RL). Accordingly the following expressions were practicable:

$$E_{n1} = |x_{lab} - x_{ref}| / U_{lab} \leq 1 \quad (12)$$

$$E_{n2} = |x_{lab} - x_{ref}| / (U_{lab}^2 + U_{ref}^2)^{0.5} \leq 1 \quad (13)$$

Expression (12) is incorrect because U_{ref} is ignored. In any event the consideration of this uncertainty as being negligible is not quoted. And expression (13) is logically wrong: the difference between the average values of two measurement results is compared with a total uncertainty in determining this difference, which is meaningless in itself. Moreover, the lessening of the quality of the reference result due to U_{ref} being increased leads to an increased difference in $|x_{lab} - x_{ref}|$, acceptable for JQMR. At the same time the following obvious permissible condition is not fulfilled in this case: taking into account U_{ref}, the difference in question should never be greater than U_{lab}.

JQMR is based on the comparison of errors, and the error due to the discrepancy of measurement results obtained by reference and examining laboratories is compared to the maximum error that is possible due to U_{lab}, i.e. to the modulus of this uncertainty. Besides, to achieve a reliable estimation the modulus of U_{lab}, this is to be considered as the constituent of the error of the above mentioned discrepancy. Thus, the main condition of the comparison (14) and consequently expression (15) (distinguishing between E_{n1} and E_{n2}) are both true:

$$|x_{lab} - x_{ref}| + U_{ref} \leq U_{lab} \quad (14)$$

$$E_n = |x_{lab} - x_{ref}| / U_{lab} \leq (1 - \rho) \quad (15)$$

where:

$\rho = U_{ref}/U_{lab}$

6 Practical application

The use of these proposed principles does not present any difficulty, though it is impossible in this paper to give detailed examples of their application. This is necessarily restricted to a brief study of the intrinsic accuracy characteristics (6.1) and to the detection of rough errors (6.2). As for evaluating errors in IC (6.3), only some important aspects of practical applications are defined here.

6.1 Intrinsic accuracy characteristics

This example illustrates the use of proposed intrinsic accuracy characteristics for improving the uncertainty budget and optimizing the requirements for its components with reference to the NPL-TESA Automatic Gauge Block Interferometer [10]. According to the budget the expanded uncertainty of this measuring system was calculated as $U \approx \pm (18.3 + 0.22L)$ nm at 99 % confidence level, where L = gauge length in mm. The uncertainty budget of the manufacturer (99 % confidence interval) is given in Table 2 (columns 1 and 2) and consists of two parts listed successively: firstly uncertainties that are not dependent on L, and secondly those which are.

The *weights* of uncertainties calculated using expression (1) both for the first and second parts of the initial uncertainty budget are listed in column 3 of Table 2. The following values of K_φ (for the first part of the budget) and $K_{\varphi L}$ (for the second) were obtained using expression (3):

$$K_\varphi = 0.214/2\pi = 0.034; \quad K_{\varphi L} = 0.252/2\pi = 0.040$$

The comparison of *weights* with respect to K_φ or $K_{\varphi L}$ in accordance with the condition defined in section 3 results in the conclusion that the budget involves eight sources of uncertainties dependent on L that may be considered as being redundant. Five of them, characterized by the condition $K_{oj} < 0.5K_{\varphi L}$, are not only redundant components, but also may be considered as creating negative information (or dis-information) about the quality of interferometer.

The optimum accuracy coefficients and confidences of informative uncertainty components calculated using expressions (5) and (6) respectively as well as the respective coverage factors are listed in columns 4, 5 and 6 of Table 2. These data clearly illustrate how important a requirement it is to ensure measurement accuracy in verification of the interferometer, including the calibration of its measuring instruments, which might be reduced for most uncertainty sources.

At this point each informative uncertainty component might be considered for the purpose of exemplifying

Table 2 Initial data and calculation results for the TESA interferometer

Source of uncertainty	Confidence interval (nm)	K_j	ρ_{oj}	C_{oj}	k_{oj}
1	2	3	4	5	6
1 Phase change on reflection due to surface roughness	± 9.6	0.214	0.16	0.92	1.75
2 Interferometer optics	± 8.9	0.198	0.18	0.91	1.70
3 Fringe fraction	± 7.96	0.177	0.19	0.90	1.65
4 Wringing film	± 7.7	0.172	0.19	0.90	1.65
5 Phase change on reflection due to $N + K_o$ with λ	± 4.4	0.098	0.35	0.83	1.37
6 Interferometer parallelism/flatness	± 3.8	0.085	0.40	0.80	1.28
7 Phase change on reflection due to $N + K_o$	± 2.5	0.056	0.60	0.70	1.04
Uncertainty components dependent on gauge length (L)					
1 Thermal expansion coefficient	± 0.135 L	0.252	0.17	0.92	1.75
2 Gauge temperature calibration	± 0.117 L	0.219	0.18	0.91	1.70
3 Temp. difference, gauge platen	± 0.088 L	0.164	0.24	0.88	1.55
4 Refractivity of air pressure calibration	± 0.056 L	0.105	0.38	0.81	1.31
5 Gauge temperature reading	± 0.036 L	0.067	0.60	0.70	1.04
6 Laser frequency	± 0.03 L	0.056	0.71	0.64	0.92
Redundant uncertainty components ($K_j < K_{\varphi L}$)					
7 Refractivity of air temperature reading	± 0.015 L	0.028	*Redundant components in the field of positive information* ($1 \le \rho_{oj} \le 2;\ 0 \le C_{oj} \le 0.5$)		
8 Interferometer obliquity	± 0.015 L	0.028			
9 Refractivity of air vapor pressure H_2O	± 0.011 L	0.021			
10 Refractivity of air temperature calibration	± 0.010 L	0.019	*Redundant components in the field of negative information* ($\rho_{oj} > 2;\ C_{oj} < 0$)		
11 Refractivity of air temperature reading	± 0.010 L	0.019			
12 Atmospheric pressure	± 0.006 L	0.011			
13 Refractivity of air pressure reading	± 0.005 L	0.009			
14 Gravity-altitude	± 0.0006 L	0.002			

the absence of optimality in verification or calibration requirements. For instance, the accuracy coefficient problem for only one source will be mentioned in this paper, namely laser frequency (see Table 2). The interferometer lasers are periodically calibrated by comparison of their frequency with the frequency of the reference laser. The frequency emitted by the reference laser is known to within $\pm 5 \cdot 10^{-11}$ relative uncertainty (u_r) at 95 % level of confidence. The similar characteristic of the laser undergoing calibration is:

$u_s = \pm 2 \cdot 10^{-8}$ as the specified value.

The corresponding accuracy coefficient is:

$\rho_s = u_r / u_s = 0.0025$.

It is clear that, comparing this value with $\rho_{oj} = 0.71$ at 64 % confidence (see Table 2 concerning laser frequency) and even with $\rho_o = 0.16$ at 92 % confidence, the calibration is carried out with unnecessary extremely high accuracy.

The calculation of intrinsic coverage factors (k_o and k_{oL}) and intrinsic parts of uncertainty (U_{in} and U_{inL}) by formulae (8) and (7) respectively and the data in Table 2 results in the following:

$k_o = 1.59$;

$k_{oL} = 1.54$;

$U_{in} = (18.3/2.6) \times 1.59 = 11.2$ nm at 89 % confidence level;

$U_{inL} = (0.22\ L/2.6) \times 1.54 = 0.13\ L$ at 88 % confidence level.

It should be noted that the intrinsic uncertainty is an especially individual characteristic of this type of interferometer. In terms of accuracy classification the uncertainty must be specified at the optimum confidence level (92 %) which coincides with the optimum confidences of the most important (j = 1) component. Thus the optimum classification expanded uncertainty of the interferometer is:

$U = \pm (12.3 + 0.14\,L)$ nm.

6.2 Rough errors detection

Table 3 gives the calculation results of $(1/\rho_{oj})^{0.5}$ required for detecting rough errors by condition (11) in respect to those informative components of intrinsic accuracy characteristics of the interferometer, for which the respective MME are to be periodically calibrated or verified. The values of ρ_{oj} are taken from Table 2.

Table 3 Data of $(1/\rho_{oj})^{0.5}$ for certain parameters of the interferometer

Laser frequency	Gauge temperature calibration	Pressure calibration	Surface roughness	Optics
1.19	2.36	1.62	2.51	2.36

6.3 Errors in inter-laboratory comparisons

The following should be taken into account when applying the proposed principle of JQMR:

(a) the rounding off of measurement results, and
(b) the optimality of ρ.

The error (r_{lab}) as a deviation due to the possible rounding off of x_{lab} in many cases is to be considered as a deterioration in the condition (15). If it is significant, the value of $r_{lab} = 0.5 \cdot 10^{-t}$ is to be added to x_{lab}; integers are to be used for t.

It should be emphasized that for evolved fields of applied metrology the capability of the calibration laboratory is to be granted in accordance with established classes of accuracy. It follows logically that U_{lab} and U_{ref} shall represent the proper levels of traceability hierarchy. This means, in turn, that the accuracy coefficient ($\rho = U_{ref}/U_{lab}$) is always to be subject to the same rule of accuracy classification. Therefore, the main initial condition of achieving high reliability in IC results is to optimize the accuracy coefficient and accuracy classification as a whole. Likewise, since the system of accredited calibration laboratories may be considered as a form of TTH, the proper selection of the IC reference laboratory is the inevitable conclusion of the suggested approach.

7 Discussion and conclusion

The variety control of accuracy for achieving the integrity of traceable measurements involves solving rather different problems, considering the effectiveness of measurement as one of the goals. Following on from the subject of this paper, variety control can be achieved on the optimization basis by jointly carrying out the following actions:

1) establishing and putting into practice a unified accuracy coefficient ($\rho_o = 1/2\pi \approx 0.16$) for the hierarchy levels of all types of traceability hierarchies. It follows that the unified level of confidence in evaluating the expanded measurement uncertainty $C_o = (1 - 1/4\pi) \times 100\ \% \approx 92\ \%$ should be accepted in practice, instead of the widespread 95 % and 99 %;

2) selection of informative components of an uncertainty budget. This action has a double effect: (a) the restriction of measurement and estimating operations without loss of information quality, and (b) an increase in the measurement accuracy of remaining sources of uncertainty due to the increase in their entropy;

3) development of the method for calculating intrinsic accuracy coefficients and confidences for the uncertainty components limited by the previous action. The optimization in the sphere of validation of measurement methods, verification and calibration of measuring systems and instruments are the aims of this subject of variety control;

4) improving the method of detecting rough errors when performing measurements;

5) improving the method of judging quality results of interlaboratory comparisons.

It is interesting that together with variety reduction (concerning the first and second points above) a comparatively unusual kind of variety control, namely the increasing of subjects to be specified (for the third point) is applicable to solve the problem.

Thus, the proposed systematic approach to accuracy requirements for MME will make it possible to:

- optimize measurement accuracy and ensure measurement traceability at all levels of MME design, development and operation;
- increase the effectiveness and quality of calibration, verification and validation of MME. For instance, assuming hypothetically the linear model of *weights* as the averaged diagram of uncertainty budget, the reduction of 16 % is expected for the number of measurement parameters concerning the less critical sources of uncertainty.

The role and contribution of the OIML in developing international Recommendations on the subject with a view to achieving the above mentioned goals is clearly very important.

8 Appendix

8.1 Selection errors estimation

The series of estimation errors reaches optimization when selecting the informative parameters. Only those errors that are essential in principle are considered below.

1) $L_o = \Delta\varphi_o/\varphi_o$ = the relative systematic error of calculating φ_o,

where $\Delta\varphi_o$ = the systematic error of estimation of redundancy R. The subsystem of R redundant components causes the existence of $\Delta\varphi_o$. This subsystem is characterized by *weights* K_φ, $K_{\varphi+1}$, ... , K_n of the totality K_1, K_2, ... , K_n, and also involves its own redundancy.

2) L_q = the relative systematic error of quality estimation, dependent on a form of *diagram of weights* and on those *weights* forming part of the subsystem of redundant parameters.

In fact both L_o and L_q are the relative quality losses. The following kinds of errors reflect different approaches in regard to L_q:

- L_{qn} = the factual error, calculated within the limits of φ_o to n. This error is useful when comparing the *weight diagrams* of different forms;
- L_{qm} = the effective error, calculating within the limits of φ_o to m, where m = the number of parameters corresponding to the positive information about a quality when $K_m = 0.5\ K_\varphi$. This error is useful for the calculation of ρ_o.

Below are the expressions for the factual and effective errors:

$$L_{qn} = k_f (K_{\varphi o} + K_{\varphi o+1} + ... + K_n) = (1/nK_1)(K_{\varphi o} + K_{\varphi o+1} + ... + K_n)$$

$$L_{qm} = k_f (K_{\varphi o} + K_{\varphi o+1} + ... + K_m) = (1/nK_1)(K_{\varphi o} + K_{\varphi o+1} + ... + K_m)$$

where k_f is the form factor of a *diagram of weights*:

$$k_f = (1/n) \sum_{j=1}^{n} (K_j/K_1) = 1/(n \cdot K_1)$$

Clearly the values of the above errors depend on the form of the *diagram of weights* taken as an appropriate optimization model.

8.2 Unified model of *weights* diagram

It is consistent that in order to solve a problem of optimum accuracy coefficient, the optimization model is first to be determined and substantiated. The unified form of *weights diagram* (UWD) is the subject of such a determination. Choosing UWD, it is reasonable to be governed by the following considerations:

1) the same criterion shall be used when establishing permissible errors of the UWD application. The accuracy coefficient serves as such a criterion;

2) the UWD shall represent an averaged diagram as against limiting convex and concave diagrams, provided the factual error L_{qna} is no more than ρ_o;

3) the approximation of the above mentioned averaged diagram by a certain standard function shall not be accompanied by an approximation error of more than $\rho_o \cdot L_{qna}$.

Therefore, the symmetry principle is a convenient criterion for choosing the UWD. Following this logic, the linear *weight diagram* ($\Delta K_j = K_j - K_{j+1}$ = constant $\neq 0$) appears to be the appropriate UWD. Table 4 below gives the relevant formulae for calculating L_{qn} according to the above statements with the above types of diagrams.

Table 4 Calculation of L_{qn} for three types of *weight diagrams*

Convex diagram	Concave diagram	Linear diagram
$(n-1)K_1 + K_\varphi = 1$	$K_1 + (n-1)K_\varphi = 1$	$0.5(n+1)K_1 = 1$
$L_{qn1} = \rho_o/n$	$L_{qn2} = \rho_o(n-1)/n$	$L_{qn3} = 0.5\rho_o(\rho_o + 1)$

Theoretically the average diagram is characterized by the following error:

$$L_{qna} = 0.5(L_{qn1} + L_{qn2}) = 0.5\rho_o$$

The asymmetry error for a linear diagram is expressed as:

$$\Delta L_{qn3} = L_{qn3} - L_{qna} = 0.5\rho^2$$

The linear *diagram of weights* meets all the requirements formulated above and can therefore be approved as UWD. In view of this conclusion, all the preceding statements are carried out for a linear *diagram of weights*.

8.3 Optimum accuracy coefficient and information cycle

The optimum accuracy coefficient (ρ_o) can be estimated in two different ways:

i) through a redundancy of information, and
ii) through quality losses.

The comparison of the results obtained is of great importance for drawing the final conclusion.

The following system of equations, which is true for a linear diagram, can be used firstly as follows:

$$\varphi_o = \varphi + (n-\varphi)\rho + (n-\varphi)\rho^2 + \ldots = \varphi + (n-\varphi)\sum_{i=1}^{\infty} \rho^i$$

$$\varphi = \exp[-\sum_{j=1}^{n} (K_1/n)j \cdot \ln(K_1/n)j]$$

$$K_1 = 2/(n+1)$$

The first equation reflects the successively more accurate calculation of φ_o. When $n \to \infty$, the number i of remaining redundancies $(n-\varphi)\rho$ tends to infinity. Substituting sums for integrals, the following results are obtained when solving the above equations for φ_o and ρ_o:

$$\varphi_o = \lim_{n\to\infty} \exp\{-[2/n(n-1)][\ln(2/n(n-1))\int_1^n i\,di + \int_1^n (j \cdot \ln j)dj]\} + \rho n \int_1^n \rho^i di$$

$$= n(1 - \rho - \rho^2/\ln\rho) \cong 0.842\, n \cong (1 - 1/2\pi)n$$

$$\rho_o = (n - \varphi_o)/n \cong 0.158 \cong 1/2\pi$$

Secondly, ρ_o can be determined as such a value of ρ, for which $L_o = \max L_{qm}$. By proceeding in this manner and taking into account the above expressions for errors, the following equations are true:

$$L_o = \rho(n-\varphi)/n(1-\rho) = \rho^2/(1-\rho)$$

$$L_{qm} = (1/nK_1)\{[0.5(K_1/n)(n-\varphi)^2 + 0.5(K_1/n)(n-\varphi)] - [0.5(K_1/n) \cdot 0.25(n-\varphi)^2 + 0.5(K_1/n)(n-\varphi)/n]\}$$

$$= 0.25\rho(1.5\rho + 1/n)$$

$$\max L_{qm} = 0.25\rho(1.5\rho + 0.5)$$

$$\rho_o \cong 0.155 \cong 1/2\pi; \quad \varphi_o = n(1-\rho_o) \cong 0.845 \cong n(1-2\pi)$$

The relative differences ($\delta[\rho_o]$ and $\delta[\varphi_o]$) between the theoretical and derived results can be expressed as follows:

$\delta[\rho_o] = \{[(1/2\pi) - \rho_o]/(1/2\pi)\} \cdot 100$ %
$\delta[\rho_o] \leq 0.8$ % for the first way, and
≤ 2.5 % for the second way.

$\delta[\varphi_o] = \{[(1 - 1/2\pi) - \varphi_o]/(1 - 1/2\pi)\} \cdot 100$ %
$\delta[\varphi_o] \leq 0.2$ % for the first way, and
≤ 0.5 % for the second way.

The occurrence of the information cyclicity may be considered as proved, due to the minute values of the above relative differences. ■

References

[1] OIML International Document D 5: Principles for the establishment of hierarchy schemes for measuring instruments, 1982.

[2] Navin S. Dedhia. Measurements Without Results. Quality World. Volume XV No. 2, April 1997.

[3] D. Kisets. Optimum Traceability Type Hierarchies. OIML Bulletin Volume XXXVIII Number 2, April 1997.

[4] D. Kisets. On Completeness of Measurement Information about the Quality of Object. Proceedings - Ninth International Conference of the ISQA, 1992.

[5] ISO/IEC Guide 2: General terms and their definitions concerning standardization and related activities. Sixth edition, 1991.

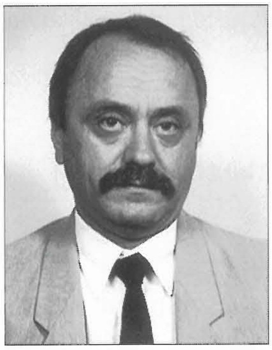
[6] Guide to Expression of Uncertainty in Measurement, First edition 1993.

[7] V. A. Kuznetsov, G. V. Yalunina. Metrology Fundamentals. Izdatelstvo Standartov. Moscow, 1995, p.p. 181–182, 223.

[8] WECC Doc. 15, 1992 WECC Interlaboratory Comparisons.

[9] EAL - P7, 1995. EAL Interlaboratory Comparisons.

[10] NPL - Tesa Automatic Gauge Block Interferometer Handbook, Tesa Metrology Ltd. Instruments and Systems for Quality Control. 1988. Appendix C.



UNCERTAINTY

Connections between various interpretations of measurement uncertainty

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1 Introduction

Supposed or estimated limits of the possible errors of measurements have traditionally been evaluated and used as a description of the measured divergence between the results of measurements and the respective values of the measurand reproduced or measured by the standards used in the course of calibration or verification.

Statistical analysis of the results of the same measurand inspired some experts to conceive an interval containing the true value of the measurand and in this way characterize the uncertainty of the results with an interval.

A multiple of the estimated standard deviation of the possible results, or a parameter that characterizes the dispersion of the values that could reasonably be attributed to the measurand, were recommended recently. Perhaps none of these concepts or interpretations are exclusive, but there is a degree of similarity between them and each has some advantages for use in specific cases or in specific fields of measurements.

The explanations given in this paper of the possible similarities are the result of the many questions and requests for advice the author received to explain the difference between confidence interval and expanded uncertainty, or the differences and perhaps the connection between errors, error limits and uncertainty.

2 Theoretical background

Unpredictable differences in the various results of the same measurand, the relative stability of the measurand and the measurement process itself (including the instrumentation and the evaluation of the results) suggest that applying the theory of probability and mathematical statistics is appropriate in handling the results of measurements.

Every measurement result based on one particular quantity constitutes a sample emanating from a population having a mathematical expectation m, which gives the true value of the measurand. A measurement result is the value obtained after all of the required calculations have been resolved, i.e. the corrected value of any difference between the mathematical expectation of the results m and their true value, taking into account the knowledge and proficiency of the staff who perform the measurement. Defined measurement processes lead to the variance σ^2 in the results and to the defined probability p of each possible result y_j over the measurement range:

$$p(y_j) = \int_{y_j - \Delta y}^{y_j + \Delta y} \varphi(y) dy \qquad (1)$$

where:

$p(y_j)$ = the probability of the result being within the range $y_j - \Delta y$ to $y_j + \Delta y$;

$\varphi(y)$ = the probability density function (parameters m and σ).

Perfect knowledge of the measurement would mean knowing the exact values of m, σ and also the shape of the function $\varphi(y)$, e.g. Gaussian, rectangular, Poisson, exponential, etc. In practice however, m and σ are estimated (for the true value of the measurand and for the uncertainty respectively), and the hypothesis on $\varphi(y)$ should be proved if there is a sufficient number of results, which is generally the case.

In order to avoid under or over-estimating accuracy and confidence, it is important that the meaning or interpretation of every uncertainty component or statement be specified.

3 Uncertainty - definition in the VIM

In the *International Vocabulary of Basic and General Terms in Metrology* [1], published on behalf of seven international institutions (BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML), the following definition can be found (3.9):

> *Uncertainty of measurement: parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand.*

In practice, this definition is difficult to apply as it is relatively abstract, though it may be used as a basis for developing more concrete definitions - this is confirmed by the first note in the VIM. Whilst the general nature of this definition is often considered as a drawback, it does imply a major step forward, as it entails comparing and associating the measured value with an uncertainty statement or parameter.

4 Uncertainty - definition in the Guide

Two more concrete definitions are presented in the *Guide to the Expression of Uncertainty in Measurement* [2], which does not contradict the VIM definition but which recommends a procedure rather than a formal definition: after estimating s or u_c a coverage factor k is chosen (on the basis of the level of confidence required). For the measurement result (Y), this gives:

$$Y = y \pm U \quad (2)$$

where:

y = the estimation of the true value of the measurand;

$U = k \cdot s$ or $U = k \cdot u_c$.

Using the Guide presents three advantages:

- since the standard deviation can be estimated in almost all practical measurements, the Guide can be applied in a wide variety of cases and there is no need for hypotheses for the distribution density function;
- this definition is nevertheless of a general nature, so there is still room to interpret it further. The results are easy to apply to a wide range of measurement fields and the choice of evaluation method remains open: type A is based on the statistical analysis of a series of observations and type B is based on the *à priori* concept of probability which deals with standard deviations which are not statistically estimated;
- it can easily be handled in more complex evaluation procedures.

5 Confidence interval for the true value of the measurand

The form $Y = y \pm U$ is in fact a combination of two estimated parameters: y is the estimation of the mathematical expectation of the result and U is a multiple of the estimated standard deviation of the possible results. This form constitutes an interval $[y - U; y + U]$ which contains the true value of the measurand with the given confidence level; calculating this confidence $(1 - P)$ requires:

- a good estimation of U and s for σ;
- a good hypothesis for $\varphi(y)$ which can be proved when using a large number of results (χ^2 test is usually used). In many cases however, the supposed distribution functions cannot be proved by statistical tests.

For the highest level of accuracy there is little need for a statement implying a confidence level, as it is always possible to determine the corresponding interval for a known (or supposed) distribution function. However, such an interval may be needed for situations where for instance a measured value or the uncertainty has to be compared with a legally imposed tolerance limit or with pre-determined test tolerances and industry specifications [4].

The use of a confidence level has to be limited to cases where the hypothesis for $\varphi(y)$ has been proved for example from at least 100 results. This is a correspondence between two interpretations of the uncertainties, but it must be proved.

6 Error and uncertainty of the result

Most users of measuring instruments or users of measurement results are not qualified metrologists, though they are aware that there may be a small unknown difference between the result obtained and the true or "exact" value of the measurand; users merely require some limitation of this difference. On the other hand, professional metrologists in calibration laboratories or verification officers can assist users by estimating or specifying the uncertainty component of the calibrated, tested or verified measuring instrument and therefore ascertain the overall uncertainty of the results. Guidance may also be given as to how best to combine these uncertainties with other components arising from the method of measurement and residual influence.

In most practical cases, when an instrument is in use a detailed statistical analysis of the results is not possible. The instrument must therefore be calibrated first, i.e. it must undergo the operations which are necessary to determine the relation between the measured values (x_{mi})and the respective values reproduced or measured by the standard (x_{si}).

The instrument error may be presented in the form:

$$h_i = x_{mi} - x_{si} \tag{3}$$

The instrument specifications state the limiting values h_{min} (usually negative) and h_{max} (usually positive), both of which can be a function of the measurand.

The instrument is qualified as good when:

$$h_{min} \le h_i \le h_{max} \tag{4}$$

supposing that the values reproduced or measured with the standard are determined with a negligible uncertainty.

The measurement result of the instrument is never predictable: it may or may not fall within the interval $[y + h_{min}; y + h_{max}]$ and so the range h_{min} to h_{max} may or may not be $2U$.

It is possible to obtain more precise statements if a hypothesis can be drawn and then proved for the distribution of the errors - it should be noted that the distribution density functions $\varphi(h)$ and $\varphi(y)$ have the same shape but not the same mathematical expectations, i.e. the expected value of the error h equals zero. In order to obtain the probability density function of the possible measurement errors, the $(x_m - x_t)$ error is substituted into the probability density function of the possible measurement results.

With this function, both the probability P of the event of $[h_{min} \le h \le h_{max}]$ and the limits of U for a given probability of the event $-U \le h \le U$ can be determined.

In other cases, the absolute values of h_{min} and h_{max} can be identified with the uncertainty $U = k \cdot s$. It should be noted that the value $k = 2$ is to be preferred, or specific values of k shall be chosen in accordance with the general rules or agreements in the particular field of measurement in question.

In cases where the uncertainty related to the measurement standard is not negligible, the following condition can provisionally be applied:

$$h_{min} + U_s \le h_i \le h_{max} - U_s \tag{5}$$

where U_s is the uncertainty of the values measured or reproduced with the measurement standard (specific values of k shall be chosen as above); this principle constitutes an important step forward.

The approach described in (4) and (5) does not comply with the quadratic approach of the Guide; therefore, the author suggests using the following equation for determining the uncertainty of an instrument if its accuracy is not specified in advance:

$$U_m = k_m \cdot s_m = k_m \cdot [[\frac{1}{n} \Sigma h_i^2] - s_s^2]^{\frac{1}{2}} \tag{6}$$

where:

k_m is the chosen coverage factor in the specific field;

$s_s = U_s/k_s$ is the estimated or specified standard deviation of the standard;

h_i are the measured data errors according to (3);

the number of measurements n should be large enough.

This is the way to obtain a realistic value (i.e. neither under nor over-estimated) for the uncertainty contribution of the measuring instrument to be taken into account in the calculation of the uncertainty of the result y according to the method suggested in the Guide.

Summary

The author accepts that all the existing traditional interpretations of the uncertainty of measurements can be considered as valid and accepts that there are certain common points between them; they must however have scope for practical field application.

Careful analysis and more detailed formulation of these connections or common points might, the author feels, help metrologists to further their work in a wide variety of fields and thus arrive at a mutually beneficial understanding. ■

References

[1] International Vocabulary of Basic and General Terms in Metrology, 1993 edition.

[2] Guide to the Expression of Uncertainty in Measurement, 1995 edition.

[3] C. Ranson: Introduction to the *Guide to the Expression of Uncertainty in Measurement* in the second Eurolab Symposium "Testing for the Years 2000".

[4] Report of the BIPM Working Group on the *Statement of Uncertainty* to the Comité International des Poids et Mesures.

[5] Dr. P. Bölöni: A Practical Approach to the Uncertainty of Measurements. Proceedings of KoREMA 1996 and Mérésügyi Közlemények, Budapest, March 1996.

AN ORIGINAL APPLICATION FOR BELT WEIGHERS

Resource control by use of belt weighers in the fishing industry

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B. SCHULTZ, Norwegian Directorate of Fisheries

1 Introduction

The fishing industry is important not only for the Norwegian coastal economy, but also for the total economy of the country. It is therefore necessary to adequately manage fisheries in order to ensure their sustainable development. The fishing industry in Norway is divided into three main sectors:

- whitefish (demersal species);
- pelagic (Norwegian pelagic species such as spring-spawning herring, north sea herring and mackerel), and
- fish farming.

The management of the first two sectors is mainly based on recommendations from the Marine Institute, statistics on fishing, and of course fishery policy in general. Therefore, it is important to be in possession of the best possible figures of landed quantities in weight, for each species.

In March 1995 the Department of Fisheries changed the legislation in the pelagic sector concerning the weighing of fish destined for human consumption, in order to obtain the best possible figures. All fish plants were ordered to install an in-line weighing system that would weigh the fish received. To avoid damaging the fish (as a batch weigher does), most of the fish plants opted to install a belt weigher.

From the outset, JV was engaged to supervise the metrological aspects of this project. Many questions arose concerning working conditions, the need for special requirements for the belt weigher for use in this kind of environment, how to construct an arrangement for the in-situ material test, test procedures and lastly type approval and verification.

All the belt weighers were installed in 1996 and the period March 1995–January 1997 was used to gain experience and evaluate the working conditions of the different weighing systems. The cut-off date for having the belt weigher verified was set to 1st January 1997 - from this date on results collected by means of belt weighers could be used for trade and resource control.

In Norway a total of about 50 fish plants have installed belt weighers and around 20 small fish plants still use nonautomatic weighing instruments. The latter represent a small part of the total quantities of landed catches.

During 1996 Norwegian fish plants processed 890 000 tonnes of pelagic species for human consumption, representing a value of NOK 2.4 billion, or US $ 370 million. Of this quantity Norway exports about 750 000 tonnes (value NOK 3.8 billion or US $ 585 million), which represents 17 % of total exports (NOK 23 billion, US $ 3.5 billion) of the Norwegian Fishing Industry.

2 Weighing fish using belt weighers

2.1 Technical solutions

Three manufacturers have each made different kinds of belt weighers (the first of which is illustrated in Fig. 1), but the maximum capacities (Q_{max}) are practically the same (80–100 t/hour).

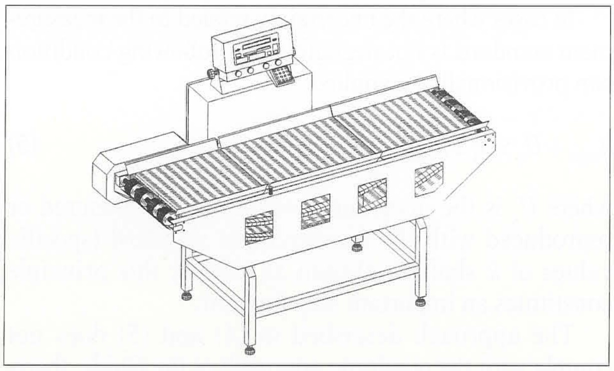

Fig. 1 Marel belt weigher

2.1.1 Marel

Marel have manufactured a belt weigher which differs from a typical belt weigher: in principle this model consists of an interlock belt that slides across a weighing plate. This scale is delivered as a complete module, and is mounted in line with the existing conveyor belt. The scale is very compact (total length 2 m) and is especially useful in plants with limited space.

2.1.2 Procon

Procon have also manufactured a belt weigher as a complete module, but it is based on a typical belt weigher. Total length is about 3 m, and a plane belt with waved side buffers is used. The weighing rollers are mounted on a frame which comes into contact with the two load cells placed on each side of the belt.

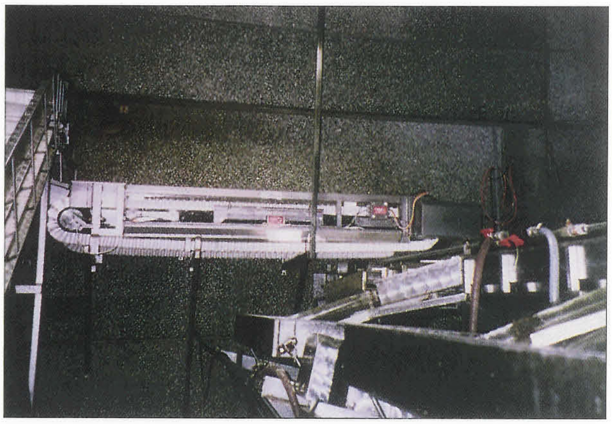

Fig. 2 Procon belt weigher

2.1.3 Scanvaegt

Scanvaegt use a conventional belt scale. This solution requires a longer weighing belt than Marel, but the advantage is that the weighing unit can be installed on an existing conveyor belt.

2.1.4 Supplementary requirements

To ensure the belt weigher's ability to fulfill the requirements for this type of use, the Norwegian Directorate of Fisheries added the following technical requirements to the installations:

- to ensure an unambiguous indication of the weighed quantity, the general totalization indicating device shall have at least 8 digits (99 999 999 kg).

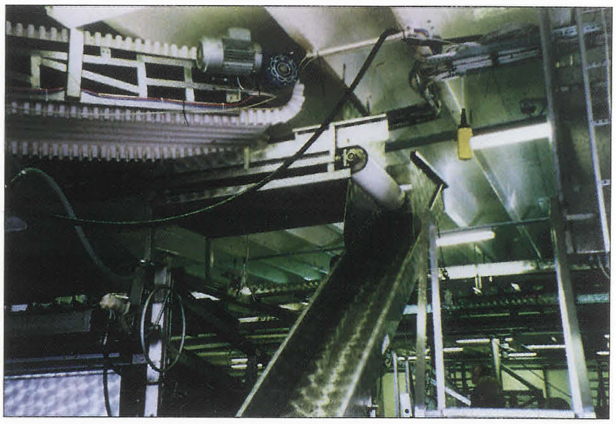

Fig. 3 Scanvaegt belt weigher, the driving drum. The reversible conveyor and the chute which are used to carry out the in-situ material test.

- the conveyor belt shall stop if the weighing instrument is switched off or ceases to function. This is a requirement of OIML R 50-1 clause 3.2.5 [4]: "If the weighing instrument is switched off or ceases to function, the conveyor belt shall stop or a visible or audible signal shall be given".

Because there is a possibility that the alarm may be ignored, the "belt-stop" function is considered to be the best way to ensure that no fish pass along the belt weigher without being weighed. If the indicator still ceases to function, a switch is installed which overrides the "belt-stop" function. (To preserve its quality, the fish has to be transferred to cold storage as quickly as possible). This switch is sealed and the operator requires permission from the Directorate of Fisheries to break the seal.

3 Working conditions

3.1 Weather

Because of the frequently harsh weather conditions such as wind, rain, snow and ice, JV requires that belt weighers be installed indoors, where the temperature must be maintained above 0 °C to prevent the belt weigher from icing up.

3.2 Water and ice

The fish are pumped from the vessel into dockside water-filled bins, from where they are transported to the belt weigher along a conveyor belt (see Fig. 4).

Fig. 4 Arrangement for pumping the fish from the vessel into the dockside bin. Conveyors bring the fish into the plant.

In the preliminary phase of the project, the question was raised as to how the scales would be affected by water and ice-cubes, as some vessels use ice to cool the fish. To avoid a weighing error, it is necessary to install one or more arrangements to separate the water and the ice-cubes from the fish. Typical arrangements could be:

- a perforated conveyor belt (or interlock belts);
- a gap between conveyor belts, wide enough to sort out water and ice-cubes but not so wide that the smallest fish would fall through;
- a chute made of parallel bars (see Fig. 5). The fish slide down the chute from one conveyor to another.

Fig. 5 A chute is used to separate water and ice from the fish.

The Norwegian Directorate of Fisheries carried out tests on some ten fishing plants with different capacities, weighing equipment and types of fish, to set a "water percentage". The water percentage specifies the mass of water which passes over the belt weigher, and was measured to be 2.5 % for herring and 1.5 % for mackerel. The water percentage, the mass of the bye-catch and that of unusable fish are subtracted from the total quantity.

3.3 Coating of the belt

In the spawn period, the belt may be coated with spawn. It may also be coated with herring flake, but this is not limited to the spawn period. This substance is very sticky, and it may therefore be necessary to use a water hosepipe to clean the belt.

4 Experience gained during initial verification

The procedure for testing belt weighers in the fishing industry does not deviate from that used for typical belt weighers. The initial verification tests were performed in accordance with the requirements of OIML R 50-1, Annex A. All the belt weighers were approved for accuracy class 1 (which gives a mpe of ±0.5 % of the totalized load for initial verification). Some 50 belt weighers were tested with either herring or mackerel at the different fishing plants over a five-month period from August to December 1996.

During the initial verification JV especially emphasized the importance of technical inspection and that of the metrological tests.

4.1 Technical inspection

Of importance here were the installation conditions. A belt weigher has to be installed indoors, usually on an existing production line, but many fish plants have very limited space available. Therefore many belt weighers had to be ceiling-mounted, and in some cases it proved difficult to carry out the technical inspection due to both the physical location of the machine and the limited surrounding space.

In spite of these difficulties, the mounting of the belt weighers was generally satisfactory. The most common difficulties experienced on the belt weigher itself (the weighing unit) were problems due to vibration and due to the fact that the weighing rollers were not always aligned in the same plane, (OIML R 50-1 clause 3.8.1) which can cause problems in the zero-load tests. Globally, the main problems were caused by the feeding device, unstable material, etc.

4.2 Metrological controls

4.2.1 Zero-load tests

The zero-load tests were performed according to OIML R 50-1 clause A.10. After adjusting the rollers as described previously, all the belt weighers passed this test.

4.2.2 In-situ material tests

The in-situ material tests (OIML R 50-1 clause A.11) were the most comprehensive and time-consuming tests to perform. Q_{max} varied from 30–80 t/hour at the different fish plants, depending on the capacity of the other installations on the production line.

The mass of the fish was control weighed after its passage over the belt weigher, and the test quantity was stored in containers (Fig. 6) (maximum storage weight 1 000 kg) before control weighing. The test quantity varied from about 800–1 500 kg dependent on Q_{max} and the belt weigher type.

To ensure constant material flow during the material test, it is important to have a large quantity of fish (> 1.5 Σ_{min}) in the bin. The arrangement to catch the fish after weighing by the belt weigher varied from installation to installation. It was important to achieve a short distance between belt weigher and container and reduce any loss of weighed material to a minimum. Figure 3 shows one type of installation - a reversible conveyor belt is placed between the belt weigher and the sorting unit. By changing the direction of the conveyor, the fish are either transported to the sorting unit or to a container (via the chute) for control weighing.

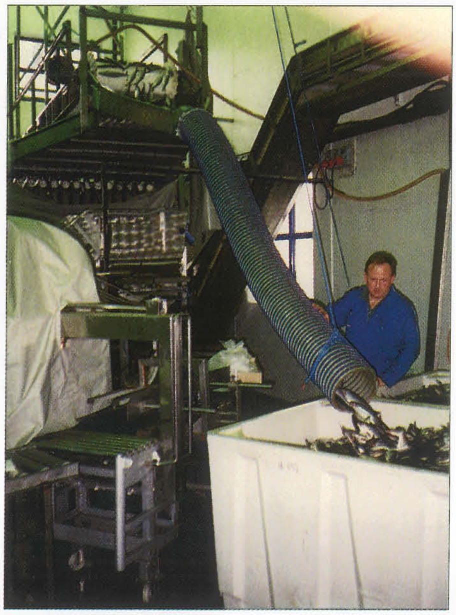

Fig. 6 Arrangement for an in-situ material test

Figure 6 shows another arrangement. In normal use the fish are dropped from the belt weigher into the sorting unit. A hinged tundish is flipped over which catches them and deposits them in the container via a flexible tube.

A nonautomatic weighing instrument with a scale division of d = 0.5 kg and maximum capacity 1 500 kg was used as a control instrument. The control scale was calibrated before use.

4.2.3 Feeding device

To obtain an accurate result with a belt weigher it is most important that the material moves at the same speed as the weighing belt when being weighed. Most of the difficulties faced during the in-situ material tests occurred at those installations where there was limited space. The feeding device was constructed so that the fish slid onto the weighing belt just before the weighing unit, and did not stabilize before they were near the middle of the load receptor. Since fish are very slippery, it is important that the feeding device is able to distribute the material symmetrically and in a stable manner on the belt before the weighing takes place. The material test therefore began with a visual inspection of the feeding of the fish at flowrates near Q_{max}, since it was at these flow rates that the problem occurred. A good feeding device can be constructed by avoiding chutes that accelerate the material just before the weighing unit, and by using a feeding conveyor in line with the belt weigher running at the same speed as the weighing belt itself.

Fig. 7 Mackerel spread symmetrically on the weighing belt

4.2.4 Rejection

Some belt weighers were rejected during the initial verification, mainly because of bad mounting of the feeding device or other adjoining mechanical installations, but not because of the belt weigher itself. The average material test error was ±0.20–0.35 % with a standard deviation of 0.75–1.50 kg.

Initial verification of these belt weighers takes 3–6 hours depending on the preparations carried out by the applicant, the capacity of the belt weigher, the number of tests, and the arrangement for collecting the test quantity and performing the control weighing.

So far experience has only been gained from initial verification and no tests have yet been performed on the long-term stability, though feedback from users so far is encouraging. Only a few installations have reported breakdowns and have needed reverification.

5 Uncertainty considerations

Tests performed according to OIML R 50 are based on shared risk [1].

When using the belt weigher, the uncertainty of the mass weighed may be calculated based on the tolerance of the belt weigher.

The in-service tolerance of belt weighers is 1.0 %. It may therefore be assumed that the uncertainty when using the belt weigher is 1.0 % for k = 2 [2].

The uncertainty of the mass of the fish passing over the belt weigher is mainly due to the belt weigher and the content of water being weighed. The amount of water being weighed varies between 0.5 % and 3.0 %; an uncertainty of ±1.5 % due to the variation in the amount of water may therefore be assumed, for k = 2 [2].

The extended uncertainty of the amount of fish weighed is then less than 2 % when using belt weighers.

6 Conclusions and evaluations

The authors' experience so far is that the mechanical construction has been the most difficult part of the project. It has also been difficult to satisfy the following points:

- Feeding device - The fish must be centered and lie stable on the belt when the weighing takes place. This is particularly a problem when dealing with plants with very limited space.
- Water and ice - Water and ice must be separated from the fish before weighing takes place.
- Vibrations - Many belt weighers are suspended from the ceiling, and so vibrations must be damped to obtain acceptable weighing results.

As far as the electrical parts of belt weighers are concerned, it is important that the indicator and junction box housings etc. are constructed in such a way as to allow for the high humidity levels and washing procedures used in this industry.

OIML R 50 can be applied to belt weighers for weighing fish - class 1 is a suitable accuracy class.

Resource control has been improved and fish weight is determined with an uncertainty of < 2 % whereas before this project was undertaken, the uncertainty was 10–20 %. ■

References

[1] ILAC Guide to the assessment and reporting of compliance with specifications (1995 draft).

[2] Guide to the expression of uncertainty in measurement (1995 edition).

[3] Myklebust T.: Belt weighers and uncertainty evaluations (Justervesenet, September 1996).

[4] OIML R 50-1 (1997 edition).

[5] OIML R 50-2 (1997 edition).

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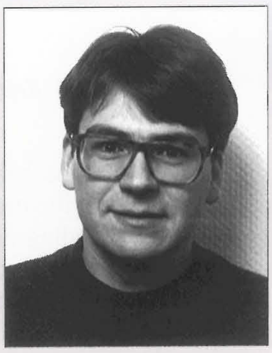
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MEASURING PROCEDURES

New Standard in the Russian Federation

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This article presents the general provisions of the Standard for Measuring Procedures (GOST R 8.563-96) which was approved by Gosstandart and came into force on July 1 this year.

1 Introduction

In Russia, measuring procedures evolved in 1972 due to the need to ensure the uniformity of measurements in two ways:

- results should be expressed in legal units, and
- the maximum permissible errors should be known.

In order to realize these objectives, it is not sufficient for measuring instruments merely to comply with the relevant metrological requirements, since measurement errors depend not only on these but also on other factors such as procedural errors, errors resulting from sampling and preparation of probes, operator errors and conditions of measurement, etc.

Basic principles for the development and application of measuring procedures were therefore established and applied to metrological services. Standards and documents detailing measuring procedures were published, and certification introduced.

Measuring procedures ensure the uniformity of measurements, such as the accuracy of the result, units and method of measurements, metrological characteristics of measuring instruments, and ways of using the results. This is why implementing current measuring procedures has a major effect on the development of Standards and their traceability/applicability to actual measuring instruments.

The Russian Federation law on *"Assurance of the Uniformity of Measurements"* (adopted in 1993) gave a new impulse to metrological activities concerning measuring procedures. This law lays down requirements for state metrological control and supervision procedures, as well as rules governing state metrological supervision of certified measuring procedures and the functions of the state metrological service. These factors led to the necessity to develop this new Standard.

2 Basic provisions

GOST R 8.563-96 defines the term "measuring procedure" as being *those operations and rules which ensure measurement results are within a given error*, a definition which implies that:

1) the measuring procedure (operation), and
2) the maximum permissible error of measurements should be specified.

"Certification" is also defined in the Standard, which deals more with the certification of measuring procedures than with the "legalization" of measuring operations.

The objective of certifying procedures is to assess and confirm their compatibility with the relevant metrological requirements. This definition sets out three stages of certification:

- investigation;
- assessment of compatibility, and
- juridical execution of the latter.

GOST R 8.563-96 renders metrological services responsible for deciding on the applicability of the measuring procedures they certify.

One of the main conditions of certification is that the requirements either for the measurement error or for the intrinsic characteristics of the error should be known beforehand; this information must be stated in the documents submitted during the certification process (also obligatory).

A distinction should be made between the actual measuring procedure and a document simply describing it, since it may not be necessary for all the measuring procedures to be documented. For example it is not necessary to determine measuring procedures with simple indicating instruments such as pressure gauges, voltmeters, etc., and so different measuring procedures using automatic measuring instruments and measuring channels in automated control systems are not required to be mentioned.

The measuring procedure is "inserted" into the algorithm and into the programs which are approved during testing procedures, including in particular pattern evaluation tests.

In Russia, certification may be carried out by:

- metrological examination of the procedural document;
- experimentally.

Since it is obligatory, certification is carried out for measuring procedures in the field of state metrological control and supervision. Other measuring procedures are certified in compliance with internal company rules.

According to the Standard, certification is carried out by:

- state research institutes for metrology;
- territorial metrological bodies of Gosstandart, RF and
- accredited metrological services within enterprises/organizations.

The Standard specifies the most important primary data and requirements for the elaboration of (1) measuring procedures and (2) measurement accuracy. A distinct determination of a measuring value (including a spatially distributed one, or one which varies with time, etc.) is necessary.

(1) Measuring procedures

The purpose of the procedure must be well-defined - for example, the application of procedures for quantitative chemical analysis is used to:

- determine the properties of a specimen sampled and prepared by a special way;
- determine the average or integral characteristics of a quantity of product. In this case the essential component of the measurement error of these characteristics depends on the process of sampling and preparation of specimens and probes.

(2) Measurement accuracy

The requirements for measurement accuracy are expressed in terms of the permissible measurement error. Usually, the probability of revealing an error within the predetermined limits is taken as ≈ 1; requirements may be given either as requirements for test result error or for permissible probability of measuring control defects. External measurement conditions such as ambient temperature changes, mains power supply disturbances, electromagnetic fields, etc. as well as factors which influence the methodical component of the measurement error refer to the primary data.

The main sources and components of measurement error are given in the Annex to GOST R 8.563-96; this information aids in the analysis of the potential sources of error of the concrete measurement processes.

The main part of the measuring procedure depends on the choice of methods and measuring instruments; this choice is considered optimal when the measurement error is slightly lower than the limit of permissible values.

It should be noted that documents on measuring procedures deal with the "assigned" characteristics of measurement error which correspond to any measurement result obtained, whilst observing the rules and provisions of the document.

In many cases, statistic estimates of measurement error are based on concrete conditions at the time the experiments were carried out. Usually, it is impossible to carry out experiments under external conditions which may influence the error; this is why care should be taken when accepting statistic estimates attributed as the assigned characteristics of the measurement error.

3 Conclusions

The Standard:

- regulates the requirements for the contents of documents on measuring procedures; in its Annex the contents of several documents are given as guidelines;
- states that Draft State Standards used in the field of metrological control and supervision shall undergo metrological examination in State Metrological Centers;
- includes general measures in preparation for its implementation within companies and institutions.

It is necessary for metrological departments within companies and institutions, together with metrological research centers and state metrological services, to analyze the conformity of applied measurement methods with GOST R 8.563-96. On the basis of this analysis a revision program of the current measuring procedures is drawn up, based on which new ones are worked out in compliance with the requirements of GOST R 8.563-96.

It is also necessary to train specialists at the various metrological services in how to carry out certification of measuring procedures, or how to accredit metrological services so that the latter may themselves carry out certification. ■

activities OIML activités

Meetings

Réunions

TC 9

Instruments for measuring mass and density

Secretariat: USA

The National Weights and Measures Laboratory (NWML) hosted a meeting of OIML TC 9 which was held on 7–9 July 1997 in Teddington, United Kingdom.

Chairwoman:
Mrs. D. McGann Ripley (NIST)

Participation: 30 delegates representing 16 P-member countries and CECIP; Ph. Degavre, BIML.

Main points

The objective of this 2 1/2 day meeting was to discuss the 1st CD revision of OIML R 60 *Metrological regulation for load cells* and Annex A to R 60 *Test report format for the evaluation of load cells* which were prepared by the secretariat and sent out for ballot in August 1996. Sufficient comments were received along with the ballot to warrant this meeting. The agenda included so many points that it is not possible in this summary to give a full account of what was nevertheless a very well organized and successful meeting. Important decisions were taken on the following points:

- Proposal to change the reference line

  The proposal to utilize a least square best fit straight line as the reference line for the error envelope (6.2) was withdrawn by the secretariat in view of the decline in support.

- Testing for creep and "MDLOR" (renamed "DR")

  After discussions to eliminate some parts of the tests, finally no changes were accepted by the International Working Group (IWG).

- Load cell classification

  The IWG voted not to add classification provisions for load cells used in multiple range and multi-interval weighing instruments. However, it was agreed to add definitions for two factors, Y and Z, on a non-mandatory basis in recognition of the fact that many Member States deemed this would be useful, especially within their national services:

  $Y = E_{max}/v_{min}$;

  $Z = E_{max}/(2 \times DR)$.

  These factors are not required to be stated, but optionally may be.

- Maximum permissible errors: apportionment

  It was decided to allow manufacturers to choose a "p" value other than p = 0.7. This p_{LC} value shall appear on the OIML certificate; however, if p_{LC} is not specified on the certificate then the value of 0.7 is to be assumed.

- Humidity tests

  The requirements of R 76 and R 60 are not identical; it was

Ian Dunmill (NWML) welcomes delegates attending the TC 9 meeting decided to add a test (referred to below as SH) equivalent to that in R 76; there are now three possibilities:

- NH: no humidity test;
- SH: 2-day steady state test, conduct additional load tests during humidity exposure;
- CH or no marking: conduct the current R 60 12-day cyclic test, and the load test only before and after exposure.

▸ Load cells to be submitted for test within their family

Following the report of the ad-hoc group of volunteer countries coordinated by Canada, a definition of the family of load cells covered by one OIML certificate was approved as well as a harmonized procedure for the selection of load cells to be tested within their family. A practical example of the process of selection was agreed upon and will be incorporated as a separate Annex to the Recommendation.

▸ Digital load cells

The secretariat will propose a definition, requirements, test procedures and report formats for digital load cells (with active electronics on-board) in the 2nd CD.

▸ Modification of the scope of R 60

In recognition of the fact that load cells certified to R 60 are being accepted for use in dynamic weighing instruments, the text of the scope (1.1) was edited.

▸ Temperature tests

It was decided to require the following temperature test order sequence: 20 °C, the higher temperature(s), the lower temperature(s), 20 °C. In order to harmonize R 76 and R 60, the temperature range limits shall be unique for all classes (except otherwise specified): –10 °C to +40 °C.

▸ Marking

Minimum information shall be required to be marked on the body of load cells. ■

TC 9

▸ Instruments de mesure des masses et masses volumiques

Secrétariat: États-Unis d'Amérique

Sur invitation du *National Weights and Measures Laboratory (NWML)*, le comité technique OIML TC 9 a tenu une réunion à Teddington (Royaume-Uni) du 7 au 9 juillet 1997.

Présidente:
Mme D. McGann Ripley (NIST)

Participation: 30 délégués représentant 16 pays membres-P et le CECIP; Ph. Degavre, BIML.

Points principaux

L'objectif de cette réunion de 2 1/2 jours était la discussion du 1er projet de comité de la révision de OIML R 60 *Réglementation métrologique des cellules de pesée* et de l'Annexe A à R 60 *Format du rapport d'essai des cellules de pesée* qui ont été préparés par le secrétariat et envoyés pour vote en août 1996. Suffisamment de commentaires ont été reçus avec les votes pour nécessiter cette réunion. L'ordre du jour comprenait tellement de points qu'il n'est pas possible de donner ici un résumé complet de cette réunion, par ailleurs très bien organisée et fructueuse. Des décisions importantes ont été prises sur les points suivants:

▸ Proposition de changement de droite de référence

La proposition d'une droite des moindres carrés comme droite de référence pour l'enveloppe d'erreurs (6.2) a dû être retirée par le secrétariat, faute de support.

▸ Essai de fluage et du "MDLOR" (renommé "DR")

Suite à des discussions pour éliminer certaines parties d'essais, finalement aucun changement n'a été accepté par le groupe de travail international (GTI).

The USA delegation, including Mrs McGann Ripley, Chairwoman

▶ Classification des cellules de pesée

Le GTI a voté de ne pas ajouter des exigences de classification des cellules de pesée utilisées dans des instruments de pesage à étendues multiples et multi-échelons. Cependant, étant donné que de nombreux États Membres le trouvent utile, spécialement dans leurs services nationaux, il a été convenu d'ajouter, en gardant ceux-ci non obligatoires, les définitions de deux facteurs, Y et Z, comme suit:

$Y = E_{max}/v_{min}$;

$Z = E_{max}/(2 \times DR)$.

Ces facteurs ne doivent pas être spécifiés, mais peuvent l'être à titre optionnel.

▶ Erreurs maximales tolérées: répartition

Il a été décidé d'autoriser les constructeurs à choisir des valeurs de "p" autres que p = 0,7. Cette valeur p_{LC} doit apparaître sur le certificat OIML; cependant si p_{LC} n'est pas spécifié sur le certificat, alors sa valeur est supposée être égale à 0,7.

▶ Essais d'humidité

Les exigences de la R 76 et de la R 60 ne sont pas identiques; il a été décidé d'ajouter un essai (appelé ci-dessous SH) équivalent à celui de la R 76; à présent, il y a trois possibilités:

- NH: pas d'essai d'humidité;
- SH: essai continu de 2 jours, avec des essais additionnels en charge pendant l'exposition à l'humidité;
- CH ou pas de marquage: essai normal de la R 60, essai cyclique de 12 jours, avec mise en charge seulement avant et après l'exposition.

▶ Cellules de pesée d'une famille à soumettre aux essais

Suivant le rapport du groupe ad-hoc de pays volontaires coordonnés par le Canada, la définition d'une famille de cellules de pesée couvertes par un certificat OIML a été approuvée ainsi qu'une procédure harmonisée pour la sélection des cellules de pesée à soumettre aux essais. Un exemple pratique du processus de sélection a été approuvé et sera publié dans une autre Annexe à la Recommandation.

▶ Cellules de pesée numériques

Le secrétariat proposera une définition, des exigences, des procédures d'essai et des formats de rapports d'essai pour les cellules de pesée numériques (c'est-à-dire avec des dispositifs électroniques actifs incorporés) dans le 2ème projet de comité.

▶ Modification du domaine d'application de la R 60

Étant donné que les cellules de pesée certifiées comme étant conformes à la R 60 peuvent être utilisées dans des instruments de pesage dynamiques, le texte du domaine d'application (1.1) a été modifié.

▶ Essais de température

Il a été décidé d'exiger l'ordre suivant pour la séquence des essais de températures: 20 °C, la(les) plus haute(s) température(s), la(les) plus basse(s) température(s), 20 °C. Afin d'harmoniser R 76 et R 60, les limites de l'étendue de température doivent être pour toutes les classes (excepté si spécifié autrement): –10 °C à +40 °C.

▶ Marquage

Le marquage d'une information minimale sera exigé sur le corps des cellules de pesée. ■

TC 9/SC 2

Automatic weighing instruments

Secretariat: United Kingdom

The NWML hosted a meeting of OIML TC 9/SC 2 which was held on 9–11 July 1997 in Teddington, UK.

Chairman: Mr I. Dunmill, NWML

Participation: 28 delegates representing 16 P- and 1 O-Members; CECIP; Ph. Degavre, BIML.

Main points

▶ Automatic instruments for weighing road vehicles in motion - second committee draft

The 2nd committee draft taking into account the decisions taken during the last meeting in Braunschweig was circulated in November 1996. Many countries and also CECIP made comments, which were circulated by the secretariat. The main points discussed during the meeting were:

- Scope of the Recommendation: limited to those instruments installed and operated under certain controlled conditions (e.g. vehicle speed, road smoothness, etc.).
- Terminology: should the measuring result be displayed in mass or force units?
- Maximum permissible errors for weighing-in-motion: six accuracy classes are defined for total vehicle weight, axle and/or axle group weights respectively, as shown below:

0.2	0.5	1	2	5	10
a_1	a_2	a_3	a_4	a_8	a_{15}

- The table below which summarizes the permissible combinations between the accuracy classes defined above was approved by a large majority of experts:

	a_1	a_2	a_3	a_4	a_8	a_{15}
0.2	Y	N	N	N	N	N
0.5	Y	Y	N	N	N	N
1	Y	Y	Y	N	N	N
2	Y	Y	Y	Y	N	N
5	Y	Y	Y	Y	Y	N
10	Y	Y	Y	Y	Y	Y

Y = Yes; N = No

- Consistency of figures and class names with European specifications on weigh-in-motion of road vehicles drafted (Draft 2.2 - June 1997) by the COST 323 Management Committee. Mr B. Jacob, French expert and Chairman of this Committee, presented different technical and metrological approaches related to slow and high speed WIM systems.

- Test procedures: the outline for a basic test method was agreed. The secretariat would carry out some practical testing to try to decide which tests are necessary, and would develop test requirements as appropriate, within the broad guidelines approved by the technical subcommittee.

▸ The 3rd CD to be prepared by the secretariat by the end of October 1997 will be distributed for ballot and comments.

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TC 9/SC 2

Instruments de pesage à fonctionnement automatique

Secrétariat: Royaume-Uni

Sur invitation du NWML, le sous-comité technique OIML TC 9/SC 2 a tenu une réunion à Teddington du 9 au 11 juillet 1997.

Président: M. I. Dunmill, NWML

Participation: 28 délégués représentant 16 pays membres-P, 1 pays membre-O, le CECIP; Ph. Degavre, BIML.

Points principaux

▸ Instruments automatiques pour le pesage en mouvement des véhicules routiers - 2ème projet de comité

Le 2ème projet de comité, tenant compte des décisions prises lors de la dernière réunion à Braunschweig, avait été distribué en novembre 1996. De nombreux pays et le CECIP ont envoyé leurs commentaires, et le secrétariat les a distribués. Les points principaux discutés pendant la réunion étaient:

- Domaine d'application de la Recommandation: limité aux instruments installés et utilisés sur des sites où certaines conditions sont contrôlées (ex.: la vitesse des véhicules, la rugosité de la route, etc.).

- Terminologie: convient-il d'afficher le résultat du mesurage en unités de masse ou de force?

- Erreurs maximales tolérées pour le pesage en mouvement: six classes d'exactitude sont définies pour le poids total du véhicule et les poids des essieux et/ou groupes d'essieux, respectivement comme indiqué ci-dessous:

0,2	0,5	1	2	5	10
a_1	a_2	a_3	a_4	a_8	a_{15}

- Le tableau ci-dessous qui résume les combinaisons permises entre les classes d'exactitude définies ci-dessus ont été approuvées par une large majorité d'experts:

Delegates attending the TC 9/SC 2 meeting in Teddington

	a_1	a_2	a_3	a_4	a_8	a_{15}
0.2	O	N	N	N	N	N
0.5	O	O	N	N	N	N
1	O	O	O	N	N	N
2	O	O	O	O	N	N
5	O	O	O	O	O	N
10	O	O	O	O	O	O

O = Oui; N = Non

- Cohérence des valeurs et des symboles désignant les classes avec les spécifications européennes sur le pesage en mouvement des véhicules routiers élaborées (Projet 2.2 - juin 1997) par le Comité de Direction de COST 323. B. Jacob, expert français et Président de ce Comité, a présenté différentes approches techniques et métrologiques concernant les systèmes de pesage en mouvement aux petites et grandes vitesses.

- Procédures d'essai: les grandes lignes de la méthode d'essai de base ont été approuvées. Le secrétariat procédera à quelques essais pratiques afin de tenter de décider quels essais seront nécessaires, et développera les exigences d'essai s'il y a lieu, dans les limites des grandes lignes approuvées par le SC.

- Le 3ème projet de comité, qui sera préparé par le secrétariat avant fin octobre 1997, sera distribué pour votes et commentaires.

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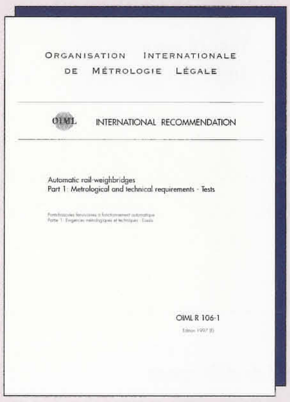
New publications



R 79 — **Labeling requirements for prepackaged products**

Exigences pour l'étiquetage des produits préemballés

R 106-1 & 2 — **Automatic rail-weighbridges**
Part 1: Metrological and technical requirements - Tests
Part 2: Test report format *(currently only available in English)*

Ponts-bascules ferroviaires à fonctionnement automatique
Partie 1: Exigences métrologiques et techniques - Essais

R 107-2 — **Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers)**
Part 2: Test report format *(currently only available in English)*

Committee drafts received by BIML

June 1997 – August 1997

Stage of development	Title	TC/SC	Secretariat
1 CD	Revision of OIML R 102 *Sound calibrators*	TC 13	Germany
2 CD	*Ergometers for foot crank work: definitions, requirements, tests*	TC 18	Germany

REGISTERED OIML CERTIFICATES - *CERTIFICATS OIML ENREGISTRÉS*

1997.06 – 1997.08

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.

► **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).

OIML Recommendation applicable within the System / Year of publication

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

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*

Centro Español de Metrologia, Spain

R51/1996-ES-97.01
DIBAL, SA.,
Astintze Kalea, 24 - Poligono Industrial Neinver,
48016 Derio-Vizcaya, Spain

Weigh price labeller type "SYSTEM 2000/1000" (Class Y(a))

► **Issuing Authority** / *Autorité de délivrance*

Sous-direction de la Métrologie, France

R51/1996-FR-97.02
Société Testut, 957 rue de l'Horlogerie, BP 11, 62401 Béthune, France + Société Lutrana, 50 avenue du Président Kennedy, 91170 Viry-Chatillon, France

Modèle EL 25 (Classe Y(a))

► **Issuing Authority** / *Autorité de délivrance*

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

R51/1996-NL-97.02
Ishida Co., Ltd., 44, Sanno-cho, Shogoin,
Sakayo-ku, Kyoto, 606, Japan

*Type DACS-W-***-** (Class X(1))*

R51/1996-NL-97.03
Garvens Automation GmbH, Hasede, Kampstraße 7,
D-31180 Giesen, Germany

Type BF-8 (Class X(1))

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Load cells
Cellules de pesée

R 60 (1991), Annex A (1993)

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

**Ministère des Affaires Économiques,
Service de la Métrologie, Belgium**

R60/1991-BE-97.01
Sensy S.A., Chaussée de Charleroi 97, 6060 Gilly, Belgium

Cellule de pesée à jauges de contrainte Sensy type 5510 (Classe C)

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

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

R60/1991-DK-97.01
Cardinal Scale Manufacturing Co., 203 East Daugherty St.,
Webb City, Missouri 64870, USA

Bending beam load cell type TSP (Class C)

R60/1991-DK-97.02
Cardinal Scale Manufacturing Co., 203 East Daugherty St.,
Webb City, Missouri 64870, USA

Shear beam load cell type SB (Class C)

R60/1991-DK-97.03
Cardinal Scale Manufacturing Co., 203 East Daugherty St.,
Webb City, Missouri 64870, USA

Bending beam load cell type TB (Class C)

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

National Weights and Measures Laboratory (NWML),
United Kingdom

R60/1991-GB-97.01
ATEX, BP 326, 07003 Privas cedex, France

Load Cell Model TA-1 (Classes C and D)

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

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

R60/1991-NL-96.01 Rev. 1
Gefran Sensori, Via Statale Sebina 74,
25050 Provaglio D'Iseo (BS), Italy

Type OD (Classes C and D)

R60/1991-NL-97.10
CAS Corporation, # 19 Kanap-ri Kwangjeok-myon,
Yangju-kun Kyungki-do, South Korea

Type BCA (Class C)

R60/1991-NL-97.13
CAS Corporation, # 19 Kanap-ri Kwangjeok-myon,
Yangju-kun Kyungki-do, South Korea

Types BCN and BCM (Class C)

R60/1991-NL-97.14
Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku,
Tokyo 146, Japan

Type P (Class C)

R60/1991-NL-97.15
A&D Instruments Ltd., Abingdon Science Park, Abingdon,
Oxford, OX14 3YS, United Kingdom

Type LC-5207 (Class C)

R60/1991-NL-97.16
ADOS S.r.l., Via Lazlo, 25, 20090 Buccinasco, Milan, Italy

Type CAX (Class C)

R60/1991-NL-97.17
Revere Transducers Europe, Ramshoorn 7, Postbus 6909,
4802 HX Breda, The Netherlands

Type HCB (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*

Office Fédéral de Métrologie, Switzerland

R76/1992-CH-97.01
Haenni & Co. Ltd., CH-3303 Jegenstorf, Switzerland

Nonautomatic mechanical wheel load weighing instrument type WL 103 (Class IIII)

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

Physikalisch-Technische Bundesanstalt (PTB), Germany

R76/1992-DE-93.02 Rev. 1
Precisa Instruments A.G., Moosmattstraße 32,
CH 8953 Dietikon, Switzerland

Types 480D, 480G, 480D-480G, 480DG-FR (Class II)

R76/1992-DE-93.05 Rev. 3
Precisa Instruments A.G., Moosmattstraße 32,
CH 8953 Dietikon, Switzerland

Models series 300 S and 300 SCS (Class II)

R76/1992-DE-96.01 Rev. 1
Sartorius A.G., Weender Landstraße 94-108,
D-37075 Göttingen, Germany

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

R76/1992-DE-97.01
Sartorius A.G., Weender Landstraße 94-108,
D-37075 Göttingen, Germany

Types DI BG 200 and DN BG 200 (Class II), DI BG 300 and DN BG 300 (Class III)

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

National Weights and Measures Laboratory (NWML), United Kingdom

R76/1992-GB-97.01
Pennsylvania Scale Co, 21 Graybill Road, Leola, PA 17540, USA

Model 7300 nonautomatic weighing instrument (Class III)

R76/1992-GB-97.02
Hobart Corporation, World Headquarters, 701 Ridge Avenue,
Troy, Ohio 45374-0001, USA

Ultima 2000 (Class III)

R76/1992-GB-97.03
NCR Corporation, 2651 Satellite Blvd, Duluth, GA 30136, USA

NCR 7875-2000 Scanner/Scale (Class III)

R76/1992-GB-97.04
NCR Corporation, 2651 Satellite Blvd, Duluth, GA 30136, USA

NCR 7880-2100 Scanner/Scale (Class III)

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

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

R76/1992-NL-96.18 Rev. 1
Balea, 8 avenue du Grand Chêne, Z.A. Les Avants,
34270 Saint-Mathieu de Tréviers, France

SCAL'UP (Class III)

R76/1992-NL-97.10
Tedea-Huntleigh Electronics Co. Ltd., No. 16, Hong DA Road,
Da Xing County, Technology Development Zone, Beijing, China

Type BT-60 (Class III)

R76/1992-NL-97.11
Teraoka Seiko Co., Ltd., 13-12 Kugahara, 5-Chome, Ohta-ku,
Tokyo 146, Japan

Type DC-180 (Class 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*

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

R117/1995-NL-97.02
Schlumberger Electronic Transactions, Retail Petroleum Systems Division, Industrieweg 5, 5531 AD Bladel, The Netherlands + Schlumberger Electronic Transactions, RPS Div., Unit 3, Baker Road, Pitkerro Industrial Estate, Dundee DD5 3RT, United Kingdom

Model EUROTRON series, respectively for the two successive manufacturers: HDM, UNIVERSAL, SPECTRA, H and PRIMA series (Class 0.5)

R117/1995-NL-97.03
Schlumberger Electronic Transactions, Retail Petroleum Systems Division, Industrieweg 5, 5531 AD Bladel, The Netherlands + Schlumberger Electronic Transactions, RPS Div., Unit 3, Baker Road, Pitkerro Industrial Estate, Dundee DD5 3RT, United Kingdom

Model EUROTRON series, respectively for the two successive manufacturers: HDM, UNIVERSAL, SPECTRA, H and PRIMA series (Class 0.5)

Automatic rail-weighbridges and totalizing hopper weighers are now covered by the OIML Certificate System

With the publication of OIML Recommendations R 106-1 & 2 *Automatic rail-weighbridges* and R 107-1 & 2 *Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers)*, two new categories of weighing instruments are now covered by the OIML Certificate System.

These instruments are widely used and have the advantage of being quick and relatively accurate. The maximum permissible errors in service are respectively 0.2 %, 0.5 %, 1 % and 2 % for the different accuracy classes.

Les ponts-bascules ferroviaires à fonctionnement automatique et les peseuses totalisatrices à trémie sont à présent couverts par le Système de Certificats OIML

Avec la publication des Recommandations OIML R 106-1 & 2 *Ponts-bascules ferroviaires à fonctionnement automatique* et R 107-1 & 2 *Instruments de pesage totalisateurs discontinus à fonctionnement automatique (peseuses totalisatrices à trémie)*, deux nouvelles catégories d'instruments de pesage ont fait leur entrée dans le Système de Certificats OIML.

Ces instruments sont très largement utilisés et présentent l'avantage d'être rapides et relativement précis. Les erreurs maximales tolérées en service sont: 0,2 %, 0,5 %, 1 % et 2 % respectivement pour les différentes classes d'exactitude.

Inauguration of the new Justervesenet offices and laboratories

(Norwegian metrology and accreditation service)

A large crowd gathered in the new Justervesenet premises and laboratories for the official inauguration of the complex on Tuesday 17 June 1997.

The small town of Kjeller, situated about twenty kilometers northwest of Oslo, offers very appropriate surroundings for the establishment of a metrology service: open space, peace and quiet, and a marked absence of any significant kinds of vibrations, pollution or such like. Moreover, the site is well served by transport links to both the capital and other important Norwegian towns, and in the medium term, the transfer of the international airport (currently located at Fornebu on the south-west side) to the north of Oslo will greatly facilitate access to the Norwegian laboratories for metrologists flying in from anywhere in the world.

All the reasons for choosing the Kjeller site were presented when the first foundation stone of the new premises was laid on 20 May 1996 (see the October 1994 issue of the OIML Bulletin, p. 55).

These new premises were designed to house both scientific metrology activities (national standards, intercomparisons, calibrations, etc.), legal metrology activities (pattern evaluation, traceability of verification equipment, etc.), and all the administrative activities connected with metrology and accreditation.

The most modern techniques were used to build the laboratories and advantage was taken of the natural geographical relief, thus allowing those laboratories which require the most protection against external disturbances to be partially buried underground.

The inauguration was conducted by Dr. Helge Kildal, Justervesenet Director General and CIML Member for Norway, in the presence of his predecessor Mr. K. Birkeland, CIML past President.

During a number of speeches architects, local authorities, representatives of industry and Justervesenet personnel expressed their satisfaction for this new complex, which endows Norway with the metrological means required to confront the turn of the century.

Mrs. Grete Knudsen, Industry and Trade Minister, went on to officially inaugurate the premises and reiterated her government's interest in the development of metrology and accreditation in Norway, and also in regional and international cooperation.

European and world-wide metrology was also represented by the Directors of the BIPM and the BIML and by the President of EUROMET, who in a few words expressed their satisfaction at seeing Norwegian metrology structures developing in this way (the President of WELMEC was unable to attend the ceremony).

A visit of the laboratories and the museum closed this inauguration day. ■

General view of the new Justervesenet premises

Vue générale des nouveaux locaux de Justervesenet

Inauguration des nouveaux bureaux et laboratoires de Justervesenet

(Service norvégien de métrologie et d'accréditation)

Une foule nombreuse occupait les nouveaux locaux et laboratoires de Justervesenet, le mardi 17 juin 1997, pour leur inauguration officielle.

Située à une vingtaine de kilomètres au nord-ouest d'Oslo, la petite ville de Kjeller offre un cadre tout à fait approprié pour l'implantation d'un service de métrologie: espace, calme, absence d'importantes vibrations et pollutions de tous genres..., avec par contre des liaisons faciles vers la capitale et autres importantes villes de Norvège et de plus, à moyen terme, le transfert de l'aéroport international du sud-ouest (Fornebu) au nord d'Oslo, permettant ainsi aux métrologues de tous pays un accès facile aux laboratoires norvégiens.

Toutes les raisons qui avaient fait choisir le site de Kjeller avaient été exposées lors de la pose de la première pierre des nouveaux locaux, le 20 mai 1994 (voir Bulletin OIML d'octobre 1994, p. 55).

Ces nouveaux locaux ont été conçus pour abriter à la fois les activités de métrologie scientifique (étalons nationaux, intercomparaisons, étalonnages, etc.), de métrologie légale (essais de modèle, raccordement des moyens de vérification, etc.), et toutes les activités administratives liées à la métrologie et à l'accréditation.

En ce qui concerne les laboratoires, les techniques les plus modernes ont été mises en oeuvre, associées à la géographie du lieu qui a permis d'enterrer partiellement ceux des laboratoires qui ont le plus besoin de protection contre les perturbations extérieures.

L'inauguration a été conduite par le Dr. Helge Kildal, Directeur Général de Justervesenet et Membre du CIML pour la Norvège, en présence de son prédécesseur M. K. Birkeland, ancien Président du CIML.

De nombreux discours ont permis aux architectes, aux autorités locales, aux représentants de sociétés industrielles, et au personnel de Justervesenet d'exprimer leur satisfaction pour cette réalisation qui dote la Norvège des moyens métrologiques nécessaires à l'approche du vingt-et-unième siècle.

Mme Grete Knudsen, Ministre de l'Industrie et du Commerce, a procédé à l'inauguration officielle et a affirmé l'intérêt qu'attache son gouvernement au développement de la métrologie et de l'accréditation en Norvège, et à la coopération régionale et internationale.

La métrologie européenne et mondiale était d'ailleurs représentée par les Directeurs du BIPM et du BIML et par le Président d'EUROMET qui ont prononcé quelques mots pour exprimer leur satisfaction de voir ainsi se développer les structures métrologiques de la Norvège (le Président de WELMEC n'avait pu assister à la cérémonie).

Une visite des laboratoires et du musée ont clôturé cette journée d'inauguration. ■

Mrs. Knudsen handing over the keys to Dr. Kildal

Mme Knudsen donne les clés au Dr. Kildal

XIV IMEKO World Congress – XIV Congrès Mondial d'IMEKO

The 14th World Congress of the International Measurement Confederation (IMEKO), organized by the Finnish Society of Automation and the IMEKO Secretariat, took place on 1–6 June 1997 in Tampere, Finland.

The theme was "New measurement - Challenges and visions".

Over 700 delegates from some 50 countries and many international and regional organizations attended this congress, as well as workshops and a symposium organized in parallel on related subjects.

Minutes of lectures and poster sessions, which were grouped by topic (see below), were published in several volumes and a CD is also available.

The Director of the BIML made two presentations:

- during one of the plenary sessions he described the OIML, its present situation and future evolutions; whilst on this subject he proposed further improving cooperation between IMEKO and the OIML;
- during a Round Table organized by IMEKO TC 11 (Metrological Infrastructure), he described OIML activity concerning development assistance and emphasized the necessity for close cooperation between the various organizations concerned, in particular IMEKO, the BIPM and OIML.

The next IMEKO World Congress will be organized in Osaka, Japan in June 1999 on the general theme "Measurement coordinates nature with human activities". ■

La Confédération Internationale de la Mesure, IMEKO, a tenu son 14ème Congrès Mondial à Tampere, Finlande, du 1er au 6 juin 1997, organisé par la *Finnish Society of Automation* et le Secrétariat de l'IMEKO.

Le thème en était: "Nouveaux mesurages - Défis et perspectives".

Plus de 700 participants provenant de près de 50 pays et de nombreuses organisations internationales et régionales ont assisté à ce congrès et à des ateliers et symposium organisés parallèlement sur des sujets connexes.

L'ensemble des conférences et sessions affichées, regroupées en thèmes (voir ci-dessous) ont fait l'objet de la publication de rapports en plusieurs volumes et d'un disque CD.

Le Directeur du BIML a fait deux présentations:

- à l'occasion d'une des sessions plénières, il a décrit l'OIML, sa situation actuelle et ses évolutions; dans ce cadre, il a proposé que la coopération entre IMEKO et OIML soit renforcée;
- au cours d'une Table Ronde organisée par IMEKO TC 11 (Infrastructure Métrologique), il a décrit l'activité de l'OIML en matière d'assistance au développement et insisté sur la nécessité d'une coopération étroite entre les diverses organisations concernées, en particulier l'IMEKO, le BIPM et l'OIML.

Le prochain Congrès Mondial de l'IMEKO sera organisé en juin 1999 à Osaka, Japon, sur le thème général "La mesure, coordination entre la nature et les activités humaines". ■

Topics dealt with during the XIV IMEKO World Congress
Thèmes traités au cours du XIV Congrès Mondial de l'IMEKO

Topic 1	Education and Training in Measurement and Instrumentation
Topic 2	Photonic Measurements
Topic 3	Measurement of Force and Mass
Topic 4	Electrical Measurements
Topic 5	Hardness Measurement
Topic 7	Measurement Science
Topic 8	Traceability in Metrology
Topic 9	Flow Measurement
Topic 10	Technical Diagnostics
Topic 11	Metrological Infrastructure
Topic 12	Temperature and Thermal Measurements
Topic 13	Measurements in Biology and Medicine
Topic 14	Measurement of Geometrical Quantities
Topic 15	Experimental Mechanics
Topic 16	Pressure and Vacuum Measurement
Topic 17	Measurement in Robotics
Topic 18	Measurements for the Pulp and Paper Industry
Topic 19	Measurements in Telecommunication
Topic 20	Environmental Measurements
Topic 21	Other Areas of the Measurement Science and Technology
ADC Workshop	ADC Modeling and Testing
ISMCR'97	Topical Workshop on Virtual Reality and Advanced Man-Machine Interfaces
CD Symposium	Cross Directional Web Measurements, Controls and Actuator Systems in Paper Machines

Reports, volumes and CD have been published by:

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meetings OIML réunions

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	32nd CIML meeting (starting in the afternoon of 29th October)	

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

November 1997

19–21	TC 8/SC 5 Water meters	VIENNA, AUSTRIA

January 1998

26–28	TC 8/SC 7 Gas metering	BRUSSELS, BELGIUM

The OIML is pleased to welcome the following new:

Committee Members:

Bulgaria: I. Temniskov
Cameroon: H. Ela Essi
Japan: H. Imai
Korea, Dem. People's Rep. of: Kim Gwang Ho
Korea, Republic of: Yoo-Jin Koh
Romania: S. Ocneanu

Corresponding Member:

Estonia

info

IMEKO TC 3

16th International Conference on Force, Mass and Torque Measurements

APMF '98

Asia-Pacific Symposium on Measurement of Mass and Force

14–18 September 1998

Taejon, Republic of Korea

Theory and Practice

The primary goal of this Conference is to review the latest worldwide R&D trends in the fields of force, mass and torque measurements; the theoretical and practical on-site applications of these trends in industry are also explored.

The Conference, which will be held at the same time as the APMF Symposium, will enable scientists, technicians and specialists from industry and research centers to gain first-hand information on some of the latest developments in areas such as:

- standards;
- dynamic measurements;
- verification of automatic weighing instruments;
- sensor technologies;
- estimation of uncertainty.

To submit a paper or attend the Conference, contact:

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PUBLICATIONS

classified by subject and number

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Other publications

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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".

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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)* — 60 FRF
Accuracy classes of measuring instruments
Classes de précision des instruments de mesurage

R 42 (1981-*1977)* — 50 FRF
Metal stamps for verification officers
Poinçons de métal pour Agents de vérification

D 1 (1975) — 50 FRF
Law on metrology
Loi de métrologie

D 2 (being printed - *en cours de publication)*
Legal units of measurement
Unités de mesure légales

D 3 (1979) — 60 FRF
Legal qualification of measuring instruments
Qualification légale des instruments de mesurage

D 5 (1982) — 60 FRF
Principles for the establishment of hierarchy schemes for measuring instruments
Principes pour l'établissement des schémas de hiérarchie des instruments de mesure

D 9 (1984) — 60 FRF
Principles of metrological supervision
Principes de la surveillance métrologique

D 12 (1986) — 50 FRF
Fields of use of measuring instruments subject to verification
Domaines d'utilisation des instruments de mesure assujettis à la vérification

D 13 (1986) — 50 FRF
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

D 14 (1989) — 60 FRF
Training of legal metrology personnel - Qualification - Training programmes
Formation du personnel en métrologie légale - Qualification - Programmes d'étude

D 15 (1986) — 80 FRF
Principles of selection of characteristics for the examination of measuring instruments
Principes du choix des caractéristiques pour l'examen des instruments de mesure usuels

D 16 (1986) — 80 FRF
Principles of assurance of metrological control
Principes d'assurance du contrôle métrologique

D 19 (1988) — 80 FRF
Pattern evaluation and pattern approval
Essai de modèle et approbation de modèle

D 20 (1988) 80 FRF
Initial and subsequent verification of measuring instruments and processes
Vérifications primitive et ultérieure des instruments et processus de mesure

V 1 (1978) 100 FRF
Vocabulary of legal metrology (bilingual French-English)
Vocabulaire de métrologie légale (bilingue français-anglais)

V 2 (1993) 200 FRF
International vocabulary of basic and general terms in metrology (bilingual French-English)
Vocabulaire international des termes fondamentaux et généraux de métrologie (bilingue français- anglais)

P 1 (1991) 60 FRF
OIML Certificate System for Measuring Instruments
Système de Certificats OIML pour les Instruments de Mesure

P 2 (1987) 100 FRF
Metrology training - Synthesis and bibliography (bilingual French-English)
Formation en métrologie - Synthèse et bibliographie (bilingue français-anglais)

P 3-1 (1996) 400 FRF
Legal metrology in OIML Member States
Métrologie légale dans les Etats Membres de l'OIML

P 3-2 (1996) 300 FRF
Legal metrology in OIML Corresponding Members
Métrologie légale dans les Membres Correspondants de l'OIML

P 9 (1992) 100 FRF
Guidelines for the establishment of simplified metrology regulations

P 17 (1995) 300 FRF
Guide to the expression of uncertainty in measurement
Guide pour l'expression de l'incertitude de mesure

Measurement standards and verification equipment
Étalons et équipement de vérification

D 6 (1983) 60 FRF
Documentation for measurement standards and calibration devices
Documentation pour les étalons et les dispositifs d'étalonnage

D 8 (1984) 60 FRF
Principles concerning choice, official recognition, use and conservation of measurement standards
Principes concernant le choix, la reconnaissance officielle, l'utilisation et la conservation des étalons

D 10 (1984) 50 FRF
Guidelines for the determination of recalibration intervals of measuring equipment used in testing laboratories
Conseils pour la détermination des intervalles de réétalonnage des équipements de mesure utilisés dans les laboratoires d'essais

D 18 (1987) 50 FRF
General principles of the use of certified reference materials in measurements
Principes généraux d'utilisation des matériaux de référence certifiés dans les mesurages

D 23 (1993) 80 FRF
Principles of metrological control of equipment used for verification
Principes du contrôle métrologique des équipements utilisés pour la vérification

P 4 (1986–*1981*) 100 FRF
Verification equipment for National Metrology Services
Equipement d'un Service national de métrologie

P 6 (1987) 100 FRF
Suppliers of verification equipment (bilingual French-English)
Fournisseurs d'équipement de vérification (bilingue français-anglais)

P 7 (1989) 100 FRF
Planning of metrology and testing laboratories
Planification de laboratoires de métrologie et d'essais

P 15 (1989) 100 FRF
Guide to calibration

Mass and density
Masses et masses volumiques

R 15 (1974–*1970*) 80 FRF
Instruments for measuring the hectolitre mass of cereals
Instruments de mesure de la masse à l'hectolitre des céréales

R 22 (1975) 150 FRF
International alcoholometric tables (trilingual French-English-Spanish version)
Tables alcoométriques internationales (version trilingue français-anglais-espagnol)

R 33 (1979–*1973*) 50 FRF
Conventional value of the result of weighing in air
Valeur conventionnelle du résultat des pesées dans l'air

R 44 (1985) 50 FRF
Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry
Alcoomètres et aréomètres pour alcool et thermomètres utilisés en alcoométrie

R 47 (1979–*1978*) 60 FRF
Standard weights for testing of high capacity weighing machines
Poids étalons pour le contrôle des instruments de pesage de portée élevée

R 50-1 (1997) 150 FRF
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

R 50-2 (1997) 200 FRF
Continuous totalizing automatic weighing instruments (Belt weighers). Part 2: Test report format
Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande)
Partie 2: Format du rapport d'essai

R 51-1 (1996) 100 FRF

Automatic catchweighing instruments. Part 1: Metrological and technical requirements - Tests
Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais

R 51-2 (1996) 300 FRF

Automatic catchweighing instruments. Part 2: Test report format
Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique. Partie 2: Format du rapport d'essai

R 52 (1980) 50 FRF

Hexagonal weights, ordinary accuracy class from 100 g to 50 kg
Poids hexagonaux de classe de précision ordinaire, de 100 g à 50 kg

R 60 (1991) 80 FRF

Metrological regulation for load cells
Réglementation métrologique des cellules de pesée

Annex (1993) 80 FRF

Test report format for the evaluation of load cells
Format du rapport d'essai des cellules de pesée

R 61-1 (1996) 150 FRF

Automatic gravimetric filling instruments. Part 1: Metrological and technical requirements - Tests
Doseuses pondérales à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais

R 61-2 (1996) 250 FRF

Automatic gravimetric filling instruments. Part 2: Test report format
Doseuses pondérales à fonctionnement automatique. Partie 2: Format du rapport d'essai

R 74 (1993) 80 FRF

Electronic weighing instruments
Instruments de pesage électroniques

R 76-1 (1992) 300 FRF

Nonautomatic weighing instruments. Part 1: Metrological and technical requirements - Tests
Instruments de pesage à fonctionnement non automatique. Partie 1: Exigences métrologiques et techniques - Essais

Amendment No. 1 (1994) NC

R 76-2 (1993) 200 FRF

Nonautomatic weighing instruments. Part 2: Pattern evaluation report
Instruments de pesage à fonctionnement non automatique. Partie 2: Rapport d'essai de modèle

Amendment No. 1 (1995) NC

R 106-1 (1997) 150 FRF

Automatic rail-weighbridges. Part 1: Metrological and technical requirements - Tests
Ponts-bascules ferroviaires à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais

R 106-2 (1997) 200 FRF

Automatic rail-weighbridges. Part 2: Test report format
Ponts-bascules ferroviaires à fonctionnement automatique. Partie 2: Format du rapport d'essai

R 107-1 (1997) 150 FRF

Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers). Part 1: Metrological and technical requirements - Tests
Instruments de pesage totalisateurs discontinus à fonctionnement automatique (peseuses totalisatrices à trémie) Partie 1: Exigences métrologiques et techniques - Essais

R 107-2 (1997) 300 FRF

Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers). Part 2: Test report format
Instruments de pesage totalisateurs discontinus à fonctionnement automatique (peseuses totalisatrices à trémie) Partie 2: Format du rapport d'essai

R 111 (1994) 80 FRF

Weights of classes E_1, E_2, F_1, F_2, M_1, M_2, M_3
Poids des classes E_1, E_2, F_1, F_2, M_1, M_2, M_3

P 5 (1992) 100 FRF

Mobile equipment for the verification of road weighbridges (bilingual French-English)
Equipement mobile pour la vérification des ponts-bascules routiers (bilingue français-anglais)

P 8 (1987) 100 FRF

Density measurement
Mesure de la masse volumique

Length and speed
Longueurs et vitesses

R 21 (1975-*1973)* 60 FRF

Taximeters
Taximètres

R 24 (1975-*1973)* 50 FRF

Standard one metre bar for verification officers
Mètre étalon rigide pour Agents de vérification

R 30 (1981) 60 FRF

End standards of length (gauge blocks)
Mesures de longueur à bouts plans (cales étalons)

R 35 (1985) 80 FRF

Material measures of length for general use
Mesures matérialisées de longueur pour usages généraux

R 55 (1981) 50 FRF

Speedometers, mechanical odometers and chronotachographs for motor vehicles. Metrological regulations
Compteurs de vitesse, compteurs mécaniques de distance et chronotachygraphes des véhicules automobiles. Réglementation métrologique

R 66 (1985) 60 FRF

Length measuring instruments
Instruments mesureurs de longueurs

R 91 (1990) 60 FRF
Radar equipment for the measurement of the speed of vehicles
Cinémomètres radar pour la mesure de la vitesse des véhicules

R 98 (1991) 60 FRF
High-precision line measures of length
Mesures matérialisées de longueur à traits de haute précision

Liquid measurement
Mesurage des liquides

R 4 (1972-*1970)* 50 FRF
Volumetric flasks (one mark) in glass
Fioles jaugées à un trait en verre

R 29 (1979-*1973)* 50 FRF
Capacity serving measures
Mesures de capacité de service

R 40 (1981-*1977)* 60 FRF
Standard graduated pipettes for verification officers
Pipettes graduées étalons pour Agents de vérification

R 41 (1981-*1977)* 60 FRF
Standard burettes for verification officers
Burettes étalons pour Agents de vérification

R 43 (1981-*1977)* 60 FRF
Standard graduated glass flasks for verification officers
Fioles étalons graduées en verre pour Agents de vérification

R 45 (1980-*1977)* 50 FRF
Casks and barrels
Tonneaux et futailles

R 49 (being revised - *en cours de révision)*
Water meters intended for the metering of cold water
Compteurs d'eau destinés au mesurage de l'eau froide

R 63 (1994) 50 FRF
Petroleum measurement tables
Tables de mesure du pétrole

R 71 (1985) 80 FRF
Fixed storage tanks. General requirements
Réservoirs de stockage fixes. Prescriptions générales

R 72 (1985) 60 FRF
Hot water meters
Compteurs d'eau destinés au mesurage de l'eau chaude

R 80 (1989) 100 FRF
Road and rail tankers
Camions et wagons-citernes

R 81 (being revised - *en cours de révision)*
Measuring devices and measuring systems for cryogenic liquids (including tables of density for liquid argon, helium, hydrogen, nitrogen and oxygen)
Dispositifs et systèmes de mesure de liquides cryogéniques (comprend tables de masse volumique pour argon, hélium, hydrogène, azote et oxygène liquides)

R 85 (being revised - *en cours de révision)*
Automatic level gauges for measuring the level of liquid in fixed storage tanks
Jaugeurs automatiques pour le mesurage des niveaux de liquide dans les réservoirs de stockage fixes

R 86 (1989) 50 FRF
Drum meters for alcohol and their supplementary devices
Compteurs à tambour pour alcool et leurs dispositifs complémentaires

R 95 (1990) 60 FRF
Ships' tanks - General requirements
Bateaux-citernes - Prescriptions générales

R 96 (1990) 50 FRF
Measuring container bottles
Bouteilles récipients-mesures

R 105 (1993) 100 FRF
Direct mass flow measuring systems for quantities of liquids
Ensembles de mesurage massiques directs de quantités de liquides

Annex (1995) 80 FRF
Test report format
Format du rapport d'essai

R 117 (1995) 400 FRF
Measuring systems for liquids other than water
Ensembles de mesurage de liquides autres que l'eau

R 118 (1995) 100 FRF
Testing procedures and test report format for pattern evaluation of fuel dispensers for motor vehicles
Procédures d'essai et format du rapport d'essai des modèles de distributeurs de carburant pour véhicules à moteur

R 119 (1996) 80 FRF
Pipe provers for testing measuring systems for liquids other than water
Tubes étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau

R 120 (1996) 100 FRF
Standard capacity measures for testing measuring systems for liquids other than water
Mesures de capacité étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau

D 4 (1981) 50 FRF
Installation and storage conditions for cold water meters
Conditions d'installation et de stockage des compteurs d'eau froide

D 7 (1984) 80 FRF
The evaluation of flow standards and facilities used for testing water meters
Evaluation des étalons de débitmétrie et des dispositifs utilisés pour l'essai des compteurs d'eau

D 25 (1996) 60 FRF
Vortex meters used in measuring systems for fluids
Compteurs à vortex utilisés dans les ensembles de mesurage de fluides

D 26 (being printed - *en cours de publication)*
Glass delivery measures – Automatic pipettes
Mesures en verre à délivrer – Pipettes automatiques

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 manovacuomètres 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)

(1) See also "Liquid measurement" D 25 – *Voir aussi "Mesurage des liquides" D 25*
(2) See also "Medical instruments" – *Voir aussi "Instruments médicaux"*

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
Accoustique 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-moyenneurs

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

R 103 (1992) 60 FRF

Measuring instrumentation for human response to vibration
Appareillage de mesure pour la réponse des individus aux vibrations

R 104 (1993) 60 FRF

Pure-tone audiometers
Audiomètres à sons purs

Annex F (1997) 100 FRF
Test report format
Format du rapport d'essai

Environment
Environnement

R 82 (1989) 80 FRF

Gas chromatographs for measuring pollution from pesticides and other toxic substances
Chromatographes en phase gazeuse pour la mesure des pollutions par pesticides et autres substances toxiques

R 83 (1990) 80 FRF

Gas chromatograph/mass spectrometer/data system for analysis of organic pollutants in water
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

R 99 (being revised - *en cours de révision)*

Instruments for measuring vehicle exhaust emissions
Instruments de mesure des gaz d'échappement des véhicules

R 100 (1991) 80 FRF

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) 80 FRF

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) 80 FRF

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) 80 FRF

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) 80 FRF

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) 60 FRF

Polarimetric saccharimeters
Saccharimètres polarimétriques

R 54 (being revised - *en cours de révision)*

pH scale for aqueous solutions
Echelle de pH des solutions aqueuses

R 56 (1981) 50 FRF

Standard solutions reproducing the conductivity of electrolytes
Solutions-étalons reproduisant la conductivité des électrolytes

R 59 (1984) 80 FRF

Moisture meters for cereal grains and oilseeds
Humidimètres pour grains de céréales et graines oléagineuses

R 68 (1985) 50 FRF

Calibration method for conductivity cells
Méthode d'étalonnage des cellules de conductivité

R 69 (1985) 50 FRF

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) 50 FRF

Determination of intrinsic and hysteresis errors of gas analysers
Détermination des erreurs de base et d'hystérésis des analyseurs de gaz

R 73 (1985) 50 FRF

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
Prescriptions pour les gaz purs CO, CO_2, CH_4, H_2, O_2, N_2 et Ar destinés à la préparation des mélanges de gaz de référence

R 92 (1989) 60 FRF

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

Refractometers for the measurement of the sugar content of fruit juices
Réfractomètres pour la mesure de la teneur en sucre des jus de fruits

R 121 (1996) 60 FRF

The scale of relative humidity of air certified against saturated salt solutions
Échelle d'humidité relative de l'air certifiée par rapport à des solutions saturées de sels

R 124 (being printed - *en cours de publication*)

Refractometers for the measurement of the sugar content of grape musts
Réfractomètres pour la mesure de la teneur en sucre des moûts de raisin

D 17 (1987) 50 FRF

Hierarchy scheme for instruments measuring the viscosity of liquids
Schéma de hiérarchie des instruments de mesure de la viscosité des liquides

Medical instruments
Instruments médicaux

R 7 (1979–*1978)* 60 FRF

Clinical thermometers, mercury-in-glass with maximum device
Thermomètres médicaux à mercure, en verre, avec dispositif à maximum

R 16 (1973–*1970)* 50 FRF

Manometers for instruments for measuring blood pressure (sphygmomanometers)
Manomètres des instruments de mesure de la tension artérielle (sphygmomanomètres)

R 26 (1978–*1973)* 50 FRF

Medical syringes
Seringues médicales

R 78 (1989) 50 FRF

Westergren tubes for measurement of erythrocyte sedimentation rate
Pipettes Westergren pour la mesure de la vitesse de sédimentation des hématies

R 89 (1990) 80 FRF

Electroencephalographs - Metrological characteristics - Methods and equipment for verification
Electroencéphalographes - Caractéristiques métrologiques - Méthodes et moyens de vérification

R 90 (1990) 80 FRF

Electrocardiographs - Metrological characteristics - Methods and equipment for verification
Electrocardiographes - Caractéristiques métrologiques - Méthodes et moyens de vérification

R 93 (1990) 60 FRF

Focimeters
Frontofocomètres

R 114 (1995) 80 FRF

Clinical electrical thermometers for continuous measurement
Thermomètres électriques médicaux pour mesurage en continu

R 115 (1995) 80 FRF

Clinical electrical thermometers with maximum device
Thermomètres électriques médicaux avec dispositif à maximum

R 122 (1996) 60 FRF

Equipment for speech audiometry
Appareils pour l'audiométrie vocale

D 21 (1990) 80 FRF

Secondary standard dosimetry laboratories for the calibration of dosimeters used in radiotherapy
Laboratoires secondaires d'étalonnage en dosimétrie pour l'étalonnage des dosimètres utilisés en radiothérapie

Testing of materials
Essais des matériaux

R 9 (1972–*1970)* 60 FRF

Verification and calibration of Brinell hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Brinell

R 10 (1974–*1970)* 60 FRF

Verification and calibration of Vickers hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Vickers

R 11 (1974–*1970)* 60 FRF

Verification and calibration of Rockwell B hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Rockwell B

R 12 (1974–*1970)* 60 FRF

Verification and calibration of Rockwell C hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Rockwell C

R 36 (1980–*1977)* 60 FRF

Verification of indenters for hardness testing machines
Vérification des pénétrateurs des machines d'essai de dureté

R 37 (1981–*1977)* 60 FRF

Verification of hardness testing machines (Brinell system)
Vérification des machines d'essai de dureté (système Brinell)

R 38 (1981–*1977)* 60 FRF

Verification of hardness testing machines (Vickers system)
Vérification des machines d'essai de dureté (système Vickers)

R 39 (1981-*1977)*
Verification of hardness testing machines (Rockwell systems B,F,T - C,A,N)
Vérification des machines d'essai de dureté (systèmes Rockwell B,F,T -C,A,N)
60 FRF

R 62 (1985)
Performance characteristics of metallic resistance strain gauges
Caractéristiques de performance des extensomètres métalliques à résistance
80 FRF

R 64 (1985)
General requirements for materials testing machines
Exigences générales pour les machines d'essai des matériaux
50 FRF

R 65 (1985)
Requirements for machines for tension and compression testing of materials
Exigences pour les machines d'essai des matériaux en traction et en compression
60 FRF

V 3 (1991)
Hardness testing dictionary (quadrilingual French-English-German-Russian)
Dictionnaire des essais de dureté (quadrilingue français-anglais-allemand-russe)
80 FRF

P 10 (1981)
The metrology of hardness scales - Bibliography
50 FRF

P 11 (1983)
Factors influencing hardness measurement
100 FRF

P 12 (1984)
Hardness test blocks and indenters
100 FRF

P 13 (1989)
Hardness standard equipment
100 FRF

P 14 (1991)
The unification of hardness measurement
100 FRF

Prepackaging
Préemballages

R 79 (1997)
Labeling requirements for prepackaged products
Exigences pour l'étiquetage des produits préemballés
60 FRF

R 87 (1989)
Net content in packages
Contenu net des préemballages
50 FRF

OIML publications classified by number
Publications OIML classées par numéros

INTERNATIONAL RECOMMENDATIONS
RECOMMANDATIONS INTERNATIONALES

R 4 (1970–*1972*) 50 FRF
Volumetric flasks (one mark) in glass
Fioles jaugées à un trait en verre

R 6 (1989) 80 FRF
General provisions for gas volume meters
Dispositions générales pour les compteurs de volume de gaz

R 7 (1979–*1978*) 60 FRF
Clinical thermometers, mercury-in-glass with maximum device
Thermomètres médicaux à mercure, en verre, avec dispositif à maximum

R 9 (1972–*1970*) 60 FRF
Verification and calibration of Brinell hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Brinell

R 10 (1974–*1970*) 60 FRF
Verification and calibration of Vickers hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Vickers

R 11 (1974–*1970*) 60 FRF
Verification and calibration of Rockwell B hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Rockwell B

R 12 (1974–*1970*) 60 FRF
Verification and calibration of Rockwell C hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Rockwell C

R 14 (1995) 60 FRF
Polarimetric saccharimeters
Saccharimètres polarimétriques

R 15 (1974–*1970*) 80 FRF
Instruments for measuring the hectolitre mass of cereals
Instruments de mesure de la masse à l'hectolitre des céréales

R 16 (1973–*1970*) 50 FRF
Manometers for instruments for measuring blood pressure (sphygmomanometers)
Manomètres des instruments de mesure de la tension artérielle (sphygmomanomètres)

R 18 (1989) 60 FRF
Visual disappearing filament pyrometers
Pyromètres optiques à filament disparaissant

R 21 (1975–*1973*) 60 FRF
Taximeters
Taximètres

R 22 (1975–*1973*) 150 FRF
International alcoholometric tables (trilingual French-English-Spanish)
Tables alcoométriques internationales (trilingue français-anglais-espagnol)

R 23 (1975–*1973*) 60 FRF
Tyre pressure gauges for motor vehicles
Manomètres pour pneumatiques de véhicules automobiles

R 24 (1975–*1973*) 50 FRF
Standard one metre bar for verification officers
Mètre étalon rigide pour agents de vérification

R 26 (1978–*1973*) 50 FRF
Medical syringes
Seringues médicales

R 29 (1979–*1973*) 50 FRF
Capacity serving measures
Mesures de capacité de service

R 30 (1981) 60 FRF
End standards of length (gauge blocks)
Mesures de longueur à bouts plans (cales étalons)

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

R 33 (1979–*1973*) 50 FRF
Conventional value of the result of weighing in air
Valeur conventionnelle du résultat des pesées dans l'air

R 34 (1979–*1974*) 60 FRF
Accuracy classes of measuring instruments
Classes de précision des instruments de mesurage

R 35 (1985) 80 FRF
Material measures of length for general use
Mesures matérialisées de longueur pour usages généraux

R 36 (1980–*1977*) 60 FRF
Verification of indenters for hardness testing machines
Vérification des pénétrateurs des machines d'essai de dureté

R 37 (1981–*1977*) 60 FRF
Verification of hardness testing machines (Brinell system)
Vérification des machines d'essai de dureté (système Brinell)

R 38 (1981–*1977*) 60 FRF
Verification of hardness testing machines (Vickers system)
Vérification des machines d'essai de dureté (système Vickers)

R 39 (1981–*1977*) 60 FRF
Verification of hardness testing machines (Rockwell systems B,F,T-C,A,N)
Vérification des machines d'essai de dureté (systèmes Rockwell B,F,T-C,A,N)

R 40 (1981–*1977*) 60 FRF
Standard graduated pipettes for verification officers
Pipettes graduées étalons pour agents de vérification

R 41 (1981–*1977*) 60 FRF
Standard burettes for verification officers
Burettes étalons pour agents de vérification

R 42 (1981–*1977*) 50 FRF
Metal stamps for verification officers
Poinçons de métal pour agents de vérification

R 43 (1981–*1977*) 60 FRF
Standard graduated glass flasks for verification officers
Fioles étalons graduées en verre pour agents de vérification

R 44 (1985) 50 FRF
Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry
Alcoomètres et aréomètres pour alcool et thermomètres utilisés en alcoométrie

R 45 (1980–*1977*) 50 FRF
Casks and barrels
Tonneaux et futailles

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

R 47 (1979–*1978*) 60 FRF
Standard weights for testing of high capacity weighing machines
Poids étalons pour le contrôle des instruments de pesage de portée élevée

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 49 (being revised - *en cours de révision*)
Water meters intended for the metering of cold water
Compteurs d'eau destinés au mesurage de l'eau froide

R 50-1 (1997) 150 FRF
Continuous totalizing automatic weighing instruments (Belt weighers). Part 1: Metrological and technical requirements - Tests
Instruments de pesage totalisateurs continus à fonction nement automatique (peseuses sur bande). Partie 1: Exigences métrologiques et techniques - Essais

R 50-2 (1997) 200 FRF
Continuous totalizing automatic weighing instruments (Belt weighers). Part 2: Test report format
Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande). Partie 2: Format du rapport d'essai

R 51-1 (1996) 100 FRF
Automatic catchweighing instruments. Part 1: Metrological and technical requirements - Tests
Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais

R 51-2 (1996) 300 FRF
Automatic catchweighing instruments. Part 2: Test report format
Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique. Partie 2: Format du rapport d'essai

R 52 (1980) 50 FRF
Hexagonal weights, ordinary accuracy class from 100 g to 50 kg
Poids hexagonaux de classe de précision ordinaire, de 100 g à 50 kg

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 54 (being revised - *en cours de révision*)
pH scale for aqueous solutions
Echelle de pH des solutions aqueuses

R 55 (1981) 50 FRF
Speedometers, mechanical odometers and chronotachographs for motor vehicles. Metrological regulations
Compteurs de vitesse, compteurs mécaniques de distance et chronotachygraphes des véhicules automobiles. Réglementation métrologique

R 56 (1981) 50 FRF
Standard solutions reproducing the conductivity of electrolytes
Solutions-étalons reproduisant la conductivité des électrolytes

R 58 (being printed - *en cours de publication*)
Sound level meters
Sonomètres

R 59 (1984) 80 FRF
Moisture meters for cereal grains and oilseeds
Humidimètres pour grains de céréales et graines oléagineuses

R 60 (1991) 80 FRF
Metrological regulation for load cells
Réglementation métrologique des cellules de pesée

Annex (1993) 80 FRF
Test report format for the evaluation of load cells
Format du rapport d'essai des cellules de pesée

R 61-1 (1996) 150 FRF
Automatic gravimetric filling instruments.
Part 1: Metrological and test requirements - Tests
Doseuses pondérales à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais

R 61-2 (1996) 250 FRF
Automatic gravimetric filling instruments.
Part 2: Test report format
Doseuses pondérales à fonctionnement automatique. Partie 2: Format du rapport d'essai

R 62 (1985) 80 FRF
Performance characteristics of metallic resistance strain gauges
Caractéristiques de performance des extensomètres métalliques à résistance

R 63 (1994) 50 FRF
Petroleum measurement tables
Tables de mesure du pétrole

R 64 (1985) 50 FRF
General requirements for materials testing machines
Exigences générales pour les machines d'essai des matériaux

R 65 (1985) 60 FRF
Requirements for machines for tension and compression testing of materials
Exigences pour les machines d'essai des matériaux en traction et en compression

R 66 (1985) 60 FRF
Length measuring instruments
Instruments mesureurs de longueurs

R 68 (1985) 50 FRF
Calibration method for conductivity cells
Méthode d'étalonnage des cellules de conductivité

R 69 (1985) 50 FRF
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) 50 FRF
Determination of intrinsic and hysteresis errors of gas analysers
Détermination des erreurs de base et d'hystérésis des analyseurs de gaz

R 71 (1985) 80 FRF
Fixed storage tanks. General requirements
Réservoirs de stockage fixes. Prescriptions générales

R 72 (1985) 60 FRF
Hot water meters
Compteurs d'eau destinés au mesurage de l'eau chaude

R 73 (1985) 50 FRF
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
Prescriptions pour les gaz purs CO, CO_2, CH_4, H_2, O_2, N_2 et Ar destinés à la préparation des mélanges de gaz de référence

R 74 (1993) 80 FRF
Electronic weighing instruments
Instruments de pesage électroniques

R 75 (1988) 60 FRF
Heat meters
Compteurs d'énergie thermique

R 76-1 (1992) 300 FRF
Nonautomatic weighing instruments. Part 1: Metrological and technical requirements - Tests
Instruments de pesage à fonctionnement non automatique. Partie 1: Exigences métrologiques et techniques - Essais
Amendment No. 1 (1994) NC

R 76-2 (1993) 200 FRF
Nonautomatic weighing instruments. Part 2: Pattern evaluation report
Instruments de pesage à fonctionnement non automatique. Partie 2: Rapport d'essai de modèle
Amendment No. 1 (1995) NC

R 78 (1989) 50 FRF
Westergren tubes for measurement of erythrocyte sedimentation rate
Pipettes Westergren pour la mesure de la vitesse de sédimentation des hématies

R 79 (1997) 60 FRF
Labeling requirements for prepackaged products
Exigences pour l'étiquetage des produits préemballés

R 80 (1989) 100 FRF
Road and rail tankers
Camions et wagons-citernes

R 81 (being revised - *en cours de révision*)
Measuring devices and measuring systems for cryogenic liquids (including tables of density for liquid argon, helium, hydrogen, nitrogen and oxygen)
Dispositifs et systèmes de mesure de liquides cryogéniques (comprend tables de masse volumique pour argon, hélium, hydrogène, azote et oxygène liquides)

R 82 (1989) 80 FRF
Gas chromatographs for measuring pollution from pesticides and other toxic substances
Chromatographes en phase gazeuse pour la mesure des pollutions par pesticides et autres substances toxiques

R 83 (1990) 80 FRF
Gas chromatograph/mass spectrometer/data system for analysis of organic pollutants in water
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

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)

R 85 (being revised - *en cours de révision*)
Automatic level gauges for measuring the level of liquid in fixed storage tanks
Jaugeurs automatiques pour le mesurage des niveaux de liquide dans les réservoirs de stockage fixes

R 86 (1989) 50 FRF
Drum meters for alcohol and their supplementary devices
Compteurs à tambour pour alcool et leurs dispositifs complémentaires

R 87 (1989) 50 FRF
Net content in packages
Contenu net des préemballages

R 88 (being printed - *en cours de publication*)
Integrating-averaging sound level meters
Sonomètres intégrateurs-moyenneurs

R 89 (1990) 80 FRF
Electroencephalographs - Metrological characteristics - Methods and equipment for verification
Electroencéphalographes - Caractéristiques métrologiques - Méthodes et moyens de vérification

R 90 (1990) 80 FRF
Electrocardiographs - Metrological characteristics - Methods and equipment for verification
Electrocardiographes - Caractéristiques métrologiques - Méthodes et moyens de vérification

R 91 (1990) 60 FRF
Radar equipment for the measurement of the speed of vehicles
Cinémomètres radar pour la mesure de la vitesse des véhicules

R 92 (1989) 60 FRF
Wood-moisture meters - Verification methods and equipment: general provisions
Humidimètres pour le bois - Méthodes et moyens de vérification: exigences générales

R 93 (1990) 60 FRF
Focimeters
Frontofocomètres

R 95 (1990) 60 FRF
Ships' tanks - General requirements
Bateaux-citernes - Prescriptions générales

R 96 (1990) 50 FRF
Measuring container bottles
Bouteilles récipients-mesures

R 97 (1990) 60 FRF
Barometers
Baromètres

R 98 (1991) 60 FRF
High-precision line measures of length
Mesures matérialisées de longueur à traits de haute précision

R 99 (being revised - *en cours de révision*)
Instruments for measuring vehicle exhaust emissions
Instruments de mesure des gaz d'échappement des véhicules

R 100 (1991) 80 FRF
Atomic absorption spectrometers for measuring metal pollutants in water
Spectromètres d'absorption atomique pour la mesure des polluants métalliques dans l'eau

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 manovacuomètres indicateurs et enregistreurs à élément récepteur élastique (instruments usuels)

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

R 103 (1992) 60 FRF
Measuring instrumentation for human response to vibration
Appareillage de mesure pour la réponse des individus aux vibrations

R 104 (1993) 60 FRF
Pure-tone audiometers
Audiomètres à sons purs

Annex F (1997) 100 FRF
Test report format
Format du rapport d'essai

R 105 (1993) 100 FRF
Direct mass flow measuring systems for quantities of liquids
Ensembles de mesurage massiques directs de quantités de liquides

Annex (1995) 80 FRF
Test report format
Format du rapport d'essai

R 106-1 (1997) 150 FRF
Automatic rail-weighbridges. Part 1: Metrological and technical requirements - Tests
Ponts-bascules ferroviaires à fonctionnement automatique. Partie 1: Exigences métrologiques et techniques - Essais

R 106-2 (1997) 200 FRF
Automatic rail-weighbridges. Part 2: Test report format
Ponts-bascules ferroviaires à fonctionnement automatique. Partie 2: Format du rapport d'essai

R 107-1 (1997) 150 FRF
Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers). Part 1: Metrological and technical requirements - Tests
Instruments de pesage totalisateurs discontinus à fonctionnement automatique (peseuses totalisatrices à trémie). Partie 1: Exigences métrologiques et techniques - Essais

R 107-2 (1997) 300 FRF
Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers). Part 2: Test report format
Instruments de pesage totalisateurs discontinus à fonctionnement automatique (peseuses totalisatrices à trémie). Partie 2: Format du rapport d'essai

R 108 (1993) 60 FRF
Refractometers for the measurement of the sugar content of fruit juices
Réfractomètres pour la mesure de la teneur en sucre des jus de fruits

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

R 111 (1994) 80 FRF
Weights of classes E_1, E_2, F_1, F_2, M_1, M_2, M_3
Poids des classes E_1, E_2, F_1, F_2, M_1, M_2, M_3

R 112 (1994) 80 FRF
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) 80 FRF
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 114 (1995) 80 FRF
Clinical electrical thermometers for continuous measurement
Thermomètres électriques médicaux pour mesurage en continu

R 115 (1995) 80 FRF
Clinical electrical thermometers with maximum device
Thermomètres électriques médicaux avec dispositif à maximum

R 116 (1995) 80 FRF
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 117 (1995) 400 FRF
Measuring systems for liquids other than water
Ensembles de mesurage de liquides autres que l'eau

R 118 (1995) 100 FRF
Testing procedures and test report format for pattern evaluation of fuel dispensers for motor vehicles
Procédures d'essai et format du rapport d'essai des modèles de distributeurs de carburant pour véhicules à moteur

R 119 (1996) 80 FRF
Pipe provers for testing measuring systems for liquids other than water
Tubes étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau

R 120 (1996) 100 FRF
Standard capacity measures for testing measuring systems for liquids other than water
Mesures de capacité étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau

R 121 (1996) 60 FRF
The scale of relative humidity of air certified against saturated salt solutions
Échelle d'humidité relative de l'air certifiée par rapport à des solutions saturées de sels

R 122 (1996) 60 FRF
Equipment for speech audiometry
Appareils pour l'audiométrie vocale

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

R 124 (being printed - *en cours de publication*)
Refractometers for the measurement of the sugar content of grape musts
Réfractomètres pour la mesure de la teneur en sucre des moûts de raisin

INTERNATIONAL DOCUMENTS
DOCUMENTS INTERNATIONAUX

D 1 (1975) 50 FRF
Law on metrology
Loi de métrologie

D 2 (being printed - *en cours de publication*)
Legal units of measurement
Unités de mesure légales

D 3 (1979) 60 FRF
Legal qualification of measuring instruments
Qualification légale des instruments de mesurage

D 4 (1981) 50 FRF
Installation and storage conditions for cold water meters
Conditions d'installation et de stockage des compteurs d'eau froide

D 5 (1982) 60 FRF
Principles for the establishment of hierarchy schemes for measuring instruments
Principes pour l'établissement des schémas de hiérarchie des instruments de mesure

D 6 (1983) 60 FRF
Documentation for measurement standards and calibration devices
Documentation pour les étalons et les dispositifs d'étalonnage

D 7 (1984) 80 FRF
The evaluation of flow standards and facilities used for testing water meters
Evaluation des étalons de débitmétrie et des dispositifs utilisés pour l'essai des compteurs d'eau

D 8 (1984) 60 FRF
Principles concerning choice, official recognition, use and conservation of measurement standards
Principes concernant le choix, la reconnaissance officielle, l'utilisation et la conservation des étalons

D 9 (1984) 60 FRF
Principles of metrological supervision
Principes de la surveillance métrologique

D 10 (1984) 50 FRF
Guidelines for the determination of recalibration intervals of measuring equipment used in testing laboratories
Conseils pour la détermination des intervalles de réétalonnage des équipements de mesure utilisés dans les laboratoires d'essais

D 11 (1994) 80 FRF
General requirements for electronic measuring instruments
Exigences générales pour les instruments de mesure électroniques

D 12 (1986) 50 FRF
Fields of use of measuring instruments subject to verification
Domaines d'utilisation des instruments de mesure assujettis à la vérification

D 13 (1986) 50 FRF
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

D 14 (1989) 60 FRF
Training of legal metrology personnel - Qualification - Training programs
Formation du personnel en métrologie légale - Qualification - Programmes d'étude

D 15 (1986) 80 FRF
Principles of selection of characteristics for the examination of measuring instruments
Principes du choix des caractéristiques pour l'examen des instruments de mesure usuels

D 16 (1986) 80 FRF
Principles of assurance of metrological control
Principes d'assurance du contrôle métrologique

D 17 (1987) 50 FRF
Hierarchy scheme for instruments measuring the viscosity of liquids
Schéma de hiérarchie des instruments de mesure de la viscosité des liquides

D 18 (1987) 50 FRF
General principles of the use of certified reference materials in measurements
Principes généraux d'utilisation des matériaux de référence certifiés dans les mesurages

D 19 (1988) 80 FRF
Pattern evaluation and pattern approval
Essai de modèle et approbation de modèle

D 20 (1988) 80 FRF
Initial and subsequent verification of measuring instruments and processes
Vérifications primitive et ultérieure des instruments et processus de mesure

D 21 (1990) 80 FRF
Secondary standard dosimetry laboratories for the calibration of dosimeters used in radiotherapy
Laboratoires secondaires d'étalonnage en dosimétrie pour l'étalonnage des dosimètres utilisés en radiothérapie

D 22 (1991) 80 FRF
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

D 23 (1993) 80 FRF
Principles of metrological control of equipment used for verification
Principes du contrôle métrologique des équipements utilisés pour la vérification

D 24 (1996) 60 FRF
Total radiation pyrometers
Pyromètres à radiation totale

D 25 (1996) 60 FRF
Vortex meters used in measuring systems for fluids
Compteurs à vortex utilisés dans les ensembles de mesurage de fluides

D 26 (being printed - *en cours de publication*)
Glass delivery measures - Automatic pipettes
Mesures en verre à délivrer - Pipettes automatiques

VOCABULARIES
VOCABULAIRES

V 1 (1978) 100 FRF
Vocabulary of legal metrology (bilingual French-English)
Vocabulaire de métrologie légale (bilingue français-anglais)

V 2 (1993) 200 FRF
International vocabulary of basic and general terms in metrology (bilingual French-English)
Vocabulaire international des termes fondamentaux et généraux de métrologie (bilingue français-anglais)

V 3 (1991) 80 FRF
Hardness testing dictionary (quadrilingual French-English-German-Russian)
Dictionnaire des essais de dureté (quadrilingue français-anglais-allemand-russe)

OTHER PUBLICATIONS
AUTRES PUBLICATIONS

P 1 (1991) 60 FRF
OIML Certificate System for Measuring Instruments
Système de Certificats OIML pour les Instruments de Mesure

P 2 (1987) 100 FRF
Metrology training - Synthesis and bibliography (bilingual French-English)
Formation en métrologie - Synthèse et bibliographie (bilingue français-anglais)

P 3-1 (1996) 400 FRF
Legal metrology in OIML Member States
Métrologie légale dans les Etats Membres de l'OIML

P 3-2 (1996) 300 FRF
Legal metrology in OIML Corresponding Members
Métrologie légale dans les Membres Correspondants de l'OIML

P 4 (1986-*1981*) 100 FRF
Verification equipment for National Metrology Services
Equipement d'un Service national de métrologie

P 5 (1992) 100 FRF
Mobile equipment for the verification of road weighbridges (bilingual French- English)
Equipement mobile pour la vérification des ponts-bascules routiers (bilingue français-anglais)

P 6 (1987) 100 FRF
Suppliers of verification equipment (bilingual French-English)
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