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Photo by Steve Satushek

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Editorial

IN the history of OIML, the greatest concentration of efforts has been focused on the technical progress of the Organisation's activities. However, other important aspects of OIML, of a more "political" nature, have not been overlooked but now deserve more attention; this includes communications. I had the valuable opportunity for increasing the channels of communication within OIML during a visit to Japan, Rep. of Korea, and China in April 1994.

The objectives of my visit began with my efforts to become acquainted with the metrology networks in these Member States: human resources, administrative and financial channels, training programs, and interconnections between manufacturers of measuring instruments and legal metrology authorities.

I also aimed to discern the impact of OIML on metrology infrastructures through discussions relative to national participation in OIML activities, implementation of OIML Recommendations, and prospects for each State's participation in developing the OIML Certificate System. It is within this framework that I was able to address matters pertaining to communications which, together with the technical activities of OIML, constitute an important part of the Organisation's development. These included the flow of OIML information, liaisons between CIML Members and key collaborators in OIML work, computer resources for information exchanges with BIML, and the promotion of metrology activities at consumer level through public relations.

In Japan, I met with the CIML Member and his colleagues at NRLM. Discussions on the future prospects for Japan's participation in OIML activities were held in a special meeting with representatives of MITI, NRLM, Japan Electric Meters Inspection Corporation, and the Japan Measuring Instruments Federation. There was also a certain number of technical visits and discussions with a local weights and measures office and a manufacturer of volume and flowmeters.

In the Rep. of Korea, I was introduced to the IAA by the CIML Member and his staff. Through visits to the Korea Academy of Industrial Technology and the Korea Research Institute of Standards and Science, I learned of various metrology training programs in Korea and was informed of the developments of the national calibration system.

My activities in China included an overview of the Chinese metrology system during a discussion with the CIML Member and his colleagues at SBTS, discussions with the staff of NIM, and technical visits to verification offices. Meetings with the staffs of the China Institute of Metrology, the Shanghai Bureau of Technical Supervision and the Shanghai Yamato Scale Co. Ltd. (the first enterprise in China to receive an OIML certificate issued by the SBTS) resulted in interesting exchanges of information. Preparations were also launched for the organization of the 30th CIML Meeting which will be held in Beijing next year.

This regional approach to communication matters between BIML and OIML Member States revealed itself to be a positive and fruitful experience. In view of the importance of sharing this experience with the OIML community, this issue features a special section entitled **"Focus on Far East Asia".** It is my hope that our readers will benefit from this approach and that continued efforts can be made through the Bulletin to promote exchanges of experience and knowledge reflective of the diverse metrology systems in OIML Member States.

Finally, I would like to extend many warm thanks to all those who contributed invaluably to the success of my visits and to the realization of this special issue.

K. French

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Quality for weights

INVESTIGATION, EXPERIMENTAL RESEARCH, AND PROSPECTS OF THE MATERIAL USED FOR WEIGHTS IN CHINA

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Weights are material measures in mass measurement which are used to reproduce the value of a quantity of mass. The quality and properties of the material used for making weights directly affect their accuracy. After several years of investigation and experimental research on weights, we present our observations concerning this topic.

Standard weights

THE material of the stainless steel weight is 1Cr 18Ni 9Ti. This material is soft, and has a low surface hardness. When in use, this material is susceptible to scratches and contamination which lead to weighing errors.

The stainless steel weight has a high magnetic susceptibility. When used on electronic balances, weights made from such material can cause systematic errors that cannot be eliminated.

The density of weights made of 1Cr 18Ni 9Ti is around 7 850 kg/m^3. This value is not very close to 8 000 kg/m^3 which is the reference value given in OIML Recommendation R 33 *Conventional value of the result of weighing in air,* which specifies the following requirement:

> *"The density of weights,..., must be chosen in such a way that when these weights are compared with a standard of 8 000 kg/m^3 density, variation in the air density of 10 % above or below the value of 1.2 kg/m^3 does not lead to variations in the result of the comparison exceeding one quarter of the maximum permissible error on the weight ...".*

From years of tests and experiments on the influence of the abovementioned factors, it has been proven that the introduced weighing error is more than 0.2 mg for the working standard of the kilogram and 10 µg for the working standard of the gram.

Class E_2 weights

Class E_2 weights are widely used; they are made of stainless steel or copper alloy whose density is about 8 400 kg/m^3 (Fig. 1).

Depending on the location in China, the air density varies from higher than 1.44 kg/m^3 to lower than 0.75 kg/m^3. In about 50 % of the locations, the air density deviations from the conventional air density 1.2 kg/m^3 exceed 10 %. In 25 % of the mass laboratories

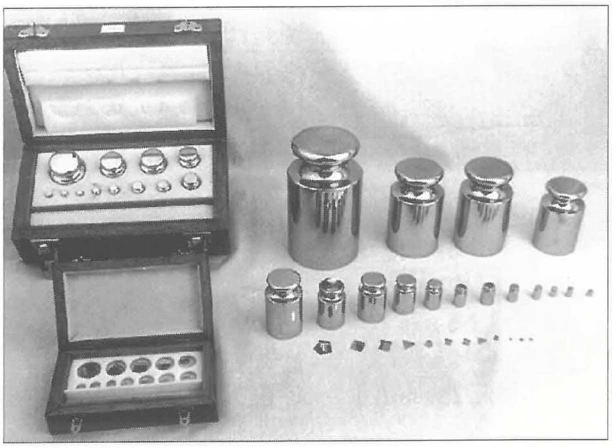


Fig. 1 Class E_2 stainless steel standard weights.

(at regional level in the Chinese metrological structure), the air density deviations from the conventional air density 1.2 kg/m^3 exceed 10 %. Therefore, air buoyancy corrections must be made when calibrating stainless steel weights by using of copper alloy weights.

Practical experiments on systematic errors of weights

The quality of weights was analyzed by weighing a few class E_1 and E_2 weights (Table 1) on mechanical and electronic balances over a certain period of time; the results of this experiment are given in Table 2. Figure 2 illustrates a 1 kg working standard weight used in the comparison and Fig. 3 shows the main author carrying out the experiment.

The weighing instruments that were used for the comparison were the following:

(a) 1 kg mechanical balance $\sigma = 0.012$ mg
(b) 1 kg electronic balance $\sigma = 0.005$ mg
(c) 200 g mechanical balance $3\sigma = 0.1$ mg
200 g electronic balance $3\sigma = 0.1$ mg

Results of experiments

Table 3 shows the maximum permissible errors, expanded uncertainties and maximum apparent mass differences between electronic balances and mechanical balances.

Table 3 Weights that were compared to determine systematic errors.

Weight number	Nominal value	Material
No. 45	1 kg	1Cr 18Ni 9Ti
No. 196	200 g – 200 g	1Cr 18Ni 9Ti
No. 426	200 g – 200 g	1Cr 18Ni 9Ti
No. 1	1 kg	JF1 non-magnetic stainless steel
No. 2	1 kg	JF1 non-magnetic stainless steel
No. 223	200 g – 200 g	JF1 non-magnetic stainless steel
No. 228	200 g	JF1 non-magnetic stainless steel

It should be noted that according to the requirements of OIML R 111 (section 3):

> *"the expanded uncertainty related to the mass of a weight, U, should not exceed 1/3 of the absolute value of the maximum permissible error of the mass of weight, except for E_1 weights.*
>
> *If m_c is the actual conventional mass value, and m_o is the nominal value of the weight, it follows that:*
>
> $$m_o - (\delta m - U) \le m_c \le m_o + (\delta m - U)."$$

Examining the results of serial Nos. 1, 2 and 3 in Table 3, the maximum apparent mass difference between electronic and mechanical balances is 0.59 mg, i.e. 3.5 times the expanded uncertainty of 0.17 mg related to a class E_1 weight of 1 kg, and 1.2 times the maximum

Table 2 Experimental results from June 1990 to December 1993.

Serial No.	Weight	Date of comparison	Nominal value g	Mechanical balance		Electronic balance		Apparent mass difference (mg)
				Result (mg)	Model	Result (mg)	Model	
1	1-No. 45	13-6-90 14-6-90	1 000 1 000	1.053 1.012	prototype "	0.634 0.421	C1000S	0.419 0.591
2	2-No. 45	13-6-90 13-6-90	1 000 1 000	2.053 2.064	" "	1.758 1.510	C1000S	0.295 0.554
3	2 – 1	11-6-90 13-6-90 12-6-90	1 000 1 000 1 000	1 100 1.139 1.111	" " "	1.101 1.128 1.120	C1000S	0.001 0.011 0.009
4	No. 426 200 g – 200 g	3-4-89	200	0.1	TG328B	1.2	DF200	1.1
5	No. 196 200 g – 200 g	2-5-93	200	0.62	TG328B	5.4	A200S	6
6	No. 223 No. 228 200 g – 200 g	30-12-93 30-12-93	200 200	0.90 0.0	L 200SM L-200SM	0.9 0.0	A200S A200S	0 0
7	No. 223 No. 228	30-12-93	200	0.0	L-200SM	0.0	A200S	0

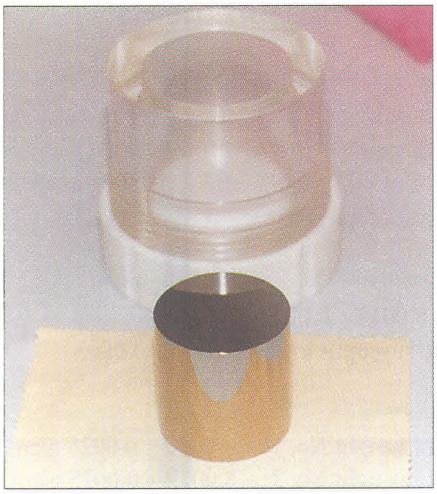


Fig. 2 1 kg working standard weight.

Table 3 Maximum permissible errors, expanded uncertainties and maximum apparent mass differences between electronic and mechanical balances.

Serial No.	Nominal value (g)	Class	Maximum permissible error δm (mg)	Expanded uncertainty U (mg)	Maximum apparent difference of mass between electronic and mechanical balances α (mg)
1	1 000	Working standard	0.5	0.17	0.591
2	200	E_1	0.1	0.033	6
3	200	E_2	0.3	0.1	1.1
4	1 000	E_1	0.5	0.17	0.011
5	200	E_2	0.3	0.1	0.0

permissible error of 0.5 mg (see Table 3 - first line). The maximum apparent mass difference between JF1 1# and JF1 2# is 0.011 mg, i.e. 6.5 % of the expanded uncertainty of 0.17 mg, and 2.2 % of the maximum permissible error of 0.5 mg.

This demonstrates that the magnetic effect on the 1 kg weight made of 1Cr 18Ni 9Ti exceeds the maximum permissible error, yet the magnetic effect of JF1 stainless steel weight can be negligible.

The serial No. 4 in Table 2 relates to the set No. 426 of 200 g weights which are presently in use at NIM. The comparison difference of the two 200 g weights on mechanical and electronic balances is 1.1 mg. It can be calculated from the third line in Table 3 that this difference is 11 times the expanded uncertainty of 0.1 mg related to Class E_2 weights, and 3.7 times the maximum permissible error of 0.3 mg. These results clearly demonstrate that the requirements for class E_2 weights are not satisfied.

The serial no. 5 in Table 2 relates to the 200 g weights of the set No. 196 of NIM; the two 200 g weights were compared on the mechanical and electronic balances respectively with an apparent mass difference of 6 mg. It can be calculated from the second line of Table 3 that this difference is 182 times the expanded uncertainty of 0.033 mg related to class E_1 weights, 60 times the maximum permissible error of 0.1 mg, 60 times the expanded uncertainty related to class E_2 weights, and 20 times the maximum permissible error of 0.3 mg (for class E_2 weights – third line in Table 3). Clearly, this error is not negligible.

The serial nos. 6 and 7 in Table 2 relate to the weights made of JF1 non-magnetic stainless steel with a nominal value of 200 g. Two 200 g weights (no. 223 and no. 228) were compared on the mechanical and electronic balances respectively: the apparent mass differences are all zero.

Experiments have shown that the magnetic effect of a weight made of 1Cr 18Ni 9Ti is 60 times the expanded uncertainty, but the magnetic effect of a JF1 weight is within the range of the accuracy of the balance, and can therefore be considered as negligible.

Density test and analysis for stainless steel weights

The following experiments were carried out in order to check the density of our JF1 weights and those imported from Switzerland, Germany, and Russia: a value close to 8 000 kg/m^3, which is the international unified conventional density value for weights, should be obtained. Our experimental method consisted in determining the density of weights by means of hydrostatic weighing.

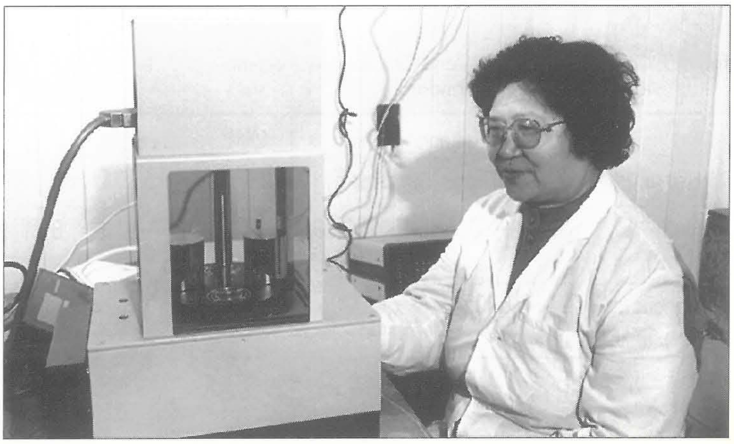


Fig. 3 The primary author of this paper carries out experimental research on the stability of a 1 kg working standard weight by using a C1000s balance.

Table 4 Results of the comparison between the measured densities and the conventional value of 8 000 kg/m³.

Class	Material	Density g/cm³	Deviation against 8.0 g/cm³	Country of origin
E1	Stainless steel	8.049	+ 0.049	Germany
E2 E2	Stainless steel Stainless steel	7.959 7.839	- 0.041 - 0.161	Switzerland Germany
E1	JF1 1# stainless steel	7.997	- 0.003	China
E1	JF1 2# stainless steel	7.995	- 0.005	China
Working standard	Stainless steel	7.878	- 0.122	Russia

The equipment used was a hydrostatic balance with a maximum capacity of 1 kg and a scale interval of 5 mg; a thermometer, equipment for measuring air density, water distilled three times and standard weights were used.

Table 4 summarizes the measurement results related to the densities of the weights used in this experiment. The average density of China's JF1 material is much closer to the conventional density (8.0 g/cm³) than that of the imported weights from Switzerland, Germany and Russia. The air density in different locations in China varies from higher than 1.44 mg/cm³ to lower than 0.75 mg/cm³. If the weight density is 8.0 g/cm³, then the error introduced by air buoyancy can be negligible. This simplifies calculations and calibration procedures and improves the accuracy that can be obtained during tests.

Table 5 Comparison of OIML and Chinese requirements for a 1 kg working standard.

	Requirements in China		OIML requirements (R 111)	
	Class E_1	Class E_2	Class E_1	Class E_2
Density (g/cm³)	8.00 ± 0.005	8.00 ± 0,008	7.934...8.067	7.81...8.21
Magnetic susceptibility	< 0.0005	< 0.0006	< 0.01	< 0.03

Reference measurements

BIPM (1991–1993) – Two 1 kg working standard weights (a and b)

Density of weight (a): 7.99981 + 0.00004 g/cm³
Density of weight (b): 8.00065 + 0.00004 g/cm³
Magnetic susceptibility: $\kappa = \mu - 1 = 0.00035$

PTB, Germany (June, 1993) – 1 kg weight

Density: 8.0013 + 0.0025 g/cm³
Magnetic susceptibility: $\kappa = \mu - 1 < 0.0005$

Two 100 g weights (Nos. 1 and 2)

Density of weight No. 1: = 8.0019 + 0.0025 g/cm³
Density of weight No. 2: = 8.0019 + 0.0025 g/cm³
Magnetic susceptibility: $\kappa = \mu - 1 < 0.0005$

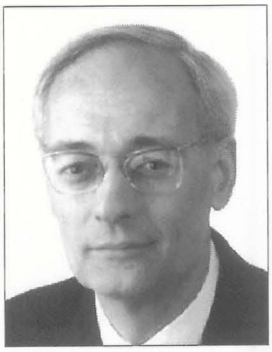
From the data shown in Table 5, it is obvious that the technical specifications of China's JF1 stainless steel weight are better than those specified by OIML R 111.

Suggestions and prospects

Based on the abovementioned experimental research and analysis, the magnetic effect of weights is a serious problem that needs to be solved urgently. With the development of science and technology, electronic balances will gradually replace mechanical balances. Without solving the problem of magnetic susceptibility, the value of mass will not be accurate.

At present, Chinese-made JF1 non-magnetic stainless steel is an ideal material for making standard weights. The advantages of this material are: density of 8.00 ± 0.005 g/cm³, very close to 8.0 g/cm³; susceptibility of 5×10^{-4}; high surface hardness (HRC 35-50), high mass stability, and anti-corrosion. It is not necessary to correct for air buoyancy by using JF1 weights in most areas in China. The JF1 weights are available for electronic and mechanical balances and no significant systematic errors will result, which means that they are free from the disadvantages associated with weights that are made of 1Cr 18Ni 9Ti.

We therefore suggest that JF1 replace 1Cr 18Ni 9Ti for making class E_1 standard weights so as to renew mass standard weights. By doing so, the stability of mass standards will be improved greatly. ■



A theoretical approach to measurement

UNCERTAINTY OF MASS, CONVENTIONAL MASS AND FORCE*

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0. Introduction

MODERN weighing instruments directly indicate the mass of the product weighed. The time-consuming handling of weights formerly used on beam scales and decimal balances is no longer necessary. This increased ease and speed of operation does not, however, alter the fact that weights must be used to adjust the indication of the weighing instrument. The accuracy of the weighing instruments thus depends on mass standards. Force and pressure measuring instruments, too, are tied to mass standards.

Ever greater demands are made on the accuracy of the determination of masses. For example, the relative errors of weights of accuracy class E_1 must not be greater than $5 \cdot 10^{-7}$. The masses in force standard machines which are referred to as deadweights, are to produce forces with relative uncertainties of a few 10^{-6}.

On the basis of the conditional equations for the calculation of mass, conventional mass and force, the fundamental formulas to determine the associated uncertainties are derived. The resulting correlations must not be neglected, as, otherwise, uncertainty values are used in the calculations which are higher than those actually given.

1. Mass

1.1 Weighing equation

A test piece (weight, deadweight or another weighing object) of mass m_T is determined on a weighing instrument by comparison with a reference of mass m_R (Fig. 1a). Taking into account the air buoyancy, the weighing instruments indicate the values

$$I_T = S\,[m_T - \rho_{aT} V_T + e_T] \quad (1a)$$
$$= S\,[m_T(1 - \rho_{aT}/\rho_T) + e_T] \quad (1b)$$

and

$$I_R = S\,[m_R - \rho_{aR} V_R + e_R] \quad (2a)$$
$$= S\,[m_R(1 - \rho_{aR}/\rho_R) + e_R] \quad (2b)$$

(Fig. 1b). I, ρ_a, ρ, V and e designate the indication of the weighing instrument, the air density, the density of the weights, the volume and the difference between the indications when the weighing instrument is loaded with the test piece T or the reference R. S is the sensitivity of the weighing instrument. Either the volume $V = m/\rho$ or the density $\rho = m/V$ of the masses is known.

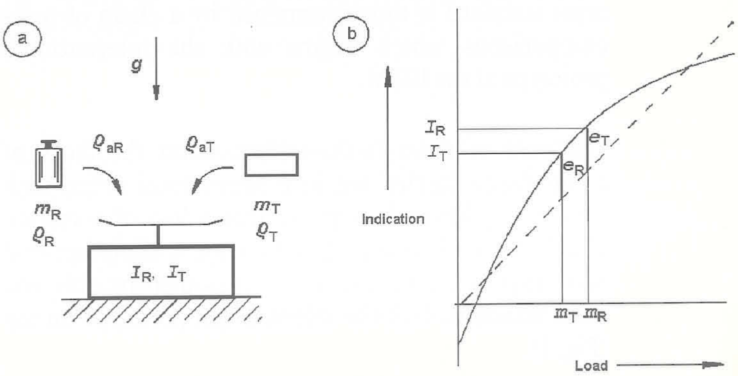

Fig. 1 Mass comparison
a) Substitution weighing
b) Relation between indication and load
----- free from error
—— affected by error
g acceleration due to gravity; m mass; ρ density of the mass; ρ_a air density; I indication; R reference; T test piece; e error of indications.

* This article is translated from the original German version which was published in *Wagen + Dosieren, 3/1993.*

The formulas in the respective equations are therefore given for both quantities, if necessary, distinguished by (..a) and (..b). When the weighing instrument is alternately loaded with T and R at short intervals – in substitution – the air densities ρ_{aR} and ρ_{aT} are identical.

The difference

$$W_T = (I_T - I_R)/S \qquad (3)$$

amounts to

$$W_T = m_T - m_R - \rho_{aT}(V_T - V_R) + e_T - e_R. \qquad (4)$$

If $m_T \approx m_R$, $e_T \approx e_R$ results (cf. Fig. 1b). This is why $e_T - e_R = 0$ is valid. The weighing equation applied to determine the mass of the test piece thus reads

$$m_T = m_R + \rho_{aT}(V_T - V_R) + W_T \qquad (5a)$$

$$= m_R \frac{1 - \rho_{aT}/\rho_R}{1 - \rho_{aT}/\rho_T} + \frac{W_T}{1 - \rho_{aT}/\rho_T}. \qquad (5b)$$

1.2 Hierarchy of the mass standards

The unit mass is realized by the *international prototype of the kilogram* as established in 1889 by the International Committee for Weights and Measures. It is kept at the *Bureau International des Poids et Mesures* (BIPM) in Sèvres near Paris. Today, the kilogram is the only unit which is still realized by a prototype; all other units of the SI system are traced back to natural constants by a physical definition. The uncertainty of a mass standard is thus determined by a chain of mass comparisons which begins with the international prototype at the BIPM.

The unit of mass is disseminated on the basis of comparisons carried out in a hierarchical order, each step of the hierarchy representing a loss of accuracy. The deviation below is based on the assumption that each step of the hierarchy is represented by only one mass standard, with the international prototype on top (Fig. 2).

The case where several standards of equal mass and equal ranking determine a test piece of greater mass is treated in [1]. The weighing equations for the determination of the masses relating to the scheme of Fig. 2, cf. eq. (5), read as follows, with the indices IP, 0, 1, ..., i-1, i, ...

$$\begin{aligned}
m_{IP} &= 1\ \text{kg} \\
m_0 &= m_{IP} + \rho_{a0}(V_0 - V_{IP}) + W_0 \\
m_1 &= m_0 + \rho_{a1}(V_1 - V_0) + W_1 \\
m_2 &= m_1 + \rho_{a2}(V_2 - V_1) + W_2 \\
&\dots \\
m_{i-1} &= m_{i-2} + \rho_{ai-1}(V_{i-1} - V_{i-2}) + W_{i-1} \\
m_i &= m_{i-1} + \rho_{ai}(V_i - V_{i-1}) + W_i
\end{aligned} \qquad (6)$$

It should be noted that the values m_i and m_{i-1} of references next to each other in the hierarchy depend on the volume V_{i-1}. When the uncertainty is calculated, the volumes V_{i-1} generate correlations, which can be avoided when the conditional equations are used for m_{i-1}, m_{i-2}, ... ([2], p. 77). The international prototype kilogram must be included, as it has been established by definition and as it is not subject to a calculation influenced by the volume.

The following results for the conditional equations:

$$m_{IP} = 1\ \text{kg} \qquad (7a)$$

$$m_0 = m_{IP} + \rho_{a0}(V_0 - V_{IP}) + W_0 \qquad (7b)$$

$$m_1 = m_{IP} + \rho_{a0}(V_0 - V_{IP}) + W_0 + \rho_{a1}(V_1 - V_0) + W_1 \qquad (7c)$$

$$m_2 = m_{IP} + \rho_{a0}(V_0 - V_{IP}) + W_0 + \rho_{a1}(V_1 - V_0) + W_1 + \rho_{a2}(V_2 - V_1) + W_2 \qquad (7d)$$

...

$$m_n = m_{IP} + \sum_{i=0}^{i=n} [\rho_{ai}(V_i - V_{i-1}) + W_i]. \qquad (7e)$$

1.3 Uncertainty

The system of equations (7) comprises only input quantities which are independent of one another. The uncertainties can therefore be calculated according to the simplified form of the Gauss error propagation law (eq. (33) in [3]), which does not require covariants and representation by matrices.

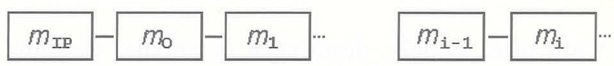

Fig. 2 Mass standards of equal mass, compared in hierarchical order with the international prototype of the kilogram.

The squares of the uncertainties are as follows:

$$u^2(m_{IP}) = 0 \quad (8a)$$

$$u^2(m_0) = + \rho_{a0}^2 u^2(V_{IP}) + (V_0-V_{IP})^2u^2(\rho_{a0}) + \rho_{a0}^2 u^2(V_0) + u^2(W_0) \quad (8b)$$

$$u^2(m_1) = + \rho_{a0}^2 u^2(V_{IP}) + (V_0-V_{IP})^2u^2(\rho_{a0}) + (\rho_{a0}-\rho_{a1})^2u^2(V_0) + u^2(W_0) + (V_1-V_0)^2u^2(\rho_{a1}) + \rho_{a1}^2 u^2(V_1) + u^2(W_1) \quad (8c)$$

$$u^2(m_2) = + \rho_{a0}^2 u^2(V_{IP}) + (V_0-V_{IP})^2u^2(\rho_{a0}) + (\rho_{a0}-\rho_{a1})^2u^2(V_0) + u^2(W_0) + (V_1-V_0)^2u^2(\rho_{a1}) + (\rho_{a1}-\rho_{a2})^2u^2(V_1) + u^2(W_1) + (V_2-V_1)^2u^2(\rho_{a2}) + \rho_{a2}^2 u^2(V_2) + u^2(W_2) \quad (8d)$$

$$u^2(m_3) = \ldots \quad (8e)$$

The price to be paid for avoiding covariants is that $u^2(m_i)$ includes uncertainties of all preceding hierarchy steps, i.e. an inconveniently large number of influencing quantities. As many expressions, which are comprised in $u^2(m_{i-1})$, appear in $u^2(m_i)$, it suggests itself to express $u^2(m_i)$ as a function of $u^2(m_{i-1})$:

$$u^2(m_i) = f[u^2(m_{i-1})]. \quad (9)$$

The squares of the uncertainties for $i \geq 1$ read

$$u^2(m_i) = u^2(m_{i-1}) - [\rho_{ai-1}^2 - (\rho_{ai-1} - \rho_{ai})^2]u^2(V_{i-1}) + (V_i - V_{i-1})^2u^2(\rho_{ai}) + \rho_{ai}^2u^2(V_i) + u^2(W_i). \quad (10)$$

1.4 Approximated uncertainty

In eq. (10), the expression in square brackets can be replaced by ρ_{ai-1}^2:

$$[\rho_{ai-1}^2 - (\rho_{ai-1} - \rho_{ai})^2] \approx \rho_{ai-1}^2 \quad (11)$$

Instead of $u(m_i)$, the approximate value $u_e(m_i) \approx u(m_i)$ is calculated. How far such an approximation is admissible can be estimated on the basis of the relative deviation

$$\left|\frac{u_e(m_i) - u(m_i)}{u(m_i)}\right| \approx \frac{1}{2}\left[\frac{(\rho_{ai-1} - \rho_{ai})}{\rho_{i-1}} \cdot \frac{u(\rho_{i-1})/\rho_{i-1}}{u(m_i)/m_i}\right]^2 \quad (12)$$

of the uncertainty $u(m_i)$ (cf. Fig. 3). The relative deviation can always remain below 10 %. Attention must, however, be paid that the parameter $u(\rho_{i-1})$ does not exceed certain values which depend on $u(m_{i-1})$.

If, for reasons of easy comparability, the indices R and T are used again for the steps i-1 and i, cf. eq. (5a), the following uncertainty equation results for the comparison with the international prototype of the kilogram

$$u^2(m_T) = u^2(m_R) + \rho_{aT}^2u^2(V_R) + \rho_{aT}^2u^2(V_T) + (V_T-V_R)^2u^2(\rho_{aT}) + u^2(W_T) \quad (13)$$

with $u^2(m_R) = u^2(m_{IP}) = 0$.

The following is valid for all other comparisons:

$$u^2(m_T) \approx u^2(m_R) - \rho_{aT}^2u^2(V_R) + \rho_{aT}^2u^2(V_T) + (V_T - V_R)^2u^2(\rho_{aT}) + u^2(W_T) \quad (14a)$$

$$\approx u^2(m_R) - [(\rho_{aT}/\rho_R)m_R\, u(\rho_R)/\rho_R]^2 + [(\rho_{aT}/\rho_T)m_T\, u(\rho_T)/\rho_T)]^2 + m_T^2(1/\rho_T - 1/\rho_R)^2\, u^2(\rho_{aT}) + u^2(W_T). \quad (14b)$$

Eq. (14b) follows from eq. (14a) using the relations

$u(V) = (m/\rho^2)\, u(\rho)$ and $m_R \approx m_T$.

With the exception of the sign preceding the term $\rho_{aT}^2\, u^2(V_R)$, equations (13) and (14) are identical. This shows the correlation between the references and test piece which has already been mentioned in section 1.2.

It means nothing else but that – within the scope of the approximation (11) – the uncertainty of the volume $u(V_R)$ included in the uncertainty $u(m_R)$ of the reference does not enter into the uncertainty $u(m_T)$ by which the determination of the test piece mass is affected. To put it differently: volume uncertainties $u(V_R)$ of the "inter-

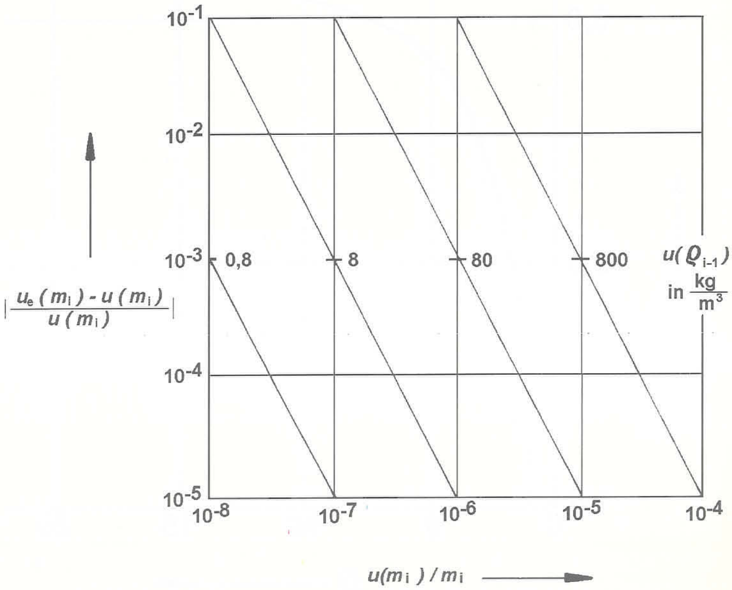

Fig. 3 Relative deviation of the uncertainty $u(m_i)$, when the approximation according to eq. (11) is introduced.
ρ_{i-1} = 8 000 kg/m³ and $\rho_{ai-1} - \rho_{ai}$ = (3 % of ρ_a) = $3.6 \cdot 10^{-2}$ kg/m³ have been taken as a basis; parameter is the uncertainty of the density $u(\rho_{i-1})$.

mediate standards" do not exert an influence on the uncertainty $u(m_T)$ of the mass of the test piece.

In order to be able to correctly calculate $u(m_T)$ from $u(m_R)$, $u(V_R)$ must always be indicated, in addition to $u(m_R)$. It would, however, be preferable to state an uncertainty for m_R, which does not contain $u(V_R)$ at all. Such value exists: it is the uncertainty of the conventional mass, cf. eq. (23).

2. Conventional mass

2.1 Equation

Force-compensating weighing instruments are so adjusted that they correctly indicate the mass m of a product to be weighed, if

- the density of the product to be weighed is identical to the reference density ρ_c = 8 000 kg/m^3, and if
- the air density is equal to the reference air density ρ_{ac} = 1.2 kg/m^3.

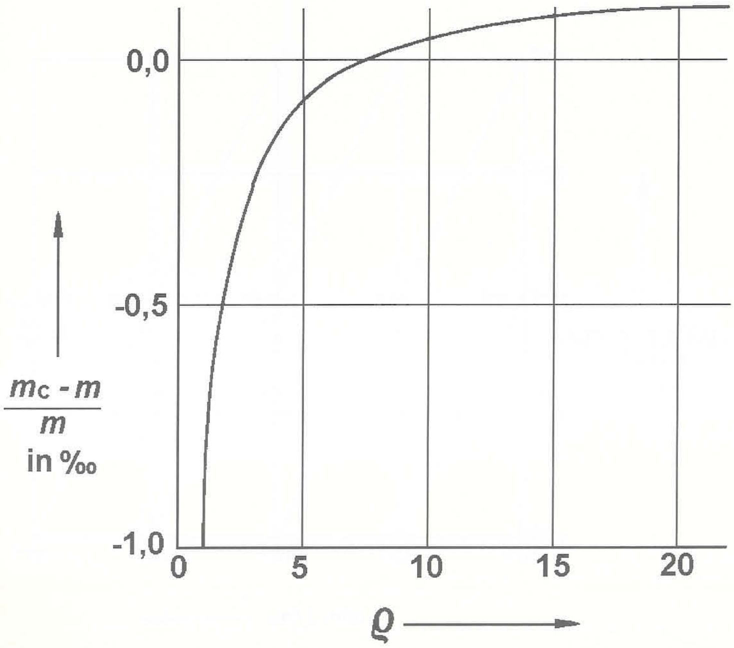

Fig. 4 Relative difference between the numerical values of m_c and m as a function of ρ.
m_c, m, ρ: conventional mass, mass and density (kg/m^3) of a product to be weighed.

For $\rho \neq \rho_c$, the weighing instrument indicates the value referred to as conventional mass, at $\rho_a = \rho_{ac}$.

The conventional mass m_c is to be calculated in such a way that m_c in air of the density ρ_{ac} generates the same force as a mass m of density ρ. The following is obtained:

$$m_c - \rho_{ac} V_c = m - \rho_{ac} V \qquad (15)$$

$$m_c = m - \rho_{ac}(V - V_c) \qquad (16a)$$

or, if the "conventional volume V_c" is replaced by $V_c = m_c/\rho_c$ and the volume V by $V = m/\rho$

$$m_c = m \frac{1 - \rho_{ac}/\rho}{1 - \rho_{ac}/\rho_c} = m \frac{\rho - 1{,}2 \text{ kg/m}^3}{0{,}999850\rho} \qquad (16b)$$

The relative deviation

$$\frac{m_c - m}{m} = \frac{1 - \rho_{ac}/\rho}{1 - \rho_{ac}/\rho_c} - 1 \approx \rho_{ac} \left(\frac{1}{\rho_c} - \frac{1}{\rho} \right) \qquad (17)$$

is shown in Fig. 4. According to this equation, for all densities ρ < 8 000 kg/m^3, the numerical value of m_c is always smaller than the numerical value of m.

In the case of foodstuffs having approximately the density of water, the actual mass m is by about 1 % greater than the value indicated by the weighing instrument.

In the following example, the uncertainties will be derived for a product with the mass m_0 – cf. Fig. 2. The results are the same for all m_i. The conditional equation for m_{c0} – cf. eq. (16a) reads

$$\begin{aligned} m_{c0} &= m_0 - \rho_{ac}(V_0 - V_{c0}) \\ &= (m_0 - \rho_{ac} V_0)/(1 - \rho_{ac}/\rho_c) \end{aligned} \qquad (18)$$

or, with m_0 according to eq. (7b),

$$m_{c0} = [m_{IP} + \rho_{a0}(V_0 - V_{IP}) - \rho_{ac} V_0 + W_0]/(1 - \rho_{ac}/\rho_c). \qquad (19)$$

2.2 Uncertainty

The respective square of the uncertainty becomes:

$$\begin{aligned} u^2(m_{c0}) = [&(V_0 - V_{IP})^2 u^2(\rho_{a0}) + (\rho_{a0} - \rho_{ac})^2 u^2(V_0) \\ &+ \rho_{a0}^2 u^2(V_{IP}) + u^2(W_0)]/(1 - \rho_{ac}/\rho_c)^2. \end{aligned} \qquad (20)$$

$u(m_{c0})$ is to be expressed as a function of $u(m_0)$ according to eq. (8b). For any mass m_i ($i \geq 0$)

$$u^2(m_{ci}) = \{u^2(m_i) - [\rho_{ai}{}^2 - (\rho_{ai} - \rho_{ac})^2]u^2(V_i)\}/(1 - \rho_{ac}/\rho_c)^2 \quad (21)$$

results. With the above approximation (11) and with $1 - \rho_{ac}/\rho_c \approx 1$, the following simple relation between $u(m_c)$ and $u(m)$ is obtained:

$$u^2(m_c) \approx u^2(m) - \rho_a{}^2 u^2(V) \quad (22a)$$

$$= u^2(m) - [m(\rho_a/\rho)u(\rho)/\rho]^2 \quad (22b)$$

Eq. (22a) can be used in eq. (14a). The uncertainty of the conventional mass of a test piece linked up with a standard of the same mass is as follows:

$$u^2(m_{cT}) \approx u^2(m_{cR}) + (V_T - V_R)^2 u^2(\rho_{aT}) + u^2(W_T) \quad (23a)$$

$$\approx u^2(m_{cR}) + m_T{}^2\left(\frac{1}{\rho_T} - \frac{1}{\rho_R}\right)^2 u^2(\rho_{aT}) + u^2(W_T). \quad (23b)$$

As weights serve to check the accuracy of weighing instruments or to determine other weights, deadweights, and test pieces using the substitution method, only the uncertainty component, which enters into the results of subsequent weighings, is decisive – and this is $u(m_c)$ alone. This relation, which is important for the statement of the accuracy of weights, is taken into consideration by OIML Recommendation R 111 [4], which states under point 3.1 that the maximum permissible errors indicated for a weight relate to the conventional mass.

2.3 Difference between $u(m_c)$ and $u(m)$

A difference in the amount of $u(m_c)$ and $u(m)$ is due to the uncertainty of the density $u(\rho)$, cf. eq. (22b) and Fig. 5. If $u(\rho)$ is sufficiently small, $u(m_c)$ and $u(m)$ are almost identical. Density determinations with relative uncertainties of $\leq 10^{-3}$ do not exert an influence worth mentioning, even in the case of weights of the highest accuracy class E_1. The case $u(\rho)/\rho > 10^{-3}$ occurs when the density of a very large test piece must be determined on the basis of small test samples. In view of the inhomogeneities of the materials, it is recommendable to assume density uncertainties to the amount of 50 kg/m³ ($\equiv u(\rho)/\rho = 6.3 \cdot 10^{-3}$ for ρ = 8 000 kg/m³). As a result, $u(m)/m$ cannot reach values below 1.10^{-6}, even if $u(m_c)/m$ is extremely small.

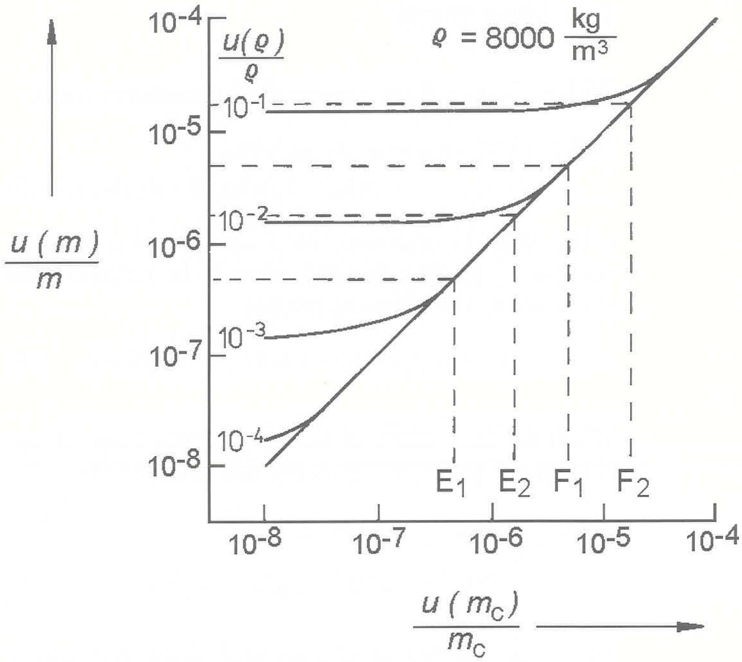

Fig. 5 Relative uncertainty of the mass as a function of the relative uncertainties of the conventional mass and the density for ρ = 8 000 kg/m³.
E_1 to F_2: accuracy classes of weights

3. Force

3.1 Equation

In force standard machines, under the influence of the acceleration due to gravity g and allowing for the buoyancy of the air, a deadweight of mass m_D generates the force

$$F_D = (m_D - \rho_{aF}V_D)g \quad (24a)$$

$$= m_D(1 - \rho_{aF}/\rho_D)g \quad (24b)$$

ρ_{aF} being the air density at the place where the deadweight is used. The derivations have again been carried out for a product of mass $m_0 = m_D$:

$$F_0 = (m_0 - \rho_{aF}V_0)g. \quad (25)$$

With m_0 according to eq. (7b), the following results

$$F_0 = [m_{IP} + \rho_{a0}(V_0 - V_{IP}) + W_0 - \rho_{aF}V_0]g. \quad (26)$$

3.2 Uncertainty

With $\rho_{a0} - \rho_{aF} \approx 0$, the square of the uncertainty reads

$$u^2(F_0) \approx g^2[(V_0 - V_{IP})^2 u^2(\rho_{a0}) + \rho_{a0}{}^2 u^2(V_{IP}) + u^2(W_0) + V_0{}^2 u^2(\rho_{aF})] + (F_0/g)^2 u^2(g) \quad (27)$$

$u^2(F_0)$ must be expressed as a function of $u^2(m_0)$ according to eq. (8b). For any object to be weighed with the mass m_i, the following results:

$$u^2(F_i) \approx g^2[u^2(m_i) - \rho_{ai}{}^2 u^2(V_i) + V_i{}^2 u^2(\rho_{aF})] + (F_i/g)^2 u^2(g). \quad (28)$$

When the uncertainty of the conventional mass (cf. eq. [22]) and $F_i/g \approx m_D$ are used, the following results

$$u^2(F_D) \approx [u^2(m_{Dc}) + V_D{}^2 u^2(\rho_{aF})]g^2 + m_D{}^2 u^2(g) \quad (29a)$$

$$\approx [u^2(m_{Dc}) + (m_D/\rho_D)^2 u^2(\rho_{aF})]g^2 + m_D{}^2 u^2(g). \quad (29b)$$

Here, too, it is first of all surprising to see that, within the scope of the approximation according to eq. (11), volume uncertainties $u(V_D)$ or density uncertainties $u(\rho_D)$ of the deadweight do not influence the amount of the uncertainty $u(F_D)$.

4 Conclusions

The unit of mass is disseminated on the basis of weights. The uncertainty of the density of these weights does not influence the accuracy with which the unit is disseminated as has been shown by the derivations in sections 1.3 and 1.4.

From this it follows that the statement of the uncertainty $u(m_c)$ of the conventional mass is essential for mass standards, see eqs. (14) and (23). Likewise, in the case of deadweights serving to generate forces, $u(m_c)$ is the decisive component contributed by the mass of the deadweight, cf. eq. (29).

If, by mistake, the uncertainty of the density is included in the uncertainty $u(m)$ of the mass of a product to be weighed, the values which are obtained for $u(m)$ are too great and prevent, for example in intercomparisons, systematic errors from being detected. ■

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Measurement of emission gases

DEVELOPMENT OF SENSORS FOR MEASURING CONCENTRATIONS OF GASES

CLEAN AIR MEASUREMENT
Interlaken 28 Sept - 1 Oct 1992

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There is an urgent need at the moment for the development of sensors capable of measuring concentrations of emission gases. This is because of the requirements for the control of emissions as well as the control of processes for reduced emissions.

Solid state gas sensors are being developed to be used for in-situ measurements. These sensors are quick in their response and resistant to aggressive environments as well as to high temperatures. They are also simple and cheap in production and use.

The development of ceramic gas sensors for the measurement of emission gases is aimed at improving the control of the emissions released into the atmosphere. Sensors can be used for monitoring concentrations of emission gases, as required by the authorities, and for controlling the processes so as to reduce emission levels.

The advantages offered by ceramic gas sensors include:

- continuous operation,
- high sensitivity,
- quick response (a few seconds),
- resistance to harsh environments and high temperatures,
- simple utilization,
- compatibility with electronics integration, and
- low price.

Ceramic gas sensors can be placed directly in the emission gas streams at the emission sources. This would enable control procedures to be developed for processes to attain better energy efficiency and to reduce the production of polluting emissions.

Sensor operation principles

Voltage cell

In the development of electroceramic gas sensors, two main operation principles have been applied. The well-known zirconia sensor is an example of the voltage cell type of sensor [1]. This type generates a voltage across the different sides of a solid electrolyte, dependant on the difference of the partial pressure of oxygen at the different sides of the cell. This dependence is logarithmic following the Nernst equation. A similar principle is also being applied to the detection of sulphur dioxide [2–4].

The basic approach of the cell type of sensor is based on using a solid electrolyte in a galvanic cell mode. The solid electrolyte is usually a ceramic material, which is ideally highly conductive to one specific ion. The concentration of the gas measured (A_2) is directly transduced into an electric voltage. The voltage (for equilibrium) is given by eq. (1).

$$E = -RT/ZF \quad ln\ p''_{A2} / p'_{A2} \qquad (1)$$

where E is the voltage generated, R is the gas constant, T is the temperature, Z is the number of charge units carried by the ions formed from A_2, F is the Faraday's constant, p'_{A2} is the reference partial pressure of A_2, and p''_{A2} is the partial pressure of A_2 to be measured.

In the case of the zirconia oxygen sensor, the charge carrying ion is the oxygen ion (O^{2-}) which can move in the stabilized zirconia by means of anion vacancies. These vacancies are formed, when the ions of the stabilizing agent (e.g. Y^{3+}) are substituted for Zr^{4+}-ions. Oxygen ions are formed at the surface of the cell by the reaction (2),

$$O_2 + 4e^- \rightleftharpoons 2O^{2-} \qquad (2)$$

where e^- is used to represent an electron.

The basis for the development of an electrochemical cell for the detection of sulphur oxides is the selection of a proper solid electrolyte. The sulphur oxides should react electrochemically and reversibly with the solid electrolyte. Sulphates have been considered to offer a natural basis.

The most appropriate materials have appeared to be the alkali sulphates, such as K_2SO_4, $N_{a2}SO_4$ and Li_2SO_4 [2–4]. In these sulphates, the electron conductivity is low and reversible reactions are possible. Such a measuring cell can be schematically represented as follows [3]:

$$(SO_2 + O_2)^1, Pt \mid K_2SO_4 \mid Pt, (SO_2 + O_2)^2$$

in which the superscripts 1 and 2 refer to different sides of the cell. As mentioned earlier, this type of sensor cell needs, at one side of the cell, a known reference concentration of the gas to be measured. Solid reference electrodes are also developed for the sulphur oxide measuring cells.

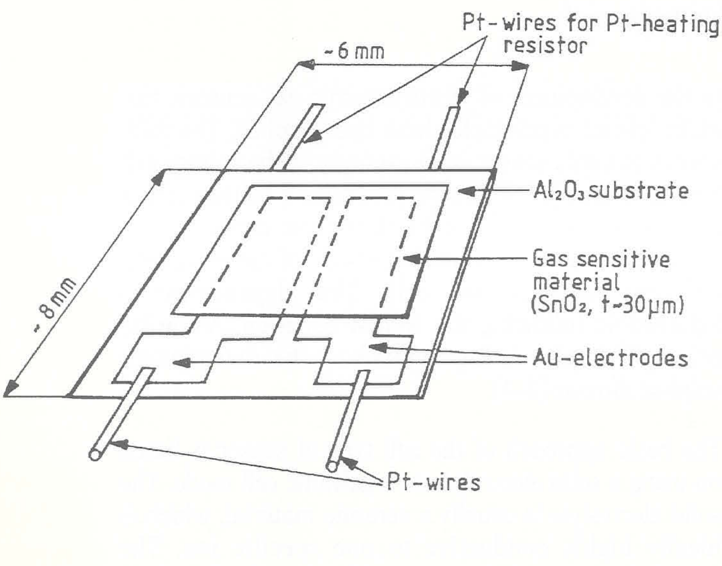

Fig. 1 Structure of a SnO_2-based thick-film gas sensor [9].

Semiconductor sensor

The operation of semiconductor gas sensors is based on the change of their conduction as a result gas reactions at the sensor surface. The indication of the concentration of the gas to be measured is obtained as a current or voltage signal and no reference gas or reference electrode is needed.

In research projects carried out in recent years, semiconductor gas sensors have been applied to the measurement of gas concentrations from process emission gases, and also from town atmospheres [5–11]. These projects have given promising results as to the application of these types of sensors to the continuous measurement of gas concentrations in both the emission gases and the outside air. A review of some results obtained so far is presented in the following, beginning with a brief discussion of the operation principle of semiconductor gas sensors.

Conductance of a semiconductor gas sensor

Tin dioxide (SnO_2) is generally used as the basic material for semiconductor gas sensors. Other materials include zinc oxide (ZnO) and tungsten oxide (WO_3). Based on oxygen vacancies, tin dioxide is an n-type semiconductor with an energy gap of about 3.6 eV. In semiconductor gas sensors, this material consists of fine particles sintered together. At the boundary layers between particles, there is a potential barrier. Together the barriers form a random barrier network which is the major factor controlling the resistance of the sensor.

The construction of one type of semiconductor sensor is presented in Fig. 1. This type has been manufactured using a screen printing technique (thick-film technique). The gas sensitive tin dioxide layer is seen in the picture. There is a heater resistor at the reverse side of the sensor to control the sensor operation temperature in the range of about 300 °C to 550 °C.

The resistance of the semiconductor gas sensor is related to the oxygen adsorbed at the surface of the particles in the sensor material. Surface states associated with oxygen can trap electrons from the sensor material.

This process reduces the conductance by removing conduction electrons and creates the surface energy barrier. Oxygen ions are formed at the surface. The equilibrium sensor conductance can thus be controlled by changing the oxygen ion concentration at the surface of sensor material particles. This change can be caused by gas reactions at the surface of the particles.

This is illustrated in Fig. 2 together with the band diagram. Here the height of the potential energy barrier (Schottky barrier) is eV_s. This leads to an exponential relationship between the conductance (G) and the height of the energy barrier [12]

$$G = G_0 \, e^{-eVs/kT}$$

where G_0 is the conductance without the energy barriers at the particle boundaries.

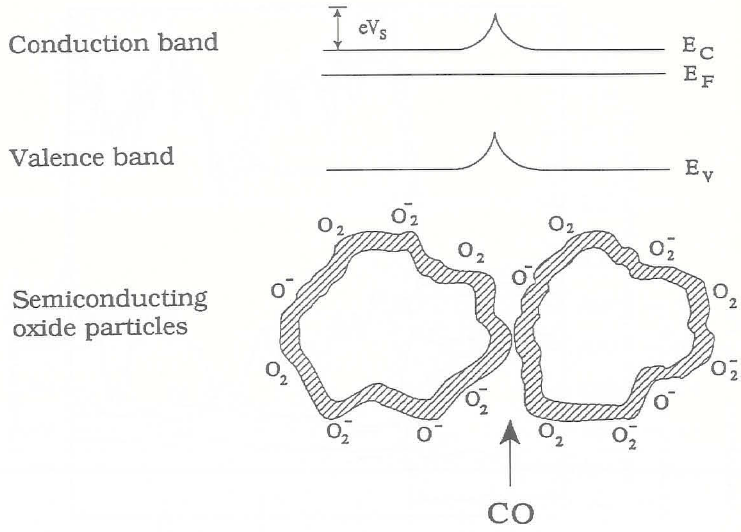

Fig. 2 Formation of the potential energy barrier at the surface of the sensor material particle. The shaded area represents the layer depleted from electrons (depletion layer), and E_F is the Fermi surface.

Gas reactions

A model for the influence of gases has been developed which describes the observed power law form of the sensor response to gases [13]:

$$G \propto p_{02}^{-\beta} (1 + \Sigma_i K_i p_i^{ni})^{\beta}$$

where p_{02} is the partial pressure of oxygen in the surrounding atmosphere, β is a constant dependant on the temperature, being normally between 0.25 and 0.5, p_i represent the partial pressures of reducing gases reacting at the surface, n_i stoichiometric factors, K_i are sensitivity coefficients for various gases.

Increasing the factor K_i for a certain gas means increasing the selectivity of the sensor towards this gas. This can be done by using catalytic additives or by controlling the sensor operation temperature, as can be seen later in this paper. The general form of the gas reaction affecting the surface oxygen ion concentration and consequently, the sensor conductance can be expressed as follows:

$$n_i G_i + O_{2surf} \rightarrow G_{prod}.$$

Here G_i denotes a reducing gas, O_{2surf} the oxygen adsorbed at the surface, and G_{prod} the desorbing gas formed as a result of the reaction.

Application of gas sensors to emission gas measurements

Semiconductor gas sensors have been tested in actual process environments for years. Some results from combustion processes using different fuels will be reviewed hereafter. These tests mainly concern the measurement of the concentration of carbon monoxide (CO). Some examples of the use of catalytic additives to improve the sensor performance are also given.

Reduction of the interference caused by nitrogen oxide (NO) and sulphur dioxide (SO_2) on the CO response of one type of semiconductor sensors will also be considered. This serves to illustrate the idea of a combined effect on the selectivity that can be obtained by controlling both the concentration of a catalytic additive and the operation temperature of the sensor. An example of research work aimed at the development of a sensitive sensor for the measurement of the concentration of hydrogen sulphide (H_2S), occurring as an impurity in industrial air environments, is also given.

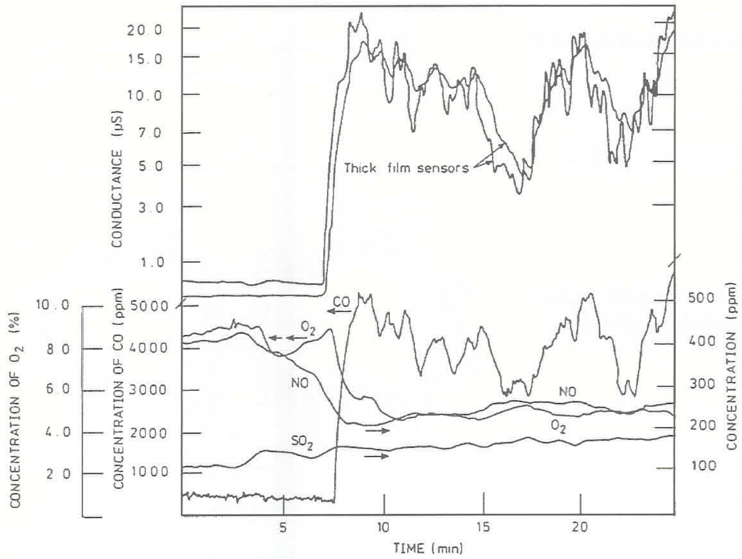

Fig. 3 The conductance responses of two thick-film sensors and the concentrations of CO, O_2, NO and SO_2 from the combustion gas of sod peat [8].

Measurement of the concentration of CO in emission gases from combustion processes

In the combustion of solid fuels, the concentration of carbon monoxide can vary widely. This can also be seen from Fig. 3, which shows a result of a measurement performed from the emission gas of a small heating power unit. Sod peat was used as the fuel.

The variation of the concentration of CO was followed by the semiconductor sensor, as can be seen. The concentration of CO, as well as that of other gases shown in the figure, was also measured using reference instruments. This has been the normal procedure in the experiments reported in this paper. An interesting feature in Fig. 3 is the simultaneous variation of NO together with CO (and O_2). This might have to be taken into account as a possible interference when monitoring CO.

One of the advantages offered by electroceramic gas sensors is that they can be placed directly in the emission gas streams. Sensors are normally protected against dust by using a porous ceramic filter around them. Sample lines used with conventional gas analyzers are not necessary with sensors, and a quicker response has therefore been noticed in many experiments.

This feature can be important when carrying out process control procedures based on emission gas measurements. This situation is shown in Fig. 4: sensor signals, as presented by curves I and II in the lower part of the figure, show quicker and more detailed responses than the commercial reference instruments.

Fig. 4 also gives an idea about the importance of catalytic additives. In this experiment, palladium (Pd) appears to be a good catalytic agent as indicated by the detailed response, whereas platinum does not show any clear effect.

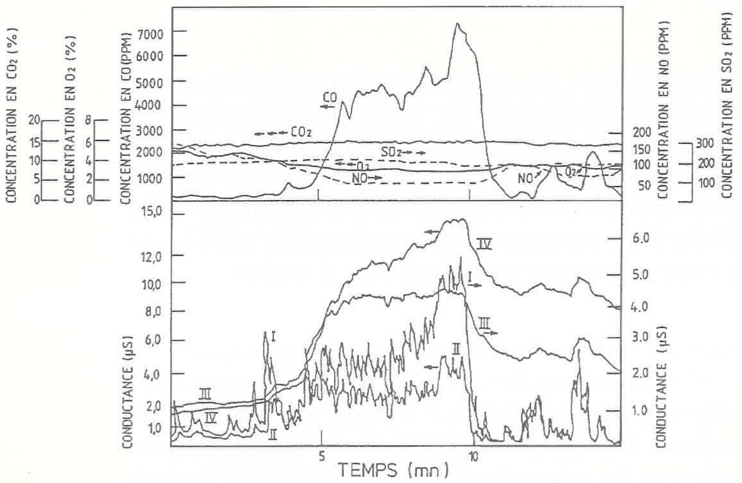

Fig. 4 Responses of three types of thick-film gas sensors from the combustion gas of milled peat measured in a thermal power station. The concentrations of CO, CO_2, O_2, NO and SO_2 are also presented [14].

Molar contents of catalytic additive: sensor I: 1 % palladium; sensor II:3 % palladium; sensor III: 1 % platinum; sensor IV contains no catalytic additive.

Control of the selectivity of semiconductor gas sensors

Main methods utilized to control the selectivity of semiconductor gas sensors are the use of minor concentrations of additives, which normally act as catalysts, and the control of the operation temperature. A semiconductor sensor is generally operated at a constant temperature, but the "cycling" of the temperature between two values is also sometimes applied [15, 16].

Another method is the use of selective filters to remove interfering gases from a gas mixture prior to the contact with the sensing surface. The microstructure of the sensor, as influenced by the preparation method and the electrode material, also has some effect on the sensor properties.

To reduce the interference caused by NO and SO_2 in the CO response of semiconductor sensors, a study was undertaken to control both the concentration of the catalytic additive and the operation temperature of the sensors. These gases often occur in emission gases simultaneously with CO which was the gas component to be measured. Since, in earlier studies, palladium had been found to be an advantageous additive in tin dioxide sensor material in the detection of CO, it was selected for use.

A series of tests was performed using different combinations of the concentration of palladium in the sensor material and the operation temperature [9]. The sensor material was also prepared by two alternative processes introducing the catalytic palladium in two different ways. The preparation method, as well as the sintering temperature, have been found to have an influence on the sensor properties. The results of the study indicated that SnO_2-based semiconductor gas sensors can be used to monitor the concentration of CO in combustion gases in the presence of NO and SO_2 [9].

By increasing the sensor operation temperature above 500 °C, the interference effects of NO and SO_2 on the conductance response to CO could be practically eliminated.

The best conductance response to CO was obtained with sensors containing about 0.5 % Pd. The thick-film paste preparation procedure in which Pd was added to SnO_2 in the chloride form and calcined at a temperature of 900 °C, yielded the best response characteristics. The response of this sensor type is represented in Fig. 5. It can be seen that the interference effects caused by NO and SO_2 under the conditions explained above were reasonably low.

Development of semiconductor sensors for the monitoring of H_2S as an air impurity

Research work has also been directed towards the application of sensors to the indication of many other gas components in emission gases and in air environments. Sensor arrays have been tested for the detection of several gas components. One of the gases quite extensively studied is hydrogen sulphide, H_2S, for which the results obtained so far seem quite promising [17].

As an example of the development work aimed at the development of an H_2S semiconductor sensor for air quality measurements, the response of a sensor is given

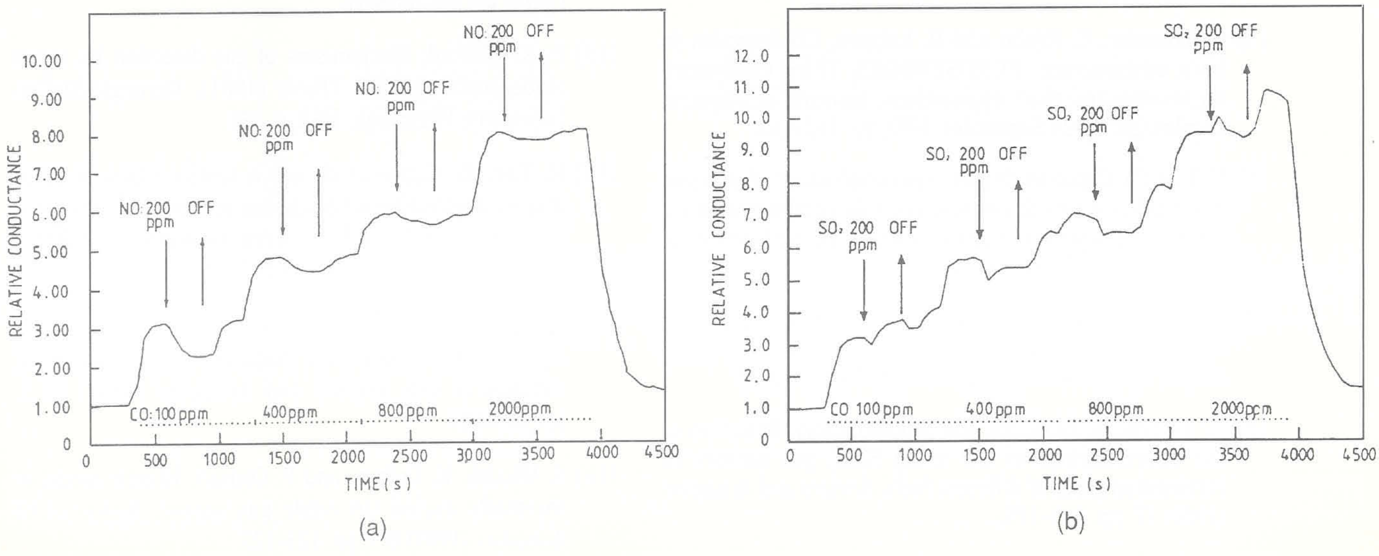

Fig. 5 The relative conductance response of the sensor type selected in the study. This was operated in dry synthetic combustion gas at 550 °C, the chamber temperature being 160 °C, with the CO concentrations of 100, 400, 800 and 1 000 ppm. The interference gas was NO (a) and SO_2 (b).

in Fig. 6. The sensor was developed in cooperation with the Technical Research Center of Finland (VTT) and the Kemi Institute of Technology. The sensor shows a sensitive response to H_2S. During testing, it was also verified that the sensor response was low to such gases as propane, carbon monoxide, sulphur dioxide and nitrogen oxide, so as to indicate good selectivity.

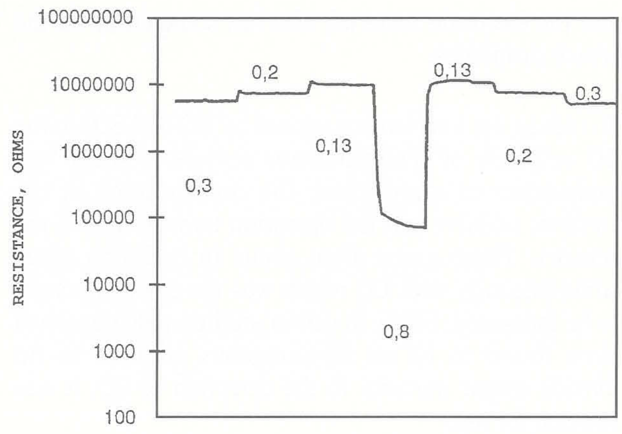

Fig. 6 Conductance response of a semiconductor sensor to hydrogen sulphide (H_2S). The concentration was changed from 0.13 to 0.8 ppm and back to 0.13 ppm in about 20 minutes.

Acknowledgement

The interesting cooperation with the Microelectronics Laboratory at the University of Oulu and the Kemi Institute of Technology is gratefully acknowledged. ■

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Calibrating infrared pyrometers

A TRANSFER STANDARD PYROMETER DEVELOPED IN THE REPUBLIC OF KOREA

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The accuracy of infrared pyrometers has been greatly improved by using stable solid state infrared detectors such as silicon, thermopile, and pyroelectric detectors and commercial infrared pyrometers are now being used in various industrial fields. Nowadays, the temperature range of infrared pyrometers has been extended to between – 50 °C and 3 000 °C. The calibration of infrared pyrometers is therefore an important task in national standards laboratories throughout the world.

According to the International Temperature Scale-90 (ITS-90), the temperature above the freezing point of silver (961.78 °C) is defined by the Planck's radiation equation [7]:

$$\frac{N_\lambda(T_{90})}{N_\lambda(T_{90}(x))} = \frac{\exp(C_2 / T_{90}(x)) - 1}{\exp(C_2 / T_{90}) - 1} \qquad (1)$$

where:

$T_{90}(x)$ refers to one of the freezing points of silver, gold, or copper.

$N_\lambda(T_{90})$ and $N_\lambda(T_{90}(x))$ are spectral concentrations at a wavelength λ of the radiance of blackbody at T_{90} and $T_{90}(x)$, respectively.

C_2 is the second radiation constant of 0.014388 mK.

In this temperature range, the temperature scale is traditionally realized by a pyrometer and a metal freezing point blackbody mentioned above. The realized temperature scale is transferred to a high-stability tungsten strip lamp.

For the calibration of visual pyrometers whose response band is near 650 nm, a tungsten strip lamp is calibrated against a metal fixed point blackbody at the response band. However, the calibration of an infrared pyrometer with the lamp is practically impossible since the spectral sensitivities of the infrared pyrometers differ from one to another. Therefore, a variable-temperature blackbody source is necessary for the calibration work.

In order to obtain an accurate temperature scale from the ratio of spectral radiances, the prior knowledge of the spectral sensitivity of the pyrometer (SSP) is essential because a major component of the uncertainty in the temperature scale may result from the uncertainty in the SSP.

Nevertheless, it is difficult, time consuming, and sometimes impractical to measure the spectral sensitivity of an infrared pyrometer with sufficient accuracy for the calibration of the pyrometer.

To avoid these problems, the multiple-point calibration method (MPCM) [10] was proposed and applied to the calibration of infrared pyrometers. In MPCM, the output signals of the pyrometer are obtained at several different temperatures and are interpolated in the temperature range of the calibration with a proper interpolation equation. Therefore, we can calibrate the infrared pyrometer without measuring SSP.

In this article, we describe the transfer standard pyrometer developed at Korea Research Institute of Standards and Science (KRISS), which is used for the realization of the ITS-90 and the calibration of infrared pyrometers. We also introduce a new interpolation equation for the calibration of infrared pyrometers.

Realization of the ITS-90 above 961.78 °C

In optical pyrometry, the temperature defined by eq. (1) is determined by the ratio of the radiance of a blackbody at a metal freezing point to that of a blackbody at a certain temperature T_{90}. This radiance ratio, R, is given by [7]:

$$R = \frac{\int_0^{\infty} N_\lambda(T_{90})\tau_\lambda S_\lambda d\lambda}{\int_0^{\infty} N_\lambda(T_{90}(x))\tau_\lambda S_\lambda d\lambda} \tag{2}$$

where

t_λ is the spectral transmittance of the narrow band interference filter adopted in the pyrometer, and

S_λ is the spectral response of remaining components of the pyrometer.

To establish ITS-90 from the ratio R in eq. (2), the exact value of optical parameters t_λ and S_λ must be measured. These parameters are measured by using a double grating monochromator (Jovin-Ivon U–1 000) with a minimum resolution of 0.04 nm.

The transmittance of two narrow band interference filters, t_λ, is measured by illuminating the entrance slit of the monochromator with a halogen lamp. To eliminate ghost images of the grating in the monochromator, a long wave pass filter (CVI RG590) is placed in front of the entrance slit.

The transmittance at each wavelength is obtained by measuring dark signals and signals with and without the filter. The spectral response of remaining components of the pyrometer is measured by referring to a silicon detector whose relative spectral response is calibrated.

To establish the accurate temperature scale in a high temperature range with eq. (2), the radiance ratio, R, must be measured precisely. Yet, the ratio, R, can be affected by the nonlinearity of the detector signal. To check the linearity of the silicon detector used in this work, linearity factors are measured by the flux addition method [5] for successive ratios of two. Two tungsten strip lamps used as a stable source for the flux addition method are operated by two homemade stabilized current sources with a drift less than 25 ppm/30 min. Two sets of linearity factors are obtained separately for two spectral response functions of the pyrometer.

It is well-known that the linearity of a silicon detector is very good, and the deviation from the linearity factor obtained in this work is less than $4 \cdot 10^{-4}$ of the signal over a wide dynamic range up to $5 \cdot 10^4$. These linearity factors are measured on the same voltage range of a digital voltmeter to avoid changes of zero and modifications of the gain on different ranges. Data sets of t_λ and S_λ are kept in computer codes. For a given R, the integral eq. (2) is solved numerically with the data sets and the temperature results.

Interpolation equation for the calibration of pyrometers with multiple point calibration method

The multiple point calibration method (MPCM) requires an interpolation equation to express the relationship between the output signal of the pyrometer and the temperature of the source. It is very important to choose a proper interpolation equation if the temperature scale is to be accurate. The interpolation equation derived from the concept of the effective wavelength method (EWM) has been widely used [2, 9, 10]. Several variations of the interpolation equation have also been used for the calibration of infrared pyrometers [8]. However, the new interpolation equation derived from the concept of the reference wavelength method (RWM) has been proposed recently [4] and can be used effectively for the calibration of infrared pyrometers.

When calibrated temperatures of the infrared pyrometer are either interpolated or extrapolated, errors can be reduced enormously by using this new interpolation equation instead of using the interpolation equation derived from EWM. Following are theories behind the interpolation equation derived from both methods.

Effective wavelength method

Applying the Wien's approximation to eq. (2), the effective wavelength λ_e is defined by the following equation [6]:

$$\frac{V(T_E)}{V(T_R)} = \exp\left[\frac{C_2}{\lambda_e}\left(\frac{1}{T_R} - \frac{1}{T_E}\right)\right] \tag{3}$$

where

T_E is the unknown temperature to be determined by the EWM,

λ_e is a function of T_E for a given T_R.

Traditionally, the EWM has been widely used for the realization of the international temperature scale with a standard optical pyrometer. It has been tested in a wide temperature range. Nevertheless, one should calculate the effective wavelength as a function of temperature with the SSP to obtain an accurate temperature scale with eq. (3).

It is well-known that the reciprocal of the effective wavelength can be approximated by a straight line in $1/T$ [6]. By describing the effective wavelength of the pyrometer with a polynomial of the inverse temperature, the following equation expresses the signal of a pyrometer when the condition, $AT \gg B$ is satisfied:

$$V_E(T) = C \exp\left(-\frac{C_2}{AT + B}\right) \tag{4}$$

where $V_E(T)$ is the signal of the pyrometer at temperature T. The coefficients A, B, and C can be determined by fitting signals of the pyrometer at calibration points with eq. (4).

Reference wavelength method (RWM)

According to the RWM, the correction factor, R, for a blackbody source is defined by [1]:

$$R(T)\, L(\lambda_r, T) = \frac{V(T)}{\int S(\lambda) d\lambda} \tag{5}$$

where λ_r is the reference wavelength.

Several authors have already applied the RWM to the calibration of multi-color pyrometers to avoid problems caused by the discontinuity of the effective wavelength at a certain temperature. They have shown that the correction factor, $R(T)$, may be fitted to polynomials of the inverse temperature. They have also shown that the radiance error caused by fitting the polynomial is negligible when the polynomial of a degree greater than two is used for fitting [3].

Here, by substituting the polynomial of degree two into $R(T)$ in eq. (5) and rewriting with respect to V(T), we derive a new interpolation equation using the RWM.

The new equation is:

$$V_R(T) = \left(a + \frac{b}{T} + \frac{c}{T^2}\right) \frac{K}{\exp(C_2/\lambda_r T) - 1} \tag{6}$$

where: $K = \frac{C_1}{\lambda_r^5} \int S(\lambda) d\lambda$,

C_1 is the first radiation constant,

$V_R(T)$ is the signal of the pyrometer at temperature T,

a, b, c are fitting parameters.

For the determination of fitting parameters, we let $R(T) = 1$ at one calibration point $T = T_o$. Then we obtain

$$K_0 = V_R(T_0)[\exp(C_2/\lambda_r T_0) - 1] \tag{7}$$

and, by substituting K_o into K in eq. (6), we find

$$\frac{V_R(T)}{K_o}[\exp(C_2/\lambda_r T) - 1] = a + \frac{b}{T} + \frac{c}{T^2} \tag{8}$$

The right hand side of eq. (8) is a simple polynomial in $1/T$. By fitting signals of the pyrometer at calibration points to eq. (8), the coefficients a, b, and c can be obtained easily. Since T is not solved analytically from eq. (6), we calculate the temperature from the signal of the pyrometer by an iteration method.

Description of the transfer standard pyrometer

Optical system

The optical system of the transfer standard pyrometer we designed in this work is shown in Fig. 1.

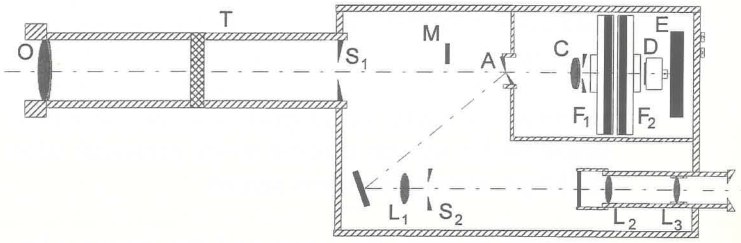

Fig. 1 Schematic diagram of the transfer standard pyrometer. O: objective lens, T: adoptive tube, S_1: objective stop, M: mechanical shutter, A: aperture mirror, C: condenser lens, F_1: absorption filter, F_2: interference filters, D: silicon detector, E: current/voltage converter, L_1, L_2: relay lenses, L_3: eyepiece.

The pyrometer is designed for the realization of the ITS-90 and the calibration system of both visual type and detector-based pyrometers. The silicon detector used (Hamamatsu S1337-1010BQ) has a good long-term stability and a high spectral response in the vicinity of 650 nm and 850 nm. An objective lens (achromatic, f = 200 mm, diameter = 3.2 cm) makes a 1:1 image on the aperture stop. The diameter of the aperture stop (f = 0.8 mm) is small enough to compare radiances from the metal fixed point blackbody and the tungsten strip lamp.

The general specification of the pyrometer is listed in Table 1.

Table 1 General specifications of the KRISS transfer standard pyrometer.

Minimum target size	0.8 mm (1:1 imaging @ 400 mm distance)
Distance from target to objective lens	400 mm – 600 mm with an adoptive tube 600 mm – ∞ without adoptive tube
Peak of measuring wavelength	650 nm or 850 nm (manually changeable)
Range of temperature measurement	650 nm band: 800 °C – 2800 °C 850 nm band: 600 °C – 3500 °C
Objective lens	Achromatic, f = 200 mm Diameter = 32 mm
Accuracy	< 0.02 % for fixed calibration < 0.2 % for MPCM with blackbody
Precision	< 0.002 %
Number of gain	Load resistor of operational amplifier: 2 ea Absorption filter: 1 ea
Dimensions	600 mm × 140 mm × 80 mm
Weight	4.7 kg
Removal of dark signal	With a mechanical shutter

The moving distance of the objective should be approximately 200 mm to make it possible for the pyrometer to use the distance between the target and the objective lens up to ∞, as it does 1:1 imaging. However, since the moving distance of the objective is too long, we make an adoptive tube of 100 mm in length so that we can attach it to the pyrometer when the longer moving distance is needed.

Distances between the target and the objective lens in accordance with the use of the tube are listed in Table 1.

For the durability of the system and the accurate lineup of the target, we use an aperture mirror. We can use both 650 nm and 850 nm interference filters interchangeably. For an extension of the temperature scale we put in a neutral filter. We observed that the blocking ratio outside the transmittance band is very high. However, we inserted an infrared blocking filter additionally because 650 nm interference filter gives a small amount of side band beyond 800 nm and the blocking ratio is very low. The 650 nm interference filter is always used in combination with a suppression filter (CVI KG-5). Each wheel has two holes to hold filters and one blank hole to measure spectroscopic characteristics of the filters or the detector used in pyrometer. The neutral density filter that has a transmittance of 6.7 % at 850 nm is used to extend the measurable temperature scale.

Detector and amplifier

The photocurrent of the silicon detector is converted to voltage by an operational amplifier (Burr-Brown OPA128). The load resistance of the operational amplifier can be changed in two steps: 100 MΩ for a high gain and 1 MΩ for a low gain.

With the mechanical shutter we measure the dark current of the detector before and after each measurement. The signal of the pyrometer is obtained by subtracting the dark current from the signal of the detector. The circuit that operates the shutter inside the standard pyrometer is connected to the computer. A block diagram of the pyrometer and its control system is shown in Fig. 2.

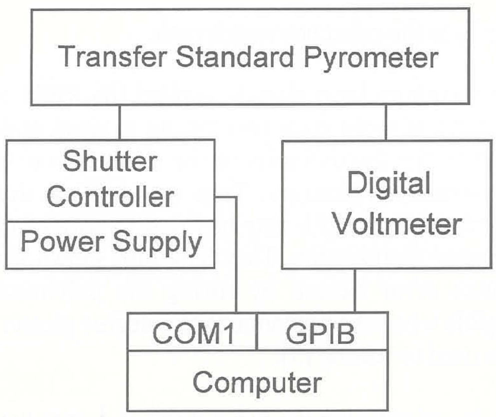

Fig. 2 Block diagram of the pyrometer and its control system.

Figure 3 shows the pyrometer and its control system. The control program is very easy to use since it runs in Windows (Microsoft 3.1).

Calibration method and uncertainty

Fixed point calibration

To maintain the temperature in accordance with ITS-90 which is defined above the freezing point of silver, we need to realize the freezing point of silver, gold, or copper. This realized temperature scale needs to be transferred to the high stabilized tungsten strip lamp. By using this scale as a standard, the temperature is determined after measuring the radiance ratio from the object with the pyrometer. In this case we need a standard pyrometer, a high stabilized tungsten lamp and a high stable current power supply to drive the lamp.

The method mentioned above is the best way for maintaining a standard temperature scale. For this system the standard lamp needs to be checked periodically (usually every two years) and the spectral characteristic of the pyrometer also needs to be measured at the same time. The uncertainty of the temperature scale near the copper freezing point is < 0.05 °C, and the long-term drift of the temperature scale due to the drift of the current of the standard lamp and the spectral characteristic of the pyrometer is estimated to be < 0.2 °C/year near the copper freezing point. The following measurements are carried out for the calibration method:

- spectral characteristic of the standard pyrometer;
- detector linearity;
- size of source effect; and
- realization of a metal fixed point and calibration of a standard lamp.

Calibration against a standard lamp

In the case where one wants to maintain the temperature scale without a standard lamp, the following method is recommended. Since there is no need for calibrating a standard lamp, the realization of the fixed point is not necessary. The standard pyrometer is

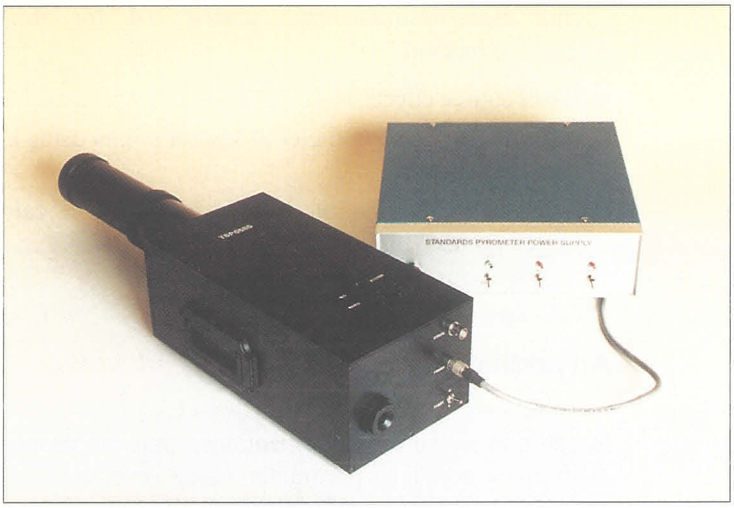

Fig. 3 The transfer standard pyrometer and its control system.

calibrated based on a calibrated standard lamp. Then, the temperature scale is defined by the signal ratio, and the signal at the calibration temperature is used as a reference. The uncertainty of the temperature scale is primarily the result of the long-term change of the spectral characteristics and the signal of the pyrometer, and is estimated to be < 1 °C/year near the copper freezing point. The following measurements are carried out for this calibration method:

- spectral characteristic of the standard pyrometer;
- detector linearity; and
- size of source effect.

Multiple point calibration with a blackbody furnace

To avoid the inconvenience of measuring the spectral characteristic of the standard pyrometer, we calibrate a pyrometer at several points by using a blackbody furnace and the standard pyrometer. Signals obtained at the calibration points are then fitted into the interpolation equation mentioned earlier to set the temperature scale. In this case, signals of the standard pyrometer are used for maintaining the temperature scale as before.

However, the temperature scale is transferred directly from a calibrated lamp at a fixed point in the preceding case. The temperature scale is determined by measuring temperatures of a blackbody furnace using the temperature scale based on a lamp in this case. The uncertainty of the temperature scale is estimated to be < 2 °C/year near the copper freezing point. The following measurements are carried out for this calibration method:

- size of source effect;
- calibration of the pyrometer at several points using a blackbody furnace; and
- fitting of the signals of the pyrometer at the calibrated points with the interpolation equation.

An additional method

In addition to the methods mentioned thus far, people calibrate a standard pyrometer using several metal fixed-point furnaces, and determine the temperature scale by interpolation and extrapolation by using the interpolation equation. For example, Hattori and Sakuma did the fixed point calibration applying fixed point blackbody furnaces of zinc, aluminum, silver, and copper. Then they determined the temperature scale from the interpolation eq. (2), which is derived by EWM. This method gives the accuracy that we mentioned in the section *Calibration against a lamp* if the temperature range is around the metal fixed point. However, the use of the metal fixed point that can realize the temperature above 1 500 °C is very difficult. Therefore, in the temperature range above 1 500 °C, the accuracy of the temperature scale is not sufficient.

Conclusions

We have discussed characteristics of the transfer standard pyrometer developed in KRISS. The use of this pyrometer enables one to maintain the standard temperature in high temperature range above the freezing point of silver. This pyrometer can also be used as calibration equipment for high temperature measuring instruments such as radiation thermometers, visual type optical pyrometers, standard lamps, etc. We analyzed calibration errors that occurred during various operation methods when this pyrometer was used as a calibration device. The pyrometer developed by KRISS is one of the best commercial pyrometers in the world, and moreover, KRISS can provide the calibration service for the realization and maintenance of the temperature scale with this pyrometer.

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As rapid developments transform the economic, scientific and technical landscapes of Asia, OIML's pursuit of international metrological harmonization is benefited by a growing participation on behalf of its Asian Member States.

"Focus on Far East Asia" portrays the metrology structures charged with OIML affairs in Japan, Rep. of Korea, D. P. R. of Korea, and China, and covers recent trends in their national and international metrology activities of these Member States.

Japan

- THE NEW MEASUREMENT LAW AND PROSPECTS FOR JAPAN'S MEASURING INSTRUMENTS INDUSTRY
- NATIONAL RESEARCH LABORATORY OF METROLOGY
- NEW NATIONAL ORGANIZATIONAL STRUCTURE FOR OIML AND METRE CONVENTION

Rep. of Korea

- THE NATIONAL CALIBRATION SYSTEM IN KOREA
- INDUSTRIAL ADVANCEMENT ADMINISTRATION

D. P. R. of Korea

- STATE COMMISSION OF SCIENCE AND TECHNOLOGY

China

- THE STATUS AND PROSPECTS OF THE NATIONAL INSTITUTE OF METROLOGY
- CHINA STATE BUREAU OF TECHNICAL SUPERVISION
- THE CHINA INSTITUTE OF METROLOGY

New metrology legislation in Japan

THE NEW MEASUREMENT LAW AND PROSPECTS FOR JAPAN'S MEASURING INSTRUMENT INDUSTRY*

H. TSUDA, Former Director, Measurement Administration Office, Machinery and Information Industries Bureau, Ministry of International Trade and Industry (MITI)

The Measurement Law in Japan, which was enforced in 1951 as the basis of measurement regulations, was thoroughly revised in May 1992. The new Measurement Law came into force in November 1993 and becomes the foundation of Japan's measurement system and regulations in the future. It is also expected to exert various influences on measuring instruments.

THE Measurement Law stipulates the basis of the measurement system in Japan such as the decision on the units of measurement used in transaction and certification; verification needed for the supply of high-precision measuring instruments; and steps to ensure accurate measurement.

The preceding Measurement Law was enacted in 1951. It was revised several times to conform to subsequent economic and social changes. However, major changes in the economy and society, including progressive internationalization and innovations of technology, intensified the demand for the introduction of a new measurement system matching the new era.

In August 1990, the Minister of International Trade and Industry asked the Weights and Measures Administration Council, an advisory organ of the minister, to submit a report on a "Desirable Form of Weights and Measures Administration in the New Era". The report was announced in August 1991 and many reforms were recommended for existing measurement regulations centering on a revision of the Measurement Law with a view to increasing internationalization, responding to technological innovations, and protecting consumer interests.

MITI immediately started work on revising the Measurement Law and enacted the new law in May 1992 after deliberation in the National Diet.

MAIN POINTS OF REVISION

Unification of legal measuring units with the International System of Units (SI)

In the past, Japan used measuring units which originated in ancient China. The government continued its effort for a unified metric system after joining the Metre Convention. General commercial transactions were unified under the metric system in 1959, and real estate transactions in 1966 under the current law.

SI has been adopted in many countries and Japan is also gradually introducing it into the Measurement Law. However, since SI is used simultaneously with previous units in our country, unification with SI is sought in principle. The recent revision, therefore, calls for the unification of legal measuring units to SI after a certain delay, with the exception of some units

* This article was originally published in JAPAN magazine, 21 March 1994, pp. 71–4. Minor editorial modifications have been made to clarify the text when necessary.

whose use is tolerated temporarily by the International Conference of Weights and Measures.

The harmonization with SI is scheduled to be completed by October 1999. Each industry and enterprise, led by the measuring instrument industry, is taking the necessary steps. About 85 % of JIS (Japan Industrial Standards) has been unified with SI.

Reconsideration of regulations regarding measuring instruments

The existing Measurement Law requires periodic verification by administrative agencies to certify the accuracy of measuring instruments used in transactions and certifications in fields relatively abounding in small businesses, those used in transactions directly related to consumers and those used for pollution measurements. At present, the number of measuring instruments requiring periodic verification is about 37 million per year, including power meters, weighing machines, clinical thermometers and sphygmomanometers.

The manufacturing and quality control technologies of measuring instruments have progressed tremendously since the time when the existing verifying regulations were enforced. As a result, a very high percentage of instruments pass verification. Various regulations related to measuring instruments are being reconsidered under these circumstances.

The most important items in this reconsideration are the conformity of verification standards for measuring instruments to the international standard, including that of OIML *(Organisation Internationale de Métrologie Légale)*, and the establishment of a new regulation to exempt specific manufacturers from the duty of verification.

The existing verifying regulation requires that all verification regarding structures and instrumental errors are to be carried out by administrative agencies in order to ensure the supply of instruments with high accuracy. Under the current regulation, which responds to the growing complexity and

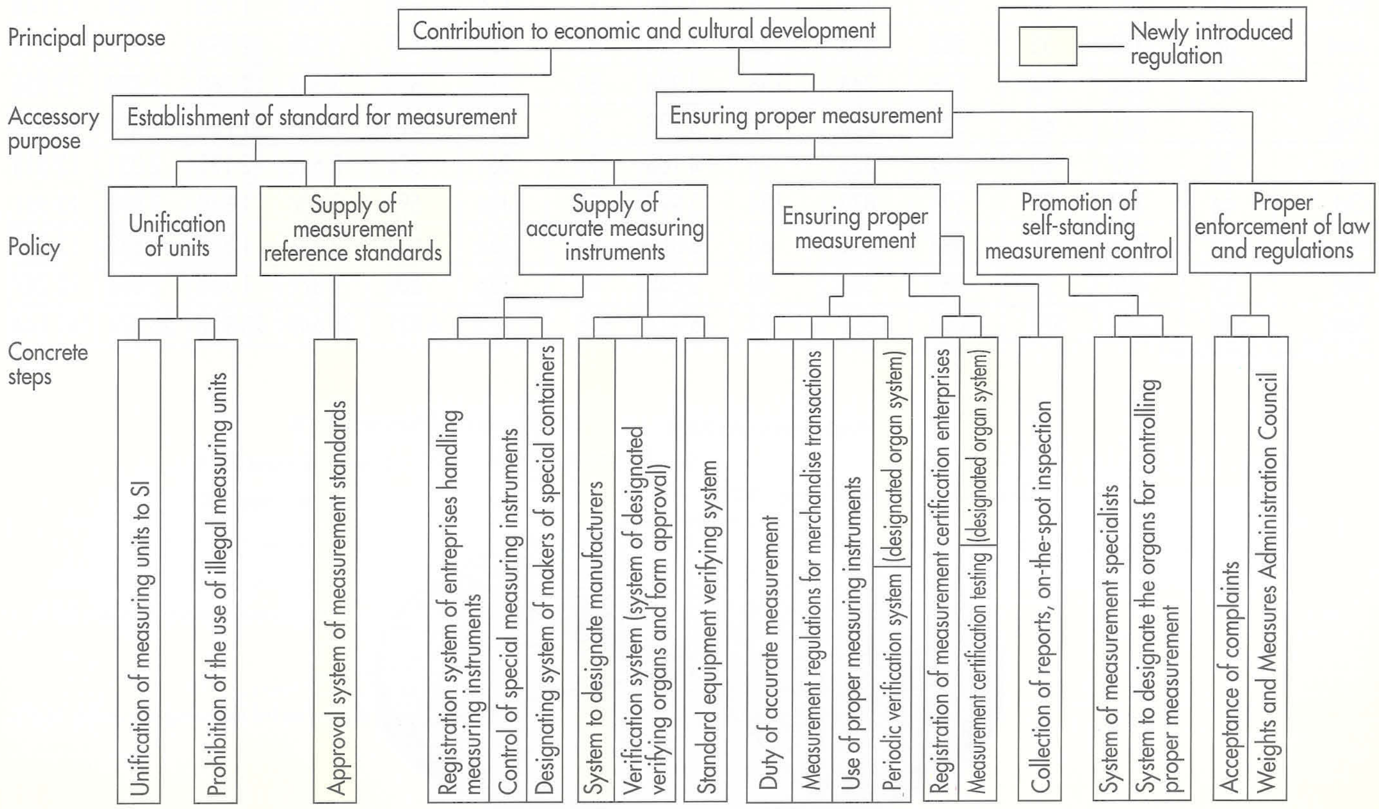


Fig. 1 New Measurement Law.

sophistication of measuring instruments, even measuring instruments which have received formal approval must undergo all verifications of instrumental error.

On the other hand, the progress of technologies for manufacture and quality control has resulted in an extremely high passing ratio. Some firms have achieved a success ratio of 100 % consecutively for the past several years. Under the circumstances, the government introduced a new regulation by which specific manufacturers with quality control above a certain level can be exempted from verification. The standard of quality control is based on the methods of ISO 9000.

This new rule will be gradually introduced by November 1998, taking into account the actual state

Table 1 Import of measuring instruments in 1992 (unit: million Yen).

Month	Gas meters, water meters and gasoline pumps	Weighing machines	Themometers	Survey instruments	Testing machines	Optical measuring instruments	Precision measuring instruments	Pressure gauges	Speedometers and tachometers	Level gauges and flow meters	Analytical instruments	Process control measuring instruments	Other measuring instruments	TOTAL
Jan	32	540	32	275	422	115	3 853	73	399	564	2 855	2 194	2 314	13 668
Feb	13	410	42	360	204	91	4 386	57	333	553	3 087	1 786	2 088	13 410
Mar	16	354	65	472	274	160	4 770	85	371	654	3 546	2 180	2 504	15 451
Apr	19	342	36	508	352	140	2 672	83	325	575	2 475	2 130	2 229	11 886
May	12	351	49	549	209	156	3 060	62	324	626	2 550	1 746	2 454	12 148
June	36	322	55	582	414	38	7 886	93	451	517	3 325	2 394	2 205	18 318
July	45	354	54	516	244	138	3 276	83	334	635	3 331	2 168	1 778	12 956
Aug	38	331	64	543	340	47	3 192	51	311	520	2 688	1 753	2 078	11 956
Sep	26	332	60	593	326	76	4 188	96	361	570	2 642	2 192	2 051	13 513
Oct	44	347	37	526	873	121	3 997	96	404	593	2 566	1 849	2 098	13 551
Nov	40	368	49	598	578	63	3 056	91	354	624	2 704	1 816	1 639	12 000
Dec	13	409	29	482	323	48	2 640	46	326	500	2 871	1 784	2 816	12 287
Total	334	4 460	572	6 004	4 559	1 193	46 976	916	4 293	6 931	34 640	23 992	26 274	161 144

(Source: Japan export & import monthly)

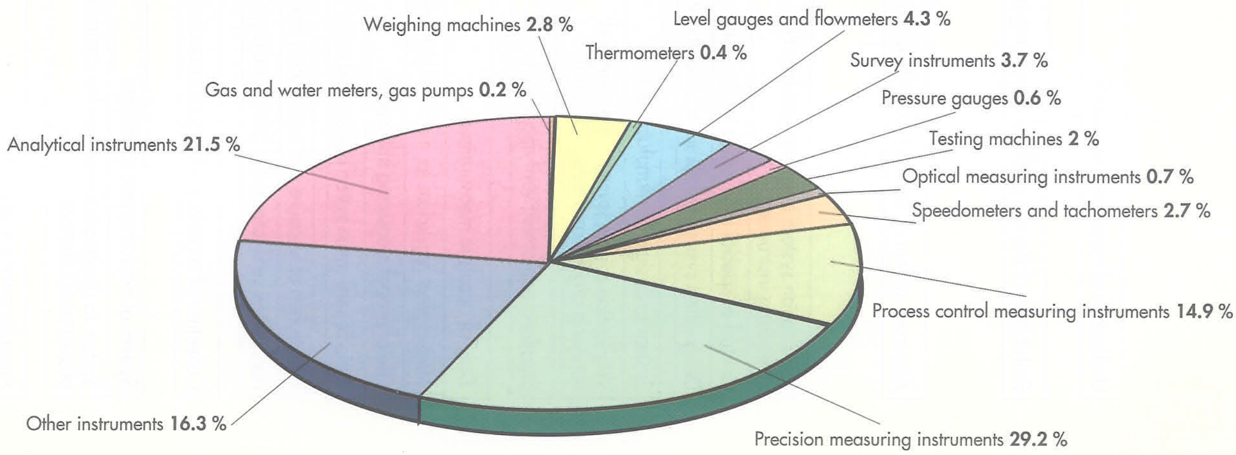


Fig. 2 Import of measuring instruments in 1992 (repartition in percentage per category).

of quality control for each instrument. The standard for quality control is being studied at present. Many enterprises desire an early implementation of this regulation. Foreign makers are also permitted to become specific makers.

Founding the State Measurement Reference Standard Supply System (traceability system)

Recent technical innovations have heightened the need for high-accuracy measurements in all industries. Hence, the State Measurement Reference Standard Supply System (so-called traceability system) is about to be founded so as to enable the calibration of instruments for precision measurement (such as block gauges) against

Table 2 Export of measuring instruments in 1992 (unit: million Yen).

Month	Length measuring instruments	Gas meters, water meters and gasoline pumps	Weighing machines	Thermometers	Survey instruments	Testing machines	Optical measuring instruments	Precision measuring instruments	Pressure gauges	Speedometers and tachometers	Level gauges and flow meters	Analytical instruments	Process control measuring instruments	Other measuring instruments	TOTAL
Jan	113	379	1 879	131	1 288	660	343	2 404	128	2 630	1 436	5 744	4 367	753	22 255
Feb	148	384	2 161	132	1 359	736	337	3 317	195	3 199	1 633	6 770	5 085	969	26 425
Mar	105	352	3 195	143	1 234	873	569	3 540	191	3 742	1 540	7 628	6 124	1 051	30 287
Apr	193	285	2 993	176	1 273	822	413	3 896	260	3 435	1 697	5 884	5 800	1 135	29 242
May	170	212	2 429	125	1 621	772	453	2 710	286	3 196	1 539	6 066	5 367	881	25 827
June	162	360	2 727	134	1 676	682	469	2 719	176	3 402	1 762	7 788	5 838	868	28 763
July	188	200	2 481	193	1 560	723	573	2 702	203	3 382	1 826	6 582	5 880	943	27 436
Aug	156	254	2 009	116	1 399	512	397	2 689	184	3 654	1 592	4 420	5 492	889	23 763
Sep	152	430	2 884	161	1 708	656	414	2 622	184	3 813	1 841	7 693	7 061	970	30 599
Oct	189	608	3 223	174	1 879	643	474	2 635	217	3 884	1 632	6 999	6 564	947	30 068
Nov	139	500	2 273	146	1 221	537	390	2 334	193	3 161	1 424	5 087	5 942	903	24 250
Dec	184	778	2 798	202	1 727	1 286	498	3 115	245	3 808	1 721	7 944	6 267	1 086	31 659
Total	1 899	4 742	31 052	1 833	17 945	8 902	5 330	34 683	2 472	41 306	19 643	79 585	69 787	11 395	330 574

(Source: Japan export & import monthly)

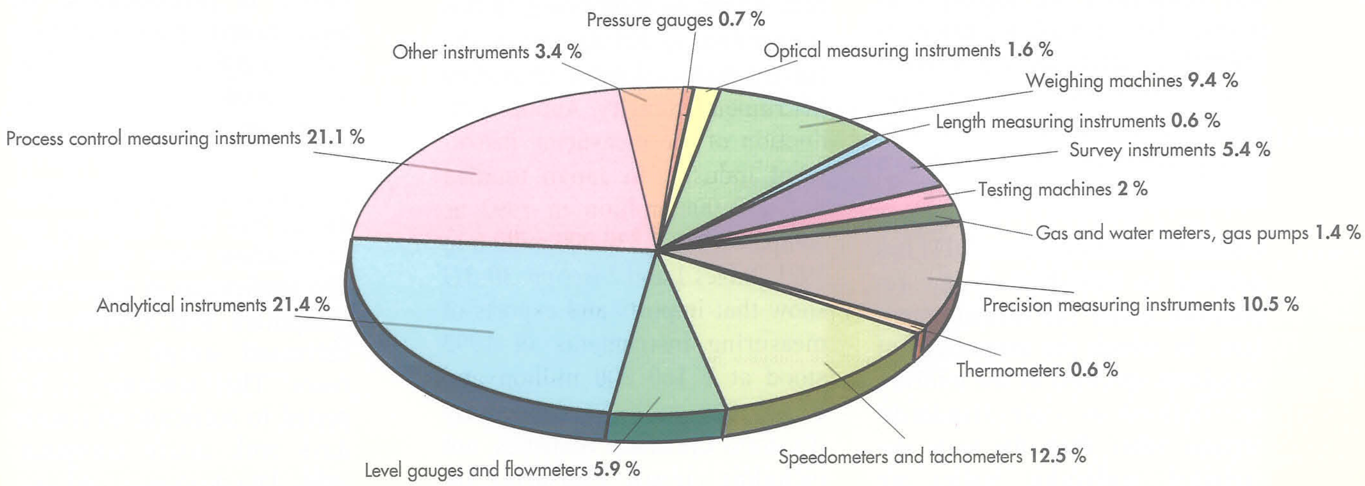


Fig. 3 Export of measuring instruments (repartition in percentage per category).

the supreme measurement reference standard (State Measurement Standard) as the basis of final certification.

The state standards for industrial measurements were supplied on request in Japan in the past by such state research institutions as the National Research Laboratory of Metrology (NRLM) and Electrotechnical Laboratory (ETL). However, the supply of standards by these institutions has been found to be inadequate for responding to the demand for measurement standards of higher reliability which are necessary for modern quality and process controls. It was necessary to depend on the supply from overseas standard supply organizations such as NIST for a part of the instruments.

In addition, the absence of any regulation for officially guaranteeing the correlation of measurement standards supplied by the private sector to state standards in Japan (the traceability system) proved to be a serious bottleneck for the supply of standards.

Technology is progressing at enormous speeds in the fields of aircraft, space, atomic energy, and semi-conductors. The accuracy of weights and measures is critical in these industries. Further, borderless economies are rapidly promoting the internationalization of industrial standards and international unification of technical norms. The international unification of measurement standards is a prerequisite for their realization.

Under the circumstances, MITI has decided to introduce a new regulation under the Measurement Law, by which the measurement standards specified by the ministry are defined as state standards; organs other than the state designated calibrating bodies are empowered to perform calibrations against the state standards. This system will ensure an adequate traceability of calibration.

The new regulation took effect in November 1993, simultaneously with the enforcement of the new Measurement Law. Applications for registration as a measurement specification enterprise are accepted consecutively for those quantities for which state standards have been established. The enterprises approved by the state will shortly obtain the "JCSS" certificate and start calibration services.

Years of preparation are needed for the implementation of the new system. At any rate, an internationally valid measurement standard system is indispensable and the government intends to actively promote its early realization.

PRESENT AND FUTURE OF THE MEASURING INSTRUMENT INDUSTRY IN JAPAN

Japan's measurement regulations were thus revised in November last year. It may be appropriate, in this connection, to briefly survey the current state of Japan's measuring instrument industry. Annual production of the measuring instrument industry in Japan totalled ¥ 1 450 000 million in 1992 as compared to ¥ 1 530 000 million in 1991. Tables 1 and 2 *(see pp. 30–31)* show that imports and exports of measuring instruments in 1992 stood at ¥ 160 000 million and ¥ 330 000 million, respectively (Customs Clearance Statistics; not including electric measuring instruments).

Measuring instruments naturally have an extremely wide variety, ranging from household equipment, such as gas meters and water meters, to instruments for controlling industrial processes and those used for testing and analysis.

It is difficult to sum up the general situation concerning measuring instruments since their market size, technical level, and producers differ according to instrument type. But the recent trend can be summarized as follows:

(1) The Japanese economy has slumped badly in the last three to four years. Some measuring instruments are relatively immune to business fluctuations. But the demand for those used for production processes and analysis is falling owing to stagnation of equipment investment. Hence, makers are doing their utmost to tide over the situation.

(2) The measuring instrument industry is characterized by multiple small-lot production depending on customer orders since its market extends over many industries and each market sector has its own professional and technical requirements. Therefore, the industry is predominated by medium and small enterprises (about 3 200 firms) specializing in the production of particular instrument types.

(3) As regards technology, the industry has been carrying out digitization since the 1960s. The application of electronics, computers and systems has increased steeply in recent years. This tendency is expected to accelerate in coming days with active computer-aided data processing and multiple functions.

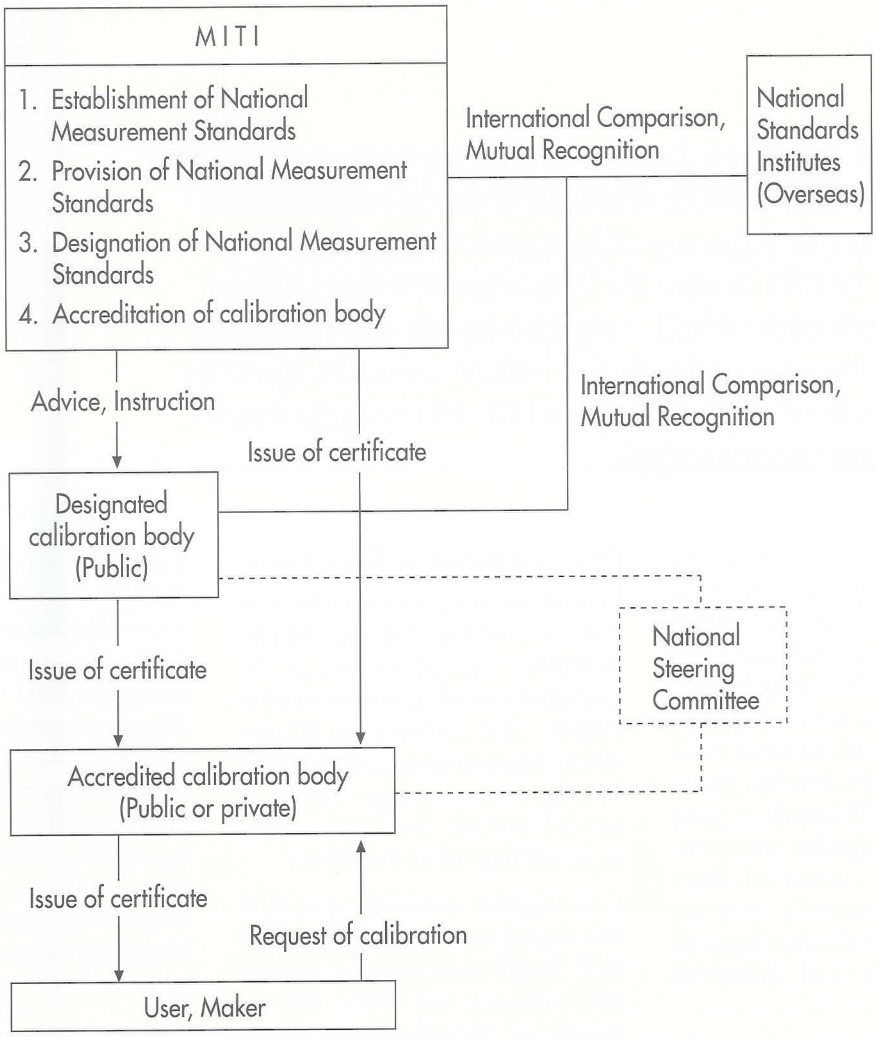


Fig. 4 Japanese national traceability system based on the new Measurement Law.

(4) Many standards for measuring instruments requiring verification (gas meters, water meters, taximeters, and gasoline meters) are being revised so as to conform to international standards under the new Measurement Law. Makers will try to manufacture products that satisfy these new standards.

Makers whose quality control ability surpasses a certain level will benefit from the new regulation allowing the verification exemption and many of them are expected to endeavor to obtain such designation. They will also desire to become approved enterprises whose conformity to state standards is guaranteed under the new traceability system. It is possible that an increasing number of enterprises will benefit from this system depending on its further evolution. ■

Japan

National Research Laboratory of Metrology
NRLM
通商産業省工業技術院
計量研究所

The National Research Laboratory of Metrology (NRLM) was established in 1903 and is one of 16 laboratories belonging to the Agency of Industrial Science and Technology (AIST) under the Ministry of International Trade and Industry (MITI). Located about 60 km north of Tokyo in the city of Tsukuba, NRLM devotes itself to the development and dissemination of measurement standards and technologies.

As Japan's national standard laboratory, the NRLM is charged with performing research on national primary standards of the five basic units (for length, mass, time, temperature and amount-of-substance) and derived units (for density, force, pressure, etc.). Research is also carried out on applied measurement techniques based on these standards to eventually play an important role in the development of the scientific and industrial fields in Japan.

The NRLM is also responsible for maintaining international liaisons with foreign standard laboratories and participating in the activities of certain international bodies such as the Metre Convention and OIML.

COMPOSITION OF NRLM

With a total staff of 202 persons (research staff: 121 and administrative staff: 81), the NRLM is composed of four departments, Quantum Metrology, Thermophysical Metrology, Mechanical Metrology and Measurement Systems, which cover a total area of almost 18 000 m^2 in Tsukuba. The three branches of NRLM (referred to as Measurement System Centers) are located in Osaka, Kyushu and Chuba.

Quantum Metrology Department

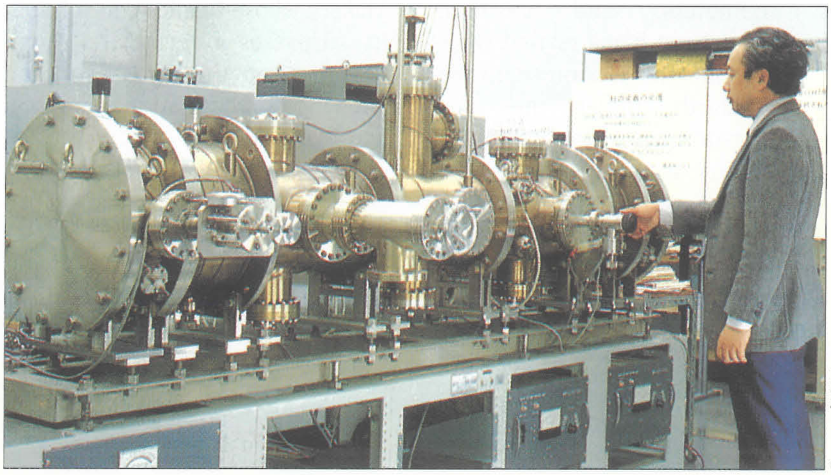
Length and frequency standards as well as related applied optical metrology are developed in the Quantum metrology department of NRLM. The elaboration of precision measurement technologies in the subnanometer region is carried out on the basis of the quantum limit of measurement.

Laser applied metrology is used in this department to establish practical length standards in science and industry and carry out research on optical interferometry and laser modulation techniques.

Thermophysical Metrology Department

This department handles all matters related to temperature standards and thermophysical properties of solids and fluids. Temperature measuring techniques are studied for developing temperature standards from 3000 °C down to 0.1 K. The thermophysical metrology department also pursues activities related to improving the accuracy of standard thermometers, and developing calibration techniques for standard radiation thermometers which are evaluated with a blackbody furnace at temperatures up to 3000 °C.

NRLM pursues research for practical applications in various fields. For example, in view of the growing importance of global environmental protection, this department is active in its studies of new methods and equipment for



Courtesy of NRLM

The cesium frequency standard of NRLM.

measuring concentrations of carbon dioxide in seawater.

Mechanical Metrology Department

The mechanical metrology department focuses on the advancement of measurement techniques in the areas of mass, force, shock acceleration, surface roughness, vibration, flow, pressure, and hardness. For example, mass fluctuation resulting from atomic interactions between the surface of a weight and the atmosphere due to the irregular gradient of the acceleration of gravity are studied by using mass comparison techniques in the 10^{-10} accuracy level.

Measurement System Department

With the tasks of testing and calibration of measuring instruments, developing practical standards, and improving measurement techniques, the Measurement System Department is concerned with both legal and industrial metrology. Through this department, NRLM pursues activities in measurement information technology (design, measurement information processing, and systematic calibration methods), and seeks to ensure an appropriate reliability of measuring instruments. The formulation of new concepts for metrological control is associated with this department.

Legal testing and calibration services

In order to maintain consistency within the broad range of measurement activities in Japan, NRLM offers measurement services based on the Measurement Law *(see pp. 28–33)*. The Testing and Inspection section of NRLM in Tsukuba consists of six subsections: length, mass, temperature, pressure, volume, and density in which verification, calibration, and pattern approvals are carried out. Technical matters concerning the legal metrology system (the responsibility of NRLM) are controlled in this section.

INTERNATIONAL COOPERATION

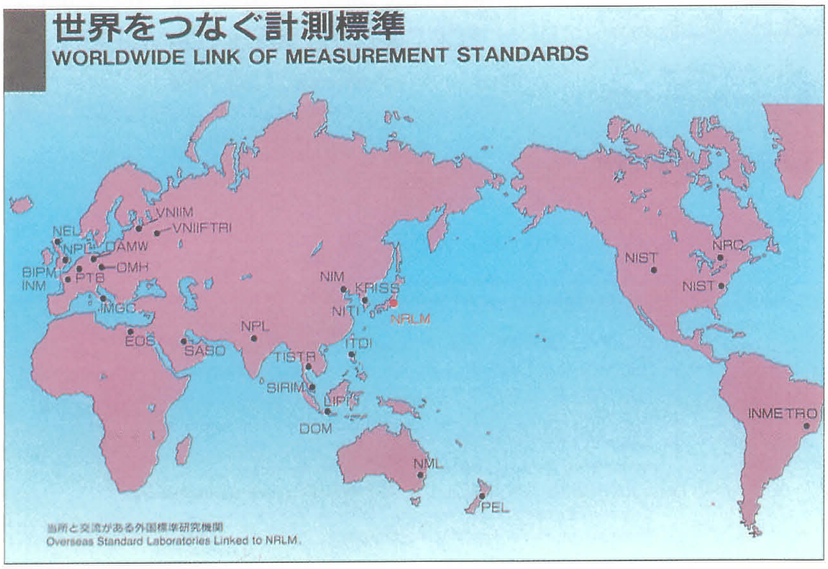
The NRLM occupies the national secretariat seat for two metrological conventions, the Metre Convention and OIML. National delegations are sent regularly to the general conferences and meetings of these bodies. With the recent approval of a new national organizational structure for international activities, Japan's participation in OIML is growing steadily *(see p. 36)*. Close cooperation is also maintained with other national standard institutes throughout the world through the organisation of joint research projects and intercomparisons.

Liaisons with developing countries are maintained by NRLM through the project "Joint Research for Transfer of Technology" which has been carried out with southeast Asian countries since 1975 with a view to promoting exchanges of standards and measurement techniques.

Courtesy of NRLM

The 20 MN hydraulic force standard machine at NRLM.

The "Group Training on Metrology and Measurement Standards", which is supported by the Japan International Cooperation Agency (JICA), is another NRLM activity whose aim is to encourage metrological advancement in developing countries. This training course has been held annually since 1973. ■



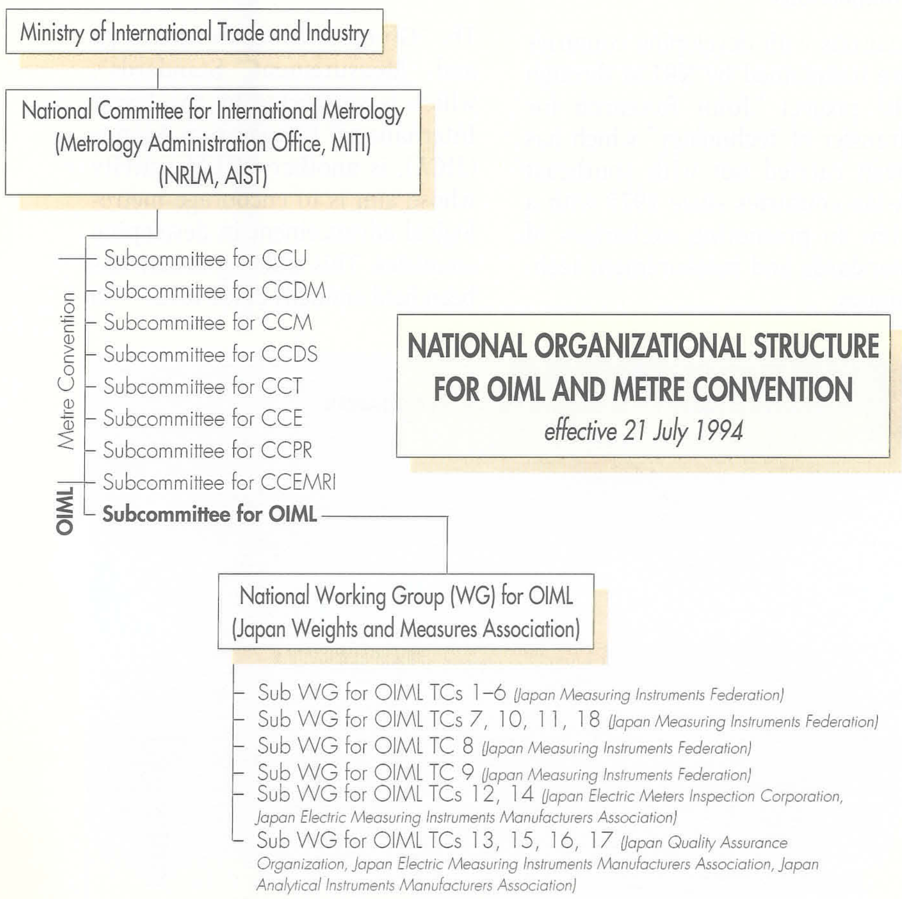
Courtesy of NRLM

NRLM maintains liaisons with overseas standard laboratories.

Japan

AFTER implementing the new Measurement Law in Japan, metrology authorities turned their attention toward the need to reorganize national participation in international metrology activities. The Weights and Measures Office of MITI recently studied a proposal submitted by Mr H. Yamamoto, organizer of the national working group for OIML, to establish a new national structure for OIML and the Metre Convention.

The proposal was officially adopted on 21 July 1994 at the first Joint Meeting of the "Subcommittee for OIML under the National Committee for International Metrology". Below is a diagram of this new structure.



Constituents of the Subcommittee for OIML, the National Working Group, and the Sub working groups are from MITI, NRLM, local W & M offices, JEMIC, JQA, JMIF and other related Manufacturers' Associations.

A brief note on
Japan and OIML

Membership

Japan became the 31st adherent of OIML on 16 May 1961. NRLM is the official body charged with OIML matters, participating regularly in Conference and Committee meetings.

CIML Member

Mr Y. Kurita, Director General of NRLM, was designated as the representative for Japan on the *Comité International de Métrologie Légale* in December 1992 and serves as the liaison between national metrology bodies and OIML.

Participation in OIML technical activities

as P-Member

TC 3, TC 3/SCs 1, 2, 4
TC 4
TC 5
TC 7
TC 8, TC 8/SCs 1–5, 8
TC 9, TC 9/SCs 1–3
TC 11, TC 11/SC 2
TC 13
TC 16
TC 18

as O-Member

TC 1
TC 2
TC 3/SC 3
TC 6
TC 7/SCs1, 3, 4, 5
TC 8/SCs 6, 7
TC 10, TC 10/SCs 1–6
TC 11/SCs 1, 3
TC 12
TC 14
TC 15
TC 16/SCs 1–4
TC 17, TC 17/SCs 1–7
TC 18/SCs 1, 2, 4, 5

A report from KRISS

THE NATIONAL CALIBRATION SYSTEM IN KOREA

J. C. AHN, Head, Calibration Center
Korea Research Institute of Standards and Science (KRISS)

ESTABLISHMENT OF THE NATIONAL CALIBRATION SYSTEM (NCS) IN KOREA

THE Korean economy has grown rapidly through successive five-year development plans that have been implemented since 1962. At that time, the economic strategy of the Korean Government was to achieve export expansion by promoting heavy and chemical industrial development.

In order to achieve the goals of these economic development plans, the Government placed emphasis on improving the quality of industrial products and productivity, and reducing production costs. For that purpose, it became necessary to establish the National Calibration System (NCS) and raise the accuracy level of Korean industries to that of advanced countries.

The establishment of NCS, however, was impossible until 1977 because there was no national primary standard organization traceable to the international standard. In order to develop the national primary standards and establish the NCS, Korea Standard Research Institute (KSRI) was formally established as an autonomous organization in 1975 under the "Weights and Measures Act". In 1991 the KSRI was renamed the *Korea Research Institute of Standards and Science (KRISS)* after basic scientific research was added to its activities. Two years after its establishment, KSRI proposed the establishment of a nation-wide calibration network in order to effectively disseminate the national measurement standards to industries.

The Industrial Advancement Administration (IAA) of the Korean Ministry of Trade and Industry accepted KSRI's proposal for the establishment of NCS and approved the KSRI as the primary calibration laboratory. It also approved NIRI, KIMM, KAERI and the Air Force Calibration Center as secondary calibration laboratories in December 1978. The NCS was thus established in a pyramid type hierarchy, consisting of the primary, secondary and tertiary calibration laboratories.

In 1986 the IAA modified the pyramid system by adding in-house calibration laboratories and established the division criteria of secondary and tertiary laboratories. In addition, the IAA increased the number of accredited calibration laboratories taking into consideration the geographic location and the number of industries in order to provide calibration services more efficiently to all industrial complexes in Korea.

STRUCTURE OF NCS

The IAA has the authority to accredit calibration laboratories in Korea. The "Weights and Measures Act" is the legal basis for this accreditation system and it specifies requirements concerning the application, assessment, approval, suspension and cancellation of calibration laboratories. There are three kinds of calibration laboratories; national standards research laboratory, calibration laboratories, and in-house calibration laboratories (Fig. 1).

KRISS, the national standards research laboratory, provides calibration services and issues authorized calibration certificates to other calibration laboratories. The calibration laboratories provide services and issue calibration certificates to other organizations. However, in-house calibration laboratories are only permitted to issue certificates for their own instruments. KRISS also provides services directly to industries in the measurement field in which other calibration laboratories do not have capabilities.

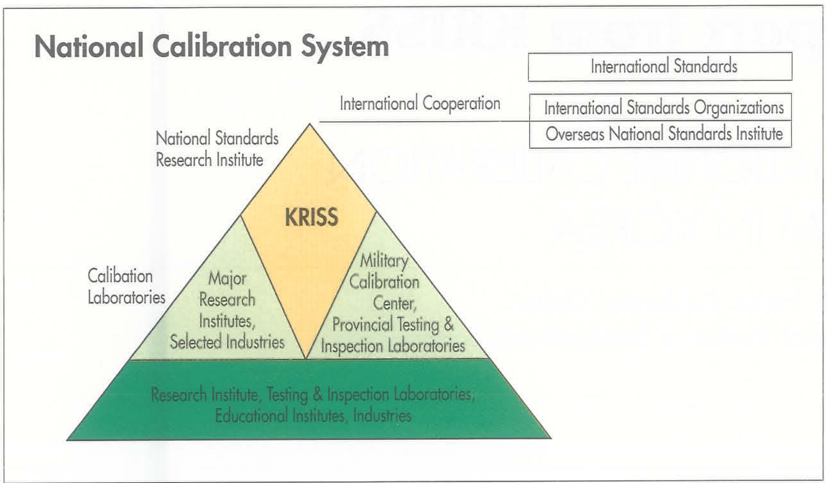


Fig. 1 National Calibration System in Korea.

The calibration laboratories are accredited for specific measurement fields for which they are authorized to issue official calibration certificates.

OPERATION OF NCS

The Korea Association of Standards and Testing Organization (KASTO) was organized in 1979 to promote effective operation of the national calibration service and close cooperation among calibration laboratories. All calibration laboratories are members of KASTO and the president of KRISS is also the chairman of KASTO. The main subject for discussion at KASTO meetings is the operation of the National Calibration System, including assessment and proficiency tests, calibration intervals, calibration fees, and reports of calibration results.

Assessment and proficiency test

KASTO-registered assessors evaluate candidate laboratories based on the following criteria:

- qualifications and experience of laboratory staff;
- adequacy of the equipment and laboratory environment;
- traceability of all measurements to national standards; and
- keeping records for equipment, measurement procedures, and calibration work that has been performed.

Because the assessors should be technical experts who are at least as qualified as the staff of the candidate laboratory, most of the registered assessors are KRISS members. KASTO organizes proficiency tests in specific fields every year to compare the performance of accredited laboratories. In this case, KRISS becomes a Reference Laboratory providing reference values for the travelling artifacts; all laboratories performing in the same measurement field should take part in the proficiency test when possible.

Instruments to be calibrated

Calibration is voluntary in the National Calibration System of Korea. But the government recommends that measuring instruments having an accuracy level higher than or equal to the 7th grade (see Table 1) be calibrated periodically according to the specified calibration intervals.

Report of Calibration

The calibration laboratory issues a formal document referred to as the "Report of Calibration" together with the label "Certificate of Calibration" for every calibrated instrument. The calibration results are recorded on a calibration report sheet which bears the statement certifying the instrument's traceability to the national primary standards together with the calibration number, identification of instrument, date of calibration, recalibration date, environmental conditions, etc.

The label "Certificate of Calibration" is affixed to an instrument for which a calibration report has been issued. The label authenticates traceability to the national primary standard, and classifies the grade of the instrument with different colours depending on the accuracy level of the calibrated instrument.

Table 1 Accuracy level of measuring instruments and their respective calibration certificates.

Classification	Accuracy level	Color of calibration certificate
Secondary standard	1st, 2nd, 3rd grade	Pink
Tertiary standard	4th, 5th grade	Blue
Precision instrument	6th grade	Yellow
Routine measument instrument	7th grade	White

RESULTS OF NCS

There has been a steady increase each year in the number of accredited laboratories as well as in the number of instruments they have calibrated. Table 2 shows the number of accredited laboratories and calibrated instruments since 1979.

Table 2 Results of the National Calibration System in Korea since 1979.

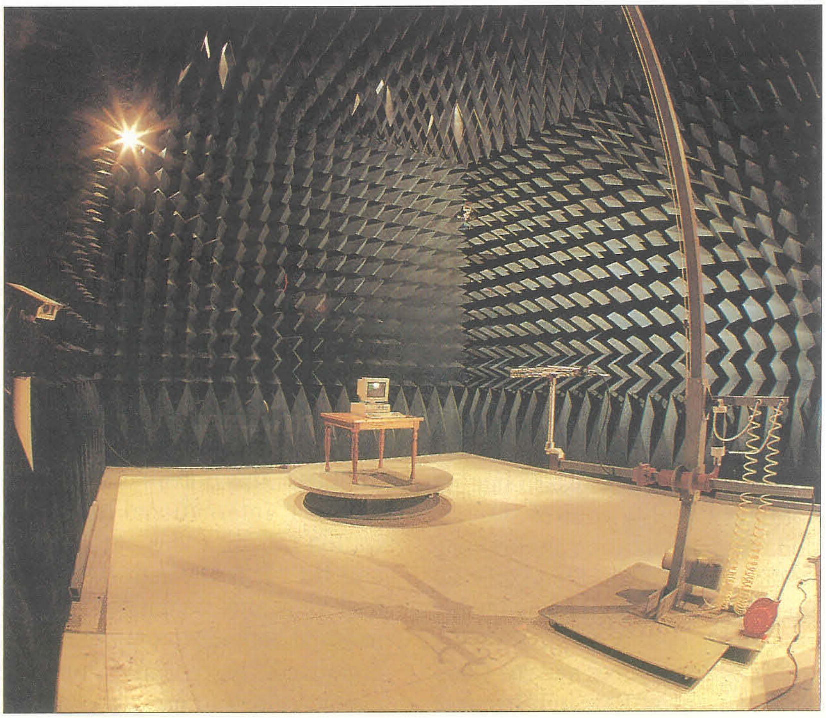
	Accredited laboratories				Calibrated instruments
	NSRL	CL	IHCL	Total	
1979	1	9	–	10	45 000
1982	1	24	–	25	94 000
1985	1	35	4	40	227 000
1988	1	51	64	116	350 000
1991	1	69	196	266	531 000
1992	1	75	211	287	568 000
1993	1	81	234	316	612 000

CONCLUSION

The needs of NCS had not been duly recognized in Korea until the 1960s when the nation began to proceed with the first and second Five-year Economic Development Plans. The turning point for the development of the NCS was the establishment of KRISS.

The Government has advocated the establishment and enlargement of the NCS since the creation of KRISS. With KRISS at the top of the system, the NCS has grown to include some 300 accredited laboratories.

There is, however, an urgent problem to be solved for the continuous development of the Korean NCS. The level of internationalization is so low that the calibration report is not duly recognized outside Korea. In this sense, the present NCS of Korea is not comprehensive enough to support industries. Therefore, the next step to be taken by the NCS is to explore and widen mutual recognition agreements with other countries. ■



Courtesy of KRISS

The electromagnetic anechoic chamber used for EMI/EMC measurement and control techniques at KRISS.

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Rep. of Korea

IAA
INDUSTRIAL ADVANCEMENT ADMINISTRATION
REPUBLIC OF KOREA

Located south of Seoul in Kwachon-city, the Industrial Advancement Administration (IAA) maintains the national metrology and calibration system for the Rep. of Korea. The IAA was created in 1973 through the unification of the Bureau of Standards and the Central Bureau of Metrology. Charged with co-ordinating national metrology activities and ensuring liaisons with international metrology and standardization bodies, the IAA is the official link between the Rep. of Korea and OIML.

THE IAA is a government agency working under the Ministry of Trade and Industry and its main functions include technical guidance, quality control, industrial standardization, quality inspection, and testing and analysis. In order to carry out these functions, the IAA headquarters is composed of five Bureaus, the National Industrial Technology Institute and nine provincial industrial test centers in its branch, all working to promote quality in industrial production and international competitiveness.

Following is a brief description of IAA' s composition.

Courtesy of IAA

The IAA plans quality control promotion events, education programs, and technical guidance for Korea's development in metrology and standardization.

Bureau of Planning and Management

This Bureau ensures the planning and coordination for the general industrial advancement in the Rep. of Korea and is responsible for managing the IAA budget. Administrative management and legal affairs are also handled in this Bureau.

Bureau of Technical Guidance

To improve the quality of industrial products and increase the level of technological competence in the Rep. of Korea, IAA dispatches experts to the manufacturing field. The Bureau of Technical Guidance selects factories in need of technical assistance, organizes guidance programs, and provides assessment and consultation services.

Bureau of Quality Control

The IAA pursues an active policy for promoting quality in industry by introducing and disseminating voluntary quality control systems and offering education and training through the Korean Standards Association. Research on new quality control models is carried out by technical committees and the Quality Management Research Institute which operate under the guidance of the Bureau of Quality Control.

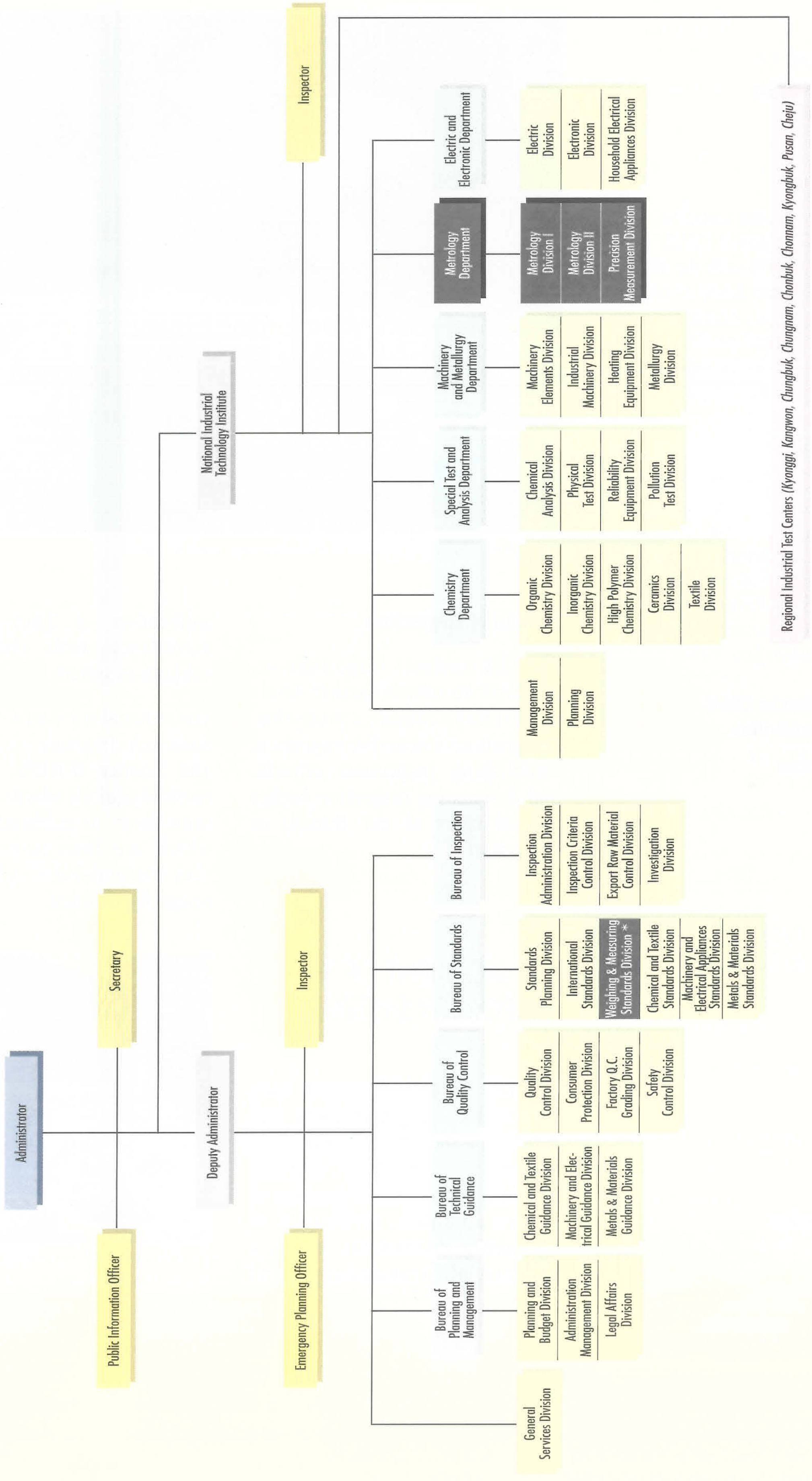
Bureau of Standards

The Bureau of Standards is responsible for establishing and managing the national industrial standards (KS), operating a national metrology standards system, and maintaining cooperation with international standards bodies. Korean Industrial Standards are introduced through State initiative to secure public health and safety and protect consumers or through an application process by interested parties.

Draft standards are reviewed by IAA and, if appropriate, are declared as national standards. Standards are reviewed every five years and close attention is paid to the establishment or revision of related international standards.

The Director of the Weighing and Measuring Division of the Bureau of Standards is in charge of coordinating OIML affairs and attending Conference and Committee meetings. This Bureau is also active in other international standardization organizations such as ISO and IEC. It is through the Industrial Standards Committee that the national technical committees are organized to permit domestic manufacturers to participate in the international standard building process.

IAA ORGANIZATION CHART



* OIML matters are handled in this department.

A brief note on
Rep. of Korea and OIML

Membership

The Rep. of Korea became the 44th adherent of OIML on 2 May 1978 with the IAA being the official body charged with the general coordination of national technical participation in OIML activities through close collaboration with KRISS.

CIML Member

Mr H. K. Oh, Director of Metrology Division, IAA Weighing Measuring Standards Division of the Bureau of Standards, was designated as the representative for the Rep. of Korea on the *Comité International de Métrologie Légale* in July 1994.

Participation in OIML technical activities

as P-Member
TC 1
TC 2
TC 3
TC 4
TC 5
TC 6
TC 7, TC 7/SC 1
TC 8, TC 8/SCs 1–6
TC 9
TC 10
TC 12
TC 13
TC 14
TC 15
TC 16
TC 17
TC 18

as O-Member
TC 7/SCs 3–5

Courtesy of IAA

The IAA headquarters located in Kwachon-city, south of Seoul.

Bureau of Inspection

The IAA conducts inspections on products to assess quality levels and to ensure consumer protection. Designation of items for inspection, establishing inspection criteria, and designating inspection bodies are all tasks of the Bureau of Inspection.

MANAGEMENT OF THE METROLOGY SYSTEM

The IAA is the government body responsible for maintaining and promoting the national metrology system and therefore oversees activities related to the granting of pattern approvals, verification of measuring instruments used for commercial transactions, and calibration of instruments in accordance with the national calibration system.

The national standards body, Korea Research Institute of Standards and Science (KRISS), maintains metrological standards and transmits them to calibration bodies which are then responsible for their transmission to industries and research institutes. ■

Courtesy of IAA

An IAA staff member working in the pressure laboratory.

Dem. P. Rep. of Korea

STATE COMMISSION OF SCIENCE AND TECHNOLOGY

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

Standardization, metrology and quality control throughout the Democratic People's Republic of Korea (DPRK) are under the supervision of the State Committee of Science and Technology (SCST) located in Pyongyang. Two main national institutes, the State Institute for Standardization (SIS) and the Central Institute for Quality and Metrology (CIQM), work to ensure the scientific and technical level of the DPRK with a view to contributing actively to national production and foreign trade.

STANDARDIZATION

The standardization process in the DPRK is coordinated by the Committee for Standardization which is the agency responsible for approving and implementing state standards (KPS). The process for standardization begins with the submission of a draft proposal by a given organization or enterprise for examination and deliberation by the Committee.

If acceptable, the proposal becomes a draft standard at the Consultative Meeting for Standardization with the participation of the experts concerned. The draft standard is then subject to consideration and approval by the Committee of Standardization during a council meeting. After approval, the standard is registered and publicized.

The Committee for Standardization promotes international cooperation and at present, the Vice-President of the Committee serves as the national representative in OIML. Relations also exist with more than 100 countries including the NAM countries and member bodies of ISO and IEC. The DPRK has been a member of ISO and IEC since 1963 and OIML since 1974.

METROLOGY

Metrology research and calibration services in the DPRK are organized in the Central Institute for Quality and Metrology (CIQM) which is under the supervision of the State Metrological Administrative Department. The CIQM's main duty is to develop and maintain national standards for the reproduction of measurement units.

The calibration centre of the CIQM ensures regular calibration of reference instruments and measuring instruments of high accuracy classes. The CIQM is also responsible for approving the manufacture of measuring instruments, supervising general metrology activities, and maintaining liaisons with international metrology bodies including OIML and BIPM. Following are the main areas of scientific research and calibration services carried out by the CIQM.

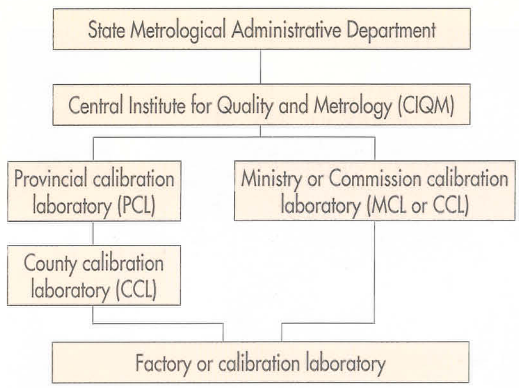
Length and angle measurements

This division is responsible for reproducing and maintaining units of length and angle and disseminating the values of quantities. Intercomparisons with BIPM have been carried out for many of the standards in this division.

Mass measurements

The mass measurement laboratory is responsible for carrying out research for the establishment of mass units. This laboratory contains a 1 kilogram mass prototype and the balance for the comparison of 1 kg mass standards, 1 kg secondary standards of stainless steel, and a series of first class balances in the measuring range from 1 g to 50 kg.

The metrology system of the DPRK



Force and hardness measurements

This section of the CIQM maintains standards and reference gauges in the field of force and hardness,

A brief note on
Dem. P. Rep. of Korea and OIML

Membership
The Dem. P. Rep. of Korea became the 41st adherent of OIML on 9 May 1974. The State Commission of Science and Technology is the official body designated to coordinate national activities in OIML and to occupy the national seat at Conference and Committee meetings.

CIML Member
Mr C. G. Ho, Vice-President of the Committee for Standardization, represents the DPRK on the *Comité International de Métrologie Légale* after being named CIML Member in January 1994.

Participation in OIML technical activities

as P-Member
TC 8/SCs 1, 2, 5
TC 9/SCs 1, 2
TC 10/SC 2
TC 11, TC 11/SCs 1, 3

as O-Member
TC 8/SCs 3, 4
TC 11/SC 2


Courtesy of SCST

One section of the liquid flowmeter used at the CIQM.

ensuring their accuracy and disseminating their units. Other activities of the force and hardness section include the verification of reference dynamometers (uncertainty of 0.1–0.5 %) and class I and II reference hardness samples and the calibration and testing of measuring instruments.

Heat and temperature measurements

As with the other sections, the heat and temperature laboratory develops new standards and reference measuring instruments. The main temperature calibration device used by this laboratory has an uncertainty of 0.1–0.003 °C in the range from – 182.962 °C to + 1064.43 °C.

Pressure Measurements

This division establishes standards in the range of vacuum, medium and high pressures and disseminates their units. The 500 MPa piston gauge is the standard for high pressure measurement. Research for raising the accuracy of reference pressure gauges used in micropressure high vacuum and super-high pressure is also carried out in this division.

Flow Measurements

This laboratory elaborates standards for liquid and gas flow and calibrates liquid flowmeters with a flowmeter (0–120 m^3/h) and reference volumeters (2000 l, 100 l and 10 l). The gas flowmeter laboratory is equipped with a flowmeter (0–700 m^3/h), reference bell-type flowmeter (150 l ± 0.01 %), and reference moisture flowmeter 100 l/min, 50 l/min, 10 l/min.

Physico-chemical Measurements

Standards and reference gauges of physical quantities including density, humidity, moisture, viscosity, and pH values are studied and maintained in the Physico-chemical Measurement division, which also calibrates related measuring instruments.

Electricity Measurements

The main activity of this division is to maintain standards for electric quantities and to calibrate measuring instruments in the field of electricity. Intercomparisons of standards maintained by this division have been carried out with the BIPM and standards institutes of other countries.

Optical and Time Frequency Measurements

The optical measurement division evaluates luminous intensity flux of various lamps, and evaluates the chromaticity of colored plates, fabrics, and paper by using a reference color plate and colorimeter. This division also maintains time and frequency units and disseminates them throughout the country.

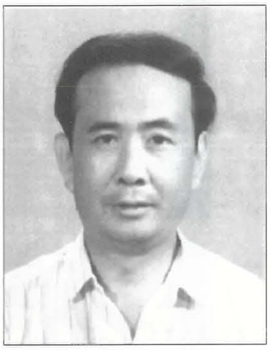
QUALITY CONTROL

The DPRK seeks to improve the quality of its products and to this end, inspection in each production process is carried out in the factories by the national quality surveillance organ. This body supervises production but factories and enterprises are encouraged to practice quality control at their initiative. ■

Research and development in China

THE STATUS AND PROSPECTS OF THE NATIONAL INSTITUTE OF METROLOGY

B. Pan, Director General of NIM, in collaboration with **L. Wang and X. Yang**



The National Institute of Metrology (NIM) in China is both the state level research and development center in metrological science and technology and the traceability service center in technical supervision and legal metrology. The NIM was established in 1965 and is affiliated with the China State Bureau of Technical Supervision (CSBTS).

GENERAL ASPECTS

Fundamental functions

THE NIM is charged with many tasks, the main one consisting of research and development associated with maintaining and improving national measurement standards for the realization and reproduction of SI units. The NIM carries out intercomparisons of values of quantities and disseminates units to ensure China's consistency with other countries.

The NIM also provides metrological assurance for the implementation of China's Law on Metrology, Law on Standardization, and Law on Quality Control and is charged by higher authorities to be responsible for laboratory accreditation of quality inspection and supervision of organizations. It is also responsible for product certification of homemade and imported measuring instruments.

Finally, the NIM's objectives include its role to serve as a precision measurement service for certain major scientific research and engineering projects and to carry out research and development of specific measuring instruments and measurement systems used in some mass-production processes.

NIM facilities

The NIM is situated in the north-eastern part of Beijing and covers an area of 100 000 m^2 with a building area of 60 000 m^2, of which 42 000 m^2 are used for research and development and 5 000 m^2 are temperature and humidity controlled. Moreover, 70 000 m^2 of residential buildings are provided for the staff.

The main buildings include: Dimension, Mechanics, Electromagnetics, Optics, RF and Microwave, Ionizing Radiation, Cryogenics, Force Measurement Hall, Machining Workshop and Administration.

The National Research Center for Certified Reference Materials (formerly the Chemistry Division of NIM) and the China Technical Supervision Information Center (formerly the Information Division of NIM) are also located on the NIM campus. A high-tech experimental base which will cover an area of 600 000 m^2 with a building area of 70 000 m^2 is planned to be established in a far suburb of Beijing.

Human resources

The NIM has an authorized staff of 1 522 persons, 947 of whom are professional technical personnel, including 21 research fellows (professors), 268 associate research fellows and senior engineers and 658 engineers and assistant engineers.

Approved by the Academy Degree Committee of the State Council, NIM has the right to confer the Master's degree. Since 1978, 78 postgraduates have enrolled in NIM.

Funding and assets

Being a public service research institute, NIM is mainly funded by the government. One third of the total funds come from the organizations who entrust NIM to conduct research, development, and measurement activities. Moreover, NIM has obtained international financial support and in 1994, NIM expects to receive a World Bank Loan of 5 million USD for the project: *Strengthening the Research Basis of Metrology and Improving the Capability of Measurement & Test services.*

The fixed assets of NIM amount to RMB 180 million yuan, in which 81.47 million yuan are allocated for measuring facilities.

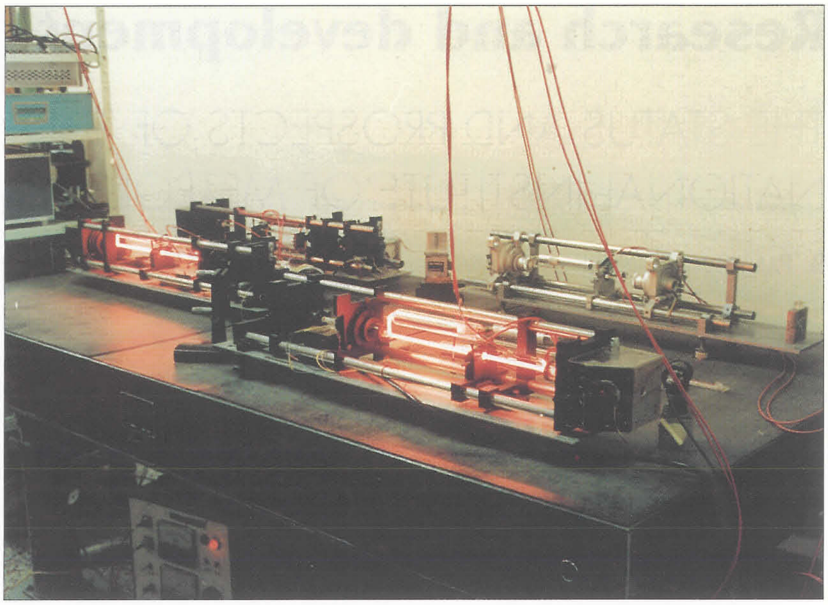


Fig. 1 The national standard of the meter.

Organizational structure

There are 11 professional divisions with 74 laboratories in NIM.

- *Length Division*

  Laser wavelength standard (Fig. 1), length, angle, gear and screw thread, micro-dimension, large dimension, photoelectric technology and precision measurement technology laboratories

- *Heat Division*

  Low, medium, and high temperatures, vacuum, thermocouple, pressure, flow and applied technology laboratories

- *Mechanics Division*

  Mass and weighing, volume, density, force, hardness, vibration, sensor, dynamic analysis, gravity and acoustics laboratories

- *Electromagnetics Division*

  National standards, resistance, impedance, DC/AC tensions, digital instruments, magnetic quantity, magnetic material and magnetic recording medium laboratories

- *RF and Microwave Division*

  RF-I, RF-II, microwave-I, microwave-II, IC measurement, petroleum water content and electromagnetic compatibility laboratories

- *Time and Frequency Division*

  Primary standards, atomic time scale, T/F dissemination, quartz crystal oscillator, calibration and measurement and optical frequency measurement laboratories

- *Optics Division*

  Photometry, radiometry and colorimetry, spectrophotometry and laser power and protection laboratories

- *Ionizing Radiation Division*

  Radionuclide activity, γ and low background spectrometry, dosimetry, high dosimetry, neutron measurement and application test laboratories

- *General Technique Division*

  Error and applied mathematics, performance test, environmental engineering and automation laboratories

- *Energy Saving Service Center*

  Test technique, supervision, information, and promotion laboratories, as well as the Secretariat of Energy Saving Association

- *Processing Technology Research Division*

  Mechanical design, technology application, electronic processing, mechanical processing, optical processing and development research laboratories

In addition, there are the following administrative departments: NIM Office; Planning Department; Scientific Research Department, Legal Metrology Department, Policy Study Office, Foreign Affairs Office, Human Source Department, Finance Department, Rear Service Center, Technology Development Center, Scientific Council and Institute Steering Committee.

PRESENT STATUS

Measurement standards

The NIM has established 110 national (primary) standards: 12 for dimensions, 13 for thermodynamic temperature, 21 for mechanics, 8 for electromagnetics, 15 for optics, 24 for RF and microwave, 2 for time and frequency (Fig. 2), and 15 for ionizing radiation. In addition, 17 secondary standards and 178 reference standards were realized.

Table 1 gives the uncertainties for the different national standards which reproduce the SI base units.

Metrological research

About 300 research projects have been completed in recent years, 70 of which have reached the international level. For example:

- I_2 and CH_4 stabilized He-Ne lasers used for realizing the definition of meter;
- Development of time and frequency standards as well as its dissemination via TV;
- Development of 20 MN standard force testing machine using hydraulic bearing and electro-hydraulic servo system;
- Establishment of laser Rockwell hardness and superficial Rockwell hardness standards;
- Reproduction of the new international temperature scale, its fixed point ovens and interpolation instruments;
- Development of digital power with voltage of 15–600 V and current of 0.1–10 A;
- Establishment of new photometry and luminous flux standards up to the end of 1993, 37 items of research projects have won the national awards (31 National Science and Technology Progress Awards, 1 National Natural Science Awards and 5 National Invention Awards).

Table 1 Uncertainties related to different national standards.

SI unit	Uncertainty
m	4×10^{-11}
s	3×10^{-13}
kg	2.3×10^{-9}
K	0.1 mK
V	8.4×10^{-9}
A	3×10^{-8}
cd	0.24 %

Development application

Under the guidance of the principle that science and technology should serve national economic development, NIM has solved many practical problems raised in engineering technology and mass-production process, including the following:

- Development of synthetic piston-parameters measuring instrument to ensure the processing quality of piston for the automobile industry;
- Development of automatic temperature monitoring and control system for beer sterilization and filling processes;
- Development of a water content analyzer to automatically detect high/low water content in crude oil for oil fields;
- Measurement of specific heat ratio of high Tc superconducting material;
- Measurement of single sheet magnetic properties;
- Measurement of the weight and center of gravity of the marine drilling platform in the South Sea oil field;
- Development of a computerized system to monitor and control thermodynamic parameters of vertical cement kilns.

Technical supervision

In order to establish a normal market order, protect consumer interests, and establish fair competition, it is necessary to set up a service of technical supervision process which includes laboratory accreditation and product certification. Entrusted by higher authorities, NIM has conducted the following:

- Metrological accreditation of 73 national supervision and inspection centers;

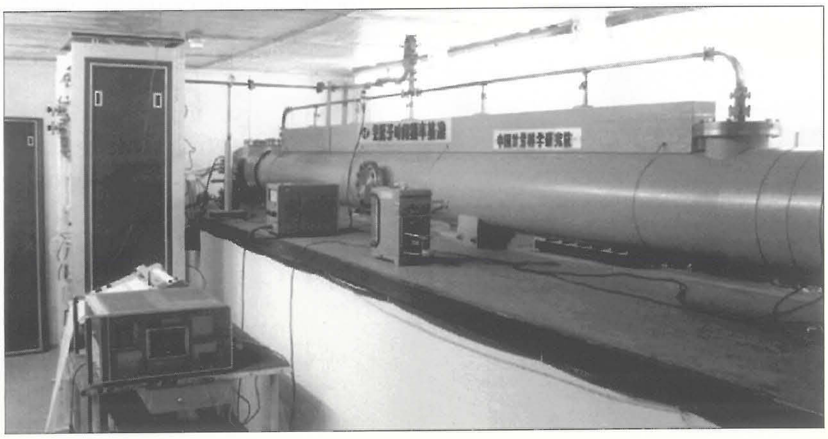


Fig. 2 The national standard of the second.

Courtesy of NIM

Fig. 3 The high-temperature platinium resistance thermometer and freezing points of aluminium, silver, and gold won the second prize of the National Scientific and Technical Advance Award.

- Agreement with the American Petroleum Institute to perform thread gauge certification of home-made petroleum pipe;
- Pattern approval of Sartorius electronic scales, Fluke digital multimeters and many other homemade measuring instruments.
- Arbitration in optical fiber quality for the telecommunica- tion departments and the manufacturing factories.

FUTURE PROSPECTS

Short-term objectives

The NIM has established a certain number of short-term objectives which are as follows:

- To keep pace with the international metrological development trends so as to reach the 1990's international level for main measurement standards by the end of this century;
- To provide technical support to the main fields of national economic development, e.g. energy source, new material, telecommunication, etc.;
- To make measurement and test technology better suit the reform of traditional industry and emerging high-tech enterprises;
- To perfect the legal metrological regulations and methods and offer better technical supports for the implementation of the ISO 9000 series.

The NIM also makes efforts to pursue new metrological research projects. Following are some topics addressed by NIM:

- Nanometer measuring technology;
- Holographic dynamic measurement of dimension;
- Position transducer application;
- Stability study of water triple point;
- Cryogenic radiometry for thermodynamic temperature;
- Performance test of various flowmeters;
- Investigation for the National standard for mass;
- Performance test of various electronic scales;
- Establishment of large volume standard;
- Establishment of high-speed A/D and D/A transfer standard;
- Development of high stability portable electric cell;
- Establishment of pulsed high magnetic field standard;
- Development of a new cesium beam time and frequency standard;
- Investigation of time dissemination by satellite;
- Development of infrared spectral radiation standard;
- On-line colorimetry;
- Noise measurement technology;
- Establishment of 60 CO standard field;
- Development of electron beam dosimetry standard;
- Research and application in uncertainty recommendations. ■

China

国家技术监督局

CHINA STATE BUREAU
OF
TECHNICAL SUPERVISION

The China State Bureau of Technical Supervision (SBTS) was formed in 1988 in Beijing with the unification of the former State Bureau of Metrology, the State Bureau of Standardization, and the Department of Quality Control, which was affiliated with the former State Commission for Economy. With the merger of these bodies, the SBTS assumed responsibility for standardization, metrology and the general technical supervision and guidance for quality control in China.

Technical supervision, implementation of state laws, formulation of metrology, standardization, and quality control legislation and promotion of legal measurement units. These are among the tasks performed by the SBTS with the combined efforts of a General Office, ten executive departments, a Committee for Science and Technology and more than 20 institutions under the direction of the Bureau.

ADMINISTRATION, POLICY AND PLANNING

The general office of the SBTS and the departments of General Planning, Policies and Legislations, and Labour and Personnel are responsible for general matters concerning the administrative operation of the SBST and the formulation of technical programs and legislation for China.

The department of General Planning studies the budgets destined for various programs and plans and guides the construction of the national technical supervision system. Proposals and problems concerning the system are analyzed in this section, whereas actual preparation for technical legislation and the elaboration of new policies take place within the department of Policies and Legislation. Personnel matters concerning the 280 staff members of SBTS are handled by the department of Labour and Personnel.

SCIENTIFIC PROGRAMMING

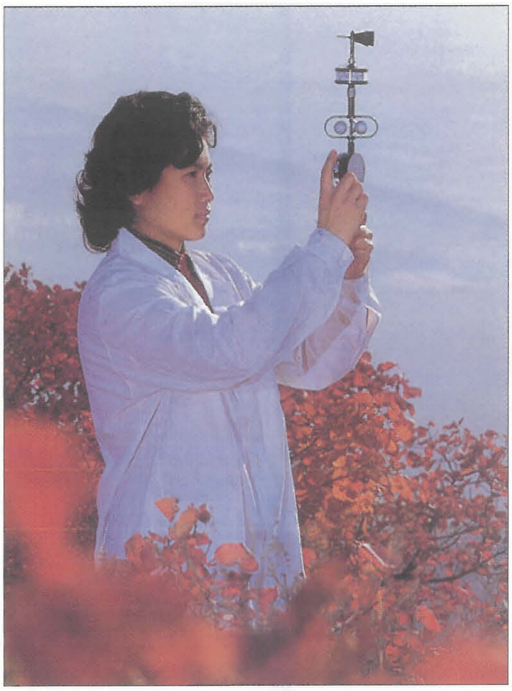
The organization and implementation of the Bureau's scientific projects are the responsibilities of the department of Scientific Programme. This department develops rules and regulations for the pursuit of scientific work within the Bureau and is charged with carrying out work assigned by the Committee of Science and Technology.

PROMOTING TECHNICAL ADVANCES

Concentrated efforts are made by the SBTS to inform and educate the general public as to the developments made in standardization, metrology, and quality assurance. The department of Public Information and Education maintains close links with the press in order to promote domestic and international scientific and technical advancement. For example, following the recent publication of OIML R 76, a televised press conference was organized to inform the public of the objectives of this Recommendation. The organization of educational programs for persons occupying posts in the technical supervision bodies and the preparation of textbooks are also functions of this department.

INTERNATIONAL LIAISONS

As the key liaison between the national technical activities of China and the work performed by various international bodies, the department of International Cooperation has the important role of maintaining a healthy exchange of information with regional and international standardization and metrology bodies including OIML, ISO, IEC, and APMP.



Courtesy of SBTS

Monitoring air pollution in China: the first step of the measurement procedure of sampling from the atmosphere is shown.

This department guides the implementation of projects based on bilateral agreements, coordinates the technical participation of national bodies in international activities and sponsors international conferences, and technical and personnel exchanges with other countries.

China has been an active member of OIML since 1985 and is represented by the Director General of SBTS, Mr C. Li, at OIML Conference and Committee meetings.

STANDARDIZATION

The general development of standardization in China, including the formulation of policies, the preparation and revision of national standards, and the implementation of international standards, is the responsibility of the department of Standardization. Relations with international standards organizations are maintained by this department which also manages the national technical committees for standardization. An article on ISO 9000 in China will be published in the OIML Bulletin in January 1995.

METROLOGY

The department of Metrology in the SBTS is occupied with the implementation of measurement laws and the promotion of the national legal measurement units. It also organizes the national calibration system, prepares regulations for national verification procedures, and handles legal metrology and metrological accreditation. This department addresses disputes concerning measurements and coordinates metrology activities between the various regions and departments of China.

These activities are carried out through a complex infrastructure which consists of the following: Division of Legal Metrology; Division of Adminstration; Office of Measurement Unit System; Division of Industrial Measurement; and Division of Measurement System, the latter being in charge of the traceability system in China. The secretariat for OIML matters is also located in the Division of Measurement System and is charged with handling activities associated with China's participation as an issuing authority for OIML certificates and the coordination of national activities for developing OIML International Recommendations and Documents.

CONFORMITY ASSESSMENT

The activities of conformity assessment in China have undergone rapid development in recent years and one result of the restructuring process was the establishment of an Office for Conformity Assessment in 1992. The main responsibilities of this office are the registration of enterprises, accreditation of laboratories and product certification. More information on this development will be published in an upcoming issue of the OIML Bulletin.

A brief note on
China and OIML

Membership

China joined OIML as its 52nd adherent on 25 April 1985. The national body charged with OIML affairs is the State Bureau of Technical Supervision (SBTS) with the majority of relations between OIML and China passing through the SBTS Department of International Cooperation.

CIML Member

Mr C. Li, Director General, State Bureau of Technical Supervision, became the CIML Member for China in April 1993.

Participation in OIML technical activities

as P-Member

TC 2
TC 3, TC 3/SCs 1–4
TC 6
TC 8, TC 8/SCs 1–5, 7, 8
TC 9, TC 9/SCs 1–4
TC 13
TC 17, TC 17/SCs 1–6

as O-Member

TC 1
TC 4
TC 5
TC 7, TC 7/SCs 1, 3–5
TC 8/SC 6
TC 10, TC 10/SCs 1–6
TC 12
TC 14
TC 15
TC 16, TC 16/SCs 1–4
TC 18, TC 18/SCs 1–5

The SBTS is the Chinese issuing authority for OIML certificates delivered for nonautomatic weighing instruments.

QUALITY FOR PRODUCTION PROCESSES

Within the SBTS, two departments are responsible for all matters connected with quality: the departments of Quality Inspection and Quality Control. The Quality Inspection department coordinates inspection activities associated with product quality in the processes of production and marketing. This includes the organization of on-site checking and the certification of products through the Testing Center Management and Certification and General Affairs divisions.

The tenth executive department of the SBTS is the Quality Control department which is charged with the general guidance for quality control throughout China. Tasks include collecting, processing and analyzing information regarding product quality and the public dissemination of this information. Close ties with enterprises are maintained to promote new methods for quality control and to encourage enterprises to initiate their own quality control systems based on the guidance provided by this department.

CONSULTATION

The Committee of Science and Technology provides consultation on programs, plans, and research and development projects intended to increase China's scientific and technical level. This Committee reports directly to the Director General of the SBTS and participates in the examination of important research results and the assessment of technical titles for scientists and engineers within the Bureau. The Committee, which serves as an important decision-making body of the SBTS, is located in the department of Scientific Programme. ■

CIM 中國計量學院

Founded in 1985 in Hangzhou (900 km south of Beijing, near Shanghai) the China Institute of Metrology (CIM) is the country's only institution for training senior engineers, technicians, and managers in the field of metrology. Since few countries have established institutions for this specific purpose, the CIM occupies an important place in the area of higher education in metrology.

The various programs of the CIM, including specializations in geometric, thermotechnical, mechanical, electronic, optical, or electrogmagnetic measurements, attract students from all regions of China. In April 1994, the student body numbered at 1800, with 600 students enrolled in classes through correspondence. Exchanges are also organized with metrology schools in other countries such as the *Ecole Supérieure des Mines* in Douai, France. There are a total of 110 professors, the majority being associate professors.

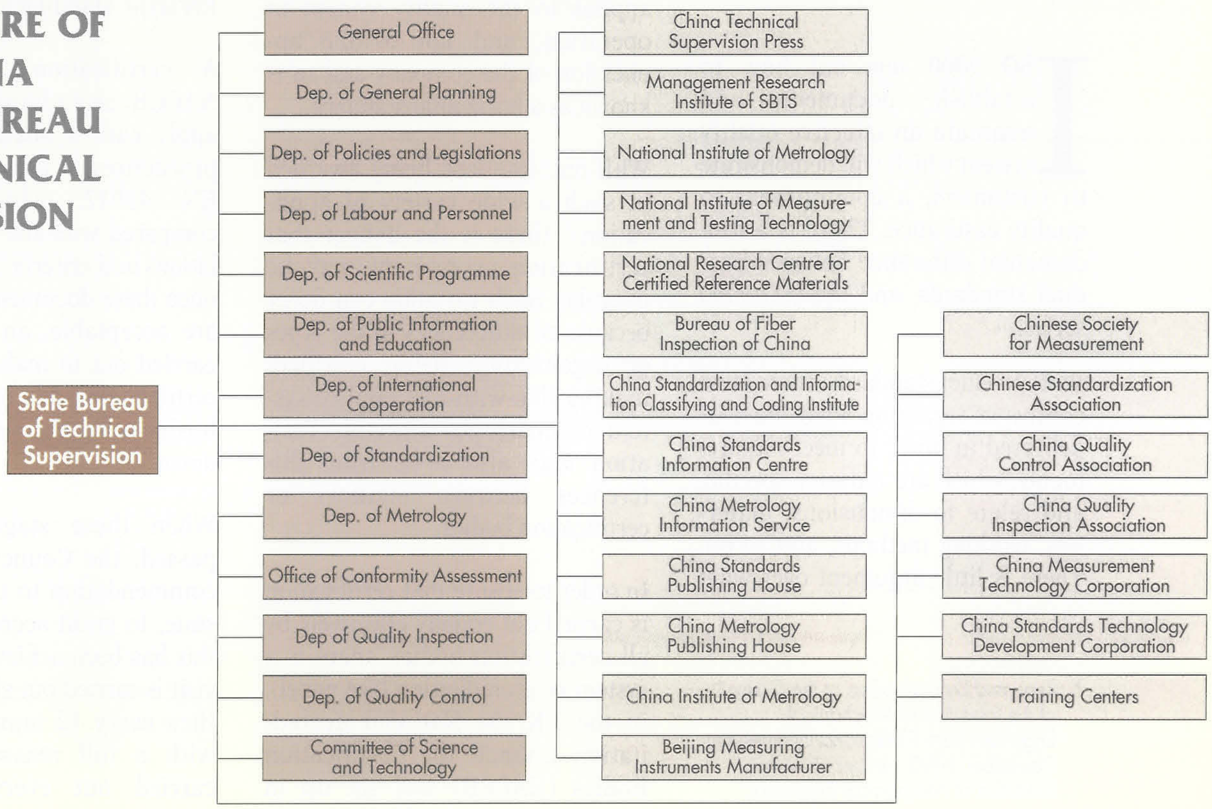
The CIM operates as a four-year university with two years devoted to general studies and two years spent in the field of specialization. Generally, 60–70 % of the students completing the program are placed in enterprises afterwards.

Students can take advantage of numerous facilities located on the CIM campus, including laboratories, a computer center, library, language center, lecture hall, and sports center. On-campus dormitories are also provided for Chinese and foreign students.

Contact information:

China Institute of Metrology, Jiao Gong San Lu, Xihu Qu, Hangzhou 310034, China,
Tel: 86 571 806 48 59 Fax: 86 571 806 48 59

STRUCTURE OF THE CHINA STATE BUREAU OF TECHNICAL SUPERVISION



ISO 9000 in Europe

KEEPING STANDARDS TO A COMMON STANDARD*

A. SHARP, European Business Management School, University College of Swansea, United Kingdom

In order to secure contracts, an increasing number of companies are having to gain ISO 9000 certification. However, simply gaining certification does not prevent a company from being excluded from a list of possible suppliers for European contracts.

ISO 9000 sets out how to establish, document, and maintain an effective quality system which will demonstrate to customers, a commitment to quality assurance. There is a fundamental difference between product standards, and the ISO 9000 series.

With product standards, there is no confusion regarding what must be delivered in order to meet requirements, which are industry specific, and relate to dimensions, materials, working methods, and so on. There is little argument over what exactly has to be done in order to meet requirements so people are confident that all certified products bearing that standard number, meet the same criteria irrespective of the company applying, or the certification body used.

ISO 9000 is not industry specific. Although its predecessor, BS 5750, was originally written for manufacturing applications, and so includes such terms as 'product' and 'material', it can be applied to any organisation, whether manufacturing or service. The standard applies to the quality system in operation, and not to the application of the company and so is known as a horizontal standard.

With one standard being awarded in such a wide variety of applications, there is the danger that certification assessment may be irregular. Such variation can occur because of differences in the types of organisation being certified, making like-with-like quality system comparisons difficult. Variation may also arise from differences between auditors or certification bodies.

In order to ensure that certification is carried out equally effectively by all certification bodies, there is a system of accreditation (see panel); in the UK the National Accreditation Council for Certification Bodies (NACCB) was set up in June 1985, under the charter of the British Standards Institution, to assist the Trade and Industry secretary in granting permission to carry out certification assessments.

The NACCB consists of representatives from a variety of groups that have interests in either quality system or product certification. Quality system certification bodies, must meet the requirements of EN 45012 – General criteria for certification bodies operating quality system certification. The standard is a European one, hence the EN term, standing for Euro-Norm.

A certification body seeking NACCB accreditation must first apply with a documented set of procedures, as required by EN 45012, which are then compared with the Council's regulations and criteria. As in ISO 9000, once these documented procedures are acceptable, an assessment is carried out to make sure that the certification body is conducting its business in the way it has laid down.

When these stages have been passed, the Council makes a recommendation to the secretary of state, to grant accreditation. Once this has been achieved, a follow-up visit is carried out after six months, then every 12 months thereafter, with a full reassessment being carried out every four years.

* Reprinted by permission of the Council of the Institution of Mechanical Engineers from *Professional Engineering*, December 1993, on behalf of the Institution of Mechanical Engineers.

In addition to meeting the requirements of EN 45012, the accredited certification company must also abide by the regulations of the NACCB.

From this it seems a logical assumption to say that as there are equivalents of the NACCB in all EC and EFTA countries, we should be confident, not only that all certifications in our own countries are being carried out to the same standard, but also those in all other European countries. However, this is not the case.

EN 45012 is just as capable of differences of interpretation as ISO 9000. It consists of 19 terms relating to all aspects of a certification body's operations; term 7 for example refers to certification personnel, and states that: 'The personnel of the certification body shall be competent for the functions they undertake' [1], before covering a list of records that must be kept on their relevant qualifications and experience, and instructions regarding their duties and responsibilities. The whole of this term uses up 100 words of text, so there is little detail and plenty of scope for interpretation; this has been a stumbling block for Europe-wide accreditation.

In the UK a scheme was set up by the Institute of Quality Assurance (IQA) with financial assistance from the Department of Trade and Industry (DTI), to register assessors. A lead assessor would have to be covered by the IQA scheme, known as the Assessor Registration Board, in order to meet the requirements of EN 45012. This is how term 7 has been interpreted in the UK, but how many other interpretations of this, and the other 18 terms are possible?

Accreditation in all the European countries is based upon the structure of EN 45012, but there was little coordination between the accreditation bodies is setting up their separate schemes, and this has brought about unnecessary problems in recognising certifications in neighbouring European countries.

In November 1992 the steering committee of the European Accreditation Council (EAC) met to discuss the problems brought about the inconsistent accreditation schemes operated by the 17 members of the EAC. The EAC is made up of the national accreditation bodies of 17 of the EC and EFTA countries. The committee announced [2] that the EAC would start a process of mutual assessment of each other's accreditation processes to begin the movement towards a common European accreditation scheme. More important was the announcement that guidelines would be published on the meaning of quality system certification and guidance on the terms of EN 45012.

The European Committee for Quality System Assessment (EQS) published its Recommendations for Third-Party Auditing and Certification of Quality Systems in June 1992 [3] and in its memorandum of understanding [4] states that it '*...will support all common actions and take the necessary initiatives to enable quality system certificates to be internationally recognised. This includes cooperation with the EAC*'. The EQS document is based on the intentions and regulations included in EN 45012, and ISO 10011, which covers auditing procedures. The working group has extended the contents of these standards, with its own interpretations of their meanings.

At present this is purely an advisory document for those certification bodies that need assistance; so where do we stand at the moment? Companies holding certifications from NACCB accredited bodies have little to worry about.

The NACCB has been in operation for longer than its counterparts, and has a great deal more experience on the subject as a result. This, along with the fact that there are more ISO 9000 certificate holders in the UK than in the rest of Europe combined, makes it unlikely that UK companies certified by bodies accredited by the NACCB, will be adversely affected at present or by future developments.

There are a few unaccredited bodies in the UK, but they account for relatively few certifications, and most are in the process of seeking accreditation. The problem is that a certification body needs evidence from previous audits it has carried out for the NACCB to view before it will accredit the body. With the growing pressure to become certified by accredited bodies, it is becoming very difficult for new bodies to break into the certification market.

The clients of an accredited certification body are able to display the accreditation symbol, the tick and crown, alongside the certification mark awarded by the certification body. However, there are some instances where this is not possible, as a certification body is accredited as being competent to audit individual industry types. Even it is accredited, if it has not been accredited to certify your industry sector, you will not be able to display the tick and crown alongside its certification mark.

If you ask for ISO 9000 certification from your suppliers, and some of these suppliers are from other EC countries, you will need to study their certification details.

Accreditation activity and organisation across Europe is very inconsistent, so there are no hard and fast rules as to what to do.

Preferably the suppliers should have been certified by bodies that are accredited in their own countries, although this may be difficult in some countries where the accreditation schemes are still in their infancy. Some people feel that certifications from abroad are of lower value due to the accreditation problems. I have found no evidence as yet to back up their claims, but one needs to be more careful by checking up on the details of certifications, and not assume that they are all identical.

Irregular accreditation practices bring about problems for trade not only within the EC, but also between the EC and US. There is a growing awareness of the problem, and schemes are being discussed to address it; the next stage is to get one recognised formally by the national accreditation bodies. With better cooperation and coordination of activities, there is no reason why this should not be possible.

Until this happens, ask a few questions of your potential certification body or supplier to be sure, before signing any contracts. ■

REFERENCES

[1] EN 45012. General criteria for certification bodies operating quality system certification.

[2] Press statement, 20 November 1992. EAC.

[3] European Committee for Quality System Assessment and Certification (EQS). Recommendations for Third-Party Auditing and Certification of Quality Systems. First Edition, June 1992.

[4] Memorandum of understanding of the EQS, October 1992.

Certification or accreditation?

The terms **certification** and **accreditation** are often confused. They are very different though, and the distinction between them should be fully understood. When an organisation wishes to apply ISO 9000 and gain a certificate of compliance, it enrols a certification company to assess its quality system this is called certification. In order to be sure that all certification bodies are equally stringent in their certification practices, they are assessed by an independent government appointed body. This is known as accreditation. So it may be summed-up thus:

You get certified to ISO 9000 by the certification body, and they get accredited to EN 45012.

Construction under way

LAYING THE FOUNDATION STONE OF NEW NORWEGIAN METROLOGY LABORATORIES

IN a ceremony held in Oslo, 20 May 1994, the stone was laid for the foundation of the new laboratories of the Norwegian Metrology Service by Mr Jens Stoltenberg, Minister of Industry. The staff of the Norwegian Measurement Service and representatives of Norwegian scientific and industrial bodies and administrations were present for the ceremony.

The international metrology community (the Metre Convention and OIML) was represented by the Presidents of both International Committees and the Bureaux Directors. The regional metrology community was represented by EUROMET and WELMEC and members of NORMET and NORJUST.

The new laboratories will be located approximately 20 km northwest of Oslo and will be built partly into a hillside in order to ensure perfect environmental conditions. The staff offices will be built in open air in direct contact with the laboratories.

K. Birkeland, Director General of the Norwegian Metrology Service and President of CIML, admires the stele presented for the new metrology laboratories in Norway.

Norwegian Minister of Industry, J. Stoltenberg and K. Birkeland.

Following the address by Mr Stoltenberg, Prof D. Kind, President of the *Comité International des Poids et Mesures*, inaugurated a stone stele incorporated with smaller stones from the members of EUROMET to symbolize international cooperation in metrology. Each stone, engraved with the acronym of the national metrology institute, is representative of the donator country: for example, the Greek stone is a marble taken from the quarry from which the Acropolis was built, and the French stone is a rare type found only in two places in the world: France and Norway.

Dr P. Clapham, Director of NPL, United Kingdom, presented a cutting from an apple tree claimed to be that under which Isaac Newton discovered the effects of gravity. The cutting will be planted in the garden of the Norwegian Metrology Service.

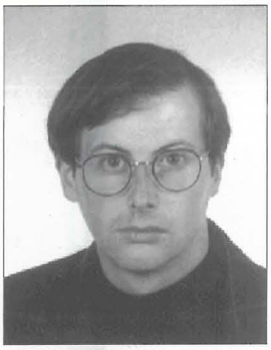
The laboratories will be finished and inaugurated in 1996. Presentations concerning their construction and use were given by the architects and the directors of the three branches of the Norwegian Metrology Service: measurement standards, legal metrology, and the accreditation service.

The Directors of the *Bureau International des Poids et Mesures*, T. J. Quinn, and *Bureau International de Métrologie Légale*, B. Athané, delivered brief addresses focusing on international metrology co-operation, in which Norway has always played a significant role. ■

Information technology

ADVANCES MADE IN THE COMPUTERIZATION OF BIML

E. WEBER, Engineer, BIML



In recent years, the tasks of BIML have increased considerably due to the multiplication of several regulatory and informative documents that are submitted to CIML Members. OIML finds itself with a considerable amount of work to do including: the drafting of International Recommendations and Documents; the definition of OIML presentation and strategy documents; the implementation of new structures for technical work; the development of the *OIML Certificate System for Measuring Instruments;* and the production of the OIML Bulletin.

One of the many roles of BIML consists of processing as rapidly as possible the mass of information collected. Therefore, it is essential for OIML that the limited staff of the BIML be able to face an increasing workload as efficiently as possible through significant automatization of the administrative processes for an optimal distribution of information to OIML Member States.

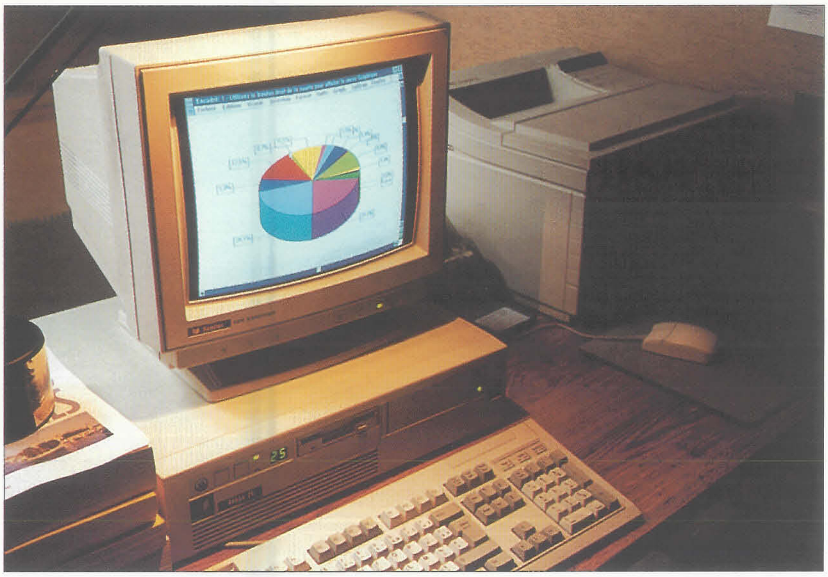
Consequently, BIML has embarked on a course since 1988 to equip the office with a certain number of tools including modern personal computers, software, laser printers, and a scanner. Several new programs and services have been made available to the BIML staff to benefit its productivity. Some of the new possibilities resulting from this modernization include the following:

- the systematic electronic recording of the definitive versions of International Recommendations and Documents in a specific format* on 3 1/2" floppy disks for the disposition of Member States and secretariats of technical committees and subcommittees, as well as the transmission of text to the printer to avoid recomposition;
- use of publication assistance software for the preparation of the OIML Bulletin;
- managing subscription information pertaining to the OIML Bulletin;
- recording OIML certificates;
- organization of the composition of OIML technical committees and subcommittees;
- computerization of the documentation center;
- scanning complex figures, diagrams, and lengthy texts to avoid recomposition (if the original versions are of sufficient quality);
- establishing more efficient mailing procedures through the use of form letters and automatization of the data retrieval process;
- computerization of administrative tasks (e.g. salaries) – a study is under way for the complete computerization of the accounting functions.

The advances made in OIML's activities imply the need to update the procedures used for realizing such development. The BIML has responded to this need by modernizing its computer resources to process to the ever-growing volume of information.

However, it is important to note that the investments made to render the BIML more effective can only be fully exploited through the efforts of the Member States.

* Data-processing software "Wordperfect 5.1" (under DOS) which comprises essential functions of array and equations editor for the presentation of technical documents and which has the advantages of being accessible to most modest systems of microprocessors due to the configuration required for its use, and being listed in other software as a conversion format because of its large commercial distribution.



Recent investments in computer equipment at OIML's headquarters lead to new possibilities for productivity and efficiency of the BIML staff.

Certain OIML Member States including Australia, France, Germany, Netherlands, United Kingdom, and United States of America already use floppy disks for exchanging documents with the Bureau, thereby avoiding duplication of secretarial work and lowering the risk of errors. This use of floppy disks, preferably after conversion to the abovementioned format, results in a major acceleration of BIML's editorial work for drafts at the approval stage and articles destined for publication in the OIML Bulletin.

It would also be appropriate to make use of a complete and direct access to information concerning the OIML Certificate System by means of a database accessible by telephone. This increase in the availability of information would contribute to the success of the System. An adaptation of the current database would make this option possible. To take advantage of this database, it will only be necessary for interested parties to possess a computer supplied with a fax or a modem of terminal simulation for connection to the telephone mains. This plan is expected to be realized in the near future and preferably, before the number of certificates increases significantly.

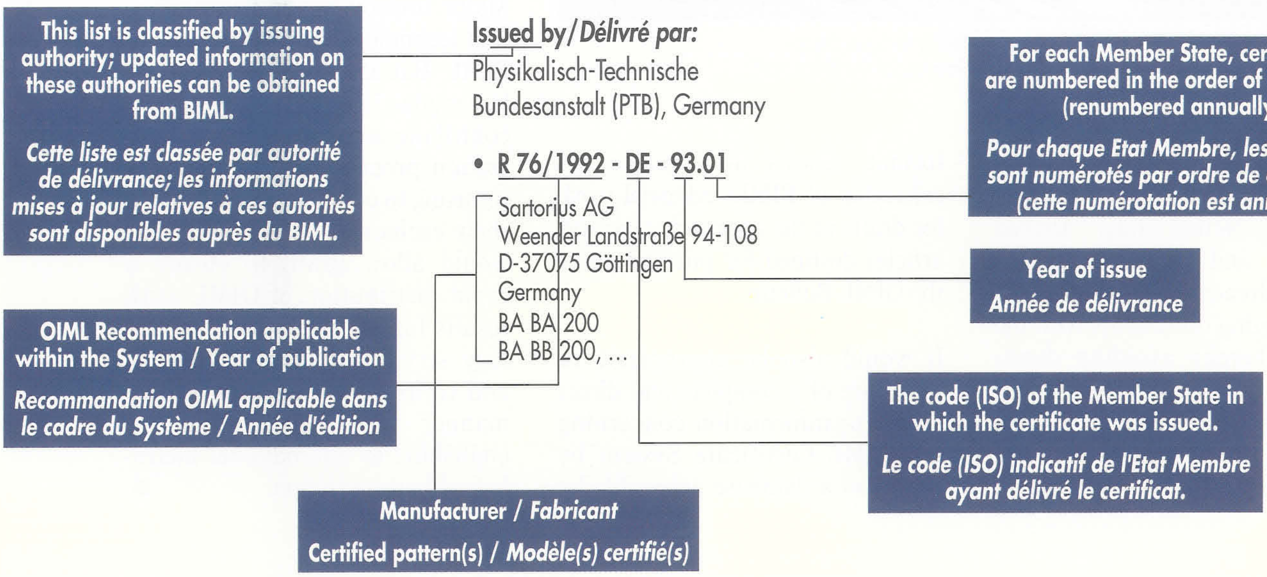
Major improvements in information technology have been made at BIML. But additional progress can be made if OIML secretariats contribute actively to the modernization process by systematically resorting to computerized means in their exchanges with BIML. This would allow BIML to ensure a rapid distribution of OIML work results for use by national metrology services in their regulatory and verification activities; in this manner they can continue to contribute to international metrological harmonization. ■

OIML CERTIFICATES registered from June 1994 to August 1994

CERTIFICATS OIML enregistrés de juin 1994 à août 1994

HOW TO USE THE LIST OF OIML CERTIFICATES

COMMENT UTILISER LA LISTE DES CERTIFICATS OIML



INSTRUMENT CATEGORY Load cells R 60 (1991), Annex A (1993)

CATÉGORIE D'INSTRUMENT Cellules de pesée R 60 (1991), Annexe (1993)

Issued by/*Délivré par:*
National Weights and Measures Laboratory (NWML),
United Kingdom

- **R 60/1991-GB-94.01**
  GEC Avery Ltd
  Foundry Lane, Smethwick, Warley
  West Midlands, B66 2LP, Great Britain
  Load Cell Model No Avery 8708
  (Class C)

- **R 60/1991-GB-94.02**
  GEC Avery Ltd
  Foundry Lane, Smethwick, Warley
  West Midlands, B66 2LP, Great Britain
  Load Cell Model No Avery T110
  (Class C)

- **R 60/1991-GB-94.03**
  GEC Avery Ltd
  Foundry Lane, Smethwick, Warley
  West Midlands, B66 2LP, Great Britain
  Digital Load Cell Model No Avery T301
  (Class C)

- **R 60/1991-GB-94.04**
  Weigh-Tronix
  PO Box 1501, 2320 Airport Boulevard,
  Santa Rosa, CA 95402-1501, USA
  Digital Load Cell Model Quartzell
  MK-100 (Class C)

- **R 60/1991-GB-94.05**
  Sensortronics Inc.
  677 Arrow Grand Circle
  Covina ,CA 91722, USA
  Load Cell Model No Sensortronics
  65023C (Class C)

- **R 60/1991-GB-94.06**
  Sensortronics Inc.
  677 Arrow Grand Circle
  Covina CA 91722, USA
  Load Cell Model No Sensortronics 65088C (Class C)

INSTRUMENT CATEGORY **Nonautomatic weighing instruments R 76-1 (1992), R 76-2 (1993)**

CATÉGORIE D'INSTRUMENT **Instruments de pesage à fonctionnement non automatique R 76-1 (1992), R 76-2 (1993)**

Issued by/*Délivré par:*
Physikalisch-Technische Bundesanstalt (PTB), Germany

- **R 76/1992-DE-94.04**
  Sartorius AG
  Weender Landstraße 94-108
  D 37075 Göttingen, Germany
  MA BA 200 and MA BB 200 (Class II)

Erratum:
OIML Certificate "R 76/1992-FR-94.01" was registered for Class III and not for Class II as printed in the OIML Bulletin, Vol. XXXV, No. 3, July 1994.

Issued by/*Délivré par:*
NMi IJkwesen B.V.
The Netherlands

- **R 76/1992-NL-94.02**
  CAS Corporation
  CAS Building #440.1 Sungnae-Dong.
  Kangdong-Ku, Seoul, Korea
  AP (Class III)

- **R 76/1992-NL-94.03**
  Teraoka Seiko Co., Ltd.
  3-13 Ohsaki, 2-Chome
  Shinagawa-ku, Tokyo 141
  Japan
  SM70 (Class III)

- **R 76/1992-NL-94.04**
  Teraoka Weigh-System PTE Ltd.
  3A Tvas Avenue 8, Singapore 2263
  Singapore
  DS-650 (Class III)

- **R 76/1992-NL-94.05**
  Ohaus Corporation
  29, Hanover Road
  Florham Park, NJ 07932, USA
  GT...E (Class II)

Special report

OIML CERTIFICATE SYSTEM: PRESENT STATUS AND DEVELOPMENT

The *OIML Certificate System for Measuring Instruments* was made operational in 1991 with the first certificate being issued towards the end of 1992. Since then, this OIML certification activity has expanded significantly, as shown by the report presented to the International Committee of Legal Metrology at its 29th meeting (October 1994), which is summarized below.

The perspectives for the development of the OIML System aim at furthering and accelerating its implementation with regard to the growing demand for international harmonization of metrological requirements and testing procedures for the measuring instruments concerned, reducing the multiplicity of national metrology controls, and eliminating technical barriers to the trade of such instruments.

INSTRUMENTS COVERED BY THE SYSTEM

The following categories of instruments, with the relevant OIML Recommendations, are presently covered by OIML certification: load cells (R 60), nonautomatic weighing instruments (R 76), barometers (R 97), high-precision line measures of length (R 98), pressure balances (as soon as R 110 is issued), and certain types of chromatographs for measuring pollutants (R 112 and R 113).

A number of new or revised Recommendations will soon be published, thus introducing additional categories of measuring instruments into the System such as direct mass flow measuring systems, fuel dispensers for motor vehicles, diaphragm gas meters, discontinuous totalizing automatic weighing instruments, sound calibrators, spectrometers for measurement of metal pollutants in water, and clinical electrical thermometers for continuous measurement or with maximum device.

New OIML Recommendations that are presently being developed by OIML technical committees and subcommittees will appear within one to two years. The application of the System is therefore expected to expand significantly to cover categories including automatic weighing instruments, static direct mass measurements of quantities of liquids, pressure gauges, and measuring instruments for acoustics and vibration, among others.

CERTIFICATES ISSUED

More than 40 OIML certificates have been issued at present (compared to 13 at this time last year). The majority of them apply to nonautomatic weighing instruments, with the remainder applying to load cells.

Although some 16 OIML Member States have established national authorities for issuing OIML certificates, only a few of them (France, Germany, Netherlands, P. R. of China, and the United Kingdom) have produced such certificates. However, the geographical distribution of the applicants is far wider, covering manufacturers from Japan, R. of Korea, Singapore, Spain, Switzerland, and the United States of America in addition to those from the countries having issued certificates.

INFORMATION ON OIML CERTIFICATION

OIML certificates and their accompanying test reports are intended to be used, on a voluntary basis, by national legal metrology authorities for accelerating the examination and testing of newly imported measuring instruments for which a national pattern approval is required. OIML certificates may also be used by manufacturers to demonstrate the compliance of their products with OIML specifications as proof of a certain degree of quality and reliability. Information on all certificates that are issued must therefore be available for all parties concerned.

To this end, BIML regularly sends a copy of all certificates to the national legal metrology services of OIML Member States and Corresponding Member Countries. In addition, a description of certificates and other relevant information is published in the OIML Bulletin. BIML has begun to establish a data base for OIML certificates and will therefore be able to answer the questions of all those concerned by OIML certification.

FUTURE DEVELOPMENTS

The OIML System is not developing independently of other international or regional certification activities. Developments in the field of conformity assessment, testing, certification, accreditation and related activities of ISO, IEC, ILAC, UN-ECE, EAL, WELMEC, CEN-CENELEC and other bodies have been followed and studied by BIML, with any relevant information being distributed to OIML Members. In turn, OIML certification has been the subject of presentations made by CIML Members and BIML staff at various international and regional forums held in 1993–1994.

As already explained, the main objective of OIML certificates and accompanying test reports is their acceptance by national legal metrology authorities as a basis for the issuing of pattern approvals.

At present, only a limited number of OIML Members have expressed their willingness to accept OIML certificates systematically. Work performed by OIML in this field must therefore focus on establishing a climate of mutual confidence between OIML Members which will permit a broad recognition and implementation of OIML certificates.

The establishment of an OIML technical advisory group is planned in order to make progress with this vital matter and to study questions such as the following:

- possible extension of the System application to include individual instruments (at present, the System applies only to patterns of instruments);
- establishment of accreditation procedures;
- organization of intercomparisons aimed at the harmonization of test procedures for type evaluation;
- permitting bi- or multi-lateral recognition agreements between Member States;

- elaboration of rules for a juridical protection of OIML certificates;
- application of a single certificate to a family of instruments; and
- coordination between OIML certification and similar activities developed by other international and regional bodies.

A seminar on OIML certification has been proposed for 1995 and this would certainly be an excellent opportunity for all those concerned by this activity – issuing authorities, test laboratories, legal metrology services, and manufacturers – to exchange views on the future developments of the OIML Certificate System. ■

A. V.

Rapport spécial

SYSTEME DE CERTIFICATS OIML: SITUATION ACTUELLE ET EVOLUTION

Le *Système de Certificats OIML pour les Instruments de Mesure* est devenu opérationnel en 1991 et le premier certificat a été délivré à la fin de 1992. Depuis, l'activité OIML de certification s'est développée de manière importante, comme le montre le rapport présenté à la 29e réunion du Comité International de Métrologie Légale (octobre 1994), dont un résumé est donné ci-après.

Les perspectives du développement du *Système OIML* visent à renforcer et accélérer sa mise en application eu égard à un besoin croissant d'harmonisation internationale des exigences métrologiques et des procédures d'essai pour les instruments de mesure concernés, de réduction de la multiplicité des contrôles métrologiques nationaux, et d'élimination des barrières techniques au commerce de ces instruments.

INSTRUMENTS COUVERTS PAR LE SYSTEME

Les catégories d'instruments ci-après, avec les Recommandations OIML qui s'y rapportent, sont actuellement couvertes par la certification OIML: cellules de pesée (R 60), instruments de pesage à fonctionnement non automatique (R 76), baromètres (R 97), mesures de longueurs à traits de haute précision (R 98), balances manométriques (dès que R 110 est publiée), et certains types de chromatographes pour la mesure des polluants (R 112 et R 113).

Un certain nombre de Recommandations nouvelles ou révisées seront prochainement publiées et de nouvelles catégories d'instruments de mesure seront couvertes par le Système: ensembles de mesurage massique direct de liquides, pompes à essence, compteurs de gaz à parois déformables, instruments de pesage totalisateurs discontinus, calibreurs acoustiques, spectromètres pour la mesure des polluants métalliques dans l'eau, et thermomètres électriques médicaux à mesurage en continu ou à dispositif à maximum.

De nouvelles Recommandations OIML, actuellement en cours de préparation par les comités techniques et sous-comités OIML, verront le jour dans un ou deux ans. L'application du Système devrait en conséquence se développer de manière significative pour couvrir, entre autres, les instruments de pesage à fonctionnement automatique, le mesurage massique direct en statique des quantités de liquides, les manomètres, les instruments de mesure pour l'acoustique et les vibrations.

CERTIFICATS DELIVRES

A ce jour, plus de 40 certificats OIML ont été délivrés (il n'y en avait que 13 il y a un an). Les trois quarts s'appliquent à des instruments de pesage à fonctionnement non automatique, les autres aux cellules de pesée.

Bien que 16 États Membres de l'OIML aient établi des autorités nationales de délivrance des certificats OIML, seul un petit nombre (Allemagne, R.P. de Chine, France, Pays-Bas, et Royaume-Uni) ont produit des certificats. Cependant, la distribution géographique des demandeurs est beaucoup plus large et recouvre des constructeurs de R. de Corée, Espagne, Etats-Unis d'Amérique, Singapour et Suisse, en plus des constructeurs des pays ayant délivré les certificats.

INFORMATION SUR LA CERTIFICATION OIML

Les certificats OIML et les rapports d'essai qui les accompagnent sont destinés à être utilisés, sur une base volontaire, par les autorités nationales de métrologie légale pour accélérer les examens et essais des instruments de mesure nouvellement importés et pour lesquels une approbation de modèle nationale est nécessaire. Les certificats OIML peuvent aussi être utilisés par les constructeurs pour démontrer la conformité de leurs produits aux spécifications OIML, preuve d'un certain degré de qualité et de fiabilité. L'information sur tous les certificats délivrés doit en conséquence être disponible pour toutes les parties concernées.

Pour cela, le BIML envoie régulièrement une copie de tous les certificats aux services nationaux de métrologie légale des États Membres et Membres Correspondants de l'OIML. De plus, une description des certificats et autres informations appropriées sont publiées dans le Bulletin OIML. Le BIML a commencé l'établissement d'une base de données pour les certificats OIML et sera ainsi en mesure de répondre aux questions de toutes les personnes concernées par la certification OIML.

FUTURS DEVELOPPEMENTS

Le Système OIML ne se développe pas indépendamment des autres activités de certification internationales ou régionales. Les développements dans les domaines de la vérification de conformité, des essais, de la certification, de l'accréditation, et autres activités connexes de l'ISO, CEI, ILAC, CEE-ONU, EAL, WELMEC, CEN-CENELEC et autres, sont suivis et étudiés par le BIML, et les informations appropriées distribuées aux Membres de l'OIML. En retour, la certification OIML a fait l'objet de présentations par des Membres du CIML et des agents du BIML dans le cadre de diverses réunions internationales et régionales en 1993-1994.

Comme déjà indiqué, l'objectif principal des certificats OIML et des rapports d'essai les accompagnant est leur acceptation par les autorités nationales de métrologie légale comme base pour la délivrance d'approbations de modèle.

Actuellement un petit nombre seulement de Membres de l'OIML ont indiqué leur intention d'accepter systématiquement les certificats OIML. Le travail de l'OIML dans ce domaine doit donc se concentrer sur l'établissement d'un climat de confiance mutuelle entre les Membres de l'OIML, afin de permettre une large reconnaissance et utilisation des certificats OIML.

L'établissement d'un groupe technique consultatif OIML est prévu afin de progresser dans ce sujet essentiel et d'étudier des questions telles que:

- possibilité d'étendre l'application du Système aux instruments individuels (actuellement le Système ne s'applique qu'aux modèles d'instruments);
- établissement de procédures d'accréditation;
- organisation d'intercomparaisons visant à harmoniser les procédures d'essai de modèle;
- établissement d'accords de reconnaissance bi- ou multilatéraux entre États Membres;
- établissement des règles de protection juridique des certificats OIML;
- application d'un certificat unique à une famille d'instruments; et
- coordination entre la certification OIML et des activités similaires développées par d'autres organismes internationaux et régionaux.

Un séminaire sur la certification OIML a été proposé pour 1995 et pourrait constituer, pour tous ceux qui sont concernés par cette activité - autorités de délivrance, laboratoires d'essai, services de métrologie légale, et constructeurs – une excellente occasion d'échanger des vues sur les futurs développements du Système de Certificats OIML. ■

A.V.

IN MEMORIAM

ADRIAN J. VAN MALE
1915 – 1994

Né le 10 août 1915 à Oostburg, Pays-Bas, A. J. van Male entra au Service National de Métrologie dès janvier 1937.

Il y accomplit toute sa carrière professionnelle, si l'on excepte une courte période de deux années (1947-1949) passées en Indonésie.

C'est en juillet 1966 qu'il fut nommé Directeur en Chef du Service Néerlandais (Dienst van het IJkwezen) et, dès cette nomination, il représenta son pays auprès du Comité International de Métrologie Légale et manifesta un vif intérêt pour les activités de l'OIML.

Cela conduisit les Membres du CIML à le choisir comme Président, en 1968, après la retraite du Dr Stulla-Götz.

Sous sa présidence, assumée en étroite liaison avec deux Directeurs du BIML (M. Costamagna jusqu'en 1973, puis B. Athané) l'OIML a connu une forte expansion. De nouvelles méthodes de travail, permettant de considérables progrès de l'activité technique de l'Organisation, ont été établies et mises en application au début des années soixante-dix.

Les relations entre l'ISO et l'OIML ont, sous son impulsion, été clarifiées et considérablement améliorées. En particulier, la solution au plan international des problèmes de normalisation des matériaux de référence a été trouvée lors d'une conférence organisée, sous sa présidence, par l'OIML en 1973 à Washington.

En 1974, le CIML le réélisait pour une nouvelle période de six ans qui s'acheva en 1980, au moment de sa retraite.

Sur le plan national autant qu'européen A. J. van Male a également joué un rôle de tout premier ordre: révision de la loi sur les poids et mesures, création du laboratoire Van Swinden et expansion du Service National de Métrologie, développement de la coopération européenne au sein du Western European Metrology Cooperation et de la Communauté Européenne.

Le 5 août 1994, à quelques jours de son 79e anniversaire, A. J. van Male nous quittait.

Tous ses anciens collègues, et en particulier ses amis de l'OIML, ont ressenti une immense tristesse à cette perte. Nos pensées vont vers lui, vers son épouse, Louise van Male-de Veer, décédée il y a moins de deux ans, et vers ceux qu'il a laissés, sa fille Jacqueline, Martin, et Vera.

A. J. van Male était Officier dans l'Ordre d'Orange-Nassau, Chevalier dans l'Ordre de la Légion d'Honneur, et Officier de l'Ordre de la Couronne de Belgique.

B. A.

GERMAN DELEGATION REPORTS ON METROLOGY IN VIETNAM

Prof. Dr M. Kochsiek, CIML Member for Germany and Member of the Presidential Board of PTB, as well as Dr E. Seiler, Director of the International Relations Office of PTB, visited the National Metrology Centre (NMC) in Hanoi, Vietnam 13–18 May 1994. Below is a report of their observations and activities concerning this visit.

THE most important place to visit during our stay in Vietnam was the metrological state institute of Vietnam, the National Metrology Centre (NMC). The Director, Dr Nhi, chaired all the discussions himself and took us around. The NMC has a staff of 102: 40 are working as scientists and engineers in 10 laboratories, 40 are working in the mechanical and electrotechnical workshop, 22 work in management, administration and infrastructure.

The representatives of PTB discuss metrology in Vietnam during their recent visit to the National Metrology Centre in Hanoï. Pictured from left to right: Prof. Dr M. Kochsiek; Dr E. Seiler; Ngo Huy Van, Vice Director, NMC; and Dr Tong Cong Nhi, Director of NMC.

The metrological infrastructure comprises the NMC, subordinate to the General Department for Standardization, Metrology and Quality Control (GDMSQ), three regional measuring and testing laboratories in Hanoi, Da Nang and Ho Chi Minh City, as well as 53 verification offices.

The verification offices only have measuring equipment for mass and volume measurement at their disposal. In some of the provinces there are material testing centres. An accreditation system (VILAS) is being set up at the moment. Twenty consultants in eight committees have taken up work. Thirty accreditations in the textile, paper coal, oil, chemistry and building fields were already granted.

The NMC has laboratories for length, mass, time and frequency, electricity, heat, force and hardness, pressure, flow, electromagnetism, physical chemistry and reference materials. The visit to the laboratories showed that they are equipped expediently but simply. Eighty percent of the staff had been abroad (mostly in socialist countries) for training. The staff situation and expert knowledge are very good. Approximately 40 % of the head staff understands German and learning English is mandatory at present.

For the extension of measuring and testing, a new building has been approved. A library with seminar rooms is being built at the moment. The main targets to be achieved are the extension of force measurement up to 1 MN, mass (extension to 2 t), high voltage up to 50 kV (new), flow (water, mineral oil), food, analytical chemistry (including cereal humidity, air humidity, viscosimetry, density) as well as reference materials (e.g. testing gases). A workshop for electronics is under construction.

Seminar on the metrological infrastructure of a country

In four lectures, which were translated into Vietnamese, reports were given on the following subjects:

- Tasks of a metrological state institute following the example of PTB;
- Legal metrology;
- Calibration services (DKD and EAL);
- Development of the metrological infrastructure in Western Europe.

Detailed discussions showed the interest in regional and international metrological developments and the intention to extend the metrological infrastructure of Vietnam. ■

TCVN **News**

Standard-Quality-Testing-Metrology in Vietnam

The Directorate for Standards and Quality (DSQ) is the new name given to the former General Department for Standardization, Metrology, and Quality and is a government body under the Ministry for Science, Technology, and the Environment (MOSTE). In view of Vietnam's recent adhesion to OIML as Corresponding Member, the DSQ is now responsible for following OIML affairs. The TCVN News is the quarterly newsletter of the DSQ (published in English) and can be obtained by contacting the address given below.

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Metrological co-operation between developing countries of the Non-Aligned Movement

METROLOGY, standardization and quality management are identified as important areas within the Action Program for Economic Cooperation of the Non-Aligned Movement (NAM). Since 1983 five meetings of the experts group in these fields were held. The Sixth meeting of the group took place in January 1994 in Colombo organized by the Sri Lanka Standards Institution. The meeting was attended by 40 delegates from 11 countries. The majority of NAM countries are Member States or Corresponding Members to OIML. The CIML Members for India and Sri Lanka and a BIML staff member were among the delegates to the meeting.

The metrology section of the group was convened by Prof. E. Gopal, Director of NPL, India, and CIPM Member. Main items of the agenda were devoted to establishing a network for comparison of national measurement standards and calibration facilities. Questionnaires on metrological activities permitted the preparation of documents entitled "Metrological status, needs and offers for comparison and calibration of national standards within NAM" and "Directory of national measurement systems".

Training in legal and applied metrology was one of the important subjects of the group. The results of two training courses were reported by NPL-Commonwealth metrology centre (CIMET) India. Another training course took place at this centre in May–June 1994 in New Delhi, and OIML participated in the informational work associated with the training program.

Joint utilization of measurement standards, continuation of training courses, exchange of information in the field of metrology, and the extension of liaisons with OIML, BIPM and other international and regional institutions were among other aspects of the NAM metrological cooperation discussed at the meeting. More information concerning NAM activities in metrology are expected to be presented at the next OIML Development Council meeting to be held in October 1994 in Paris. ■

A.V.

UNITED NATIONS

Metrological assurance of testing

THE 49th session of the Economic Commission for Europe (UN/ECE) held in April 1994 approved a Recommendation concerning the metrological assurance of testing.

The document recommends that the Governments of the ECE member countries support the development and implementation of harmonized standards and technical regulations promoting methods and means of metrological assurance on the basis of relevant OIML International Recommendations and ISO/IEC Standards and Guides.

National standards and regulations should cover metrological control including the corresponding verification or calibration of measuring instruments used for testing. Accredited test laboratories must have a set of measurement standards traceable to national or international measurement standards. In addition, the appropriate level of competence of test laboratories and, consequently, the metrological assurance level should be established according to criteria characterizing the products from the point of view of their safety and influence on health and environment.

Following the decision of the 49th UN/ECE, the fourth meeting of the UN/ECE Working Party on standardization policies (9–11 May 1994, Geneva) approved the work program for 1994–1998 which included as a high priority activity the continuation of developing aspects of metrology relevant to testing.

Organization of seminars and training courses in metrology was another element of this program. The demand for training was displayed by some ECE (and OIML) countries in transition to a market economy. A preliminary agreement was made to hold a training course in the field of general metrology and metrological aspects of testing in two parts in France and Slovakia in 1995. BIML confirmed its possible participation in the UN/ECE metrology training course.

Conformity assessment, international certification systems, measures to achieve mutual confidence in the technical competence of testing and measuring laboratories are other high priority sectors within the program of the ECE Working Party which are of interest to continued cooperation between OIML and UN/ECE. ■

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Standards and the consumer: Partners for a better world

25th World Standards Day
14 October 1994

How International Standards meet consumer demands for safety, compatibility, reliability and quality is this year's theme for World Standards Day, celebrated on 14 October each year by all member countries of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

"Consumers need standards to protect them; standards need a consumer input to be practical and useful," say the organizations in a World Standards Day message signed by Mr. John A. Hinds (President of ISO) and Dr. Hans Gissel (President of the IEC), who are joined again this year by Dr. Pekka Tarjanne (Secretary-General of the International Telecommunication Union).

Technical standards impacting consumers are applied in a range of fields that stretches far beyond household goods and domestic appliances, such as to medical instruments, plastics, telecommunications, transport, computers and sports equipment, to mention but a few. Smart cards and smart cars are already here, smart houses and highways are just around the corner.

These exciting new technologies are designed to help consumers, and the World Standards Day message emphasizes how ISO, IEC and ITU standards and recommendations play a vital role not only in the design process, but also in the protection of consumers, and their environment, from unwanted side-effects.

Even if it is often the apparent absence of standards that worries consumers, the consumers' voice is more and more heard as specialists elaborate the documents themselves. The international standards bodies increasingly seek and encourage participation by consumer organizations in the development of standards. "Consumer interests in standardization are represented on committees and in working groups within national and regional standards organizations," says the message. "These in turn are engaged in setting international standards in ISO, the IEC and ITU."

Value for money is another gain the consumer makes from standards, the three organizations again stress. "Worldwide standards create the conditions for open trade, which puts manufacturers and consumers in a win-win situation. For the manufacturer, the cost of seeking to satisfy different national market needs is reduced, and the consumer benefits from competition among suppliers vying to meet his needs."

While ISO, IEC and ITU standards and recommendations are inevitably technical documents, their aims are ultimately human. They are there, says the message, to help societies and thus consumers in general to achieve their natural aspirations.

The World Standards Day message says that International Standards help consumers "to enjoy and use their environment without damaging it, to have durable goods they can afford, to perform their daily tasks safely with minimum manual labour and maximum efficiency, to have a common language for communicating quickly, and to have the freedom to use and exchange their products over international frontiers."

"The partnership between standards and the consumer for a better world is a very real one," the organizations conclude, "but it is not often made explicit. By focusing on this partnership in our 1994 World Standards Day message, we hope to contribute to changing this situation." ■

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It is with deepest regret that we announce the passing away of

Jean HUGOUNET

CIML Member for France
on 2 August 1994.

Mr Hugounet dedicated his professional life to legal metrology. He began his career in Paris as an expert in gas measurement in the *Sous-Direction de la Métrologie.* Continuing his work in the Regional Direction in Lyon, he was in charge of the local controls in legal metrology. After assuming the function of *Sous-Directeur de la Métrologie* in Paris, he was designated as CIML Member in July 1991.
Jean Hugounet will be missed deeply by his colleagues within OIML.

OIML

OIML extends a warm welcome to its newcomers:

Member State
BELARUS

CIML Members
MR N. A. KUSAKIN
BELARUS
MR KRASSIMIR ZHELEV
BULGARIA
MR L. REVUELTA FORMOSO
CUBA
MR OH HYOUNG KEUN
REP. OF KOREA
MRS A. EBBESSON
SWEDEN

Corresponding Members
BENIN
CROATIA
LITHUANIA
VIETNAM
SINGAPORE

WELMEC

Western European
Legal Metrology Cooperation

The Welmec Type Approval Agreement is now available after its publication in July 1994. This agreement is the result of work carried out in the WELMEC Committee after a decision in 1993 to pursue efforts to reduce barriers to trade in measuring instruments. The agreement, which is based on OIML Recommendations, was elaborated with a view to removing the need for multiple type approvals against national legal requirements. The agreement manifests a clear declaration of intent to grant approvals with a minimum of examination and testing in cases where an instrument has already been granted approval by one of the WELMEC signatories.

This publication includes the background and operation of the agreement as well as the full text and list of signatories.

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READER'S CORRESPONDENCE

The need for certainty in expressing uncertainties

The main incentive of the *Comité International des Poids et Mesures* in publishing its Recommendation: *Expression of experimental uncertainties,* and of the seven international organizations that together published the *Guide to the Expression of Uncertainty in Measurement,* was to avoid the quoting of uncertainties derived from varying principles and methods of calculation, some of dubious logic.

The need was vividly illustrated in your issue of July 1994 (Vol. XXXV, No. 3), where my article introducing the new *Guide* was immediately preceded by a report in which the uncertainty of measurement results was expressed by two incompatible methods, giving (in this case), slightly differing values. The first method was that of the CIPM Recommendation and of the *Guide;* the second was in accordance with a cited document, of restricted circulation, that had been submitted to and rejected by a majority of Member Bodies of ISO. The reader is left to choose between them.

The article in question may, of course, have been written before the *Guide* had appeared; but it is to be hoped that in the future all uncertainties of measurement quoted in the Bulletin and other OIML publications will be strictly and solely in accordance with the only internationally-accepted procedure: that of the Recommendation and *Guide* cited above.

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meetings OIML réunions

November 1994

12 TC 13 — LONDON
Measuring instruments for acoustics and vibration

December 1994

13–15 TC 9/SC 2 — TEDDINGTON
Automatic weighing instruments

ISO

November 1994

11 ISO/TC 28/SC 5 — TOKYO
Petroleum products and lubricants/Measurement of light hydrocarbon

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21–25 ISO/TC 30, TC 30/SC 2 and TC 30/SC 9 — BERLIN
Measurement of fluid flow in closed conduits

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CONFERENCE

MAKING THE MOST OF EUROPEAN STANDARDS

15–16 NOVEMBER 1994

THE EUROPEAN PARLIAMENT

ESPACE LÉOPOLD
RUE WIERTZ
BRUSSELS

The three European standards organizations CEN, CENELEC and ETSI have acquired a wide reputation as the competent mechanisms for the delivery of voluntary technical standards responding to the needs of European market forces and of the European legislator.

Every year CEN, CENELEC and ETSI meet on a common public platform to give their 'account' of the previous year's activities, look into the future and engage in debate with all interested parties. The 1994 conference will focus particularly on the adequacy of the present work programmes and standards already available for market requirements, and on the new challenge posed to the standards makers by the need to reconcile environmental aspects with economic development.

The conference is addressed primarily to the managers who are expected to prepare or make policy decisions on standardization within their companies, professional associations or government departments.

In 1994 the conference is taking place on the premises of the European Parliament in Brussels, a location particularly symbolic of the spirit of open and full debate with standards users, which CEN, CENELEC and ETSI wish to promote.

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Below is a list of OIML publications classified by subject (*) and indicated as follows: International Recommendations (R), International Documents (D), vocabularies (V), and other publications (P). Publications are available in French and English in the form of separate leaflets, unless otherwise indicated.

Publications may be ordered(**) by letter or fax from:

BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE
11, RUE TURGOT, 75009 PARIS, FRANCE
TEL: 33 1 48 78 12 82 OR 33 1 42 85 27 11
FAX: 33 1 42 82 17 27

On trouvera ci-dessous une liste des publications OIML classées par sujets(*) et indiquées comme suit: Recommandations Internationales (R), Documents Internationaux (D), vocabulaires (V) et autres publications (P). Ces publications sont disponibles en français et en anglais sous forme de fascicules séparés sauf indication contraire.

Ces publications peuvent être commandées(**) par lettre ou fax au BIML (voir adresse plus haut).

I 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 (in revision - en cours de révision)
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

(*) A list of publications classified by number may be obtained from BIML.
Une liste des publications par numéro est disponible auprès du BIML.

(**) Prices are given in French-francs and do not include postage.
Les prix sont donnés en francs-français et ne comprennent pas les frais d'expédition.

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 1990 200 FRF
Metrology in Member States and Corresponding Member Countries
Métrologie dans les Etats Membres et Pays Membres Correspondants de l'OIML

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

P 17 1993 300 FRF
Guide to the expression of uncertainty in measurement

II MEASUREMENT STANDARDS AND VERIFICATION EQUIPMENT
ÉTALONS ET EQUIPEMENT DE VERIFICATION

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

III 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 1994 100 FRF
Continuous totalizing automatic weighing instruments
Instruments de pesage totalisateurs continus à fonctionnement automatique

R 51 1985 80 FRF
Checkweighing and weight grading machines
Trieuses pondérales de contrôle et trieuses pondérales de classement

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

R 61 1985 80 FRF
Automatic gravimetric filling machines
Doseuses pondérales à fonctionnement automatique

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

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

R 106 1993 100 FRF
Automatic rail-weighbridges
Ponts-bascules ferroviaires à fonctionnement automatique

R 107 1993 100 FRF
Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers)
Instruments de pesage totalisateurs discontinus à fonctionnement automatique (peseuses totalisatrices à trémie)

R 111 1994 80 FRF
Weights of accuracy classes E_1, E_2, F_1, F_2, M_1, M_2, M_3
Poids des classes de précision 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 weigh-bridges (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

IV 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

V 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 5 1981 60 FRF
Meters for liquids other than water with measuring chambers
Compteurs de liquides autres que l'eau à chambres mesureuses

R 27 1979 - 1973 50 FRF
Volume meters for liquids other than water. Ancillary equipment
Compteurs de volume de liquides autres que l'eau. Dispositifs complémentaires

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

R 57 1982 80 FRF
Measuring assemblies for liquids other than water fitted with volume meters. General provisions
Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Dispositions générales

R 63 (being printed - en cours de publication)
Petroleum measurement tables
Tables de mesure du pétrole

R 67 1985 50 FRF
Measuring assemblies for liquids other than water fitted with volume meters. Metrological controls
Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Contrôles métrologiques

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 77 1989 60 FRF
Measuring assemblies for liquids other than water fitted with volume meters. Provisions specific to particular assemblies
Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Dispositions particulières relatives à certains ensembles

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

R 81 1989 80 FRF
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 1989 80 FRF
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

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

VI GAS MEASUREMENT
MESURAGE DES GAZ

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

R 31 1989 80 FRF
Diaphragm gas meters
Compteurs de volume 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

VII PRESSURE
PRESSIONS(*)

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)

(*) See also medical instruments - *Voir aussi instruments médicaux.*

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 (being printed - en cours de publication)
Pressure balances
Manomètres à piston

VIII TEMPERATURE
TEMPÉRATURES(*)

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 (being printed - en cours de publication)
Total radiation pyrometers
Pyromètres à radiation totale

P 16 1991 100 FRF
Guide to practical temperature measurements

IX 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 (in revision - en cours de révision)
General requirements for electronic measuring instruments
Exigences générales pour les instruments de mesure électroniques

X ACOUSTICS AND VIBRATION
ACCOUSTIQUE ET VIBRATIONS

R 58 1984 50 FRF
Sound level meters
Sonomètres

R 88 1989 50 FRF
Integrating-averaging sound level meters
Sonomètres intégrateurs-moyenneurs

(*) See also medical instruments - *Voir aussi instruments médicaux.*

R 102 1992 50 FRF
Sound calibrators
Calibreurs acoustiques

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

XI 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 1991 100 FRF
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

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

XII PHYSICO-CHEMICAL MEASUREMENTS
MESURES PHYSICO-CHIMIQUES

R 14 (in revision - en cours de révision)
Polarimetric saccharimeters
Saccharimètres polarimétriques

R 54 (in revision - en cours de révision)
pH scale for aqueous solutions
Echelle de pH des solutions aqueuses

R 56 1981 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

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

XIII 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

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

XIV 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 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 62 1985 80 FRF

Performance characteristics of metallic resistance strain gauges
Caractéristiques de performance des extensomètres métalliques à résistance

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

V 3 1991 80 FRF

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

P 10 1981 50 FRF

The metrology of hardness scales - Bibliography

P 11 1983 100 FRF

Factors influencing hardness measurement

P 12 1984 100 FRF

Hardness test blocks and indenters

P 13 1989 100 FRF

Hardness standard equipment

P 14 1991 100 FRF

The unification of hardness measurement

XV PREPACKAGING
PRÉEMBALLAGES

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Information on package labels
Etiquetage des préemballages

R 87 1989 50 FRF

Net content in packages
Contenu net des préemballages

OIML BULLETIN

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In addition to a manuscript and visual materials (photos, illustrations, slides, etc.), a disk copy of the submission should be included whenever possible (floppy disk or 3 1/2" microdisks - Wordperfect/DOS or other compatible software). Authors are also encouraged to send a passport-size photo for publication. Selected papers will be remunerated at the rate of 150 FRF per printed page, provided that they have not been previously published. The Editors of the OIML Bulletin reserve the right to edit contributions for style and space restrictions.

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