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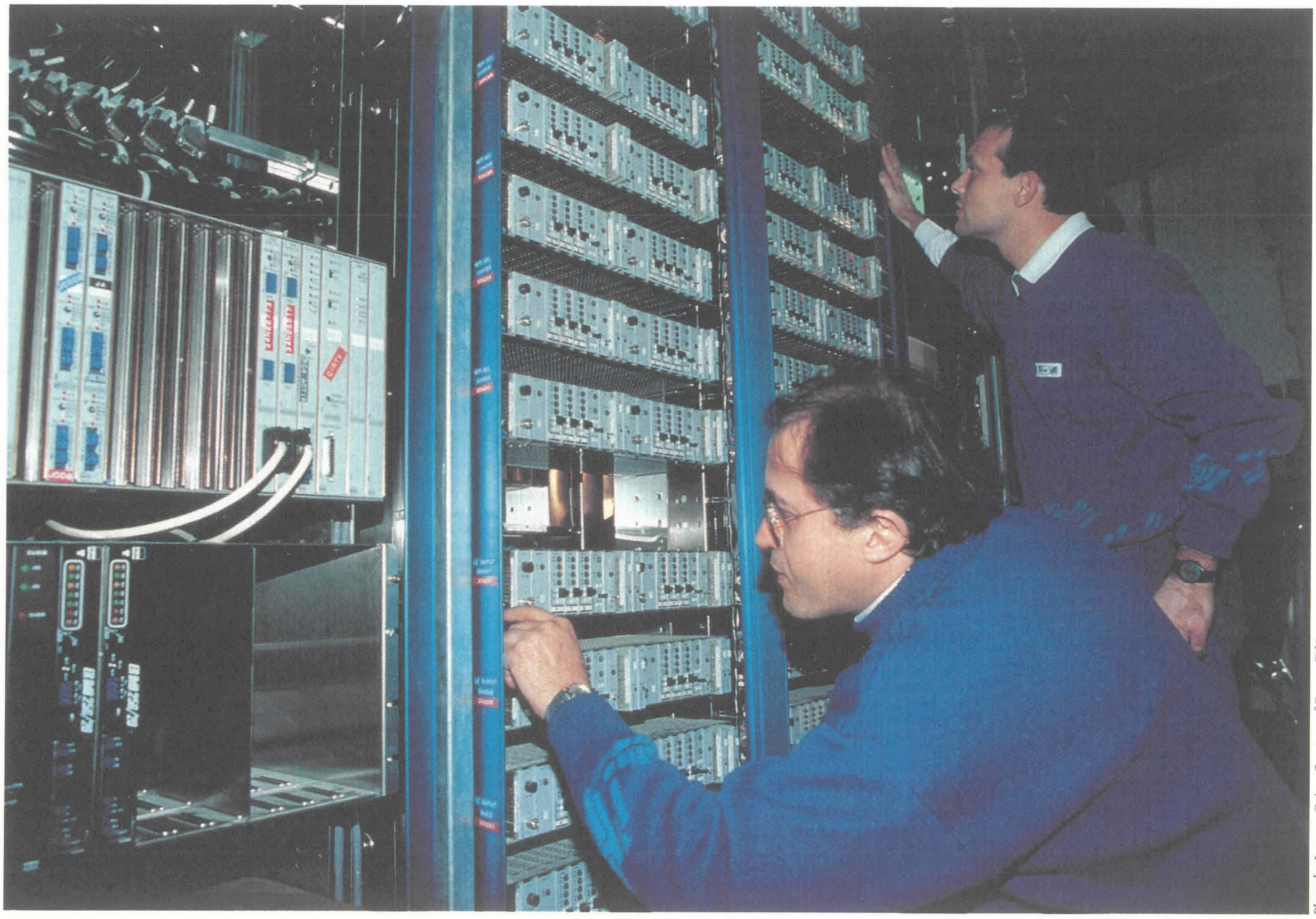

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Pattern approval of electronic customer meters for telephone call charging

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

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BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE (BIML)

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

EDITOR-IN-CHIEF
Bernard Athané

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Courtesy of France Télécom

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Editorial

New applications for legal metrology?

LEGAL metrology originated from the necessity to ensure fair trade and consumer protection. Consumer protection in legal metrology extended to applications other than trade, with the development of measuring techniques in fields such as medicine and safety. Here the notion of "unfair measurement" was replaced by that of "incorrect result", for example, with doctors (in the field of medicine) or policemen (in the field of road-safety) often unable to ensure the correct operation of the instruments they use, and on which the results of their activities (medical diagnosis or penalties) are largely based.

More recently, environmental measurements constituted a new and additional field of responsibility for legal metrology, although it should be noted that, from its start in 1955, OIML's technical work program included activities concerning air pollution.

Is the general scope for the application of legal metrology now definitively defined and limited to the four abovementioned topics (to which measurements for official operations - such as land surveys - should be added)?

For many years now, there has been a field in which legal metrology services in certain countries are active, and which presents certain similarities with the verification of measuring instruments: it is the control of gambling and slot machines, and of roulettes and other similar devices in casinos. Whether purely mechanical or electronic, such devices may be "tricked" by skilled persons, just as in the case of measuring instruments, so as to increase the statistical gain of the owner to the detriment of the consumer, the player in this case. Because of their expertise in technical controls, legal metrology services have been able to fully satisfy the requisites from their respective administrations. At present, however, it is dubious that a corresponding OIML activity would be appropriate.

Another field where a necessity of ensuring consumer protection is developing - and which is more connected with legal metrology - is the counting and invoicing of telephonic pulses. BIML has recently conducted an inquiry among certain OIML Members in order to obtain information on this subject. As an interesting output, we have received a paper, featured in this issue, from the Australian National Standards Commission (NSC) concerning the pattern approval and verification of electronic customer meters for telephone call charging.

For the time being, no discussion has been conducted within OIML to know whether it is appropriate for our Organization to start working on this topic, the economic importance of which - from the point of view of consumer protection - is evident. This will largely depend upon reactions we might receive following the publication of the NSC paper, as well as upon the actions of other international bodies that may have responsibilities in this field. If appropriate, OIML will be willing to cooperate closely with telecommunication and standardization bodies, and contribute to the search for an adequate solution to the problem. ■

B. Athané

B. Athané, Director
Bureau International
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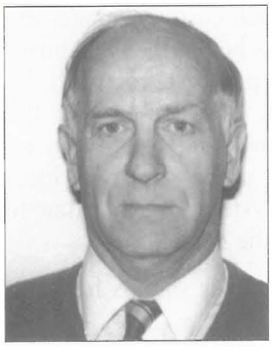


TELECOMMUNICATIONS SYSTEMS

Pattern approval and verification of electronic customer meters for telephone call charging

I. M. HOERLEIN, National Standards Commission, Australia

Abstract

This paper describes the methods used by the National Standards Commission to pattern approve and verify electronic customer meters which replace existing electromechanical meters in some Australian telephone exchanges. The meters were installed to provide itemised accounts of all calls made on customer's telephones. The process involved laboratory testing of the meters, site testing of meters installed in an exchange and auditing of the conversion and verification processes carried out by the telephone company.

Introduction

The Australian Telecommunications Authority held an inquiry into standards for telephone call charging and billing in 1992 and one of the many recommendations stated that the proposed electronic customer meter (ECM) to be used as replacements for electromechanical meters by the telephone company should be independently pattern approved by the National Standards Commission. Another recommendation stated that the time of day, time intervals, etc. used in the call charging process should be checked using equipment calibrated and traceable to a national time standard.

As neither the International Organization of Legal Metrology (OIML) nor the Commission had any standards for evaluating the performance of telephone meters, it was necessary to establish test procedures prior to carrying out the tests. This was done in conjunction with the telephone company which had also designed the ECM. The procedures follow those used for other legal measuring instruments and specified in various OIML Recommendations.

The only international standards found during the inquiry were those produced by the International Telegraph and Telephone Consultative Committee (CCITT) and included "CCITT Recommendation E433, *Billing Integrity*". This Recommendation contains objectives for charging accuracy and identifies network parameters affecting charging. It defines charging correctness as "the probability that the network correctly charges the communication by type, destination, time, location and duration". The recommendation established an objective that the probability of call charging error should be less than, or equal to, one in 10 000 calls.

The tests were generally carried out to this error although better performance of the meter was expected as it is only one of the sources of failure in the system. The objectives of the test plan were as follows:

- to demonstrate that the ECM will reliably register meter pulses associated with individual customer's telephone services in normal operation;
- to demonstrate that the ECM will perform reliably under environmental conditions including elevated temperatures, electromagnetic interference and electrostatic discharge;
- to show that the physical characteristics of meter pulses measured at the test site are in accordance with the specified detection range of the ECM;
- to demonstrate an effective process for installation and conversion to electronic customer metering;
- to demonstrate procedures and documentation for ensuring traceable measurement of meter pulse, voltage and time levels; and
- to demonstrate procedures and documentation for ensuring correct meter pulse period for the time of day, day of week and distance of call (where applicable).

The Commission's test program therefore stopped at the output of the ECM. The transmission of this information and its use in billing the customers was not included in the test plan. The Australian telecommunication authority audits this process.

Electronic Customer Meter, Metering System (ECM MS)

An electronic customer meter, metering system (ECM MS) suitable for an ARF-type telephone exchange (Fig. 1) may include up to 10 ECM metering units. Each ECM unit contains up to 10 electronic circuit boards, each with 50 customer meter inputs (Fig. 2). A fully equipped ECM MS may therefore have up to 5 000 meter inputs.

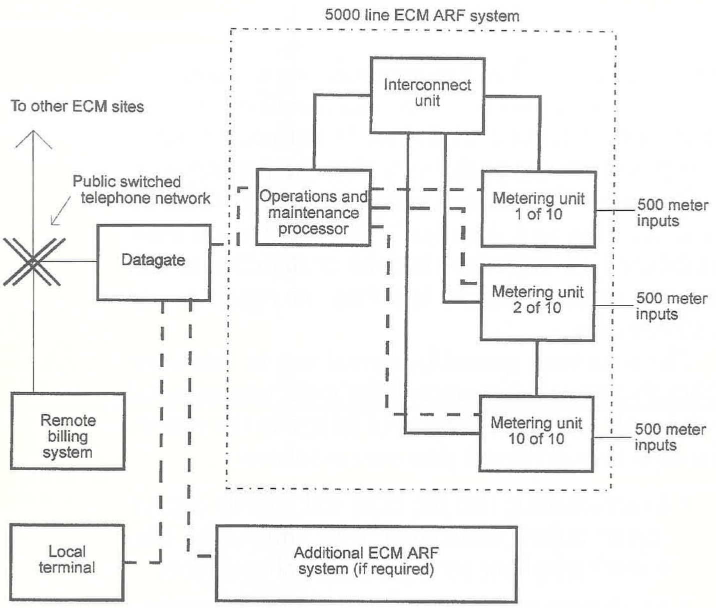


Fig. 1 The ECM ARF system.

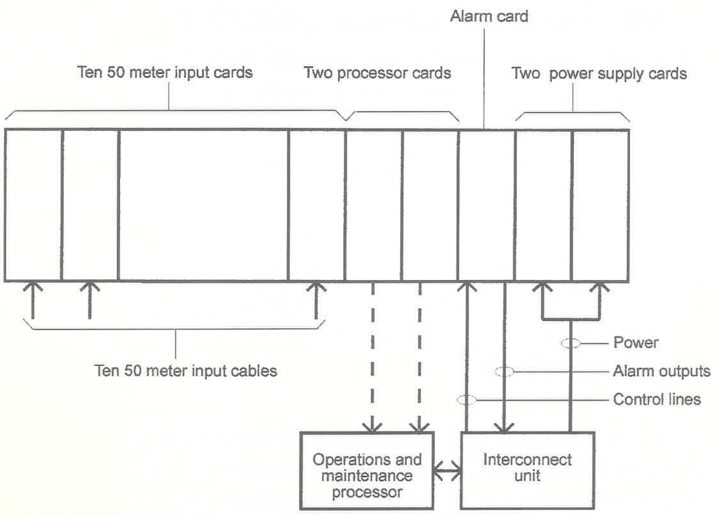


Fig. 2 The ECM ARF metering unit.

Meter pulses detected on each customer meter are subjected to a validation process before they increment duplicated software registers provided for each exchange customer line circuit. The contents of the software registers may be downloaded through an operations and maintenance processor to a local terminal or remote billing system via a Datagate modem. The main functions of the ECM MS are:

- to identify and validate meter signals for each customer;
- to record meter registrations in software meters;
- to output individual customer meter readings for processing service orders and verifying charging on meter tests;
- to output bulk charging information via the public switched telephone network to a data processing centre;
- to identify, record and output statistical meter readings as required;
- to allow operational and maintenance processor functions; and
- to record maintenance and operating data.

The metering system is verified using the operation and maintenance processor fitted to each ECM MS, a meter pulse generator and a personal computer workstation (local terminal).

Each customer has duplicate software meters arranged so that any hardware or software failure does not corrupt both meters. There is also a dual backup storage system and a periodic alignment check and automatic correction. A fault detection system is included to detect invalid meter pulses. The invalid pulses are not added to the customer meters but are stored and counted and provide alarms for the maintenance staff.

Pulse Specifications

The specification for the meter pulse (Fig. 3) are:

- Pulse width (range accepted by meter) is 60^{0}_{-30} ms to 540^{+30}_{0} ms. The exchange is set to produce pulse widths from 100 to 350 ms with the normal being 150 ± 30 ms.
- Pulse amplitude (range accepted by meter) is – 18 to – 52 V d.c. The exchange is set to produce from – 25 to – 43 V d.c. with the normal being – 40 V d.c.

Pulse Period

For local calls, only one pulse is received and a fixed charge applies. For long-distance calls, the charge is based on the number of pulses counted (Fig. 3).

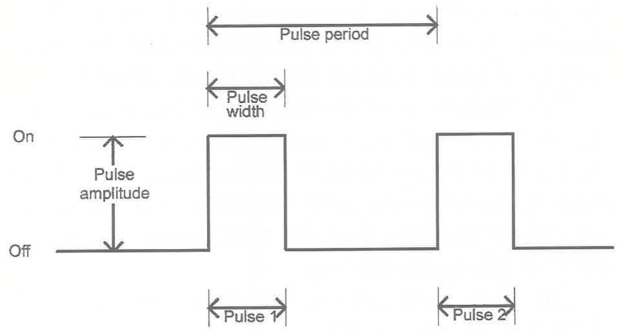


Fig. 3 Meter pulse specification.

The pulse period varies depending on the time of day, day of week and distance. The minimum pulse period acceptable is 330 ms.

The ECM MS is equipped with three fault counters which record invalid pulses outside the above specifications, namely:

- meter pulse too long (pulse width > 540 ms);
- meter pulses too close (pulse period < 330 ms); and
- permanent meter pulse (pulse width > 7 s).

Laboratory tests

Laboratory tests were carried out on a sample ECM MS in three groups covering meter pulse registration tests, including elevated temperatures; meter pulse specification tests; and electromagnetic compatibility tests.

Meter pulse registration tests

The purpose of the meter pulse registration tests was to determine if the ECM MS would register all valid pulses under normal operating conditions. Simulated meter pulses were generated and counted by a meter pulse generator.

The response of the ECM MS was monitored by an ECM workstation. A meter pulse timer was used to double check the meter pulses produced by the meter pulse generator. All of the outputs of the meter pulse generator, meter pulse timer and workstation could be printed. Figure 4 shows the test equipment. The following tests were carried out at 20 °C:

- 1 000 000 pulses were applied to each of the 500 customer meters in the ECM MS, namely 2 000 to each meter;
- a single pulse was applied sequentially to each of the 500 meters with only one meter being active at any time;
- a series of three pulses at the burst metering rate was applied to each of the first 100 meters; and
- a series of pulses at the maximum metering rate of one pulse every second was applied to one meter.

The inputs and outputs for each test were compared. It should be noted that each meter was zeroed before the test and all fault counters and alarms were reset. The aim of the tests was to show that all meter pulses were counted and no faults or alarms were registered.

An additional test was carried out by generating invalid pulses into the ECM MS and checking that the meters did not register any pulses but that they were recorded as meter faults. The invalid pulses included:

- pulse width too long;
- pulse period too short; and
- pulse period continuous.

The first test was repeated with the ECM MS in a chamber controlled at 50 °C. Telephone exchanges are usually air-conditioned. However, in the event of a failure in the air-conditioning (particularly for an unmanned exchange) the temperature could rise to 50 °C. No cold temperature tests were considered necessary.

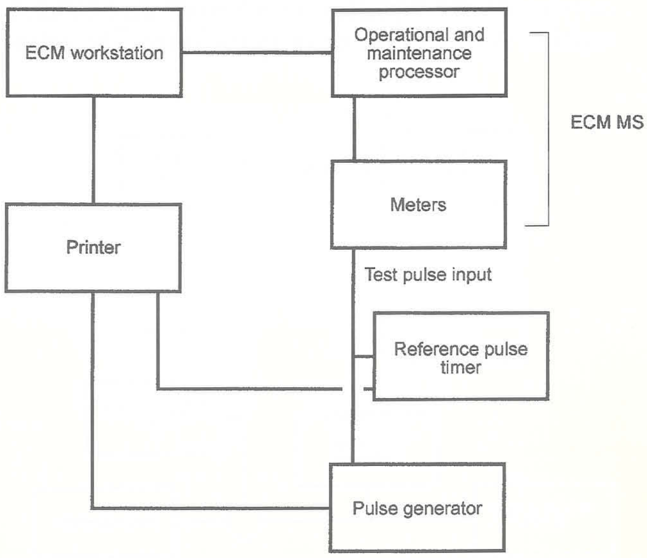


Fig. 4 Test setup for meter pulse registration tests.

Meter pulse specification tests

The purpose of the meter pulse specification tests was to determine the limits of the meter pulse specification which could be accepted by the ECM MS.

The ECM MS was set up with the ECM workstation to record and print the results. Pulse inputs of varying specifications were applied by a variable voltage source with reference voltmeter and a pulse generator with reference pulse timer (Fig. 5). The details of the pulse specifications are shown in Fig. 3. The following tests were carried out:

- input pulse voltage levels – a series of valid pulse widths (single pulses of varying measured voltage levels above and below the designed limits) were applied to check the limits;
- input pulse width levels – a series of nominal voltage (single pulses of varying measured pulse widths greater and smaller than the designed limits) were applied to check the limits; and
- input pulse period levels – a series of pairs of nominal voltage pulses (valid pulse widths) were applied with measured varying pulse periods to check the designed limits.

Electromagnetic compatibility tests

Tests were carried out for immunity to conducted radiofrequency disturbances, radiated radiofrequency electromagnetic fields, electrostatic discharge and electrical fast transients.

The ECM MS was mounted in a typical metal rack as found in a telephone exchange. The various power leads, communication RS232 cable and the wires carrying the meter pulses for each meter were bundled together as they would be in an exchange. The radiofrequency tests were carried out inside an anechoic chamber with the pulse generation and reference equipment being mounted outside the chamber.

This equipment comprised a meter pulse generator, the operations and maintenance processor, a personal computer acting as the ECM MS workstation to record the performance of the ECM MS and another computer controlling and recording the meter pulses applied to the ECM MS during the tests.

The tests were carried out in accordance with IEC 801 standards, namely:

- IEC 801-2 (1991) Electromagnetic Compatibility for Industrial-process Measurement and Control Equipment, Part 2: Electrostatic Discharge Requirements;
- IEC 801-3 (1991) Electromagnetic Compatibility for Industrial-process Measurement and Control Equipment, Part 3: Radiated Electromagnetic Field Requirement (latest draft 65A/77B (Secretariat) 135/100, July 1991);
- IEC 801-4 (1988) Electromagnetic Compatibility for Industrial-process Measurement and Control Equipment, Part 4: Electrical Fast Transients/ Burst Requirements; and
- IEC 801-6 (draft 5, first edition) Electromagnetic Compatibility for Electrical and Electronic Equipment, Part 6: Immunity to Conducted Disturbances, Induced by Radio Frequency Fields above 9 kHz.

The severity levels applied were:

- conducted radiofrequency disturbances for severity level 2 is 3 V RMS, 80 % modulated with 1 kHz sine wave in the frequency range 150 kHz to 80 MHz;
- radiated radiofrequency disturbances for severity level 2 is 3 V/m RMS, 80 % modulated with 1 kHz sine wave in the frequency range 80 to 1 000 MHz;
- electrostatic discharge for severity level 2 is 4 kV; and
- electrical fast transients for severity level 2 is 1 kV on power supply lead and 0.5 kV on meter pulse wires and RS232 cable.

It was not considered necessary to carry out short time voltage reduction tests as the ECM MS is powered by batteries. The conducted radiofrequency disturbances for the power leads, meter pulse wires and RS232 cable and the electrical fast transients for the meter pulse wires and RS232 cable were applied to the cables by means of a capacitive clamp.

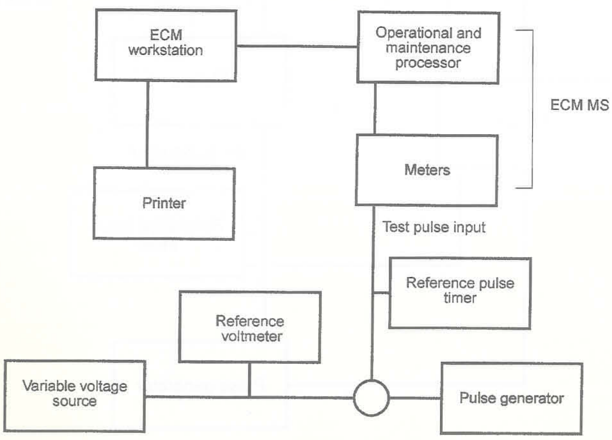


Fig. 5 Test setup for meter pulse specification tests.

The radiated radiofrequency disturbances were applied by a biconical antenna for the range 80 to 200 MHz and a log-periodic antenna for the range 200 to 1 000 MHz.

During each of the tests mentioned here, the ECM MS was supplied with between 50 000 to 250 000 meter pulses with a total number exceeding 1 000 000 pulses.

Site tests

Following the successful completion of the laboratory tests, an ECM MS was installed in an exchange for trial purposes. The telephone company uses a call charge analysis system which monitors calls on a random number of telephone lines over a period of time. A report issued for the ECM MS installation at the trial site showed 47 213 pulses were monitored on 68 telephone lines. Two invalid pulses showed on the report but the fault counters identified the faults. The results were within the limit of one in 10 000 calls.

The Commission witnessed a series of tests on the installation designed to achieve the following:

- to show that the physical characteristics of meter pulses measured at the test site are in accordance with the specified detection range of the ECM MS;
- to demonstrate an effective process for installation and conversion to electronic customer metering;
- to demonstrate procedures and documentation for ensuring traceable measurement of meter pulse, voltage and time levels; and
- to demonstrate procedures and documentation for ensuring correct "meter pulse period for the time of day, day of week and distance of call".

These points were audited by carrying out a number of tests in accordance with installation and verification procedures published by the telephone company and referenced in the certificate of approval issued by the Commission. The procedures fall into three steps:

(1) Exchange Preconditioning

Exchange preconditioning involved testing the pulses generated in the exchange to see that they were within the limits suitable for the ECM MS.

(2) ECM MS Validation

A meter pulse generator was used to apply valid pulses to all of the customer meters in various ways. Invalid pulses were also applied to check the fault counters and alarms.

(3) Maintenance

Powerdown tests were carried out to check for power failures as well as deliberately switching off the power for maintenance.

Test equipment

The test setup is shown in Fig. 6. A cathode ray oscilloscope was used to measure the pulse width and amplitude. A STD meter tester was used to check the pulse period. The tests were carried out using 10 of the 50 SR relay sets in the exchange. The 50 relay sets are shared between the 500 exchange customers. The relay sets connect the customer lines to their meter in the ECM MS when a call is registered. A personal computer was connected to the operation and maintenance processor to check the invalid pulse counters and alarms. This was also used to check the customer meters before and after powerdown tests.

Test results

The following results illustrate the expected performance of the ECM MS.

Pulse width and amplitude

The criteria for meter pulses generated in an exchange is:

- pulse width from 100 to 350 ms (normal 150 ± 30 ms);
- pulse amplitude from –25 to – 43 V d.c. (normal – 40 V d.c.).

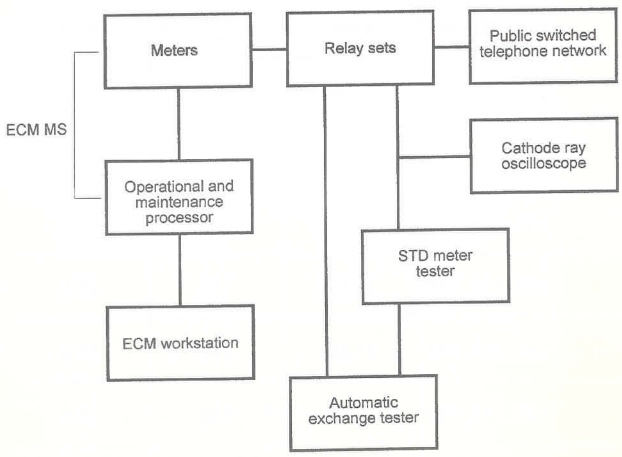


Fig. 6 Test setup for site testing.

Both long-distance and local call pulses were measured (Table 1). All test results were within the expected ranges. The differences are due to the different electro-mechanical equipment responsible for the pulse generation for each relay set. The low voltage levels were due to an electromechanical meter being connected as well as the ECM MS. The system was designed for a changeover period where both the mechanical and electronic meters would be registering pulses. Without the mechanical meter the pulse amplitude was – 42 V d.c.

Pulse period

For long-distance calls, multi-pulses are counted with varying pulse periods between each pulse depending on the distance, time of day and day of the week. Calls were made to five destinations on different charge rates (Table 2). Note that the first pulse period is different from successive periods. The maximum allowable variation was ± 1 s. All pulse periods agreed with the published rates within the allowable variation.

Table 1 Pulse width and amplitude for local and long-distance calls.

SR relay number	Long distance call		Local call	
	Pulse width (ms)	Pulse amplitude (V)	Pulse width (ms)	Pulse amplitude (V)
3	155, 155, 156	30.88	134	36.6
7	143, 142, 142	30.88	128	36.6
22	165, 167, 167	30.00	223	35.0
36	157, 157, 156	31.00	129	35.6
39	137, 141, 132	31.60	142	35.6
41	141, 134, 135	31.68	138	35.6
48	135, 138, 139	31.60	153	35.6
52	147, 142, 144	31.60	210	35.6
62	149, 148, 150	31.60	139	35.6
70	155, 157, 157	31.60	146	35.6

Invalid pulse test

Using the test meter pulse generator (automatic exchange tester) and the personal computer work-station to access the customer meter counters and fault counters (Fig. 6), the following invalid pulses were applied:

- meter pulse too long – three pulse periods of 304 ms; and
- continuous pulse – three pulses of width 8 s.

The invalid pulses were not recorded on the customer meter but were recorded on the fault counters. An alarm is set to operate after three faults are recorded on the fault counter in 5 min.

Powerdown test

The powerdown test was done to check the operation of the ECM MS in the event of a power failure, either intentional or unintentional. The ECM MS has battery backup to hold the meter count on each customer's non-resettable counter. No meter pulses can be counted during a power failure. Printouts were compared of 100 meters before and after the powerdown. No counts were lost on any of the meters.

Time and distance tests

The pulse period depends on the time of day, the day of the week and the distance between exchanges. The telephone company maintains one of the standard reference clocks in Australia for its time service. This is used to carry out regular checks on the exchange clocks. A report showing the time checks for the exchange clocks was examined. All checks were within ± 10 s.

The distance is measured from a central map reference in each designated area covered by each exchange. If the pulse periods are altered for tariff changes, a detailed procedure is used for notifying each exchange so that the changes can be made and checks carried out to ensure that they are correct.

Reference test equipment

All reference test equipment used in the various test setups had current calibration certificates provided by a NATA laboratory. NATA is the Australian authority

Table 2 Pulse width and amplitude for local and long-distance calls.

Call rate	First pulse period		Second, third etc. pulse period	
	Expected (seconds)	Actual (seconds)	Expected (seconds)	Actual (seconds)
M	40.0–50.6	44.93 44.64 46.13	45.0	44.99 45.00 45.00 45.00 44.99 45.00
Q	43.5–48.9	47.33	43.5	43.50 43.49
T	30.0–33.8	32.63	30.0	30.0 30.0
F	65.5–73.7	66.23	65.5	65.49 65.50
A	114.0–128.2	117.43	114.0	113.98 113.99

responsible for accrediting test laboratories. As well as ensuring that the procedures used for calibration are correct, it is also a prerequisite that all calibrations are traceable to Australian national physical standards.

Conclusions

Modern telecommunication systems are extremely complex. However, in this pattern evaluation, by concentrating on the measurement aspects of the ECM, it was quite straightforward to evaluate the performance in a similar way to other trade measuring instruments. This could not have been done, however, without the expertise of the specialist staff of the telephone company. The continued operation of the metering system also could not be assured without the expertise of specialist staff. The pattern evaluation program therefore also included evaluation of the procedures and facilities of the telephone company to ensure correct installation and maintenance of the measuring equipment. ■

DEVELOPING CONSISTENT RECOMMENDATIONS

Do we really need six Recommendations for weighing instruments?

OIML Seminar
WEIGHING TOWARDS THE YEAR 2000
13–15 September 1995 Maison de la Mécanique, Paris

CHR. U. VOLKMANN, Physikalisch-Technische Bundesanstalt, Germany

1 Introduction

The International Working Group TC9/SC2 of OIML has just completed the important work of finalizing no less than five Recommendations for different categories of automatic weighing instruments:

R 50 Continuous totalizing automatic weighing instruments (belt weighers); second edition 1994 (formerly: 1980);

R 51 Automatic catchweighing instruments - Part 1: Metrological and technical requirements - Tests (Edition 1996);

R 61 Automatic gravimetric filling instruments - Part 1: Metrological and technical requirements - Tests (being printed);

R 106 Automatic rail-weighbridges (1993);

R 107 Discontinuous totalizing automatic weighing instruments (totalizing hopper weighers) (1993).

All five Recommendations - or *drafts* - have been extended to include test procedures, and test report formats to render them applicable within the OIML Certificate System. All documents have already been accepted by the CIML (with the exception of the Annex to OIML R 50, which has been submitted to vote by CIML Members and expected to be approved by the next OIML Conference) and they will undoubtedly be formally sanctioned by the Tenth International Conference of Legal Metrology in Vancouver in November 1996.

Together with *R 76 - Nonautomatic weighing instruments (1992) Part 1: Metrological and technical requirements - Tests,* a set of six Recommendations for weighing instruments is now available, each suitable for use in the OIML Certificate System.

There were several factors which led the OIML community to speed up the elaboration of these Recommendations:

- the urgent need to have requirements for weighing instruments with electronic technology, in addition to those existing for traditional mechanical construction;
- the request from industry to have sets of requirements which they could expect to be applied uniformly throughout the world, or at least in large regions, e.g. in the European Union;
- the need to reduce the time lag between the introduction of new technologies and the adaptation of technical regulations;
- OIML's objective to widen the scope of the OIML Certificate System, which is intended to contribute to a reduction of time and money spent on pattern approval procedures.

The completion of this work is a good occasion to examine the set of Recommendations as a whole. Altogether, they comprise a total ot 764 printed or typewritten pages divided into 184 pages of requirements, 212 pages of test procedures, and 368 pages of test report formats. Large portions of the sections: *Terminology, Requirements for electronic instruments,* and *Test procedures* are identical, many identities are found in the *Technical requirements* and in the *Test protocols* as well. The duplications are the consequence of a general OIML strategy: to deal with any one kind of measuring instrument in only one Recommendation. A striking example is the combination of the former R 3, with metrological requirements, and R 28 with technical requirements for nonautomatic weighing instruments, into one new R 76.

The weighing instruments covered by the six Recommendations determine mass using the action of gravity; they can be used for commercial purposes, and for this reason some or all of them are subject to legal control in many countries. Such a statement justifies that the Recommendations have been established; it does not necessarily mean that all kinds of weighing instruments used for commercial purposes anywhere in the world, are covered by the existing Recommendations. There is, however, a fair chance that they are indeed covered, since the Recommendations have been drafted in a general manner, aiming at certain essential functions of the instruments, rather than at a particular technology or special design. It can therefore be assumed that for the time being, the world of legally controlled weighing instruments is sufficiently covered by the present set of six Recommendations.

2 Comparison of characteristics

Some essential characteristics of the different kinds of weighing instruments, together with basic requirements contained in the relevant Recommendations, are presented in Table 1 *(see p. 14)*.

2.1 Weighing process

Lines 1 to 3 of Table 1 identify the weighing procedure performed by the instrument in its normal operation, in view of the following factors:

- *Any treatment or handling of the load by the instrument (line 1):*

  The three types under R 51, R 76 and R 106 function with discrete loads, while the remaining three types separate a small portion from bulk for the purpose of weighing.

- *The character of the measuring process (line 2):*

  The weighing process is identified as "static" or "WIM" (weighing in motion). The term "static" is used where the instrument first determines the weighing result – by physically static equilibrium or the corresponding result of any signal processing routine – and thereafter releases any subsequent action such as printing and transporting. The term "WIM" denotes all other processes where the load is actually transported over the load receptor while its mass is being determined, and where any subsequent action is performed after a predetermined time interval, but not upon a release signal from the measuring system, as in "static" weighing.

- *The character of the weighing result (line 3):*

  This is identified as the mass of either a totalized load, an individual load or a partial load, and in the case of R 61, as a load of approximately constant mass. The output of the result of the normal weighing procedure is, on most of the instruments, the indication of a mass value m, or several values m_i, m being either an individual or a totalized load.

  There are two special cases: For class X instruments under R 51, the checkweighers for the control of prepackages, the primary output is a signal to sort out packages whose mass m is smaller than a set limit m*; they may also indicate the mean m and the standard deviation s_m of the checked number of packages. On gravimetric filling machines there is no output at all; the weighing procedure controls the filling operation so that the mass m of any load (the "fill") is no further off the set or nominal value m_N than the maximum permissible error (mpe).

It is important to realize that these weighing procedures have only been considered with respect to the actions performed (or not performed) by the instrument, and not by an operator. The intervention of an operator is, however, the main criterion for the distinction of a "nonautomatic weighing instrument" (NAWI) from an "automatic weighing instrument" (AWI) in all six Recommendations, as stated in the respective terminology.

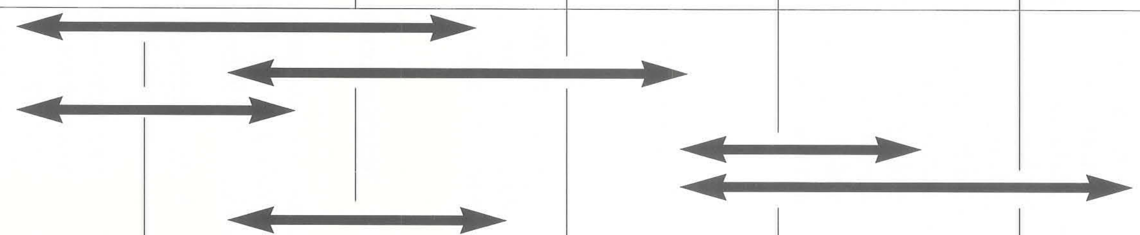
2.2 Maximum permissible errors in service

Line 4 of Table 1 discriminates three different types of maximum permissible errors (mpe): the mpe's may be defined as the following:

- a percentage of the load m or m_i,
- a function f of the verification scale interval e (different indices indicating different functions),
- a function (other than a percentage) of the load m (different indices indicating different functions).

For the totalizing instruments under R 50, R 106 and R 107, the "natural" mpe's are those based on a percentage of the load. It is then a logical approach that the mpe for the weight of an individual wagon (R 106) is also percentage-based, because the mpe for a sum of several loads should be equal to the sum of the mpe's for the individual loads.

Table 1 Comparison of weighing instruments and OIML Recommendations.

		Belt weigher R 50	Catchweigher R 51 X: Check-weigher	Catchweigher R 51 Y: other instrument	Gravimetric Filling instrument R 61	Nonautomatic Weighing instrument R 76	Automatic Rail Weighbridge R 106	Discontinuous Total. Automatic Weigh. Instr. R 107
1	Object to be weighed	bulk material to bulk, continuous	discrete load		bulk material, subdivided in discrete loads	discrete load	discrete load	bulk material to bulk, subdivided in discrete loads
2	Weighing process	w i m	static or w i m		w i m	static	w i m	static
3	Weighing result	total. load $m = \int dm$	X: m-m*	Y: ind. load m	ind. load of nominal value m_N	ind. load m	ind. load m_i or total. load $m = \Sigma m_i$	Total. load $m = \Sigma m_i$
4	Character of mpe for load	% of m	X: s_m: f_1 (m) $\overline{m} - m^*$: f_1 (e)	Y: m : f_2 (e)	$m - \overline{m}$: f_2 (m) $\overline{m} - m_N$: f_3 (m)	f_1 (e)	% of m, m_i	% of m
5	Special mpe for pattern examination	influence tests: % (reduced)	option: static weighing f_1 (e) (R 76, III, IIII)		m: f_3 (m) sf = f_3 (m_{min})	–	influence tests and/or static control weighing: f_1 (d_c) (R 76, III)	influence tests: f_1 (d_t) (R 76, III)
6	Special mpe for static control weighing for verification tests	–	–		m: $\frac{1}{5} \cdot f_2$ (m) $\overline{m}$: $\frac{1}{5} \cdot f_3$ (m)	–	$\frac{1}{5} \cdot$ min {% of m|f_1 (d_c)}	$\frac{1}{5} \cdot$ (% of m)
7	Optional NAWI use mentioned in Recommendation	–	–		–	–	Class III, IIII	Class III, IIII
8	Possible combination of instrument functions							

While the mpe's for these three types of AWI's are basically independent of the scale interval of the indication, the well-known error limits for NAWI's (R 76) are linked to the verification scale interval e, with m acting as a mere parameter. For a given mass m, the value of the relative mpe which is mpe/m, may be anything from less than 10^{-5} to 5×10^{-2} depending on the accuracy class of the instrument. In class III, the most common class for use in trade, the range is still from 1.5×10^{-4} to 2.5×10^{-2}.

This is not the occasion to discuss the justification for this particular system of mpe's for discrete loads. It must be recognized that the system was introduced by OIML more than 20 years ago, that it has since been taken over by national legislation in many countries, and that it could not be replaced by another system without severe problems and a considerable transition period.

The mpe system of R 76 has (with two modifications) been transferred to automatic weighing instruments for individual loads which are not checkweighers, i.e. "catchweighing instruments" under class Y of R 51. The modifications are:

- a limitation to classes III and IIII of R 76; and
- an addition of 1 e to all mpe's as per R 76, to account for the rounding error which cannot be determined on automatic instruments, and for the dynamic effects of weighing in motion, i.e. if $f_1(e)$ is the mpe function of R 76, the function for class Y of R 51 is always $f_2(e) = 1e + f_1(e)$.

The obviously close relation to the R 76 mpe can be justified by the fact that there are many commonalities, both in design and use for trade, between NAWI's and the AWI's under class Y of R 51. People dealing with type examination are aware of the problems associated with classifying a given instrument with little duties being left to the operator, as automatic or non-automatic. The existence of the border-line cases gives rise to the question: *Why must there be a difference in the mpe's – functions $f_1(e)$ and $f_2(e)$ – at all?*

Yet another type of mpe applies to checkweighers (R 51, class X) and to gravimetric filling machines (R 61). The indication of an individual weighing result is not required; the mpe is, nevertheless, related to the load the mass of which has been determined. For checkweighers, the mpe limits the standard deviation s_m over a number of weighing results for the same mass. The function $f_1(m)$ is a sequence of percentages of m, the percentage rate itself being reduced with increasing load. The mpe values $f_1(m)$ are in fact small fractions of the tolerable deficiencies T for the net content in packages which have been specified in R 87. The same T table (R 87) is also the basis for the mpe applicable to R 61 instruments. The important difference from R 51 is that in R 61, $f_2(m)$ applies to the difference of any individual fill m from the average.

Some of these values are represented in Fig. 1. Putting aside the possibility of modifying the mpe's by selecting a class factor different from X = 1, the functions are $f_2(m) = T$ and $f_1(m) = T/15$. Where an instrument under either R 51 class X or R 61 has a device for entering a pre-set value for m* or m_N, the difference between the actual mean m of a number of loads, and the pre-set value m* or m_N must also be within special mpe's: these are equal to $f_1(e)$ for R 51 class X, and equal to $f_3(m) = 0.25 \times f_2(m) = 0.25$ T for R 61 instruments (Fig. 1). A brief summary of this intercomparison goes as follows:

- for totalizing weighing instruments (R 50, R 106, R 107), the mpe's are defined as a percentage of the load;
- for weighing instruments for discrete loads (R 51, R 61, R 76, R 106), the mpe's are either related to the verification scale interval of the indication, or they are a percentage of the indicated mass;

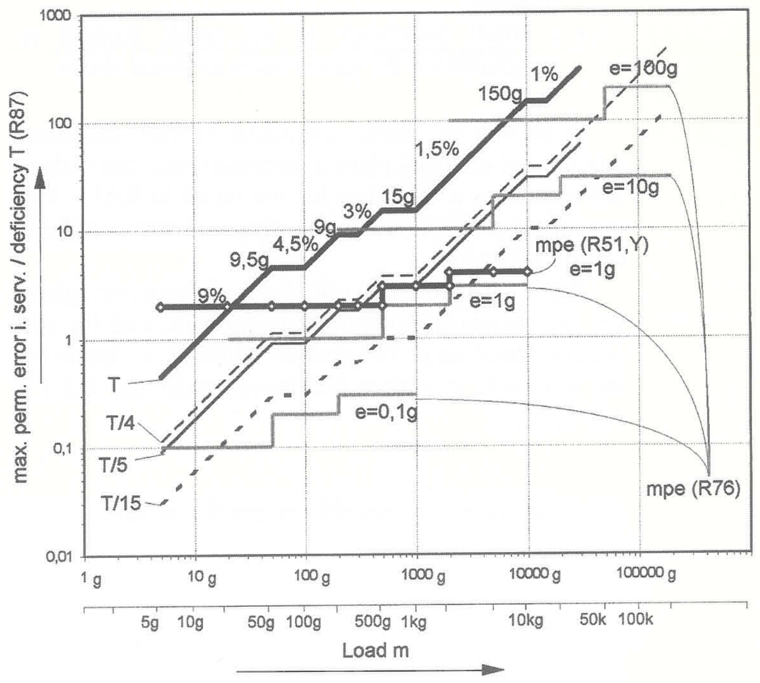


Fig. 1 Maximum permissible errors in service (mpe) for weighing instruments related to prepackages.

- (thick line) Tolerable deficiency T for prepackages (R 87) = mpe for individual fills (R 61)
- (thin line) Uncertainty of checking procedure = T/5 (R 87)
- (short dashes) mpe for average of fills = T/4 (R 61)
- (long dashes) mpe for standard deviation on checkweighers = T/15 (R 51X)
- (line with diamonds) mpe for catchweighers (R 51Y)
- (grey line) mpe for nonautomatic weighing instruments (R 76) = mpe for average on checkweighers (R 51Y)

- where many loads of nominally constant mass are concerned, the mpe's apply either to the standard deviation (R 51-X) or to the individual load (R 61). In addition, a separate mpe applies to the average, if applicable, in both cases.

Some inconsistencies that arise in view of R 87 must be noted as well. Both R 51 (X) and R 61 instruments deal with packages of constant nominal net content. The tolerable deficiencies fixed in R 87 are zero for the average, and a mass related tolerance T for any individual package. Among the rules given in R 87 for checking packages (regrouped into batches – or *lots* – whose size is defined in the Recommendation), the following directly influence the metrological requirements for the machines that fill and/or check the packages:

- the determination of net contents shall be made within the limits of uncertainty of ± 0.2 × T (probability level of unstated uncertainty);
- a small percentage of non-conforming packages (content less than m_N – T) is acceptable in view of statistical considerations related to sample testing);
- a small deficiency of the mean content is acceptable for the same reason as stated above.

In the two last points, the actual standard deviation s of the net contents plays a dominant role, but it does not appear as a reference for the mpe's in R 61 – this may cause problems when selecting an instrument for a certain filling job.

For R 51(X) instruments, the mpe's have been given for the standard deviation based on m, and for the average based on e. This makes it difficult to decide on the suitability of a given instrument under the "0.2 T"-rule of R 87.

2.3 Maximum permissible errors for testing

Lines 5 and 6 of Table 1 present special mpe's that are valid at type examination and *in situ* verification. In many cases, testing for influence factors at type examination may not be possible on the complete instrument in dynamic operation. It is then permitted to perform tests in static, nonautomatic weighing mode and/or on a suitable simulating setup representing the instrument, with mpe's that are either those for dynamic operation (R 50, R 61), significantly reduced (R 51, R 106, R 107), or those for NAWI's (R 76).

Instruments under R 61, R 106 and R 107 may be designed such that for verification tests, they can be used to determine the conventional true value of the measured (indicated) load, by a static weighing procedure. The mpe is then 1/5 of the mpe to be controlled; on R 106 instruments, however, it may be 1/5 of the mpe for static influence tests if this gives a smaller value than 1/5 of the mpe for dynamic weighing.

It is obvious that for type testing and verification, the R 76 mpe regime is effective for some kinds of instruments that must satisfy fundamentally different mpe's in automatic operation; there seems, however, to be no systematic approach. Putting aside R 50 as the only type with a continuous loading and measuring process, we find the R 76 mpe's replacing percentage-based mpe's in R 106 and R 107, and replacing the mass-related mpe's for class X in R 51, but not the mass-related mpe's in R 61.

So far, the mpe's have only been considered under the systematic aspect of their relation to the measured mass and/or to the measuring device of the weighing instrument. Looking further into the actual values of the mpe's would go beyond the scope of this paper, as all six Recommendations offer the manufacturer the choice of several accuracy levels:

- R 50: from 0.5 % to 2 %
- R 51 X, R 61: unlimited
- R 51 Y: equivalent to classes III or IIII (R 76)
- R 76: four classes and ranges of errors
- R 106, R 107: from 0.2 % to 2 %

It is, however, considered worthwhile to briefly consider the needs or expectations of those who use "verified instruments", which in this case are restricted to use for trade.

2.4 External requirements concerning accuracy

For direct sales to the public, no accuracy requirements based on the traded mass have been fixed in OIML Recommendations other than those in R 87 for prepackages. A WELMEC survey covering 12 EU Member States shows that national regulations for weighing instruments for direct sales to the public address the following:

- the instrument class, mostly requiring "at least class III",
- the prevention of using the instrument below minimum capacity (20 e in class III), and
- the obligation to tare off any container or wrapping material, i.e. to sell net weight only.

This means that the largest possible relative error for a load equal to Min, on a class III instrument which perfectly satisfies R 76, is 4 % of the mass! This results from adding the zero tolerance 0.25 e, the possible rounding error 0.5 e, and a conservative estimate of

0.06 e for the portion of the mpe in service. The frightening value of 4 % for the theoretically possible extreme has only a small probability of occuring, and decreases rapidly with increasing load, e.g. to 1 % for m = 125 e and to 0.35 % for m = 500 e. No regulation anywhere is known to the effect that a minimum uncertainty or a mpe related to the mass itself would be required.

For commercial transactions other than direct sales to the public or the elaboration of prepackages, the situation is fairly the same: governments normally prescribe the use of "verified weighing instruments" but not a lower limit of inaccuracy – neither as an absolute, nor as a relative value. A few countries require the use of "at least class III" instruments, with the difficulty of transposing this requirement related to NAWI's into the specification for the different AWI's.

Requirements directed at the accuracy of the instrument to be used for a given application are specified by the user, and negotiated with the manufacturer of the instrument – and with his competitors! The general impression is that traders have a tendency to ask for a determination of masses to an error of about 1 in 1 000 where large quantities are at stake. They seem to be ready to accept higher errors, up to 1 % for varying reasons such as: using an instrument for small loads as compared to its maximum capacity, preference for faster operation, buying a cheaper instrument and difficulties in handling the product to be weighed.

3 Technology of the instruments

Modern weighing instruments are electromechanical instruments, i.e. they have a high-tech load cell that converts a force resulting from mass and gravity into an electrical quantity and a sophisticated electronic data processing system. The latter determines the weighing result, controls mechanical functions of the instrument if necessary, and exchanges data with other electronic devices. In principle, this measuring device is the same for all types of weighing instruments. It is made suitable for a given application by special variants in signal processing, and by combining it with the appropriate mechanical construction of the instrument.

As a consequence of this situation, there is an increasing number of "hybrid", "combined", "multi-purpose" instruments being designed and produced. Such instruments are capable of performing functions and meeting different requirements for more than one type of instrument; in legal metrology terms, they are capable of satisfying more than one Recommendation. Well-known examples are the combination of a NAWI with some kind of AWI. These combinations are explicitly mentioned in R 106 and R 107 *(see line 7 in Table 1)* and also occur in other cases.

A typical combination of two automatic weighing instruments is that of R 61 and R 51 class X instruments for a machine that produces prepackages in addition to performing the checking function. More possible combinations are indicated in line 8 of Table 1.

4 Conclusion

An attempt shall now be made to answer the title question: *Do we need six Recommendations for weighing instruments?* There are considerable commonalities between the different types of weighing instruments:

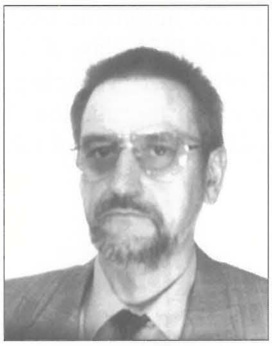
- in the measuring device: advanced electromechanical systems with electronic data processing;
- in the function: all but the beltweighers determine the mass of discrete loads;
- in the capability to combine different operations in one instrument;
- in important portions of the requirements in the OIML Recommendations.

Significant differences exist in the operations performed on the loads in addition to and beyond the actual measurement, leading to different instrument designs, individual OIML Recommendations and to different mpe systems. Related to this are the distinctions between automatic and nonautomatic instruments, and between "static" and "dynamic" or "in motion" weighing. The criteria we have for these distinctions, however, are based on a given technology, and thus are always in danger of becoming obsolete.

To have a specific Recommendation for each of the different types of weighing instruments has acknowledgeable benefits. Nevertheless, a plea is made for concentrating these requirements in a smaller number of Recommendations. Such an effort could be made when technical progress and experience with the present Recommendations make revisions necessary.

A starting point has been set by R 51, which comprises two different kinds of instruments to which different mpe's apply. Another encouraging example has been presented by the former SP 5-SR 1, which has combined five former Recommendations into one new R 117 *Measuring systems for liquids other than water.*

The proposal to concentrate on fewer Recommendations implies neither modifications to existing mpe systems, nor a reduction in the scope of regulated weighing instruments. It could, however, facilitate an adequate response of legal metrology to changes in technology, and help to avoid problems in everyday legal metrology activities arising from formal distinctions which may not correspond to the actual state of the art. ■



MODULAR APPROACH TO TESTING INSTRUMENTS

OIML Seminar WEIGHING TOWARDS THE YEAR 2000

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Reflections on NAWIs Module "Load Cells"

B. MEIßNER, Physikalisch-Technische Bundesanstalt (PTB), Germany

Introduction

The load cell is the "heart" of a weighing machine; most often, it transforms the force of a weight as a quantity of mass into an electric measurable quantity. The load cell determines the accuracy of a nonautomatic weighing instrument (NAWI), as confirmed by the apportioning of errors in Table 7 of OIML R 76-1. This Recommendation (edition 1992, with Amendment 1, 1994) is the fundamental basic regulation nearly for all metrological weighing purposes of a NAWI. The regulation for the module load cell, OIML R 60 (edition 1991) has been developed in parallel to the predecessors of R 76 (OIML R 3 and R 28). The test report format for the evaluation of load cells, OIML R 60-Annex A was edited in 1993. Nevertheless, all technical regulations must at least be improved to allow and to regulate technical progress.

A) Metrological regulations for load cells – OIML R 60

OIML R 60 for load cells (LC) is divided in chapters (I to VI) which are grouped as follows:

Terminology

This part of the Recommendation describes essential terms and their definitions (numbered from T.1 to T.19); some of this terminology is illustrated in Fig. 1.

I General deals with

1. Scope
2. Principles of the Recommendation
3. Units of measurement

II Classification of LCs gives more details on the following:

4. Principle of LC classification

4.2. Accuracy classes: (A, B, C or D)

4.3. Maximum number of LC intervals: (n_{max}, not defined in terminology, in R 76: n_{LC})

4.4. Minimum LC verification interval, (v_{min})

4.5. Supplementary classifications

4.6. Complete classification: e.g.: C6 ↑ -5/35 *Accuracy class; n_{max}; direction of loading; temperature limits and if necessary, designation NH, which means that no humidity tests have been performed*

4.6.6. Additional information: name, SN, E_{min}, E_{max}, E_{lim}, v_{min}; classification symbols

4.7. Presentation of information on the load cell or in an accompanying document

III Maximum permissible errors

5. The maximum permissible load cell errors (mpe) are defined as an envelope, and are established to 0.7 times the error limits of a nonautomatic weighing instrument.

6. Rules concerning the determination of errors:
   - validity for all measuring ranges with $n \le n_{max}$, $v \ge v_{min}$;
   - reference line for this envelope passing through E_{min} and 75 % of measuring range ($E_{max} - E_{min}$)
   - times of loading and reading.

7. Permissible variation of results
   - Creep, changing of LC output is limited to 0.7 times mpe during 30 min. and

additionally limited to 0.15 times mpe for changing in the last 10 min. of the 30 min. creep test.

- Minimum (dead) load output return: changes after 30 min. loading in between are limited to 0.5v
- Humidity (stability by treatment with humidity test acc.15.5): change of no load output ≤ 4 % of maximum output; change of output caused by E_{max} before and after treatment ≤ 1v.

8. Measurement standards, combined uncertainty ≤ 1/3 mpe

IV Metrological qualities

9. Repeatability error, the maximal difference between results of identical loadings is fixed to mpe.

10. Influence quantities

10.1 Temperature

- limits unless otherwise specified: for classes A & B: (+10 °C to +30 °C)*, classes C & D: –10 °C to +40 °C after setting output to zero at no load (more correct at MDLO) the LC shall perform within the limits of mpe
- special limits
- temperature effects on minimum load output, maximal 0.7 times v_{min} for a change of 2 °C for class A and 5 °C for classes B, C and D.

10.2 Barometric pressure, the change of the LC output shall not vary more then v_{min} at a barometric pressure change of 1kPa.

10.3 Humidity: LCs which are not tested against humidity shall be marked with NH.

V Metrological controls

11. Liability to legal metrology controls

VI Test procedures for pattern evaluation

12. Scope

13. Purpose

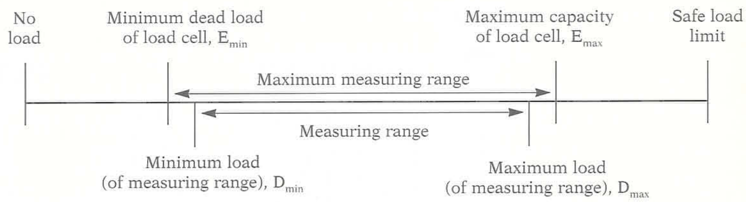

Fig. 1 Illustration of certain definitions from OIML R 60.

14. Test conditions. These points describe step by step conditions to observe for dealing with conditions of the equipment (force-generating system and output measuring instrument), environmental conditions, stabilities, loading, etc.

15. Test procedures. These points describe step by step checks and handlings, load exercising, loading and temperature sequence, etc. The loading sequence is shown in Figs. 2 and 3 *(see p. 20)*.

B) Test report format for the evaluation of LCs, OIML R 60-Annex A

The practical test measurements concern D_{min} and D_{max} as shown in Fig. 1, whereby they shall be close to E_{min} and E_{max}. Therefore the calculation in the Annex is done with D_{min} and D_{max}.

Calculation procedures

- Load cell errors (E_L = Error Load test)
- Repeatability error (E_R=Error Repeatability)
- Temp. effects on min. dead load output (MDLO) (C_M = Change MDLO)
- Creep and min. dead load output return (MDLOR) (C_C = Change Creep, C_{MDLOR} = Change MDLOR)
- Barometric pressure effects (C_P = Change Barometric Pressure)
- Humidity effects (C_{Hmin} = Change Humidity effects min; C_{Hmax} = Change Humidity effects max)
- General notes

* *Note 1: To avoid any confusion with R 76, always indicate temperature range for load cells classes A and B.*

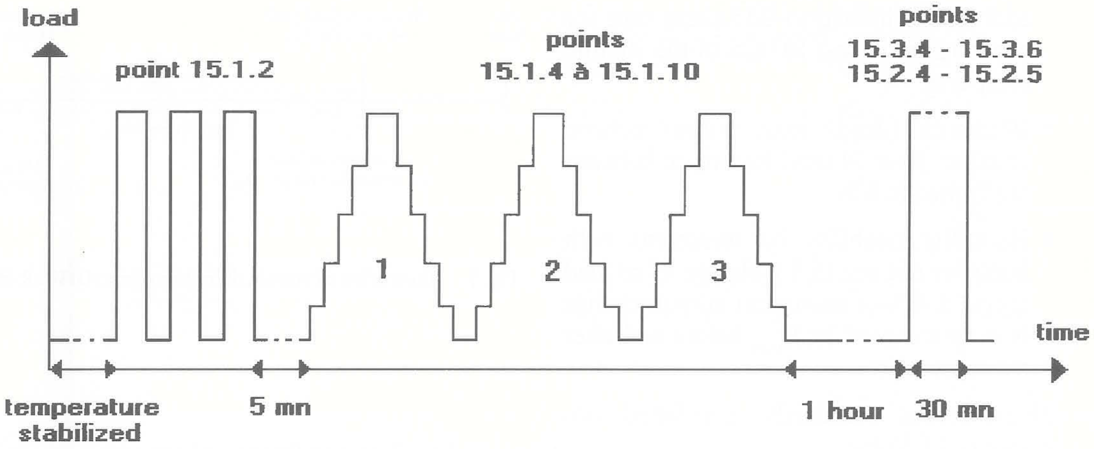

Fig. 2 Recommended test sequence for each test temperature when all tests are carried out in the same machine.

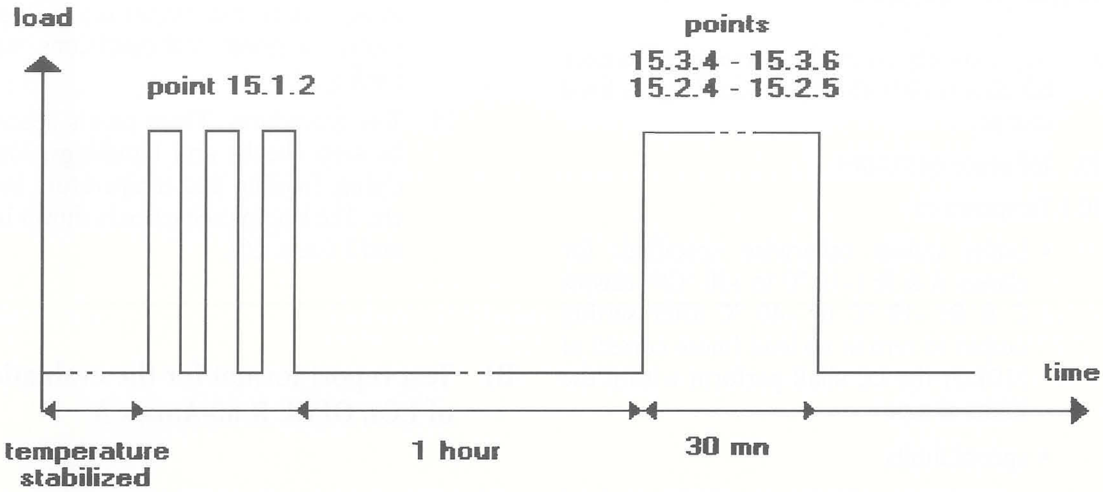

Fig. 3 Recommended test sequence for each test temperature for the minimum dead load output return and creep tests when carried out in a machine different than that used for the load tests.

Information concerning the pattern (provided by the manufacturer)

- Names, classification and some technical data
- Load cells submitted: Table: name, SN and E_{max}
- Various designs within model range: Table: E_{max}, v_{min}, E_{min} and n_{max} **
- Miscellaneous and secondary equipment, if necessary (load adapters, ...)

** *Note 2: This last table can give rise to confusion when using the test reports. How to use, or at least how to calculate load cells for a smaller maximum number of verification intervals and greater minimum verification intervals is not determined in the regulation. How to handle load cells with different maximum capacities that are not submitted is not fixed either.*

Note 2.1: The model name used is no guarantee for a similar construction.

General information concerning test conditions

Tables: use one set for every submitted tested pattern

Summary of the test (check list of passing requirements A.2 to A.8)

A.1 Load cell test data : test, *(use at least 4 sheets, for each temp. 1 sheet)*

A.2 Load cell errors (E_L): calculation, *(data of tables A.1, one sheet)*

A.3 Repeatability error (E_R): calculation, *(data of tables A.1, four sheets)*

A.4 Temperature effects on MDLO (C_M): calculation, *(data of tables A.1, one sheet)*

A.5 Creep and MDLOR test (C_C, C_{MDLOR}): test and calculation

A.6 Barometric pressure effects (C_P): test and calculation

A.7 Humidity effects (C_{Hmin}, C_{Hmax}): test and calculation

A.8 Marking requirements: formal check list

C) Further applications of OIML R 76 for LCs

The following devices and weighing instruments have appeared as a result of technical developments:

- load cells for single point application in small platforms;
- load cells with complete electronic conversion from the analog force input to a rated digital signal output;
- multi-interval weighing instruments;
- multiple range weighing instruments.

In addition to the tests specified in R 60, the testing of the load pick-up element or load cell leads for checking the appropriateness of this load cell considered as a module which is intended to constitute a part of a NAWI.

1. Single point LCs for direct load application in a small platform without any lever or extra leading element will be tested with eccentric loading and possibly durability according to R 76 points 3.6.2 and 3.9.4.3 (A.4.6 and A.4.7 respectively). The maximum dimensions of the platform are written into the report and in this case it makes sense to express v_{min} in units of weights (e.g. 1, 2, 5 or 10 g).

2. Load cells with rated digital signal output will be tested for variations in power supply, and disturbances according R 76 points 3.9.3 and 5.3.4, A.4.5 (B.2.3) and B.3 respectively. If this load cell shall not be humidity tested according to R 60 point 15.5, at least the damp heat and span stability tests shall be carried out according to R 76 points 5.3.2 and 5.3.3 /5.4.4 (B.2.2 and B.4 respectively). The fraction p_i can be chosen to 0.8, the maximum value for a module. [Note that the combination of (1) and (2) allows $p_i = 1$.]

3. For multiple range weighing instruments, the load cell has to meet two further conditions:

   - The minimum load cell verification interval v_{min} must be appropriate for the smallest verification scale interval e_1. $v_{min} \leq \sqrt{N} \cdot e_1 \cdot R/N$
   - For higher ratios Max / $e_1 > 2.5 \cdot n_{LC}$ the creep behavior has to be limited by comparison with a normal single range application of a load cell. It is more convenient to use MDLOR, according to point 4.12.2 of R 76. $DR \leq e_1 \cdot R/N$

4. Multi-interval weighing instruments can be tared at any load and start with the small e_1 for the net weight indication, so that the creep condition according to R 76 point 4.12.2 is stronger.

$$DR \leq 0.5 \cdot e_1 \cdot R/N$$

* *Note 3: According to R 60, MDLOR is in unit of mass and gained by testing with about E_{max}. By using the load cell in the weighing instrument the maximum load for the LC will be D(Max), caused by Max of the weighing instrument. It will be more correct to use relative calculation as: $DR = MDLOR \cdot D(Max)/E_{max}$.*

A more convenient calculation and classification for purposes of (3) and (4) is proposed hereafter in section (F).

D) Differences in evaluating according to R 60 or R 76

Creep and MDLOR tests are required by R 60 points 15.2.6 and 15.3.7 at all temperatures; the temperature can influence these results for strain gauge load cells essentially. A temperature different from normal room temperature can be a stable environmental condition, so this requirement is not a combination of two disturbances.

The criteria in point 3.9.4 of R 76 for variations with time differ only slightly and further ask for a four-hour test when the half-hour conditions fail; the conditions for returning to zero are identical; but these tests are required only for normal room temperature!

In our 15 years of experience testing load cells that are not hermetically sealed with humidity penetration, we found some plastic covered strain gauge conceptions that typically failed more than one verification interval in the first days, returning to below half a verification interval after ten days. That type would probably fail tests according to point 5.3.3 of R 76.

E) Reports for LCs or wide range application in NAWIs

On the one hand, manufacturers of load cells produce series of a model with different n_{max}, v_{min} and E_{max}; on the other hand, weighing machine manufacturers like to use these products for different NAWIs. In any event, manufacturers have to follow metrological regulations to guarantee the accuracy of the weighing.

Testing and certifying institutions like PTB do not use a statistical approach to a group of load cells; rahter, only one pattern of a classification is tested and such classification must be clearly defined. PTB certificates normally include a group of different classifications containing, for example, a picture of the LC; the newer ones are fitted with additional drawings showing appropriate mechanical application. Local verification officers want to be able to identify the LC module. Manufacturers of LCs, as well as PTB, do not appreciate submissions of different classifications of a product line.

Criteria for choosing number of tested patterns

1. For <u>different classifications within one capacity,</u> we test the pattern with the highest accuracy, and request that the manufacturer submit his test results with the pattern in order to carry out an inter-comparison test.
   These results should not differ more than 0.15 v with respect to the error curve characters – linearity, hysteresis, temperature influence on span – when test points in loading and unloading sequences are spaced at approximately equal time intervals than those of the manufacturer; otherwise, the creep behavior must be considered. The absolute span (e.g. in mV/V), which depends on gravity acceleration, electrical instrumentation, absolute accuracy of the loading equipment, the load application to the pattern and some small other unknown effects, is not evaluated. Minimum verification interval, creep behavior and minimum dead load output return results should be equal to the given value within 5 % to 10 %.

   Greater differences are examined with the manufacturer. With these results, we are able to certify the manufacturer's ability to produce and test these LCs. For smaller n_{max} and greater v_{min}, we check the data on supplied data sheets. It is the opinion of PTB that the manufacturer must classify and guarantee his products at the end of the production line within the error limits.

2 For <u>different capacities,</u> we test the more critical products of a product line (normally the smallest and highest ones) to look for a resemblance to the model for construction; LCs with a strain gauge application changed from a bending type to a shear type do not have an equal construction, regardless of whether outer dimensions were observed or not!

Given the above conditions, the interpolations and extrapolations given in Table 1 may be acceptable depending on the maximum number of verification intervals. The written capacities in boldface shall be tested at least; it should be noted that the lower accuracy series need not be tested, when the higher accuracy series is proved. The manufacturer should deliver additional test results with at least half of these ratios.

3 For very small v_{min} in relation to E_{max} and n_{max}, tests with different pre-loads appear to be necessary. The shape of the error curve can be a good indicator for deciding on additional testing, but extra tests are indicated at least for $v_{min} / (E_{max} / n_{max}) \leq 0.1$.

4 According to R 60 point 15.5, LC treatment with humidity at all constructions that are not sealed hermetically, three patterns of the smallest capacity must be tested, all of which must pass. Regarding this wide range purpose of PTB - LC Certificates, PTB has not yet issued an OIML certificate.

Table 1 Acceptable interpolations and extrapolations depending on the maximum number of verification intervals.

n_{max}	interpolation ratio tested to tested E_{max}	extrapolation ratio tested to untested E_{max} or vice versa	E_{max} (examples) unit (once at one time kg or t)										
1000	**1:22**	1:2.5	10	**20**	30	50	70	100	200	300	**500**	700	1000
2000	**1:15**	1:2.5	10	**20**	30	50	70	100	200	300	**500**	700	1000
3000	**1:10**	1:2.5	**10**	20	30	50	70	**100**	200	300	500	700	**1000**
4000	**1:7**	1:2.0	10	**20**	30	50	70	**100**	200	300	500	**700**	1000
5000	**1:5**	1:1.5	**10**	20	30	**50**	70	100	**200**	300	500	700	**1000**
6000	**1:4**	–	**10**	20	**30**	50	70	**100**	200	**300**	500	700	**1000**
10000	**1:2.5**	–	**10**	20	**30**	50	**70**	100	**200**	300	**500**	700	**1000**

PTB Load Cell Certificates

PTB certificates for load cells use the Recommendation OIML R 60 for the test procedures of the submitted LCs. Today, a report consists of the actual certificate, a one-sheet document containing all essential information such as:

- the type (in this case, load cell) and the name of the module,
- the certifying institute, the applicant and the manufacturer,
- the basic regulations (OIML R 60, and for additional tests, the EN 45501 which is based on OIML R 76),
- the type of the load cell and
- all metrological data of the certified load cell family in a table containing: accuracy classes; capacities E_{max}; maximum number of verification intervals n_{max}; minimum verification interval (expressed in $v_{min} = E_{max} / Y$; minimum dead load output return (expressed in DR = 1/2 E_{max} / Z); minimum dead load E_{min} and safe load limit E_{lim}. It certifies the property of the load cell to be used in weighing instruments which shall be verified.

The annex is declared as part of the document; it contains a short description of the function, a picture, the coding of the manufaturer name, the technical documentation, technical data, tests and patterns applied, the data sheet of the manufacturer, the dimensions and examples for appropriate mechanical application.

The tests results furnished by the manufacturer can become the basis of a report when the manufacturer's test field is accredited and registrated according to ISO 9000 Standards series on Quality management and/or when PTB staff have taken part in testing the pattern.

F) Proposal for a more moderate handling of metrological data for LCs

According to R 60, the minimum verification interval v_{min} is an absolute value of weight. Test reports issued by NMi and PTB for load cell families normally express this value in the form $v_{min} = E_{max} / Y$, whereby Y is a helpful calculation value normally greater than n_{max}. For different E_{max} of a family, Y is often constant; at the end it may become also a classification value , which is of interest to be written on the label similar like n_{max}. We call this value Y based on a former manner of writing of the dutch colleagues and it should not be confused by marketing with n .

Classifying symbols and calculations are shown below. In addition, for platform load cells, we still keep and express v_{min} in absolute values.

The minimum dead load output return (MDLOR in R 60 and DR in R 76) is, like v_{min}, expressed in absolute values according to R 60. DR in R 76, point 4.12.2, is not identical to the MDLOR *(see Note 3)*. For further calculation and classifying symbols we introduced MDLOR = 1/2 · E_{max} / Z , keeping in mind the limit of MDLOR = 1/2 · v.

Proposal for additional LC classification for multiple range weighing instruments: MR y , whereby
$y = (E_{max} / v_{min}) / 1\,000 = Y / 1\,000$.

Requirements for a multiple range weighing instrument:

- normal: $n_{max} \geq n_i = Max_i / e_i$, i being the number of the actual range;
- additional: $e_1 \geq \sqrt{N} \times E_{max} / Y$, and $Max / e_1 \leq 2.5 \times Z$.

In a multiple range weighing instrument Y must be greater than in a comparable single-range weighing instrument.

Proposal for additional LC classification for multi-interval weighing instruments: MI z , whereby
$z = (1/2 \times E_{max} / MDLOR) / 1\,000 = Z / 1\,000$

Requirements for a multi-interval weighing instrument

- normal $n_{max} \geq n_i = Max_i / e_i$ and $e_1 \geq \sqrt{N} \times E_{max} / Y$
- additional $Max / e_1 \leq Z$

The complete classification (e.g. C3 MI 7.5) means that every range can have 3 000 intervals and that Max / e_1 is allowed to be 7 500. ■

TESTING LOAD CELLS

OIML Seminar WEIGHING TOWARDS THE YEAR 2000

13–15 September 1995 Maison de la Mécanique, Paris

New facilities for testing load cells in the measuring range from 10 kg up to 50 t

J. A. ROBLES, J. A. FERNÁNDEZ, Centro Español de Metrología, Spain

Abstract

The new facilities of the Centro Español de Metrología (CEM) *for testing load cells consist of a set of three deadweight force machines of 1 kN, 20 kN and 500 kN of nominal loads, that enable the generation of a force range from 10 N up to 500 kN, both in tension and compression. This paper describes their technical and metrological characteristics and some details concerning their set-up.*

Introduction

The *Centro Español de Metrología (CEM)* is a governmental and autonomous institution responsible for the metrology infrastructure in Spain. The main tasks of the CEM include the following:

- obtaining, maintaining, developing and disseminating national measurement standards,
- national legislative development in the field of metrology,
- performance of State Administrative functions in metrological control,
- carrying out of research and development projects in metrological fields,
- training specialists in the field of metrology.

In 1993, the *Centro Español de Metrología (CEM),* decided to set up a new force laboratory. The decision was made with regard to the following factors:

- the need for force standard facilities capable of providing services to the national industry and making available a calibration center in the south of Europe to support the African continent as well as Latin America,
- the existence of large weighing instrument manufacturers in Spain,
- the significant load cell production in Spain,
- the national regulation of load cells which requires the manufacturer to submit and pass the pattern approval,
- worldwide implementation of the OIML Certificate System on load cells,
- the philosophy concerning "modules" in the 90/384/EEC Directive and the mutual agreement between notified bodies to accept test certifications,
- the significant national demand for the calibration of force transducers.

From 1993 to 1994, the implementation of the force laboratory equipment was carried out with the acquisition and setting up of three deadweight force standard machines of 1 kN, 20 kN and 500 kN of nominal values that allow one to generate a force range from 10 N up to 500 kN, both in tension and compression with a desirable accuracy of about 2 x 10^{-5} (Fig. 1).

The main criteria taken into account for designing the deadweight force standard machines have been the following:

- the supporting structures and the loading frames should have the highest stiffness and at the same time, their geometry must enable one to obtain a symmetric deformation maintaining the axial axis of the machines in their reference positions under load,
- the introduction of the load to the transducer or load cell under test has to be gradual, sequential and without shocks and in discrete steps without intermediate unloading; it must also have available restriction motion devices to reduce the swinging of the weight stacks,
- the load changes and stabilization times established by OIML R 60 should be taken into account,
- the mechanisms and devices that allow loading and unloading to be carried out instantaneously should be available in order to carry out the creep and preload tests,

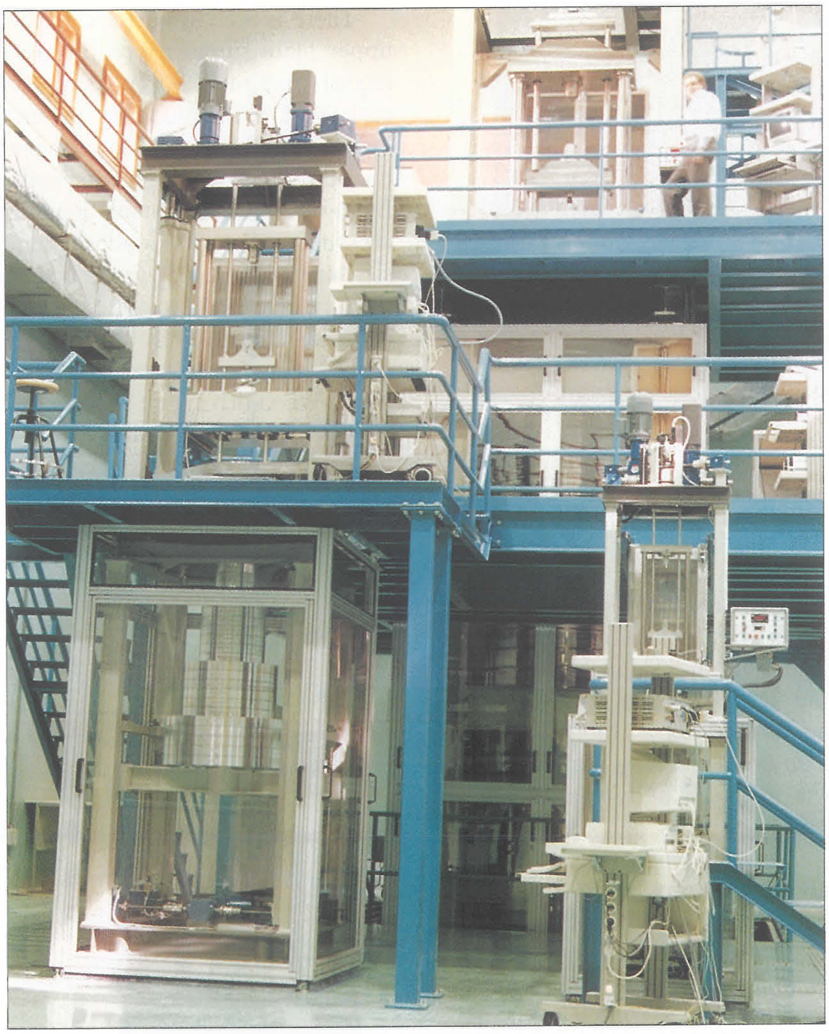

Fig. 1 Overview of the Force Standard Machines.

Machine set-up

Figure 2 shows the force machines which are located in a laboratory room with 323.31 square meters of floor space and a height of 12.34 m. The gravity value measured is 9.79950659 m/s^2.

It is known that the environmental vibration is a noticeable cause for disturbance in mass and force measurements. In the case of deadweight machines, where the force is generated by known masses being acted upon by the local gravity value, the gravitational force may be disturbed by vibrations of the machine foundations.

In order to reduce and dampen the environmental vibration as much as possible, the machines are set up on an isolated concrete foundation of 12.00 m x 7.50 m with an inertial mass of about 400 t. As shown in Fig. 3, the isolation consists of:

- a water isolation, with porous bricks and a fibre-glass coating;
- an environmental vibration isolation with a sand bed on the ground for vertical vibrations,

- servosystem drivers should be used in order to be able to work with different speeds in the main movements of the machines and to obtain a high accuracy in the stop points,
- the control of the machines should be carried out through a PLC which, when in automatic mode, will act under the control of a PC acting as man-machine interface,
- the climatic equipment installed in the upper frames of the machines for testing the load cells at different temperatures (-10 °C to 40 °C), should be available.

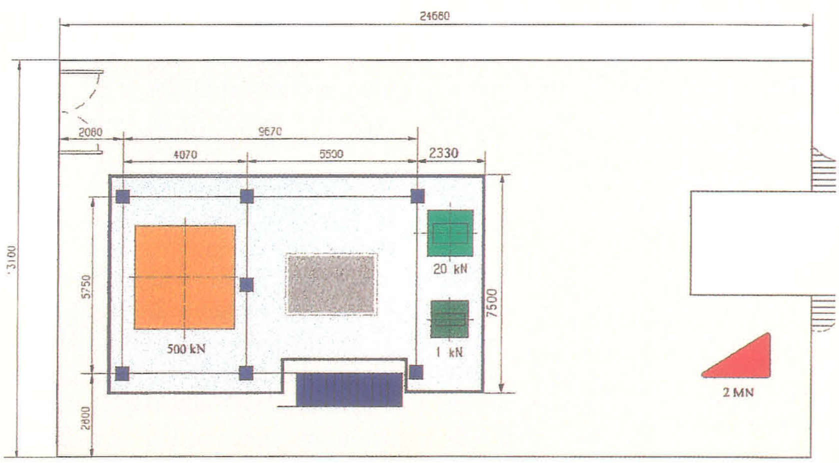

Fig. 2 Layout of the laboratory room with the set-up of the three force machines.

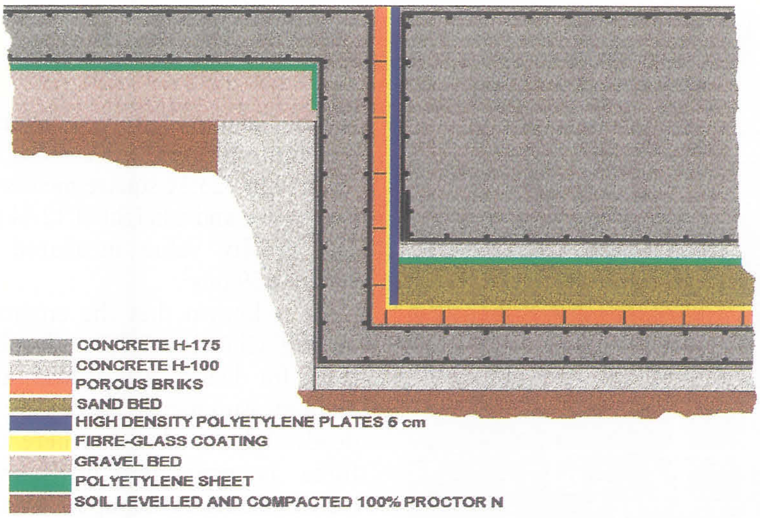

Fig. 3 Description of the deadweight machines.

and high density polyethylene plates on the wall for horizontal vibrations.

A metallic platform resting on the isolated foundation provides easy access to the working areas of the 20 kN and 500 kN machines. The room laboratory is equipped with an air conditioning system that maintains the temperature at 20 °C ± 1 °C.

Description of the deadweight machines

Generalities

The force standard machines are made of a supporting structure (lower supporting structure and upper supporting structure), a load generation system (stack of load elements) and a load transmission system (loading frame), as shown in Fig. 4.

The deadweight force standard machines have coaxial design of a single weight stack comprising, in each case, the necessary number of weights to generate forces up to the nominal value of the machines in various ranges and in 10 % step plus a 110 overload step in each one, both in tension and compression.

All masses rest on a lift table when they are not acting on the loading frame. This table allows for the stack of weights to be driven up and down in order to introduce the load on the loading frame and into the load cell or force transducer under test.

The movements of the adjustable crossbeams and lift table are generated by means of recirculating ball spindles driven by gearboxes and DC servo-motors of Siemens via a transmission axis with elastic coupling. The movements are accurately controlled by means of inductive sensor devices and pulse counters. There are sets of limit switches that provide safety to the movements of the lift tables and crossbeams.

In order to fulfill the time requirements of OIML R 60, there are two programmed operating speeds for the movement of the lift table: one high speed to cover about 90 % of the distance between the individual load elements, and a lower speed for when the individual load elements are engaged.

In the case of a 500 kN deadweight force machine, there is also a special crossbeam (OIML crossbeam) as shown in Fig. 5; it allows a package of weights (maximum 50 kN) to be prepared before their introduction into the loading frame to save time.

There is a crossbar fixed to the upper plate support (creep crossbeam) that makes it possible to carry out a fast loading or unloading of the load cell by driving the adjustable loading crossbeam. By lowering the adjustable loading crossbeam, the first load element sits upon the creep crossbeam; then by driving down the lift table the load elements are applied in sequence over this creep crossbeam. When driving up the loading crossbeam, all loads supported by the creep crossbeam are introduced directly to the loading frame and to the load cell (Fig. 6).

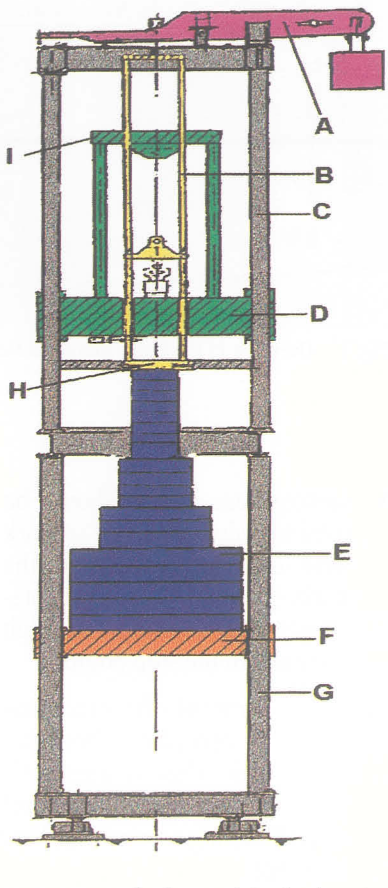

Fig. 4 General scheme of the deadweight force machines.

A – Counter weight and balancing lever. B – Loading frame C- Upper supporting structure. D – Adjustable crossbeam E – Weight stack. F – Lift table. G – Lower supporting structure H – Creep crossbeam. I – Tension frame.

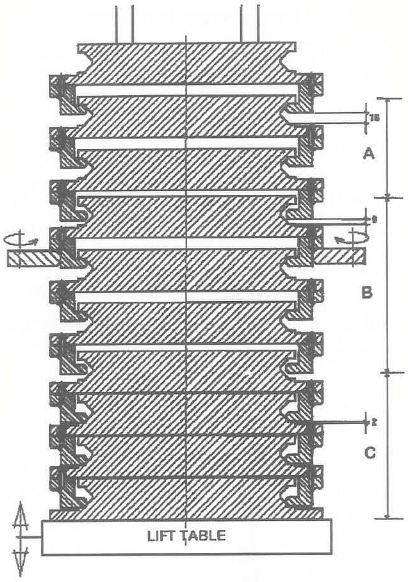

Fig 5. OIML crossbeam principle.

A – Load elements supported by the loading frame; B – Load elements prepared for the next load step; C – Load elements resting on the lift table

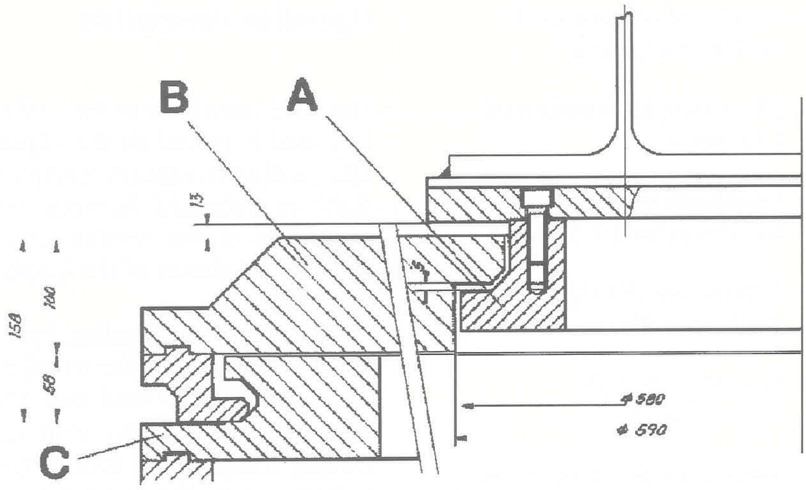

Fig. 6 Creep crossbeam.

A – Creep crossbeam; B – Disk crossbar designed to engaged the first load element and the loading frame; C – Stack of weights

The weight of the loading frame is compensated by a tare compensating device which consists of a counterweight and a balancing lever. The position of the lever is known in every moment by means of a no-contact displacement sensor and an electronic indicator. The same sensor is used to correct automatically the deformation of the load cell or force transducer and the loading frame when placed under load. The adjustment is made by driving up and down the adjustable loading crossbeam.

Specific characteristics

<u>500 kN deadweight machine:</u>

- Force ranges : 500 kN, 250 kN, 200 kN, 100 kN, 50 kN
- Reproducibility : 2×10^{-5} (to be checked)
- Uncertainty of the force: 2×10^{-5} (to be checked)
- Stack of weights: 36 weight disks made of steel ST-52-3 with chemically nickel-plated coating of 25 m and surface roughness of Ra ≤ 5 μm and Rz ≤ 10.5 μm.
- The stack of load elements is composed of: 17 × 5 kN; 7 × 10 kN; 2 × 15 kN; 2 × 20 kN; 3 × 25 kN; 5 × 50 kN
- Testing space – Maximum vertical space allowable: Compression: 50/300 mm Tension: 500/750 mm Horizontal span between columns: 670 mm
- Number of columns of the loading frame work: 4 (compression)/ 2 (tension)
- Lift table speed (maximum): 10 mm/s
- OIML crossbeam travel speed (max): 40 mm/s at no load, 5 mm/s at load
- Crossbeam travel speed(maximum): 10 mm/s
- Approx. overall height of the machine: 11.065 m
- Base area, W × D : 3.30 × 3.30 m
- Approx. weight of the machine: 95 215 kg

<u>20 kN deadweight machine:</u>

- Force ranges : 20 kN, 10 kN, 5 kN, 2 kN
- Reproducibility : 2×10^{-5} (to be checked)
- Uncertainty of the force: 2×10^{-5} (to be checked)
- Stack of weights: 32 weight disks made of stainless steel AISI 304 with a surface roughness of Rz ≤ 10 μm. The stack of load elements is composed of: 4 × 0.1 kN; 9 × 0.2 kN; 1 × 0.3 kN; 7 × 0.50 kN; 6 × 1 kN; 5 × 2 kN
- Testing space – Maximum vertical space allowable: Compression : 0/250 mm Tension : 400/650 mm Horizontal span between columns: 270 mm

- Number of columns of the loading frame work: 2
- Lift table speed (maximum): 7.14 mm/s
- Crossbeam travel speed(maximum): 7.4 mm/s
- Approx. overall height of the machine: 5.806 m
- Base area, W × D : 1.40 × 1.40 m
- Approx. weight of the machine: 5 345 kg

<u>1 kN deadweight machine:</u>

- Force ranges : 1 kN, 500 N, 200 N, 100 N
- Reproducibility : 2×10^{-5} (to be checked)
- Uncertainty of the force: 2×10^{-5} (to be checked)
- Stack of weights: 31 weight disks made of stainless steel AISI 304 with a surface roughness of $Rz \leq 10$ µm. The stack of load elements is composed of: 14 × 10 N; 4 × 20 N; 1 × 30 N; 7 × 50 N; 5 × 100 N
- Testing space : Maximum vertical space allowable: Compression: 0/140 mm; Tension : 295/435 mm Horizontal span between columns: 130 mm
- Number of columns of the loading frame work: 2
- Lift table speed (maximum): 10.4 mm/s
- Crossbeam travel speed (maximum): 6.94 mm/s
- Approx. overall height of the machine: 3.515 m
- Base area, W × D : 0.8 × 0.8 m
- Approx. weight of the machine: 697 kg

Operation description

The force transducer or *load cell* to be tested is placed on the adjustable loading crossbeam (compression) or mounted between the crossbeam of the tension frame and the crossbeam of the loading frame (yoke).

The adjustable loading crossbeam is driven in order to adjust the height of the load cell and obtain a quasi-contact with the loading frame whose own weight is balanced by the compensating tare device.

At the beginning, all load elements rest on the lift table. After regulating and adjusting the starting position of the machine, the lift table is driven down and the first weight step is applied to the force transducer by the loading frame. This procedure is followed in sequence by all other load elements selected to reach the desired value of force. The deformations of the force transducer and the loading frame are corrected in each step of force by moving the adjustable loading crossbeam automatically. The unloading process is carried out in a similar way by driving up the lift table.

The force standard machines have three operating modes: manual, semi-automatic and automatic:

Manual

The manual control is utilized by the technical service or by the laboratory technicians in certain emergency operations. This manual control is located in the control cabinet.

Semi-automatic

The semi-automatic control is located in a rack close to the loading frame; it allows the load cell to be loaded and unloaded by manually selecting the weights to be loaded or unloaded.

Automatic

This mode is the most common for operation. The system is controlled by a personal computer connected with a PLC via RS 422. There is a flexible programming language (including an editor program) that makes it possible to carry out all required standards or procedures after compiling the program.
The personal computer works into a windows network in the laboratory (Fig 7). All values of force and environmental data (temperature, humidity, pressure,) taken during

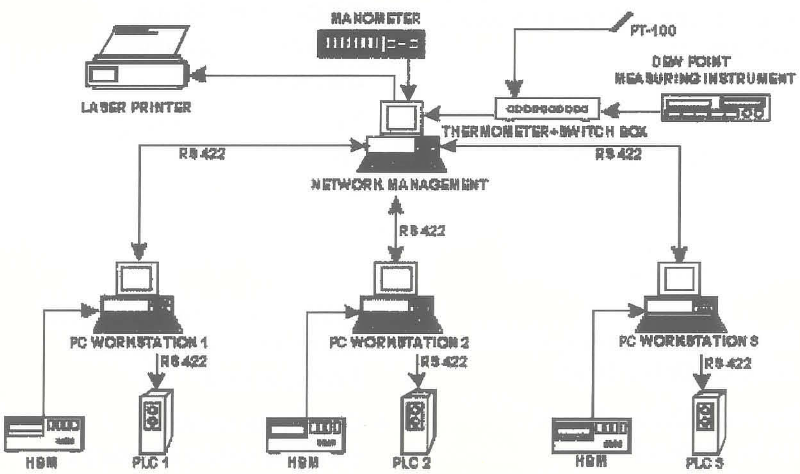

Fig. 7 Network in the laboratory.

the test are sent to the main computer in order to elaborate the test reports and certificates automatically.

Auxiliary equipment and measuring instruments

In addition to the deadweight force machines there are two temperature conditioners connected to three portable chambers installed in each of the force machines, as well as a set of accurate force measuring instruments.

In order to carry out the temperature tests specified in point 15.1.11 of OIML R 60, two temperature generating systems have been installed. The temperature generating system consists of a separate air conditioning unit connected by means of two flexible air ducts, to a portable chamber that is installed in the force application area.

For a 500 kN deadweight force machine: temperature conditioning unit: Type VR 06/500 (Heraeus):

- Temperature range: – 60 °C to + 180 °C
- Temperature fluctuation and deviation: 1 °C
- Average heating rate without test specimen: 5.0 °C/min
- Average cooling rate without test specimen: 2.5 °C/min

For 20 kN and 1 kN deadweight force machine: temperature conditioning unit: Type VR 06/500 k/S (Heraeus):

- Temperature range: – 60 °C to + 180 °C
- Temperature fluctuation and deviation: 1 °C
- Average heating rate without test specimen: 3.5 °C/min
- Average cooling rate without test specimen: 3.5 °C/min
- humidity range: 10 % to 95 % HR; temp. range: + 10 °C to + 90 °C

The temperature conditioning unit is connected to the personal computer which can control the functions of the unit. The unit can also be operated manually.

For measuring the signal of the load cells and force transducer, the laboratory has the following force measuring instruments:

- 1 digital measuring unit Type DK38 (HBM)
- 3 digital precision instruments for strain gauge measurements Type DMP 39 (HBM)
- 1 digital measuring amplifier Type DMC (HBM)
- Some accuracy power supplies and multimeters (6/9 digits)

For measuring the environmental conditions of the testing area in the machines, the laboratory is equipped with:

- 1 thermometer type F250 (AΣA)
- 4 Pt-100 sensors
- 1 switch box multichannel type SB250
- 1 dew point measuring instrument type AP3-D-B/C-I (MBW)
- 1 manometer type 6220 (Ruska)

Conclusions

The new CEM facilities for testing load cells and calibrating the force transducers that have been described in this paper will allow Spanish manufacturers of load cells and weighing instruments to have a high level certification center where OIML conformity certificates, test certificates (WELMEC) and calibration certificates (EN 10010-3, ...) may be obtained. These new facilities will introduce the possibility of supplying traceability and other services to Latin American countries, taking into account the advantage of using their language. ■

Acknowledgement

The authors are indebted to Prof. Dr. Manfred Peters of the PTB. His invaluable advice and assistance since 1989, have made it possible to select and set up these new force standard machines in Spain.

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TYPE EVALUATION

OIML Seminar WEIGHING TOWARDS THE YEAR 2000
13–15 September 1995 Maison de la Mécanique, Paris

Evolution of the U.S. National Type Evaluation Program and Canada/U.S. mutual recognition

J. C. TRUEX, State of Ohio, U.S.A.

Introduction

Most weights and measures programs of the U.S. were established in the early 1900's. The Federal government had made no effort other than to establish the units of measure. Consequently, there were state and local government programs and only a few included type evaluation. It soon became evident that it was necessary to provide for harmonization among the states in order to eliminate technical trade barriers.

The National Bureau of Standards (NBS) conducted the first National Conference on Weights and Measures (NCWM) in 1905, and subsequently issued a Handbook for weights and measures officials containing recommended metrological and technical requirements for many kinds of measuring instruments. In 1911, the NCWM adopted its first model Weights and Measures Law, which was subsequently accepted as law in several State jurisdictions.

Type evaluation was not included in this first model law, but in 1967 regulations for type evaluation existed in legal metrology programs in 14 states, two cities, and one county. The remaining states simply stated that it was necessary for commercial (used in trade) weighing and measuring instruments to meet metrological and technical requirements for instruments. It could be considered that other states also had a type evaluation program since before an instrument could be placed in service, it was necessary for a weights and measures official to conduct a thorough initial verification, which was in effect a type evaluation.

Measuring instrument manufacturers considered it an unnecessary and costly process to apply for a type approval in 17 different jurisdictions. Through the National Conference on Weights and Measures, the Scale Manufacturers Association (SMA) requested the NBS establish a voluntary prototype examination program.

The NBS agreed to conduct such a program, which consisted of an evaluation of an instrument by NBS staff to determine its compliance with NBS Handbook 44. If found to comply with requirements in the Handbook 44, a test report was issued indicating such compliance. If found not to comply, a letter would be returned to the submitter outlining the reasons for noncompliance. This program served its purpose for a number of years since most all states used the NBS test report as the basis for issuing a type approval certificate.

In the early 1980's it became apparent that an official national or federal program was necessary. In 1984, a model national type evaluation regulation was adopted by the NCWM and the NBS was charged with the responsibility of administering or managing the national type evaluation program (NTEP). The first NTEP certificate was issued in 1985.

As of September 1995, 37 states had adopted this regulation, and many of the remaining 13 were in the process. An NTEP certificate of conformance (CoC) is accepted or recognized by all states and there is no need for a manufacturer to submit an instrument to any individual state.

Four certified state laboratories (California, Maryland, New York and Ohio) perform the majority of the type evaluations. National Institute of Standards and Tech-

U.S. type evaluation history

1994: National Conference on Weights and Measures adopts model National Type Evaluation Program (NTEP) regulation

NTEP laboratories

- NIST
- California
- Ohio
- New York
- Maryland
- USDA/Federal grain inspection service

nology (NIST – formerly NBS) has type evaluation facilities for testing load cells and the United States Department of Agriculture's federal grain inspection service evaluates grain moisture meters and some grain bulk-weighing systems. These laboratories meet the criteria of ISO/IEC Guide 25 – *General requirements for the competence of calibration and testing laboratories*.

In 1988 the U.S. and Canada entered into a free trade agreement. Canada provided the catalyst for the Canada/U.S. harmonization program when it requested that the U.S. participate with Canadian metrology services to harmonize the legal metrology requirements of both countries. After two years of negotiation between the staff of Canada's Legal Metrology Branch (LMB) and the staff of the NIST Office of Weights and Measures (OWM), it became evident that involvement of representatives of the state laboratories and instrument manufacturers was necessary. The sequence of events concerning mutual recognition between Canada and the U.S. is briefly outlined hereafter.

Canada/U.S. mutual recognition

Phase I

Agreement to alleviate unnecessary industry trade barriers

Phase II

Harmonize instrument requirements

Phase III

Decision to "mutually recognize" not "harmonize"

Phase IV

Canada/U.S. mutual recognition agreement

Phase I

Two government bodies, the NIST/OWM and the Canadian LMB decided that weights and measures should constitute an important part of the free trade agreements, i.e. harmonizing as many of the countrys' device requirements as possible to alleviate unnecessary industry trade barriers.

Phase II

The NCWM S&T committee proposed several changes to Handbook 44 to harmonize requirements. All changes were considered to be noncontroversial in nature, but this proved to be otherwise as many thought some of the proposed changes were not merely cosmetic and should not be made hastily.

Phase III

The OWM and the NCWM called a special meeting in December of 1990 to discuss the situation. U.S. industry, Canadian industry, NIST/OWM, Canadian LMB, and NCWM representatives attended the meeting. The message from industry was, *"Do not try to make the requirements and Handbooks the same; rather, work out the details toward accepting each others type evaluation data so we do not have to submit the same instrument to both countries for type evaluation"*. After being advised not to use the "H" word (harmonization), the working group changed the name of the effort to "Mutual recognition of type evaluations".

Phase IV

After more meetings and the development of a work plan, the mandate of the U.S./Canada mutual recognition working group was defined. This NCWM policy statement was adopted by the executive committee. It reads:

With respect to weights and measures instruments, the parties agree that the most effective means to remove barriers to free trade is to achieve mutual recognition of instrument type evaluation testing. This will necessarily involve the comparative analysis of type evaluation codes and test procedures together with the intent of streamlining and minimizing differences in so far as possible so as to enable efficient equipment evaluation while preserving the technical capability and competence of their mutual laboratories.

The working group then devised a plan for following the mandate. The first five steps were:

1. To define mandate, objectives, priorities
2. To develop and update materials
3. To study differences in requirements
4. To review results
5. To report results and seek endorsement

Step one was the first meeting of the working group held in April, 1993. During that meeting, the group defined its mandate, objectives, and priorities. The group decided which instrument types would be considered initially and, reviewed basic test procedures and equipment needs. It was agreed that electronic floor scales and weighing elements up to 1 000 kg capacity, non-computing electronic bench scales, and digital indicators would be evaluated under the agreement. It was expected that computing scales, other scales, and even retail motor fuel dispensers would soon follow.

Step two of the work plan was for the working group members to begin assigned tasks. The tasks that were assigned included: updating NCWM Publication 14, developing a laboratory instruction manual, developing an applicant guide and a U.S./Canada application form.

Step three was a meeting of technical representatives in Canada. The purpose of the meeting was to review work that had been done and to look in-depth at the different requirements and test procedures.

Step four was a brief meeting at the NCWM in Kansas City to review the drafts and timetable, and to make further assignments to the working group members.

Step five was a meeting of the full working group and interested industry in Ottawa, Canada. During that meeting the revised checklist, checklist answer sheets, worksheets, application form and the applicant's guide were reviewed. Possible areas of uniformity and unresolved technical issues were also discussed.

The remaining five steps of the Canada/US mutual recognition work plan were the following:

6. Training of U.S. technicians by Canadian technicians
7. Canada (LMB)/U.S. (NIST) memorandum of understanding
8. Review/endorsement
9. Training Canadian technicians by U.S. technicians
10. Mutual recognition of type evaluation work by both countries

Step six of the work plan was scheduled for December 1993 at the California NTEP laboratory in Sacramento. U.S. NTEP technicians were trained on Canadian requirements and test procedures by LMB representatives.

Step seven was the development of a NIST/LMB memorandum of understanding. NIST and LMB management were assigned that task.

Step eight was a review of the progress of the mutual recognition effort by the NCWM executive committee during the interim meeting in January 1994. The executive committee reviewed and endorsed the objectives of the working group at that time.

Step nine consisted of NTEP representatives going to the LMB type evaluation laboratory to conduct a training session for LMB technicians. The training covered Handbook 44/NTEP requirements and test procedures.

Step ten was the implementation of the mutual recognition of type evaluations on schedule in April 1994 only twelve months after the first meeting of the working group. As of June 1995, several weighing instruments and indicators for weighing instruments had been through the Canada/U.S. mutual type evaluation process and had received approval certificates from both countries.

As with most major projects, adjustments were made during the initial implementation of the program. For example, policy stated initially that if a manufacturer only needed U.S. approval, he must submit to a U.S. laboratory for evaluation, with the same applying for Canada. At the request of manufacturers, the two countries have changed the policy. A manufacturer can submit an instrument to either country for testing applicable to the requirements of either country.

Another change in policy is that a manufacturer can submit an instrument to a laboratory in either country and request that testing be conducted independently, as it relates to each country's requirements (i.e. first evaluate the instrument for compliance with U.S. requirements, then evaluate the instrument for compliance with Canadian requirements). The program initially established that one evaluation would be conducted with a single checklist that contained both Canada and U.S. requirements. The policy was established to save time and money; however, after manufacturers expressed their preference for taking the chance of increased expense if they wished, the policy was modified.

It is important to understand that each country still reserves the right to evaluate the checklist, reports, data, etc. independently and issue its own certificate of conformance (U.S.) or notice of approval (NOA) in Canada. Following is a brief description of the process a manufacturer and device must follow under the Canada/U.S. mutual recognition of type evaluation program:

I. An application is received for U.S. and Canada type approval.

II. Both OWM and LMB review the application and accompanying information and confirm acceptance.

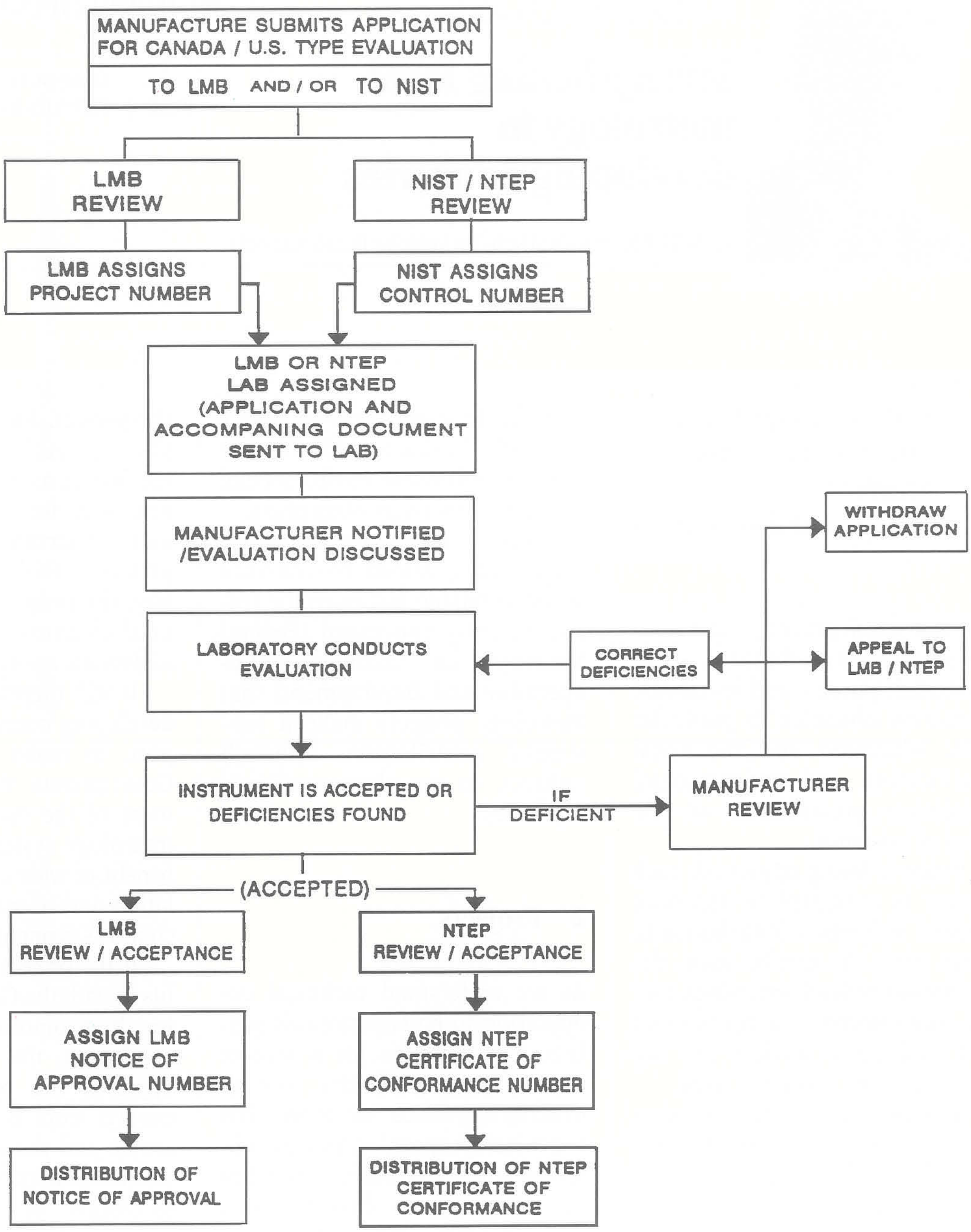
III. OWM assigns an NTEP control number and the LMB assigns a project number.

IV. The application, drawings, operating instructions, brochures, etc. are sent to the assigned laboratory and the manufacturer is notified.

V. The laboratory conducts the type evaluation. As a result of the evaluation, the instrument is either accepted or found to be deficient in meeting all requirements. The manufacturer may either correct deficiencies, withdraw the application, or appeal the decision of the laboratory (extremely rare).

VI. When the laboratory determines that the instrument has met all Canada and U.S. requirements, the completed report form, performance data, performance charts, etc. are sent to NTEP and LMB administrators. Each country then reviews the evaluation results and makes the final determination of

CANADA / U.S. TYPE EVALUATION PROCESS



compliance. It is possible for an instrument to be accepted by one country and rejected by the other.

VII. The final step is the preparation, issuance and distribution of the NTEP certificate of conformance in the U.S. and the preparation, issuance and distribution of the LMB notice of approval in Canada.

U.S. participation in the OIML Certificate System

The Canada/U.S. type evaluation venture has been a success and the U.S. is now preparing to participate in the OIML certificate system through NTEP. NTEP expects to perform complete OIML R 76 and R 60 tests in order to issue OIML certificates. It should be noted that the U.S. Handbook 44 does not require all R 76 and R 60 disturbance tests, which are not new to international manufacturers in the U.S., but which are new to the U.S. type evaluation program.

The Canada/U.S. mutual recognition effort will continue to improve our type evaluation program in the U.S, and we believe that the OIML Certificate System will do the same. ■

METROLOGICAL INFRASTRUCTURES

METROLOGICAL ACTIVITIES IN DEVELOPING COUNTRIES

23–24 OCTOBER 1995
BEIJING, PEOPLE'S REPUBLIC OF CHINA

Strengthening legal metrology in developing countries

E. SEILER, Physikalisch-Technische Bundesanstalt

1 Legal metrology in the context of the German Government's development cooperation

German development cooperation is concentrated on three key areas: combating poverty and its causes; promotion education, in particular basic education and vocational qualification; and environmental protection preservation of the bases of existence.

Prior to being approved, each project is evaluated to ascertain whether it makes a contribution to these areas. As can be seen, the promotion of legal metrology and the establishment of verification and calibration services are not included in the above key areas.

Despite this, in the past years the PTB was increasingly entrusted with the implementation of projects aimed at promoting metrology. This is not in contradiction to the official strategy of the German development policy. It proves, however, that the PTB has succeeded in making those responsible aware of the importance of a well-ordered metrology system for the economic and social development of a country.

These interrelations are evident particularly in applied metrology. The problem is to make it clear to the political decision-making bodies that a functioning metrological infrastructure is necessary for trade, business, industry, the public health sector, environmental protection and many other areas.

Intensive discussions for a long period have helped to convince decision-making bodies in the federal ministry concerned (Federal Ministry for Economic Cooperation and Development) that metrology projects make a substantial contribution, although indirect, to the abovementioned objectives.

2 Projects

As we understand technical cooperation to be *help towards self-help,* the initiative for a project must be taken by the country desiring assistance. We expect that a project proposal states an objective and, if possible, describes concrete measures through which this objective can be reached. Figure 1 shows schematically the development of a project.

The project proposal will usually be drawn by the institution responsible for the field of metrology. In a second step, this institution must convince the national ministry concerned of the project's eligibility for promotion. As the idea for the project is usually developed by metrology experts, they will also have to find the political arguments in support of the project. Further, the national planning authority must classify the project as being important and necessary for economic development. After having classified the project in this way, it will have to pass the proposal on through official channels, i.e. via Germany's diplomatic agency in the country.

It will therefore be the task of developing countries seeking support, to make it clear to their Governments that the improvement of the metrology and legal metrology systems will be to the benefit of wide circles of the population and of many sectors of the country's economy.

If the project is convincing and fits in with the German programme for the promotion of the country concerned, the PTB is asked to appraise the project. It selects experts from both the metrology sector and the sector of development economics who check the suitability of the project and whether the prerequisites for its realization are given.

To begin with, the special services required in the specific country must be determined, as well as which services can be rendered by the organization responsible for this sector and which contributions from the German and other sides are required for a successful implementation of the project. The appraisal usually ends with an objective-oriented project plan in which representatives of the bodies involved in the project and of the respective country cooperate.

The PTB then submits to the BMZ (Federgal Government office) a project appraisal report, which, if favourable, comprises an offer for project implementation. The BMZ evaluates the results of the appraisal and decides on the eligibility for promotion. If the decision is positive, the Federal Republic concludes an agreement under international law with the government of the partner country. The PTB is then entrusted with the implementation of the German project contribution. If this is not feasible with the PTB's own staff, it enlists the services of experts from other institutes, especially those of German verification authorities.

During the implementation phase, PTB and BMZ check whether the project runs according to plan or whether modifications are necessary. After conclusion of the project, the proper use of the funds and the achievement of the objective are checked.

Although the conditions may differ from one country to the other, the following kinds of project contributions can generally be identified, and are weighted according to the country's specific needs and distributed among the sectors of metrology, standardization, testing and quality management:

- Consulting services
- Basic and advanced training
- Supply of equipment, technical literature and written standards
- Calibrations and comparison measurements
- Accreditation of calibration laboratories

The advice given concerns:

- the planning and construction of laboratories and the installation of engineering facilities,
- the equipping with instruments,

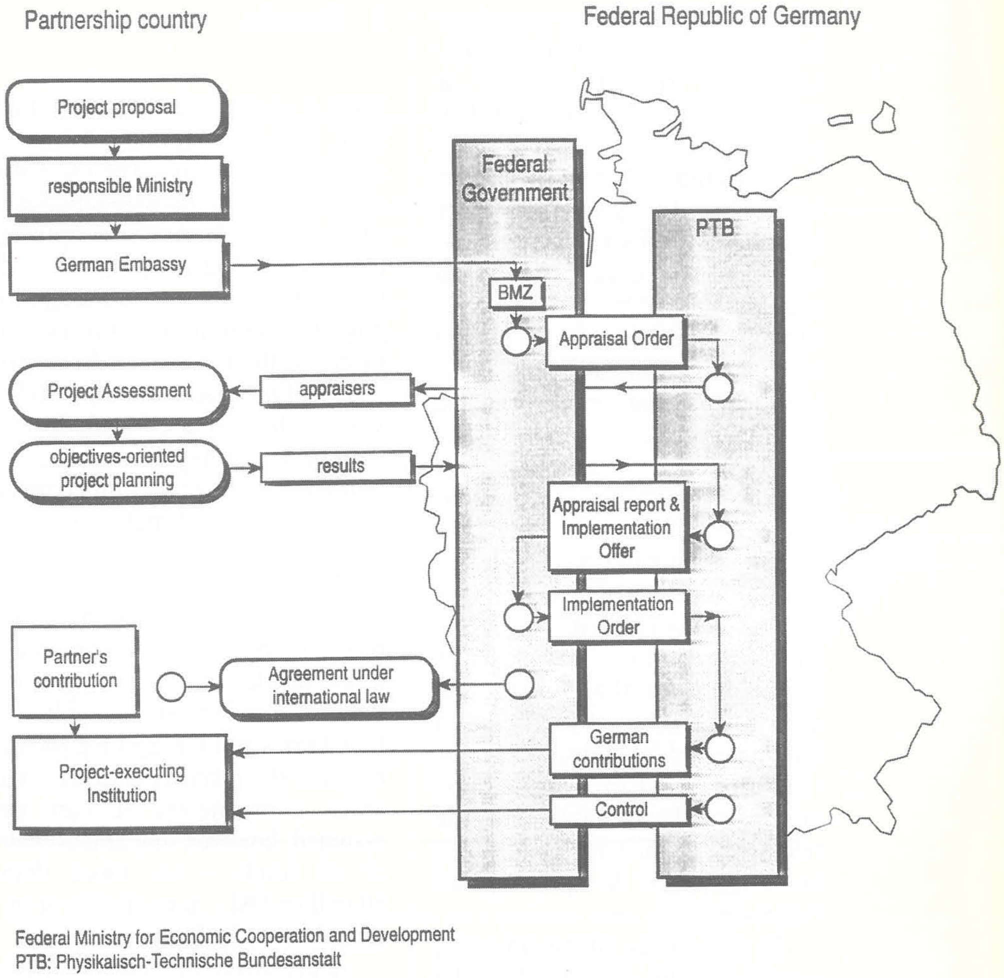


Fig. 1 Development of a German project for developing countries.

- recommendations with regard to laws, ordinances, technical rules, written standards,
- preparatory work in order that services can be rendered,
- making industry, economy, political decision-making bodies and the public sensitive to the importance and benefits of a technical infrastructure,
- the establishment and equipping of libraries and information centres,
- programs for basic and advanced training,
- the solution of special problems.

Consulting services are rendered by long-term and short-term experts in the respective country and from the Federal Republic by the project-executing agencies. Basic and advanced training tailored to future needs of the partner institutes' staff members is the key to project success. It is necessary to impart knowledge so that partners can solve problems independently before prerequisites for further development can be given.

To reach this aim, a one-year specialized training program in partner organizations in the Federal Republic is usually offered to staff members who will later assume important functions in their countries. Training is also offered in the respective country by long-term and short-term experts. Additional special courses or seminars are also organized if necessary.

A substantial part of the project funds is used to equip the partner institutes with the necessary measuring and testing facilities, which are calibrated at the PTB, if necessary. Technical literature, testing instructions, standards and other technical rules are made available from project funds as well. They are translated into a language frequently used or into the language of the country, if necessary.

The contributions of the German side are set against the commitments entered into by the recipient country. It is usually responsible for the construction and maintenance of the required buildings and laboratories and for the recruitment of staff; it must create the legal bases and the necessary framework conditions; and it must bear the operating and follow-up costs.

In view of the follow-up costs, which may be considerable, the project design must be such that the financial burden can be borne by the partner country. Appraisers and consultants therefore bear special responsibility during project planning and implementation; they must carefully check which measures are necessary for the country's needs and which can be financed continually for optimum use of limited funds.

Implementation takes place in several phases, each two to four years long. Even after the official promotion has come to an end, the PTB does not break off contact to the partner institutes. By means of audits and comparison measurements, the PTB promotes the recognition of the younger partner institutes on the international level. Joint research and development tasks form an essential part of the cooperation once the project has been concluded.

3 Results

Table 1 shows the countries that have been assisted by bilateral supporting measures. The intensity and the extent of the assistance can vary, ranging from the supply of used measuring instruments and instruction in how to use them, to projects with terms of 10 years and more, with a German financial contribution of several million DM. Within the scope of such large-scale projects, legal metrology is promoted together with other areas such as industrial metrology and standardization.

The overall expenditure in DM for the technical cooperation projects that were implemented in the last few years are shown in Fig. 2. As can be seen, not all funds have been spent for legal metrology because the projects also covered other components. It can be assumed, however, that at least half of all funds – i.e. more than 50 million DM – have directly or indirectly benefited legal metrology.

Apart from bilateral projects implemented in more than 20 countries, a number of workshops were held on various legal metrology subjects. A preferred place for workshops is Munich, the seat of the *Deutsche Akademie für Metrologie* (DAM = German Academy for Metrology) which also provides the theoretical training of German verification officers.

Table 1 Countries supported by PTB's technical cooperation projects in the field of legal metrology.

Argentine	Korea (Rep.)
Brazil	Mexico
Bulgaria	Mongolia
China	Panama
Columbia	Peru
Costa Rica	Portugal
Ecuador	Saudi Arabia
Egypt	Slovenia
Guatemala	Thailand
India	Turkey
Indonesia	Uruguay
Jamaica	Venezuela

Table 2 gives an overview of the subjects of the workshops held in Munich, and the number of participants. The workshops were mainly held in English but there were also some held in Latin America in German, with translation into Spanish. Furthermore, the *Bayrisches Landesamt für Maß und Gewicht* (Bavarian Authority for Weights and Measures) and the

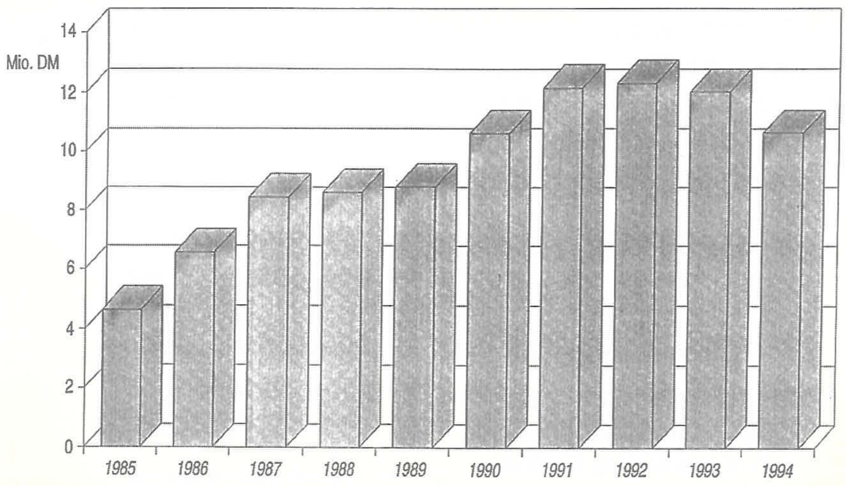


Fig. 2 Expenditures for PTB's technical cooperation projects.

Table 2 Workshops conducted in München, Germany at the German Academy of Metrology.

Subject	Date	Participants	Countries
Medical Measuring Instruments	15–26 April 1991	20	14
	17–28 Aug. 1992	19	18
Verification of Weighing Instruments	19–28 June 1991	22	19
	22 June–23 July 1992	19	19
	2–13 August 1993	20	20
Volume Determination of Fixed Storage Tanks	3–14 July 1995	20	20
Gesetzliches Meßwesen in der Fertigungsmeßtechnik	21–25 Nov. 1994	21	China
Das gesetzliche Meßwesen	2–10 Nov. 1995	20	Middle and Eastern Europe

Table 3 Training imparted by the German Academy of Metrology, München in the field of legal metrology.

Country	No. of trainees
Turkey	10
India	10
Korea	1
Malaysia	1
Bangladesh	1
Madagascar	1
Burkina Faso	1
Portugal	2
China	2
Thailand	2
Jamaica	1
Tunisia	1
Guatemala	2
Argentine	4
Mexico	1
Columbia	3
Tanzania	1

Munich Verification Office provide advantageous conditions for becoming acquainted with practical verification. Table 3 shows the number of trainees from different countries that have been trained in Munich.* We define and publish participation criteria and make the admission of an applicant dependent on compliance with these criteria because we seek to ensure that the participants put the knowledge and skills they acquire within the scope of the workshops to good use in their home countries.

As witnessed from the reactions of the participants who subsequently request testing instructions or assistance in the selection of measuring and testing instruments, the work is often intensified after the workshops.

* *I should like to thank all German colleagues from the field of verification for actively supporting our programs and imparting their knowledge and experience to colleagues from other countries. They do so on their own initiative without any financial assistance from PTB projects. I also wish to mention that a German expert gave advice to the Caribbean states in August and September 1995 in how to organize, coordinate and extend legal metrology in that region.*

4 Outlook

The following conclusions can be drawn with regard to technical cooperation projects:

1. The projects have led to the substantial strengthening of legal metrology systems of the countries promoted by such projects.
2. The project measures have essentially concentrated on the legal metrology area of "consumer protection".
3. The measures have contributed to the expansion of OIML and support for its activities.

Future activities can serve to pursue the following objectives: to extend cooperation to other countries; to extend cooperation to other areas of legal metrology; or a combination of these two.

What other areas of legal metrology come into question? In its strategy paper, the OIML gives four areas: trade, safety, environment and health. In the author's opinion, the area of environment must be given highest priority because we are well on the way to destroying our own bases of life. Effects such as the pollution of air due to traffic or the degradation of the quality of our drinking water due to the waste and residues of industry and agriculture can already be felt.

Much more dramatic effects are to be expected from extensive climatic changes which, for the first time in the history of the Earth, are caused by human beings. But what contribution can legal metrology make to environmental protection? There are several answers to this question. The OIML strategy paper gives the following description of the tasks:

Legal metrology is applied in fields where conflicting interests may exist with regard to measurement results or where incorrect measurement results may adversely affect individuals or the society.

This means that legal metrology will be challenged if conflicting interests exist. This is typical of environmental problems because the actions of individuals or of small groups may have negative consequences for persons not involved. For example, traveling by car produces exhaust which will debase the quality of the air for many other persons.

In order to limit the harmful effects from what cannot be avoided by the state of the art, many countries have enacted regulations on the maximum permissible concentrations of various exhaust components such as CO, CO_2 or nitrogen oxides. OIML has already published a number of International Recommendations for environmental protection (Rs 82, 83, 99, 100, 112, 113, 116 and D 22). Although it is necessary to extend cooperation to these areas, many countries neither know the legal commitment to comply with limiting values nor have regulations prescribing that limiting values be measured and offences punished. A solution to this problem is necessary to make efforts to change the situation. This objective requires the assignment of experts from the field of legal metrology in particular. The creation and development of the legal bases must not take second place to the technical aspects of the enforcement of the laws and ordinances.

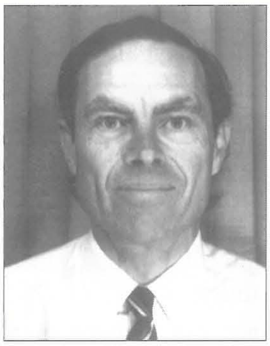
Members of OIML are not only entitled, but committed – though only in a moral sense – to enforce International Recommendations in their countries. When the governments of the OIML member countries signed the convention, they committed themselves to do so, and they should time and again be reminded of this commitment.

The work of the OIML for environmental protection would be of no account if it was allowed for in national laws only in a few countries. In this respect much is to be done by the Member States.

Neither should the OIML as an organization let up; it should redouble its efforts to prepare further recommendations for environmental protection. Environmental protection is a global task and can be effectively fulfilled only through international efforts. For this purpose, international conferences have adopted international conventions. Modest partial success, such as the reduced use of the fluorocarbons which destroy the ozone layer, has been achieved. But there is no doubt that further measures must follow.

The OIML can and must prepare further Recommendations, and it is the task of its Members to translate these Recommendations into national law. In the future, legal metrology and OIML must take over tasks which ensure, for example, compliance with international agreements on environmental protection and standards on environmental management.

As has been mentioned at the beginning, the preservation of the natural bases of life is a focus of the German development cooperation. Whether projects will be carried out by PTB in the field of legal metrology (including measures for environmental protection) will depend on the initiative taken by developing countries, who are encouraged to be active and take advantage of the technology and knowledge PTB has to offer. ■



METROLOGICAL INFRASTRUCTURES

METROLOGICAL ACTIVITIES IN DEVELOPING COUNTRIES

23–24 OCTOBER 1995
BEIJING, PEOPLE'S REPUBLIC OF CHINA

Legal metrology – training requirements

C. B. ROSENBERG, National Weights and Measures Laboratory, United Kingdom

1 Background

Legal Metrology may be briefly defined as "the process of making measurements under conditions dictated by statute". For these statutory conditions to be realised there has to be some underlying metrological infrastructure of demonstrable integrity, and personnel capable of making the measurements and maintaining the infrastructure.

The people who perform legal metrology as part of a service at the point of delivery are usually from a wide variety of backgrounds and are performing measurements as part of their day-to-day jobs. From the trader who weighs out produce to the engineer who performs an exhaust emission analysis they will be trained accordingly. By and large these people and their techniques are not of interest except to the inspector or auditor who wishes to ascertain whether appropriate and legal equipment is being used and operated correctly.

What interests governments, the associations of users of metrological equipment and the representatives of those affected by legal metrology (e.g. consumer associations) is the underlying infrastructure. These organisations must have confidence that the measurements are being made in accordance with the law and this involves a whole raft of approval schemes, standards and traceability which, for the whole system to function properly, must have high integrity. This paper considers the training requirements of the people engaged in the maintenance of the legal metrology infrastructure.

Most countries with developed infrastructures operate some sort of type approval and verification process for equipment such as electricity meters, taxi meters, weighing machines, fuel dispensers, etc. That is where a measuring instrument is relatively complex, and perhaps subject to a wide range of operating conditions and environments; it is considered necessary for the designs to be approved and certificated by independent engineers. This highlights the need for competent engineers in legal metrology to assess designs often against very complicated and wide ranging criteria such as OIML R 76 for nonautomatic weighing instruments.

The verification function can usually be carried out by someone who is less of a specialist than the type approval engineer but none the less who has an appreciation of testing to specifications and metrology techniques. For surveillance and enforcement work, the personnel must not only be able to appreciate the technical functions of equipment but also have the skills to deal with the users in situations where compliance with the law may be in doubt.

Finally, all measurements rest on traceability to national and international standards; such traceability must be carried by an unbroken chain of intercomparisons. Each link in the chain must be of high integrity and involves the intervention of an operator at some level of expertise. Clearly, the requirements for a metrologist calibrating an E_2 weight against an E_1 weight are very different from those required by the inspector who carries out a surveillance check on a street trader.

2 Training requirements – identification

For a person to operate effectively in any or all of the roles discussed above, he must have adequate competence and a mix of knowledge and ability to apply operational skills. The first priority in assessing training requirements is to identify the need. With the roles as discussed above the main areas are:

- Type approval engineer
- Verification officer
- Surveillance inspector
- Metrologist for maintenance of standards

For all aspects of metrology work there is a core of knowledge and understanding which forms the foundation on which specialisms are built. In the UK this core has traditionally been encapsulated in a formal training programme resulting in the award of a Diploma in Trading Standards. To ensure the right calibre of people the entry requirements are set high, with "A" levels or a degree being typical.

More recently the routes to qualification have broadened with the introduction of specialist university degrees in Consumer Affairs, followed by endorsements in such areas as professional practice. The principle has always been to produce broad-based practitioners who would be effective Weights and Measures Inspectors soon after being hired by a Trading Standards Department.

The exact need will depend on the legal metrology regime existing in the nation requesting training. For example, it may be that no structure exists and what is required is assistance in developing weights and measures legislation in concert with training personnel to form the infrastructure. Alternatively there may already be a well-developed infrastructure requiring an upgrading of the personnel to develop confidence with modern metrological apparatus.

The second priority in assessing training requirements is to ensure that the recipients can benefit from such training and have the potential to become competent. This means selecting people of an appropriate calibre. Constraints on manpower resources usually mean that a compromise has to be obtained and that all personnel will not necessarily be trained in the same way nor to the same level. However, if skilled people are selected for key posts an investment in training can be enhanced by the people so trained acting in a supervisory way and passing on expertise through internal training.

3 Training requirements - meeting the need

Providers

Selection of a provider of training involves the following factors:

- Appropriateness of what is being offered
- Price
- Availability in the required timescale
- Geographic location
- Experience and reputation of provider

For the first point it is a matter of matching the requirement to the offer from the providers. For technical metrology training the provider may be a rather different organisation from one providing the necessary training for writing effective legislation.

Method

A competent practitioner will possess the knowledge to be able to adapt and apply that knowledge in addition to operational skills. He must be educated and trained. In many cases what is to be achieved must be done in a relatively short time; it is therefore important for the teaching/training to be carried out effectively.

There is also the question of availability of the staff to be trained. Seldom is it convenient or possible to release a large number of staff on extended training courses. For a developing country the options are:

- training in own country or overseas;
- group or selected individual training;
- a combination whereby users from different countries club together to obtain the best efficiency in training.

There are advantages and disadvantages with each option. In the first option (in own country) advantages are:

- generally a reduction in travel costs;
- participants are more relaxed and receptive by being in their home country;
- the trainer can acquire first-hand knowledge of the situation and the requirements of the trainees.

The disadvantages are:

- it may not be easy for participants to get away from the pressures of their routine work;
- trainees do not receive first-hand knowledge of another country's organisation to enable them to compare and contrast systems.

The arguments for and against going overseas are more or less the opposite of the above.

In the second option, the argument for training a small number of the best personnel rather than attempting to bring all to a common level simultaneously seems compelling. The people with a lower educational level can then pass on their knowledge and skills in their own country at a slower pace and, if required, in their native tongue.

The third option of bringing together several countries in a location close to all and bringing out the provider represents a compromise which could keep costs down while improving availability.

Funding

For most developing countries the cost of sending personnel overseas or of drafting in a trainer or trainers is the major stumbling block to progress. There are organisations which have funds available for such use: the World Bank, agencies of the United Nations and overseas aid agencies in individual countries. The process of receiving funding, from initial application to receipt of grant, is generally quite long; it is therefore essential to plan ahead and anticipate the level of expenditure in order to make an early bid.

4 Future trends

In countries with long histories of legal metrology the infrastructure has always ranked alongside provision of policing and other community services. Traditionally these functions have been carried out by central or local government personnel employed directly. In recent years there has been a significant move away from directly-employed labour towards contracting out functions to the private sector, with local or central governments setting the standards and meeting the costs.

There is also evidence of a splitting up of the various roles in legal metrology work to permit less qualified people to assume some of the work, resulting in fragmentation and decreasing coordination. Some benefits of a common and minimum level of competence are being lost but savings in staff costs may be obtained.

Another significant move in the last 10 years has been the introduction of strict "quality" methods and procedures from industrial manufacturing and metrology into legal metrology. The impact of third party accreditation on the providers of measuring equipment and the users has not yet been fully felt.

It is uncertain where legal metrology will be in the future; an educated or inspired guess should be made, with training designed with regard to that guess. The view of the OIML was determined recently, resulting in the publication of a document on the long-term policy of the Organisation.

Quality systems will play an increasing role in legal metrology and the trend towards empowering organisations to operate independently within an enforced framework will continue. This suggests that the legal metrology enforcement practitioner of the future may be 50 % quality auditor and 50 % metrologist.

The significant increase in the use of high technology, particularly software and the integration of measuring with other functions such as stock control etc. has made it much more difficult for anyone not directly involved with the development of a piece of equipment to be able to assess it. The indications are that proof of integrity will be sought within the quality control systems of the organisations concerned.

5 Conclusions

First and perhaps most importantly this paper recommends a systematic, rational and planned approach to determine the requirements and implementation of a training programme. The steps are generally:

- to define the task in the context of the existing or planned legal metrological regime;
- to select a provider(s) to ensure best effectiveness and efficiency;
- to plan well ahead to make sure funding is available in time;
- to carry through the programme; and
- to assess the results and implement any spin-off.

Secondly, as part of the task definition, it will be necessary to anticipate the future. Otherwise, there is the risk that what has been learnt will quickly become obsolescent. To minimise the risk the best approach is to select the skills and knowledge with the broadest possible applicability.

Lastly, it should be remembered that the acquisition of training is an investment analogous to investing in a piece of equipment. Appropriateness, cost, and longevity all play roles in the skills imparted to staff; training must therefore be recognised as an asset. ■

activities
OIML
activités

Metrological cooperation for a workshop on controlling prepackages

The German Academy of Metrology (DAM) collaborates with the *Physikalisch-Technische Bundesanstalt (PTB)* and the *Organisation Internationale de Métrologie Légale (OIML)* in technical cooperation projects. Following the success of the workshop "Volume Determination of Fixed Storage Tanks" that took place in Munich in 1995, a workshop entitled "Checking the net content in prepackages" was held in Munich, 2–10 May 1996 and was jointly organized by PTB, DAM and OIML.

The main objective of this workshop was to familiarize inspectors of national legal metrology services with regulations, measuring principles and statistical methods and test procedures regarding prepackages (OIML and EC requirements for net content and labelling of prepackages).

Lectures on measuring principles, measuring and statistical methods, types of measuring instruments to be used, international, EC and German rules, as well as practical work at the verification office and on site (with importers and manufacturers) provided an excellent opportunity for participants to become acquainted with most of the metrological aspects of prepackage controls.

The teaching staff was composed of specialists from PTB, OIML and DAM who were ready to discuss problems the participants may face in their countries. In addition, manufacturers of non-automatic weighing instruments presented their software for prepackage controls.

Participants of the workshop "Checking the net content in prepackages", which was held 2–10 May 1996 in Munich *(from left to right):* Dr. Wallerus, DAM - Mr. Vichenkov, BIML - Mr. Rank, DAM - Mr. Noorma, Estonia - Mr. Brus, Slovenia - Mr. Schmalhofer, Hungary - Dr. Nguyen, Vietnam - Mr. Ramful, Mauritius - Dr. Geller, LMG - Mr. Kamau, Kenya - Mrs. Lisowska, Poland - Mr. Muryanto, Indonesia - Mr. Dimitrov, Bulgaria - Mrs. Bouaziz, Tunisia - Mr. Popa, Romania - Ms. Habaybeh, Jordania - Mr. Sinyangwe, Zambia - Mr. Sambanthan, Malaysia - Mr. Jiang, China - Mr. Teklehaimnot, Ethiopia - Mr. Dervishi, Albania - Mr. Tedla, Eritrea - Mr. Er, Turkey - Mr. Breuer, LMG - Mrs. Kuzmanovska, Macedonia - Dr. Bencic, Croatia - Mr. Gába, Czech Republic.

Workshop participants gain practical experience for checking prepackages.

Participants were selected from countries already having legal requirements for prepackages or starting work in this field, with the number being limited to 22 in order to ensure an effective performance, particularly regarding the practical part of the workshop.

The participants, who expressed that the knowledge gained at the workshop would be very useful for upgrading the quantity and quality of prepackage controls in their countries, represented the following countries: Albania, Bulgaria, China, Croatia, Czech Rep., Eritrea, Estonia, Ethiopia, Hungary, Indonesia, Jordania, Kenya, Macedonia, Malaysia, Mauritius, Poland, Romania, Slovenia, Tunisia, Turkey, Vietnam and Zambia.

The DAM also organized a welcome dinner, a Bavarian evening, and a city tour in Munich. BIML expresses its thanks to the organizers, and in particular: Dr Seiler, Head of the technical cooperation group in PTB, Dr Wallerus, Director of DAM, Mr Breuer, Director of the Bavarian Central Verification Office, and Messrs Geller, Hempel, Eggers, Seidl, Rutte, Luy and Rank, and Mrs Schröter, for the quality of this workshop.

Workshop program

Official welcome

Presentation of the workshop concept

Introduction of participants and lecturers

Tasks and activities of the OIML Development Council

Legal metrology in Germany and Europe
- Motives for the introduction of regulations regarding prepackages
- Prepackages as part of our legal system
- Infrastructure of legal metrology in Germany
- Enforcement bases (checks, fees; punishment of offenses)

Basic statistics: statistical distributions, mean value, standard deviation, confidence interval, basis requirements for statistical tests

Prepackages
- Bases, definitions
- Legal bases in Germany and EC
- OIML Recommendation

Labelling of prepackages
- Net contents, basic price, information by the manufacturer
- EC marking
- Differences between German regulations, EC regulations and OIML Recommendations

Requirements for net contents: length, base, number of pieces, mass, volume, varying nominal quantity

Test methods, sampling schemes: operating characteristic, single sampling scheme / double sampling scheme

Prepackage control by public authorities, checking of prepackages in trade
- With the importer
- With the manufacturer (commodities are taken out of stock, out of production)

Measuring containers / test by templates

Determination of density
- By using displacement method for lacquers, bottle used as pycnometer, metal pycnometer, glass pycnometer, densimeter, DMA (flexural mode method)
- Determination of density of aerosols

Determination of density (practice)

Interval controls by the manufacturer
- Obligation to keep records
- Suitable measuring instruments

Prepackage control with an importer

Prepackage control at 2 breweries
- Taking of commodities out of production
- Checking of records

Prepackage controls at the Munich Verification Office
Test of commodities:
- bottles filled with wine, beer or mineral water
- solid commodity (e.g. noodles)
- sour canned goods (determination of drip weight)

Discussion on prepackage controls Presentation of weighing instruments and software for prepackage control with practical lectures

Presentation of weighing instruments and software for prepackage control with practical lectures

OIML: introduction into the tasks of OIML, relevant OIML recommendations, members, documents

Evaluation and official farewell

OIML activities MEETINGS

TC 9

Instruments for measuring mass and density

Secretariat: U.S.A.

The *Physikalisch-Technische Bundesanstalt* hosted a meeting of OIML TC 9 which was held 20–22 May 1996 in Braunschweig.

Chairman: Mr O. Warnlof, U.S.A.

Participation: 30 delegates representing 13 P-member countries and CECIP; Ph. Degavre, BIML.

Main points

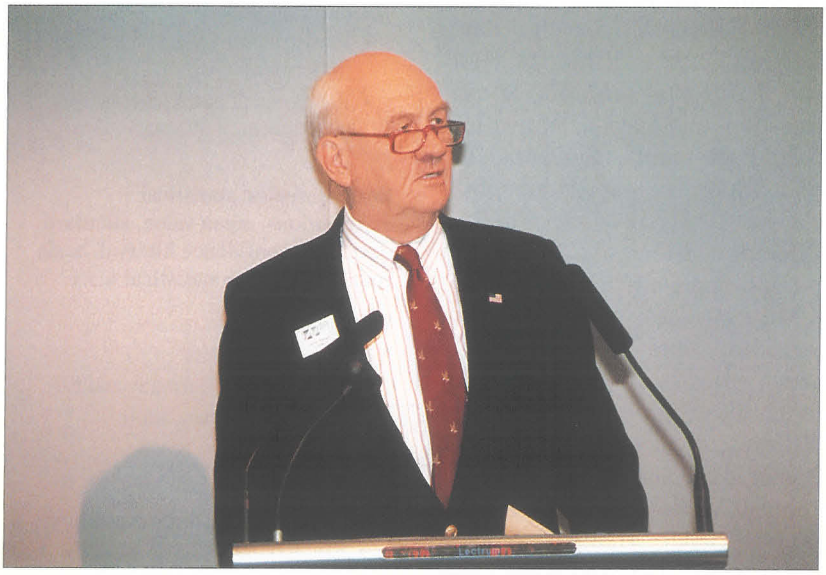
- Load cells: draft revision of OIML R 60

  A draft revision of OIML R 60 was distributed in Feb. 1996 with 11 countries or organizations (CECIP) sending their votes and comments on this draft during spring 1996. The main objectives of the meeting was to discuss these comments, together with the replies of the secretariat, and to analyze the problems that were encountered in the draft with particular regard to the following:

  - the reference line of the error envelope;
  - the definition of a family of load cells; only certain load cells are tested for the type evaluation of the entire family; interpolation and extrapolation rules must be explained for clarification;
  - additional classifications characterizing load cells used in multi-interval and multiple range nonautomatic weighing instruments;
  - revision of humidity testing for harmonizing and clarifying purposes (in particular for load cells marked NH that are used as module in nonautomatic weighing instruments conforming to OIML R 76 in which a humidity test is required).

- A clear majority of the representatives present at the meeting was obtained for a short draft Amendment to OIML R 60 concerning urgent changes that are needed for harmonizing laboratory practices in testing load cells, particularly for applying the OIML Certificate System. The text of this draft Amendment is expected to be edited by a small group of volunteering countries coordinated by Canada, and then transmitted to the secretariat. By the end of June 1996, the draft will be circulated for comments and votes with the objective of submission to a CIML vote next year.

- This meeting was chaired by Otto Warnlof, who informed the international working group of his intention to retire soon. We therefore take this opportunity to thank our colleague who become a friend for everyone and who participated actively or chaired so many OIML meetings that a complete article



Otto Warnloff, Technical Advisor for the Office of Standards Services at NIST (USA) chairs his last OIML meeting (TC 9) before taking his retirement after more than 20 years of active participation in OIML activities.

would be needed for giving this history. During more than twenty years, he collaborated within OIML technical structures and served legal metrology in various fields. Be sure, Otto, that we will miss you, with your competence, your friendship, and your humor. We wish you a happy retirement.

Contact information:

Mr Otto WARNLOF
Technical Advisor
Office of Standards Services
Building 417, Room 121
National Institute of Standards and Technology
Gaithersburg, Maryland 20899
United States of America

Tel: 1-301-975 40 26
Fax: 1-301-963 28 71

TC 9

Instruments de mesure des masses et masses volumiques

Secrétariat: États-Unis d'Amérique

Sur invitation de la *Physikalisch-Technische Bundesanstalt,* le comité technique OIML TC 9 a tenu une réunion à Braunschweig du 20 au 22 mai 1996.

Président: M. O. Warnlof, États-Unis d'Amérique

Participation: 30 délégués représentant 13 pays membres-P et le CECIP; Ph. Degavre, BIML.

Points principaux

- Cellules de pesée: projet de révision de OIML R 60

  Un projet de révision de OIML R 60 avait été distribué en février 1996; onze pays et organisations (CECIP) avaient envoyé leurs votes et commentaires sur ce projet au printemps 1996. Les principaux objectifs de cette réunion étaient la discussion de ces commentaires et des réponses du secrétariat, ainsi que l'analyse des problèmes rencontrés à la lecture de ce projet, en particulier en ce qui concerne les points suivants:

  - la droite de référence de l'enveloppe d'erreur;
  - la définition d'une famille de cellules de pesée; seulement certaines cellules de pesée sont essayées lors de l'évaluation de modèle de la famille toute entière; des règles d'interpolation et d'extrapolation doivent être expliquées en vue d'une clarification;
  - des classifications supplémentaires caractéristiques des cellules de pesée utilisées dans des instruments de pesage à fonctionnement non automatique à échelons multiples et à étendues multiples;
  - révision des essais d'humidité dans un but de clarification et d'harmonisation (en particulier pour les cellules de pesée marquées NH qui sont utilisées comme module dans des instruments de pesage à fonctionnement non automatique conformes à la Recommandation OIML R 76 dans laquelle un essai d'humidité est requis).

- Une nette majorité des représentants présents à la réunion a été obtenue pour un court projet d'Amendement à OIML R 76 relatif à des modifications urgentes nécessaires pour harmoniser les pratiques des laboratoires pour l'essai des cellules de pesée, en particulier pour l'application du Système de Certificats OIML. Un petit groupe de pays volontaires coordonnés par le Canada va éditer le texte de ce projet d'Amendement et le transmettra ensuite au secrétariat; le projet sera alors distribué fin juin 1996 pour commentaires et votes avec pour objectif sa soumission au CIML l'année prochaine.

- Cette réunion a été présidée par Otto Warnlof qui a informé le groupe de travail international de son intention de bientôt prendre sa retraite. Nous profitons donc de cette opportunité pour remercier notre collègue qui était devenu un ami pour tous et qui a participé à de si nombreuses réunions OIML, ou les a présidées, qu'il faudrait un article complet pour écrire cette histoire. Pendant plus de vingt ans, il a collaboré au sein des structures techniques de l'OIML et a servi la métrologie légale dans de nombreux domaines. Sois certain, Otto, que tu nous manqueras, avec ta compétence, ta gentillesse et ton humour. Nous te souhaitons une heureuse retraite.

Contact pour information:

M. Otto WARNLOF
Technical Advisor
Office of Standards Services
Building 417, Room 121
National Institute of Standards and Technology
Gaithersburg, Maryland 20899
États-Unis d'Amérique

Tél: 1-301-975 40 26
Fax: 1-301-963 28 71

TC 9/SC 2

Automatic weighing instruments

Secretariat: United Kingdom

The *Physikalisch-Technische Bundesanstalt* hosted a meeting of OIML TC 9/SC 2 which was held 22–24 May 1996 in Braunschweig.

Chairman: Mr I. Dunmill, NWML

Participation: 31 delegates representing 15 P-member countries and CECIP; Ph. Degavre, BIML.

Main points

- In-motion road vehicle weighing instruments – first committee draft

  The 1st committee draft taking into account the decisions taken during the last meeting in Paris was circulated in Feb. 1996. Twelve countries and CECIP made comments; the secretariat circulated them with his replies; the main points discussed during the meeting were:

  - Scope of Recommendation
  - Maximum permissible errors for weighing-in-motion (total vehicle weight, axle and/or axle group weights)
  - Definition of references and requirements for the application of maximum permissible errors
  - Minimum capacity, minimum axle load or axle group load depending on the scale interval and the error regime
  - Test procedures (particularly reference vehicles to be used for in-motion tests)

- A 2nd CD should be prepared by the secretariat within three months. Another meeting is expected to be organized for obtaining a general consensus, at least on the principles of this Recommendation.

Contact information:

Mr I. Dunmill
National Weights and Measures Laboratory
Stanton Avenue
Teddington, Middlesex TW 11 OJZ
United Kingdom

Tel: 44 81 943 72 74
Fax: 44 81 943 72 70

TC 9/SC 2

Instruments de pesage à fonctionnement automatique

Secrétariat: Royaume-Uni

Sur invitation de la *Physikalisch-Technische Bundesanstalt*, le sous-comité technique OIML TC 9/SC 2 a tenu une réunion à Braunschweig du 22 au 24 mai 1996.

Président: M. I. Dunmill, NWML

Participation: 31 délégués représentant 15 pays membres-P et le CECIP; Ph. Degavre, BIML.

Points principaux

- Instruments pour le pesage en mouvement des véhicules routiers – premier projet de comité

  Le premier projet de comité tenant compte des décisions prises lors de la dernière réunion à Paris avait été distribué en février 1996. Douze pays et le CECIP ont envoyé leurs commentaires. Le secrétariat les a distribués avec ses réponses; les points principaux discutés pendant la réunion étaient:

  - Objet de la Recommandation
  - Erreurs maximales tolérées pour le pesage en mouvement (poids total du véhicule, poids des essieux et/ou des groupes d'essieux
  - Définitions des références et des exigences pour l'application des erreurs maximales tolérées
  - La capacité minimale, la charge minimale des essieux ou des groupes d'essieux en fonction de l'échelon et des régimes d'erreur
  - Procédures d'essai (en particulier les véhicules de référence à utiliser lors des essais en mouvement)

- Un deuxième projet de comité sera préparé par le secrétariat dans les trois mois. Une autre réunion sera nécessaire afin d'obtenir un consensus général, au moins sur les principes de cette Recommandation.

Contact pour information:

M. I. Dunmill
National Weights and Measures Laboratory
Stanton Avenue
Teddington, Middlesex TW 11 OJZ
United Kingdom

Tél: 44 81 943 72 74
Fax: 44 81 943 72 70

certificate system
OIML
système de certificats

REGISTERED OIML CERTIFICATES – *CERTIFICATS OIML ENREGISTRÉS*

1996.03 – 1996.05

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

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

▶ **Issuing authority** / ***Autorité de délivrance***

Physikalisch-Technische Bundesanstalt (PTB), Germany

R 76/1992 - DE - 93.01
Sartorius AG
Weender Landstraße 94-108, D-37075 Göttingen, Germany
BA BA 200, BA BB 200, ...

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

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

OIML Recommendation applicable within the System / Year of publication

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

Year of issue
Année de délivrance

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

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

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

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Load cells
Cellules de pesée

R 60 (1991), Annex A (1993)

▶ **Issuing Authority / Autorité de délivrance**

Ministère de l'Industrie, des Postes et Télécommunications et du Commerce extérieur - Sous-direction de la Métrologie, France

R60/1991-FR-96.01
Scaime S.A., Le bois de Juvigny, B.P. 501, 74105 Annemasse, France

Cellules de pesée à jauges de contrainte Scaime types AG1 C1,5 NH et AG2,5 C2 NH (Classe C)

▶ **Issuing Authority / Autorité de délivrance**

National Weights and Measures Laboratory (NWML), United Kingdom

R60/1991-GB-96.01
GEC Avery Ltd., Foundry Lane, Smethwick, Warley, West Midlands, B66 2LP, Great Britain

Load Cell Model No Avery T110 (Class C)

R60/1991-GB-96.02
Transdutec S.A., C/ Joan Miró 11, 08930 - Sant Adrià de Besós, Barcelona, Spain

Load Cell Model No Transdutec S.A TPP-1 (Class C)

Issuing Authority / Autorité de délivrance

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

R60/1991-NL-95.17
Precision Transducers Ltd., 7 Marken Place, Glenfield, Auckland 10, New Zealand
HPC (Classes C and D)

R60/1991-NL-95.18
HBM Inc., 19 Bartlett Street, Marlboro, MA 01752, USA
RSC (Classes C and D)

R60/1991-NL-96.01
Gefran Sensori, Via Statale Sebina 74, 25050 Provaglio D'Iseo (BS), Italy
OD (Classes C and D)

R60/1991-NL-96.02
ADOS S.r.l., Via Lazlo, 25, 20090 Buccinasco, Milan, Italy
TBX ... (Classes C and D)

INSTRUMENT CATEGORY
CATÉGORIE D'INSTRUMENT

Nonautomatic weighing instruments
Instruments de pesage à fonctionnement non automatique

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

Issuing Authority / Autorité de délivrance

Office Fédéral de Métrologie, Switzerland

R76/1992-CH-96.01
Haenni & Co. Ltd., CH-3303 Jegenstorf, Switzerland
Nonautomatic mechanical wheel load weighing instrument type WL 101 (Class IIII)

Issuing Authority / Autorité de délivrance

Physikalisch-Technische Bundesanstalt (PTB), Germany

R76/1992-DE-94.02 Rev. 1
Soehnle-Waagen GmbH + Co., Fornsbacher Straße 27-35, D-71540 Murrhardt, Germany
Nonautomatic electromechanical weighing instrument types S20-2740, S20-2760 and S20-2761 (Classes III and IIII)

R76/1992-DE-95.01 Rev. 1
Sartorius A.G., Weender Landstraße 94-108, D-37075 Göttingen, Germany
DI BC 200 and DI BE 211 (Class II)

Issuing Authority / Autorité de délivrance

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

R76/1992-NL-94.09 Rev. 1
Mettler-Toledo A.G., Im Langacher, 8606 Greifensee, Switzerland
SR and SG (Classes II and III)

R76/1992-NL-95.26 Rev. 1
Teraoka Seiko Co., Ltd., 12-13 Kugahara, 5-Chome, Otha-ku, Tokyo 146, Japan
DPS-3600 (Class III)

R76/1992-NL-95.28 Rev. 1
A&D Instruments Ltd., Abingdon Science Park, Abingdon, Oxford, OX 14 3YS Great Britain
HF-EC (Class II)

R76/1992-NL-95.29 Rev. 1
Teraoka Seiko Co., Ltd., 12-13 Kugahara, 5-Chome, Otha-ku, Tokyo 146, Japan
FX-3600 (Class III)

R76/1992-NL-95.30 Rev. 1
A&D Instruments Ltd., Abingdon Science Park, Abingdon, Oxford, OX 14 3YS Great Britain
HR-EC (Class I)

R76/1992-NL-95.31
Teraoka Seiko Co., Ltd., 12-13 Kugahara, 5-Chome, Otha-ku, Tokyo 146, Japan
DS-580 H (Class III)

R76/1992-NL-95.32
Mettler-Toledo Inc., 1150 Dearborn Drive, Worthington, OH 43085-6712, USA
Lynx (Classes III and IIII)

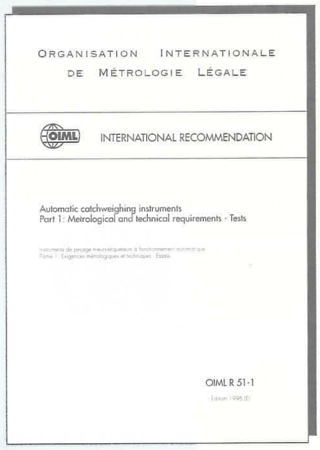
R76/1992-NL-95.33 Rev. 1
Teraoka Seiko Co., Ltd., 12-13 Kugahara, 5-Chome, Otha-ku, Tokyo 146, Japan
SM-25.. (Class III)

R76/1992-NL-95.34
Avery Berkel, Foundry Lane, Smethwick, West Midlands, B66 2LP Great Britain
$n \leq 6000$ or $n \leq 3000$ per partial weighing range, maximum of two partial weighing ranges: 6 kg $\leq$ Max ≤ 30 kg, $e \geq 1$ g (Class III)

R76/1992-NL-96.01
Teraoka Seiko Co., Ltd., 12-13 Kugahara, 5-Chome, Otha-ku, Tokyo 146, Japan
SM-80 B and SM-80 P (Class III)

NEW PUBLICATIONS
NOUVELLES PUBLICATIONS

R 120	Standard capacity measures for testing measuring systems for liquids other than water *Mesures de capacité étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau*
R 51-1	Automatic catchweighing instruments. Part 1: Metrological and technical requirements – Tests *Instruments de pesage trieurs-étiqueteurs à fonctionnement automatique* *Partie 1: Exigences métrologiques et techniques – Essais*
R 51-2	Automatic catchweighing instruments. Part 2: Test report format *Version française non encore disponible*
D 24	Total radiation pyrometers *Pyromètres à radiation totale*


ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE
OIML INTERNATIONAL RECOMMENDATION
Automatic catchweighing instruments
Part 1: Metrological and technical requirements - Tests
OIML R 51-1

Available in French and English (see OIML Bulletin supplement for price-list). To order a publication, please contact OIML headquarters:
Bureau International de Métrologie Légale   11, rue Turgot - 75009 Paris - France   Fax: 33 1 42 82 17 27

Bibliography

The New Approach – Legislation and Standards on the Free Movement of Goods in Europe

Comité Européen de Normalisation (CEN)
Rue de Stassart 36
B-1050 Brussels

Fax: (32) 2-519-68-19

Which SI?

J. Magn. Magn. Mater. (Netherlands), vol. 149, no. 1–2, p.57–9 (Aug. 1995). (Seventh International Conference on Magnetic Fluids, Bhavnagar, India, 7–14 Jan. 1995).

Influences of humidity and moisture on the long-term stability of piezoresistive pressure sensors

A. Nakladal, K. Sager, G. Gerlach (Inst. of Precision Eng., Tech. University of Dresden, Germany). *Measurement (Netherlands), vol. 16, no. 1, p. 21–9 (Sept. 1995).*

Fluids and Process Technologies (1996)

National Engineering Laboratory (NEL)
East Kilbride
Glasgow, G75 OQU, United Kingdom
Fax: (44) 1355 272946

Committee drafts received by BIML
March 1996–May 1996

Stage of development	Title	TC/SC	Secretariat
3 CD	Revision R 81: Dynamic measuring devices and systems for cryogenic liquids	TC 8/SC 6	U.S.A.
1 CD	In-motion road vehicle weighing instruments	TC 9/SC 2	U.K.
2 CD	Multi-dimensional measuring instruments	TC 7/SC 5	Australia
2 CD	Revision R 99: Instruments for measuring vehicle exhaust emissions	TC 16/SC 1	Netherlands

liaison activities
OIML
activités de liaison

Metrology Serving Economic Development

The second seminar on the topic of "Metrology Serving Economic Development" was organized by the Economic Commission for Europe of the United Nations, Slovak Office of Standards, Metrology and Testing and co-sponsored by OIML. The seminar was held 22–26 April 1996 in Piestany (Slovakia) and was attended by senior managers from national institutions of metrology and standardization of nine countries "in transition to market economy".

The objective of the event was to address the tasks of metrology in a market economy, including matters of legal, applied and scientific metrology, traceability, calibration, testing and accreditation.

Lectures were submitted by leading representatives of European organizations: WELMEC, EUROMET, EAL, EUROLAB, as well as national metrology services of Finland, France, Russia and Slovakia. The representative from BIML gave a lecture on recent OIML and national legal metrology developments and cooperation with regional and international organizations.

The growing role of metrology and related disciplines were highlighted at the seminar, with participants elaborating a recommendation for UN/ECE and other institutions to promote the organization of metrology seminars in the future.

In addition to the seminar, visits to the Technical Testing Centre in Piestany and to the Slovak Metrological Institute in Bratislava were organized for participants.

Proposed topics for upcoming seminars are intercomparisons, traceability and accreditation, among others. This recommendation was submitted to the session of the UN/ECE working party on technical harmonization and standardization policies, which was held in May 1996 in Geneva *(see below)*.

The participants noted the high professional level of the lectures and the usefulness of the seminar and expressed gratitude to its organizers. ■

Working Party on Technical Harmonization and Standardization Policies

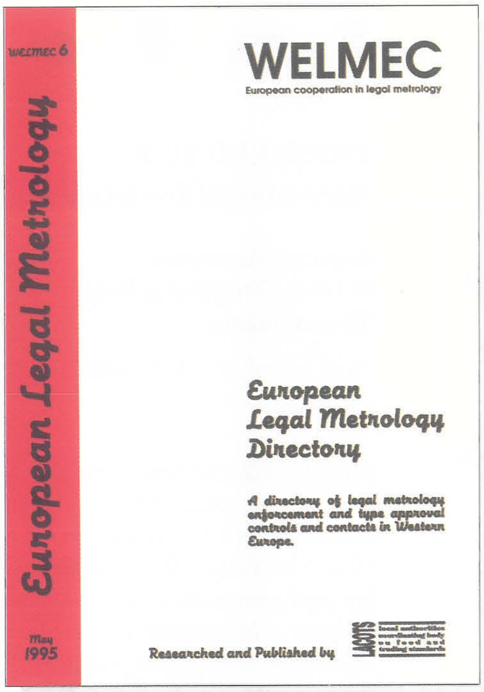
The sixth session of the Working Party on Standardization Policies of the United Nations Economic Commission for Europe (UN/ECE) was held 13–15 May 1996 in the Palais des Nations, Geneva.

The meeting was attended by senior representatives of national standardization and metrology bodies from 19 countries and BIML, ISO, IEC, WTO, EUROMET, CEN, EUROLAB, ETSI. The principal items of the agenda covered developments in the field of standardization and related activities at international, regional and national levels, matters of conformity assessment, harmonization and coordination in implementing the ECE recommendations and metrological aspects in testing.

A report on OIML main activities was given to inform the working party of the development of International Recommendations, certification, international co-operation, assistance to developing countries, seminars and publications. OIML co-sponsored two seminars of UN/ECE on "Metrology serving economic development" held in Paris (1995) and in Piestany (1996).

The Working Party endorsed the organization of two further seminars on intercomparisons, traceability, determination of uncertainty and accreditation of calibration laboratories. These seminars may be held in 1997 in Russia and in Hungary and would be co-sponsored by European and international organizations in metrology, testing and accreditation.

The general work program for 1996–2000, which comprises aspects of metrology relevant to testing activities, was approved. ■



Now available:

▶ EUROPEAN LEGAL METROLOGY DIRECTORY

Researched by the Local Authorities Coordinating Body on Food and Trading Standards (LACOTS) in the UK, produced in association with WELMEC, and sponsored by the European Commission and the European Free Trade Association (EFTA).

A useful Directory containing up-to-date details of all key legal metrology supervisory and enforcement personnel in eighteen European and EFTA Countries is now available.

The Directory, with over 140 pages of invaluable information, gives a fascinating insight into the application of European legal metrology controls, structures and sanctions and should prove to be an informative reference tool. Each of the countries referred to in the Directory is a member of WELMEC European cooperation in legal metrology.

The Directory will be of interest not only to countries within the European Union and EFTA but will also benefit those external to the EEA, including government, regional and local authority agencies involved in legal metrology control and regulation; weighing and measuring equipment companies; retailers, manufacturers and consumer organisations.

The Directory also includes key legal metrology supervisory and enforcement contacts in each of the countries in the European Economic Area and Switzerland.

- ▶ **Language:** English
- ▶ **Cost:** £50 sterling *(inclusive of postage and packaging)*

For further details please contact **LACOTS**

PO Box 6, 1A Robert Street, Croydon, CR9 ILG, United Kingdom

Tel: (44) 181-688 1996 Fax: (44) 181-680 1509

meetings
OIML
réunions

September 1996

4–5	TC 8/SC 5 Water meters	GLASGOW, U.K.

October 1996

2–4	OIML workshop: Practical test procedures for classes E_1 to M_3 weights	BORÅS, SWEDEN
28–30	TC 7/SC 5 Dimensional measuring instruments	GAITHERSBURG, U.S.A.

November 1996

4–8	Tenth International Conference of Legal Metrology	VANCOUVER, CANADA
	31st CIML meeting	
	Development Council meeting	
7	Round table "Accreditation in legal metrology"	

March 1997

10–12	TC 8/SC 7 Gas metering	BRUSSELS, BELGIUM

October 1997

10	TC 13 Measuring instruments for acoustics and vibration	JAPAN

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15th IMEKO TC 3 International Conference

Accuracy, Assurance in Force, Torque and Mass Measurements

Basic metrology to industrial applications

The 15th Imeko TC 3 International Conference on Force and Mass Measurements will be held in Madrid (Spain) in October 1996. This event is a good opportunity for an exchange of information, a comparison of experiences and a meeting with old and new friends working in the field of force, mass and torque measurements.

Organized by:

- TC 3 IMEKO Technical Committee "Measurement of Force and Mass"
- CEM - Centro Español de Metrologia
- MINER - Ministerio de Industria y Energia

Scope of the Conference

Scientists, technicians and specialists from industry and research centres related with force, mass and torque can exchange knowledge and experiences through the conference, poster session and specific exhibitions of measuring instruments. The Conference will put emphasis on accuracy, assurance in force, and torque and mass measurements from basic metrology to industrial applications.

Contact information:

Centro Español de Metrologia
C/ Alfar n° 2
28760 Tres Cantos (Madrid)

Tel: 34-1-807 47 00
Fax: 34-1-807 48 07

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

OIML

SECRETARIAT
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

CONTACT INFORMATION

Member States – Members of the International Committee of Legal Metrology
Corresponding Members – National metrology services

PUBLICATIONS

classified by subject and number

International Recommendations
International Documents
Other publications

MEMBER STATES

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

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

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

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

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

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

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

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

CANADA
Mr A. E. Johnston
Director General
Legal Metrology Branch
Industry Canada
Standards Building, Tunney's Pasture
Ottawa, Ontario K1A OC9
Tel.: 1-613-952 06 55
Fax: 1-613-957 12 65
Telex 053 3694

CHINA
Mr Li Chuanqing
Director General
State Bureau of Technical Supervision
4, Zhi Chun Lu, Hai Dian
Beijing 100088
Tel.: 86-10-202 58 35
Fax: 86-10-203 10 10
Telex 210209 SBTS CN
Telegram 1918 Beijing

CUBA
Eng. L. Revuelta Formoso
c/o Mr J. Acosta Alemany
Director, International Relations
National Bureau of Standards
Calle E No. 261 entre 11 y 13
Vedado, La Habana 10400
Ciudad de la Habana
Tel.: 53-7-30 08 25
Fax: 53-7-33 80 48
Telex 512245

CYPRUS
Mr G. Tsiartzazis
Controller of Weights and Measures
Ministry of Commerce and Industry
Nicosia
Tel.: 357-2-40 34 41
Fax: 357-2-37 51 20
Telex 2283 MIN COMIND
Telegram Mincommind Nicosia

CZECH REPUBLIC
Mr Pavel Klenovský
Director General
Czech Metrological Institute
Okružni 31
63800 Brno
Tel.: 42-5-45 22 27 27
Fax: 42-5-45 22 27 28

DENMARK
Mr P. C. Johansen
Assistant Head
Secretariat for Metrology
Danish Agency for Development of Trade and Industry.
Tagensvej 135
DK-2200 Copenhagen N
Tel.: 45-35-86-86-86
Fax: 45-35-86-86-87
Telex 15768 INDTRA DK

EGYPT
Mr A.B. El Sebai
President
Egyptian Organization for Standardization and Quality Control
2 Latin America Street, Garden City
Cairo
Tel.: 20-2-354 97 20
Fax: 20-2-355 78 41
Telex 93 296 EOS UN
Telegram TAWHID

ETHIOPIA
Mr Berhanu Werede
Head of Metrology Department
Ethiopian Authority for Standardization
P.O. Box 2310
Addis Ababa
Tel.: 251-1-61 01 11
Fax: 251-1-61 31 77
Telex 21725 ETHSA ETH

FINLAND
Mrs Marja Leena Junttila
Director, Legal Metrology and Articles of Precious Metals
Turvatekniikan Keskus
Safety Technology Authority
P.O. Box 123 (Lönnrotinkatu 37)
FIN-00181 Helsinki
Tel.: 358-9-40 580 3161
Fax: 358-9 605 474

FRANCE
Mr J.F. Magana
Sous-Directeur de la Métrologie
Ministère de l'Industrie, des Postes et Télécommunications
et du Commerce extérieur
22, rue Monge
75005 Paris
Tel.: 33-1-43 19 51 40
Fax: 33-1-43 19 51 36

GERMANY
Mr M. Kochsiek
Member of the Presidential Board
Physikalisch-Technische Bundesanstalt
Postfach 3345
D-38023 Braunschweig
Tel.: 49-531-592 30 00
Fax: 49-531-592 30 02
Telex 9-52 822 PTB d
Telegram Bundesphysik Braunschweig

GREECE
Mr A. Dessis
Technical Officer
Directorate of Weights and Measures
Ministry of Commerce
Canning Sq.
10181 Athens
Tel.: 30-1-381 41 68
Fax: 30-1-384 26 42
Telex 21 67 35 DRAG GR
and 21 52 82 YPEM GR

HUNGARY
Mr P. Pákay
President
Országos Mérésügyi Hivatal
P.O. Box 919
H-1535 Budapest
Tel.: 36-1-1567 722
Fax: 36-1-1550 598
Telegram HUNGMETER Budapest

INDIA
Mr P. A. Krishnamoorthy
Director, Weights & Measures
Ministry of Civil Supplies, Consumer Affairs and Public Distribution
Weights and Measures Unit
12-A, Jam Nagar House, Shahjahan Road
New Delhi 110 011
Tel.: 91-11-338 94 89
Fax: 91-11-338 83 02

INDONESIA
Mr G. M. Putera
Directorate of Metrology
Directorate General of Domestic Trade
Departemen Perdagangan
Jalan Pasteur 27
40171 Bandung
Tel.: 62-22-44 35 97 and 43 06 09
Fax: 62-22-420 70 35
Telex 28 176 BD

IRELAND
Mr S. Murray
Principal Officer
Department of Enterprise and Employment
Frederick Building, Setanta Centre
South Frederick Street,
Dublin 2
Tel.: 353-1-661 44 44
Fax: 353-1-671 74 57
Telex 93478

ISRAEL
Mr A. Ronen
Controller of Weights, Measures and Standards
Ministry of Industry and Trade
P.O. Box 299
Jerusalem 91002
Tel.: 972-2-75 01 11
Fax: 972-2-24 51 10

ITALY
Mr G. Visconti
Direttore Generale del Commercio Interno e dei Consumi Industriali
c/o Ufficio Centrale Metrico
Via Antonio Bosio, 15
I-00161 Roma
Tel.: 39-6-841 68 25
Fax: 39-6-841 41 94

JAPAN
Mr Y. Kurita
Director General
National Research Laboratory of Metrology
1-4, Umezono 1-Chome, Tsukuba
Ibaraki 305
Tel.: 81-298-54 41 49
Fax: 81-298-54 41 35
Telex 03652570 AIST
Telegram KEIRYOKEN TSUCHIURA

KAZAKHSTAN
The President of Gosstandart of Kazakhstan
83, prospect I. Altinsarina
Almati 480035
Tel.: 7-327-21 08 08
Fax: 7-327-28 68 22

KENYA
The acting Director of Weights and Measures
Weights and Measures Department
Ministry of Commerce and Industry
P.O. Box 41071
Nairobi
Tel.: 254-2-50 46 65
Fax: 254-2-21 88 45
Telegram ASSIZERS, Nairobi

DEM. P. REP. OF KOREA
Mr Ho Chang Guk
Vice-President
Committee for Standardization of the D.P.R. of Korea
Zung Gu Yok Sungli-street
Pyongyang

REP. OF KOREA
Mr Yoon Kyo-Won
Director, International Cooperation and Metrology Division
Standards and Metrology Department,
National Institute of Technology and Quality
1599 Kwan Yang-Dong, DongAhn-Ku,
An Yang-City
KyungGi-DO 430-060
Tel.: 82-343 84 1861
Fax: 82-343 84 6077

MONACO
Mr A. Veglia
Ingénieur au Centre Scientifique de Monaco
16, Boulevard de Suisse
MC 98000 Monte Carlo
Tel.: 33-93-30 33 71

MOROCCO
Mr Abdellah Nejjar
Directeur de la Normalisation et de la Promotion de la Qualité
Ministère du Commerce et de l'Industrie,
Quartier administratif
Rabat-Challah
Tel.: 212-7-76 37 33
Fax: 212-7-76 62 96

NETHERLANDS
Mr G. J. Faber
Director General
Nederlands Meetinstituut nv
Hugo de Grootplein 1
3314 EG Dordrecht
Tel.: 31-78-633 23 32
Fax: 31-78-633 23 09
Telex 38 373 IJKWZ NL

NORWAY
Mr H. Kildal
General Director
Norwegian Metrology and Accreditation Service
Postbox 6832 St. Olavs Plass
0130 Oslo 1
Tel.: 47-22-20 02 26
Fax: 47-22-20 77 72

PAKISTAN
Mr M. Asad Hasan
Director
Pakistan Standards Institution
39-Garden Road, Saddar
Karachi-74400
Tel.: 92-21-772 95 27
Fax: 92-21-772 81 24
Telegram PEYASAI

POLAND
Mr Krzysztof Mordziński
President
Central Office of Measures
ul. Elektoralna 2
P.O. Box P-10
PL 00-950 Warszawa
Tel.: 48-22-620 07 47
Fax: 48-22-620 83 78

PORTUGAL
Mr J. N. Cartaxo Reis
Director Serviço de Metrologia Legal
Instituto Português da Qualidade
Rua C à Avenida dos Três Vales
2825 Monte da Caparica
Tel.: 351-1-294 81 96
Fax: 351-1-294 81 88

ROMANIA
Mr D. Stoichitoiu
Directeur Général
Bureau Roumain de Métrologie Légale
21, Boulevard Nicolae Balcescu, sector 1
70112 Bucarest
Tel.: 40-1-613 16 54
Fax: 40-1-312 05 01

RUSSIAN FEDERATION
Mr L. K. Issaev
Vice-President
Gosstandart of Russia
Leninsky Prospect 9
117049 Moscow
Tel.: 7-095-236 40 44
Fax: 7-095 237 60 32
Telex 411 378 GOST
Telegram Moskva-Standart

SAUDI ARABIA
Mr Khaled Y. Al-Khalaf
Director General
Saudi Arabian Standards Organization
P.O. Box 3437
11471 Riyadh
Tel.: 966-1-452 00 00
Fax: 966-1-452 00 86
Telex 40 16 10 saso sj

SLOVAKIA
Mr Lubomír Sutek
President
Úrad pre Normalizáciu Metrológiu a Skúšobníctvo SR
Štefanovičova 3
814 39 Bratislava
Tel.: 42-7-491 085
Fax: 42-7-491 050

SLOVENIA
Mr Vasja Hrovat
Deputy Director of SMIS
Ministrstvo za znanost in tehnologijo
Urad za standardizacijo in meroslovje
Kotnikova 6
61000 Ljubljana
Tel.: 386-61-13 12 322
Fax: 386-61-314 882

SPAIN
The Director
Centro Español de Metrologia
c/ del alfar 2
28760 Tres Cantos (Madrid)
Tel.: 34-1-807 47 00
Fax: 34-1-807 48 07
Telex 47254 CEME E

SRI LANKA
Mr H. L. R. W. Madanayake
Deputy Commissioner of Internal Trade
Measurement Standards, and Services Division
Department of Internal Trade
101, Park Road
Colombo 5
Tel.: 94-1-83 261
Telex 21908 COMECE CF

SWEDEN
Mrs A. Ebbesson
Technical Officer
Section for General Technology
SWEDAC
Box 878
S-501 15 Borås
Tel.: 46-33-17 77 00
Fax: 46-33-10 13 92

SWITZERLAND
Mr B. Vaucher
Vice-Directeur
Office Fédéral de Métrologie
Lindenweg 50
CH- 3084 Wabern
Tel.: 41-31-323 32 05
Fax: 41-31-323 32 10
Telegram OFMET

TANZANIA
Mr A. H. M. Tukai
Commissioner for Weights and Measures
Weights and Measures Bureau
Ministry of Industries and Trade
P.O. Box 313
Dar es Salaam
Tel.: 864046/864808
Telex 41 689 INDTRA

THE FORMER YUGOSLAVE REPUBLIC OF MACEDONIA
Mr Grkov Zoran
Bureau of Standardization and Metrology
Ministry of Economy
Samoilova 10
91000 Skopje
Tel.: 389-91-13 11 02
Fax: 389-91-11 02 63

TUNISIA
Mr Ali Ben Gaid
Président Directeur Général
Institut National de la Normalisation et de la Propriété Industrielle
Boîte postale 23
1012 Tunis Belvedere
Tel.: 216-1-785 922
Fax: 216-1-781 563
Telex 13 602 INORPI

UNITED KINGDOM

Mr S. Bennett
Chief Executive
National Weights and Measures Laboratory
Stanton Avenue
Teddington, Middlesex TW 11 OJZ
Tel.: 44-181-943 72 72
Fax: 44-181-943 72 70
Telex 9312131043 (WM G)

UNITED STATES OF AMERICA

Mr S. E. Chappell
Chief, Standards Management Program, 212
Office of Standards Services
National Institute of Standards
and Technology
Building 820, Room 162
Gaithersburg, Maryland 20899
Tel.: 1-301-975 40 24
Fax: 1-301-963 28 71
Telex 197674 NBS UT

YUGOSLAVIA

Mr Z. M. Markovic
Deputy Director
Federal Bureau of Measures
and Precious Metals
Mike Alasa 14
11000 Beograd
Tel.: 381-11-328 27 36
Fax: 381-11-18 16 68
Telex 11 020 YUZMBG

ZAMBIA

Mr L. N. Kakumba
Superintendent Assizer
Assize Department
Weights and Measures Office
Ministry of Commerce and Industry
P.O. Box 30 989
Lusaka
Tel.: 260-1-21 60 62
Fax: 260-1-22 67 27
Telegram Assize, LUSAKA
Telex 45630 COMIND ZA

HONORARY MEMBERS

Mr K. Birkeland
Norway
Immediate Past President of CIML

Mr V. Ermakov
Russian Federation
former CIML Vice-President

Mr A. Perlstain
Switzerland
former member of the Presidential Council

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Germany
former CIML Vice-President

Mr H. W. Liers
Germany
former member of the Presidential Council

CORRESPONDING MEMBERS

ALBANIA

The Director
National Directorate
Drejtoria Kombëtare e Metrologjisë
dhe e Kalibrimit (DKMK)
Rruga "Sami Frashëri", Nr.33
Tirana

BAHRAIN

The Responsible of Metrology
Standards and Metrology Section
Ministry of Commerce and Agriculture
P.O. Box 5479
Manama

BANGLADESH

The Director General
Bangladesh Standards
and Testing Institution
116-A Tejgaon Industrial Area
Dhaka 1208

BARBADOS

The Director
Barbados National Standards Institution
Culloden Road
St. Michael
Barbados W.I.

BENIN

Direction de la Qualité
et des Instruments de Mesure
Ministère du Commerce et du Tourisme
Cotonou

BOTSWANA

The Permanent Secretary
Division of Weights and Measures
Department of Commerce
and Consumer Affairs
Private Bag 48
Gaborone

BURKINA FASO

Direction Générale des Prix
Ministère du Commerce
et de l'Approvisionnement du Peuple
BP 19
Ouagadougou

COLOMBIA

Superintendencia de Industria y Comercio
Carrera 13 No. 27-00
Piso 10
Santafé de Bogotá, D.C.

COSTA RICA

Oficina Nacional de Normas y Unidades
de Medida
Ministerio de Economia y Comercio
Apartado 10 216
San Jose

CROATIA

Director General
State Office for Standardization
and Metrology
Avenija Vukovar 78
41000 Zagreb

ECUADOR

The General Director
Instituto Ecuatoriano de Normalizacion
Baquerizo Moreno No. 454 y Almagro
Casilla 17-01-3999
Quito

FIJI

The Chief Inspector of Weights and Measures
Ministry of Economic Development, Planning
and Tourism
Government Buildings
P.O. Box 2118
Suva

GHANA

The Director
Ghana Standards Board
P.O. Box M. 245
Accra

HONG KONG

Commissioner of Customs and Excise
Customs and Excise Department
Trade Department Tower
16/F
700 Nathan Road
Kowloon

ICELAND

The Director
Icelandic Bureau of Legal Metrology
Löggildingarstofan
Sidumula 13
108 Reykjavik

JORDAN
Jordanian Institution for Standardization and Metrology
P.O. Box 941287
Amman 11194

KUWAIT
The Under Secretary
Ministry of Commerce and Industry
Department of Standards and Metrology
Post Box No 2944
Kuwait

LATVIA
Latvian National Centre of Standardization and Metrology
157, Kr. Valdemara St.
LV-1013 Riga

LITHUANIA
The Director
Lithuanian Standards Board
T. Kosciuskos g.30
2600 Vilnius

LUXEMBURG
Le Préposé du Service de Métrologie
Administration des Contributions
Zone commerciale et artisanale
Cellule A2
rue J.F. Kennedy
L-7327 Steinsel

MALAWI
Malawi Bureau of Standards
P.O. Box 946
Blantyre

MALAYSIA
The Director of Standards
Standards and Industrial Research Institute of Malaysia
P.O. Box 7035
40911 Shah Alam
Selangor Darul Ehsan

MAURITIUS
The Permanent Secretary
Ministry of Trade and Shipping
(Division of Weights and Measures)
New Government Centre
Port Louis

MEXICO
Direccion General de Normas
Secretaria de Comercio y Fomento Industrial
Sistema Nacional de Calibracion
Ave. Puente de Tecamachalco no. 6
Planta Baja
Lomas de Tecamachalco, Seccion Fuentes
53950 Naucalpan de Juarez

MONGOLIA
The Director General
Mongolian National Institute for Standardization and Metrology
Peace Str.
Ulaanbaatar 51

MOZAMBIQUE
Mrs G. Rebello da Silva
Director
Instituto Nacional de Normalizaçao e Qualidade
Av. 25 de Setembro n° 1179, 2° andar
Maputo

NEPAL
The Chief Inspector
Nepal Bureau of Standards and Metrology
P.B. 985
Sundhara
Kathmandu

NEW ZEALAND
The Manager
Trade Measurement Unit
Ministry of Consumer Affairs
P.O. Box 1473
Wellington

OMAN
The General Director for Specifications and Measurements
Ministry of Commerce and Industry
P.O. Box 550
Muscat

PANAMA
The Director
Comision Panamena de Normas Industriales y Tecnicas
Ministerio de Comercio e Industrias
Apartado 9658
Panama 4

PAPUA NEW GUINEA
The Director General
National Institute of Standards and Industrial Technology
P.O. Box 3042
Boroko

PERU
The Director General
INDECOPI
Instituto Nacional de Defensa de la Competencia y de la Proteccion de la Propiedad Intelectual
Prolong. Guardia Civil No.400
Esq. con Av. Canada, San Borja
Lima 41

PHILIPPINES
Bureau of Product Standards
Department of Trade and Industry
3rd floor DTI Building
361 Sen. Gil J. Puyat Avenue
Makati, Metro Manila
Philippines 3117

SEYCHELLES
The Director
Seychelles Bureau of Standards
P.O. Box 648
Victoria

SINGAPORE
Weights and Measures Office
Ministry of Trade and Industry
6 Bright Hill Drive
Singapore 57 95 98

SYRIA
The General Director
The Syrian Arab Organization for Standardization and Metrology
P.O. Box 11836
Damascus

THAILAND
The Director General
Department of Commercial Registration
Ministry of Commerce
Maharaj Road
Bangkok 10200

TRINIDAD AND TOBAGO
The Director
Trinidad and Tobago Bureau of Standards
Century Drive, Trincity Industrial Estate,
P.O. Box 467
Macoya, Tunapuna, Trinidad, W.I

TURKEY
The General Director
Sanayi ve Ticaret Bakanligi
Ölçüler ve Standardlar Genel Müdürlügü
06100 Tandoğan
Ankara

URUGUAY
Director Nacional
Direccion Nacional de Metrologia Legal
Ministerio de Industria, Energia y Mineria
Buenos Aires 495
Montevideo

S. R. VIETNAM
General Department for Standardization, Metrology and Quality Control
70 Tran Hung Dao St.
Hanoi

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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

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Classes de précision des instruments de mesurage

R 42 (1981–*1977*) 50 FRF
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D 1 (1975) 50 FRF
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Loi de métrologie

D 2 (in revision - *en cours de révision*)
Legal units of measurement
Unités de mesure légales

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Qualification légale des instruments de mesurage

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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
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D 12 (1986) 50 FRF
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Conseils pour les arrangements bi- ou multilatéraux de reconnaissance des: résultats d'essais - approbations de modèles - vérifications

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D 15 (1986) 80 FRF
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Vocabulary of legal metrology (bilingual French-English)
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V 2 (1993) 200 FRF
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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 (1996) 400 FRF
Legal metrology in OIML Member States
Métrologie légale dans les Etats Membres de l'OIML

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

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

Measurement standards and verification equipment
Étalons et équipement de vérification

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

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

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

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

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

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

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

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

P 15 (1989) 100 FRF
Guide to calibration

Mass and density
Masses et masses volumiques

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

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

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

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

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

R 50 (1994) 100 FRF
Continuous totalizing automatic weighing instruments
Instruments de pesage totalisateurs continus à fonctionnement automatique

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

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

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

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

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

R 61 (being printed - *en cours de publication*)
Automatic gravimetric filling instruments
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

Amendment No. 1 (1994) free / *gratuit*

R 76-2 (1993) 200 FRF
Nonautomatic weighing instruments Part 2: Pattern evaluation report
Instruments de pesage à fonctionnement non automatique Partie 2: Rapport d'essai de modèle

Amendment No. 1 (1995) free / *gratuit*

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

Annex (being printed - *en cours de publication*)
Test procedures and test report format
Procédures d'essai et format du rapport d'essai

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)

Annex (being printed - *en cours de publication*)
Test procedures and test report format
Procédures d'essai et format du rapport d'essai

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

P 5 (1992) 100 FRF
Mobile equipment for the verification of road 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

Length and speed
Longueurs et vitesses

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

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

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

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

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

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

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

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

Liquid measurement
Mesurage des liquides

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

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

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

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

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

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

R 49 (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 63 (1994) 50 FRF
Petroleum measurement tables
Tables de mesure du pétrole

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

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

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

R 81 (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
Annex (1995) 80 FRF
Test report format
Format du rapport d'essai

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

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

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

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

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

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

D 25 (being printed - *en cours de publication)*
Vortex meters used in measuring systems for fluids
Compteurs à vortex utilisés dans les ensembles de mesurage de fluides

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

Gas measurement
Mesurage des gaz(*)

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

R 31 (1995) 80 FRF
Diaphragm gas meters
Compteurs de gaz à parois déformables

R 32 (1989) 60 FRF
Rotary piston gas meters and turbine gas meters
Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine

Pressure
Pressions(**)

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

(*) See also "Liquid measurement" D 25 – *Voir aussi "Mesurage des liquides" D 25.*

(**) See also "Medical instruments" - *Voir aussi "Instruments médicaux".*

R 53 (1982) 60 FRF

Metrological characteristics of elastic sensing elements used for measurement of pressure. Determination methods
Caractéristiques métrologiques des éléments récepteurs élastiques utilisés pour le mesurage de la pression. Méthodes de leur détermination

R 97 (1990) 60 FRF

Barometers
Baromètres

R 101 (1991) 80 FRF

Indicating and recording pressure gauges, vacuum gauges and pressure vacuum gauges with elastic sensing elements (ordinary instruments)
Manomètres, vacuomètres et manovacuomètres indicateurs et enregistreurs à élément récepteur élastique (instruments usuels)

R 109 (1993) 60 FRF

Pressure gauges and vacuum gauges with elastic sensing elements (standard instruments)
Manomètres et vacuomètres à élément récepteur élastique (instruments étalons)

R 110 (1994) 80 FRF

Pressure balances
Manomètres à piston

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 (1996) 60 FRF

Total radiation pyrometers
Pyromètres à radiation totale

P 16 (1991) 100 FRF

Guide to practical temperature measurements

(*) See also "Medical instruments" - *Voir aussi "Instruments médicaux".*

Electricity
Électricité

R 46 (1980-*1978*) 80 FRF

Active electrical energy meters for direct connection of class 2
Compteurs d'énergie électrique active à branchement direct de la classe 2

D 11 (1994) 80 FRF

General requirements for electronic measuring instruments
Exigences générales pour les instruments de mesure électroniques

Acoustics and vibration
Accoustique et vibrations(*)

R 58 (in revision - *en cours de révision)*
Sound level meters
Sonomètres

R 88 (in revision - *en cours de révision)*
Integrating-averaging sound level meters
Sonomètres intégrateurs-moyenneurs

R 102 (1992) 50 FRF

Sound calibrators
Calibreurs acoustiques

Annex (1995) 80 FRF
Test methods for pattern evaluation and test report format
Méthodes d'essai de modèle et format du rapport d'essai

R 103 (1992) 60 FRF

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

R 104 (1993) 60 FRF

Pure-tone audiometers
Audiomètres à sons purs

Annex (being printed - *en cours de publication*)
Test report format
Format du rapport d'essai

Environment
Environnement

R 82 (1989) 80 FRF

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

R 83 (1990) 80 FRF

Gas chromatograph/mass spectrometer/data system for analysis of organic pollutants in water
Chromatographe en phase gazeuse équipé d'un spectromètre de masse et d'un système de traitement de données pour l'analyse des polluants organiques dans l'eau

R 99 (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

R 116 (1995) 80 FRF

Inductively coupled plasma atomic emission spectrometers for measurement of metal pollutants in water
Spectromètres à émission atomique de plasma couplé inductivement pour le mesurage des polluants métalliques dans l'eau

R 123 (being printed - *en cours de publication*)

Portable and transportable X-ray fluorescence spectrometers for field measurement of hazardous elemental pollutants
Spectromètres à fluorescence de rayons X portatifs et déplaçables pour la mesure sur le terrain d'éléments polluants dangereux

D 22 (1991) 80 FRF

Guide to portable instruments for assessing airborne pollutants arising from hazardous wastes
Guide sur les instruments portatifs pour l'évaluation des polluants contenus dans l'air en provenance des sites de décharge de déchets dangereux

Physico-chemical measurements
Mesures physico-chimiques

R 14 (1995) 60 FRF

Polarimetric saccharimeters
Saccharimètres polarimétriques

R 54 (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

R 121 (1996) 60 FRF

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

D 17 (1987) 50 FRF

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

Medical instruments
Instruments médicaux

R 7 (1979-*1978*) 60 FRF

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

R 16 (1973-*1970*) 50 FRF

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

R 26 (1978-*1973*) 50 FRF

Medical syringes
Seringues médicales

R 78 (1989) 50 FRF

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

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

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

R 93 (1990) 60 FRF
Focimeters
Frontofocomètres

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

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

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

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

Testing of materials
Essais des matériaux

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

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

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

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

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

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

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

R 39 (1981-*1977*) 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

Prepackaging
Préemballages

R 79 (in revision - *en cours de révision*)
Information on package labels
Etiquetage des préemballages

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

INTERNATIONAL RECOMMENDATIONS
RECOMMANDATIONS INTERNATIONALES

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

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

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

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

R 10 (1974-1970) 60 FRF
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Verification and calibration of Rockwell C hardness standardized blocks
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R 14 (1995) 60 FRF
Polarimetric saccharimeters
Saccharimètres polarimétriques

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Visual disappearing filament pyrometers
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Taximètres

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

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

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

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

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

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

R 31 (1995) 80 FRF
Diaphragm gas meters
Compteurs de gaz à parois déformables

R 32 (1989) 60 FRF
Rotary piston gas meters and turbine gas meters
Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine

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

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

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

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

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

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

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

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

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

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

R 44 (1985) 50 FRF
Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry
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Tonneaux et futailles

R 46 (1980-1978) 80 FRF
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Compteurs d'énergie électrique active à branchement direct de la classe 2

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

R 48 (1980-1978) 50 FRF
Tungsten ribbon lamps for calibration of optical pyrometers
Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques

R 49 (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 50 (1994) 100 FRF
Continuous totalizing automatic weighing instruments (belt weighers)
Instruments de pesage totalisateurs continus à fonctionnement automatique (peseuses sur bande)

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

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

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

R 53 (1982) 60 FRF
Metrological characteristics of elastic sensing elements used for measurement of pressure. Determination methods
Caractéristiques métrologiques des éléments récepteurs élastiques utilisés pour le mesurage de la pression. Méthodes de leur détermination

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

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

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

R 58 (in revision - *en cours de révision*)
Sound level meters
Sonomètres

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

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

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

R 61 (being printed - *en cours de publication*)
Automatic gravimetric filling instruments
Doseuses pondérales à fonctionnement automatique

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

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

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

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

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

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

R 69 (1985) 50 FRF
Glass capillary viscometers for the measurement of kinematic viscosity. Verification method
Viscosimètres à capillaire, en verre, pour la mesure de la viscosité cinématique. Méthode de vérification

R 70 (1985) 50 FRF
Determination of intrinsic and hysteresis errors of gas analysers
Détermination des erreurs de base et d'hystérésis des analyseurs de gaz

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

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

R 73 (1985) 50 FRF
Requirements concerning pure gases CO, CO_2, CH_4, H_2, O_2, N_2 and Ar intended for the preparation of reference gas mixtures
Prescriptions pour les gaz purs CO, CO_2, CH_4, H_2, O_2, N_2 et Ar destinés à la préparation des mélanges de gaz de référence

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

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

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

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

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

R 79 (in revision - *en cours de révision*)
Information on package labels
Etiquetage des préemballages

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

R 83 (1990) 80 FRF
Gas chromatograph/mass spectrometer/data system for analysis of organic pollutants in water
Chromatographe en phase gazeuse équipé d'un spectromètre de masse et d'un système de traitement de données pour l'analyse des polluants organiques dans l'eau

R 84 (1989) 60 FRF
Resistance-thermometer sensors made of platinum, copper or nickel (for industrial and commercial use)
Capteurs à résistance thermométrique de platine, de cuivre ou de nickel (à usages techniques et commerciaux)

R 85 (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 87 (1989) 50 FRF
Net content in packages
Contenu net des préemballages

R 88 (in revision - *en cours de révision*)
Integrating-averaging sound level meters
Sonomètres intégrateurs-moyenneurs

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

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

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

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

R 93 (1990) 60 FRF
Focimeters
Frontofocomètres

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

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

R 97 (1990) 60 FRF
Barometers
Baromètres

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

R 99 (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 101 (1991) 80 FRF
Indicating and recording pressure gauges, vacuum gauges and pressure vacuum gauges with elastic sensing elements (ordinary instruments)
Manomètres, vacuomètres et manovacuomètres indicateurs et enregistreurs à élément récepteur élastique (instruments usuels)

R 102 (1992) 50 FRF
Sound calibrators
Calibreurs acoustiques

Annex (1995) 80 FRF
Test methods for pattern evaluation and test report format
Méthodes d'essai de modèle et format du rapport d'essai

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

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

Annex (being printed - *en cours de publication*)
Test report format
Format du rapport d'essai

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

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

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

Annex (being printed - *en cours de publication*)
Test procedures and test report format
Procédures d'essai et format du rapport d'essai

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)

Annex (being printed - *en cours de publication*)
Test procedures and test report format
Procédures d'essai et format du rapport d'essai

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

R 109 (1993) 60 FRF
Pressure gauges and vacuum gauges with elastic sensing elements (standard instruments)
Manomètres et vacuomètres à élément récepteur élastique (instruments étalons)

R 110 (1994) 80 FRF
Pressure balances
Manomètres à piston

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

R 112 (1994) 80 FRF
High performance liquid chromatographs for measurement of pesticides and other toxic substances
Chromatographes en phase liquide de haute performance pour la mesure des pesticides et autres substances toxiques

R 113 (1994) 80 FRF
Portable gas chromatographs for field measurements of hazardous chemical pollutants
Chromatographes en phase gazeuse portatifs pour la mesure sur site des polluants chimiques dangereux

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

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

R 116 (1995) 80 FRF
Inductively coupled plasma atomic emission spectrometers for measurement of metal pollutants in water
Spectromètres à émission atomique de plasma couplé inductivement pour le mesurage des polluants métalliques dans l'eau

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

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

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

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

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

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

R 123 (being printed - *en cours de publication*)
Portable and transportable X-ray fluorescence spectrometers for field measurement of hazardous elemental pollutants
Spectromètres à fluorescence de rayons X portatifs et déplaçables pour la mesure sur le terrain d'éléments polluants dangereux

INTERNATIONAL DOCUMENTS
DOCUMENTS INTERNATIONAUX

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

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

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

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

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

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

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

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

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

D 13 (1986) 50 FRF
Guidelines for bi- or multilateral arrangements on the recognition of: test results - pattern approvals - verifications
Conseils pour les arrangements bi- ou multilatéraux de reconnaissance des: résultats d'essais - approbations de modèles - vérifications

D 14 (1989) 60 FRF
Training of legal metrology personnel - Qualification - Training 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 17 (1987) 50 FRF
Hierarchy scheme for instruments measuring the viscosity of liquids
Schéma de hiérarchie des instruments de mesure de la viscosité des liquides

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

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

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

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

D 22 (1991) 80 FRF
Guide to portable instruments for assessing airborne pollutants arising from hazardous wastes
Guide sur les instruments portatifs pour l'évaluation des polluants contenus dans l'air en provenance des sites de décharge de déchets dangereux

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

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

D 25 (being printed - *en cours de publication*)
Vortex meters used in measuring systems for fluids
Compteurs à vortex utilisés dans les ensembles de mesurage de fluides

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

VOCABULARIES
VOCABULAIRES

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

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

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

OTHER PUBLICATIONS
AUTRES PUBLICATIONS

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

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

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

P 4 (1986-1987) 100 FRF
Verification equipment for National Metrology Services
Equipement d'un Service national de métrologie

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

P 6 (1987) 100 FRF
Suppliers of verification equipment (bilingual French-English)
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 8 (1987) 100 FRF
Density measurement
Mesure de la masse volumique

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

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

P 15 (1989) 100 FRF
Guide to calibration

P 16 (1991) 100 FRF
Guide to practical temperature measurements

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

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