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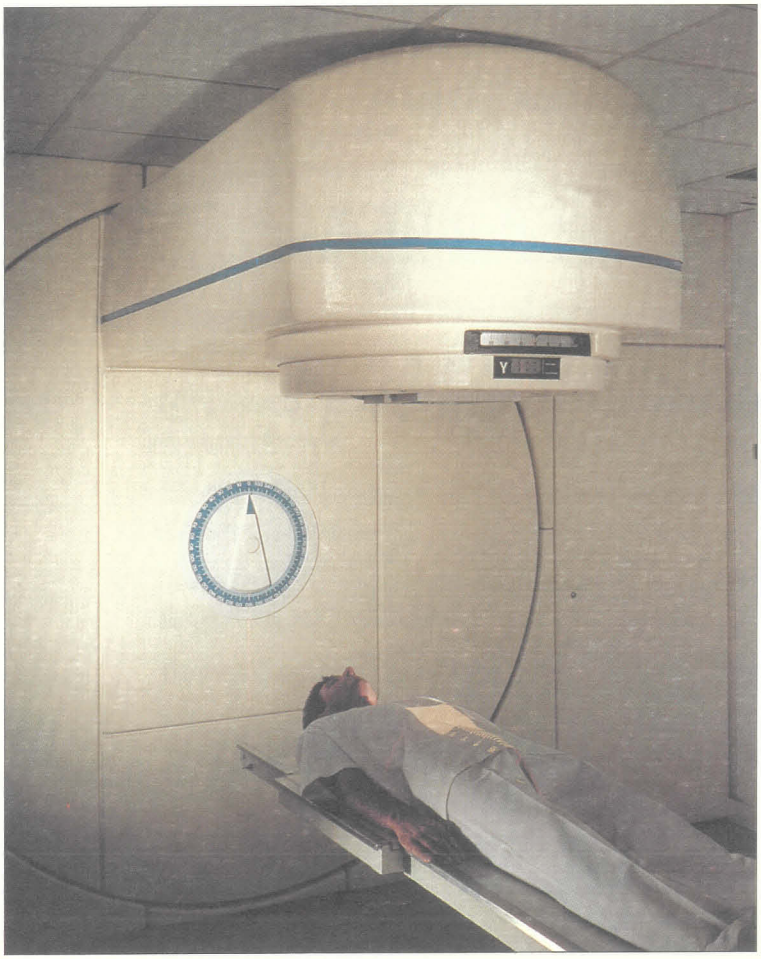

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MEDICAL MEASURING INSTRUMENTS

The ever-growing role of metrology in health care

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NUMERO SPECIAL: INSTRUMENTS DE MESURE MEDICAUX

technique

évolutions

d'un bulletin à l'autre

Editorial

As early as 400 BC, Hippocrates estimated the temperature of ill patients by sensing with his hand. More than 2000 years later, in 1872, Wunderlich in Leipzig, Germany, introduced the temperature measurement of the human body in routine diagnostics. Since these first measurements, the areas and the number of medical measuring instruments have increased dramatically. There are some special aspects where metrology in medicine deviates from classical metrology:

- it is man who is to be measured and as man is not a standardized object due to his inviolability, he cannot be measured by the usual standardized methods,
- the measuring systems used are often very complex,
- with modern measuring methods, there is a high degree of variability of measured data; nevertheless most reliable values are required for application in diagnostics.

Beginning in the fifties of this century, several countries developed national standards and requirements on the safety and performance of medical measuring instruments. International standardization was covered by the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and later by OIML. After some activities in the field of public health, OIML formed a Pilot Secretariat entitled "Measuring instruments used in the field of public health" in 1973 which was later transformed into TC 18 "Medical measuring instruments". The main interest of OIML is to formulate requirements on the performance of instruments and on test procedures.

As one consequence of the formation of regional markets, technical requirements and standards have to be harmonized to allow the free movement of goods. The European standardization organizations CEN and CENELEC have launched programs to develop harmonized standards for medical devices, e.g. for thermometers and sphygmomanometers. These are based on OIML Recommendations. From a global point of view and bearing in mind the GATT treaty, there is no doubt that the international standardization process has to be continued.

The articles of this special edition describe the experiences and future developments envisaged by different countries in the field of metrology in medicine as well as the efforts to establish OIML Recommendations for special medical measuring instruments. Such topics will also be featured in the Jan. 1996 issue of the Bulletin.

M. Kochsiek
CIML Vice President

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Secretary of OIML TC 18

MEDICAL MEASURING INSTRUMENTS: METROLOGY AND RADIOTHERAPY

Radiation dosimetry in health care: Expanding the reach of global networks*

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The IAEA and WHO are jointly taking steps to improve quality assurance services for hospitals and radiotherapy centres

Services and networks in dosimetry

Back in 1968, a panel of international experts meeting in Caracas were given some disconcerting news: While more than 50 cobalt-60 radiotherapy units were in routine use throughout Latin America, there were only five qualified hospital physicists and no laboratory for performing instrument calibration. In other words, there was no system in place to ensure the accuracy of doses that patients under radiotherapeutic care were receiving.

The news from the Caracas meeting – jointly convened by the IAEA and World Health Organization (WHO) – triggered an action plan for improving the situation, not only in Latin America but in all regions of the world.

The plan featured three components: (1) establishment of an IAEA/WHO dose intercomparison service for hospitals in developing countries to help them monitor and correct treatment doses; (2) establishment of an IAEA/WHO network of dosimetry laboratories to help standardize radiation measurements in radiotherapy centres; and (3) provision of training in radiation dosimetry, through the IAEA. Today, these three components are in worldwide service, playing important roles in supporting efforts to improve patient care and treatment involving radiotherapy.

In this article, the strides that have been taken, and problems that still remain, are reviewed in a global context. Also discussed are steps being taken toward a formidable goal, namely setting up a worldwide quality assurance programme covering dosimetry checks for millions of patients that undergo radiotherapy each year.

(*) *This article was published in the IAEA BULLETIN, the quarterly journal of the International Atomic Energy Agency, Vol. 36, No. 4 1994, pp. 33–36.*

Malignant tumours – cancer – will affect many of us. In the industrialized world, generally 20 % and 30 % of the population gets cancer. The overall percentage right now is lower for developing countries, mainly because people there have such short expected lifetimes. That situation is likely to change as the causes of early death are reduced.

Cancer treatment includes surgery, chemotherapy, and radiotherapy, or any combination of the three. In many countries, radiotherapy plays a role in the management of 50 % to 60 % of all cancer patients, either as a curative treatment or as an agent to relieve pain.

For treatments with a curative aim, it is of great importance to concentrate the radiation to the solid tumour and surrounding tissue, including what is called the microscopic spread of cancer cells. The radiation effect is dependent on the amount of radiation energy that is transferred to the tumour or the healthy tissues – i.e. the absorbed dose to the tumour and tissue. Since water absorbs radiation in a similar way as tissue, the physical quantity that has been agreed upon to specify the irradiation is therefore the absorbed dose to water. This quantity has to be determined with the highest achievable accuracy, taking into account the delicate balance of radiation damage (destruction of healthy tissue) and radiation benefit (tumour eradication or tumour growth control). The dose determination for each patient involves highly specialized work generally carried out by a medical physicist in close co-operation with a radiation oncologist. It is based on qualified measurements and computations.

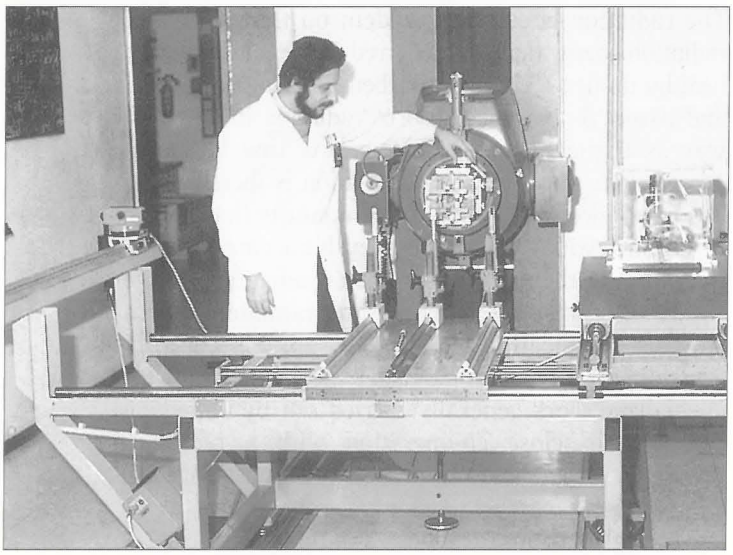
Through various avenues, a number of services are available to assist countries in the field of radiation dosimetry.

The IAEA/WHO postal TLD dose intercomparison service

For participating hospitals, the IAEA and WHO jointly offer an intercomparison service using small radiation dosimeters, technically called thermoluminescence dosimeters (TLDs). They consist of encapsuled lithium fluoride powder and are prepared and calibrated at the IAEA's Dosimetry Laboratory in Seibersdorf, Austria.

Through the service, the TLDs are mailed, together with a mountable irradiation stand, to WHO offices for distribution to participating radiotherapy hospitals in developing countries. There, under defined patient treatment conditions, they are exposed in the cobalt-60 beam of the treatment unit to what the resident physicist determines to be the specified dose. The TLD capsules are then returned to the IAEA's Laboratory for evaluation of the actual dose. The deviation between the hospital's quoted dose and the IAEA evaluated dose is reported through WHO to the hospital. A deviation of more than 5 % is considered to be unacceptable and should result in a recalibration of the hospital's radiation beam used for patient treatment.

Courtesy of IAEA



Courtesy of IAEA

At the IAEA's Dosimetry Laboratory: Evaluation of irradiated TLDs *(above)*, and the calibration of an ionization chamber.

The IAEA/WHO network for secondary dosimetry laboratories (SSDLs)

One of the recommendations of the Caracas panel was to establish conformity of radiation measurements in radiotherapy departments throughout the world. In industrialized countries, hospitals achieve conformity through calibration of their dosimeters to national primary standards. The heavy workload of the world's existing 13 Primary Standard Dosimetry Laboratories (PSDLs) unfortunately does not allow the calibration of reference dosimeters from thousands of other hospitals worldwide. Competent national authorities, therefore, have designated SSDLs to provide certified calibrations.

One requirement in the science of radiation measurements (radiation metrology) is that standardizing laboratories should compare their standards against each other at regular intervals. For primary standards, the organization of such intercomparisons is the responsibility of the *Bureau International des Poids et Mesures (BIPM)* in Paris, France.

A test programme for SSDLs: Results of an IAEA pilot study

Three SSDLs, those in Argentina, India, and Thailand, are participating in an IAEA pilot study designed to strengthen quality assurance services in radiotherapy. The study has involved quality control tests that the three SSDLs have successfully passed:

Test 1
The SSDLs were asked to calibrate a set of ionization chamber dosimeters. Their calibration factors were then compared with previously established ones from the IAEA. (This test remains to be completed by Thailand.)

Test 2
The SSDLs evaluated TLDs from hospitals during an intercomparison run, using their own calibration curves as well as one supplied by the IAEA. Results were then compared.

Test 3
The IAEA participated as a "hospital" in a national intercomparison run organized by each SSDL.

Test 4
TLDs were sent for irradiation to their respective national hospitals by the SSDLs and the IAEA, with the IAEA's TLDs going to 10 % of the hospitals. The SSDLs evaluated their returned TLDs, while the IAEA evaluated its own, and the results were then compared.

For SSDLs, the same need applies, and an international SSDL network was set up in 1976 by the IAEA and WHO. It includes a technical assistance branch, whereby most of the participating developing countries can receive financial support and expert guidance and advice. Today, the network extends to nearly 60 laboratories, most of them in developing countries. The administrative and co-ordinating work is shared by the IAEA and the WHO, with the IAEA being responsible for the technical development of member laboratories.

The IAEA's Dosimetry Laboratory in Seibersdorf functions as the network's central laboratory. Many national PSDLs and some international bodies – among them the BIPM, the International Organization of Legal Metrology (OIML), and the International Commission on Radiation Units and Measurements (ICRUM) – support the work of the SSDL network. Additionally, a standing SSDL Scientific Committee is available for advice when needed. Consultants and advisory groups further can provide assistance in the implementation of specific projects, such as the drafting of technical reports, guidelines, and manuals.

The existing global distribution of SSDLs and PSDLs shows that most countries have established an infrastructure for standardization of radiation measurements. However, additional efforts are necessary for expanding the network's reach, especially for the African continent.

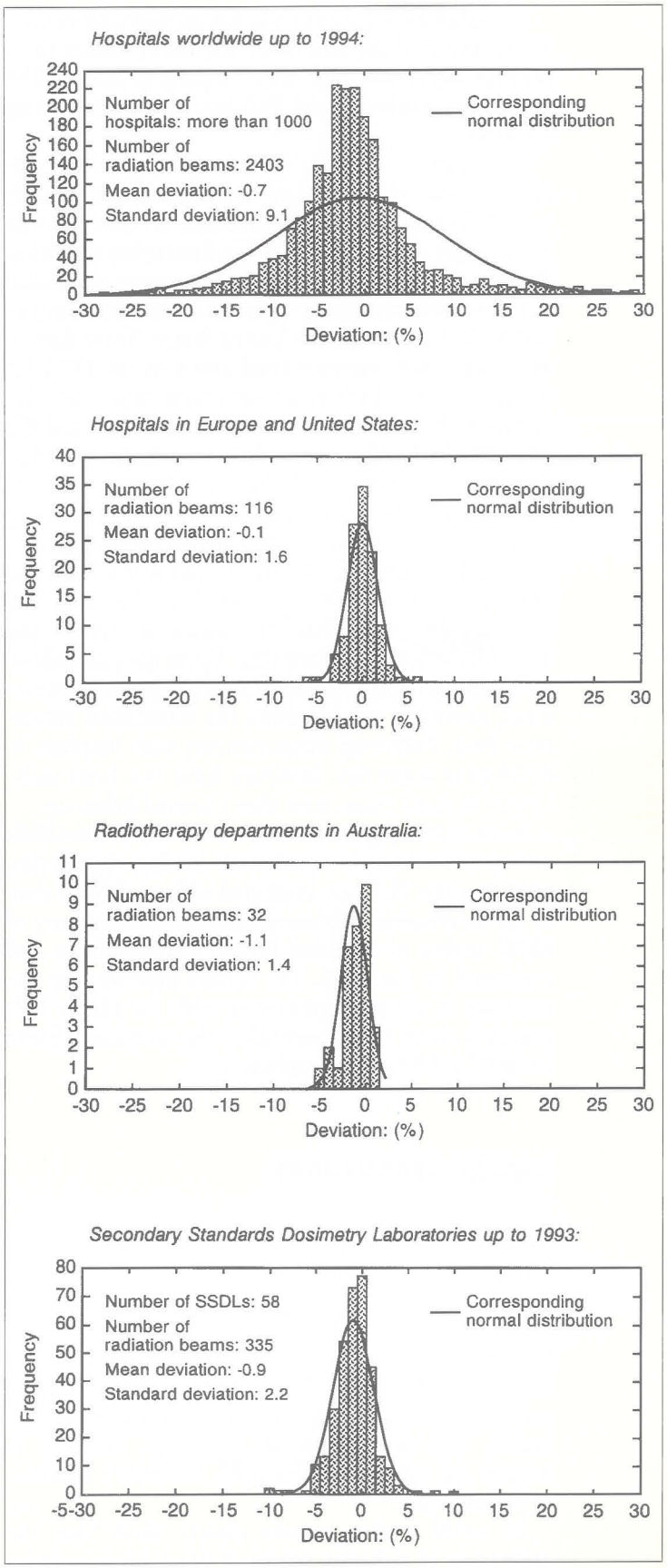
A note on OIML activity in dosimetry

Following a request by the United Nations Industrial Development Organization (UNIDO), OIML published in 1990 an International Document on "Secondary standard dosimetry laboratories for the calibration of dosimeters used in radiotherapy" (D 21).

The IAEA's Dosimetry Laboratory

As previously noted, the IAEA's Dosimetry Laboratory at Seibersdorf, about 30 kilometers from Vienna, Austria, is the Central Laboratory of the IAEA/WHO network of SSDLs. The laboratory's work covers the following:

- organization of dose intercomparison measurements for SSDLs;
- performance of dose intercomparisons for some 100 radiation therapy centres each year;
- provision of calibration certificates for reference dosimeters from SSDLs and hospitals;
- acceptance of SSDL staff for on-site training;
- design and development of special methods and devices for use in hospitals and SSDLs;
- operation of the International Dose Assurance Service for radiation processing facilities in IAEA Member States.



Results of intercomparisons conducted by the IAEA's Dosimetry Laboratory: Frequency distributions

The laboratory, for example, has prepared more than 80 batches of TLDs, sent them out, and evaluated them through the postal dose intercomparison service. The service has reached about 1000 hospitals in developing countries.

Until 1991, all results were from cobalt-60 irradiations. Since then, the service has been expanded to include X-ray beams from medical accelerators that increasingly are being installed in developing countries. This expanded service involved the support of medical physics departments in 12 renowned radiotherapy centres in Europe and the United States. These departments provided reference irradiations to the IAEA for evaluation. Two TLD intercomparison runs, one with 48 hospitals in Europe and the United States, and the other with all radiotherapy departments in Australia, were done *(see graphs p. 7)*. They can be considered as representative samples of the situation regarding radiation beam calibration in industrialized countries.

Since 1991, the IAEA laboratory has sent a follow-up TLD set to those SSDLs and hospitals that have had poor results; they thus are asked to repeat the intercomparison measurements. Up to now, all follow-up measurements with SSDLs have shown improvement, providing results within the established acceptance limit. Follow-up measurements with hospitals in developing countries, however, have not been satisfactory in many cases, even after a second follow-up.

In all intercomparison runs, the quality of the IAEA's own performance is monitored. In that monitoring process, some TLDs are irradiated with a reference dose in the International Primary Dosimetry Laboratory of BIPM and/or at National Primary Laboratories and evaluated by the IAEA. The results indicate that the accuracy of dose determination with the IAEA's TLD system is about 1 % — well below the acceptance limits for SSDLs (3.5 %) and hospitals (5 %).

A quality audit network

Today about 2000 cobalt-60 units and medical accelerators are in routine use in developing countries, based on responses to a survey being done by the IAEA. In addition, more and more accelerators are being installed that also produce electron beams for patient treatment. The TLD service, therefore, needs to expand accordingly by providing calibration checks for electron beams. The coverage of all machines, however, is beyond the capacity of the IAEA Dosimetry Laboratory's small staff.

As noted earlier, results clearly show that the calibration of radiation beams in developing countries has to improve considerably to reach the conformity prevailing in hospitals of industrialized countries and in SSDLs. Follow-up measurements of poor results only solved the problem in some of the hospitals. Consequently, more attention is required, as well as on-site measurements and discussion with hospital physicists. This, however, cannot be done with a quality control service centralized in the IAEA.

In addition, an effective quality control system for dosimetry involving patient treatment must look at more than just the calibration of the radiation beam. It also has to examine all dosimetric steps from dose prescription to dose delivery to the patient. Only then can the dose to the tumour in each individual patient be known with the required high accuracy, and only then can the different centres share their experiences to find the best treatment procedure.

A pilot study for a quality control programme is now being carried out by European centres with the IAEA's co-operation. Such a programme necessitates the use of dosimeters in human shaped phantoms that undergo radiotherapy as if they were patients. To include all European hospitals, the participation of several reference centres is required to operate a TLD service and to follow-up detected discrepancies.

The European scheme has been modified by the IAEA/WHO for implementation in developing countries. For several years, three SSDLs - those of Argentina, India, and Thailand - have been operating their own national TLD radiotherapy service based on the IAEA's methods. They have, therefore, been asked to participate in the pilot study using their TLD systems *(See p. 6)*. At these centres, the IAEA will continuously monitor the quality of TLD work, as a step toward achieving conformity worldwide in the determination of absorbed dose and the accuracy of the absorbed dose measurements.

In years ahead, radiotherapy is expected to increase in importance for cancer treatment, especially in the developing world. An improvement in the accuracy in dosimetry is needed to introduce modern treatment techniques. In principle, a quality assurance programme should ensure that all patients treated with a curative aim receive the prescribed dose within a margin of about 5 %. Setting up a such a programme by the year 2000 is a formidable task, since it would have to include dosimetry checks for several million patients irradiated each year.

While the major work for such a programme must be decentralized, the IAEA and WHO through the organization of SSDLs are in the best position to co-ordinate the global effort. The pilot studies of the European quality assurance network and of the three SSDLs in IAEA Member States move into closer view the introduction of similar networks for SSDLs and hospitals in other regions. This could lead to a global programme having the potential to significantly improve patient care for millions inflicted with cancer. ■

MEDICAL MEASURING INSTRUMENTS: METROLOGY AND RADIOTHERAPY

Calibration of X-ray kVp-meters: Measurement procedure and results

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Introduction

Quality assurance is developing rapidly in the field of diagnostic radiology as it is in many other fields. Initially, quality assurance in diagnostic radiology focused mainly on the quality of the diagnostic image. Over the last decade, regulations regarding the protection of the patient have resulted in more attention to the X-ray unit itself as a subject of quality control programmes. Parameters of the X-ray unit influencing the dose to the patient for a radiographic procedure ought to be checked regularly and should meet certain limits in order to get maximum diagnostic information at a minimum dose. The parameters influencing the dose to the patient include generating potential, tube current, time and added filtration.

As a result, instruments were developed for the determination of parameters of the X-ray unit by measurement of characteristics of the X-ray beam. The introduction of these so-called non-invasive measuring devices has led to the development of calibration facilities and measurement procedures at NMi Van Swinden Laboratorium. This paper describes the measurement procedure and preliminary results of the calibration of non-invasive kVp-meters, instruments used to measure the generating potential of the X-ray units.

kVp-meters

The generating potential of X-ray units is generally not a DC-voltage. The *waveforms* (high voltage as a function of time) produced by the X-ray generators vary from single-phase or multiple-phase rectified voltages to high voltages that can be considered as a DC voltage with a small ripple (constant potential generators). Several definitions of the high voltage are possible (Fig. 1). The most commonly used definition is the average peak voltage (kVp_{avg}). Other definitions are the maximum peak voltage (kVp_{max}) and the average high voltage (kV_{avg}).

Non-invasive solid state kVp-meters use at least two radiation detectors (photodiodes) in combination with absorbing materials (Fig. 2). The absorbers may differ in composition and thickness. The resulting difference in the signals from the radiation detectors is used to determine the generating potential of the X-ray unit. Commercially available kVp-meters use a microprocessor based algorithm to derive the high voltage from the difference in detector signals. Adjustment of parameters used in the algorithms is therefore restricted to the manufacturer. For this reason, calibration of kVp-meters is limited to its definition: determination of the deviation of the instrument compared to a suitable standard.

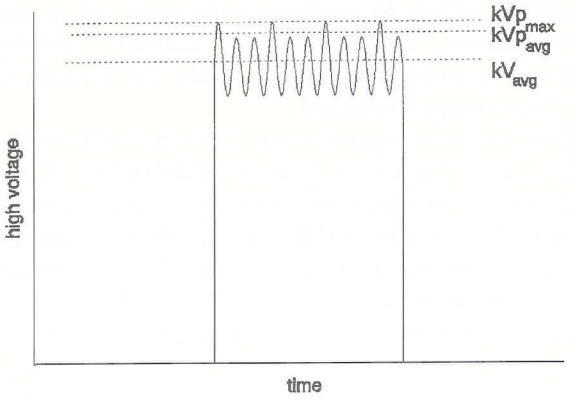

Fig. 1 Different quantities for the characterization of high voltage.

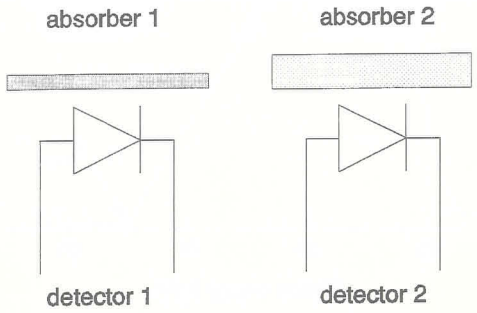

Fig. 2 Principle of operation of a non-invasive kVp-meter.

Measurement procedure

A commonly used method to realize a standard for kVp-calibrations is based on an electrical method. A high-voltage (resistance) divider is used to bring the high-voltage down to a level where it can be measured, traceable to standards for the volt. The main advantage of this method is that it is possible to measure the waveform of the X-ray generator. All previously mentioned definitions of the kVp-value can be applied.

At the moment, the high voltage dividers are perfectly suited to DC-voltages, but too little is known about the frequency characteristics of the high-voltage dividers for AC-voltages of up to 20 kHz. Traceability of the kVp-measurements by means of high voltage dividers is therefore questionable. NMi is working on the solution of this traceability problem.

At present, the standard for the kVp-calibrations is established by means of a spectrometric method. The method is based on the fact that the value of the maximum photon energy in the X-ray beam (expressed in keV) is equal to the value of the high voltage (expressed in kV). Automatically, the quantity measured by this method will meet the definition of kVp_{max}.

The spectrometric method is very straightforward. A HPGe semiconductor detector is placed in the X-ray beam and a pulse height spectrum is recorded. To limit dead time effects (depending on the pulse rate in the spectrometer), the X-ray beam is limited in size by means of a tungsten diaphragm and/or the filtration of the X-ray beam is increased.

The maximum photon energy is determined from the pulse height spectrum (Fig. 3). Calibration of the spectrometer by means of suitable gamma-ray lines of several radionuclides (133Ba, 109Cd) offers traceability of the measurements to the so-called 198Au-standard that forms the basis for the energy of gamma-ray lines. The spectrometric method was used to "calibrate" the setting of NMi's X-ray generator. Since the high voltage is slightly dependent on the tube current, this calibration was performed as a function of tube current over the high voltage range from 30 kV to 250 kV. With the spectrometric method it is possible to determine the value of kVp_{max} with a maximum overall uncertainty of 0,5 kV (2s) over the total range.

The NMi calibration facility for kVp-meters is the same as that used for calibration of dosimeters (for radiotherapy, radiodiagnostics and for radiation protection purposes). The facility consists of a Philips MCN321 tungsten anode X-ray tube connected to a Philips MG324 X-ray generator. The generator is a constant potential X-ray generator with low ripple (< 500 V).

For the calibration of a kVp-meter, the instrument is placed in the X-ray beam of the NMi calibration facility, and for a number of high voltages the reading of the instrument is compared to the high voltage obtained with the spectrometric method. For the calibrations X-ray qualities with 2,5 mm aluminium added filtration are used.

Calibration results

In 1994, a number of kVp-meters were calibrated by NMi. The total of 17 kVp-meters calibrated that year originated from seven different users and five different manufacturers and concerned eight different types. Since it is not the objective of this paper to make a selection between good and bad kVp-meters, the results are presented in a coded form.

Figures 4 and 5 show the calibration results for 15 kVp-meters for the conventional diagnostic range at the calibration points of 70 kV and 110 kV respectively. As can be seen from the figures, some kVp-meters deviate substantially from the value obtained with the spectrometric method.

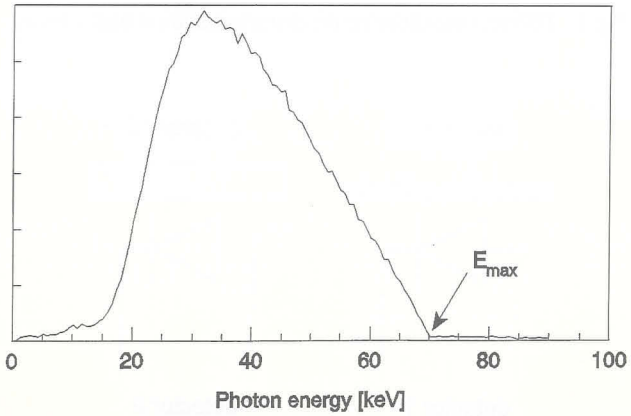

Fig. 3 Measured pulse height spectrum at a high voltage setting of 70 kV.

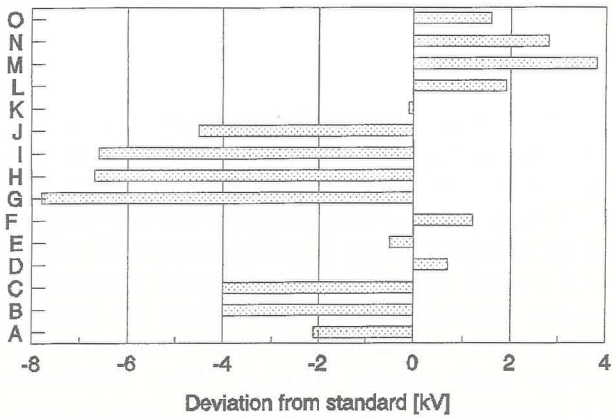

Fig. 4 Calibration results for a high voltage of 70 kV.

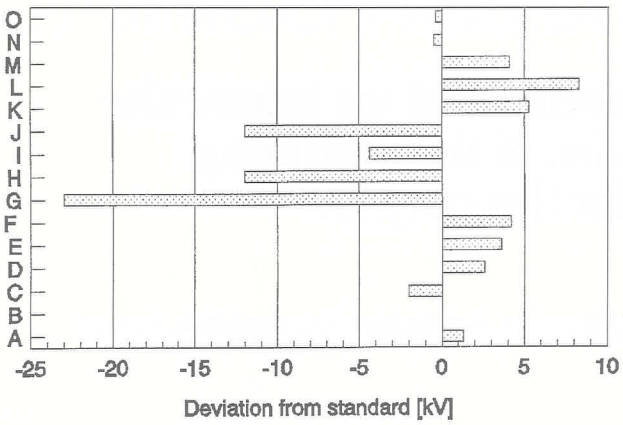

Fig. 5 Calibration results for a high voltage of 110 kV.

Conclusions

Preliminary results of the calibration of non-invasive kVp-meters indicate that the performance of the kVp-meters does not always meet the specifications of the manufacturer which specify a maximum deviation of 2 % to 3 %. From the 17 kVp-meters calibrated, only eight were within specifications over the total range. In some cases the deviations were so large that the kVp-meters were reported as defective to the user. The results indicate the need for routine calibration of non-invasive kVp-meters. A number of instruments have been scheduled for re-calibration in 1995. The results will provide information about the long-term stability of the instruments. ■

MEDICAL MEASURING INSTRUMENTS: TONOMETERS

Non-contact measurement of the intraocular pressure – verification of the measuring instruments used for this purpose

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Introduction

The glaucoma is one of the most frequent, avoidable causes of the loss of sight. This disease is the consequence of an increased intraocular pressure. The non-expert will recognize signs of the existence of this disease only if a clear contraction of the visual field has taken place.

In glaucoma diagnosis, the determination of the intraocular pressure by means of a tonometer is of great importance for the ophthalmologist. The mean intraocular pressure should normally amount to 1999.83 pascal (Pa) in both eyes, corresponding to 15 millimetres mercury column (mmHg)*. Pressure values are pathological from a value of approximately 2933.084 Pa, corresponding to 22 mmHg. The ophthalmologist will most probably be able to influence a glaucoma positively by intensive treatment with suitable medical preparations, provided the disease has been diagnosed in good time. Regression is, however, not possible.

A great variety of tonometers is used in medical practice and in hospitals. A special type of tonometer is the air pulse tonometer, or non-contact tonometer (NCT), which will be dealt with here in more detail.

Legal regulations in Germany

The Verification Act [1] and the Verification Ordinance [2] make specifications for medical measuring instruments that may be brought into commercial dealings, used or held in readiness only if they have been verified.

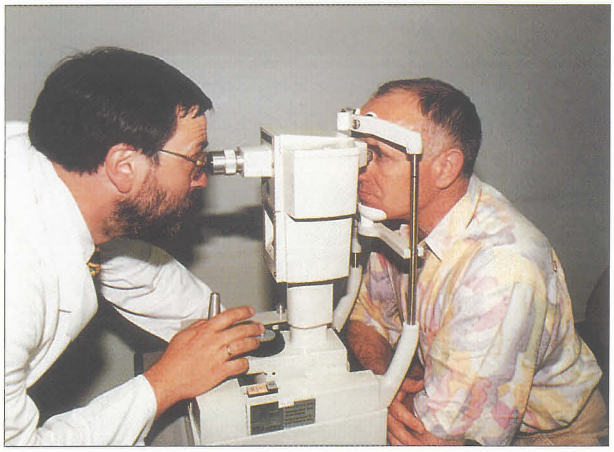


Fig. 1 Practical use of an NCT.

Special medical measuring instruments must also be approved by the Physikalisch-Technische Bundesanstalt (PTB). A pattern approval certificate is issued for such instruments, confirming that they meet the requirements of the regulations in force [3], [4]; these instruments are thus approved for verification. It is of utmost importance for the doctor and for other users of medical measuring instruments that the accuracy of measurement is guaranteed and that the instruments function reliably, because in the majority of cases the users will have no possibility of checking the instruments themselves. A regular check of the accuracy of measurement is at present ensured by an official verification of the measuring instruments in question, here the NCTs, which is carried out by the verification authorities of the federal states every two years.

In Rhineland-Palatinate, one of the federal states of the Federal Republic of Germany, the verification of the NCTs is carried out at the doctors' request either in their practices or in the verification office. This has made necessary the procurement of a transportable NCT test facility, including transport case and accessories. The costs of the test facility, including accessories, amount to a total of 32 000,— DM.

(*) *In a recommendation dated 22 May 1981, the World Health Organization (WHO) pronounced itself in favour of retaining the unit of millimetres mercury column, in addition to the unit "pascal", for the measurement of blood pressure and the pressure of other body fluids. This recommendation has been taken over by a Council Directive of the European Community dated 18 December 1984 (85/1/EEC).*

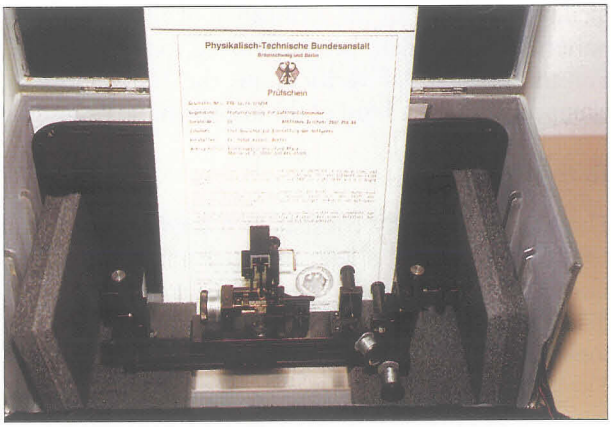


Fig. 2 NCT test facility in the transport case.

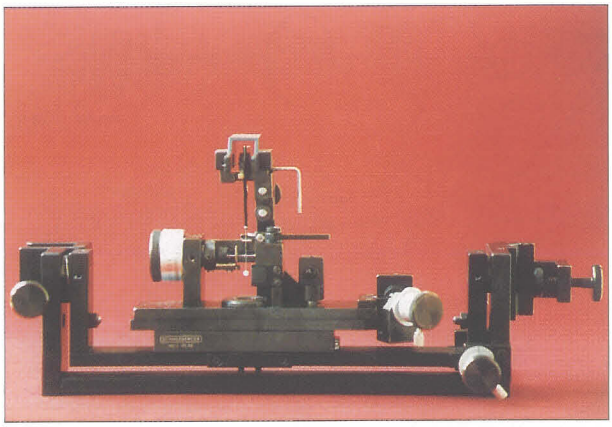


Fig. 3 NCT test facility.

Fundamentals of NCT measurement

The NCT deforms the cornea by means of an air pulse. When an NCT is used for the measurement, the intraocular pressure is not determined by the mechanical application of a pressure body as is the case with other tonometer types; rather, the pressure is measured "pneumatically", without the cornea being touched. The time between the triggering of an air pulse which hits the eye and the flattening of the cornea is measured. The value of the pressure as a function of time is displayed. The measuring principle is explained in detail by the example of the NC tonometer type NCT II with PTB pattern approval number 15.08/82.04.

The measuring method is based on the following principle *(see Fig. 4, p. 14)*:

An air pulse generated by a pumping system (PL) hits the cornea after having passed through a nozzle (D) arranged in the centre of the lens (O), whose axis coincides with the optical axis of the lens. The air pulse hits the eye, which is at a distance of 11 mm from the nozzle, and deforms the cornea. This deformation caused by the air pulse continues until the marginal rays (RS) of a parallel beam (T) falling on the cornea are reflected to the axial beam and the full light intensity strikes a radiation detector (D1). At the moment of deformation (flattening), the circuit of the pumping system is interrupted. The time between the initiation of the measurement process and the flattening of the cornea, which is determined electronically, is digitally displayed on the side of the NCT where the observer is sitting. The measurement process takes 5 to 8 milliseconds.

This NCT is adjusted to the eye with the aid of an optical system. A red point on a white background is imaged on the cornea as a test mark. A pulse can be triggered only if the system's axis points exactly to the vertex of the cornea so that the test mark lies inside a centering ring mounted in the plane of the eyepiece of the observer's microscope [5].

The basic idea and advantage of this measurement method is that for the non-contact measurement of the intraocular pressure,

1. an anaesthetization of the eye is not necessary, and
2. an efficient means is available to prevent the transmission of infectious conjunctivitis.

The measurement of the intraocular pressure with the aid of the NCT is suitable for mass examinations and can be carried out by auxiliary medical personnel.

The first NCT was developed in the USA by Grolmann in 1972. Comparison measurements between an NCT and an applanation tonometer were carried out by K. Jessen and F. Hoffmann [6]. These comparisons showed that there is good agreement between the two different types of tonometers. W. Leyendecker and E. Krehn [7] proved that the values measured in a comparison of an applanation tonometer with the NCT II differed by 1 mmHg at the most.

Five NCT patterns have to date been approved in Germany by the PTB. Further NCT designs are at present being submitted to clinical tests.

NCT test facility

A test method and a test facility were required for these new types of measuring instruments to make the retesting and verification of these instruments possible. The test method and the test facility developed by the PTB are still used today. Adapters allow the NCT test

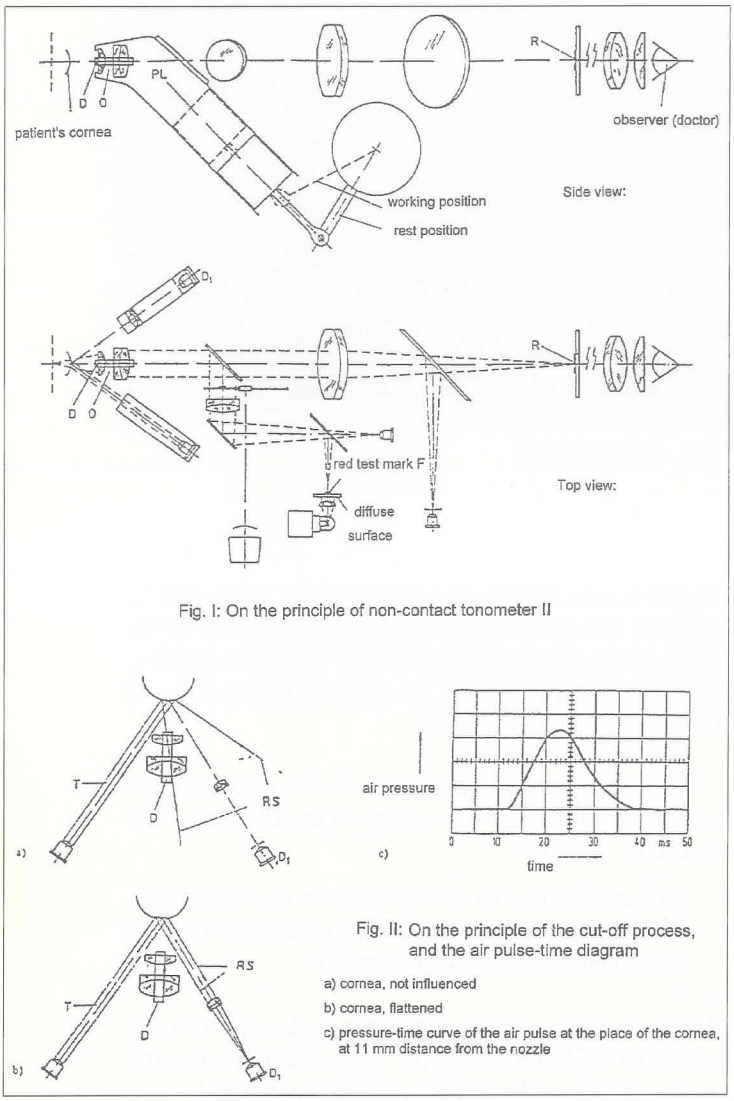


Fig. 4 Drawings illustrating the measuring principle, Figs. I and II [5].

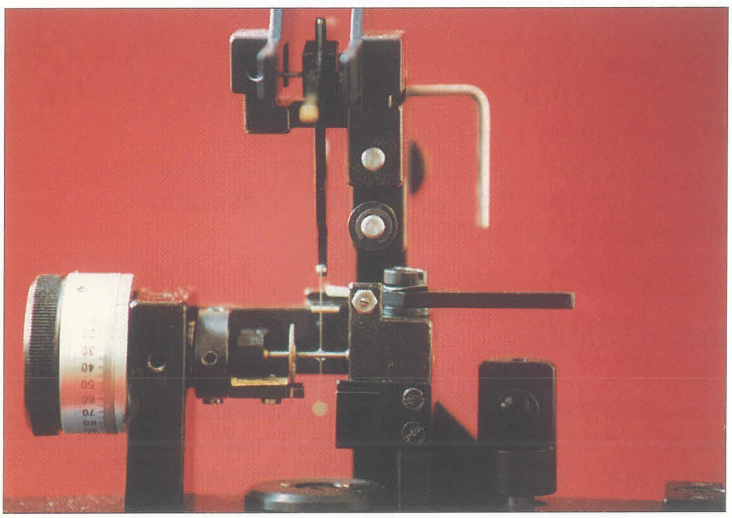


Fig. 5 Mirror and torsion system of the NCT test facility.

facility to be used for the verification of all NCTs whose patterns have to date been approved for verification. For the purpose of verification, the test facility is clamped on the head rest of the instrument to be tested.

Testing procedure

The NCT test facility consists of a torsion balance, a control balance and a lens arranged transversely on a movable slide (path A). A small mirror 2.5 mm in diameter and a torsion spring are fastened to the torsion balance.

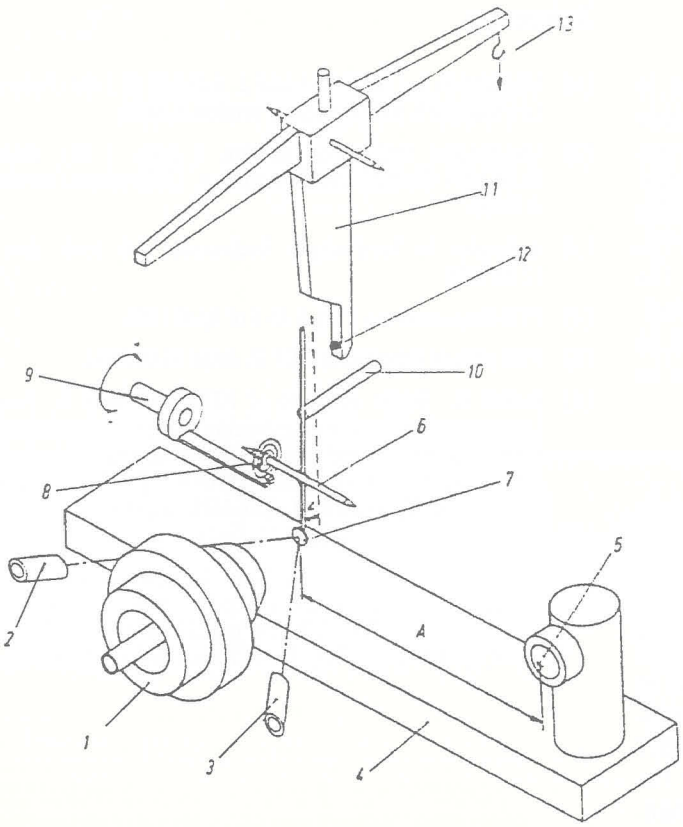
The NCT and the test facility are adjusted to the required nominal distance of 11 mm with the aid of a lens provided with a centering cross. After the test facility has been alternately centered to the lens and to the mirror by moving it laterally along path A, the measuring force is tested on the mirror. In the resting position, the mirror axis is inclined to the vertical axis of the eyepiece through an angle of 2 degrees. To achieve this, a weight is applied via the control balance. A force acts on the torsion system. By turning the knurled screw, the required measuring force on the torsion spring is brought into equilibrium with the reference weight on the control balance when the mirror is perpendicular to the optical axis of the lens. The beams strike the mirror but are not reflected to the detector.

When an air pulse is triggered onto the mirror, the torsion system and the mirror are moved until the reflected beams hit the detector and the air pulse is cut off. The measured value is digitally displayed on the observer side. The masses of the weights for the reference display are stated in the PTB test certificate issued for the NCT test facility. The reference displays of "15", "30" and "45" are checked. In the range between 15 and 30 digits, a deviation of ± 1 digit is permissible while a deviation of ± 2 digits is permissible in the range around 45 digits.

Parts of the test facility are manufactured by a firm headquartered in Berlin. The measuring system of the test facility (torsion system, control balance and lens) is then supplemented by PTB, adjusted and compared with the PTB's standard NCT. This ensures the link-up of the NCT test facilities with the "national standard".

The verification authorities of the individual federal states thus have a test facility at their disposal, which must be re-tested in the same manner as that used by the NCT in the ophthalmologist's office. The test and the link-up with the standard NCT are carried out at the PTB in Berlin every three years.

After completion, the NCT test facilities are tested at PTB (Berlin) and handed over to the verification authorities as "working standards", together with a test certificate.



A. Path lens - mirror
1. Lens
2. Light source
3. Detector
4. Movable slide
5. Lens with centering cross
6. Torsion balance
7. Plane mirror
8. Torsion spring
9. Knurled screw
10. Stop
11. Control balance
12. Contact ball
13. Hook

Fig. 6 Schematic drawing of the NCT test facility (by H. Thiemich, B.Eng., PTB).

The NCT test facility of the verification authority of Rhineland-Palatinate

The NCT test facility used in this federal state is employed above all in field service, in medical practices and for verifications in the verification office. As a result of the working conditions prevailing in field service, including the transportation required for this purpose, misadjustment of the test facility due to impact or shock may occur at any time. For this reason, the stability of the test facility is confirmed by the verification authority on the basis of additional check measurements, i.e. our test facility is checked against the verification authority's own NCT prior to each verification.

Experience gained by other verification authorities has shown that a functional test of the NCT test facility should be carried out and a check measurement made to avoid faulty measurements in practice and, as a consequence, diagnostic errors on the part of the ophthalmologists.

After the introduction of a quality management system according to DIN EN 45 000, regular check measurements on all tonometric test facilities are to be carried out in the test laboratory for medical measuring techniques established at the Verification Board of Rhineland-Palatinate; the results are to be documented.

Plans have been made to supplement the existing test facility by a device which will allow the angle of tilt of the NCT test facility to be measured. It will be possible, with the aid of this measuring facility (consisting of meter section and laser), to re-measure the angle between the mirror and the optical axis. The angle of 2.4 degrees stated in the PTB test certificate, and the angular change by 0.5 degrees due to the application of a load of 10 mg can be checked in the test laboratory of the Verification Board at any time.

Fig. 7 Technical test of an NCT.

Summary

The NCT test facility described in this article is intended for the verification of the five NCT patterns approved thus far in Germany by the PTB. To carry out verifications in the medical practice of an ophthalmologist, the NCT test facility must be transported with utmost care. In addition to the re-testing by the PTB, which must be carried out at three-year intervals, the verification authority arranges check measurements. The intervals between such internal checks should be selected such that correct measurement values can be obtained with the NCT test facility at any time.

Outlook

The *Deutsche Akademie für Metrologie (DAM)* in Munich is planning an informative meeting on NCT, which will be held in the near future. It is intended to exchange information and know-how in NCT verification so far gained by all verification authorities and to carry out an intercomparison of all NCT test facilities used in Germany. Within the framework of this intercomparison, a verification is to be carried out with all NCT test facilities using a verified NCT measured by the PTB. The evaluation of the test records is to demonstrate that the measurement error of the individual NCT test facilities is small and lies within the range of the permissible error limits. ■

References

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[2] Verification Ordinance, section 1 para. 1 (5), dated 21.06.1994 (Federal Law Gazette I, p. 1293) present version in force.

[3] Appendix to Verification Ordinance, EO 15-8, dated 12.08.1988.

[4] PTB-Requirements, PTB-A 15-8 of April 1988.

[5] PTB pattern approval of NCT II, dated 17.09.1982.

[6] Jessen K., Berlin Institute of PTB, Hoffmann F., Freie Universität Berlin, Klinikum Steglitz, Augen- und Poliklinik: Gegenwärtiger Stand der Standardisierung von Luftimpulstonometern und ihre Prüfung - Als Beispiel: Das Non-Contact-Tonometer II. Klin.Mbl. Augenheilkunde 183 (1983), pp. 296–300, F. Enke Verlag Stuttgart.

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Photographs by D. Scheidt, Directorate of Legal Metrology, Rhineland-Palatinate

TYPE EVALUATION AND VERIFICATION

Pattern approval and verification of weighing instruments constructed from modules*

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Abstract

The National Standards Commission has developed a system which allows the pattern approval and verification of weighing instruments constructed from modules. With the advent of electronic weighing instruments it has become practical to construct a variety of instruments from a wide range of modules such as load cells and digital indicators. The Commission's system enables these modules to be approved separately and various other certificates of approval to be issued, thereby allowing the modules to be combined into an instrument which may be verified in the field.

1 Introduction

The system has evolved over a number of years since the advent of load cells and digital indicators being used as the measurement devices in a weighing instrument. Initially the certificates of approval for electronic weighing instruments were based on the traditional method of describing a pattern and variants of the pattern. This method is still used for small weighing instruments up to 100 kg used mainly for weighing in the presence of the purchaser, e.g. in supermarkets or other shops. In this case the instrument is pattern evaluated as a complete instrument and not as separate modules.

However, it soon became obvious that for larger instruments there would be a wide variety of uses to which the load cells and digital indicators could be applied. The Commission was testing load cells as separate modules even before OIML R 60 was published. The load cells and digital indicators were tested to reduced maximum permissible errors (70 %) as specified in OIML R 3 (preceding OIML R 76).

(*) *This article was presented at the OIML seminar "Weighing towards the year 2000" which was held 13–15 Sept. 1995 in Paris. It is the first of a series of seminar papers to be published in future issues of the Bulletin.*

2 The system

The following are a number of points which have influenced the development by the Commission of the system described in this paper:

- It is relatively simple to carry out pattern evaluation testing on a complete instrument when it is of low capacity. However, in a laboratory environment it becomes more difficult to test a complete instrument as its capacity (and size) increase. Therefore, for larger instruments it becomes desirable to conduct testing for pattern approval purposes on modules of the instrument – primarily these are the load cell and digital indicator.
- Equipment manufacturers often specialise in the field of either load cells or digital indicators. It therefore follows that such manufacturers wish to obtain approvals for load cells or digital indicators as modules on their own.
- When a weighing instrument is constructed using particular load cells and a particular digital indicator, it is necessary to ensure that the instrument as a whole complies with the requirements applicable to a complete weighing instrument. This includes ensuring that the load cells and digital indicator are used within the parameters for which they were approved.
- Weighing instrument manufacturers are frequently called upon (particularly in the higher capacity ranges) to develop weighing instruments which, whilst different due to the particular needs of industry, are based on common basic principles. It is not desirable that this innovation be unduly inhibited by the need for complete pattern approval for each design, and the time delays and costs which this would entail.
- Weighing instrument manufacturers (if they are independent of particular manufacturers as is frequently the case in Australia) wish to have flexibility

to utilise different modules in the construction of instruments according to availability, features and cost. Requiring complete pattern approval for each change in module reduces this flexibility.

The system has evolved in various phases over the last 12 years:

- the approval of load cells and digital indicators as separate modules (the Commission was doing this even before the publication of OIML R 60);
- the development of a system of calculations for weighbridges, to allow flexibility in design;
- the incorporation of provisions covering the conversion of mechanical instruments to lever/load cell instruments, and the implementation of a requirement for Analysis Reports to be obtained; and
- the extension of the above system to lower capacity instruments, initially those above 1 500 kg maximum capacity and then those above 100 kg maximum capacity.

It should be emphasized that it is not compuslory for instruments to be approved as modules and to be subject to the scheme described. Instruments may be approved as a single unit (whether or not separate testing of modules has been necessary), however in this case the flexibility provided by the scheme is not available.

The system (Fig. 1) consists of the following components:

- legislation to cover approval of modules;
- pattern approval requirements for modules and weighing instruments;
- supplementary certificates of approval for modules;
- certificate of approval for the pattern and variants of a weighing instrument;
- general certificate of approval covering the combination of modules into a weighing instrument (this is only applicable to instruments of over 100 kg maximum capacity);
- analysis reports for each weighing instrument design to ensure that the criteria of the general certificate have been met; and
- verification of each weighing instrument to ensure correct operation in the field.

The pattern approval and verification of trade measuring instruments in Australia is a two-tier system with the Commission (Commonwealth Government) being responsible for pattern approval and the trade measurement authorities (State/Terrirory Governments) being responsible for verification. The latter also appoint licensees to certifiy instruments.

The Commission is therefore responsible for the system up to the issuing of the various certificates of approval, with the trade measurement authorities and certifiers being responsible for the verification or certification. The analysis report is generally provided by the Commission (though the trade measurement authority may also do this) once the information provided by the manufacturer has been checked. An instrument may not be verified or certified unless an applicable analysis report has been obtained.

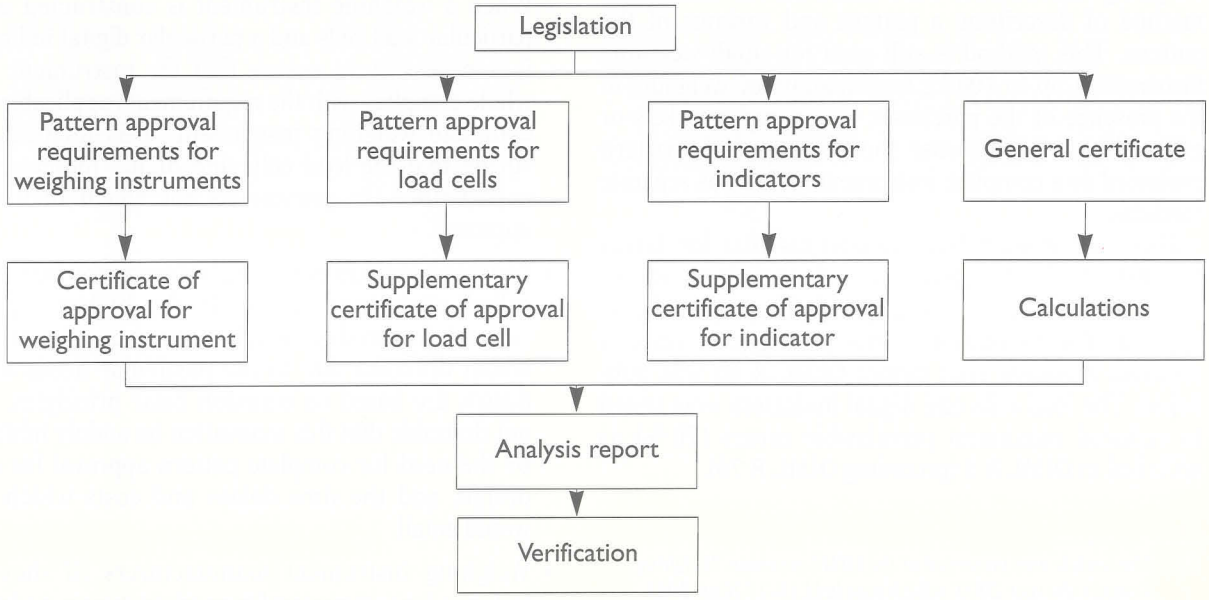


Fig. 1 The Commission's pattern approval and verification system for weighing instruments constructed from modules.

2.1 Legislation

The pattern approval of trade measuring instruments is carried out by the National Standards Commission under the National Measurement Act 1960 and the National Measurement (Patterns of Measuring Instruments) Regulations. The Act defines a measuring instrument as:

- a thing by means of which a measurement of a physical quantity may be made; or
- a component of such a thing.

This allows the Commission to issue a supplementary certificate of approval for load cells and indicators which are considered components. OIML R 76 for non-automatic weighing instruments states that a module, which is defined as a part of an instrument which performs a specific function, can be examined separately and is subject to specified partial error limits.

2.2 Pattern approval requirements

The Commission has adopted, with very few modifications, OIML recommendations for the evaluation of non-automatic weighing instruments and their modules, i.e.:

- OIML R 76-1 (1992)
  Nonautomatic weighing instruments. Part 1: Metrological and technical requirements - tests;
- OIML R 76-2 (1993)
  Non-automatic Weighing Instruments. Part 2: Pattern evaluation report;
- OIML R 60 (1991)
  Metrological regulations for load cells; and
- Annex to OIML R 60 (1993)
  Test report format for the evaluation of load cells.

With the lack of specific requirements, digital indicators are evaluated in accordance with OIML R 76-1 and the results are recorded in OIML R 76-2.

The same methods and requirements are applied to automatic weighing instruments which can also weigh statically and for which the errors specified in OIML R 76-1 are applicable for static loads. However for automatic weighing instruments for which relative errors are specified in the OIML recommendation, a different approach is required. The Commission has developed calculations applicable for fitting load cells (tested in accordance with OIML R 60) to belt weighers in accordance with OIML R 50 (1994) – *Continuous totalising automatic weighing instruments (Belt Weighers)*. These calculations are given later in this paper.

2.3 Supplementary certificate of approval for load cells

The Commission pattern approves modules of instruments; these approvals are known as supplementary certificates of approval.

In the case of load cells the pattern approval is based on testing (according to the test procedure in OIML R 60) of four load cells of each type and capacity. These load cells are tested for the required performance in accordance with the parameters specified by the submittor. The Commission believes that the testing of four load cells provides a more accurate indication of the performance of the population of load cells than a sample of one.

The parameters for which the load cells have been approved are given in the supplementary certificate of approval. These parameters are:

- maximum capacity of the load cell, E_{max} (kg);
- maximum number of verification intervals, $n_{LC\ max}$;
- minimum value of verification interval, v_{min} (kg);
- minimum dead load output return, DR (kg);

  Note: The parameter DR is not specifically mentioned in OIML R 60 - Annex A. However, it is required for the calculations relating to multi-interval and multiple range instruments given in point 4.12.2 of OIML R 76.

  The value of C_{MDLOR} calculated according to OIML R 60 - Annex A is the parameter required, but is in units of v. Therefore the value required can be calculated as $DR = (C_{MDLOR} \times E_{max})/n_{max}$.

- output rating (nominal) (the units used are generally mV/V) - this parameter is also often called load cell sensitivity, it indicates the load cell output voltage per volt (of excitation) when the maximum capacity of the load cell is applied;
- input impedance (Ω);
- supply voltage range (V);
- number of leads (plus shield); and
- cable length (m).

The supplementary certificate also specifies conditions relating to the fitting of the approved load cell to a weighing instrument, such as:

- the supplementary certificate number shall be marked on the weighing instrument;
- the values of the performance criteria for the weighing instrument incorporating the approved load cell shall be within the performance limits specified in the supplementary certificate for the load cell.

2.4 Supplementary certificate of approval for indicators

The pattern evaluation of electronic digital indicators is carried out using standard load cells as a reference input. Two cells are used to provide a range of input sensitivities. All influence factors and disturbances specified in OIML R 76-1 are applied to the indicator while keeping the standard load cells at reference conditions. The cells are corrected for any variations in the conditions.

The apportioning of maximum permissible errors to the indicators is in accordance with the typical module fractions shown in OIML R 76-1 (Table 7) and the test results are recorded on OIML R 76-2.

The indicators are tested to the required specifications requested by the submittor and these are included in the supplementary certificate of approval for the indicator, i.e.:

- Maximum number of verification intervals – represented as n_{INDmax}
- Minimum sensitivity (mV/verification scale interval or µV/verification scale interval) – the minimum input voltage per verification scale interval at which the indicator can be expected to operate whilst still complying with the requirements of OIML R 76;
- Excitation voltage (V) – the excitation voltage which will be applied to the load cells; and
- Maximum excitation current (mA) – which reflects the ability of the indicator to supply a certain number of load cells of a given input impedance; Alternatively in some cases the Minimum load impedance (Ω) is given;

The same conditions as described for load cell certificates are also included in indicator certificates.

2.5 Certificate of approval for manufacture of non-automatic weighing instruments

All manufacturers or importers of weighing instruments used for trade purposes in Australia have to obtain pattern approval of each model together with any variants of that model.

For weighing instruments up to 100 kg the sample instrument is tested in a complete form and approved as such; these instruments are not included in the modular system. In addition, instruments with single load cell support of the load receptor and full load cell overhead track scales are not included in the system and therefore are only approved and tested as an instrument.

For other weighing instruments the procedure is as follows:

- If the load cells and/or indicator do not already have a supplementary certificate of approval and the submittor wishes to take advantage of the flexibility of the modular system, it will be necessary to obtain supplementary certificates of approval as follows:
  - The load cells are tested and a supplementary certificate of approval is issued; and /or
  - The indicator is tested for all influence factors and disturbances and a supplementary certificate of approval is issued.
- A sample instrument is tested either at the Commission (up to 3 000 kg) or on-site for larger instruments. This instrument would incorporate the modules as tested and approved.
- If any variants are required (i.e. for instruments which are of a substantially different design), a sample instrument may be tested.

A certificate of approval is issued which describes the pattern, refers to the supplementary certificate of approval for the load cell and indicator and includes the specifications of maximum capacity and maximum number of verification scale intervals for which the approval is valid.

The maximum capacity for which the approval is valid is specified in one or more of the following ranges:

- from 100 kg up to 1 499 kg;
- from 1 500 kg up to 14 999 kg;
- from 15 000 kg up to 149 999 kg; and
- 150 000 kg and above.

2.6 Certificates of approval for conversion of non-automatic weighing instruments

Instrument owners frequently wish to convert a mechanical weighing instrument (e.g. a steelyard or dial weighbridge) to an electronic instrument by replacing the mechanical indicator with a load cell and digital indicator (which we term lever/load cell instruments). To allow companies other than the original manufacturer to convert mechanical weighing instruments to lever/load cell instruments, the company must apply for a conversion certificate of approval.

The holders of a conversion certificate of approval are also permitted to replace the load cell and/or indicator of an existing lever/load cell instrument with another type of load cell and/or indicator, or to replace the indicator of a fully electronic instrument with another indicator (in both cases with the proviso that

the parameters of such components must be satisfied by following the procedures of the general certificate mentioned below). The holder of a conversion certificate of approval is not permitted to manufacture a new instrument or to replace the load cells of a fully electronic instrument with another type of load cell.

To obtain a conversion certificate of approval, a sample instrument using approved modules must be submitted for examination so that the instrument can be checked to ensure that the conversion is done correctly and complies with the various approvals. The conversion certificate describes this sample instrument and the restrictions mentioned above.

2.7 General certificate of approval for non-automatic weighing instruments

The certificates of approval previously mentioned are specific to a submittor and to a particular type of instrument. However, it is possible to construct a large range of variant instruments to the approved pattern using a wide variety of approved modules. To avoid specifying the conditions for this in each certificate of approval, a general certificate of approval has been issued. This general certificate is not issued to any submittor in particular, but can be used by all manufacturers and converters who hold specific approvals of non-automatic weighing instruments. The scope of the general certificate includes:

- the manufacture of new weighing instruments of different sizes and capacities to the approved pattern;
- the conversion of weighing instruments by the substitution of components (i.e. modules);
- the conversion of mechanical weighing instruments (including mechanical overhead track instruments) to lever/load cell instruments;
- the compliance of the weighing instrument with its certificate of approval; and
- checking that the components used for the instrument are installed correctly, and are within their approved criteria, in accordance with their supplementary certificates of approval.

To ensure that the new or converted instruments comply with the various approvals of modules and instruments, the general certificate includes a series of calculations which have to be carried out as shown below.

Calculations

The following variables are used:

E_{max} is the maximum capacity of the load cell;

N is the number of load cells;

r is the lever ratio (for a full load cell type instrument $r = 1$);

R is the reduction ratio = 1/lever ratio = $1/r$ (for a full load cell type instrument $R = 1$);

Max_{INST} is the maximum capacity of the instrument;

e is the verification scale interval for the instrument.

Dead load

In many cases load cell manufacturers do not specify a particular minimum dead load value, and as a result a value for this parameter is generally not given in the supplementary certificate of approval for a load cell. Nevertheless, it is considered desirable that a significant dead load be applied to a load cell, and as a result the following requirement is applied.
First determine the receptor dead load, e.g. length × dead load per unit length.

- For a full load cell instrument, the dead load supported by each load cell (i.e. receptor dead load/number of load cells) shall be greater than or equal to 1 % of the capacity of that load cell.
- For a lever/load cell instrument, the force applied by the dead load to the load cell(s) of a lever/load cell instrument shall be not less than 2 % of the capacity of the load cell(s).

  Note: This force includes a contribution due to the mass of the levers (effective lever mass). While this value can be calculated, it is often better to measure the force at the nose end of the lever system using a force balance. The larger of the values (measured or calculated) shall be used in subsequent calculations.

Loaded capacity of the load cell(s)

The maximum capacity of the load cell(s) should not be exceeded. Components which contribute to the load which may be applied to any particular load cell are the dead load of the load receptor, non-uniform distribution of the load, possible effects of eccentric loading, and the initial zero-setting range.
As the initial zero-setting range is used to zero-out the dead load, this factor is not considered further. It is only possible to consider the non-uniform distribution and eccentric loading effects for a specified load, and as the load is often quite variable either an assumed loading pattern must be used or each situation must be considered individually.
In general, the Commission uses the following formulas which are simplified versions of formulas based on a uniform loading distribution. However for special instruments where a specific well-defined load is used, individual calculations for the particular situation may be used.

The maximum capacity of the load cell(s) shall be greater than the load determined as follows:

- For six or more load cells*:

$E_{max} \geq (Max_{INST} + \text{dead load}) / K$

Where $K = (N - 2)H / J$ and H and J are as shown in Fig. 2:

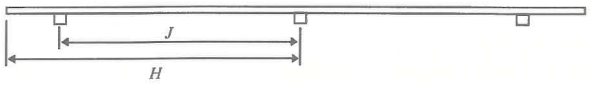


Fig. 2

- For up to five load cells or for hopper weighing instruments*:

$E_{max} \geq (Max_{INST} + \text{dead load}) / N$

- For a lever/load cell instrument*:

$E_{max} \geq (Max_{INST} / r) + \text{dead load force to the load cell}$

Note: Point 4.12.1 of OIML R 76 gives the equation

$$E_{max} \geq \frac{Q \cdot Max \cdot R}{N}$$

where Q = a correction factor designed to take account of various additional factors.

Therefore the above calculations are equivalent to the following:

- For six or more load cells

$$Q = \frac{J \cdot (Max + \text{dead load})}{H \cdot Max \cdot (N-2)} \text{ and } R = 1$$

- For up to five cells

$$Q = \frac{(Max + \text{dead load})}{N \cdot Max} \text{ and } R = 1$$

- For a lever/load cell instrument

$$Q = 1 + \frac{\text{dead load force to the load cell}}{R \cdot Max} \text{ and } R = \frac{1}{r}$$

(*) *For instruments where there is more than one load cell at each load support point, the maximum capacity of the 'load cell' is the sum of the capacities of the load cells at the support point.*

Number of verification scale intervals for the instruments

Each module must be approved for the appropriate number of verification scale intervals. This number is determined by dividing the maximum capacity of the instrument by the value of the verification scale interval marked on the instrument.
For a multiple-range or multi-interval instrument, the maximum capacity and the value of the verification scale interval of each individual weighing range or partial weighing range, are used.
The number of verification scale intervals for the instrument shall be not greater than the smallest of those specified in the appropriate certificates of approval for the various components and shall be not less than the minimum for the relevant class of instrument, see appropriate table in OIML R 76-1.
For a multiple-range or multi-interval instrument, special requirements (OIML R 76-1, point 4.12.2) apply between the minimum dead load output return for the load cell and the scale interval of the first range.
The minimum dead load output return (DR) for the load cell as specified in the certificate for the load cell shall satisfy the following:

- for a multi-interval instrument $DR \leq 0.5\ e_1 / rN$; and
- for a multiple range instrument $DR \leq e_1 / rN$,

where e_1 is the verification scale interval of the first range.

Note: To be consistent with the approach of point 4.12.3 of OIML R 76, where a factor of $\sqrt{N}$ is used to account for an assumed distribution of load cell parameters, the above formulas should properly contain the factor $\sqrt{N}$ rather than N. This inconsistency in OIML R 76 should be corrected. This is in fact the approach taken by the Commission, however this is achieved by setting DR in a multi-cell instrument = DR of the load cell / $\sqrt{N}$.

Minimum value of verification interval for the load cell

The minimum value of verification interval (v_{min}) is a parameter of the load cell which is related to the temperature effect on minimum dead load output. The value is given in the supplementary certificate for the load cells. This value shall satisfy the following (for a multi-interval or multiple range instrument e should be replaced by e_1).

$$v_{min} \leq \frac{e}{r\sqrt{N}}$$

Minimum sensitivity of the digital indicator

The minimum sensitivity of the digital indicator specifies the value of input voltage (per verification scale interval) above which the compliance of the digital indicator with the approval criteria is assured.
The approved minimum sensitivity of the digital indicator shall satisfy the following:

$$\text{Minimum sensitivity} \leq \frac{\text{excitation voltage} \times \text{load cell output rating} \times \text{load ratio}}{\text{number of verifcation scale intervals for the instrument}}$$

$$\text{where load ratio} = \frac{Max_{INST}}{r \times N \times E_{max}}$$

Note: The units of voltage used for minimum sensitivity of the indicator and load cell output rating should be the same, i.e. either mV/e and mV/V or µV/e and µV/V.

Maximum excitation current

The ability of the indicator to supply current to the required number of load cells should also be considered. Either the maximum excitation current or the minimum load impedance of the indicator may be specified.
To be satisfactory the maximum excitation current shall satisfy the following:

$$\text{maximum excitation current} \geq \frac{N \times \text{excitation voltage}}{\text{load cell impedance}}$$

Or, where the minimum load impedance of the indicator is given:

$$\text{load cell impedance} > N \times \text{minimum load impedance of the indicator}$$

2.8 Compatibility table for indicators

The Commission has produced a compatibility table for those indicators for which a Supplementary Certificate of Approval has been obtained. This is used by manufacturers to select alternative indicators. If an indicator X is shown in this table as being a compatible replacement for indicator Y, this replacement can be carried out without obtaining an Analysis Report as indicated below.

However, we now believe that it is preferable that a complete analysis of the compatibility of the indicators be carried out in each specific case. This is because the number of significant indicator parameters which need to be considered, may result in misinterpretation of any compatibility table which is prepared.

To provide reasonable confidence that indicator X may replace indicator Y and still operate within its approved parameters it is necessary that:

- $n_{INDmax}\ (X) \geq n_{INDmax}\ (Y)$;
- $\text{minimum sensitivity}\ (X) \leq \frac{\text{excitation voltage}\ (X)}{\text{excitation voltage}\ (Y)} \cdot \text{minimum sensitivity}\ (Y)$;

  and
- maximum excitation current $(X) \geq$ maximum excitation current (Y) or minimum load impedance $(X) \leq$ minimum load impedance (Y).

It is also necessary to consider whether the excitation voltage (X) is within the parameters allowable for the load cell.

2.9 Analysis report for non-automatic weighing instruments

When an instrument constructed from approved modules is submitted for verification, the manufacturer has to supply an analysis report which demonstrates that:

- All modules are covered by supplementary certificates;
- The instrument is covered by a certificate of approval or a conversion certificate;
- The approvals are current, i.e. they have not expired (certificates of approval have a five-year expiry date at which time they have to be reviewed); and
- The specifications of the modules are complied with for that installation.

Figure 3 shows a sample calculation sheet in accordance with the general certificate. The calculations involved are submitted either to the Commission or to a trade measurement authority for checking. An analysis report is then issued if the calculations and other facts are correct. The instrument cannot be verified without an analysis report.

3 An application of the system to automatic weighing instruments

For automatic weighing instruments which can also be used and tested in a non-automatic mode, the system of establishing conformance using approvals of modules is the same as already described. For automatic instruments which cannot be used or tested in a non-

6B/0 Calculations for a full load cell weighing instrument (single range)

6B/0 Converter Details: XYZ Scales — 1 Australia St — SYDNEY NSW 2000
6B/0 Conversion Certificate: 6B/nnn — Phone No: 123 4567 — Fax No: 123 4568
Contact Person: J Smith

Type of situation: Manufacture of full electronic weighbridge — Hopper: NO

Instrument		Load Cell		Indicator	
NSC No:	6/10B/aaa	NSC No:	Sbbb	NSC No:	Sccc
Expiry Date:	01/10/97	Expiry Date:	01/05/99	Expiry Date:	01/07/97
Manufacturer:	XYZ Scales	Manufacturer:	Load Cell Manuf. Co	Manufacturer:	Indicator Manuf. Co
Description:	Model 1234 Weighbridge	Model:	LC9876	Model:	Ind3456
Max =	60000 kg	Max =	25000 kg	Nmax =	7500
e =	20 kg	Nmax =	3500	Sensitivity =	0.66 µV/e
Width:	3 m	vmin =	1.53 kg	Excitation Voltage =	10 V
Length:	15 m	mV/V =	1	Min Input Imp =	43.48 Ω
Dead load/unit length:	2010 kg/m	Input Impedance =	650 Ω	Max Exc Current =	230 mA
Dead load:	30150 kg	Voltage range =	4 to 24 V		
H =	7.5 m	Cable length =	10,15 m		
J =	6.7 m				
H/J ratio =	1.12	Number of Cells =	6	Exc Volts Used =	10 V

Expiry dates are **ACCEPTABLE**

6B/0 Clause 6.1: Dead Load
Dead Load per load cell = 5025 kg = 20.10 % of load cell capacity >= 1% so the result is **ACCEPTABLE**

6B/0 Clause 6.2: Loaded Capacity of the Load Cells
Note: Calculations may not be applicable where there is more than one load cell at each load support point, the maximum capacity of the "load cell" is treated as the sum of the capacities of the load cells at the support points.
Applicable formula is (Max of Inst + Dead Load) / ((No of Cells -2)*H/J) = 20134 kg, it is < Load Cell Max so the result is **ACCEPTABLE**

6B/0 Clause 6.3: Number of Verification Scale Intervals for the Instrument
Number of Verification Scale Intervals (e) for the instrument is 3000
This is <= the number approved (Nmax) for the load cell and hence is **ACCEPTABLE**
And is <= the number approved (Nmax) for the indicator and hence is **ACCEPTABLE**

6B/0 Clause 6.4: Minimum Value of Verfiication Scale Interval for the Load Cell
Applicable formula is e/sqrt(No of Cells) = 8.16 kg
This is > the vmin value for the load cell and hence is **ACCEPTABLE**

6B/0 Clause 6.5: Minimum Sensitivity of the Digital Indicator
Applicable formula is Exc_Volts_Used * LC_Sensitivity * Inst_Max / (Inst_No_of_e * No_of_Cells * LC_Max)
This = 1.33 µV/e which is > the sensitivity limit of the indicator and hence is **ACCEPTABLE**

6B/0 Clause 6.6: Load Cell Impedance
Total current required = 92.3 mA which is < the capability of the indicator and hence is **ACCEPTABLE**
Or No_of_Cells * Min_Imped = 260.9 Ω which is < the load cell impedance and hence is **ACCEPTABLE**

RESULT: The calculations are ACCEPTABLE

Fig. 3 A sample calculation sheet submitted with a manufacturer's analysis report for nonautomatic weighing instruments.

automatic mode, a different approach has to be taken. The following system has been drafted to cover the application of separately approved load cells to continuous totalising automatic weighing instruments (belt weighers).

Belt Weighers

Belt Weigher installations are characterized by the following specifications in accordance with OIML R 50 – *Continuous totalising automatic weighing instruments (Belt Weighers):*

- Maximum capacity (of the weighing unit) (Max_{BW});
- Maximum flowrate (Q_{max});
- Minimum flowrate (Q_{min});
- Weigh length (of the weighing unit) (L); and
- Belt speed (V).

The total maximum load on the load cells supporting the weighing unit is made up of the maximum capacity (live load) and the weight of the weighing unit (dead load).

The approved parameters for load cells (E_{max} , n_{max} and v_{min}) are based on the required performance for fitting the load cells to non-automatic weighing instruments on the basis that the load cell contributes no more than 70 % of the total weighing instrument errors.

Although the maximum permissible errors for automatic weighing instruments such as belt weighers are different to non-automatic weighing instruments, the performance specifications given in the load cell recommendation can be applied to belt weigher installations.

The following calculations are based on knowing the characteristics of the belt weigher installation and from these, determining the required performance of each load cell. If the calculated performance is equal to or less than the performance of the load cell then the load cell selected is satisfactory for that installation.

Load cell capacity

Total maximum load on load cells (W_{BW}) = Max_{BW} + dead load

Note: $Max_{BW} = Q_{max} \times L / V$

The maximum load on each load cell (W_{LC}) is W_{BW} divided by the number of load cells (N) and/or the lever ratio (r) if applicable, i.e.: $W_{LC} = W_{BW} / N r$.

If W_{LC} is $\leq E_{max}$, the load cells are satisfactory, i.e.: if $E_{max} \geq (Max_{BW}$ + dead load) / $N r$.

Maximum permissible errors

The relative maximum permissible error for belt weighers tested under simulated conditions for influence factors (OIML R 50 point 2.2.3) are for class 0.5: ± 0.18 %, for class 1: ± 0.35 % and for class 2: ±0.7 %.

The load cells are also tested under simulated conditions for influence factors and they can be considered to contribute no more than 70 % of the total belt weigher errors specified above (OIML R 50 point 2.2.3.1). Therefore, the maximum permissible relative errors required for the load cells used in belt weighers are for class 0.5: ± 0.126 %, for class 1: ± 0.245 % and for class 2: ± 0.49 %.

Therefore, for a Class C load cell to be satisfactory for use in a class 0.5, 1 or 2 belt weigher, the relative error of the load cell at the worst case load should not exceed the above figures.

For load cells the maximum permissible error specified in terms of the scale interval v in OIML R 60 (class C) are as follows:

± 0.35v for 0 to 500v ;

± 0.7v for 501 to 2 000v ; and

± 1.05v for 2 001 to 10 000v.

The worse relative error will be at low load, i.e. a low number of scale intervals for the load cell (< 500v).

The limiting relative error for each class for the load cells will occur at the following number of verification intervals (n):

class 0.5 n = 0.35 × 100 / 0.126 = 277 intervals

class 1 n = 0.35 × 100 / 0.245 = 143 intervals

class 2 n = 0.35 × 100 / 0.49 = 71 intervals

Considering that the worst case will represent 20 % flow rate of the belt weigher, the maximum flow rate will be equivalent to:

class 0.5 1 385 intervals

class 1 715 intervals

class 2 355 intervals

Rounding these to the next highest 500 intervals:

class 0.5 1 500 intervals

class 1 1 000 intervals

class 2 500 intervals

Therefore any class C load cell with n_{max} equal to, or more than, these values will be satisfactory for use in the three classes of belt weighers.

Temperature effect on minimum load

The value of the minimum verification interval (v_{min}) for the load cell is determined by the effects of a temperature change at minimum load (also a pressure effect but this is usually less than the temperature effect). The maximum permissible effect is 0.7 v_{min} for 5 °C temperature change for class C load cells. This is equivalent to 1.4 v_{min} for 10 °C change.

The corresponding requirement for a belt weigher is a maximum variation (for say class 1) of 0.07 % of the load totalised at the maximum flow rate for the test and for 10 °C temperature change.

Therefore, 0.07 % of the live load on the load cells at maximum flow rate (the live load on the load cells at Q_{max} is Max_{BW}) should exceed the temperature effect on the load cells for 10 °C, i.e. 1.4 v_{min}.

The total temperature effect on the weigh-frame for multiple load cells (N) or for a lever ratio (r) if applicable, is 1.4 $v_{min}\, r \sqrt{N}$ where $\sqrt{N}$ is used to take into account the possible variation in the temperature effect for each load cell. This is similar to OIML R 76-1).

Also, the live load on the weigh-frame at maximum flow rate equals Max_{BW}, so:

$$1.4\, v_{min}\, r \sqrt{N} \leq \frac{0.07\, Max_{BW}}{100} \Rightarrow v_{min} \leq \frac{0.07\, Max_{BW}}{1.4 \times 100 \times r \sqrt{N}}$$

Therefore if

$$v_{min} \leq \frac{0.0005\, Max_{BW}}{r \sqrt{N}},$$

the load cells are satisfactory.

Similarly for class C load cells fitted to class 0.5 and class 2 belt weighers:

class 0.5:

$$v_{min} \leq \frac{0.035\ Max_{BW}}{1.4 \times 100 \times r\sqrt{N}} \Rightarrow v_{min} \leq \frac{0.00025\ Max_{BW}}{r\sqrt{N}}$$

class 2:

$$v_{min} \leq \frac{0.14\ Max_{BW}}{1.4 \times 100 \times r\sqrt{N}} \Rightarrow v_{min} \leq \frac{0.001\ Max_{BW}}{r\sqrt{N}}$$

4 Future developments

At present, the Commission carries out most of the checking of the calculations required for the analysis report. In a significant number of cases the information provided does not comply with the specified requirements. This may be partly due to inadequate access to parameters of approved load cells and indicators, and partly to a lack of understanding of the calculation and procedures involved. It is also time-consuming for the Commission to search out all the aspects required for checking the conformity of the instrument with the various approvals.

The Commission is therefore developing a computerized system to carry out the above calculations. Initially the package will be for internal use but the ultimate intention is to sell the package to industry. The package would contain all the necessary load cell and indicator parameters, together with the calculations and procedures.

The intention would then be that the industry would be able to carry out the calculations without each case being checked by the Commission. Unusual cases would still be required to be referred to the Commission for analysis, and an auditing process would be required to ensure correct use of the calculation program.

The Commission will then need to keep the computer package up-to-date with the following information as new approvals, interpretations and changes occur:

- load cell parameters and certificate status;
- indicator parameters and certificate status (including variants);
- conversion certificate scope and status;
- acceptable load cell mounting methods (described in the load cell certificate); and
- interpretations of the General Certificate 6B/0.

5 An alternative approach

The National Measurement Act in Australia provides for the pattern approval of instruments, it does not provide for the approval or licensing of the capabilities of particular people or companies. This restriction has influenced the development of the system.

If the system was to be developed without this restriction (but still retaining the system of modular approval of load cells and digital indicators), it may be preferable to concentrate on the capabilities of the manufacturers, converters and repairers, and to attempt to license the type of work which each can carry out, taking into account their knowledge and capabilities.

Some companies may have the knowledge, experience and quality systems to justify a licence to manufacture, convert and repair a wide range of capacities and designs of instruments (using approved modules) with minimal regulation. However, another company may have more limited knowledge and experience, resulting in a licence which limits the activities to conversion of existing instruments, and in the absence of a suitable quality system closer regulation of this company may be warranted.

6 Conclusions

The system has been in operation for twelve years and has allowed the Australian weighing industry to be reasonably flexible with the construction of weighing instruments without the need for multiple approvals by the Commission. This has also benefited the Commission as it reduces the number of approvals required.

Whilst the flexibility of the system is generally appreciated by industry (with the possible exception of some companies which had previously operated somewhat outside the pattern approval system), the operation of the system is not without difficulty. Some of these difficulties include:

- ensuring that the information supplied is correct – the verifier or certifier rarely checks (or has difficulty in checking) whether the figures provided for dead load or lever ratio are accurate;
- defining clearly the point at which a change in design requires a variant to the approval of the instrument rather than simply the obtaining of an analysis report;
- the treatment of situations in which there is a wish to use (for conversions or replacements) existing 'second-hand' modules which are in the field, but whose certificate of approval has expired;

- the treatment of situations (fortunately not common) in which there is a wish to use refurbished or re-manufactured modules. There is a tendency toward this where the supplementary certificate has expired for load cells, and in some cases the relocation of 'old' weighbridge lever-works is carried out.

In addition there is pressure from industry to allow even more flexibility and to reduce costs (an analysis report costs A$140). The development of a computer package to allow a degree of self-assessment is intended to address this need.

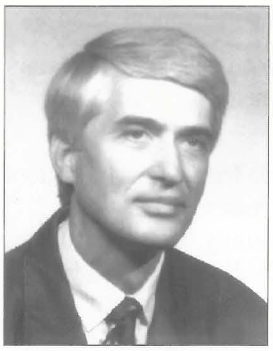
The system has mainly been used for non-automatic weighing instruments and in the last three to four years OIML R 76-1 has included similar requirements for load cells (point 4.12). Handbook 44 of the National Conference of Weights and Measures in the USA also includes similar requirements. However there is still a need for OIML technical committees to include specific requirements for the following:

- modular evaluation of indicators;
- fitting of indicators to weighing instruments; and
- similar provisions for fitting load cells and indicators to automatic weighing instruments.

Welmec has published a Guide for Testing Indicators – Non-automatic Weighing Instruments (WELMEC 2.1) for use in the European Community but such information is of relevance to all OIML members. Future developments such as the use of personal computers as the indicator also need consideration.

OIML R 50 – *Continuous totalising automatic weighing instruments (Belt weighers)* – makes brief reference to the testing of load cells and indicators fitted to these instruments (point 2.2.3) but more detail as proposed in this paper is needed.

It would therefore seem timely for the subcommittees of TC 9 responsible for non-automatic and automatic weighing instruments to consider the above as new projects so that international harmonisation can be achieved. ■



HIGH-CURRENT MEASUREMENTS

A multi-function standard instrument for current transformer calibration

I. ZOLTÁN, Technical University of Budapest, Hungary

Abstract

A new current-comparator and digital ratio-meter-based multi-function standard instrument for current transformer calibration has been developed at the Technical University of Budapest. The instrument measures the in-phase and quadrature components of the error by means of a digital ratio-meter. The built-in ratio matching unit facilitates comparison and direct calibration of current transformers of different ratios. Two-stage CTs can also be measured with this instrument. A set of built-in auxiliary windings ensures complete on-site self-testing. The instrument can be tested and calibrated by a combination of the artificial offset and anti-offset method. Using the error-injection technique, in-phase, quadrature and complex errors can be generated for the calibration of the instrument. The basic accuracy of the instrument is ± 2 ppm with 0.1 ppm resolution.

1 Introduction

Measuring and protective current transformers are widely used in the power industry for high-current measurements and isolation. Accuracy tests have to be carried out in accordance with the appropriate national standards. The aim of the research and development work at the Technical University of Budapest was to find new measurement methods, to increase the accuracy and speed of measurements, to extend the functions of the instrument and to ensure self-calibration.

2 Principle of operation

The new multi-function standard instrument for current transformer calibration comprises an analogue signal processor and a digital ratio-meter. The analogue signal processor in Fig. 1 consists of a current comparator CC [1], a high-precision current transformer CT [2], and current-to-voltage converters. It produces the reference and error voltages, which are proportional to the input current at the N-side and to the error current at the X-side, respectively. Normally, the standard current transformer is connected to the N-side and the device under test to the X-side.

The precision current transformer CT in Fig. 1 has a group of primary windings, a detection winding N_{D1} and a compensation winding N_{C1} located on the same high permeability iron core. The CT operates in the zero-flux-mode, i.e. the primary excitation is balanced by the compensating excitation. For this purpose, the detection winding detects the magnetic flux in the core and controls the amplifier A_1, which outputs the reference current I_r. This current, flowing through the compensation winding, produces the desired compensating excitation.

The current comparator CC in Fig. 1 comprises a group of primary windings at both the N- and X-side, a detection winding N_{D2}, a compensation winding N_{C2} and a three-decade ratio matching winding N_R, located on a magnetic core. The current comparator also operates in the zero-flux-mode, where the amplifier A_2 outputs the error current I_e.

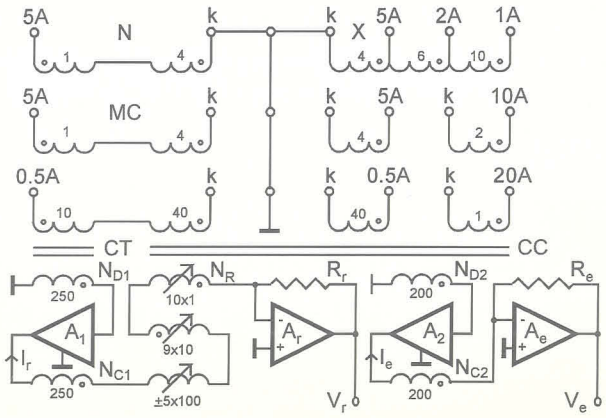


Fig. 1 Analogue signal processor.

The current comparator compares the input currents of the N- and X-sides. The error current measured by the current comparator is converted to error voltage V_e by means of the current-to-voltage converter, composed of operational amplifier A_e and precision resistor R_e. To obtain relative error, the input current at the N-side is measured by the high-precision current transformer and the measured reference current is converted to reference voltage V_r by the other current-to-voltage converter, consisting of operational amplifier A_r and precision resistor R_r.

The digital ratio-meter in Fig. 2 has a special analogue multiplexer MPX for changing the mode of operation, a programmable-gain amplifier PGA for range extension and a digital vector voltmeter DVVM [3] for measuring the complex error of the current transformer to be calibrated.

The ratio V_e/V_r, proportional to the complex relative error, is measured by the digital ratio-meter which computes the in-phase and quadrature components of the error. Thanks to the discrete Fourier-transform used in the DVVM, the higher-order harmonics are suppressed to a great extent. The operation of the instrument is controlled by a unit which also controls the printer and the data-stream through an RS-232C interface.

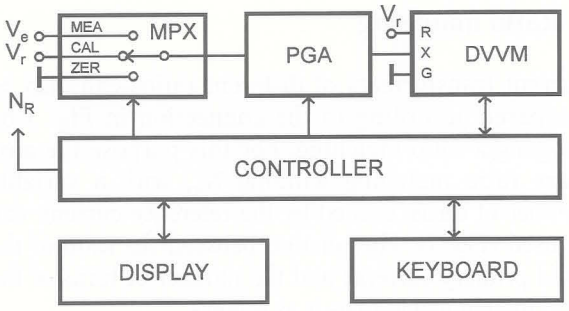


Fig. 2 Digital ratio-meter.

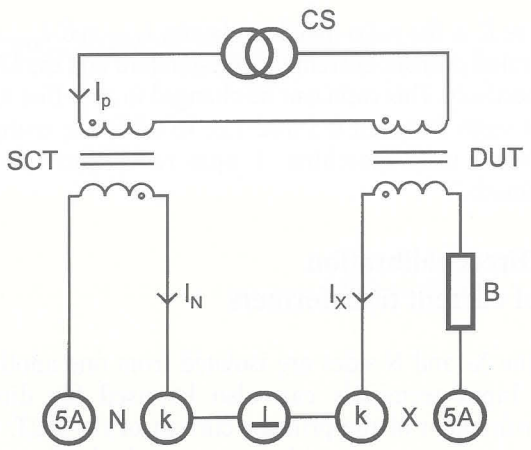


Fig. 3 Comparison of current transformers.

3 Comparison of current transformers

The instrument can be used for comparison of one-stage and special two-stage current transformers in any combination. For this purpose the instrument has isolated twin inputs for 5 A at both the N- and X-side.

3.1 Comparison of one-stage CTs

Comparison of one-stage CTs is shown in Fig. 3. The input terminals of the instrument are symbolized by circles, as in Fig. 1. The secondaries of the CTs are connected to the corresponding terminals of the instrument, according to the rated secondary currents. The primary current I_P generated by current source CS excites the primary winding of the standard current transformer SCT and that of the device under test DUT. The DUT is loaded by burden B.

3.2 Comparison of two-stage CTs

Comparison of a two-stage standard current transformer and a one-stage device under test is shown in Fig. 4. The second stage of the standard CT is connected to the MC-input having the same rated current as the N-input. As the first and second stage of the standard CT have no common burden, the highest accuracy is ensured. In other words, the secondary current I_s of the first stage and the output current I_m of the second stage can be precisely added by the separated input windings of the instrument. The double inputs for 5 A at the X-side also enable the device under test to act as a two-stage CT.

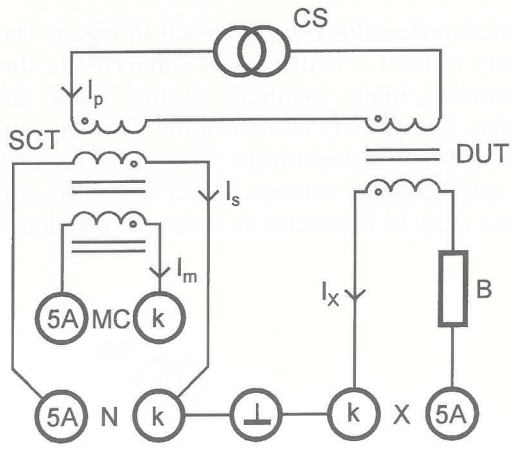


Fig. 4 Comparison of one-stage and two-stage current transformers.

4 Ratio matching

Current transformers of different ratios can also be compared according to the connection in Fig. 3 by applying a ratio matching. For this purpose the auxiliary ratio matching winding N_R, with a variable number of turns, excited by the reference current, can be used (Fig. 1). The relation between the ratio of the rated primary currents and the number of turns of the ratio matching windings is as follows:

$$K = \frac{I_{NPR}}{I_{XPR}} = 1 + \frac{N_R}{1\,000}, \qquad (1)$$

where K is the ratio matching factor, I_{NPR} and I_{XPR} are the rated primary currents of the standard and the DUT, respectively. This ratio can be changed in very fine one-turn steps between 0.5 and 1.6. In addition, using a software ratio matching, 1 ppm resolution can be achieved.

5 Direct calibration of current transformers

As the X- and N-sides are isolated from one another, the input terminals can also be used for direct measurement of the primary current of the DUT, i.e. direct measurements without any standard CT can be carried out.

5.1 Normal-mode calibration

Normal-mode calibration is shown in Fig. 5. The secondary of the CT under test is connected to the corresponding input terminals of the X-side via the burden. The primary current of the CT is measured at the N-side of the instrument. To achieve, for example, the rated primary current of 2.5 A, the N- and MC inputs must be connected in series. In addition, using ratio matching, CTs having any kind of rated primary currents I_{PR} in the region of 2.5 A can be measured according to the following equation:

$$I_{PR} = \frac{2.5}{1 + \frac{N_R}{1\,000}} \qquad (2)$$

Obviously, two-stage curent transformers can also be measured in this normal mode, when the second stage is connected to the other input of 5 A.

5.2 Inverse-mode calibration

Inverse-mode calibration is shown in Fig. 6. The secondary of the CT under test is connected to the corresponding input terminals of the N-side via the burden. The primary current of the CT is measured at the X-side of the instrument. To achieve, for example, the rated primary current of 20 A, the X-input of 20 A is used. In addition, using ratio matching, CTs having any kind of rated primary currents in the region of 20 A can be measured according to the following equation:

$$I_{PR} = 20\left(1 + \frac{N_R}{1\,000}\right) \qquad (3)$$

Furthermore, by proper connection of the input windings at the X-side, the number of turns can be selected between 1 and 67 in one-turn steps, i.e. 67 different rated input currents can be realized. For this reason and using the ratio matching unit, the calibration of current transformers having any kind of rated primary currents between 0.15 A and 32 A can be carried out without any standard current transformer, eliminating the error caused by the instrument.

As in the case of normal-mode calibration, two-stage current transformers and the standard current transformer of the measuring system can also be calibrated in inverse-mode.

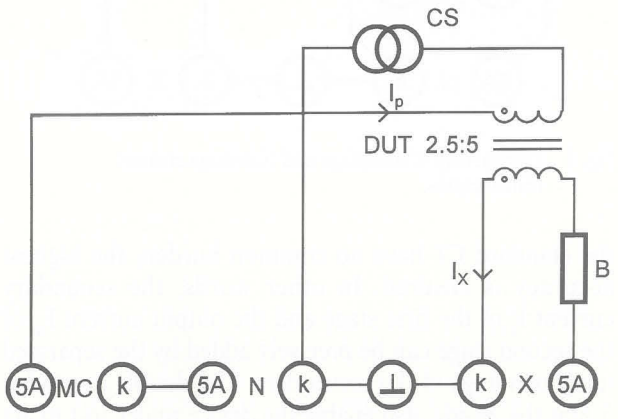


Fig. 5 Normal-mode calibration of current transformer.

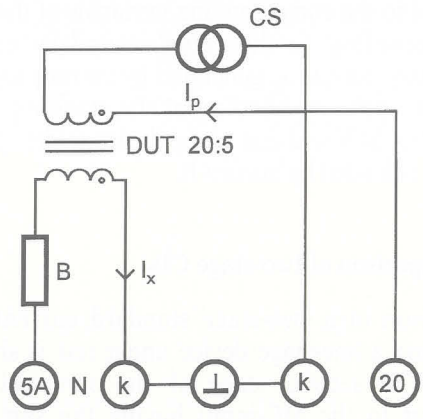


Fig. 6 Inverse-mode calibration of current transformer.

6 Self-calibration

Using the set of built-in auxiliary windings, complete on-site self-testing of the functional units and of the complete instrument is possible. This self-test does not need any auxiliary standard equipment. The most important self-calibrating features are described below.

6.1 Zero-point test

Two input windings at the N- and X-sides, having the same rated current, are connected in series and excited by a current I as shown in Fig. 7. The zero-point of the complete instrument can be checked on the display of the instrument with a resolution of 0.1 ppm and 0.1 µrad. The displayed value should be 0.000 00 % and 0.000 00 crad, if $N_R = 0$.

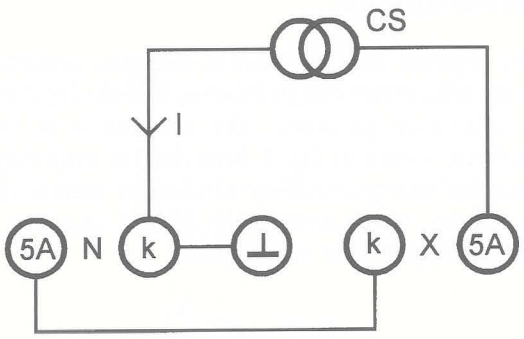


Fig. 7 Zero-point test.

6.2 Artificial offset

Two input windings having the same rated current, and a third auxiliary winding "A", are connected in series and excited by a current I (Fig. 8). This connection provides a well-defined ratio error which can be measured by the instrument. The sign of the artificial offset can be changed by changing the terminals of the auxiliary winding. The displayed ratio error should be

$$\varepsilon_p = \pm \frac{N_A}{N_X}, \qquad (4)$$

where N_A and N_X are the number of turns of the auxiliary and of the X-winding, respectively. For example, supposing that $N_A = 1$, $N_X = 4$ and $N_R = 0$, the displayed value should be ± 25.00 % and 0.00 crad. Note that the artificial offset is determined by the ratio of turns.

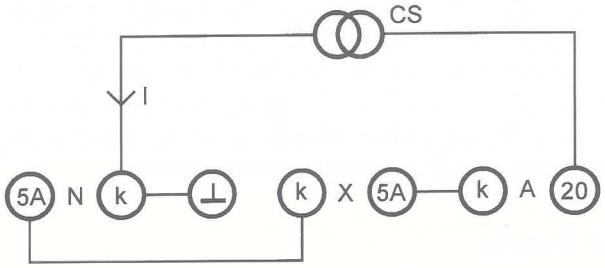


Fig. 8 Artificial offset.

6.3 Anti-offset

Using the built-in ratio matching unit, the artificial offset can be fully compensated. In this case the instrument measures the difference between the artificial offset and anti-offset. The condition of compensation is as follows:

$$N_R = N_A T, \qquad (5)$$

where $T = 250$ is the ratio of turns of the precision current transformer. The displayed value should be 0.000 00 % and 0.000 00 crad. Note that the anti-offset is also determined by the ratio of turns and that the instrument can operate in the most sensitive range with the highest resolution. In this mode, the auxiliary winding producing artificial offset, the ratio matching winding producing anti-offset, and the precision current transformer, can be tested with full precision.

6.4 Ratio-meter test

Using the special multiplexer, the input of the programmable-gain amplifier can be grounded or connected to the reference input of the voltmeter. In this way both the zero-point and the full-scale value of the voltmeter can be tested. When $N_R = 0$, the displayed values should be 0.000 00 % and 0.000 00 crad in ZER-mode, and – 20.00 % and 0.00 crad in CAL-mode.

Using the ratio matching unit, the linearity of the ratio-meter can also be tested. Applying the connection shown in Fig. 7, the displayed ratio error in MEA-mode of the digital ratio-meter should be

$$\varepsilon_p = -\frac{N_R}{1\,000 + N_R} \qquad (6)$$

As presented in (6), the linearity can be tested in steps of one turn in the full operating range, from – 20.00 % to + 20.00 %. This test also qualifies the programmable-gain amplifier.

There are many other combinations of the above basic methods which will ensure a complete verification of the instrument and of the standard current transformer.

7 Error-injection

Using external RC-components, in-phase, quadrature and complex errors can be injected into the instrument for calibration purposes. The connection of error-injection is shown in Fig. 9. Note that the error-current is injected into an auxiliary winding by means of RC components, which ensures the highest accuracy. The injected complex error is as follows:

$$\varepsilon = R_r (G + j\omega C) \frac{N_A}{N_X} \qquad (7)$$

if

$$(R_r + R_A)(G + j\omega C) \ll 1 \qquad (8)$$

where R_A is the resistance of the auxiliary winding. Using RC-components of known value, the injected complex error can be calculated. In special cases however, the resistances R_r and R_A in (8) can cause an error in the calculation. Modifying (7), the effect of the resistances in (8) can be taken into account.

8 Results

A new multi-function standard instrument for current transformer calibration was developed at the Technical University of Budapest for the National Office of Measures, Hungary. The front panel of the instrument is shown in Fig. 10. The built-in ratio matching unit enables the instrument to be used for comparison and direct calibration of current transformers of different stages and ratios. Self-calibration procedures and the error-injection technique ensure complete on-site calibration of the instrument. The principal technical parameters are as follows:

- Rated input currents: 0.5, 1, 2, 5, 10, 20 A *plus 61 other values*
- Ratio matching factor: 0.500 000 - 1.600 000
- Measuring ranges: 0.02, 0.2, 2, 20 %
- Basic accuracy: ± 2 ppm, ± 2 µrad
- Resolution: 0.1 ppm, 0.1 µrad
- Frequency range: 15...100 Hz (10...1000 Hz, optionally)
- Measuring speed: 2.5 measurements/s

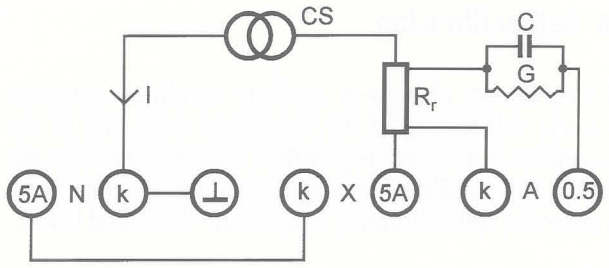


Fig. 9 Error-injection.

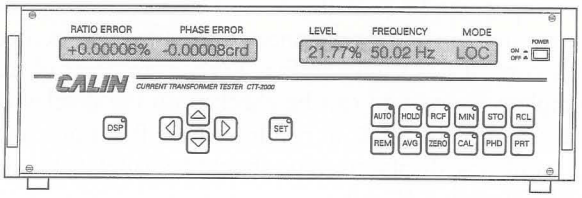


Fig. 10 Current transformer tester.

The instrument, together with a new programmable power-controller replacing conventional burdens and with a LabWindows-based man-interface, can satisfy the requirements of national standards laboratories. Its high speed of measurement makes the instrument a powerful tool in the production of current transformers. ■

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MEDICAL MEASURING INSTRUMENTS

Legal metrology for medical measuring instruments in Japan

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All medical appliances are controlled by the "Drugs, Cosmetics and Medical Instruments Act" for which the Ministry of Health and Welfare is responsible. Among them, medical measuring instruments, mainly used by household consumers and requiring proper measurement for health care, are covered by the "Measurement Law" which controls legal measuring instruments in Japan.

Medical measuring instruments subject to metrological control by the Measurement Law are:

(1) Glass clinical thermometers,
(2) Resistance clinical thermometers, and
(3) Aneroid electric sphygmomanometers (blood pressure gauges).

According to the Measurement Law, these measuring instruments must display either a verification mark by local metrology services or a declaration mark by the manufacturer to show instrument conformity to national requirements.

Since the suitability of such instruments with regard to medical applications is specified in the *Drugs, Cosmetics and Medical Instruments Act,* only their metrological performance is checked by pattern approval tests and initial verification according to the Measurement Law.

The *Drugs, Cosmetics and Medical Instruments Act* controls all medical appliances, including clinical thermometers and sphygmomanometers, to ensure their effectiveness and safety for the benefit of the people who use them. The Act controls not only the manufacture of medical appliances, but also sales, advertising, information on effectiveness and safety, and the maintenance, inspection, and repair of medical instruments, thereby improving the health and welfare of citizens. In addition to the Act, there is another control system, *"Good Manufacturing Practice (GMP)"*, for domestic manufacturers of medical appliances.

Following is a list of the main items included in the technical requirements for instruments subject to metrological control in Japan. ■

GLASS CLINICAL THERMOMETERS

Structural requirements

- markings
- material (glass, temperature-detecting liquid)
- scale mark
- mechanism

Performance requirements

- maximum permissible errors

RESISTANCE CLINICAL THERMOMETERS

Structural requirements

- markings
- structure
- outside temperature range
- power supply voltage drop
- ambient temperature
- response characteristics
- high temperature operation
- storage temperature
- storage humidity
- thermal impact
- leakage-proof
- mechanical impact
- withstanding voltage
- cleaning and sterilization
- power consumption, etc.

Performance requirements

- maximum permissible errors

ANEROID ELECTRIC SPHYGMOMANOMETERS

Structural requirements

- markings
- analog indicating mechanism and/or digital indicating mechanism
- battery voltage alarm
- measuring range
- leakage
- creep
- hysteresis
- reproducibility
- durability
- temperature characteristics
- power supply voltage variation
- electrostatic discharge
- impulse noise
- short-time power reduction

Performance requirements

- maximum permissible errors

MEDICAL MEASURING INSTRUMENTS

Metrological control of clinical thermometers in Brazil

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Introduction

INMETRO, *Instituto Nacional de Metrologia, Normalização e Qualidade Industrial* (National Institute of Metrology, Standardization and Industrial Quality), is a federal institution under the MICT, *Ministério da Indústria, do Comércio e do Turismo* (Ministry of Industry, Trade and Tourism) which was inaugurated 11 December 1974 as the executive branch of SINMETRO, *Sistema Nacional de Metrologia* (National System of Metrology).

The tasks of INMETRO include the coordination of different programs related to the technical regulation of medical measuring instruments, and conformity certification for biomedical equipment used for life support, safety and environmental control and protection. INMETRO aims at improving the *modus vivendi* of the working force and the general population by assuring the quality of instruments and equipment. Such programs are developed together with the Health, Justice and Labor Ministries.

Considering that some hospital and medical products are measuring instruments, the Brazilian Government has decided, via INMETRO, to implement the control of products covered by OIML International Documents and Recommendations.

Brazil became a member of OIML in 1983 and began its activities in the field of health by issuing in 1989 a technical regulation based on OIML Recommendation R 7 on clinical thermometers. This Recommendation was adapted to suit the needs of Brazil after studying the corresponding regulations applied in France, Germany, Japan and the U.S.A.

Historical background

The effective metrological control of clinical thermometers started in 1990 with the first pattern approval based on INMETRO's Ordinance nr. 239/89 establishing methods and procedures for pattern approval and initial verification of these instruments. Initial verification was carried out for the first time in September 1993, at the Juiz de Fora Branch of the Institute of Weights and Measures of the Minas Gerais State.

Pattern approval of such instruments, both domestically manufactured and imported, has been performed at INMETRO laboratories in Rio de Janeiro using German standard liquid-in-glass thermometers (0.01 °C) certified by Physikalisch- Technische Bundesanstalt (PTB) and compared with our national Pt/Rh standards every five years at the RBC laboratories – *Rede Brasileira de Calibração* (Brazilian Calibration Net) at INMETRO; in turn, these national standards undergo intercomparisons every five years in laboratories of Germany, UK, Italy, France and the U.S.A.

Since 1990, four laboratories have been equipped to perform the initial verification of clinical thermometers in different regions of Brazil, where technicians trained by the Legal Metrology Directorate of INMETRO for this purpose carry out such tasks. The approximately 200 000 clinical thermometers made in Brazil each month undergo initial verification according to a sampling plan (see Tables 1 and 2), and initial verification of imported clinical thermometers is expected for the near future. First, the problem of multiple land borders with other Latin American countries must be solved.

Brazil has already updated its specific regulation on clinical thermometers after having discussed the matter with other MERCOSUL Members (Argentina, Paraguay and Uruguay). The only issue that remains to be solved in this discussion concerns the system of applying the verification stamp on the instrument; due to the high production of Brazilian manufacturers, INMETRO adopted the procedure for marking during production (serigraphic process in the enclosed scale or in the instrument). The mark can be the INMETRO logo, a lot number or both.

Table 1 Sampling plan according to ISO 2859-1/1989.

Lot or Batch size	Sample size code letters
2 to 8	A
9 to 15	B
16 to 25	C
26 to 50	D
51 to 90	E
91 to 150	F
151 to 280	G
281 to 500	H
501 to 1200	J
1201 to 3200	K
3201 to 10000	L
10001 to 35000	M
35001 to 150000	N
150001 to 500000	P
500001 or more	Q

Table 2 Sampling plan according to ISO 2859-1/1989.

Sample size code letter		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
Sample size		2	3	6	8	13	20	32	60	80	125	200	315	500	800	1250
AQL	Ac	0	0	0	0	0	0	0	0	1	1	1	2	3	5	8
0,40	Re	1	1	1	1	1	1	1	1	2	2	2	3	4	6	9
AQL	Ac	0	0	0	0	1	1	1	2	3	5	8	12	18	18	18
2,5	Re	1	1	1	1	2	2	2	3	4	6	9	13	19	19	19

AQL – Acceptable Quality level
Ac – Acceptance Number
Re – Rejection Number

Pattern approval

For pattern approval of clinical thermometers, ten prototypes should be present for testing and all of them should compy with the relevant requirements.

Metrological reliability of Brazilian clinical thermometers is determined by results obtained from laboratory measurements. Instruments are submitted to a temperature test where the points 37 °C and 41 °C are checked and the maximum permissible error is within the range of - 0.15 °C and + 0.1 °C, the same as that recommended by OIML; for thermometers used for birth control, the points 36 °C and 37.5 °C are checked. Visual inspection, dimensional tests, response time test and replacement of mercury column are also performed.

Pattern approval is granted after the editing of specific INMETRO ordinances which correspond to the pattern approval certificate issued in some European countries. Up to now, INMETRO has granted seven pattern approvals and has also carried out six compliance tests to approved models.

Initial verification

Initial verification is carried out by technicians in INMETRO laboratories or in factories (through a network of verification offices) according to Brazilian regulation (INMETRO Ordinance 234/1994). The sampling process is used due to the large number of clinical thermometers manufactured in the country. It should be noted that manufacturers' standards are intercompared every three years against INMETRO's standards.

According to ISO 2859-1/1989, INMETRO has adopted the "Simple and Severe Sampling Plan" with 0.40 AQL (acceptable quality level) for temperature tests and 2.5 AQL for other tests (Tables 1 and 2). Both pattern approval and initial verification are required for national and foreign manufacturers, both of which are subject to the same rules.

When a lot is rejected after initial verification, it should be destroyed inside the factory and the resulting materials should always be handled so as not to cause any harm to the environment. The aim of this procedure is to avoid that these instruments reach the internal market or be exported to countries where there is no relevant metrological control (metrological controls are not required for exportation).

Solid-stem clinical thermometers are made in the southeastern region of Brazil and 80 % of their production is sold within the country. Rejection of Brazilian instruments during 1994 was barely 3 %, which is a significant percentage compared with that indicated in the OIML Bulletin No. 125 (Dec. 1991, p. 9). From Sept. to Nov. 1993, 4 835 clinical thermometers were tested in one factory as samples from a total of 508 588; in 1994, 8 855 clinical thermometers were tested from a total of 1 212 048 units.

Conclusions

Implementation of a verification program for imported clinical thermometers has not yet been fully established, and the same applies to digital clinical thermometers and disposable thermometers. Studies are underway for the installation of new laboratories, training courses for metrologists and the acquisition of equipment. ■

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MEDICAL MEASURING INSTRUMENTS

Metrological control of absorption photometers and spectrophotometers in Poland

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According to the Polish "Law on measures" and ordinances issued by the Główny Urzad Miar (GUM), the Central Office of Measures, absorption photometers and spectrophotometers in Poland are subject to verification or compulsory calibration if they are used in production and testing of pharmaceuticals, or in the fields of health, safety and environment. Instruments used in these fields are also subject to pattern approval.

In Poland, absorption photometers and ordinary spectrophotometers are traditionally called "chemical spectrocolorimeters". These instruments are commonly used in clinical and biochemical laboratories to determine the concentration of analytes in specimens of blood, serum, plasma etc. by measuring the spectral transmittance or spectral transmittance density (spectral absorbance).

There are many different types of chemical spectrocolorimeters used in health services, with varying manufactural qualities, methods of measurement, and metrological characteristics. At present, more than 30 different types of spectrocolorimeters, both domestically manufactured and imported, are used in Poland. This situation causes difficulties for the harmonization of technical specifications and metrological performances for spectrocolorimeters as well as for their calibration.

The Optical Radiation Laboratory of GUM and all Regional Verification Offices perform the verification and calibration of spectrocolorimeters. Sets of reference neutral density filters for which the true values of spectral transmittance and spectral absorbance are known, are used as absorption-reference materials. These standards, which are traceable to national standards, are made of Scottish glass and placed in special holders.

Calibration of the wavelength scale of spectrocolorimeters is performed with didymium or holmium filters which have known wavelengths of maximum and minimum spectral transmittance for different spectral bandwidths.

Polish metrological regulations stating the requirements and permissible errors for spectrocolorimeters are amended based on the OIML Committee Draft for the International Recommendation entitled "Absorption photometers for medical use; metrological description of technical specifications" and other metrological documents and standards. ■

Medical measuring instruments subject to metrological control in Poland

- Westergren tubes for measurement of erythrocyte sedimentation rate
- Sphygmomanometers
- Clinical thermometers
- Absorption photometers
- Spectrophotometers
- Medical dosimeters
- Density hydrometers of urine
- Non-automatic weighing instruments
- Audiometers

MEDICAL MEASURING INSTRUMENTS: INTERNATIONAL REPORT

International Electrotechnical Commission
Commission Electrotechnique Internationale

TC 62: Electrical equipment in medical practice

Scope
To prepare international standards concerning the manufacture, installation and application of electrical equipment used in medical practice and concerning surgery, dentistry and other specialities of the healing arts. This scope includes systems, equipment and accessories within the scope of other technical committees and is confined to aspects in which special requirements for medical use arise, particularly as regards safety. TC 62 and its subcommittees are not directly engaged in the field of medical measuring instruments, but work mainly in the field of safety standards for medical equipment.

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MEDICAL MEASURING INSTRUMENTS

METROMED 95

Measuring information technologies and instruments for health care

Report on METROMED 95, International Scientific and Practical Conference, 19–22 June 1995, St. Petersburg

The International Scientific and Practical Conference "Metromed-95" was held in St.Petersburg, Russia 19–22 June, 1995. This Conference was devoted to the problems of measuring information technologies and instruments for health care, and was organized by the State Committee of the Russia Federation for Higher Education and the State St. Petersburg Technical University, together with the Academy of Metrology and the International Scientific and Technical Society of Instruments Engineers and Metrologists.

Plenary session of METROMED 95. Prof. Yu. V. Tarbeyev, S. A. Tsynlayev (giving a lecture), and Prof. Yu. S. Vasiliev.

The International Programme Committee included 15 leading scientists and metrologists from different countries and was headed by Prof. E. Carson, IMEKO/TC 13 Member and Director of the Centre for Measurement and Information in medicine (City University, London, United Kingdom); and Prof. Ju.V. Tarbeyev, Member of the CIPM, Director of the D. I. Mendeleyev Institute for Metrology and President of the Metrological Academy of Russia in St. Petersburg.

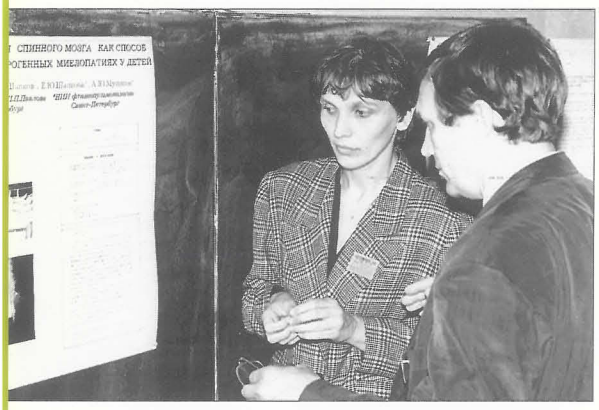
The conference aimed at consolidating efforts by metrologists, instrument manufacturers and medical specialists for the development and production of up-to-date measuring instruments and technologies capable of providing an effective realization of the most advanced medical methods for prophylaxis, diagnosis, treatment and post-treatment rehabilitation.

The chairman of the Russian Organizing Committee, Prof. Ju.S. Vassiliev, opened the Conference. Participants were welcomed by S. A. Tsyplyaev, RF President's Plenipotentiary in St. Petersburg; V. M. Mutko, Vice-Mayor of St. Petersburg; V. V. Lozhko, Chief expert of the Department for Science and Higher Education of St. Petersburg; and Prof. G.M. Cherkessov, Head of the Russian Co-ordination Council of Medical Aid Quality.

In addition to reports made during the general session of the conference, lectures were given on several key topics for metrology in medicine.

Some subjects addressed at METROMED 95

- Metrological assurance in medicine
- Traceability systems
- Gerontechnology
- Human visual system
- The human organism and its interaction with the environment
- The objective signs of health state
- Measurements in urgent laparoscopy
- Medical and engineering education in Russia
- Bioelectric and biomagnetic measurements
- Magnetic and resonance tomography
- Fluorimetry
- Simulation of body circulatory
- Iconics and optometry
- Measuring and information technologies in clinical laboratory diagnosis
- Metrological assurance for acoustic stimulation



Poster session – Mrs E. Yu. Shapkova and Mr A. A. Red'ko (Section leader).

Poster sessions constituted more than 80 communications of recent data on medical equipment, methodologies, mathematical methods, computer technologies and applied medicine. In conjunction with the conference, a substantial exhibition of medical instruments took place. Among the exhibits, there were instruments for an immune-ferment analysis and an audiometer complex designed for investigation of the potentials being evoked as well as some compact means for analogue signals for input and output of personal computers.

The general result of the conference was considered at a joint meeting of the Committee for Social Problems of the St. Petersburg Mayor's Office, Members of the Russian Organizing Committee of the conference, Co-chairman of the International Programme Committee Prof. Yu. Tarbeyev and Representative of the Committee for Science and Higher Education of the St.Petersburg Mayor's Office Mr. V.V. Lozhko. Participants of the meeting arrived at a conclusion for the elaboration of an organizational and scientific programme for realizing joint developments in the area of medical instrumentation and information, and improving metrological qualifications of specialists working in medicine and health protection. ■

MEDICAL MEASURING INSTRUMENTS: INTERNATIONAL REPORT

International Organization for Standardization
Organisation Internationale de Normalisation

Technical Committees with activities in the field of health care

TC 76	Transfusion, infusion and injection equipment for medical use
TC 84	Medical devices for injections
TC 106	Dentistry
TC 121	Anaesthetic and respiratory equipment
TC 150	Implants for surgery
TC 157	Mechanical contraceptives
TC 168	Prosthetics and orthotics
TC 170	Surgical instruments
TC 172	Optics and optical instruments
TC 173	Technical systems and aids for disabled or handicapped persons
TC 194	Biological evaluation of medical devices
TC 198	Sterilization of health care products
TC 210	General aspects for health care products
TC 212	Clinical laboratory testing and in vitro diagnostic test systems

ISO Central Secretariat
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MEDICAL MEASURING INSTRUMENTS: REGIONAL REPORT

Comité Européen pour la Normalisation
European Committee for Standardization

Activities in the field of medical measuring instruments

At present, CEN standardization activity in the field of medical measuring instruments is restricted to a very limited number of projects within CEN/TC 170 "Ophthalmic optics", CEN/TC 205 "Non-active medical devices" and CEN/TC 215 "Respiratory and anaesthetic equipment".

Activities within CEN/TC 170 are closely related to those of ISO/TC 172/SC 7 "Ophthalmic, endoscopic, metrological instruments and test methods" and some projects have been mandated by the European Commission and the European Free Trade Association (EC/EFTA) to support relevant essential requirements of the Medical Device Directive (93/42/EEC).

Within CEN/TC 205, EC/EFTA have mandated several projects concerning medical measuring instruments in support of the Medical Device Directive, including "Non-invasive sphygmomanometers" and clinical thermometers.

The draft OIML recommendations concerning "Clinical electrical thermometers with maximum device" and "Clinical electrical thermometers for continuous measurement" have been circulated to CEN/TC 205/WG 12 with other relevant national standards concerning clinical thermometers for consideration in the drafting of future European Standards.

The Medical Device Directive makes reference, under its essential requirements and annexes, to "risk" and "acceptable risk" and to the needs for a risk analysis. In this context EC/EFTA have mandated the preparation by CEN of a European Standard detailing a procedure for the risk analysis of medical devices. This project reached the stage of CEN enquiry in October 1994.

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MEDICAL MEASURING INSTRUMENTS

International Federation of Clinical Chemistry: Committee on Analytical Systems

In 1974, the International Federation of Clinical Chemistry (IFCC) created the Expert Panel on Instrumentation to address aspects concerning instrumentation in the field of clinical chemistry. Initially, this panel focused on standardization of specific instruments used in clinical laboratories. In order to better address and respond to the technical and operational problems resulting from the evolution of a system approach to clinical analyzers, the name and the scope of the panel was changed in 1986 to "Committee on Analytical Systems" (CAS).

GOALS

1. To assist the profession in the integration and utilisation of analytical systems into the practice of laboratory medicine,
2. To develop logistics in the use of analytical systems and its integration in the information network of a clinical laboratory,
3. To develop an information data base on new technology and to review critically its usefulness for the practice of laboratory medicine,
4. To develop guidelines for the preanalytical and analytical processes in clinical laboratories,
5. To develop an international forum to discuss and resolve the scientific and practical problems encountered with the use of analytical systems in the clinical laboratories.

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MEDICAL MEASURING INSTRUMENTS

International Organization of Legal Metrology: Technical Committee 18 – Medical measuring instruments

OIML TC 18

MEDICAL MEASURING INSTRUMENTS
INSTRUMENTS DE MESURE MEDICAUX

SECRETARIAT: GERMANY

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Austria	Australia	World Health Organization (WHO)
Brazil	Czech Republic	
Bulgaria	Egypt	
Cuba	Finland	
Germany	France	
Hungary	Indonesia	
Japan	Netherlands	
Rep. of Korea	Norway	
Russian Federation	P. Rep. of China	
Saudi Arabia	Poland	
U. S. A.	Romania	
	Slovakia	
	Spain	
	Switzerland	
	Yugoslavia	

OIML TC 18/SC 1

BLOOD PRESSURE INSTRUMENTS
INSTRUMENTS POUR PRESSION SANGUINE

SECRETARIAT: AUSTRIA

Bundesamt für Eich- und Vermessungswesen (BEV)
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Austria	Australia	International Electrotechnical Commission (IEC)
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Czech Republic	Japan	World Health Organization (WHO)
Germany	Netherlands	
Hungary	P. Rep. of China	
Slovakia	Poland	
U. S. A.	Russian Federation	
Yugoslavia	Sri Lanka	

OIML TC 18/SC 2

MEDICAL THERMOMETERS
THERMOMETRES MEDICAUX

SECRETARIAT: GERMANY

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Czech Republic	Indonesia	International Organization for Standardization (ISO)
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Russian Federation	Netherlands	
Slovakia	P. Rep. of China	
Spain	Poland	
Sweden	Sri Lanka	
U. S. A.	Switzerland	
	Yugoslavia	

OIML TC 18/SC 3

MEDICAL DOSIMETRY
DOSIMETRIE MEDICALE

SECRETARIAT: UNITED KINGDOM

National Weights and Measures Laboratory
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Teddington, Middlesex TW 11 OJZ

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Bulgaria	P. Rep. of China	
Czech Republic	Poland	International Electrotechnical Commission (IEC)
Germany	Slovakia	
Hungary	Spain	World Health Organization (WHO)
Netherlands	Sri Lanka	
Russian Federation		
Switzerland		
United Kingdom		
U. S. A.		
Yugoslavia		

OIML TC 18/SC 4

BIO-ELECTRICAL INSTRUMENTS
INSTRUMENTS BIO-ELECTRIQUES

SECRETARIAT: RUSSIAN FEDERATION

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Tel.: 7-095-236 40 44
Fax: 7-095 237 60 32

Bulgaria	Australia	International Electrotechnical Commission (IEC)
Germany	Czech Republic	
Russian Federation	Japan	
U. S. A.	Netherlands	
	P. Rep. of China	
	Slovakia	
	Spain	
	Sri Lanka	
	Switzerland	
	Yugoslavia	

OIML TC 18/SC 5

MEASURING INSTRUMENTS FOR MEDICAL LABORATORIES
INSTRUMENTS DE MESURE POUR LABORATOIRES MEDICAUX

SECRETARIAT: GERMANY

Physikalisch-Technische Bundesanstalt (PTB)
Postfach 3345, D-38023 Braunschweig

Tel.: 49-531-592 30 00
Fax: 49-531-592 30 02

Austria	Australia	International Electrotechnical Commission (IEC)
Germany	Belgium	
Poland	Bulgaria	International Federation of Clinical Chemistry (IFCC)
Russian Federation	Czech Republic	
Slovakia	Hungary	International Organization of Standardization (ISO)
U. S. A.	Japan	
	Netherlands	World Health Organization (WHO)
	P. Rep. of China	
	Spain	
	Sri Lanka	
	Switzerland	
	Yugoslavia	

Note: OIML has pursued activities concerning clinical thermometers and sphygmomanometers since its beginning in the mid-1950's, and in 1973, pilot secretariat SP 26, *Measuring instruments used in the field of public health,* was established. Following a restructuring of OIML's technical activities, SP 26 was later transformed into TC 18.

activities
OIML
activités

Metrological cooperation

OIML collaborates with PTB and DAM in Germany for a metrology workshop

Cooperation in metrological activities continues between OIML and various regional and national organizations. Most recently: the workshop "Volume determination of fixed storage tanks", held in Munich, 3–14 July 1995.

Previous workshops

The *Deutsche Akademie für Metrologie (DAM)* collaborates with the *Physikalisch-Technische Bundesanstalt (PTB)* and the International Organization of Legal Metrology (OIML) in technical cooperation projects. In 1991, 1992 and 1993, workshops on "Verification of Weighing Equipment" were held for verification inspectors. Theoretical and practical work dealt with nonautomatic weighing instruments (self-indicating and non-self-indicating weighing instruments class III and class II), as well as road vehicle scales, belt weighers and mass comparison of heavy test weights. In 1991 and 1992, two workshops were held on "Medical Instruments" and concerned measuring principles, technical standards and test procedures for clinical thermometers and blood pressure measuring instruments.

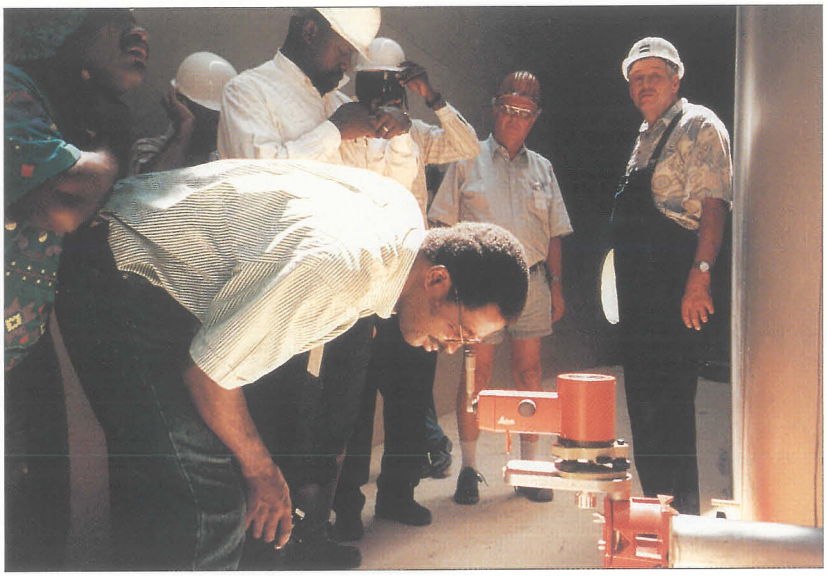
Participants of the workshop "Volume determination of fixed storage tanks" which was held in Munich, 3–14 July 1995 and sponsored by PTB, DAM and OIML.

1995 workshop

As part of the technical cooperation program, a workshop entitled *"Volume determination of fixed storage tanks"* was held in Munich, 3–14 July 1995 and was jointly organized by PTB, DAM and OIML. The main objective of this workshop was to familiarize inspectors of national legal metrology and calibration services with the measuring principles, the technical standards and test procedures for fixed storage tanks.

Lectures on measuring principles, measuring methods, types of measuring instruments, international and national standards, in combination with practical work at the verification office and at a tank

Workshop participants performing manual gauging of tanks.



A workshop participant uses a sophisticated automatic instrument for tank gauging.

farm, provided an excellent opportunity to become acquainted with the metrological aspects of the volume determination of fixed storage tanks.

The teaching staff was composed of specialists from PTB, OIML and DAM who were ready to discuss problems that the participants encounter in their countries. Manufacturers of level measuring instruments were also present to give presentations of their products.

Participants were selected from those countries with legal requirements for storage tanks or those having begun or going to begin work in this field. The number of participants was limited to 20 in order to ensure an effective performance, particularly with regard to the practical part of the workshop. Countries represented included Albania, Belarus, Bulgaria, Burkina Faso, Cameroon, Chile, Czech Republic, Ecuador, Indonesia, Kenya, Morocco, Mexico, Mongolia, Nepal, Nigeria, Papua New Guinea, Tanzania, Vietnam and Zambia.

In addition to the lectures and practical exercises, a welcome dinner, a Bavarian barbecue evening, an excursion to the castle of Neuschwanstein and a city tour in Munich were organized by DAM. ■

WORKSHOP PROGRAM IN BRIEF

1 Theoretical Instructions

Horizontal cylindrical tanks
- Introduction to wet calibration of containers: construction, standards, error curves
- Data "smoothing" of measured values: conventional method, capacity tables, least square fit, spline method

Vertical cylindrical tanks
- Overview, definitions
- Sump determination of a vertical cylindrical tank
- Determination of circumference and plumbing
- Computation of a capacity table
- Calculation of expansion at increasing liquid levels

Level measuring instruments
- Instrument with radar dipping device
- Determination of tank diameter by an optical method

Introduction into the tasks of OIML and the relevant OIML Recommendations

2 Practical Instructions

At the verification office Munich
- Determination of an error curve of a standard water meter
- Measurement of a horizontal cylinder by a calibrated standard water meter and a dip-tape with counterweight

At the tank farm in Ingolstadt
- Adjustment of dip-plate
- Plumbing of a tank
- Inspection and weight determination of a floating-roof tank

3 Technical Visits
- Munich verification office
- Tank farm in Ingolstadt

Metrology training

DEUTSCHE AKADEMIE FÜR METROLOGIE (DAM)

The *Deutsche Akademie für Metrologie* welcomes applicants for its annual program of courses aimed at higher training in metrology-related subjects. The majority of courses are given in German and therefore, basic knowledge of this language is necessary. Following is a sample program of courses based on the 1995 curriculum.

DAM SAMPLE ACADEMIC PROGRAM

Courses for higher intermediate verification service
- Seminar "Handling with citizens"
- Workshop with a manufacturer of weighing instruments

Courses for verification administrations
- Workshop "Exhaust fumes measuring instruments"
- Technical seminar (in English)
- Training for quality assurance assessors
- Training for quality assurance assessors in medical laboratories
- Advanced training for quality assurance auditors
- Seminar "Programmable taximeters"
- Training of verification officers in executive positions
- Seminar "Uncertainty in measurement"
- Seminar "Medical products act"
- Management for verification officers in executive positions

Training and advanced training for scholarship holders
- International workshop "Volume determination of fixed storage tanks"
- International workshop "Prepackages"

Courses for executive staff in accredited test centres
- Course for accredited test centres for measuring instruments for electricity, gas, cold/warm water and heat

Contact information:

Deutsche Akademie für Metrologie (DAM) beim Bayerischen Landesamt für Maß und Gewicht, München

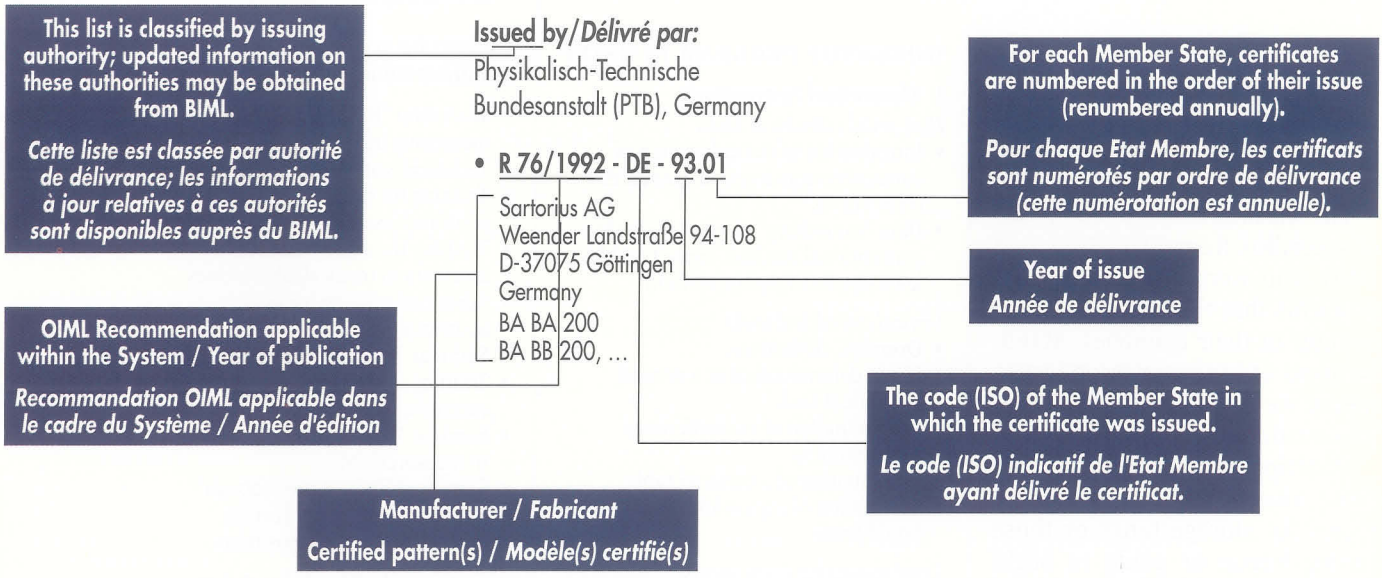
Tel.: (49) 89 17901-0
Fax: (49) 89 17901 386

(German Academy of Metrology, Verification School at the Bavarian State Office for Weights and Measures, Munich)

certificate system
OIML
système de certificats

OIML CERTIFICATES registered from June to August 1995
CERTIFICATS OIML enregistrés de juin à août 1995

HOW TO USE THE LIST OF OIML CERTIFICATES
COMMENT UTILISER LA LISTE DES CERTIFICATS OIML



INSTRUMENT CATEGORY Load cells R 60 (1991), Annex A (1993)
CATÉGORIE D'INSTRUMENT Cellules de pesée R 60 (1991), Annexe A (1993)

Issued by/Délivré par:
Office Fédéral de Métrologie, Switzerland

- **R 60/1991-CH-95.01**

Vibro-Meter SA
Moncor 4, 1700 Fribourg, Switzerland
Load Cell Type LB 256/121 (Class D)

Corrigendum – On page 45 of the previous issue of the OIML Bulletin (Vol. XXXVI, July 1995), a misprint appeared in the address of the first certificate listed (R 60/1991-CH-94.01): Switzerland should replace Germany as the country of manufacture.

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

- **R 60/1991-GB-95.08**

Sensortronics Inc.
677 Arrow Grand Circle
Covina, CA 91722, USA
Load Cell Model No Rice Lake RLETB (Class C)

- **R 60/1991-GB-95.09**

Sensortronics Inc.
677 Arrow Grand Circle
Covina, CA 91722, USA
Load Cell Model No Rice Lake RLETS (Class C)

- **R 60/1991-GB-95.10**

Sensortronics Inc.
677 Arrow Grand Circle
Covina, CA 91722, USA
Load Cell Model No Rice Lake RLHSS (Class C)

• **R 60/1991-GB-95.11**

Sensortronics Inc.
677 Arrow Grand Circle
Covina, CA 91722, USA

Load Cell Model No Sensortronics 65040C (Class C)

Issued by/Délivré par:

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

• **R 60/1991-NL-95.06**

Tedea Huntleigh International
60 Medinat Hayehudim
Herzliya 46120, Israël

1260 (Classes C and D)

• **R 60/1991-NL-95.07**

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

M (Classes C and D)

• **R 60/1991-NL-95.08**

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

MC-1 (Classes C and D)

• **R 60/1991-NL-95.09**

Tedea Huntleigh Europe Ltd.
37 Portmanmoor Road
Cardiff, CF2 2HB, United Kingdom

220/230 (Classes C and D)

• **R 60/1991-NL-95.10**

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

MC-3 (Classes C and D)

• **R 60/1991-NL-95.11**

HBM Inc.
19 Bartlett Street
Marlboro, MA 01752, USA

SP4 (Classes C and D)

• **R 60/1991-NL-95.12**

Vibro-Meter SA
Moncor 4, 1700 Fribourg, Switzerland

LB 256/131 (Class D)

• **R 60/1991-NL-95.13**

Revere Transducers Europe BV
Ramshoorn 7
4824 AG Breda, The Netherlands

SSB (Classes C and D)

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

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

Issued by/Délivré par:

Secretariat for OIML Affairs
State Bureau of Technical Supervision,
P. Rep. of China

• **R 76/1992-CN-94.01**

Taihang Instruments Factory, China
General Aircraft Industrial
Sanyingpan Bingzhounanlu Taiyuan,
Shanxi, China

Electronic price computing scale types ACS-3-JJ, ACS-6-JJ, ACS-15A-JJ (Class III)

• **R 76/1992-CN-95.01**

Shanghai SIIC Scales Co. Ltd.
135 Laohumin Road
Shanghai, China

Electronic price computing scale types ACS-6A-JJ, ACS-15A-JJ (Class III)

• **R 76/1992-CN-95.02**

Shanghai SIIC Scales Co. Ltd.
135 Laohumin Road
Shanghai, China

Electronic price computing scale (multi-intervals) types ACS-6C-JJ, ACS-15C-JJ (Class III)

Issued by/Délivré par:

Physikalisch-Technische
Bundesanstalt (PTB), Germany

• **R 76/1992-DE-93.01 Rev. 1***

Sartorius AG
Weender Landstraße 94-108
D-37075 Göttingen, Germany

BA BA 200, BA BB 200, MD BA 200, MD BB 200, MB BB 200 (Class II)

• **R 76/1992-DE-93.03 Rev. 1***

Sartorius AG
Weender Landstraße 94-108
D-37075 Göttingen, Germany

BB BA 200, BB BB 200 (Class II)

• **R 76/1992-DE-93.04 Rev. 1***

Sartorius AG
Weender Landstraße 94-108
D-37075 Göttingen, Germany

BA BB 212 (Class II)

• **R 76/1992-DE-93.05 Rev. 1***

PAG Oerlikon AG
Wallisellenstraße 333
CH 8050 Zurich, Switzerland

Series 300 and 310 (Class II)

• **R 76/1992-DE-94.03 Rev. 1***

Sartorius AG
Weender Landstraße 94-108
D-37075 Göttingen, Germany

KB BA 100, KC BA 100, MC BA 100, MC BB 100, MD BA 100 (Class I)

• **R 76/1992-DE-93.03 Rev. 1***

Sartorius AG
Weender Landstraße 94-108
D-37075 Göttingen, Germany

MA BA 200, MA BB 200 (Class II)

Issued by/Délivré par:

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

• **R 76/1992-FR-95.02**

MASTER-K
38, avenue des Frères Montgolfier
B.P. 186
69686 Chassieu Cedex, France

Pont-bascule MASTER-K type PB (Classes III and IIII)

• **R 76/1992-FR-95.03**

MASTER-K
38, avenue des Frères Montgolfier
B.P. 186
69686 Chassieu Cedex, France

Bascule MASTER-K type BA
(Classes III and IIII)

Issued by/Délivré par:
Netherlands Measurement Institute
(NMi), IJkwezen B.V., The Netherlands

• **R 76/1992-NL-94.04 Rev. 1***

Teraoka Weigh-System PTE Ltd.
3A Tvas Avenue 8
Singapore 2263

DS-650 (Class III)

• **R 76/1992-NL-95.09 Rev. 1***

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

DS-73x (Class III)

• **R 76/1992-NL-95.11 Rev. 1***

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

DS-680 (Class III)

• **R 76/1992-NL-95.12**

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

BSC-060A (Class III)

• **R 76/1992-NL-95.13**

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

TLC-060A (Class III)

• **R 76/1992-NL-95.18**

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

PR (Class I), PR and PG (Class II)

• **R 76/1992-NL-95.19**

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

8525 (Classes III and IIII)

• **R 76/1992-NL-95.20**

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

Jaguar (Classes III and IIII)

• **R 76/1992-NL-95.21**

Ohaus Corporation
29, Hanover Road, Florham Park
New Jersey, USA

D-series (Class III)

• **R 76/1992-NL-95.22**

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

AC-3000 series (Class III)

(*) Certificates followed by an asterisk replace all those previously issued with the same registration information.

OIML CERTIFICATION NOW APPLIES TO SOUND CALIBRATORS

With the publication of Annexes B, *Test methods for pattern evaluation,* and C, *Test report format,* to OIML Recommendation R 102, sound calibrators can now receive OIML certificates. A certificate guarantees that a sound calibrator pattern was examined in conformity with the provisions of Annex B and that as a result of this examination, all requirements in R 102 are satisfied by the given pattern. The certificate is accompanied by a test report established along the lines of the format provided in Annex C.
It should be noted that the requirements of R 102 were taken from IEC 942-1988, an IEC International Standard; however, among the provisions of this Standard, only those of interest for legal metrology controls appear in R 102. Consequently, an OIML certificate of conformity to R 102 does not guarantee conformity to all provisions found in IEC 942-1988. ■

LA CERTIFICATION OIML S'APPLIQUE AUX CALIBREURS ACOUSTIQUES

Avec la publication des annexes B "Méthodes d'essai de modèle" et C "Format du rapport d'essai" à la Recommandation OIML R 102, les calibreurs acoustiques peuvent maintenant recevoir des certificats OIML. Un certificat garantit qu'un modèle de calibreur acoustique a été examiné conformément aux dispositions de l'annexe B, et qu'il résulte de cet examen que toutes les exigences de la R 102 sont satisfaites par le modèle en question. Le certificat est complété par un rapport d'essai établi selon le modèle donné en annexe C.
Il convient de rappeler que les exigences de la R 102 ont été reprises de la Norme Internationale CEI 942-1988; cependant, parmi les dispositions de cette Norme, seules celles d'intérêt pour les contrôles de métrologie légale apparaissent dans la R 102; en conséquence, un certificat OIML de conformité à la R 102 ne saurait garantir la conformité à toute les dispositions de CEI 942-1988. ■

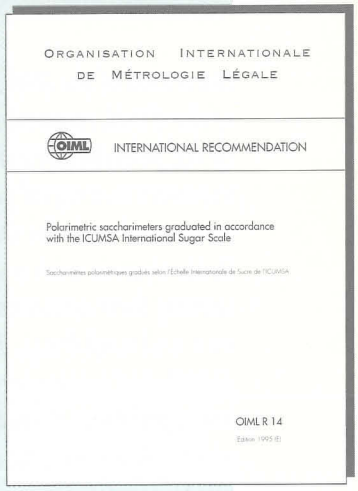
NEW PUBLICATIONS / *NOUVELLES PUBLICATIONS*

R 14 Polarimetric saccharimeters
Saccharimètres polarimétriques

R 102 Annex: Test procedures and test report format
Annexe: Procédures d'essai et format du rapport d'essai

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



OIML WELCOMES ITS NEW MEMBERS

CIML Member

Mr R. Luiz de Lima Guimarães, Brazil
Mr B. Vaucher, Switzerland

Corresponding Member

Mozambique

Committee drafts received by BIML

June–August 1995

Stage of development	Title	TC/SC	Secretariat
2 CD	Procedure for the kinetic viscosity measurements by means of standard viscometers	TC 17/SC 5	Russia
1 CD	Octave-band and fractional octave-band filters	TC 13	Germany

9th WELMEC Committee Meeting

11–12 September 1995

A WELMEC committee meeting was held in Paris, 11–12 September 1995. As agreed at the previous meeting of the Committee, the following countries were invited to participate as Observers: Bulgaria, Hungary, Poland, Romania, Slovakia and the Czech Republic.
A complete report on this meeting will be given in the January 1996 issue of the OIML Bulletin, with particular attention to the following:

- WG2 – Directive implementation
- WG3 – EMeTAS
- WG4 – EN 45000
- WG5 – WELMEC Legal Metrology Review
- WG6 – Prepackages
- WG7 – Peripherals and PCs
- WG8 – Measuring Instruments Directive
- WG9 – Type approval agreement
- Reports from observer organizations: EC, EFTA, OIML, EUROMET, EAL, EOTC

OIML CERTIFICATE SYSTEM — Results of 1995 inquiries

Decisions of the 29th meeting of the CIML recommended that BIML periodically conduct inquiries among all parties concerned with the OIML Certificate System with a view to obtaining their opinions on its operation and usefulness. The Bureau distributed questionnaires to manufacturers of measuring instruments, issuing autorities of OIML certificates, and to members of the technical advisory group on certification (TAG_{cert}). The responses received from these three questionnaires were reviewed by the Bureau. Following are some preliminary results of this review.

▶ Manufacturers of measuring instruments

This questionnaire was distributed to 32 manufacturers granted with OIML certificates. The Bureau received 13 responses:

3 – China
Shanghai SIIC Scale, Shanghai Yamato Scale, Shenzhen M.G. Electronics Co.

1 – France
Precia

2 – Germany
Sartorius, Soehnle-Waagen

2 – Japan
Teraoka Seiko Co., Ishida Co.

1 – Netherlands
Revere Transducers Europe BV

2 – Spain
Epel Industrial S.A., Campesa S.A.

1 – Switzerland
Vibro-Meter S.A.

1 – USA
Mettler-Toledo, Inc.

Although the low number of replies does not yet provide a representative picture, some typical features for the initial operation and further development of the OIML certification may be noted:

- It seems that information on the OIML Certificate System, its aims reached many manufacturers.
- Applications for OIML certificates were associated in most cases, with national/regional (EC) type approvals.
- The majority of manufacturers confirmed the use (or intention to use) of OIML certificates to facilitate national/regional approval and commercialization of their products; they considered OIML certificates as giving an added value to their products and used them in publicity materials.
- Many manufacturers intended to apply for additional certificates.

Suggestions for developing the OIML Certificate System

- OIML certification of nonautomatic weighing instruments should replace national certificates similar to EC certification.
- International acceptance of certificates for legal metrology instruments in all OIML Members States.
- Extension of the System to modules of measuring instruments.
- Extension of the System to automatic weighing instruments.

With regard to opinion concerning conduct of tests, costs, use of tests previously performed by issuing authorities, etc., the replies were less unanimous. These subjects will be readdressed through future inquiries.

▶ Issuing authorities

The Bureau received 11 responses from issuing authorities of the following Member States:

Belgium, China, Denmark, France, Germany, Netherlands, Norway, Romania, Switzerland, U.K., U.S.A.

The present status of implementation by issuing authorities of the OIML Certificate System may be outlined as follows:

- Among the 16 Member States that have registered issuing authorities for various categories of patterns of measuring instruments, there are so far seven Members (China, Denmark, France, Germany, Netherlands, Switzerland, and U.K.) that have issued OIML certificates.
- All OIML certificates issued up to present were granted for only two categories of measuring instruments: "nonautomatic weighing instruments" (R 76) – 78 certificates; and "load cells" (R 60) – 43 certificates. The other seven categories pertaining to R 97, R 98, R 110, R 112, R 113, R 114, and R 115 have not yet been granted certificates and the reasons for this situation must be considered by national experts of issuing authorities and by TAG_{cert}.
- Responses from five issuing authorities confirmed that applications for OIML certificates were associated with national or regional (EC) pattern evaluations. Results of previous tests were received and taken into consideration by four issuing authorities, either to full extent, or by omitting some tests already performed by accredited manufacturers. Five responses revealed that there were cases where the submitted pattern did not meet all the requirements of the relevant OIML IR, and a modified pattern was submitted and re-tested.

Results of 1995 inquiries — OIML CERTIFICATE SYSTEM

Comments

Some comments were made by six issuing authorities on policies concerning conduct of tests, their cost, and issuing certificates and test reports:

The cost of the test is identical to that applied in national or European (EC) procedures. The policy is to issue OIML certificates and test reports at minimum cost. To reduce the cost, PTB (Germany) favours the issuing of OIML certificates for groups of technically similar instruments instead of individual instruments. In the case of applications for EC-type approvals, the Netherlands would be able to offer certificates for R 76 and R 60 free of charge.

Proposals

Following are some proposals for improving the role of issuing authorities:

1. Acceleration of mutual recognition by intercomparisons, exchanges of test reports.
2. Expansion of the System to include individual instruments.
3. Continuation of inquiries on the OIML Certificate System.
4. Distribution of information on the System, including prices of certification work.
5. Clarification of the procedures for issuing OIML certificates for families of measuring instruments.

▶ TAG_{cert} work topics

At present, the Bureau has received 14 responses from Members of TAG_{cert} and some other OIML Member States: Australia, Belarus, Bulgaria, China, Denmark, Germany, Hungary, Indonesia, Norway, Poland, Slovakia, U.K., U.S.A., and Yugoslavia.

The results of this questionnaire confirm that the majority of its items constitute very broad and complex subjects. It therefore appears that at the beginning of TAG_{cert} activities in 1995-1996, priority should be given to those subjects which are of the most interest to the majority of OIML Members. In order to accelerate the work, it is suggested to appoint a Rapporteur for each subject. The subjects and their rapporteurs are proposed by the Bureau as follows:

- **Application of a certificate to a family of patterns**

The definition of a family of patterns and the limitation of tests to certain patterns should be addressed.

Proposed Rapporteur: Australia, in collaboration with all other parties concerned.

- **Certification of modules of measuring instruments**

Guidelines issued by WELMEC should be taken into account, and experts from some technical committees and subcommittees could be invited to participate in the work (e.g. TC 9, TC 9/SC 1).

Proposed Rapporteur: U.K., Germany.

- **Application of ISO/IEC accreditation procedures to issuing authorities and test laboratories**

A report on possible application of existing procedures to OIML certification should be prepared.

Proposed Rapporteur: Slovakia, in collaboration with OIML TC 4 and other relevant bodies.

- **Application of ISO 9000 certification procedures for manufacturers of measuring instruments**

The work, as proposed by U.S.A., may be based, at this stage, on the Draft OIML Document "Initial verification of measuring instruments utilizing the manufacturer's quality system" to be completed and distributed.

Proposed Rapporteur: U.S.A., in collaboration with OIML TC 3.

- **Establishment of rules for recognition agreements of certificates and test results**

Criteria should be developed and included in the revision of OIML Document 13 "Guidelines for bi- or multilateral arrangements on the recognition of: test results – pattern approvals – verifications".

Proposed Rapporteur: U.S.A., in collaboration with TC 3 and other bodies concerned.

- **Periodic reviews of opinions concerning OIML certification**

Inquiries, reports, information concerning activities of issuing authorities, test laboratories, manufacturers and other related issues should be reviewed periodically. This item could also comprise such activities as an inquiry on jurisdictional protection of the System, seminars on OIML certification and proposals for the Development Council.

As Secretariat of TAG_{cert}, BIML will proceed with such activities.

- **Review of the paper "The OIML Certificate System for measuring instruments"**

In light of experience acquired after two years of implementation, the abovementioned paper should be reviewed by BIML.

▶ *The results of the inquiries will be discussed and implemented by TAG_{cert} and other OIML technical bodies concerned with a view to futher developing the OIML Certificate System.*

Metrology for the Americas

OAS nations seek to improve quality, standards and trade through collaboration

The United States National Institute of Standards and Technology (NIST) has announced that all 34 nations of the Organization of American States (OAS) have officially agreed to participate in the Interamerican Metrology System (abbreviated SIM for the Spanish translation, Sistema Interamericano de Metrologia), a reestablished organization seeking to harmonize measurement standards among its members.

The rebirth of the SIM marks the first successful interamerican effort toward realizing two major goals set forth at the "Summit of the Americas" held in December 1994: increasing cooperation in science and technology within the Americas, and promoting prosperity and free trade by eliminating technical trade barriers.

NIST, in cooperation with the OAS, U.S. Department of State, U.S. Agency for International Development, U.S. Trade and Development Agency, National Science Foundation and the metrology laboratories of the North American Free Trade Agreement (NAFTA) partners, revived the SIM through a series of workshops, seminars and summits over the past six years. The SIM seeks to develop a strong interamerican infrastructure using metrology and quality to enhance trade and commerce. Members focus on improving their national measurement and standards activities, and harmonizing these activities in the framework of SIM.

The SIM carries out its mission by the following:

- fostering the development of standards and standard reference materials acceptable throughout the Americas;
- establishing a series of regional workshops dealing with issues such as quality, industrial modernization and development;
- training advanced staff of member nations in specialized metrology technology; and
- working to establish an interamerican metrology system through international agreements (such as the collaborative program between the United States and Chile to improve techniques for analyzing environmental samples and advanced materials).

The SIM is divided into five regional metrology organizations *(see table below)*: NORAMET (North American nations); CAMET (Central American nations); ANDIMET (Northern South American nations); SURAMET (Southern South American nations); and CARIMET (Caribbean Island nations). Each region selects representatives to the SIM General Council, as well as to SIM committees on technical metrology and professional development. A council president is elected for a two-year term; the current president is Jaime Gonzáles Basurto of Mexico.

NIST will lead a series of intercomparisons to evaluate measurement capabilities of SIM members. ■

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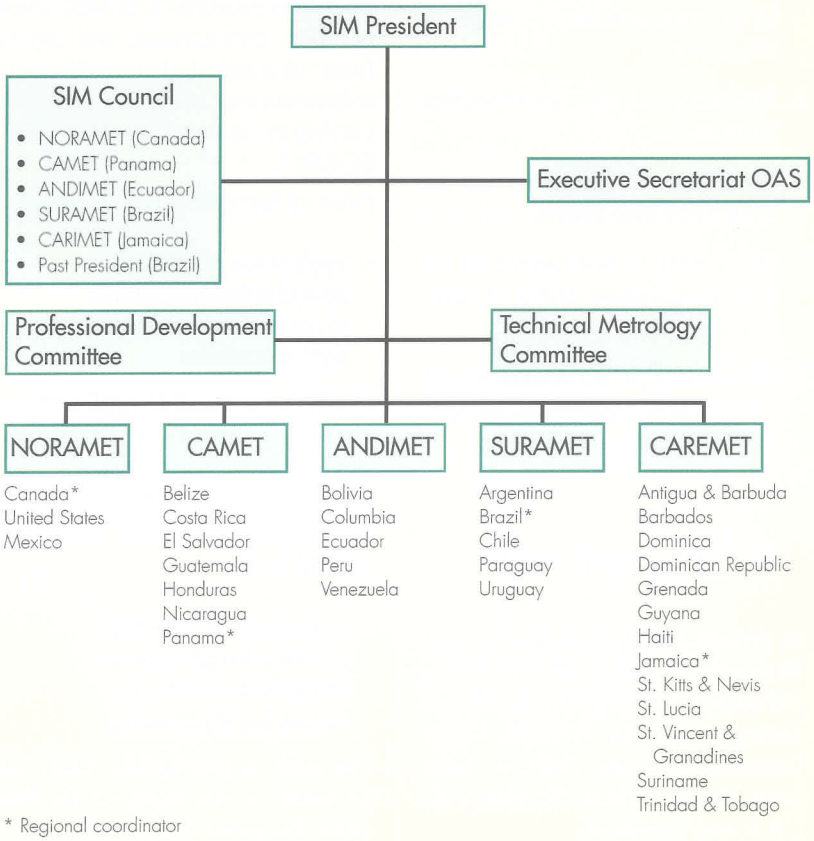
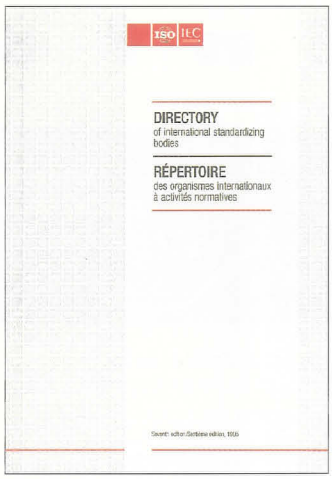


* Regional coordinator



Seventh edition (1995): Directory of international standardizing bodies

Published by ISO and IEC, this directory provides information on the membership, aims and activities of 45 international organizations dealing with aspects of standardization. It may be obtained from the ISO and IEC general secretariats. ■

OIML Seminar WEIGHING TOWARDS THE YEAR 2000

13–15 September 1995 Maison de la Mécanique, Paris

The OIML seminar "**Weighing towards the year 2000**" was held 13–15 September 1995 in Paris. This international seminar focused on key topics for the present and future of weighing instruments and featured exposés by various representatives of government and industry. An article highlighting the three-day seminar will be published in the January 1996 issue of the OIML Bulletin.
In order to enable our readers to benefit from the new ideas developed during the lectures, a series of seminar papers will be published in upcoming issues of the Bulletin. The first article of this series appears in the rubric *technique* (pp. 17–27) of this issue. ■

United States of America

National Voluntary Laboratory Accreditation Program (NVLAP)

The National Voluntary Laboratory Accreditation Program (NVLAP) issued its first *Certificates and Scopes of Accreditation* under its new Calibration Accreditation Program (CALLAB). As of spring 1995, the first six laboratories were accredited under CALLAB, which is expected to lead to an extensive network of NVLAP accredited calibration laboratories throughout the U.S.A., therefore strengthening the U.S. calibration and testing infrastructure and reducing barriers to international trade.
NVLAP was established in 1976 by the United States Department of Commerce, National Institute of Standards and Technology and operates as a government-based, third party for accrediting calibration and testing laboratories. ■

Bibliography

Standards library for measurement and control, 12th edition (1995)

THE INTERNATIONAL SOCIETY FOR MEASUREMENT & CONTROL
67 Alexander Drive, PO Box 12277, Research Triangle Park, North Carolina 27709 U.S.A.
495 USD (members)
550 USD (list price)

ISO Standards Handbook: Statistical methods for quality control, Fourth edition (1995)

INTERNATIONAL ORGANIZATION OF STANDARDIZATION, Central Secretariat, 1, rue de Varembé, CH-1211 Geneva 20, Switzerland. Volume 1 (ISBN 92-67-10211-7), 492 pages. Volume 2 (ISBN 92-67-10212-5), 384 pages.

The role of metrology in quality management and quality improvement (1995)

Published by Commonwealth-India Metrology Centre (CIMET), NPL Cell. EDITORS: B.S. MATHUR, A.C. GUPTA, V.N. OJHA, National Physical Laboratory, Dr K.S. Krishnan Marg, New Delhi-110012.

DIRECTORY OF LEGAL METROLOGY IN THE ASIA-PACIFIC

Published by the Asia-Pacific Legal Metrology Forum, the **Directory of legal metrology in the Asia-Pacific** comprises information provided by legal metrology authorities in the Asia-Pacific Economic Co-operation (APEC) economies on legislation, insitutional and operational aspects of legal metrology in this region. This Directory should be useful for improving the understanding on the nature of legal metrology in each economy, therefore contributing to regional harmonization of legal metrology requirements.

The Directory contains information provided by Member Countries up to March 1995 with regard to:

- metrology laws
- legal units of measurement
- structures on metrological control authorities
- equipment subject to legal metrology
- type (pattern) approval
- verification (conformity assessment), inspection and reverification
- accreditation and certification systems
- legal metrology practitioners
- packaging
- sanctions

Directory price: $A 50

To order the **Directory of legal metrology in the Asia-Pacific,** contact the Secretariat:

Asia-Pacific Legal Metrology Forum, PO Box 282 North Ryde, New South Wales 2113, Australia
Tel.: (02) 888 3922 Fax: (02) 888 3033

meetings OIML réunions

October 1995

23–24	OIML Symposium on metrological activities in developing countries	BEIJING
25	Development Council meeting	BEIJING
25–27	30th CIML meeting	BEIJING
To be fixed	TC 8/SC 7 Gas metering	BRUSSELS

Beginning 1996

To be fixed	TC 17/SC 3 pH-metry	TO BE FIXED

CEN CENELEC ETSI

Conference

CANNES - MANDELIEU, FRANCE 7-8 DECEMBER 1995

EUROPEAN STANDARDS:
Obstacle or Opportunity for the Information Society?

A conference hosted by the three European Standards Organizations, CEN, CENELEC and ETSI for presenting the results achieved during the year and progress made towards technical standards to meet the needs of a market entering the age of the Information Society.

Target audience: Those who specify standardization policies as well as users of standards who make strategic decisions related to the development of telecommunications equipment and products applying information and communication technologies.

Languages: English, French and German (simultaneous translation)

Registration fee: 2600 FF

Sessions: 1–The achievements of European standardization; 2–Reconciling information technology/standardization and Telecom standardization; 3–Building critical mass; 4–Global competitiveness and regional standardization

Conference location: Royal Hotel Casino - Mandelieu La Napoule, France
Tel.: (33) 92 97 70 00 Fax: (33) 93 49 51 50

Conference Secretariat: European Telecommunications Standards Institute (ETSI)
F-06921, Sophia Antipolis Cedex France
Tel.: (33) 92 94 42 00 Fax: (33) 93 65 47 16

info

European Quality Week
6–12 November 1995

Organised on behalf of the European Commission by the European Quality Platform
(The European Organization for Quality - EOQ, and the European Foundation for Quality Management - EFQM)

The European Commission is convinced that the practice of quality management is the key to further developing and enhancing Europe's global competitiveness. To this end, week 45 (starting November 6) has been designated in 1995 to celebrate quality in Europe and to emphasize the European Quality Promotion Policy (EQPP). The week will be held under the banner **"Quality in Europe – the way towards excellence"**, and the main mission is to help people make sense of the EQPP, as well as projects concerning quality, both now and in the future.

During European Quality Week, a campaign of public awareness will be held with a view to promoting and demonstrating the advantages and the importance of quality for the competitiveness of the European economy, for the economic operators, public services and customers.

The Commission plans to support the PEQ (European Quality Platform) for carrying out integrated activities and initiatives (for example: conferences, videoconferences, press releases, informational booklets, posters, etc.), throughout the territory of the European Union, through national and European organizations dealing with quality. These actions will be concentrated over the second week of November, in order to include the "world quality day" which has been set for the second Thursday in November.

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PUBLICATIONS

Below are lists of OIML publications classified by subject and number. The following abbreviations are used: International Recommendation (R), International Document (D), vocabulary (V), miscellaneous publication (P). Publications are available in French and English in the form of separate leaflets, unless otherwise indicated. Prices are given in French-francs and do not include postage.

To order publications, please contact the OIML Secretariat by letter or fax:

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

On trouvera ci-dessous une liste des publications OIML classées par sujets et par numéros. Les abréviations suivantes sont utilisées: Recommandation Internationale (R), Document International (D), vocabulaire (V) et autre publication (P). Ces publications sont disponibles en français et en anglais sous forme de fascicules séparés sauf indication contraire. Les prix sont donnés en francs-français et ne comprennent pas les frais d'expédition.

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

General
Généralités

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

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

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

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

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

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

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

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

D 13 (1986) 50 FRF
Guidelines for bi- or multilateral arrangements on the recognition of: test results - pattern approvals - verifications
Conseils pour les arrangements bi- ou multilatéraux de reconnaissance des: résultats d'essais - approbations de modèles - vérifications

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

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

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

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

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

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

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

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

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

P 3 (being printed - *en cours de publication)*
Metrology in Member States and Corresponding Member Countries
Métrologie dans les Etats Membres et Pays Membres Correspondants de l'OIML

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

P 17 (1995) 300 FRF
Guide to the expression of uncertainty in measurement

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 (1985) 80 FRF
Checkweighing and weight grading machines
Trieuses pondérales de contrôle et trieuses pondérales de classement

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

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

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

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

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

R 76-1 (1992) 300 FRF
Nonautomatic weighing instruments Part 1: Metrological and technical requirements - Tests
Instruments de pesage à fonctionnement non automatique Partie 1: Exigences métrologiques et techniques - Essais

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

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

R 117 (being printed - *en cours de publication)*
Measuring assemblies for liquids other than water
Ensembles de mesurage de liquides autres que l'eau

R 118 (being printed - *en cours de publication)*
Testing procedures for pattern examination of fuel dispensers for motor vehicles
Procédures d'évaluation des modèles de distributeurs de carburant pour véhicules à moteur

R 119 (being printed - *en cours de publication)*
Pipe provers for testing of measuring systems for liquids other than water
Tubes étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau

R 120 (being printed - *en cours de publication)*
Characteristics of standard capacity measures and test methods for measuring systems for liquids other than water
Caractéristiques desmesures de capacité étalons et méthodes d'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 (being printed - *en cours de publication*)
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 (1984) 50 FRF
Sound level meters
Sonomètres

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

R 102 (1992) 50 FRF
Sound calibrators
Calibreurs acoustiques

Annex (1995) 80 FRF
Test procedures and test report format
Procédures d'essai 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

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

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 (being printed - *en cours de publication)*

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 (being printed - *en cours de publication)*
Equipement 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 (1989) 50 FRF
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
Verification and calibration of Vickers hardness standardized blocks
Vérification et étalonnage des blocs de référence de dureté Vickers

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

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

R 14 (1995) 60 FRF
Polarimetric saccharimeters
Saccharimètres polarimétriques

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

R 46 (1980–*1978*) 80 FRF
Active electrical energy meters for direct connection of class 2
Compteurs d'énergie électrique active à branchement direct de la classe 2

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

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

R 49 (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 (1985) 80 FRF
Checkweighing and weight grading machines
Trieuses pondérales de contrôle et trieuses pondérales de classement

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

R 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 (1984) 50 FRF
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 (1985) 80 FRF
Automatic gravimetric filling machines
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 (1989) 50 FRF
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 (1989) 50 FRF
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 procedures and test report format
Procédures d'essai 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

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

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

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

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

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 (being printed - *en cours de publication*)
Measuring assemblies for liquids other than water
Ensembles de mesurage de liquides autres que l'eau

R 118 (being printed - *en cours de publication*)
Testing procedures for pattern examination of fuel dispensers for motor vehicles
Procédures d'évaluation des modèles de distributeurs de carburant pour véhicules à moteur

R 119 (being printed - *en cours de publication*)
Pipe provers for testing of measuring systems for liquids other than water
Tubes étalons pour l'essai des ensembles de mesurage de liquides autres que l'eau

R 120 (being printed - *en cours de publication*)
Characteristics of standard capacity measures and test methods for measuring systems for liquids other than water
Caractéristiques des mesures de capacité étalons et méthodes d'essai des ensembles de mesurage de liquides autres que l'eau

R 121 (being printed - *en cours de publication*)
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 (being printed - *en cours de publication*)
Equipment for speech audiometry
Appareils pour l'audiométrie vocale

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 (being printed - *en cours de publication*)
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 (being printed - *en cours de publication*)
Metrology in OIML Member States and Corresponding Member Countries
Métrologie dans les Etats Membres et Pays Membres Correspondants de l'OIML

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

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

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

OIML BULLETIN

CALL FOR PAPERS

The Editors of the OIML Bulletin welcome the submission of technical papers and articles that address new advances in metrology, particularly in the fields of trade, health, environment, and safety in which the credibility of measurements remains a challenging priority.

Metrology is adapting to the changes that are rapidly occuring worldwide and the OIML Bulletin strives to reflect this adaptation. National, regional, and international activities concerning evaluation procedures, accreditation and certification, measuring techniques and instrumentation, and implementation of OIML Recommendations as well as other international publications relative to metrology are of interest to the expanding audience of the OIML Bulletin.

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

Papers should be sent to the *Bureau International de Métrologie Légale*, Attn. Editors of the OIML Bulletin, 11, rue Turgot, 75009 Paris France.