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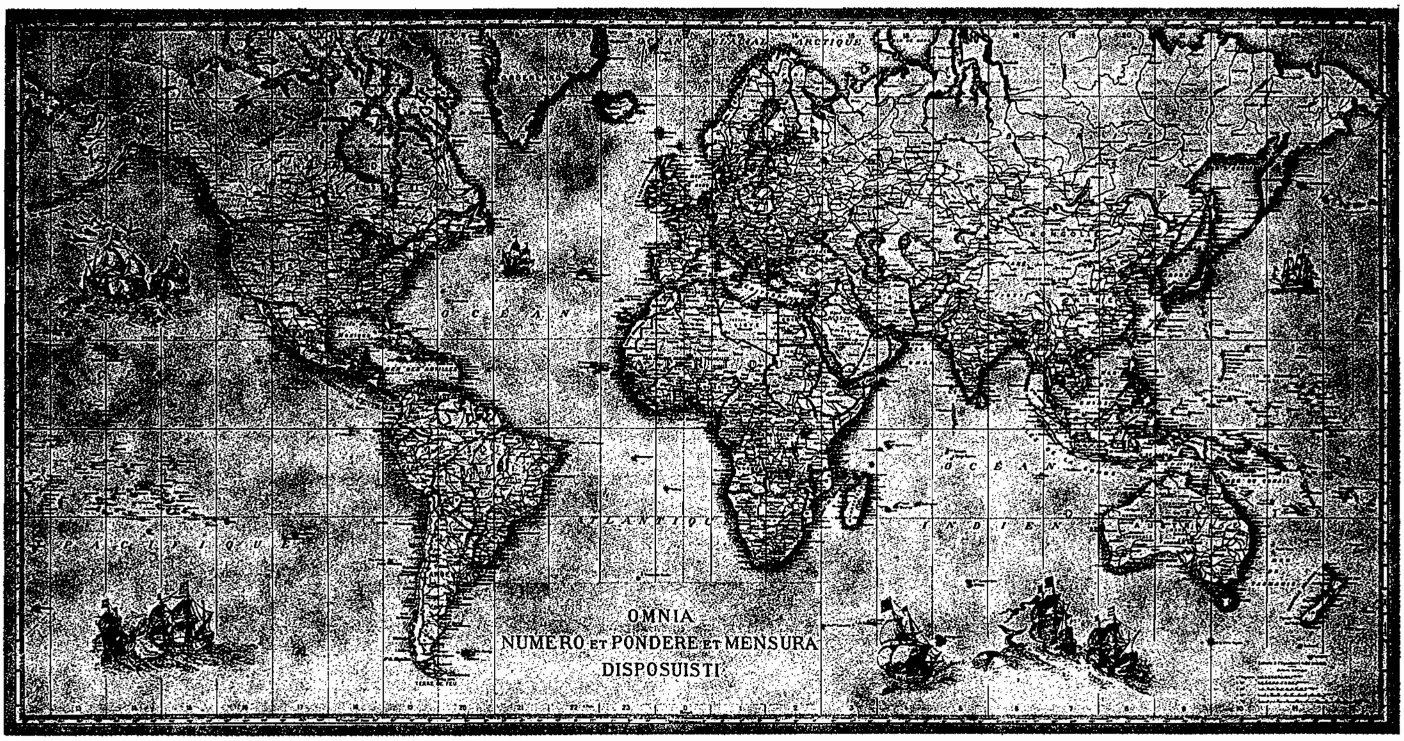
BULLETIN

DE

L'ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE



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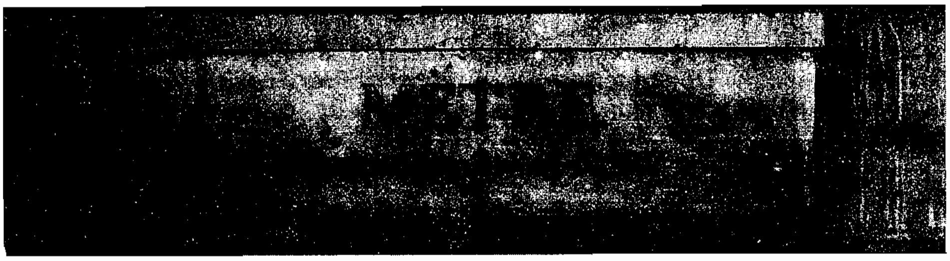
CEREMONIE COMMEMORATIVE DE LA CREATION DU SYSTEME METRIQUE

Les réunions simultanées à Paris du Comité International des Poids et Mesures et du Comité International de Métrologie Légale ont donné lieu le 27 septembre 1989 à une cérémonie commémorative de la création du système métrique, organisée par la France dans le cadre de la célébration du bicentenaire de la Révolution.

Après une visite, par les membres des deux comités, de l'exposition du Musée national des Techniques sur "l'Aventure du Mètre", la cérémonie proprement dite s'est déroulée place Vendôme, au Ministère de la Justice. Sur la façade de ce bâtiment se trouve en effet l'un des deux derniers exemplaires des mètres en marbre qui, dans les débuts du système métrique, avaient été apposés en divers endroits de Paris pour familiariser les habitants de la capitale avec cette unité révolutionnaire.

M. Louis MARQUET, président de la Société métrique de France, rappela l'histoire de ces mètres en marbre. Les techniciens du Laboratoire National d'Essais procédèrent ensuite à un étalonnage de ce mètre au moyen d'un théodolite informatique à laser, pendant que M. J. BLOUET, secrétaire général du Bureau National de Métrologie, donnait les explications techniques sur cette opération.

La longueur trouvée fut 1,002 1 m ± 0,5 mm, soit légèrement inférieure à celle du mètre-gâteau qui ornait le buffet du cocktail offert ensuite dans les salons du Ministère de la Justice conjointement par MM. le Ministre de la Justice et le Ministre chargé de l'Industrie.



The simultaneous meetings in Paris of the International Committee of Weights and Measures and the International Committee of Legal Metrology were the opportunity for a commemoration on 27 September 1989 of the creation of the metric system which was organised by France within the framework of the celebration of the bicentenary of the French Revolution.

After a joint visit by the two Committees to the exhibition "l'Aventure du Mètre" at the Musée National des Techniques, the ceremony itself took place at the Ministry of Justice, Place Vendôme. There remains in fact on the wall of this building one of the two last copies of the marble metres which were installed at various places in Paris in the beginning of the metric system to familiarize the inhabitants of the city with this revolutionary unit.

Mr Louis MARQUET, Chairman of the French metric association, recalled the history of these metres made of marble. The metrologists of the Laboratoire National d'Essais then made a calibration of the metre by using a data processing laser theodolite while technical explanations of this operation were given by Mr J. BLOUET, General Secretary of the Bureau National de Métrologie.

The length was found to be 1.002 1 m ± 0.5 mm and was slightly smaller than that of the cake in the form of the metre which decorated the buffet at the cocktail which followed in the reception rooms of the Ministry of Justice at the joint invitation of the Minister of Justice and the Minister in charge of Industry.

SEMINAIRE DE L'OIML SUR
LA PLANIFICATION DE LABORATOIRES DE METROLOGIE ET D'ESSAIS
ET
REUNION DU CONSEIL DE DEVELOPPEMENT DE L'OIML

Paris, 25-26 septembre 1989

Séminaire

Le sujet de ce séminaire fut proposé il y a deux ans par l'actuel Président du Conseil de Développement, M. Mohamed Benkirane, du Maroc.

Le séminaire était donc principalement orienté vers des problèmes qui se présentent aux pays en développement lorsqu'ils doivent s'équiper afin de faire face aux développements commerciaux et industriels.

Le sujet avait également suscité un grand intérêt de la part de certains pays fortement industrialisés, qui ont actuellement besoin d'améliorer, moderniser ou étendre leurs activités en matière d'essais.

La manifestation avait ainsi attiré plus de 60 participants de 26 pays différents. Quatre institutions internationales étaient également représentées (ONUDI, ARSO, GCC, IMEKO).

Le Directeur du BIML a ouvert le séminaire en souhaitant la bienvenue aux participants. Un discours d'ouverture a ensuite été prononcé par M. le Dr M.H.A. Hamdy, Directeur de la Division des Institutions et Services Industriels de l'ONUDI, qui a décrit les activités de son Organisation dans le domaine de la métrologie et de l'assurance de la qualité. Son exposé est reproduit dans ce Bulletin.

A l'origine il avait été envisagé de discuter dans le séminaire la planification relative aux essais de produits en général qui pour un pays en développement est au moins aussi importante que celle qui concerne exclusivement la métrologie. Beaucoup de pays en développement ont en effet choisi ce qui est appelé l'approche intégrée, en combinant les activités métrologiques et celles des essais de produits.

A cause du manque de temps et d'orateurs spécialisés, nous avons dû nous restreindre à l'objet principal de l'OIML, la métrologie.

Les essais des produits tels que textiles, plastiques, matériaux de construction, matériel électrique, etc. sont des sujets si vastes qu'ils demandent pratiquement à être traités chacun dans des séminaires à part. Quelques indications générales concernant les nécessités pour la planification des bâtiments pour les essais de ces produits sont données dans la brochure du BIML "Planification de Laboratoires de Métrologie et d'Essais" dont la version française avait été préparée spécialement pour le séminaire.

Les points de départ de la planification pour les activités métrologiques étaient résumés dans un exposé d'introduction par M. S.A. Thulin, BIML. Les laboratoires de métrologie peuvent être séparés en ceux destinés aux étalons primaires de référence et ceux utilisés pour des essais et étalonnages de routine. Ces derniers sont parfois plus difficiles à planifier car ils exigent un inventaire précis des besoins afin que les bâtiments construits permettent de travailler d'une façon efficace.

Le temps qu'un métrologiste passe dans un laboratoire spécial pour étalons primaires est souvent court par rapport au temps qu'il passe dans son bureau. Le type de construction pour les étalons primaires peut ainsi être largement influencé par les moyens dont on dispose maintenant pour effectuer des mesures et manipuler les étalons par des moyens automatiques en utilisant des dispositifs d'acquisition et de traitement de données. Ceux-ci permettent souvent de réaliser une amélioration considérable aussi bien en exactitude qu'en confort. Le métrologiste peut ainsi limiter son séjour dans les salles de laboratoire de ce type au temps nécessaire pour effectuer les préparations des mesures, phase pendant laquelle les conditions telles que température, humidité et pression peuvent ne pas être aussi critiques que pendant les mesures définitives.

La planification pour les laboratoires d'essais de routine doit tenir compte des aspects tels que réception et expédition des instruments soumis aux essais, y compris leur déballage et leur réemballage, leur stockage et préconditionnement pour essais ainsi qu'en grande partie la commodité et le confort pour le personnel.

En d'autres termes, il est souvent possible de placer les laboratoires primaires de métrologie très en dessous du niveau du sol afin d'obtenir la stabilité optimale alors que les laboratoires d'essais de routine doivent être localisés dans des salles plus commodes ou dans des salles de machines. Ces laboratoires peuvent également exiger le transport du matériel de laboratoire vers des sites industriels en utilisant des unités mobiles motorisées.

Pour un pays en développement, il est nécessaire de combiner les deux conceptions, laboratoire de référence et laboratoire d'essais de routine, en choisissant le meilleur compromis et en tenant compte des besoins et de la disponibilité du personnel qualifié.

Ces différents problèmes et leurs solutions ont fait l'objet des exposés ci-dessous, présentés par des conférenciers spécialement invités. Les exposés ont été suivis par des discussions. La plupart de ces exposés seront publiés dans le Bulletin de l'OIML en commençant par ce numéro.

— Conception des bâtiments, par M. J.P. Holuigue, Ecole Supérieure de Métrologie, Douai, France
— Conception de systèmes d'air conditionné, par Dr W. Schollmeier, PTB, R.F. d'Allemagne (en anglais)
— Planification et expériences d'un laboratoire régional de métrologie, par Dr W. Gögge, Eichdirektor, Rheinland-Pfalz, R.F. d'Allemagne (en anglais)
— Laboratoires de mesures de masse, par Dr E. Seiler, PTB, R.F. d'Allemagne (en anglais)
— Laboratoires de métrologie de volume de liquides, par M. A. Renard, Laboratoire de Métrologie, DRIR Ile de France, Ivry, France
— Laboratoires de métrologie dimensionnelle, par M. B. Schatz, Laboratoire National d'Essais, France
— Laboratoires de métrologie des forces, par M. F. Petik, BIML (en anglais)
— Laboratoires de métrologie des pressions, par Dr R. Lewisch, Vice-Président, Bundesamt für Eich- und Vermessungswesen, Wien, Autriche (en anglais)
— Laboratoires de thermométrie, par M. Henry E. Sostmann, Métrologiste Consultant, Etats-Unis d'Amérique (en anglais)
— Laboratoires de mesures électriques, par Dr H. Bachmair, PTB, R.F. d'Allemagne (en anglais)
— Expériences de l'URSS dans la construction des laboratoires de métrologie, par M. A.S. Vishenkov, Gosstandart, URSS (en anglais).

Réunion du Conseil de Développement de l'OIML

Le séminaire fut suivi d'une brève réunion du Conseil de Développement, sous la Présidence de M. Mohamed Benkirane.

Cette réunion a d'abord passé en revue les activités de l'OIML pour les pays en développement pour la période d'avril 1988 à septembre 1989 selon un rapport présenté par le BIML. En plus des préparations pour le séminaire sur la Planification et l'Equipement des Laboratoires de Métrologie et d'Essais, ces activités ont surtout porté sur la production de deux nouvelles publications du BIML:
"Guide to Calibration" et "Guide to Practical Temperature Measurements".

Bien que principalement destinées aux pays en développement, ces brochures peuvent également intéresser des pays plus industrialisés.

Certains délégués ont ensuite brièvement décrit les activités d'aide bilatérale de leur pays dans le domaine de la métrologie.

Le point principal de l'ordre du jour était la discussion sur les actions futures de l'OIML pour les pays en développement en tenant compte de tous les facteurs contraignants d'ordre économique.

Le Président a en particulier estimé que les problèmes des pays les moins développés n'avaient probablement pas été suffisamment traités dans le séminaire précédent qui avait dans plusieurs cas mis l'accent sur des problèmes surtout rencontrés dans des pays plus avancés.

Il a notamment suggéré que le BIML renouvelle l'enquête faite il y a quelques années sur la possibilité pour les pays en développement de recevoir, à bas prix ou gratuitement, des équipements de vérification en bon état mais n'étant plus utilisés par des services de métrologie d'autres Etats Membres de l'OIML.

Une autre enquête du BIML effectuée à la demande du précédent Président avait démontré un très grand intérêt pour des cours de formation en métrologie, qui cependant sont difficiles à organiser pour des raisons économiques.

L'assemblée a décidé que ces cours doivent être considérés comme sujets prioritaires et a demandé au BIML d'enquêter sur les possibilités d'organiser un cours en 1991 avec l'aide de pays pouvant prêter leur concours.

Certains pays ont en effet des écoles de métrologie et disposent ainsi de facilités pour un tel cours qui pourrait avoir lieu à une période de l'année où les étudiants réguliers sont en vacances. Le problème primordial serait ainsi limité au financement. La poursuite de l'enquête du BIML avait en effet mis en évidence qu'extrêmement peu de pays seraient en mesure de payer les frais de voyage et de séjour des participants.

Le BIML a été chargé par le Conseil de Développement d'étudier plus en détail le contenu, le niveau technique et la durée du cours, le lieu, la langue de travail ainsi que la possibilité d'obtenir des bourses pour les participants.

Le Conseil a décidé également de présenter à la 24e réunion du CIML la demande que les fonds alloués pour une réunion du Conseil de Développement en 1991 puissent être utilisés pour faciliter la participation des pays en développement à ce cours de formation de l'OIML.

Cette proposition fut par la suite acceptée par le CIML, qui a adopté une résolution dans ce sens.

Il y a par conséquent de bonnes perspectives qu'un tel cours de formation puisse être organisé pourvu toutefois qu'au moins 15 bourses supplémentaires puissent être obtenues de la part des Etats Membres ou des autres organisations internationales ou régionales.

OIML SEMINAR ON
PLANNING AND EQUIPPING METROLOGY AND TESTING LABORATORIES
AND
MEETING OF OIML DEVELOPMENT COUNCIL

Paris, 25-26 September 1989

Seminar

The subject of this seminar was proposed two years ago by Mr Mohamed Benkirane of Morocco who is the President of the OIML Development Council.

The scope of the seminar was thus mainly directed towards problems that developing countries encounter when they have to equip themselves to keep pace with the industrial and commercial developments.

The seminar had however raised great interest on behalf of several countries with advanced industrialization which need to improve, modernize or extend their testing activities.

The event was thus attended by a total of 60 participants from as much as 26 different countries. Four international institutions were also represented (UNIDO, ARSO, GCC, IMEKO).

The seminar was opened by the Director of BIML who welcomed the participants. An opening speech on the activities of UNIDO in the field of metrology and quality assurance was delivered by Dr M.H.A. Hamdy, Director of the Industrial Institutions and Services Division of UNIDO. His speech is reproduced in this Bulletin.

Originally it was thought of discussing in the seminar the problems of laboratories for general product testing which, for a developing country, are at least as important as those concerned purely with metrology. Many developing countries have in fact chosen the so-called integrated approach, combining their metrological and product-testing activities.

Due to lack of both time and specialist speakers we had to restrict ourselves to the main subject of OIML, i.e. metrology.

The testing of products such as textiles, plastics, building materials, electrical materials and appliances etc. are so extensive subjects that they would in fact need separate seminars. Some general indications as regards prerequisites for product testing are given in the BIML brochure "Planning of Metrology and Testing Laboratories" which had also been translated into French specially for the seminar.

The concepts of planning for metrology were briefly reviewed in an introductory speech by Dr S.A. Thulin, BIML. Metrology laboratories can be divided into those for primary reference standards and those for routine testing and calibration. The latter are sometimes more difficult to plan as they require a careful inventory of needs so that the buildings that are provided allow work to be done efficiently.

The time a scientist spends in a special laboratory for primary reference standards is frequently short compared to the time he spends in his office. The type of construction of buildings for primary standards can thus be greatly influenced by the means now available for making measurements and handling standards automatically using modern facilities for data acquisition and processing. They usually mean a considerable improvement both in accuracy and human comfort. The scientist may in such laboratories enter and work in the special rooms only during the preparatory phase of the measurements when conditions such as temperature, humidity and pressure may not be as critical as during the final measurements.

The planning of laboratories for routine testing has to take into account aspects such as the in-flow and out-flow of test items including their unpacking and packing, storage and preconditioning for testing and, to a large extent, the staff's convenience and comfort.

In other words primary metrology laboratories can be constructed so that they are deep underground for maximum stability, whereas routine testing has to be done in more conveniently located rooms, machine halls, etc. and may even require the transportation of laboratory equipment to an industrial or other site by use of test vans, etc.

For a developing country the two design concepts, reference standards laboratory and routine testing laboratory, will have to be combined into a suitable compromise taking into account both needs and the availability of suitably qualified staff.

The various needs and their solutions were presented by the invited speakers and each time followed by fruitful discussions.

A list of the specialized lectures is given below. The majority of them will be published in the OIML Bulletin on a progressive basis starting with this issue.

— Lay-out of buildings by Mr J.P. Holuigue, Ecole Supérieure de Métrologie, Douai, France (in French)

— Design of air-conditionning systems by Dr W. Schollmeier, PTB, F.R. of Germany

— Planning and experience of a regional metrology laboratory by Dr W. Gögge, Eichdirektor, Rheinland-Pfalz, F.R. of Germany

— Mass metrology laboratories by Dr E. Seiler, PTB, F.R. of Germany

— Metrology laboratories for volume of liquids by Mr A. Renard, Laboratoire de Métrologie, DRIR Ile-de-France, Ivry, France (in French)

— Laboratories for dimensional metrology by Mr B. Schatz, Laboratoire National d'Essais, France (in French)

— Laboratories for force metrology by Mr F. Petik, BIML

— Laboratories for pressure metrology by Dr R. Lewisch, Vice-President, Bundesamt für Eich- und Vermessungswesen, Wien, Austria

— Thermometry laboratories by Mr Henry E. Sostmann, Consulting Metrologist, USA

— Laboratories for electrical metrology by Dr H. Bachmair, PTB, F.R. of Germany

— Experiences of designing metrology laboratories in the USSR by Mr A.S. Vishenkov, Gosstandart, USSR.

Meeting of the OIML Development Council

The seminar was followed by a short meeting of the OIML Development Council chaired by its President Mr Mohamed Benkirane.

This meeting first reviewed the OIML activities for developing countries during the period April 1988 to September 1989 in accordance with the report presented by BIML. In addition to the preparations for the seminar on Planning and Equipping Metrology and Testing Laboratories these activities have mainly consisted in the production by BIML of two new publications:

"Guide to Calibration" and "Guide to Practical Temperature Measurements".

Though these brochures are largely based on training given to metrology staff in developing countries they may be useful in industrialized countries as well.

Some of the delegates then briefly surveyed the bilateral aid activities to metrology projects undertaken by their country.

A main item of the agenda was the discussion of possible future OIML activities for developing countries taking into account all the economic constraints.

The President considered that the special problems of the least developed countries had probably not been sufficiently dealt with in the preceding seminar which in several cases treated problems mainly encountered in more industrialized countries.

He suggested in particular that BIML should renew the enquiry made several years ago concerning the availability to developing countries, at low or no cost, of verification equipment in good condition but no longer needed by the metrology organisations of other OIML Member States.

Another enquiry already made by BIML at the initiative of the previous President had shown a very great interest for training courses in metrology which, however, are difficult to organize for economic reasons.

The meeting decided that a training course should be considered as priority subject and asked BIML to investigate the possibilities of organizing a course in 1991 with the help of sponsor countries.

Some countries have metrology schools and thus available facilities for such a course which could possibly take place at a suitable period when the regular students are on holidays. The main problem is thus of financial nature. The BIML follow-up on the enquiry had in fact showed that extremely few countries would be in a position to pay travel and accommodation costs for the trainees to be sent to a metrology course.

The BIML was requested by the Development Council to further investigate the matter as regards the content, technical level and duration of the course, its location, working language and the possibility for obtaining travel grants.

The Council furthermore decided to present to the 24th meeting of CIML the request that the budget provided for a meeting of the Development Council in 1991 be used to facilitate the attendance in OIML training course by legal metrologists from developing countries.

This proposal was accepted in a resolution passed at the subsequent CIML meeting.

There are thus presently good prospects that a training course can be organized provided however that at least 15 additional followship grants can be obtained from OIML Member States or from other international or regional organisations.

ACTIVITIES of UNIDO in the FIELD of METROLOGY and QUALITY ASSURANCE *

by **Dr M.H.A. HAMDY**
Director of the Industrial Institutions and Services Division of UNIDO

Mr Chairman,
Ladies and gentlemen,

I would like to present to you, briefly, UNIDO's activities in developing countries in the field of quality control, standardization and metrology. As you know, developing countries have been seeking to develop their exports of manufactured goods. This requires the improvement in the quality of locally manufactured products in order to be able to compete in international markets. At the same time, people in the developing countries are likewise demanding better quality, reliability, and safety of locally produced or imported goods. Therefore, it is evident that the consideration and management of QUALITY are major objectives in developing countries.

UNIDO Assistance

Given their growing need, UNIDO has been providing technical assistance to developing countries in establishing, developing and strengthening quality control, standardization and metrology systems through the design and undertaking of technical cooperation projects and activities at the national, regional and international levels.

The objective of its endeavours is twofold:

1. To assist industrialists to assure the quality of production. This includes strengthening existing and/or setting up new institutions such as standardization and quality control bureaux and metrology and testing laboratories. These institutions prepare standards and provide advisory, training, testing and calibration services to local industries.
2. To assist Government authorities in developing countries to ensure the quality of locally produced or imported goods through national and sectoral institutions.

UNIDO Approaches to Technical Assistance

Based on our experience of more than 22 years, our technical assistance has been channelled through two main approaches which have been successfully applied in no less than 65 countries. The two approaches are:

* Opening speech at the OIML Seminar on Planning and Equipping Metrology and Testing Laboratories, Paris, 25-26 September 1989.

The Integrated Approach

The development and improvement of quality through quality control, quality assurance, certification marking, laboratory accreditation, measurement and testing, cannot be achieved without the following four interlinked components:

a) Standardization: the availability of adequate standards and specifications.

b) Metrology, precise and continuously checked, maintained and calibrated measuring instruments and equipment.

c) Testing laboratories, adequate and independent testing facilities.

d) Service Centers to Industry, advisory and training services in the field of quality control for industry.

In line with our integrated approach to quality control, standardization and metrology, UNIDO tries to ensure that in elaborating, formulating and executing technical co-operation projects, the above four components are integrated or at least co-ordinated.

As far as metrology is concerned, it is clear that this is the main infrastructural tool regarding quality control, because "there is no quality without measurement". Therefore UNIDO is deeply involved in setting up institutions and laboratories which have two main tasks: first, to ensure the maintenance of national metrological standards and their link-up with international standards and, second, to offer industrialists and testing laboratories the measuring instruments which they use. These two operations should make it possible to ensure that the measures taken locally in a laboratory or enterprise are comparable with the measures taken by a foreign laboratory or customer.

For example, in Ethiopia a national metrology laboratory was set-up with the assistance of UNIDO and covers the following fields: length and angles, mass, volume, force, pressure, electricity, density and viscosity, and time and frequency. The laboratory has started to assume a regional role among African countries in organizing training for technicians and in calibrating standards of some neighbouring countries in the region.

It is worth mentioning that owing to the broad experience of UNIDO in this field, the Greek Government has called upon UNIDO to develop the national metrology system in the country.

The Regional Approach

Developing countries located in the same region may, for a great part, have similar developmental conditions and hence similar problems. Alleviating these problems and improving the prevailing conditions should suggest the consideration of a regional approach. In addition, a regional approach would ensure complementarity, better co-ordination and promote co-operation among the countries of the region.

Therefore, the establishment of a regional institutional infrastructural mechanism addressing this field of activity, whether in the form of a regional institution and/or regional networking of national institutions (bureaux, laboratories, etc.) has indeed significant advantages, namely:

— reducing technical barriers (relating for example to national standards or technical regulations) and thus developing and promoting regional commercial exchanges;

— strengthening the participation of the countries in the region in the work of international organizations in this field of activity thus enabling the countries to benefit more from international activities;

— having access to existing national facilities in the region leading to economy in operation, co-ordination, and complementarity thus avoiding unnecessary duplication; and

— promoting co-operation among countries in the region (South/South) in the exchange of information, provision of technical assistance and establishment of sound regional industrial development policies, and the launching of joint activities and ventures to implement these policies.

For example: African countries have established a regional organization for standardization; the African Regional Organization for Standardization (ARSO), which has 23 member states. It promotes standardization activities in Africa, as well as elaborating and publishing regional standards. 500 regional African standards have so far been elaborated. Since 1977, ARSO has been receiving important assistance from UNIDO. It is worth mentioning that UNIDO and ARSO have been working on a project aimed at the developing metrological activities in Africa. Besides the elaboration and publication of regional standards in the field of metrology, the main objective of this project is the design of a network of adequate primary national metrology laboratories depending on the needs and capabilities of the countries of the region.

Conclusion

At present, UNIDO is responsible for 27 quality related operational projects for a total amount of no less than US $ 18 million. Our programme currently covers 19 developing countries.

The majority of the technical co-operation projects executed by UNIDO in the field of quality control, standardization and metrology are large-scale projects lasting two to five years. In certain cases and according to the needs of the countries, technical co-operation projects may be extended or may be followed by other projects in the same field.

The UNIDO programme for quality control, standardization and metrology is visibly expanding. I am convinced that co-operation between UNIDO and OIML, similar to that with other organizations, could be instrumental in providing more support to developing countries in this important field.

EFTA

INTERCOMPARISON TESTS OF ELECTRONIC NON-AUTOMATIC WEIGHING INSTRUMENTS ACCORDING TO OIML R 76

by

Håkan KÄLLGREN and **Rolf OHLON**
Statens provningsanstalt, Sweden

Introduction

A Memorandum of Understanding was signed on May 28, 1987 in Helsinki between the EFTA-countries — Austria, Finland, Iceland, Norway, Sweden and Switzerland — on mutual recognition of test results and certificates for measuring instruments being subject to mandatory testing and certification in any of the countries concerned. At the same occasion it was decided to start two projects with interlaboratory test comparisons; one concerned with electronic non-automatic weighing instruments, the other with power fuel meters for motor vehicles. The intention with the projects was to promote confidence for each other's work and to disclose differences in procedures which may give rise to discrepencies in the results.

The projects comply with recommendations in the proposed European Standard prEN 450019: Recommendations for the building of confidence in testing laboratories, test reports and certificates. This document namely states:

"Mutual confidence is basically erected by examining each other's criteria and regulations concerning acceptance of test reports and certificates, by organizing comparative testing etc." "A closer look at already existing agreements on reciprocal recognition of test reports clearly demonstrates that such agreements normally are based on longstanding contacts between the parties. In many cases these contacts are based on personal relationship between individual members. All these contacts will help building up the necessary confidence in the technical competence of the appropriate partner institute."

Thus, one important factor for the projects was to establish contacts between persons being active in the technical work and giving them possibility to exchange experiences and ideas.

Similar kinds of projects have earlier been performed in the Nordic collaboration between metrological institutes which started in the middle of 1970. Experience from this work was the base for working out Annex A in R 76 Part 1 and Part 2: Pattern evaluation report of R 76 Non-automatic weighing instruments.

In what follows a summary of the findings and conclusions from the interlaboratory test comparisons for electronic non-automatic weighing instruments is given. Sweden was acting as the coordinator for this project.

Test scheme

Besides the EFTA-countries, Denmark was invited to participate due to its active contribution to the Nordic work. It was decided that the tests were to be performed according to the draft of R 76 which was endorsed by the Conference in Sydney, 1988.

The intercomparisons were to be performed on two kinds of balances, one class II-type and one class III-type with maximum capacities of 12 and 15 kg respectively. The tests were performed on two samples of each type.

The following bodies praticipated in the project.

— Bundesamt für Eich- und Vermessungswesen, Austria
— Dantest, Elektronikcentralen, (only class III), Denmark
— Technical Inspection Centre, Finland
— Löggildingarstofan, (only class III), Iceland
— National Measurement Service, Norway
— National Testing Institute, Sweden (pilot secretariat)
— Eidgenössisches Amt für Messwesen, Switzerland.

Thus, the Danish representation included two laboratories: Dantest and Electronikcentralen respectively. The other laboratories are parts of the central metrological national institutes in their respective countries. Elektronikcentralen and Löggildingarstofan only participated in intercomparisons of class III-instruments.

The two samples were in principle circulated according to the following scheme.

Sample	1	2
	Sweden	Sweden
	Finland	Iceland
	Norway	Denmark I
	Austria	Denmark II
	Switzerland	Sweden
	Sweden	

The circulation started W845 and ended W914. The average test time available for a laboratory was about 4 weeks.

Summary of findings from the tests

In what follows a summary of the findings of the tests will be given. The designation "pos" in Table 1 means that the object was found to comply with the requirements; "neg" that it did not. The designation "—" means that the test was not performed. Thus, the specification "8 pos; 2 neg; 1 —" means that eight laboratories found the type to fulfil the requirement of R 76, two laboratories were of the opposite opinion and the test in question was not performed by one laboratory.

The results are summarized in Table 1 according to the format for summary of tests described in R 76-2. A quick glance on the table verifies that the laboratories in some cases arrived to different conclusions and that this was most evident for the class III-instrument. Only two of the laboratories were able to perform all the elements needed for a complete electromagnetic compability test according to R 76.

However in that respect the participating laboratories arrived to the same conclusions concerning the different points. The conclusion from the tests concerning electromagnetic susceptibility on the class II-instrument was that the instrument did not fulfil the requirements in that respect. The reason is that the instrument was designed before the new requirements were specified and known.

The different conclusions concerning the level indicator were due to a slight misinterpretation of the requirements. However, the laboratories reached a common agreement which withdraw the negative views. The contradictory results concerning examination of the construction are more difficult to solve as different opinions exist about the interpretation of R 76 due to unclearness in its present text.

A common understanding concerning most elements in the checklist was reached with the exception of durability and disturbances respectively.

The other discrepancies for the class III-type may be due to different preloading of the scale, differences in performance of the temperature chambers or irregular behaviour of one of the test objects. The later cause is the most likely reason.

Conclusions

In summary the following conclusions are derived from the intercomparison tests:

— all bodies were not able to do all tests in R 76

— tests on one sample may be unsufficient in certain cases

— implementation of some requirements in R 76 can cause problems due to different interpretations

— implementation of some of the new requirements on electronic parts and software may cause problems in the beginning due to unsufficient knowledge and experience of bodies not being involved in that type of testing earlier

— intercomparison projects must be well prepared and planned

— intercomparison tests are positive for reaching concensus, for establishing mutual confidence and for establishing personal contacts

— the quality of new recommendations could be improved if text proposals are verified by intercomparison tests during the drafting period.

TABLE 1 SUMMARY OF FINDINGS FROM INTERCOMPARISON TESTS

Class II-type

Weighing test (incl. temp): 9 pos (all)
Stability of zero: 9 pos
Excentricity tests: 9 pos
Discrimination: 9 pos
Repeatability: 9 pos
Half hour test: 9 pos
Four hour test: 9 pos
Tilting: 9 pos
Level Indicator: 8 pos; 1 neg
Tare: 8 pos; 1-
Warm up time: 9 pos

Voltage var: 9 pos
Freq. var: 6 pos; 3-
Power interruptions: 7 pos; 2-
Spikes: 6 pos; 3-
Electric bursts: 2 pos; 7-
Electrostatic discharge: 6 pos; 3-
Electromagn. susceptibility: 4 neg; 5-
Damp heat: 2 pos; 7-
Construction exam.: 6 pos; 3 neg
Checklist: 9 pos

Class III-type

Weighing tests
20 °C: 11 pos (all)
40 °C: 9 pos; 1 neg; 1-
5 °C: 8 pos; 2 neg; 1-
20 °C: 9 pos; 1 neg; 1-
Stability of zero: 9 pos; 2 neg
Excentricity: 11 pos
Discrimination: 11 pos
Repeatability: 11 pos
Half hour test: 9 pos; 2 neg
Four hour test: 10 pos; 1-
Tilting: 9 pos; 1 neg; 1-

Level indicator: 11 pos
Tare: 11 pos
Warm up time: 11 pos
Voltage variations: 11 pos
Freq. variations: 7 pos; 4-
Power interruptions: 8 pos; 3-
Spikes: 7 pos; 4-
Bursts: 3 pos; 8-
Electrostatic discharge: 7 pos; 4-
Electromagn. susceptibility: 5 pos; 6-
Damp heat: 4 pos; 7-
Construction exam: 10 pos; 1-
Check list: 7 pos; 4 neg

PLANNING and EXPERIENCE of a REGIONAL METROLOGY LABORATORY *

by Dipl.-Ing. **Wolfhard GÖGGE**
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The Rhineland-Palatinate State Verification Office is one of the 11 regional verification offices of the Federal Republic of Germany, with responsibility for legal metrology in this Federal State. The Rhineland-Palatinate, being of medium size among the States of the German Federal Republic, covers an area of 19 848 km² or 7 663 square miles with 3.635 Million inhabitants.

Our staff of slightly above 100 employees work in the field of legal metrology, which, in the Federal Republic of Germany, includes:

measuring instruments used in trade,

verification of measuring instruments used by official authorities,

measuring instruments for environmental control,

measuring instruments in the field of health.

The Eichdirektion Rheinland-Pfalz used to be located right in the heart of a private housing area of Bad Kreuznach in buildings which were completed in 1957. The premises and especially the yard area were much too small; buildings for testing of road tankers or taxis, for example, did not exist.

To reconstruct or to enlarge the buildings on the old property was impossible. Planning and new construction was the only solution. For this purpose a lot of approx. 14 000 m² or 150 695 sq.ft. was bought on the outskirts of Bad Kreuznach.

This gave us also the chance to build a 100 m test-range for testing of the correct functioning of verified speed measuring instruments. Up to then, these measuring instruments could be tested in the laboratory only; however, after reassembly of the tested components the measuring instruments should be tested in operation — at least on a random sample basis.

The highest structure to be built is a water tower of 35 m of height for a 50 m³ elevated storage basin for testing water-meters. In addition we needed laboratories and space for indoor testing ranges (figure 1).

Because of the high costs involved — more than 20 Million DM or more than 10 Million US$ — the total project was split into 2 stages. After the buildings and test equipment of construction stage 1 were put into operation it became evident that our plans had been fully realized. Therefore, it is to be hoped, that the planning for stage 2 will be similarly successful.

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* Lecture presented at the OIML Seminar on Planning and Equipping Metrology and Testing Laboratories, Paris, France, on 25 September 1989.

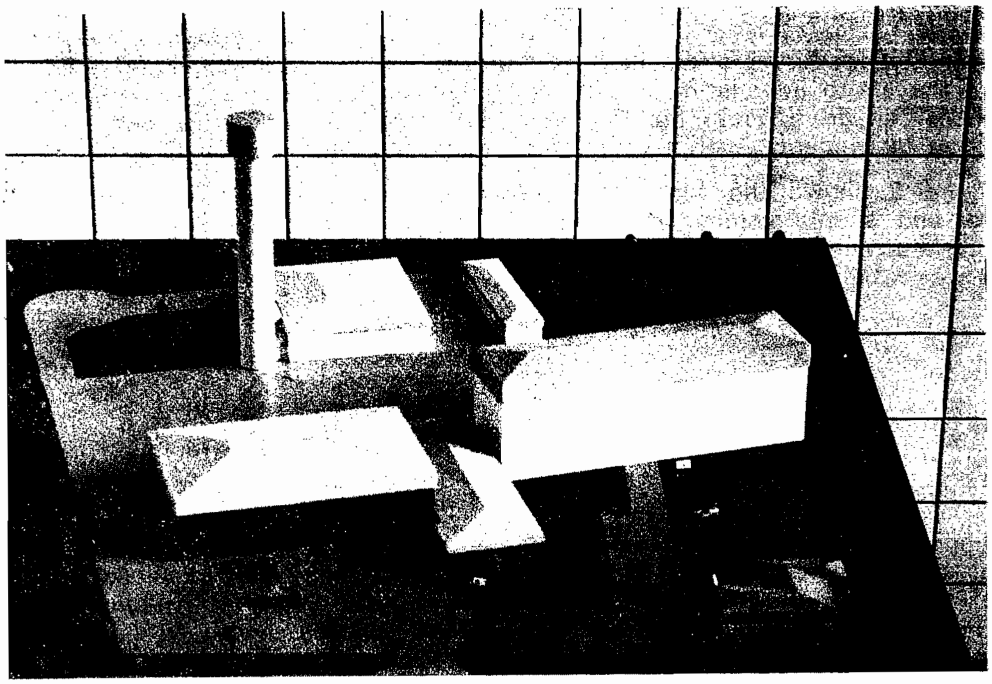

Figure 1 Model of the planned installation

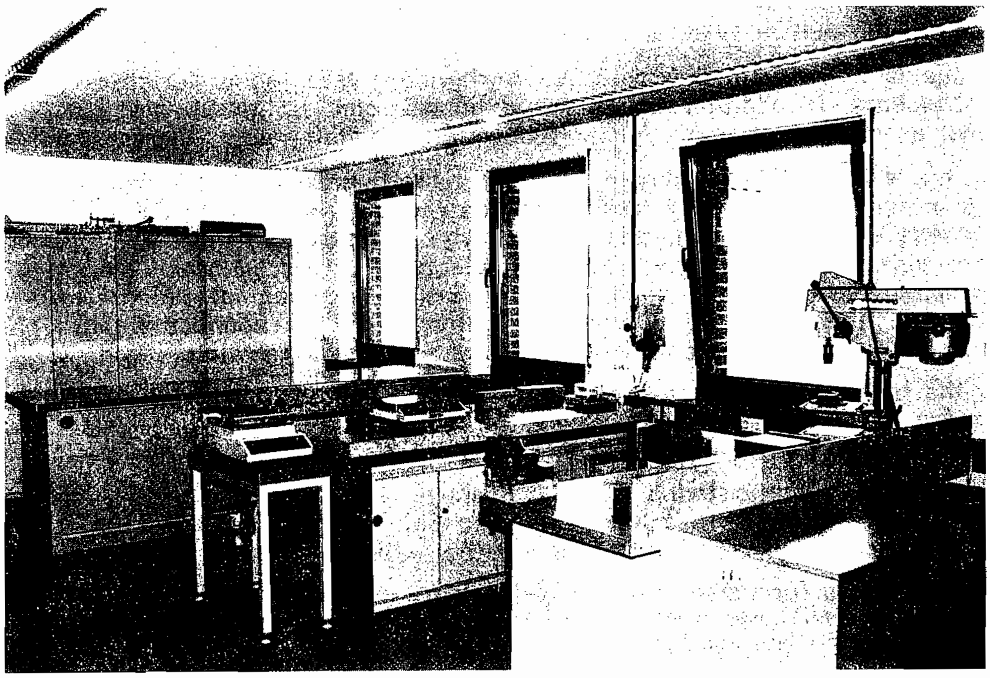

Figure 2 Laboratory for verification of weighing machines, weights and simple volumetric measuring instruments

The buildings completed during the 1st construction stage are the low laboratory building and a hangar-type building with 4 large doors leading to 4 lanes for various types of tests (the dark buildings, front left of figure 1).

From the reception office built in front of the laboratory building the entrance area of the entire installation and of the halls can be observed and controlled. Our customers can drive up to the laboratory building with their cars and unload their measuring instruments over a small ramp in front of the entrance.

Figure 2 shows the room where measuring instruments (weighing machines, weights and simple volumetric measuring instruments) are verified. The following weighing machines are installed:

max. load	scale intervals	suitable for test of weights used in trade with nominal values
60/610 g	0,001 g/0,01 g	from 1 g to 500 g
16 kg	0,1 g	from 1 kg to 10 kg
60 kg	0,1 g	20 kg and 50 kg

Laboratories for testing of electronic measuring instruments are also provided. Part of our equipment is a receiver for the radio transmission of the standard time by the Physikalisch-Technische Bundesanstalt. It provides an exact frequency standard for a number of measurements. For example, we use this device to verify electronic instruments used by the police for traffic control.

Figure 3 shows a test stand for testing of measuring instruments for traffic control. Measuring instruments to determine the speed of passing vehicles are tested for correctness, in addition we control marginal conditions (i.e. characteristic of the antenna, trigger level, and voltage control).

During the test, the radar measuring instruments are disassembled, the components are separately tested. After reassembly or mounting into the police vehicle, however, an operational test (functional test) must be performed. The operational test is made on the 100 m test range already mentioned.

In the laboratory building we have furthermore test rooms for medical measuring instruments. In addition this building houses also utilities rooms, like heating facilities, a compressor room, locker rooms for the staff, etc.

At the side of this building is a large hall (figure 4) with a ceiling height of about 8 m and 4 test lanes. 4 large doors on the front side and 4 in the back allow easy access to the individual test lanes. Large vehicles can drive into the building from one side and leave it from the other. Electrical drives open and close the doors quite quickly (the doors are rolled up to the ceiling for opening), so that even during cold weather the loss of heat remains within limits. In connection with the gas heaters at the ceiling the room can be easily heated during winter time.

In the hall (figure 5) is the test stand for road tankers used as measuring containers for beverages and other liquids for human consumption. Barrels and other volumetric measuring instruments can here be tested as well.

The standards are installed on a level above the test area and the road tankers are filled from above. From a gallery on one side small bridges can be lowered to permit the verification officers to step on the vehicles under test.

The standards for these tests as well as the piping are made of stainless steel, to meet special hygienic requirements set forth for testing of containers used for the transport of food (figure 6).

Three types of standards are installed:

— overflow-type provers of the following capacities:
1 000 L, 500 L, 200 L.

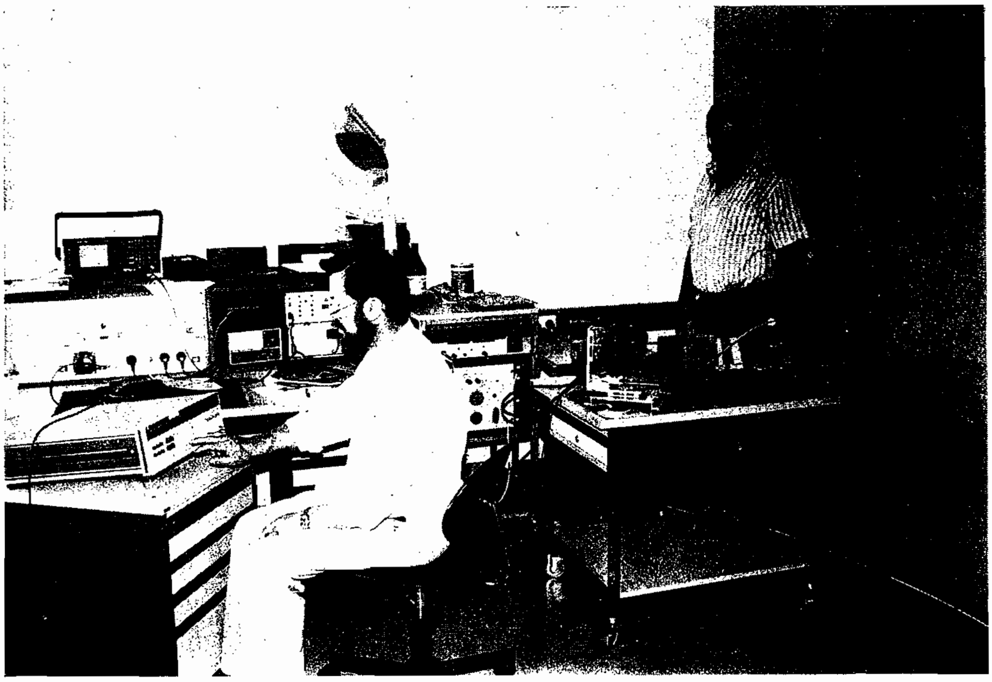

Figure 3 Test stand for measuring instruments for traffic control

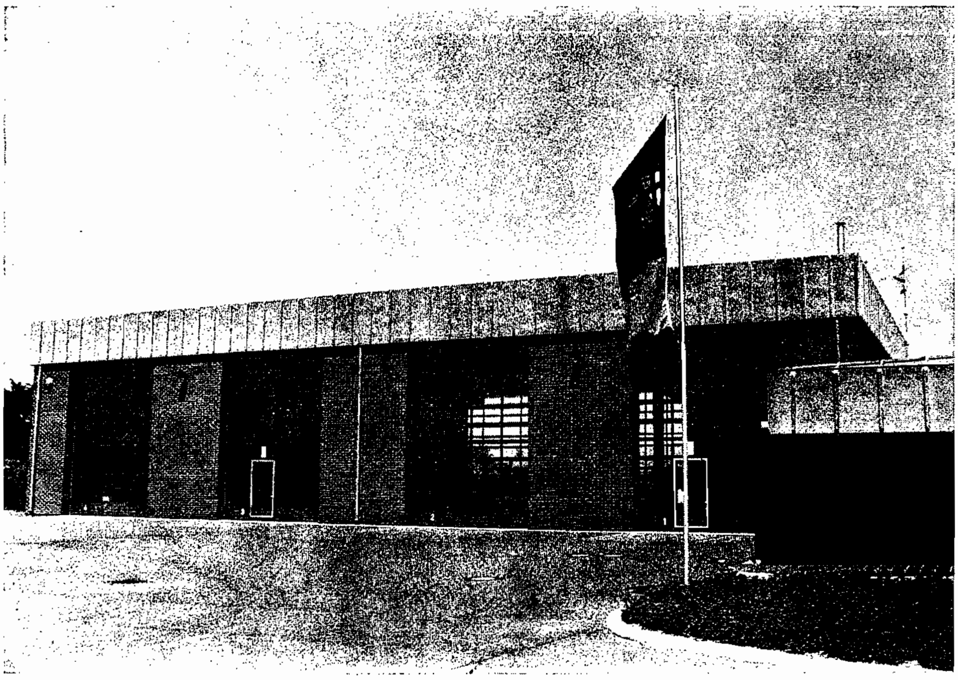

Figure 4 Hall for indoor testing lanes for road tankers, taxameters and weights

Figure 5 Test stand for road tankers

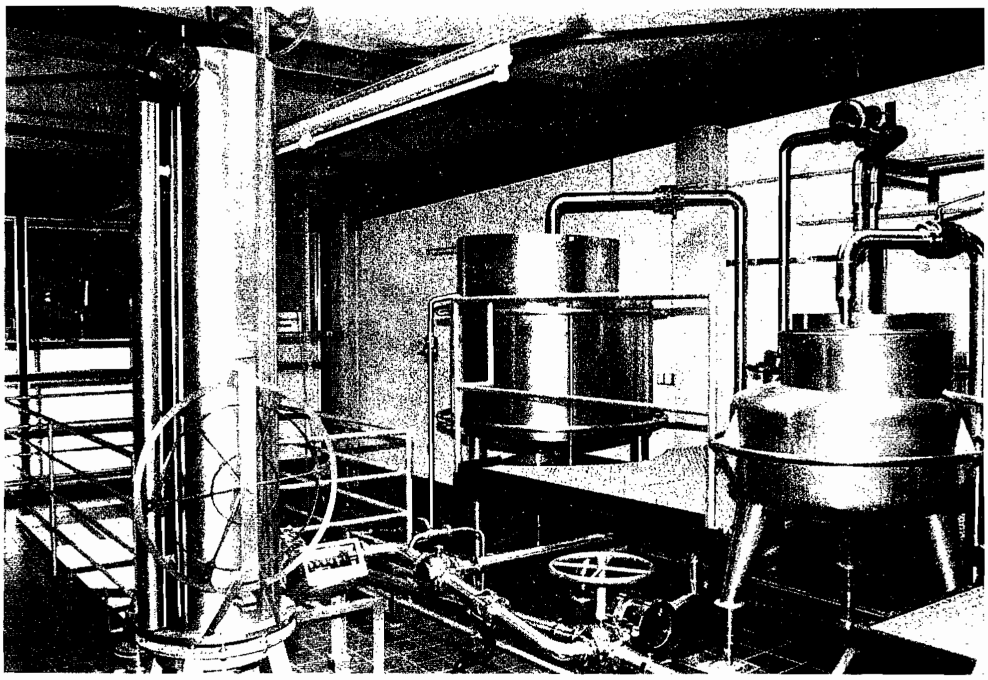

Figure 6 Volumetric standards

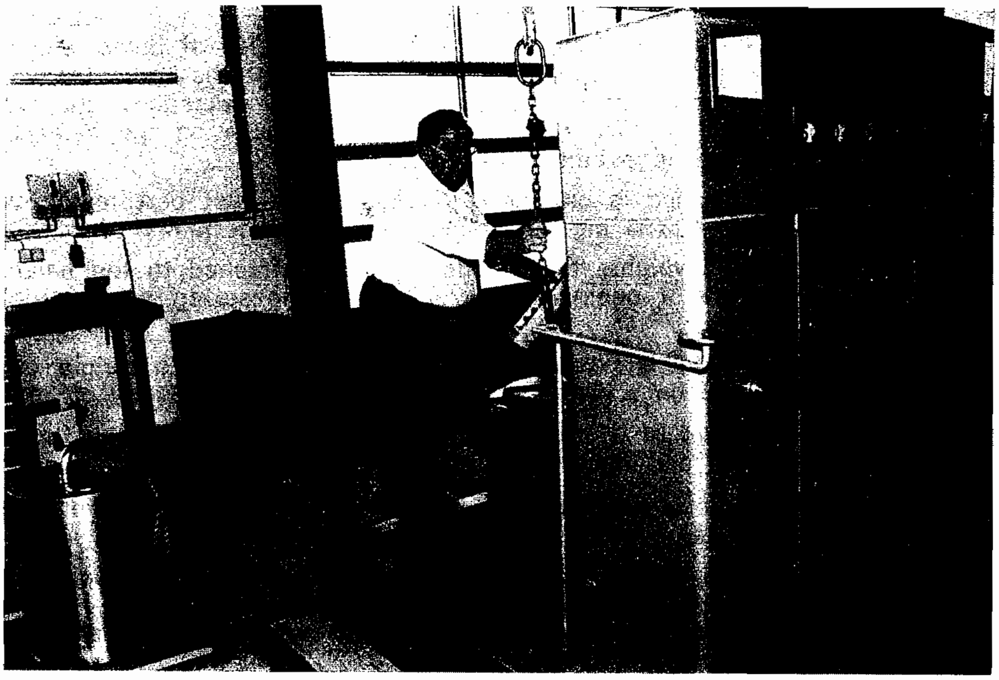

Figure 7 Drop-weight balance for 500-kg-weights

The 500 L prover is equipped with a graduated viewing glass with a reading range of 493 L to 498 L (required for the test of the flowmeter).

— a flowmeter with a maximum flow rate of 260 L/min. The meter is connected to the 500 L prover via a stand-line to permit the control of the meter at any given time.

— a gauging apparatus with a capacity of 125 L for precise measuring of very small flow with interruptions of the filling process — for example when filling exactly up to the mark in the dome.

The prover and the flow meter can be switched over a valve to the pipe-system for filling of containers.

The next test lane in this building is a roller type test stand for testing of price indicators in taxis. To avoid the generating of exhaust gases inside the building, the test stand is equipped with an electrical drive. If however, the test stand is driven by the vehicle under test, an exhaustor removes exhaust gases from the building.

The test stand is automatically operated by a control unit. Data received are transmitted to the computer in which the test requirements have been stored to provide the verification officer with a complete picture of the metrological aspects of the taximeter.

The verification officer performs the test from within the vehicle with a portable control unit to enable him to read at the same time the values appearing on the taximeter.

Still today, it is important for a weights and measures organization to control and verify weights.

We own a total of 154 pieces 500 kg weights for testing of large scales (weighbridges) with our test vehicle (see also OIML Bulletin no. 114 "Mobile Equipment for the Verification of Weighbridges up to 50 Tonnes"). These weights must be checked and restored after relatively short periods (approximately every 6 months).

We use a drop-weight-balance (figure 7) to compare the weight under test with the standard.

The 500 kg standard has been calibrated by the PTB with an uncertainty of ± 2 g.

The 50 kg weights — in Bad Kreuznach we have about 300 of these weights — are tested in a test stand that is separated from the rest of the room to avoid influences by air flow or temperature. A roller-type conveyor transports the weights into the test room to the weighing machine. To avoid shocks on the balance, the weights are attached to a bridge below the balance.

At the side of the balance is our 50 kg standard. The test certificate for this weight states an error of + 150 mg determined with an uncertainty of ± 125 mg.

During the test of the weights the standard is also attached to the balance in regular intervals to provide a constant control of the measuring accuracy of the balance.

The trailer of our test vehicle is designed as a standard with a weight of 24 t. This standard can be tested on a weighbridge with a maximum capacity of 30 t.

The weighing mechanism of this balance is basically mechanical. The forces are reduced by a lever system and then transmitted to the gyroscopic weighing device.

The standard deviation of this balance is 350 g for 10 consecutive weighing operations with the maximum load of 30 t.

Our experience shows, that weights must be cleaned and newly painted prior to adjustment. For this purpose we use sand blasting equipment which — as far as we know — is unique among German weights and measures directorates.

A crane lifts the weights into a chamber and puts them on a turning table. The operator can reach into the chamber with protective gloves and sand blast the weights. The weights are then put by crane on a rotary support and painted with a spraying gun.

During the second construction stage we will build the laboratory shown on the right of figure 1. Furthermore a hall for testing of water meters for cold and warm water and for mineral oil meters, a bungalow for the housekeeper and even a little pool. Water used for tests shall be lead into this pool. So we as a technical organization hope to contribute our share to create a suitable environment for water plants and animals.

The water container on top of the tower is designed as a ring type container to enable the lift to reach even the top level. The lift control permits the lift to stop at any given point. This will serve to verify vertically hanging measuring tapes used to measure the level of liquid in storage containers.

The planned laboratory building will have 4 storeys and be constructed in traditional style. We have, however, foreseen some specialties which in this paper can only be mentioned very briefly. For example, the test of new medical measuring instruments will be completely separate from that of used ones. Any contamination from used to new instruments can so be avoided.

Used medical instruments will be unpacked in one special room and cleaned as far as possible, they are tested in a separate adjacent room and then prepared for dispatch in another room.

New medical instruments are tested on the level below.

Measurements requiring especially constant temperatures will be performed in the basement of the building. While we do not plan to equip the entire building with air conditioning because of the high installation and maintenance costs involved, rooms, where special conditions are required, will be equipped with individual temperature controls. This applies, for example, for the test laboratories for scales and weights of the highest class of accuracy. For these laboratories in the basement even special substructures — separated from the buildings foundation walls — will be provided. All laboratories are equipped with the necessary utilities (power, air, water) and with the necessary lines for data transfer.

The planning for the entire project has now been completed, we hope to start construction work of stage 2 in 1990.

REP. DE COREE

In situ DIRECT DETERMINATION of AIR DENSITY USING Pt-Ir and STAINLESS STEEL KILOGRAM STANDARDS

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RESUME — La masse volumique d'air a été mesurée en utilisant l'étalon de kilogramme en Pt-Ir No. 39 et un kilogramme en acier inoxydable de masse connue dans une balance capable de manœuvrer quatre poids sur le plateau d'échange automatique de poids. L'écart-type relatif de la répétabilité de mesures de la masse volumique d'air était de l'ordre de 10^{-5}. Les valeurs de masse de deux autres poids en acier inoxydable placés sur le même plateau ont été déterminées par la comparaison avec l'étalon et en employant la masse volumique d'air ainsi mesurée. L'écart-type de la répétabilité des mesures de masse était inférieur à 5 μg.

SUMMARY — The density of air was directly measured using the No. 39 Pt-Ir kilogram prototype and a stainless steel kilogram as buoyancy artifacts in a balance capable of transporting four weights by use of an automatic weight exchange turntable. The relative standard deviation of the repeatability of the measurement of the air densities was found to be of the order of 10^{-5}. The mass values of two other stainless steel weights placed on the same turntable were determined by comparing them with the prototype and using the air density measured in situ. The standard deviation of the repeatability of the mass measurements was found to be less than 5 μg.

1. Introduction

In the mass comparison of two weights of different densities in the air, a major uncertainty arises from the determination of the air density. In the comparison of a Pt-Ir kilogram prototype with secondary stainless steel standards the buoyancy effects of the air is about $0.8 \times 10^{-4} \times \rho$, where ρ is the air density in kg/m^3. On the other hand, the relative uncertainty of the BIPM equation for ρ can be estimated to 10^{-4} and results in an uncertainty of about 10 μg in the buoyancy correction to be applied in such comparisons [1].

Mass comparison balances with a capacity of 1 kg and a resolution of 1 μg are now commercially available.

Therefore, aiming at the uncertainty of a few parts in 10^5 in the air density measurements, a study on the direct determination of air density via buoyancy artifacts is in progress by a group of the consultative committee for mass and related quantities (CCM). [2,3] The method is to measure the apparent mass difference of the two buoyancy artifacts made of stainless steel or quartz, which are of similar surface and mass but different volume.

We propose a method for directly measuring the air density by employing a Pt-Ir kilogram prototype and a stainless steel kilogram weight as buoyancy artifacts. Using a mass comparator equipped with an automatic weight exchange turntable with positions for four weights, the mass values of two other stainless steel weights were determined by comparing them to the prototype and using the air density measured in situ.

2. In Situ Measurements of Air Density and Mass

The buoyancy artifacts are compared to give the apparent mass difference, $\Delta M_a = (M_A - \rho V_A) - (M_B - \rho V_B)$, is measured, where M_A, V_A and M_B, V_B are the mass and volume of the prototype and the stainless steel kilogram, respectively. We then have the following expression for the density of air

$$\rho = \frac{(M_A - M_B) - \Delta M_a}{V_A - V_B} \tag{1}$$

With the values of M_A, M_B, V_A and V_B we can determine the density of air by measuring the apparent mass difference. Table 1 shows the values of mass and volume of No. 39 kilogram prototype and the stainless steel kilogram employed as buoyancy artifacts. The values of M_A and V_A for the kilogram prototype were determined at the BIPM [4], while those for the stainless steel kilogram were determined from the comparison with the prototype using the air density equation of BIPM. The gravity compensation of 3 µg due to the difference of center of mass was taken into account in the determination of M_B. The uncertainty in M_B is found to be 2.0×10^{-8} kg.

TABLE 1. MASS AND VOLUME VALUES OF THE BUOYANCY ARTIFACTS

	Pt-Ir Kilogram (A)	Stainless steel Kilogram (B)
True Mass in g	999.999 206	1 000.011 308
Volume in cm^3 (temperature t in Celsius)	$46.403\,0\ [1 + (25.863 + 0.005\,62\ t) \times 10^{-6}\ t]$	$M_B/(7.998\,92 - 0.000\,367\,14\ t)$

3. Consideration of Surface Area Effects

The effects of water vapor adsorption on the surface were considered because of the difference in the surface area between No. 39 Pt-Ir kilogram prototype and the stainless steel kilogram weights. To correct the errors due to water vapor adsorption on the surface, Kobayashi's empirical formula was adopted [5].

$$Ac = -0.010\ Sk + (0.0092\,H - 0.103)\ (Sk - Ss) \tag{2}$$

where Ac is the correction in µg,
Sk is surface area of the Pt-Ir kilogram prototype in cm^2,
Ss is surface area of the stainless steel kilogram in cm^2,
and H is relative humidity in %.

Since the mass of the stainless steel kilogram of the buoyancy artifacts was determined at humidity Hr, we need to adjust the equation (2) as follows.

$$Ac = 0.0092\ (H - Hr)\ (Sk - Ss) \qquad (3)$$

where, Sk and Ss are 71.7 cm^2 and 156.8 cm^2, respectively. Measured values of $(H - Hr)$ were within ± 1.1 %, which gave ± 0.86 μg in Ac.

4. Results

A one-pan type mass comparator of 1 μg readability with an automatic weight exchange device (HK1000MC, Mettler) was used in the air. Fig. 1 shows the top view of the weight exchange device. The positions of each weight A, B, C and D are indicated in the figure.

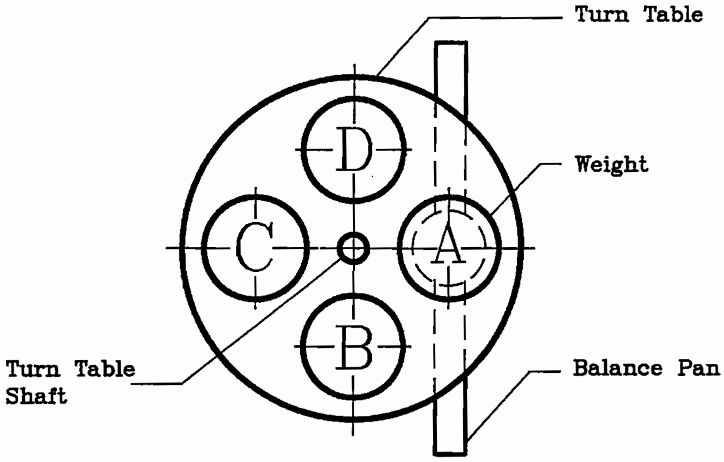

Fig. 1 Top view of weight arrangement on weight exchange device and balance pan

The direct measurements of the air density were performed by using Eq (1). The apparent mass difference between the prototype and the stainless steel kilogram on positions A and C was measured without any other weights on positions B and D. Six measurements were conducted in 20 minutes to obtain the value of the air density, and the corresponding air density was also calculated from the equation of BIPM. The relative uncertainty in the air density from the direct measurements is of the order of 10^{-4}, which is same as the uncertainty in the calculated air density, and the major contribution comes from the uncertainty in M_B which was determined using the calculated value of the air density.

In order to compare the two methods for the air density determination, the air densities from the equation of BIPM were also obtained by measuring temperature (Hewlett-Packard, 2804A), relative humidity (Hygrodynamics, 15-3080), atmospheric pressure (Tokyo Kokukeiki, DG-430k), and CO_2 concentration (Horiba, PIR-2000), whose uncertainties (1 σ) were 1.7 mK, 0.5 %, 0.02 mmHg and 2 ppm, respectively. The relative uncertainty in the air densities resulting from the measurements then becomes 5×10^{-5}.

The differences ($\Delta\rho$) between the calculated (ρ_{eq}) and the directly measured (ρ_{ba}) air densities were plotted in Fig. 2. Since the measurements of ρ_{ba} are independent of those of ρ_{eq}, we may have write

$$s_\Delta^2 = s_{ba}^2 + s_{eq}^2 \qquad (4)$$

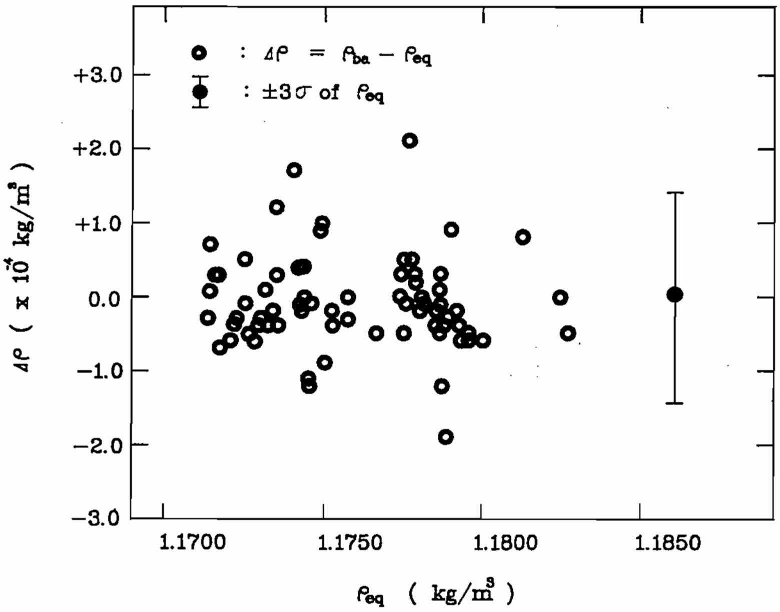

Fig. 2 Comparison of air density values via buoyancy artifacts with those from the equation of BIPM

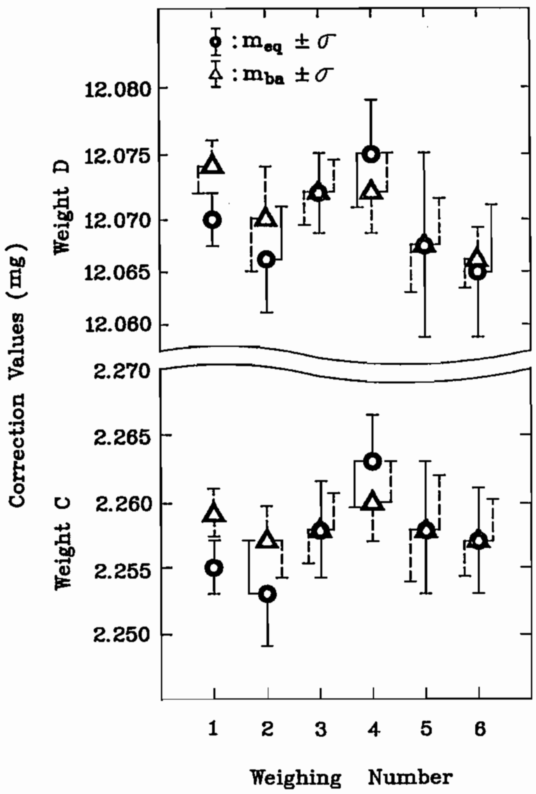

Fig. 3 Comparison of mass values of stainless steel weights via buoyancy artifacts with those from the equation of BIPM

where s_Δ, s_{ba} and s_{eq} are the standard deviations of ρ_Δ, ρ_{ba} and ρ_{eq}, respectively. With 80 pairs of ρ_{ba} and ρ_{eq}, s_Δ is found to be 5.7×10^{-5} kg/m³. The small difference between s_Δ and s_{eq} indicates that s_{ba} is significantly smaller than s_{eq}. However, from the 170 measurements of the apparent mass difference s_{ba} was obtained to be 5×10^{-5} kg/m³. The fairly large value of s_{ba} is believed to be resulting from the change in the environmental conditions during the measurements.

Pairs of mass values of the two stainless steel weights of 1 kilogram were obtained by comparing their weights to the kilogram prototype. The air densities from the direct measurements and those from the equation of BIPM were simultaneously obtained for the respective buoyancy compensation. The prototype was on position A, the two stainless steel weights were on C and D, and the stainless steel kilogram of buoyancy artifacts was on B. The respective determination of the mass of the two weights required 30 rotations of the turntable, and it took 4.5 hours. The results were shown in Fig. 3. In Fig. 3, m_{eq} is the final value by the equation of BIPM and m_{ba} is that by the buoyancy artifacts. The standard deviation of m_{ba} was shown to be less than that of m_{eq} in all of the six measurements of weights C and D. The standard deviation of m_{ba} in the 6 measurements was found to be less than 5 µg.

5. Conclusion

The Pt-Ir kilogram prototype No. 39 was used not only as the mass standard but also as a buoyancy artifact paired with a stainless steel weight. The buoyancy artifacts enabled us to measure the air density with a better repeatability than the uncertainty of the air density equation of BIPM.

As the balance used is equipped with an automatic turntable capable of transporting four weights the method allows direct determination of the air density correction to be applied to two other kilogram standards which are being calibrated at the same time.

The accuracy of the in situ direct determination of the air density could be improved by utilizing a stainless steel buoyancy artifact whose true mass and volume are known more accurately.*

References

[1] P. Giacomo: Equation for the Determination of the Density of Moist Air (1981). Metrologia 18, 33-40 (1982)

[2] M. Kochsiek: Report of the Comité Consultatif Pour la Masse et les Grandeurs Apparentées (2nd Meeting-1985) to the Comité International des Poids et Mesures. English version of BIPM, G38-G40 (1985)

[3] R.S. Davis : Report of the Comité Consultatif Pour la Masse et les Grandeurs Apparentées (3rd Meeting-1988) to the Comité International des Poids et Mesures. Draft No. 1 (1988)

[4] Certificat du Kilogramme Prototype No. 39. BIPM No. 44 (1983)

[5] Y. Kobayashi: A study on the Preciser Establishment of the Mass Standard, Bulletin of NRLM, Vol. 30, Supplement (No. 103), 54 (1981).

* Note by BIML: Though there has been successful attempts to improve the global accuracy of measurements of air density by other methods than by using the BIPM formulas, the lowest uncertainty of mass measurements at the density level of 8 000 kg/m³ seems presently still to remain at about 10^{-8} in relative value. The repeatability of mass determinations can however be considerably better as demonstrated by this paper.

ETATS-UNIS D'AMERIQUE

The THERMOMETRY STANDARDS LABORATORY *

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SUMMARY — The author discusses the fundamentals of temperature as a physical quantity, the basics of temperature scales, and then the laboratory in which these scales are realized for the calibration of thermometers. Considerations of the new International Temperature Scale of 1990 (ITS 90) are included.

Introduction

Temperature is, of course, the measure of the hotness of something. For a measure to be useful, there must be agreement upon a scale of numerical values for degrees of hotness, and means for realizing and displaying these values.

We can define and construct standards for mass, force and pressure with almost any value, and we may do so continuously and indefinitely, at our pleasure. No such convenience exists for temperature. Instead, temperature is defined in terms of certain physical states which are discrete, and of means for interpolating continuously between them.

So before we begin a discussion of thermometer calibration, it is, I think, necessary to consider the concept of temperature, how temperature scales are defined and constructed, and then how these scales are realized in practical thermometry.

The Thermodynamic Kelvin Temperature Scale

There exists only one temperature scale with an absolute basis in nature. That is the Thermodynamic Kelvin Temperature Scale, (TKTS), which can be deduced directly from the first and second laws of thermodynamics. The lower limit of the TKTS is at absolute zero, called zero Kelvin, and is represented by a straight line drawn between zero, passing through a single point which establishes its slope, and extending indefinitely toward higher temperature. That single point could be any non-zero temperature; it has been arbitrarily chosen to be the temperature at which pure water exists simultaneous in its liquid and solid phases under its own vapor pressure. The scale intervals are also chosen arbitrably and are called Kelvin units or simply kelvins; on the TKTS the temperature value assigned to the single point which establishes the slope of the line is 273.16 kelvins, or 0.01 °C.

The temperature at which pure water exists as a liquid and a solid under its own vapor pressure is called the "triple point of water", meaning that all three possible phases of the pure material are in equilibrium. It is also called a "thermometric fixed

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* Presented at the OIML Seminar on Planning and Equipping Metrology and Testing Laboratories, Paris, France, 26 September 1989.

point". There are a number of other thermometric fixed points, some of which are three and others two-phase equilibria. To name several, the triple point of argon, the triple point of mercury, the freezing points of pure metals, such as zinc and silver. The thermodynamic temperatures of these points are determined experimentally and assigned values so that they fall along the straight line of the TKTS.

The principal tool for the determination of these temperatures is the constant-volume gas thermometer, which relies upon the relationship

$$P/P_r = T/T_r$$

where P_r and T_r is a reference pressure and a reference temperature respectively, and T is measured as a result of the change of pressure of an ideal gas as a function of change of T. The simple appearance of this measurement is deceptive; the experimental difficulties are considerable, because there is no ideal gas, and because corrections must be made for sorption, effects of temperature on the measuring system, aerostatic head, thermomolecular pressure, condensation of the gas as 0 kelvin is approached, etc.

Where it is possible, determinations of temperatures are confirmed by other means, such as acoustic thermometry and radiation thermometry. While these thermodynamic instruments have a crucial role in establishing the temperature scale, they are unsuitable for the practicable measurement of temperature in science and industry.

"Practical" temperature scales

The unsuitability of thermodynamic instruments for the measurement of temperature in the real working world has led to the development of other schemes, other temperature scales, other thermometers which rely upon some relationship between temperature and the physical property of a material which, while it may not be thermodynamic, is yet repeatable and monotonic. Such properties may be the expansion or contraction of solids or liquids, change in the electrical properties of conductors, the color or brilliance of light emitted from a very hot source, as a function of temperature. Any of these properties can be used to make a thermometer, and such thermometers can be related to the TKTS, over their useful range, by calibration at the fixed points of the TKTS and agreement upon an artifact scale, a consensus scale, which includes the properties of the thermometer and mathematical relationships which allow interpolation of temperatures between the fixed-point temperatures, and limited extrapolation beyond them.

It would be too long to go into the fascinating history of the development of practical temperature scales, but I will only relate the present state. Suffice it to say that we have a scale called the International Practical Temperature Scale of 1968 (IPTS 68), which, on the first day of 1990, will give place to the International Temperature Scale of 1990 (ITS 90).

The International Scale stipulates a number of fixed points which define the Scale, and which are called, appropriately, defining fixed points. It includes a number of other fixed points which are not accorded the dignity of definition, but which are very useful in practical work. It specifies also acceptable interpolation instruments. In the Scale of 1968, these instruments were defined platinum resistance thermometers over the range from 13.81 K to 630.74 °C, platinum/platinum-rhodium thermocouples between 630.74 °C to 1 064 °C, and any radiation thermometer obeying Planck's Law above 1 064 °C. In the Scale of 1990 the range is extended downward to 0.6 K, using vapor pressure or gas thermometry below 13.81 K for interpolation; the thermocouple is deleted, the range of the platinum resistance thermometer is extended upward to 961 °C, and the radiation thermometer down to 961 °C. Most of the assigned values for fixed-point temperatures are also changed. Table 1 shows the fixed-point values on the IPTS 68 and the ITS 90.

TABLE 1

FIXED POINTS OF THE IPTS 68

AND OF THE ITS 90 AS ADOPTED BY CIPM, OCTOBER 5 1989

Substance	State	IPTS 68 °C	ITS 90 °C
e-H_2	Triple	— 259.34	— 259.346 7
O_2	Triple	— 218.789	— 218.791 6
Ar	Triple	— 189.352	— 189.344 2
Hg	Triple	— 38.842	— 38.834 4
H_2O	Triple	0.01	0.01
Ga	Melt	29.772	29.764 6
In	Freeze	156.634	156.598 5
Sn	Freeze	213.968 1	231.928
Zn	Freeze	419.58	419.527
Al	Freeze	660.46	660.323
Ag	Freeze	961.93	961.78
Au	Freeze	1 064.43	1 064.18
Cu	Freeze	1 084.88	1 084.62

Notes:

e-H_2 represents hydrogen in equilibrium between the ortho and para molecular forms

Boiling, melt and freeze points are at 1 standard atmosphere = 101 325 Pa.

TABLE 2

RANGES OF THE ITS 90

Low limit	High limit	Fixed points required
— 259.346 7	0.01	e-H_2 (TP), e-H_2 (VP), Ne (TP), O_2 (TP), Ar (TP), Hg (TP), H_2O (TP)
— 218.791 6	0.01	O_2 (TP), Ar (TP), Hg (TP), H_2O (TP)
— 189.344 2	0.01	Ar (TP), Hg (TP), H_2O (TP)
0.01	29.764 6	H_2O (TP), Ga (MP)
0.01	156.598 5	H_2O (TP), Ga (MP), In (FP)
0.01	231.928	H_2O (TP), Ga (MP), Sn (FP)
0.01	419.527	H_2O (TP), Sn (FP), Zn (FP)
0.01	660.323	H_2O (TP), Sn (FP), Zn (FP), Al (FP)
0.01	961.78	H_2O (TP), Sn (FP), Zn (FP), Al (FP), Ag (FP)
— 38.834 4	29.764 6	Hg (TP), H_2O (TP), Ga (MP)

(TP) = triple point, (VP) = a vapor pressure determination, (FP) = freezing point at 1 standard atmosphere, (MP) = melting point at 1 standard atmosphere

Note: The purchaser of a calibration must state the range required.

He may choose to specify a combination of several ranges, for example, — 189.344 2 to + 419.527 °C, or some extrapolation, for example, — 200 to + 500 °C.

Calibration laboratory realization of the scale

The objective of the thermometer calibration laboratory is to establish a relationship between a working thermometer and the International Scale, within required limits of uncertainty. I intend to describe two approaches to this problem, one as primary and as precise as may be possible, and the second more economical of time and equipment at some expense to precision and accuracy. For brevity, let us agree to call these a Primary Method and a Secondary Method, respectively. The design of any calibration laboratory should take into account (a) the ranges of temperature which are required by the demands of the economy which is to be served (b) the precision and accuracy required of these calibrations.

Unlike the IPTS 68, the ITS 90 allows a number of distinct calibration ranges. It is no longer necessary to calibrate a thermometer over the full range, if only a portion of it is of concern; however it becomes the obligation of the purchaser of the calibration to stipulate, in his order, the range or ranges required. These ranges, and the fixed points required to calibrate them, are shown in Table 2.

Since all thermometers will require new calibration tables, it is important to ask what is the situation with regard to thermometers which have recently been recalibrated on IPTS 68. Most suppliers of calibration services will be prepared to furnish ITS 90 tables from recent calibrations, although of course they cannot accept responsibility for the validity of the data. At least one manufacturer-calibrator has also available for sale a complete ITS 90 interpolation program for MS-DOS microcomputers.

The primary method

The primary method requires calibration of thermometers at fixed points of the International Scale. I will limit the discussion to the temperature range from — 189 to + 960 °C, since outside this range I believe that interest is limited, and the problems are substantial. In most cases, any required calibrations below — 200 °C are best managed by one of the major National Laboratories; for example, NBS, PTB, NPL.

The calibration problem is to realize the fixed points of the Scale over the range of the Scale which is of concern. The equipment necessary will include:

- Apparatus for realizing the required fixed points
- Platinum resistance thermometers, having valid National Laboratory calibration tables, and suitable for the ranges. The resistance thermometer range of the ITS 90 cannot be accommodated with a single design of thermometer. The traditional long-stem 25.5 ohm thermometer is not suitable for use above 650 °C, and use even at that temperature should be limited. Platinum resistance thermometers are now available with an ice point resistance of 0.25 ohm and a range of — 50 to + 1 000 °C.
- Resistance-measuring bridges, current comparators, etc., capable of resolution of 1 ppm or 0.1 ppm, and reference resistors of suitable range having valid calibrations.

Table 3 shows a list of commercially available equipment and approximate price. I have not hesitated to include such a list, because there are very few sources for such equipment, in many cases only one. The equipment selected will be determined by the temperature ranges over which thermometers are to be calibrated.

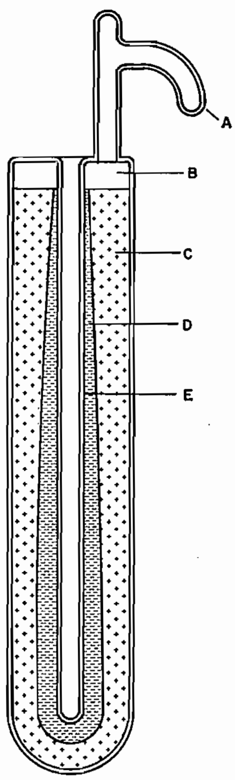
The laboratory in which this equipment is installed will require at minimum 100 m^2 plus accommodations for personnel. A source of running water and drain is required if a high-temperature furnace is installed, since it should be water-cooled with a flow of about 0.5 l/sec. The effluent may be wasted or cooled and recovered. Illumination should be adequate for the purpose.

The environmental requirements for the fixed-point equipment are not severe; for example, 15 to 30 °C and RH less than 70 %. The environmental requirements for the resistance measuring equipment will be more restrictive, and the manufacturers' recommendations should be followed.

For both the fixed points and the electrical instruments, vibration should be minimal. Vibration can cause a molten metal to nucleate early and improperly. Also, the resistance bridges may include sensitive components such as galvanometer amplifiers. It is a good idea to put such a laboratory in the basement of a solid building.

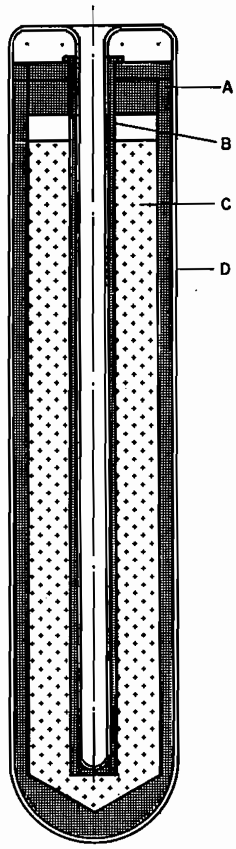
You may have noticed, on the list of calibration ranges of Table 2, that the triple point of water appears in every range. Any laboratory engaged in thermometry, whether it does primary or secondary calibrations, should be prepared to realize the triple point of water. It is the most fundamental of the fixed points. The resistance value at this point is the denominator of the W-ratio of standard thermometer calibration tables, or is derived from it. Furthermore, it is an excellent quality-assurance technique to make a reading of the water triple point resistance every time you measure a temperature, and to put these values on a control chart. If the thermometer has not shifted at the water triple point, it is almost certainly in calibration. The point is inexpensive to establish and easy to use to an accuracy of better than 150 microdegrees. In a proper bath, the cell may be maintained in its triple-point state for many weeks. A water triple point cell is shown in Fig. 1.

Beginning at the cold end of the — 200 °C to + 962 °C range, the triple point of argon is the low fixed point. I do not know of any commercially available apparatus for realizing this point. I recommended instead a calibration by comparison, using an available comparator employing liquid oxygen, argon or nitrogen, in which a thermometer under test can be inserted alongside a certified thermometer, and the two



A — Handle
B — Water vapor space
C — Liquid water
D — Solid water (ice)
E — Liquid-solid interface at the thermometer well

Figure 1
Water triple point cell



A — Graphite crucible
B — Graphite thermometer well sleeve
C — Pure metal
D — Continuous sealed quartz envelope

Figure 2
Freezing-point-of-pure-metal cell

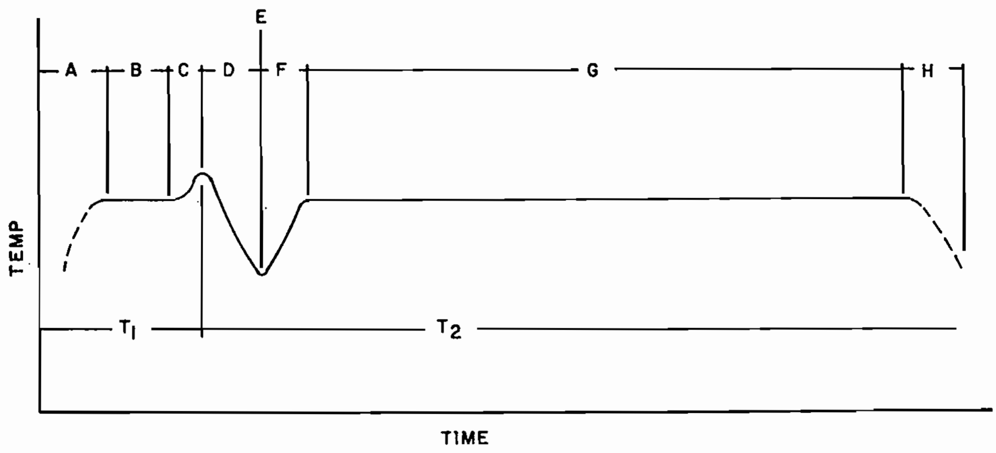


Figure 3
A typical melt-freeze cycle

A — Temperature rise to melt
B — Melt arrest
C — Rise to furnace temperature after melt
(Furnace is reset to lower temperature)
D — Drop to lower furnace temperature
E — Bottom of undercool - Nucleation occurs
F — Rise to freeze plateau
G — Freeze plateau - Constant temperature for calibration of thermometers
H — Temperature drop following end of freeze plateau

compared. If the certified thermometer is connected to the bridge in place of the reference resistor, and the thermometer under test as the unknown, the readout will be the ratio of the test thermometer resistance to the calibrated thermometer resistance, and the value of the test thermometer can be calculated from the standard thermometer's calibration table. Pressure effects are removed automatically. A calibration accuracy better than 2 mK can be obtained. Most National Laboratories will use such a scheme for calibration services.

The triple point of mercury is required for four ranges of the ITS 90. Cells are available in which mercury, with impurities as little as 15 parts in 10^9, is sealed under its own vapor pressure within a stainless steel housing, avoiding any potential problem of environmental hazard. An apparatus, including built-in mechanical refrigeration and a control system, is also available, and it makes the mercury triple point almost automatic to realize.

The melting point of gallium is required for four ranges of the ITS 90. This near-ambient temperature is also important in thermometry used in environmental studies. The cell can be operated in any closely controlled water-bath, or as an alternative, a melt apparatus is available which makes realization of the point fully automatic.

Freezing points of high-purity metals are specified for the five ranges whose low end is 0.01 °C. These metals are commonly contained within graphite crucibles surrounded by an envelope of quartz, and including a reentrant well for the thermometer. Cells are now available in which the quartz envelope completely surrounds the crucible, so that the cell may be filled with an inert atmosphere, and sealed at a pressure which will be 1 standard atmosphere at the freezing point temperature. Sealed cells avoid the inevitable contamination of open cells, and remove the need to make pressure measurements and corrections. Such a sealed cell is shown in Fig. 2.

The realization of a fixed-point is similar for all materials, although details will differ. Let us use a metal freeze-point as an example. A cell containing a pure metal is assured to be in one state; for a metal freeze point cell, this state is usually the solid phase. It is placed in a temperature environment, for example a furnace, and the furnace controller is set a few degrees above the expected melt temperature. A thermometer is placed in the cell to monitor its temperature rise. At the onset of melting, temperature rise will cease — this is called the "melt arrest" — and will rise again when all the metal is in the liquid phase. The furnace controller is then set slightly below the melt temperature, and, as the cell temperature drops, a "freeze arrest" will be seen, perhaps preceded by an undercool. The freeze arrest indicates that the freezing temperature has been reached, and thermometers may be calibrated. Properly manipulated, the freeze arrest can be prolonged for many useful hours, generally 12 or more. A typical melt-freeze cycle is shown in Fig. 3.

Table 4 lists the typical accuracies with respect to the Scale of the realization of the fixed point temperatures.

Secondary calibrations

Secondary calibrations are almost always comparison calibrations, made by comparing the resistance of a test thermometer to the resistance of a certified thermometer in a thermal situation. Instead of the Scale fixed points, secondary laboratories obtain their relationship to the Scale via calibrated thermometers. Secondary calibrations do not have the inherent accuracy of fixed-point calibrations; on the other hand, the usual apparatus can produce a range of temperatures, sometimes continuously variable, which fall between the fixed points of primary calibrations. One fixed-point standard, at least, should be included, either the water triple point or the gallium melt point, as a quality-assurance device for the standard thermometers.

A secondary laboratory requires electrical measuring equipment similar to that for primary laboratories, but it may be of reduced accuracy and resolution consonant with its purpose. Criteria of space and environment are similar.

Calibration environments which operate below room temperature require cooling. In general, temperatures between — 190 °C and — 80 °C employ liquified gases, such as liquid nitrogen, as cooling media, and may be dedicated to the single temperature at which the liquid cooling gas boils or may be varied over a limited range of temperature. Temperatures above — 80 °C are usually achieved by mechanical refrigeration, Peltier cooling, or other common methods of achieving low temperatures. Many low-temperature baths employ stirred silicone oils as a heat transfer medium, and are continuously variable in temperature. A typical bath may have a range of — 80 °C to + 300 °C, and require three changes of oil media to cover this range.

Above approximately 300 °C, one approaches the flash point of an oil medium, and the proper choice may be a metal block furnace (typical upper limit 1 000 °C), a molten salt bath (typically to 600 °C) or a levitated sand bath (typically to 700 °C).

The range of temperatures available, accuracies, and nature of calibration environments for secondary calibration are such that the most productive approach is to (a) define the requirement (b) enlist the aid of manufacturers of such equipment in making the proper choice.

Afterword

This necessarily brief text may provoke as many questions as it provides answers. The author belongs to the small community of practitioners of temperature metrology and is eager to be helpful in replying to questions by correspondence.

TABLE 3

EQUIPMENT FOR THE PRIMARY CALIBRATION LABORATORY FOR THE REALIZATION OF THE FIXED POINTS

	Source	Price*
Low temperature furnace (150 ° to 500 °C)	ISO	$13 000
High temperature furnace (500 ° to 1 000 °C)	ISO	15 500
Indium fixed-point cell	ISO	10 500
Tin fixed-point cell	ISO	6 800
Zinc fixed-point cell	ISO	6 000
Aluminium fixed-point cell	ISO	6 000
Silver fixed-point cell	ISO	10 500
Mercury triple-point cell	ISO	4 000
Mercury triple-point apparatus	ISO	8 500
Gallium melt-point cell	ISO	3 000
Gallium melt apparatus	ISO	3 500
Liquid nitrogen or argon comparator	ISO	5 500
Water triple-point maintenance bath	ISO	13 000
Water triple-point cells	ISO	1 500
	NPL	1 500
	JAR	1 000
Standard platinum resistance thermometers		
25.5 ohm, — 200 ° to + 650 °C	ISO	3 500
	YSI	3 500
0.25 ohm, — 50 ° to + 1 000 °C	ISO	3 500
Bridges for resistance measurement		
Precision Current Comparator, 9975	GUI	35 000
Automatic AC bridge, F-18	ASL	35 000
MS-DOS Computer program for interpolation		
ITS 90 interpolation program	ISO	250

* Note: This information is for convenience, prices are an indication of price range only.

ISO = Isothermal Technology Ltd., Southport, England
YSI = YSI Inc., Yellow Springs, Ohio USA
GUI = Guildine Instruments, Smith Falls, Ontario, Canada
ASL = Automatic Systems Ltd, Keighton Buzzard, England
NPL = National Physical Laboratory, Teddington, England
JAR = Jarrett Instrument Cp., Wheaton, Maryland, USA

TABLE 4

REALIZABLE ACCURACIES OF THE FIXED POINTS

WITH RESPECT TO ITS 90

Fixed point	Uncertainty °C or K
Argon, nitrogen, by comparison method	0.002
Mercury, triple point	0.000 5
Water, triple point	0.000 15
Gallium, melt point	0.000 4
Indium, freeze point	0.000 5
Tin, freeze point	0.001
Zinc, freeze point	0.001
Aluminium, freeze point	< 0.002
Silver, freeze point	< 0.004

A brief bibliography of thermometry

There is no lack of information about the calibration of thermometers, temperature scales, fixed points, etc., but much of it is scattered through the literature. This is a list of books which are recommended as important in the field.

J.L. Riddle, G.T. Furukawa, H.H. Plumb, *Platinum Resistance Thermometry. NBS Monograph 126,* Superintendant of Documents, Washington DC, USA (1972)

B.W. Mangum, *Platinum Resistance Thermometer Calibrations, NBS Special Pub. 250-22,* Superintendant of Documents (1987)

CCT Working Group 1, *Supplementary Information for the IPTS-68 and the EPT-76,* Bureau International des Poids et Mesures, Sèvres, France (1983)

J. Schooley, *Thermometry,* CRC Press, Boca Raton, Florida USA (1986)

T. Quinn, *Temperature,* Academic Press, London, New York (1986)

F. Henning, *Temperaturmessung,* (3rd edition Moser), Springer Verlag, Berlin, Heidelberg, New York (1977)

H. Preston-Thomas, *The International Practical Temperature Scale of 1968 (revision of 1975),* Metrologia *12,* 1 (1976)

The International Temperature Scale of 1990, when published (scheduled for late 1989), Bureau International des Poids et Mesures, Sèvres, France

Techniques for Approximating the International Temperature Scale of 1990, (scheduled for late 1989), Bureau International des Poids et Mesures, Sèvres, France.

SUISSE

A SPECIAL WEIGHT SET for the DETERMINATION of OIML WEIGHT SETS and ITS USE

by **J.-G. ULRICH**

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SUMMARY — A special weight set for the calibration of weights of 500 g, 200 g and 100 g by group weighing using a kilogram reference standard has been developed at the Federal Office of Metrology. The present article describes this auxiliary weight set and its use in the determination of the first decade (1 kg down to 100 g) of a weight set under test with the aid of an electronic mass comparator with automatic weight transporting and loading device.

RESUME — Un jeu de poids spécial a été développé à l'Office fédéral de métrologie pour l'étalonnage en série fermée des poids de 500 g, 200 g et 100 g à partir d'un étalon de référence de 1 kg. Le présent article décrit ce jeu de poids auxiliaire et son utilisation pour déterminer la première décade (1 kg à 100 g) d'un jeu de poids à l'aide d'un comparateur de masses électronique avec système automatique de transport et charge.

1. Description of the weight set

The auxiliary weight set developed is intended for use as an accessory with mass comparators (e.g. Mettler HK1000MC). This not only offers the possibility to use a mass comparator to perform pure comparative weighing at the same nominal value, but it also makes it possible to determine the first decade of a weight set (1 kg down to 100 g) with the automatic facility.

Precision balances have hitherto allowed only manual performance of the numerous comparative weighings needed to determine the weight decade. The operator had to load all combinations of weights whose mass differences were to be determined one by one on a large weighing pan exercising the utmost care in the positioning of the weights. To obtain statistically reliable measured values, the entire time-consuming comparison procedure has to be repeated several times. Thanks to the automatic mode of operation of the HK1000MC mass comparator in the repetition of measurements and with the aid of a weight set of special geometric dimensions, it has been possible to eliminate virtually all sources of interference due to the operator, and to the fluctuations of the air temperature and the temperature of the weights themselves.

The overall performance of the comparator has been improved by enclosing it in a special container in which the air pressure can be kept practically constant (see Fig. 1).

The auxiliary weight set comprises three disc-shaped weights of 58 mm diameter, one of 100 g with a height of 4.8 mm and two of 200 g with a height of 9.6 mm (see Fig. 2). The selected shape allows stacking of the three disc weights (totalizing 500 g) together with a 500 g cylindrical weight of OIML shape beneath the hanger of the weighing pan at one of the four positions of the turntable and permits automatic weighing free from disturbances. In a similar manner, a mixed combination of 200 g comprising the 100 g disc and a 100 g weight of OIML shape can be loaded. Centering rings on the discs and special tweezers allow proper handling of the auxiliary weight set. The nonmagnetic stainless steel used in the production of

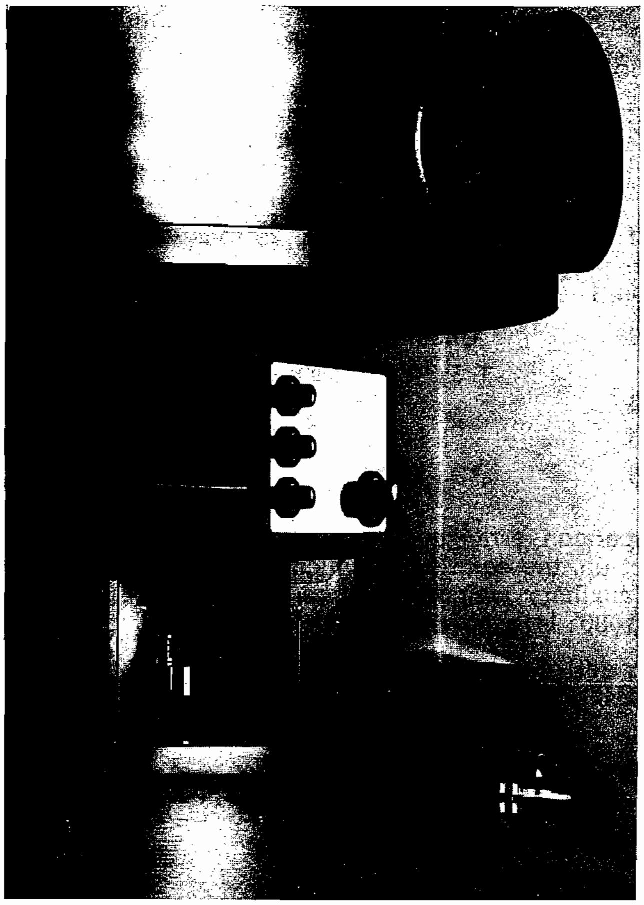

Fig. 1 — Mass comparator METTLER HK1000MC installed in a constant pressure container (open)

this special weight set is the same as that used by Mettler in the manufacture of weights of the OIML accuracy class E_2 [1].

2. Determination of the first decade of a weight set

With the aid of the auxiliary weight set described above, an unknown set comprising maximum 6 weights of composition 1 × 1 kg, 1 × 500 g, 1 × 200 g and up to 3 × 100 g can be determined in a single cycle of weighings starting from one or two main references of 1 kg. The HK1000MC mass comparator with its automatic weight transporter is especially suitable to perform the comparative weighings of such a weighing program. Individual weights or the stacked combinations for each of the four load ranges 1 000 g, 500 g, 200 g and 100 g can be placed on the four positions of the turnable (see Fig. 3).

The mass comparator is controlled by a computer and performs the weighing cycles automatically as well as the recording of the measured values. To achieve optimum measurement conditions it was found to be best to carry out measurements only within one load range per 24 hours and preferably at night; the number of repetitions for a good statistical evaluation can be increased to maximum 10 series of experiments each with 10 full revolutions of the turntable. The total operating time of the comparator for such a measurement cycle is typically 16 hours.

The computation of the unknown weights in the four weighing cycles (one per load range) is done by using the following designations:

Nominal value	References		Tested weights			Auxiliary weights	
1 000 g	R1000	R1000'		U1000			
500 g				U500			
200 g				U200		H200	H200'
100 g			U100	U100'	U100"	H100	

The turntable of the comparator is loaded as follows for the four weighing ranges:

Range	Position 1	Position 2	Position 3	Position 4
1 000 g	R1000	U500 + U200 + H200' + H100	U1000	R1000'
500 g	U500	—	H200 + H200' + H100	—
200 g	U200	H200	U100 + H100	H200'
100 g	U100	H100	U100'	U100"

From this comparison arrangement, a system of equations with 9 independent equations can be set up, the solution of which gives the values of all unknown weights (6 test weights, 3 auxiliary weights) on the basis of the known value of the main reference R1000 (R1000' is used only for confirmation of the R1000 reference).

In the following set of equations, the designations D0 to D8 represent the differences in the readings obtained in the comparisons with the mass comparator:

D0 = U1000 — R1000
D1 = U500 + H200 + H200' + H100 — U1000
D2 = H200 + H200' + H100 — U500
D3 = H200 — U200
D4 = H200' — U200
D5 = U100 + H100 — U200
D6 = H100 — U100
D7 = U100' — U100
D8 = U100" — U100

The solution of this set of equations gives the values of the 9 unknown weights. The development of the solution is explained in Appendix A1.

If there are not great differences in density between the reference, the tested weights and the auxiliary weights the solution in Appendix A1 will give directly the value of the various unknown weights expressed in either mass or in conventional weighing value depending on the value R_0 introduced in the equations for the reference weight R1000. The conventional weighing value is usually sufficient for most practical applications, i.e. verification of weights of lower class, adjustment of direct-reading balances and weighing of goods for commercial purposes.

3. Mass and conventional weighing value

The conventional weighing value of a weight weighed in air [2] is understood to mean a computed value that is equal to the mass of a mass standard of density 8 000 kg/m^3 (conventional material density) that keeps this weight in equilibrium at a temperature of 20 °C and in air of density 1.2 kg/m^3 (conventional air density). The equilibrium equation for the weighing in air gives the relation between mass m and conventional weighing value m_c of a weight of material density ρ (in kg/m^3) (see Appendix A2).

$$m_c = m \cdot (\rho - 1.2) / 0.999\,850 \cdot \rho$$

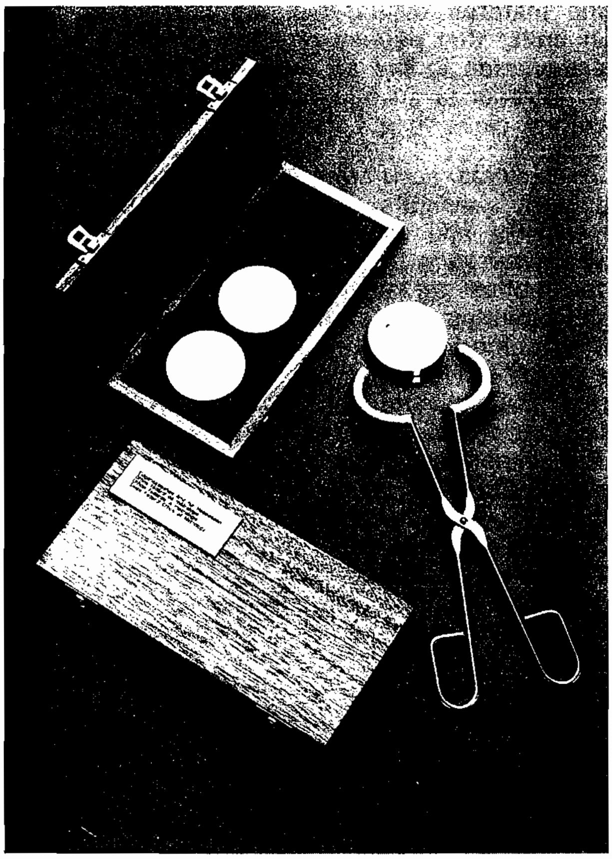

Fig. 2 — Special weight set 2 × 200 g, 1 × 100 g

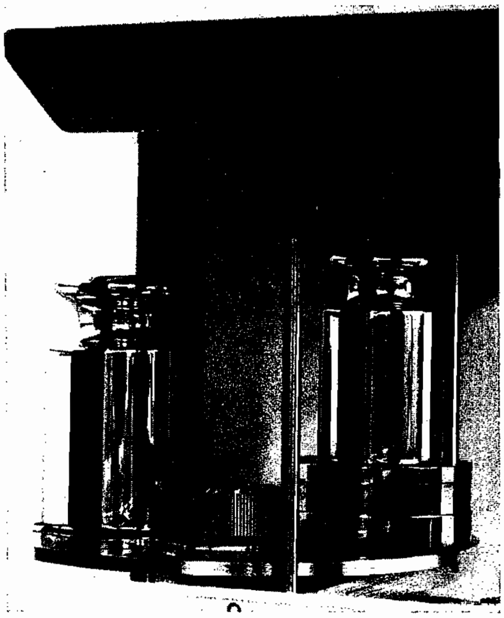

Fig. 3 — Mass comparison of a 1 kg weight with a 500 g weight and the special weight set (1 × 100 g and 2 × 200 g)

The density of the material of the weights that meet the OIML requirements must be within certain limits that depend on the accuracy class. If the buoyancy correction is neglected a deviation in the air density of 10 % from the conventional air density 1.2 kg/m^3 then introduces an additional error of maximum one quarter of the error limit of the accuracy class in question (see [2]).

If it is desired to calculate accurately the mass using the experimental results of a comparison of kilogram weights obtained with a mass comparator that has a resolution of 1 µg over 1 kg and with which a standard deviation also of 1 µg is achieved, it is however necessary to recognize that the volume of the weights (or the density) has to be identical or known within a relative uncertainty of 10^{-5} if the advantages of the high resolution of the scale are not to be lost through an inaccurate correction. The following numerical example is intended to show the order of magnitude of the difference in the deviations from the nominal value, depending on whether the value of the mass or the conventional weighing value of the same weight is considered: let us assume that a value for the error in the conventional weighing value of a kilogram of 0.150 mg has been obtained (thus m_c = 1 000.000 150 g). We further assume that the density of the material of the kilogram is 7 921.50 kg/m^3. By rearranging the formula given above, we obtain the value for the mass m = 1 000.001 637 g, i.e. a value greater than the conventional weighing value by 1.487 mg. It can easily be seen that when the density is known exactly, each weight with a known error in the conventional weighing value may also be considered as a mass standard with a known measurement deviation of its mass from the nominal value (or the reverse).

4. Determination of the mass error

In a metrological laboratory and in highly accurate mass determinations of solids in general, one has primarily the need to know the deviation of the mass from the nominal value of the weights used. When using the comparator the value of the mass is therefore computed for each weight. The volumes (or the densities) of all weights involved are thus also needed and for every comparative weighing the prevailing air density must be calculated from measurement of the barometric pressure, temperature, relative humidity and CO_2 concentration of the air to allow calculation of the individual buoyancy corrections [3]. These operations are greatly facilitated by controlling the pressure and the temperature of the enclosure of the balance and thus maintaining the air density approximately constant.

The differences in density between the weights are taken into account by extending the computation programme described in section 2 and Appendix A1 as follows: the deviation of the mass of the reference weight from its nominal value and the densities of all the weights are used as a point of departure. The mean air density during the comparative weighing is calculated and buoyancy corrections are applied for all the weights involved.

A typical result of observations and computations is shown in Table 1 which states both mass and conventional weighing values.

References

[1] Recommandation Internationale OIML n° 20, "Poids des classes de précision E_1, E_2, F_1, F_2 et M_1 de 50 kg à 1 mg", (1973), International Recommendation OIML n° 20, "Weights of accuracy classes E_1, E_2, F_1, F_2 and M_1 from 50 kg to 1 mg".

[2] Recommandation Internationale OIML n° 33, "Valeur conventionnelle du résultat des pesées dans l'air", (1973), International Recommendation OIML n° 33, "Conventional value of the result of weighing in air".

[3] Formule pour la détermination de la masse volumique de l'air humide (1981), Bureau International des Poids et Mesures, Sèvres (France), Equation for the determination of the density of moist air (1981), Metrologia 18, 33-40, (1982).

TABLE 1

NUMERICAL EXAMPLE OF A COMPUTER EVALUATION:
DETERMINATION OF A SET OF WEIGHTS 100 g TO 1 kg

Designation: Set 4

Date: 2 Nov. 1988

Mass of Reference: 1 kg + 0.963 mg

Measured differences		Mass comparator reading
D0 = U1000 — Reference	:	+ 0.192 8 mg
D1 = U500 + H200 + H200' + H100 — U1000	:	— 2.046 8 mg
D2 = H200 + H200' + H100 — U500	:	— 2.164 3 mg
D3 = H200 — U200	:	— 0.239 6 mg
D4 = H200' — U200	:	+ 0.887 6 mg
D5 = H100 + U100 — U200	:	— 2.485 8 mg
D6 = H100 — U100	:	— 1.559 3 mg
D7 = U100' — U100	:	+ 0.020 2 mg
D8 = U100'' — U100	:	+ 0.735 9 mg

Mean air density: 1.124 5 kg/m³

Computed results taking into account buoyancy

Designation		Nominal value	Density	Error mass	Error conv. weighing value
Reference		1 000 g	7 938.81 kg/m³	+ 0.963 mg	— 0.193 mg
Tested weight	U1000	1 000 g	7 914.27 kg/m³	+ 1.595 mg	— 0.030 mg
	U500	500 g	7 914.30 kg/m³	+ 0.856 mg	+ 0.044 mg
	U200	200 g	7 938.30 kg/m³	— 0.059 mg	— 0.293 mg
	U100	100 g	7 919.80 kg/m³	— 0.460 mg	— 0.612 mg
	U100'	100 g	7 924.36 kg/m³	— 0.448 mg	— 0.591 mg
	U100''	100 g	7 776.08 kg/m³	+ 0.538 mg	+ 0.106 mg
Auxiliary weight	H200	200 g	7 914.30 kg/m³	— 0.213 mg	— 0.538 mg
	H200'	200 g	7 914.30 kg/m³	+ 0.914 mg	+ 0.589 mg
	H100	100 g	7 914.30 kg/m³	— 2.009 mg	— 2.172 mg

Appendixes

A1. ALGEBRAIC SOLUTION OF THE SET OF EQUATIONS IN SECTION 2

For the purpose of simplification, we shall rewrite the equations with slightly shortened designations as follows:

With R_0 = R1000			
U_0 = U1000	$D_0 = U_0 - R_0$	(1)
U_5 = U500	$D_1 = U_5 + H_2 + G_2 + H_1 - U_0$	(2)
U_2 = U200	$D_2 = H_2 + G_2 + H_1 - U_5$	(3)
U_1 = U100	$D_3 = H_2 - U_2$	(4)
V_1 = U100'	$D_4 = G_2 - U_2$	(5)
W_1 = U100"	$D_5 = U_1 + H_1 - U_2$	(6)
H_2 = H200	$D_6 = H_1 - U_1$	(7)
G_2 = H200'	$D_7 = V_1 - U_1$	(8)
H_1 = H100	$D_8 = W_1 - U_1$	(9)

We solve the 9 equations for one of the unknowns:

$$U_0 = R_0 + D_0 \quad (10)$$
$$H_1 = D_1 + U_0 - U_5 - H_2 - G_2 \quad (11)$$
$$U_5 = H_2 + G_2 + H_1 - D_2 \quad (12)$$
$$H_2 = D_3 + U_2 \quad (13)$$
$$G_2 = D_4 + U_2 \quad (14)$$
$$U_2 = U_1 + H_1 - D_5 \quad (15)$$
$$U_1 = H_1 - D_6 \quad (16)$$
$$V_1 = D_7 + U_1 \quad (17)$$
$$W_1 = D_8 + U_1 \quad (18)$$

Insertion of (16) in (15, 17, 18):

$$U_2 = 2H_1 - D_6 - D_5 \quad (19)$$
$$V_1 = H_1 - D_6 + D_7 \quad (20)$$
$$W_1 = H_1 - D_6 + D_8 \quad (21)$$

Insertion of (19) in (13, 14):

$$H_2 = 2H_1 - D_6 - D_5 + D_3 \quad (22)$$
$$G_2 = 2H_1 - D_6 - D_5 + D_4 \quad (23)$$

Insertion of (22, 23) in (12):

$$U_5 = 2H_1 - D_6 - D_5 + D_3 + 2H_1 - D_6 - D_5 + D_4 + H_1 - D_2 =$$
$$= 5H_1 - 2D_6 - 2D_5 + D_3 + D_4 - D_2 \quad (24)$$

and of (10, 22, 23, 24) in (11), then solving for H_1 gives:

$$H_1 = D_1 + R_0 + D_0 - 5H_1 + 2D_6 + 2D_5 - D_3 - D_4 + D_2 - 2H_1 + D_6 +$$
$$+ D_5 - D_3 - 2H_1 + D_6 + D_5 - D_4$$

$$H_1 = (R_0 + D_0 + D_1 + D_2 - 2D_3 - 2D_4 + 4D_5 + 4D_6)/10 \quad (25)$$

We now insert (25) in (22, 23, 16, 20, 21, 19, 24) and together with (10) obtain the complete algebraic solution of the system of equations:

$$
\begin{aligned}
&H100 &= H_1 &= (R_0 + D_0 + D_1 + D_2 - 2D_3 - 2D_4 + 4D_5 + 4D_6)/10\\
&H200 &= H_2 &= (R_0 + D_0 + D_1 + D_2 + 3D_3 - 2D_4 - D_5 - D_6)/5\\
&H200' &= G_2 &= (R_0 + D_0 + D_1 + D_2 - 2D_3 + 3D_4 - D_5 - D_6)/5\\
&U100 &= U_1 &= (R_0 + D_0 + D_1 + D_2 - 2D_3 - 2D_4 + 4D_5 - 6D_6)/10\\
&U100' &= V_1 &= (R_0 + D_0 + D_1 + D_2 - 2D_3 - 2D_4 + 4D_5 - 6D_6)/10 + D_7\\
&U100'' &= W_1 &= (R_0 + D_0 + D_1 + D_2 - 2D_3 - 2D_4 + 4D_5 - 6D_6)/10 + D_8\\
&U200 &= U_2 &= (R_0 + D_0 + D_1 + D_2 - 2D_3 - 2D_4 - D_5 - D_6)/5\\
&U500 &= U_5 &= (R_0 + D_0 + D_1 - D_2)/2\\
&U1000 &= U_0 &= R_0 + D_0
\end{aligned}
$$

A2. RELATION BETWEEN CONVENTIONAL WEIGHING VALUE AND MASS

To derive the conventional weighing value of a body (e.g. a weight), we have to set up the equilibrium condition for the comparison on a scale between this body of mass m and density ρ and a mass standard m' of density 8 000 kg/m³ in air of density 1.2 kg/m³. We have:

Weight	m (kg)	Standard	m' (kg)
Density	ρ (kg/m³)	$\rho_c = 8\,000$ kg/m³	
Volume	$V = m/\rho$ (m³)	$V' = m'/\rho_c$ (m³)	
Local acceleration due to gravity g (m/s²)		Air density $\rho_a = 1.2$ kg/m³	

The equilibrium equation for all forces acting in the weighing (weight forces and buoyancy forces) is:

$$m \cdot g - V \cdot \rho_a \cdot g = m' \cdot g - V' \cdot \rho_a \cdot g$$

We divide by g and replace V and V'

$$m \cdot (1 - \rho_a/\rho) = m' \cdot (1 - \rho_a/\rho_c)$$

According to definition, the conventional weighing value m_c is equal to the mass of the mass standard m'. With $m_c = m'$ we obtain from the above equation

$$m_c = m \cdot (1 - \rho_a/\rho)/(1 - \rho_a/\rho_c)$$

and after insertion of all known quantities finally

$$m_c = m \cdot (\rho - 1.2)/0.99985 \cdot \rho$$

COOPERATIONS METROLOGIQUES EN EUROPE

(suite)

Le Bulletin de l'OIML N° 106 - mars 1987 contient un article sur les différentes formes de coopération entre les pays européens dans le domaine de la métrologie.

La création en septembre 1987 d'EUROMET fut annoncée dans le Bulletin de l'OIML N° 109 - décembre 1987 qui contient également un sommaire des objectifs de cette organisation qui groupe actuellement 17 pays européens. Nous rappelons que les buts d'EUROMET sont de renforcer la coopération métrologique d'une façon générale mais surtout en ce qui concerne les étalons.

La création d'EUROMET émanait des discussions tenues au sein du Western European Metrology Club (WEMC), une association informelle créée en 1973. Lors d'une réunion en Suède en mai 1989 il a été décidé de dissoudre le WEMC puisque ses activités avaient en grande partie été reprises par EUROMET.

Le Western European Calibration Cooperation (WECC) était à ses débuts un groupe de travail du WEMC ayant pour buts d'assurer les raccordements métrologiques et favoriser des accords inter-laboratoires dans le domaine des étalonnages. Le WECC, qui réunit les responsables de différents réseaux nationaux d'étalonnages, est rapidement devenu indépendant. Après avoir été longtemps une association informelle, le WECC a dernièrement approuvé et signé un document formel de constitution: "Memorandum of Understanding between National Calibration Services", Copenhague 9 juin 1989. Par ailleurs, les services nationaux d'étalonnage de certains pays européens ont signé, à Turin, le 1er décembre 1989, dans le cadre de WECC, un accord de reconnaissance mutuel des certificats d'étalonnage. Les pays signataires sont la Rép. Féd. d'Allemagne, la Finlande, la France, l'Italie, le Royaume-Uni, la Suède et la Suisse. Le nouvel accord a été conçu de façon à permettre son extension à d'autres services nationaux d'étalonnage (le WECC comprend actuellement 16 pays).

Le besoin de renforcer la coopération également en métrologie légale a récemment donné lieu à la création d'une nouvelle association, WELMEC décrit dans une note d'information que son Président nous a fait parvenir et dont nous donnons ci-après une traduction en français.

WELMEC — WESTERN EUROPEAN LEGAL METROLOGY COOPERATION

Une réunion inaugurale de Western European Legal Metrology Cooperation — WELMEC — s'est tenue à la PTB (Braunschweig) les 19 et 20 octobre 1989 avec la participation de représentants des autorités de métrologie légale des pays membres de la Communauté Européenne (CE) et de l'Association Européenne de Libre-Echange (AELE) ainsi que de la Commission de la Communauté Européenne et du Bureau International de Métrologie Légale. La réunion, entièrement informelle, était organisée dans le cadre d'EUROMET.

Les développements rapides vers l'harmonisation de la métrologie légale dans la CE et dans l'AELE nécessitent une coopération suivie entre les autorités nationales afin d'assurer l'interprétation et l'application uniformes des directives issues dans le cadre de la "nouvelle approche" portant sur les instruments de mesure et sur des exigences similaires. La réunion a pris la décision de poursuivre ces objectifs avec un programme d'activités comprenant échanges d'informations, intercomparaisons des essais pour approbation de modèle et séminaires sur des aspects spécifiques d'harmonisation. WELMEC constituera également un point de focalisation pour la métrologie légale dans les arrangements européens qui tendent à se développer en matière d'organisation d'essais et de certification et cherchera à établir des liaisons avec d'autres groupes concernés par tous les aspects de la métrologie.

Il est prévu que les statuts et objectifs formels de WELMEC soient établis après une réunion d'Euromet en mars 1990 et une autre réunion de WELMEC à Berne en juin 1990. Les membres ont en attendant décidé de poursuivre le programme de travail convenu sur une base informelle.

Les demandes de renseignements peuvent être adressées au Président de WELMEC: Dr P.B. Clapham, Director, National Weights and Measures Laboratory, Stanton Avenue, Teddington, Middlesex TW11 OJZ, Royaume-Uni.

METROLOGICAL COOPERATION IN EUROPE (continued)

The OIML Bulletin No. 106 - March 1987 contains a survey paper on the various forms of cooperation between countries in Europe in the field of metrology.

The creation in September 1987 of EUROMET, devoted to general cooperation in the field of measurement standards, was announced in the OIML Bulletin No. 109, December 1987 which also gives a summary of the statutes and objectives of this organization which to-day covers 17 European countries.

The creation of EUROMET originated from discussions within the Western European Metrology Club (WEMC) an informal association created in 1973. At a meeting in Sweden in May 1989 it was decided that WEMC should cease its activities as a great part of them had been taken over by EUROMET.

The Western European Calibration Cooperation (WECC) was in the beginning a working group within WEMC in the field of calibration activities for ensuring traceability of measurements and favouring interlaboratory agreements in the field of calibration. The WECC, grouping mainly the heads of the various calibration services, became rapidly independent. After having been for a long time an informal association it has recently signed a formal document of constitution: Memorandum of Understanding between National Calibration Services, Copenhagen, 9 June 1989. The national calibration services of some of the countries, members of WECC, have signed on 1st December 1989, in Torino, an agreement on mutual acceptance of calibration certificates. The signatories are Finland, France, Fed. Rep. of Germany, Italy, the Netherlands, Sweden, Switzerland and the United Kingdom. The new agreement has been drafted to enable its extension to other national calibration services (the WECC presently covers 16 countries).

The need to re-enforce the cooperation also in the field of legal metrology has recently resulted in the creation of a new association WELMEC described in the following information release supplied by its Chairman:

WELMEC: WESTERN EUROPEAN LEGAL METROLOGY COOPERATION

An inaugural meeting of the Western European Legal Metrology Cooperation — WELMEC — was held at PTB (Braunschweig) on 19 and 20 October 1989, and was attended by representatives of EC and EFTA national legal metrology authorities, the EC Commission and the International Bureau of Legal Metrology. The meeting, which was entirely informal, was arranged under the auspices of Euromet.

The rapid developments towards the harmonization of legal metrology in both the EC and EFTA call for regular collaboration between national authorities to ensure the consistent interpretation and application of "new approach" directives on measuring instruments and similar requirements. The meeting resolved to pursue these objectives with a programme of activities to include information exchange, intercomparisons of type approval tests and seminars on specific aspects of harmonization. WELMEC will also provide a focus for legal metrology in the developing European arrangements for the organization of testing and certification, and will seek to develop links with other groups concerned with all aspects of metrology.

The formal status of WELMEC and its terms of reference are expected to evolve following a meeting of Euromet in March 1990 and a further meeting of WELMEC to be held in Bern, in June 1990. Meanwhile, members resolved vigorously to pursue the agreed work programme on an informal basis.

Enquiries may be addressed to the Chairman of WELMEC: Dr P.B. Clapham, National Weights & Measures Laboratory, Stanton Avenue, Teddington, Middlesex TW11 OJZ, United Kingdom.

INFORMATIONS

MEMBRES DU COMITE

CHYPRE — Le nouveau membre du CIML succédant à Mr M. EROTOKRITOS est Mr George TSIARTZAZIS, Controller of Weights and Measures, Ministry of Commerce and Industry.

PAYS-BAS — Le nouveau Membre du CIML est Monsieur J.A.J. BASTEN, Directeur du Service de métrologie légale (IJkwezen), en remplacement de Monsieur G. FABER qui, comme cela a été annoncé dans le Bulletin précédent, est nommé Directeur Général de l'Institut Néerlandais de Mesures (NMi) à partir du 1er janvier 1990.

CUBA

Un symposium international de métrologie orienté vers les applications dans l'industrie aura lieu au Palais des Congrès à La Havane, du 12 au 14 février 1990, avec les thèmes suivants:

— méthodes et moyens employés en matière de mesurage dans la construction de machines, la métallurgie et l'électronique

— méthodes et instruments de mesure employés en matière d'essais ou d'analyses dans la construction de machines, la métallurgie et l'électronique

— méthodes et moyens d'étalonnage/vérification des instruments mécaniques et électroniques

— tendances actuelles dans la conservation, le stockage, l'emploi, l'exploitation et le soin des instruments de mesure en climat tropical, ainsi que la technologie de pointe dans la fabrication d'instruments de mesure.

Pour obtenir davantage de renseignements sur l'organisation et les exposés présentés, s'adresser à:

Monsieur Javier Acosta Alemany
Comité d'Etat de Normalisation
Egido 610 entre Gloria y Apodaca
Habana 1, Cuba
Telex: 51.2236 cen dh cu
Téléphone: 32.9345; 7.3153; 9.4769; 9.2347.

FRANCE

L'Ecole Centrale de Lyon organise fréquemment des stages de formation de courte durée dans le domaine de la métrologie pratique et légale, axés principalement sur des applications industrielles.

Nous donnons ci-dessous quelques exemples de ces cours prévus en 1990:

— Débitmétrie — du 6 au 9 mars 1990

— Contrôle des doseuses et trieuses pondérales: méthodes statistiques, nouvelle réglementation — du 13 au 15 mars 1990

— Méthodes modernes optiques de mesure: application aux lasers — du 19 au 23 mars 1990

— Pesage industriel	du 19 au 23 mars 1990
— Electronique associée au pesage industriel	du 23 au 26 avril 1990
— La mesure des vibrations dans l'industrie	du 2 au 4 mai 1990
— Capteurs et circuits associés	du 14 au 17 mai 1990
— Les mesures thermiques dans l'industrie	du 15 au 17 mai 1990
— Le dosage pondéral dans l'industrie	du 6 au 8 juin 1990
— Technique de la mesure électrique industrielle et de laboratoire	du 12 au 14 juin 1990

Pour obtenir des renseignements détaillés, s'adresser à:

Ecole Centrale de Lyon, Formation permanente
36, avenue Guy-de-Collongue - B.P. 163 - 69131 Ecully Cedex
Tél.: 78 33 81 27 - Télex: ECE 310856 F - Télécopie: 78 43 39 62

Pour célébrer le bicentenaire de la création du système métrique, le Ministère chargé de l'Industrie a édité une brochure en couleur de 64 pages, abondamment illustrée, sur l'histoire du système métrique décimal.

Un chapitre dont l'auteur est Monsieur L. MARQUET décrit les différentes étapes de la création du système métrique décimal de 1790 à 1799. Le second chapitre, dont l'auteur est Monsieur A. LE BOUCH, retrace les moments essentiels de la diffusion du système métrique.

Pour acheter cet ouvrage dont le titre est "L'épopée du mètre", s'adresser à:

Délégation à l'Information et à la Communication,
Ministère de l'Industrie et de l'Aménagement du Territoire
101, rue de Grenelle - 75700 Paris.

Un recueil (380 pages) des textes des 60 exposés présentés au Congrès International de Métrologie à Paris les 21, 22 et 23 novembre 1989, peut être acheté en s'adressant à:

Association Française pour la Qualité
Tour Europe Cedex 7
92080 Paris la Défense

IRLANDE

Un congrès mondial sur les normes dans les domaines des technologies de la santé sera organisé à Dublin du 26 au 29 août 1990, par le Conseil électrotechnique d'Irlande en coopération avec l'ISO et la CEI.

Pour plus de renseignements, s'adresser à:

The Electro-Technical Council of Ireland
1 Fitzwilliam Place, Dublin 2, Ireland
Tél.: (353-1-) 612591
Fax: (353-1-) 611730/682595

MEXIQUE

Le VIIe Séminaire Annuel de Métrologie aura lieu dans le complexe touristique Ixtapa-Zihuatanejo du 8 au 11 mai 1990.

Le propos de ce séminaire est de rassembler les chercheurs spécialisés dans la métrologie au Mexique, des pays latino-américains et ceux avec renommée internationale afin d'obtenir un échange de connaissances entre les spécialistes des différents domaines de la métrologie.

Les principaux sujets abordés aux sessions techniques du séminaire auront les thèmes suivants:

— Développement, conservation et transfert des étalons
— La métrologie dans les programmes d'assurance de la qualité
— Nouvelles méthodes de mesures
— Développement d'instruments et systèmes de mesures
— Métrologie générale.

Pour plus de renseignements, s'adresser à:

Metrologia 90
Av. Instituto Politecnico Nacional 2508
Apartado Postal 14-740, 07000 Mexico D.F.

ROYAUME-UNI

Une conférence internationale sur la mesure de débit des fluides à valeur commerciale élevée est organisée à Londres le 28 février et le 1er mars 1990. La conférence comporte des exposés sur les techniques d'étalonnage, les compteurs à effet Coriolis, à turbine, électromagnétiques et vortex. Le recueil des exposés peut être vendu aux non-participants, s'adresser à:

Annabelle Simpson
IBC Technical Services Ltd.
Bath House, 56 Holborn Viaduct
London EC1A 2EX

INFORMATION

COMMITTEE MEMBERS

CYPRUS — The new CIML member succeeding Mr M. EROTOKRITOS is Mr George TSIARTZAZIS, Controller of Weights and Measures, Ministry of Commerce and Industry.

NETHERLANDS — The new CIML Member is Mr J.A.J. BASTEN, Director of the Legal Metrology Service (IJkwezen) succeeding Mr G. FABER who, as announced in the previous Bulletin, has been nominated General Director of the Netherlands Measurement Institute (NMi) from 1st January 1990.

CUBA

An international symposium on metrology specially directed towards industrial applications takes place at the International Conference Centre in Habana, 12-14 February 1990.

The subjects treated are announced as follows:

- methods and means used in measurements applied to machinery construction, metallurgy and electronics
- measuring instruments and methods used in tests or analysis applied to machinery construction, metallurgy and electronics
- methods and means of calibration/verification of mechanical and electronic instruments
- current trends in conservation, storage, use, care and exploitation of measuring instruments in tropical conditions, as well as the state-of-the-art concerning the manufacture of measuring instruments.

For more information on the organisation and the papers presented please contact:

Mr Javier Acosta Alemany
State Committee for Standardization
Egido 610 entre Gloria y Apodaca
Habana 1, Cuba

Telex: 51.2236 cen dh cu
Telephone: 32.9345; 7.3153; 9.4769; 9.2347.

FRANCE

L'Ecole Centrale de Lyon frequently organises short training courses in practical and legal metrology applied to industrial applications. The courses are given in French language. Examples and address for further details are given in the French section "Information" in this Bulletin.

To celebrate the bicentenary of the creation of the metric system the Ministry in charge of Industry has edited a booklet in colourprint containing 64 pages with numerous illustrations and relating the history of the metric decimal system.

The first part of the booklet, written by Mr L. MARQUET, describes the different steps in the creation of the system from 1790 to 1799. The second part, written by Mr A. LE BOUCH, narrates the essential events in the spread of the metric system. The booklet has the title "L'épopée du mètre" and can be purchased from

Délégation à l'Information et à la Communication,
Ministère de l'Industrie et de l'Aménagement du Territoire
101, rue de Grenelle - 75700 Paris.

The collection (380 pages) of the 60 papers presented at the International Metrology Congress held in Paris, 21, 22 and 23 November 1989 may be purchased from

Association Française pour la Qualité
Tour Europe Cedex 7
92080 Paris La Défense

IRELAND

The Electro-Technical Council of Ireland in conjunction with the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) are organizing the 1990 World Congress on Health Technology Standards to be held in Dublin 26-29 August 1990.

The purpose of the Congress is to bring together the developers and manufacturers of equipment and devices used in medicine, the users of such equipment and experts in the field of standards.

For further information and application form please contact:

The Electro-Technical Council of Ireland
1 Fitzwilliam Place, Dublin 2, Ireland
Tel.: (353-1-) 612591
Fax: (353-1-) 611730/682595

MEXICO

The VII Metrology Annual Seminar, will be held at the touristic complex Ixtapa Zihuatanejo in Mexico from May 8 to May 11, 1990.

The purpose of this International Seminar is to bring together specialists and researchers from Mexico, Latin-America and countries with recognized prestige, dedicated to metrology activities, in order to promote a broader interdisciplinary exchange of knowledges than possible at overly specialized meetings.

The technical sessions will be mainly focused on the following topics:

— Development, maintenance and traceability of standards
— Metrology in quality assurance programs
— New measurement methods
— Development of measurement instruments and systems
— General metrology.

UNITED KINGDOM

An International Conference on Flow Measurement of Commercially Important Fluids is organized in London on 28 February and 1 March 1990. The conference includes 21 papers covering subjects such as calibration techniques, Coriolis, electromagnetic, vortex and turbine flowmeters. The Conference papers are also available for sale to non-participants.

For more information contact

Annabelle Simpson
IBC Technical Services Ltd.
Bath House, 56 Holborn Viaduct
London EC1A 2EX

REUNIONS OIML

	Groupes de travail	Dates	Lieux
SP 14 + Sr	Acoustique et vibrations *Acoustics and vibration*	3-4 Mai/May 1990	BIML, PARIS
SP 7-Sr 5	Instruments de pesage à fonctionnement automatique *Automatic weighing instruments*	7-11 Mai/May 1990	TEDDINGTON ROYAUME-UNI
SP 12-Sr 7	Thermomètres médicaux *Clinical thermometers*	8-11 Mai/May 1990	R.F. d'ALLEMAGNE
SP 7-Sr 4	Instruments de pesage à fonctionnement non automatique *Non-automatic weighing instruments*	21-23 Mai/May 1990	BRAUNSCHWEIG R.F. d'ALLEMAGNE
SP 8-Sr 5	Poids utilisés dans le commerce et l'industrie *Weights used in trade and industry*	Mai/May 1990 (provisoire/*provisional)*	
SP 8-Sr 6	Poids de précision *Weights of high accuracy*		
SP 20 + Sr	Produits préemballés *Prepackaged products*	11-15 Juin/June 1990	WABERN SUISSE
SP 2-Sr 5	Contrôle par échantillonnage *Control by sampling*		
SP 22-Sr 3	Principes de l'essai de modèle *Principles of pattern evaluation*	18-20 Juin/June 1990	BIML, PARIS
SP 22-Sr 4	Principes de la vérification des instruments *Principles of verification of instruments*		

Conseil de la Présidence *Presidential Council*	7-9 Février/February 1990	BIML, PARIS
Séminaire technique de l'OIML: Instruments de pesage électroniques *Electronic weighing instruments*	15-18 Mai/May 1990	BRAUNSCHWEIG R.F. d'ALLEMAGNE

Note: Liste à jour fin décembre 1989.
List as per end December 1989.

PUBLICATIONS

— Vocabulaire de métrologie légale
Vocabulary of legal metrology

— Vocabulaire international des termes fondamentaux et généraux de métrologie
International vocabulary of basic and general terms in metrology

RECOMMANDATIONS INTERNATIONALES

INTERNATIONAL RECOMMENDATIONS

R N°

1 — Poids cylindriques de 1 g à 10 kg (de la classe de précision moyenne)
Cylindrical weights from 1 g to 10 kg (medium accuracy class)

2 — Poids parallélépipédiques de 5 à 50 kg (de la classe de précision moyenne)
Rectangular bar weights from 5 to 50 kg (medium accuracy class)

4 — Fioles jaugées (à un trait) en verre
Volumetric flasks (one mark) in glass

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

6 — Dispositions générales pour les compteurs de volume de gaz
General provisions for gas volume meters

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

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

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

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

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

14 — Saccharimètres polarimétriques
Polarimetric saccharimeters

15 — Instruments de mesure de la masse à l'hectolitre des céréales
Instruments for measuring the hectolitre mass of cereals

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

17 — Manomètres, vacuomètres, manovacuomètres indicateurs
Indicating pressure gauges, vacuum gauges and pressure-vacuum gauges

18 — Pyromètres optiques à filament disparaissant
Visual disappearing filament pyrometers

19 — Manomètres, vacuomètres, manovacuomètres enregistreurs
Recording pressure gauges, vacuum gauges, and pressure-vacuum gauges

20 — Poids des classes de précision E_1 E_2 F_1 F_2 M_1 de 50 kg à 1 mg
Weights of accuracy classes E_1 E_2 F_1 F_2 M_1 from 50 kg to 1 mg

21 — Taximètres
Taximeters

22 — Tables alcoométriques internationales
International alcoholometric tables

23 — Manomètres pour pneumatiques de véhicules automobiles
Tyre pressure gauges for motor vehicles

24 — Mètre étalon rigide pour agents de vérification
Standard one metre bar for verification officers

25 — Poids étalons pour agents de vérification
Standard weights for verification officers

26 — Seringues médicales
Medical syringes

27 — Compteurs de volume de liquides (autres que l'eau). Dispositifs complémentaires
Volume meters for liquids (other than water). Ancillary equipment

29 — Mesures de capacité de service
Capacity serving measures

30 — Mesures de longueur à bouts plans (calibres à bouts plans ou cales-étalons)
End standards of length (gauge blocks)

31 — Compteurs de volume de gaz à parois déformables
Diaphragm gas meters

32 — Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine
Rotary piston gas meters and turbine gas meters

33 — Valeur conventionnelle du résultat des pesées dans l'air
Conventional value of the result of weighing in air

34 — Classes de précision des instruments de mesurage
Accuracy classes of measuring instruments

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

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

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

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

39 — Vérification des machines d'essai de dureté (systèmes Rockwell B, F, T - C, A, N)
Verification of hardness testing machines (Rockwell systems B, F, T - C, A, N)

40 — Pipettes graduées étalons pour agents de vérification
Standard graduated pipettes for verification officers

41 — Burettes étalons pour agents de vérification
Standard burettes for verification officers

42 — Poinçons de métal pour agents de vérification
Metal stamps for verification officers

43 — Fioles étalons graduées en verre pour agents de vérification
Standard graduated glass flasks for verification officers

44 — Alcoomètres et aréomètres pour alcool et thermomètres utilisés en alcoométrie
Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry

45 — Tonneaux et futailles
Casks and barrels

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

47 — Poids étalons pour le contrôle des instruments de pesage de portée élevée
Standard weights for testing of high capacity weighing machines

48 — Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques
Tungsten ribbon lamps for calibration of optical pyrometers

49 — Compteurs d'eau (destinés au mesurage de l'eau froide)
Water meters (intended for the metering of cold water)

50 — Instruments de pesage totalisateurs continus à fonctionnement automatique
Continuous totalising automatic weighing machines

51 — Trieuses pondérales de contrôle et trieuses pondérales de classement
Checkweighing and weight grading machines

52 — Poids hexagonaux. Classe de précision ordinaire de 100 g à 50 kg
Hexagonal weights. Ordinary accuracy class, from 100 g to 50 kg

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

54 — Echelle de pH des solutions aqueuses
pH scale for aqueous solutions

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

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

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

58 — Sonomètres
Sound level meters

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

60 — Réglementation métrologique des cellules de pesée
Metrological regulations for load cells

61 — Doseuses pondérales à fonctionnement automatique
Automatic gravimetric filling machines

62 — Caractéristiques de performance des extensomètres métalliques à résistance
Performance characteristics of metallic resistance strain gages

63 — Tables de mesure du pétrole
Petroleum measurement tables

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General requirements for materials testing machines

65 — Exigences pour les machines d'essai des matériaux en traction et en compression
Requirements for machines for tension and compression testing of materials

66 — Instruments mesureurs de longueurs
Length measuring instruments

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

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

69 — Viscosimètres à capillaire, en verre, pour la mesure de la viscosité cinématique
Glass capillary viscometers for the measurement of kinematic viscosity.

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

71 — Réservoirs de stockage fixes. Prescriptions générales
Fixed storage tanks. General requirements

72 — Compteurs d'eau destinés au mesurage de l'eau chaude
Hot water meters

73 — 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
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

74 — Instruments de pesage électroniques
Electronic weighing instruments

75 — Compteurs d'énergie thermique
Heat meters

76 — Instruments de pesage à fonctionnement non automatique
Non-automatic weighing instruments

Partie 1 : Exigences métrologiques et techniques - Essais
Part 1 : Metrological and technical requirements - Tests

Partie 2 : Rapport d'essai de modèle
Part 2 : Pattern evaluation report

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

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

79 — Etiquetage des préemballages
Information on package labels

80 — Camions et wagons-citernes
Road and rail tankers

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

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

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Resistance-thermometer sensors made of platinum, copper or nickel (for industrial and commercial use)

85 — Jaugeurs automatiques pour le mesurage des niveaux de liquide dans les réservoirs de stockage fixes
Automatic level gauges for measuring the level of liquid in fixed storage tanks

86 — Compteurs à tambour pour alcool et leurs dispositifs complémentaires
Drum meters for alcohol and their supplementary devices

87 — Contenu net des préemballages
Net content in packages

88 — Sonomètres intégrateurs-moyenneurs
Integrating-averaging sound level meters

DOCUMENTS INTERNATIONAUX

INTERNATIONAL DOCUMENTS

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1 — Loi de métrologie
Law on metrology

2 — Unités de mesure légales
Legal units of measurement

3 — Qualification légale des instruments de mesurage
Legal qualification of measuring instruments

4 — Conditions d'installation et de stockage des compteurs d'eau froide
Installation and storage conditions for cold water meters

5 — Principes pour l'établissement des schémas de hiérarchie des instruments de mesure
Principles for the establishment of hierarchy schemes for measuring instruments

6 — Documentation pour les étalons et les dispositifs d'étalonnage
Documentation for measurement standards and calibration devices

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

8 — Principes concernant le choix, la reconnaissance officielle, l'utilisation et la conservation des étalons
Principles concerning choice, official recognition, use and conservation of measurement standards

9 — Principes de la surveillance métrologique
Principles of metrological supervision

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

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

12 — Domaines d'utilisation des instruments de mesure assujettis à la vérification
Fields of use of measuring instruments subject to verification

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

14 — Formation du personnel en métrologie légale - Qualification - Programmes d'étude
Training of legal metrology personnel - Qualification - Training programmes

15 — Principes du choix des caractéristiques pour l'examen des instruments de mesure usuels
Principles of selection of characteristics for the examination of measuring instruments

16 — Principes d'assurance du contrôle métrologique
Principles of assurance of metrological control

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

18 — Principes généraux d'utilisation des matériaux de référence certifiés dans les mesurages
General principles of the use of certified reference materials in measurements

19 — Essai de modèle et approbation de modèle
Pattern evaluation and pattern approval

20 — Vérifications primitive et ultérieure des instruments et processus de mesure
Initial and subsequent verification of measuring instruments and processes

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