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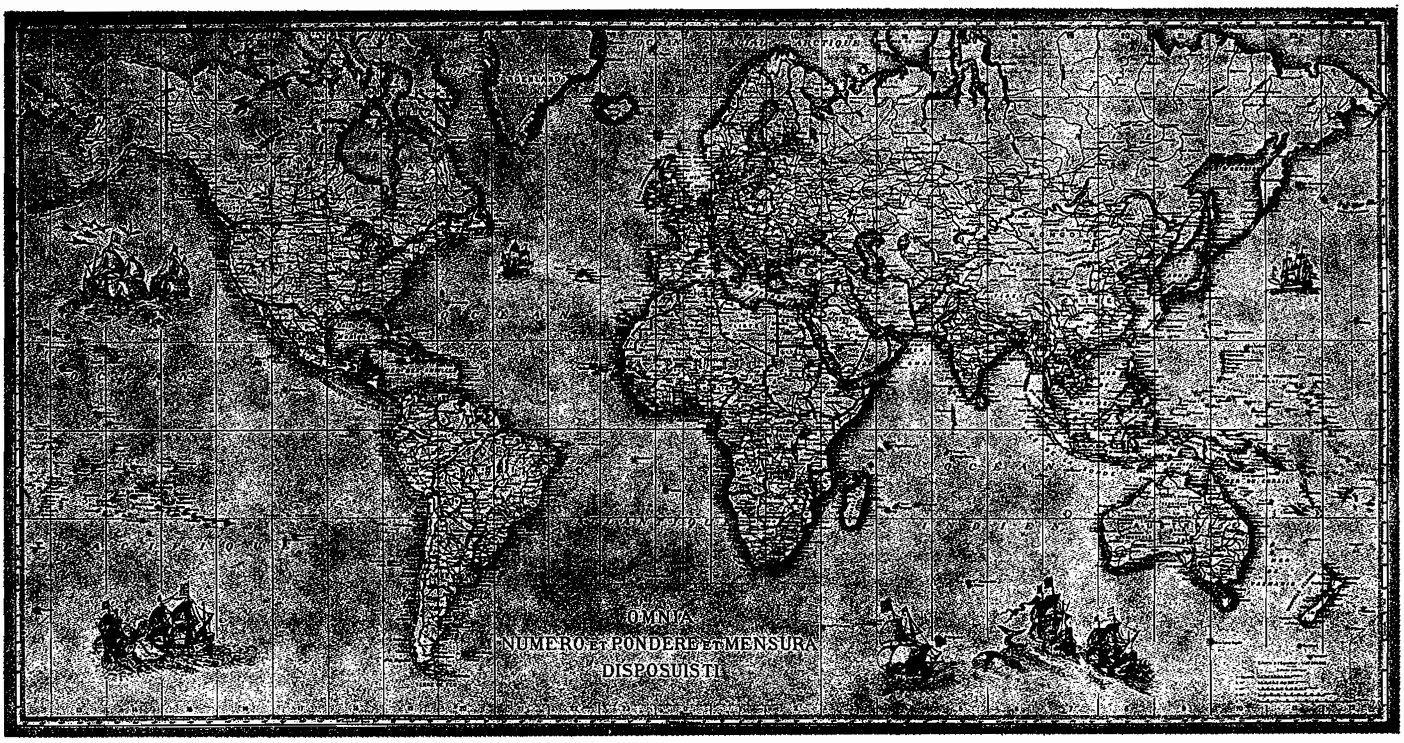

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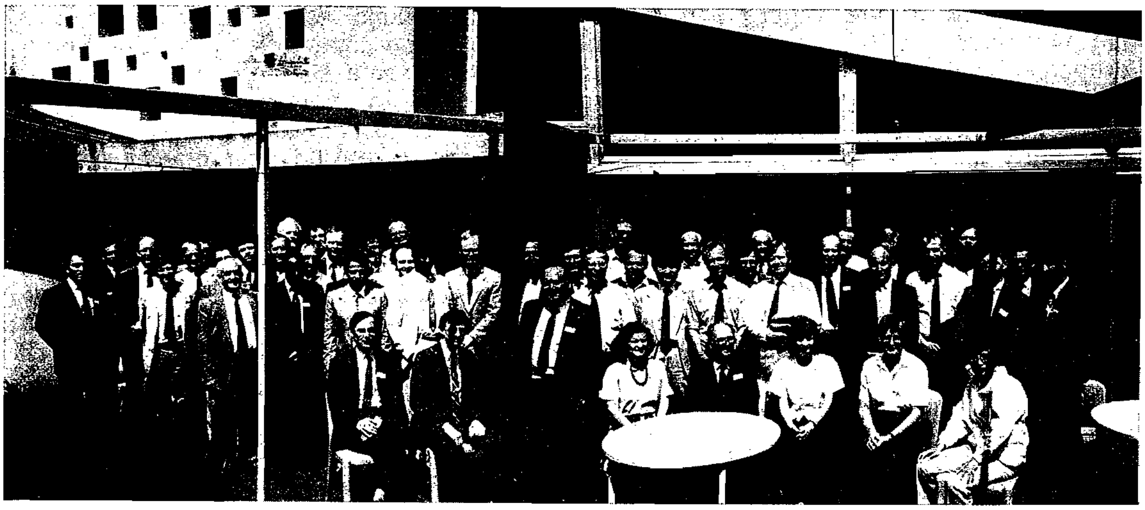


CALIBRATION of LIQUID VOLUME MEASURING INSTALLATIONS

OIML Seminar at Arles, France, 11-15 May 1987

The aim of OIML seminars is to inform staff from national metrology services about the latest developments in various technical fields and to provide an exchange of experience between specialists on problems they encounter in the accomplishment of their duties.

Following the successful seminar on testing of bulk weighing installations which took place in Paris in April 1985 and for which the presentations have been published in the Bulletin, the priority list showed particular interest for bulk liquid volume measurement and gauging problems. At an OIML Reporting Secretariat meeting it was suggested that bulk and retail liquefied petroleum gas measurements was a suitable seminar subject. Finally in view of the growing interest for mass metering of liquids it was decided to include also this subject in the seminar.

On proposal by the French metrology service, l'Institut de Régulation et d'Automation located at Arles in the south of France accepted to provide the facilities for the seminar. This Institute belonging to the Chambre of Commerce and Industry in Arles trains technicians and engineers employed in French and foreign industries in the field of measurement and control technology.

The participants were able during a special visit to admire the excellent training facilities available at this Institute.

Arles is an ancient city with numerous remains from the Roman time. The Lordmayor of Arles offered guided tours for the participants to see some of these followed by a reception at the Town Hall.

The subject of the seminar had attracted a total of 63 participants whereof 23 from France. Compared to previous seminars there was a much broader geographical distribution of the participation comprising 26 different countries whereof one corresponding member country (Albania) and one invited country (Saudi Arabia).

In addition to the papers and subsequent discussions listed below a half-day visit was arranged to see the turbine meter calibration installations of the South European Pipeline Company at Fos-sur-Mer and at the same time the verification of a tank truck meter by a mobile loop prover operated by the approved calibration company Mestrole. In connection with these visits the participants were given the opportunity to have a look to the bird life in the lake and marshland area of Camargue.

As illustrations of French activities in the field of liquefied petroleum gas a video-film was shown by the Geostock company of the important and quite unique underground storage facilities installed at the site of Lavera on the Mediterranean sea. The Mestrole company also showed a video-film of their activities and demonstrated by small groups the verification of a LPG dispenser at a gas station not far from the seminar premises. (The piston prover used for this purpose is described in a paper by L. Silvert in the OIML Bulletin No. 88, September 1982).

The seminar was opened by Mr J.A. Videau, Director of l'Institut de Régulation et d'Automation who greated the participants welcome and explained briefly the activities of his Institute.

The following lecturer Mr J. Dumolard, responsible for the metrology division of the Regional Directorate for Industry and Research, explained the administration of legal metrology in France in particular on regional level.

Most of the papers presented at the seminar will be published in the OIML Bulletin and we are only giving a brief summary below.

1 — *Bulk liquid metering, a survey of current practice and future trends*

by Alan T.J. Hayward, Moore, Barrett & Redwood, U.K.

The lecturer who is the author of a well-known book on flow measurements had responded favourably to the request of BIML to present a review paper on the various types of bulk flow meters and their calibration. This paper, which may be well fit as source material for basic training in flow metering principles, has already been published in the No. 107, June 1987 issue of the OIML Bulletin.

2 — *Metrological implications at the terminal stations of distribution of petroleum products to individual consumers*

by A. Nadolo, Institutul National de Metrologie, Romania

This paper was only distributed as the author was unexpectedly prevented from arriving in due time for the seminar. It analyses and sums up the various errors which can result in the custody transfer of petroleum products from the very first point of delivery at the distillery (accounted in units of mass) down to the final retail delivery (accounted in units of volume).

3 — *Pattern approval testing of liquid metering assemblies*

by D. Mencke, Physikalisch-Technische Bundesanstalt, F.R. of Germany

The lecturer reviewed the steps for pattern approval testing and examination of the various parts constituting a liquid measuring assembly (filters, gas extractor, flow streightener, volume measuring, indicating and conversion devices, ancillary equipment, etc.). The development follows the rules applied in the Federal Republic of Germany and in general the OIML Recommendations No. 5, 27 and 57. Finally the paper described briefly the measurement standards and other equipment used for pattern approval at the PTB

4 — *The development, calibration and implementation of metering systems on bulk milk tankers in England and Wales*

by J.W. Burgess, National Flowmeter and Calibration Centre, Milk Marketing Board, U.K.

The author first explained the role of the Milk Marketing Board of England and Wales, which acting as a farmer's cooperative for 37 000 milk producers, collects the milk and finds a market for it.

This organisation has its own calibration centre for calibrating the turbine (or electromagnetic) flowmeters installed on most of the 2 000 tank trucks operated by haulers under contract. The paper gives a very detailed account of the metrological, technical and administrative aspects of the milk metering for which the Board is responsible in cooperation with the legal authorities.

5 — *Liquid flow calibration using a load cell weighing machine*

by J.S. Paik, Korea Standards Institute, Republic of Korea

The author described the development of load-cell weighing machines of 300, 600 and 6 000 kg capacity for gravimetric calibration of flowmeters. The reproductibility of load cell indication was found to be maintained within 0.02 % of full scale over one year and systematic weighing errors are within 0.05 % of the indicated mass. The over-all uncertainty of the water flow standard facility constructed at Korea Standards Institute is believed to be less than ± 0.2 % in mass flow rate determination.

6 — *Experience from field calibration with a mobile piston prover*

by Mrs K. Mattiasson, National Testing Institute, Sweden

The Swedish metrology service has recently been provided with a mobile unit comprising a truck-mounted compact prover using a moving piston and allowing accurate on-site verification of liquid metering equipment up to flowrates of 26 000 litres per minute. Repeated tests have shown that the uncertainty in on-site calibrations using this mobile prover can be kept less than 0.1 %.

7 — *Bulk measurement of liquid fuel in the U.K.*

by K.R. Searle, Trading Standards Department, Buckinghamshire County Council, U.K.

In past time fraud at tank truck deliveries of liquid fuel was quite frequent. The regulations in the U.K. were modified in 1979 by introducing the provisions of the European Community directives and since 1984 all meter measuring systems are checked by inspectors for conformity to pattern approval certificates. The paper reviewed the principles and procedures of verification including meter tests, system performance, accuracy, etc and highlighted the problems encountered in particular as regards correct operation of the gas extractor and associated devices.

8 — *Activities of independent calibration companies in the metrology of bulk liquids*

by Alan T.J. Hayward, Moore, Barrett & Redwood, U.K.

Independent calibration companies in the field of bulk measurement of liquids are giving services to industry, and mainly the petroleum industry, for calibrating tanks, metering equipment and pipe provers. They usually have close links with the national legal metrology authorities in particular as regards the traceability to primary standards.

From the discussions following the presentation of the paper it appears that the effective accuracy in field calibrations in many countries is limited by the accuracy and range of the primary volume measuring standards available at the central national laboratories, installations which may on the whole be very expensive but necessary though not frequently used.

9 — *Verification of LPG flowmeters in Australia*

by T.J. Buca, National Standards Commission, Australia

Several types of verification methods of liquefied petroleum gas dispensers are used throughout Australia including volumetric provers, master meters and gravimetric methods. The volumetric system has for several reasons not proved to be a very successful method for field use. The main difficulty with the rather convenient gravimetric method is related to the measurement or appreciation of the density of the various LPG mixtures. The master flow-meter method is also convenient but usually requires frequent access to a calibration check facility.

A combination of a turbine flowmeter with a loop prover of 245 L capacity was found to be a versatile solution by some of the State verification authorities and furthermore allows extension to higher flowrates enabling the verification of tank truck LPG meters. The author concluded that there is any way need for comparing the different methods with the national central laboratory calibration facility.

10 — *Survey of methods used in Europe for the verification of retail LPG dispensers*

by J. Goellner, Sous-direction de la métrologie, France

This paper, which was presented in French with a distributed translation in English, reviewed the results of an intercomparison of various LPG calibration methods undertaken in 1982 within the framework of the European Community.

LPG dispensers located at four different places in Europe were calibrated with a mobile piston prover and with one of the four following measuring systems : closed volumetric prover (bombola), prover with double water displacement, single water displacement prover and master meter.

From the discussions which followed the presentation of this and some of the other papers, it appears that attention has to be paid by the verification authorities to improve the accuracy of the primary calibration facilities for LPG volume measurements. To-day LPG meters used on dispensers and tank trucks are of such quality that the limits of error of 0.5 % can be maintained over a flowrate ratio (turndown) of 10. The piston provers which have been developed for testing such meters show a very good reproducibility, but the uncertainty of the means available for their initial verification is high and sometimes reaches the maximum permissible errors of modern LPG metering assemblies.

Some of the participants suggested that OIML should elaborate a Recommendation on calibration methods for LPG meters before concluding the work which has just started on drafting a special Recommendation on LPG metering assemblies.

11 — *Calibration of volumetric tank truck LPG meters*

by S. Miraucourt, Sous-direction de la métrologie, France

This paper was also presented in French with distributed English translation.

In France the number of LPG tank truck meters is about 1 200 and legal control started in 1965. There are presently two fixed calibration installations using double water displacement provers.

The other method currently employed makes use of mobile units equipped with pipe provers. The author reviewed the various practical problems such as cavitation of pumps, elimination of vapour, meter slip and more specific calibration problems related to temperature variations, adjustment of test pressure and impulse generator fitting to the meters when using the pipe prover, as well as wear problems.

A statistical analysis of calibration results of tank truck meters over a number of years revealed noticeable drift requiring readjustment of the meters at least once a year. Some petroleum distributing companies now even prefer to make a recalibration (and if necessary readjustment) 6 months after each regulatory verification.

12 — *Examination of an LPG liquid measuring meter installed on a tank truck*

by O.K. Warnlof, National Bureau of Standards, Gaithersburg, USA

This presentation covered the operations generally conducted in the U.S.A. for field examination of LPG metering systems installed on trucks. These operations are listed in the guidelines named « Examination Procedure Outline » published by NBS (Handbook 112 under revision) which refer to the well-known NBS Handbook 44 as regards specifications, tolerances and other technical requirements.

13 — *Verification of high flowrate industrial meters in France*

by C. Rey, Direction Régionale de l'Industrie et de la Recherche, Aix-en-Provence, France

This short paper very briefly described the mobile on-site and the centralized systems used in France for calibrating high capacity industrial flowmeters and served mainly as introduction to the following paper and the subsequent technical visits.

14 — *Improvement of the accuracy of the measuring stations of the South European Pipeline (SPSE)*

by Y. Barriol & J.L. Convert, Société du Pipeline Sud-Européen, Fos-sur-Mer, France

The measurement of the quantity of crude oil supplied through the South European Pipeline is made by turbine meters. Density meters are also installed for the evaluation of the mass supplied. The turbine meters are periodically calibrated on the standard pipe prover installed at Fos-sur-Mer which allows tests up to a flowrate of 4 000 m^3/h and which the participants could see in operation.

Even though the meters are all calibrated under the same conditions at the calibration station it is necessary to consider the geometrical configuration of the pipework at each metering station installed on the pipeline and which creates systematic differences in indication. These differences are attenuated by the prescribed streight pipes and flow streighteners which are all identical and practically form an assembly with the meter. However, a still better overlapping of metering results was obtained by the SPSE company by using, at all the metering stations and at the calibration station, a specially designed flow conditioner (or flow mixer) installed upstream at the entry of the streight pipe of each metering assembly. The paper describes the results obtained with this device which has been approved by the legal metrology authorities concerned.

15 — *LPG measuring for retail in the Netherlands*

by J.J. Françoijs and A. Kooiman, Dienst van het IJkwezen, Netherlands

The authors described in a short paper the volumetric prover used in the Netherlands for verifying road-side LPG dispensers. Thanks to some modifications introduced in the mechanical design, improved temperature measurements and the use of a computerized calibration procedure, the authors think that this system can now be evaluated as a high quality standard and has the advantage of moderate pressure loss at the same time as water is avoided which could otherwise develop corrosion in the meters to be tested.

16 — Verification of retail LPG dispensers in the U.K.

by C.S. Cornwall, National Weights and Measures Laboratory, U.K.

This paper, which was presented by W.D. Jones, described a new mobile LPG calibrating unit developed by the National Weights and Measures Laboratory for hire to Local enforcement authorities in the U.K. The new unit which can be used for verification of both dispensers and tank truck meters consists of a trailer on which two proving tanks of 200 L and 100 L capacity are mounted. The calibration of these provers is done in the central laboratory in Teddington using water and 2 × 50 L standard measures which are calibrated gravimetrically using a 125 kg balance.

17 — *Direct mass flow measurement*

by B.R. Hoover, Micromotion Inc., Boulder, USA

Considerable interest in direct mass flow metering has been noticed in recent years. The Coriolis-effect seems to be the most favoured measuring principle and at least 8 manufacturers have, or are, developing meters based on this principle.

The author who represents a wide-spread make of such meters, reviewed a few of the early developments and described tests made at the PTB on new designs of such meters. These tests were also commented by Dr Mencke from PTB. Work on drafting requirements for such meters is envisaged by OIML and an enquiry is now in progress. In the USA it is proposed to apply maximum permissible errors of ± 0.2 % on initial verification and 0.3 % in service over a 1:5 flow rate ratio for such meters. Mass provers must also be made available which have sufficient accuracy and can be used for on-site calibration of installed mass meters.

18 — *Direct mass flow metering - principles, equipment and basic properties*

by W. Steffen and W. Stumm, Krohne Messtechnik Massametron GmbH, Fed. Rep. of Germany

Dr Stumm, who presented this paper, first reviewed the historical development of direct mass metering including thermal and momentum methods followed by descriptions of various Coriolis-effect mass flow measuring devices. The paper analyzed in detail the design of oscillating systems of this type, the output signals and general measuring characteristics. The means for suppression of noise resulting from shock and external vibration by using digital filtering were also treated as well as calibration results obtained for varying temperature and pressure conditions.

The accuracy of such meters is at low flowrates limited by thermal noise of the movement and at high flowrates by pressure loss and cavitation effects. However, the calibration results under various conditions show that error limits of ± 0.2 % over a flow rate ratio of 1:5 can easily be maintained as already mentioned by the previous lecturer.

The application of such meters for multiple phase flow measurements is possible as regards finely injected gas or fine solid grain admixtures but becomes more difficult in gas-liquid systems when the gas volume represents more than 4 %.

19 — *Comparison of geometrical methods used for calibrating storage tanks*

by I. Chren, Czechoslovak Institute of Metrology

As the author could finally not attend the seminar, this paper was only distributed. It analyses the errors in calibration of cylindrical vertical tanks by two methods : inner radii measurements and the circumferential strapping technique.

20 — *Internal calibration of tanks by laser theodolite*

by P. Canavaggio and P. Demany, Sous-direction de la métrologie, France

This presentation, which was accompanied by a demonstration of the equipment, described the new system now used by the French legal metrology service for gauging of reservoirs. Previously a system requiring two theodolites was used but not found convenient for gauging ship reservoirs due to the movement of the tank and the necessity of maintaining a fixed distance between the two instruments.

The new system uses one theodolite with electronic reading of horizontal and vertical angles on which the sight tube is equipped with a direct distance measuring laser. The instrument when installed inside a tank has a repeatability of about 3 mm for distances between 2 to 10 m and does not require any reflector for measuring short distances which makes it very convenient to use.

This theodolite is connected to a computer and data system which allow direct evaluation and recording of tank volume from a number of measurements taken on the various tank surfaces. For the purpose of computation these surfaces are divided into individual elements (plane, cylinder, annulus, spherical cap, etc.). The coordinates of the theoretical model of each surface element are computed from the actual measurements by using the method of least squares.

Conclusions

It seems from the satisfaction expressed by several participants that the seminar attained the goals which we had set up.

From the technical point of view, and as mentioned above under the titles of some of the presentations, the meeting concluded that

— the national metrology services should make efforts to improve the accuracy of their national reference standards for large liquid volume and high flowrate,

— particular efforts should be made to develop better reference standards for systems measuring liquefied petroleum gas,

— the increasing use of mass metering in industry requires the development of mobile mass provers.

We thank the French metrology services, on national and regional level as well as the participating industries for their technical and logistic cooperation.

We also extend our gratitude to the Chamber of Commerce and Industry and to the Lordmayor of Arles and to the persons in charge and technicians at the Institut de Régulation et Automation who accepted to host the seminar and ensured its success.

La VÉRIFICATION des INSTALLATIONS de MESURE de VOLUME de LIQUIDES

Séminaire OIML à Arles, France, 11-15 mai 1987

Le but des séminaires de l'OIML est de mettre le personnel des services nationaux de métrologie au courant du progrès technologique dans différents domaines et de permettre un échange entre spécialistes sur des problèmes rencontrés dans l'exercice de leurs activités.

Faisant suite au séminaire sur la vérification des installations de pesage en vrac, qui a eu lieu à Paris en avril 1985 et dont les exposés ont été publiés dans le Bulletin, la liste des priorités montrait un intérêt particulier pour les mesures de gros volumes de liquides. A la réunion d'un secrétariat-rapporteur de l'OIML il avait également été demandé de traiter les problèmes de mesure de gaz de pétrole liquéfié (GPL). De plus, en vue de l'intérêt croissant pour le comptage massique, il fut également décidé d'inclure ce sujet dans le programme du séminaire.

L'Institut de Régulation et d'Automation à Arles, dans le sud de la France, avait sur proposition du Service français de métrologie bien voulu accepter de nous accueillir dans leurs murs. Cet Institut qui est régi par la Chambre de Commerce et d'Industrie d'Arles, dispense une formation continue aux ingénieurs et techniciens de l'industrie française et étrangère dans les domaines de la mesure et de la régulation. Les participants ont pu apprécier les excellentes installations de cet Institut au cours d'une visite des salles de cours et des laboratoires.

Arles est une ville ancienne riche de nombreuses antiquités romaines. Monsieur le Maire d'Arles a offert des tours guidés aux participants permettant de voir quelques-uns de ces monuments, suivis d'une réception à l'Hôtel de Ville.

Le sujet du séminaire avait attiré au total 63 participants dont 23 de France. En comparaison aux séminaires précédents, on constate une répartition géographique bien plus large de la participation embrassant ainsi 26 pays différents dont un pays membre-correspondant (Albanie) et un pays invité (Arabie Saoudite).

En plus des exposés et discussions résumés ci-dessous, nous avions pu arranger des visites techniques d'une demi-journée permettant de voir les installations d'étalonnage de la Société du Pipe-line Sud-Européen (SPSE) à Fos-sur-Mer et en même temps la vérification d'un compteur de camion-citerne à l'aide d'un tube étalon mobile appartenant à Mestrole, une société d'étalonnage agréée par le service français de métrologie. En liaison avec ces visites les participants ont pu voir brièvement un peu du pays de Camargue et ses oiseaux.

Afin d'illustrer les activités françaises dans le domaine du gaz de pétrole liquéfié, la société Geostock a bien voulu nous montrer un vidéo-film sur les importantes installations souterraines de stockage situées à Lavera en bordure de la Méditerranée. La société Mestrole a également montré un film sur ses activités et organisé des démonstrations par petits groupes de la vérification d'un compteur routier de GPL dans une station de carburants proche des locaux du séminaire. (La jauge à piston utilisée pour ces étalonnages a été décrite dans un article de L. Silvert dans le Bulletin de l'OIML N° 88, septembre 1982).

La majeure partie des exposés a eu lieu en anglais (sans traduction). Comme la plupart seront publiés dans le Bulletin de l'OIML, nous ne donnons ci-dessous que de brefs résumés.

M. J.A. Videau, Directeur de l'Institut de Régulation et d'Automation, a en ouverture souhaité la bienvenue aux participants et résumé les activités de son Institut.

Le conférencier suivant M. J. Dumolard, responsable pour la section de métrologie de la Direction Régionale de l'Industrie et de la Recherche, a ensuite expliqué l'organisation administrative de la métrologie légale en France et en particulier au niveau régional.

1 — *Comptage de liquides à gros débit, revue des méthodes actuelles et tendances*
par Alan T.J. Hayward, Moore, Barrett & Redwood, Royaume-Uni

Le conférencier qui est l'auteur d'un livre bien connu sur les mesures de débit de liquides, avait répondu favorablement à la demande du BIML de présenter un exposé passant en revue les différents types de gros compteurs et leur étalonnage. Cet article qui peut bien convenir à l'enseignement de ces techniques, a déjà été publié dans notre Bulletin N° 107, juin 1987.

2 — *Implications métrologiques aux stations de distribution de produits pétroliers*
par A. Nadolo, Institutul National de Metrologie, Roumanie

Cet exposé a simplement été distribué, l'auteur étant empêché de se présenter à temps pour le séminaire. L'exposé analyse et additionne les différentes erreurs qui peuvent résulter dans les transferts et transports de produits pétroliers depuis le premier point de livraison à la raffinerie (comptabilisée en masse) jusqu'au point final de livraison au détail (comptabilisée en volume).

3 — *Approbation de modèle des ensembles de mesure de liquides*
par D. Mencke, PTB, R.F. d'Allemagne

Le conférencier a passé en revue les différentes étapes des essais pour l'approbation de modèle des constituants d'un ensemble de mesure de liquides (filtres, purgeurs de gaz, redresseurs d'écoulement, mesureurs de volume, indicateurs et dispositifs de conversion, dispositifs auxiliaires, etc.). La conduite des essais suit la réglementation établie en Rép. Féd. d'Allemagne et en général les RI 5, 27 et 57 de l'OIML. L'auteur a également décrit les étalons et autres équipements d'essai utilisé par la PTB.

4 — *L'évolution, l'étalonnage et l'installation des systèmes de mesure sur les camions citernes laitiers en Angleterre et au Pays de Galles*
par J.W. Burgess, National Flowmeter and Calibration Centre, Milk Marketing Board, Royaume-Uni

L'auteur a d'abord expliqué le rôle du Milk Marketing Board (Comité de commercialisation du lait) d'Angleterre et du Pays de Galles qui, sous forme de coopérative, groupe 37 000 producteurs de lait, prend livraison du lait et s'occupe de sa commercialisation.

Cette organisation a son propre centre d'étalonnage pour les compteurs turbine (et électromagnétiques) installés sur un grand nombre des 2 000 camions citernes de ramassage gérés ou appartenant à des transporteurs sous contrat. L'exposé comporte une description très détaillée des aspects métrologiques, techniques et administratifs de comptage du lait dont l'organisation est menée en coopération avec les autorités légales.

5 — *Etalonnage des compteurs de liquides utilisant un instrument de pesage à cellules de charge*
par J.S. Paik, Korea Standards Institute, République de Corée

L'auteur a décrit la construction de peseuses à cellules de charge ayant des capacités de 300, 600 et 6 000 kg pour l'étalonnage gravimétrique de compteurs de liquides. La reproductibilité des indications des cellules de charge est maintenue à 0,02 % de la capacité pendant une année et les erreurs systématiques sont inférieures à 0,05 % de la masse indiquée. L'incertitude globale de l'étalon de mesure de débit d'eau de l'Institut est estimée inférieure à ± 0,2 % en débit massique.

6 — *Expérience des étalonnages avec une unité mobile comportant un tube étalon à piston*

par Mme K. Mattiasson, Statens provningsanstalt, Suède

Le service suédois de métrologie a récemment été équipé d'une unité mobile comportant une jauge à piston montée sur camion qui permet la vérification in situ de compteurs de liquides allant jusqu'à un débit de 26 000 litres par minute. Des essais répétés ont montré que l'incertitude des étalonnages utilisant ce type de jauge peut être maintenue au-dessous de ± 0,1 %.

7 — *Mesure de grosses quantités d'hydrocarbures liquides au Royaume-Uni*

par K.R. Searle, Trading Standards Department, Buckinghamshire County Council, Royaume-Uni

Il y a encore quelques années, la fraude lors de livraisons de fuel était assez fréquente. La réglementation du Royaume-Uni a été modifiée en 1979 par l'introduction des dispositions des directives de la Communauté Européenne et depuis 1984 tous les systèmes de comptage sont vérifiés par les inspecteurs pour leur conformité aux certificats d'approbation de modèle. L'exposé passe en revue les procédures de vérification comportant les essais de compteurs, les performances du système, les exactitudes, etc. et mentionne en particulier quelques problèmes rencontrés en ce qui concerne le fonctionnement correct du purgeur de gaz et des dispositifs auxiliaires.

8 — *Activités des sociétés indépendantes d'étalonnage dans le domaine de la métrologie de grosses quantités de liquides*

par Alan T.J. Hayward, Sté Moore, Barrett & Redwood, Royaume-Uni

Les sociétés indépendantes dans le domaine de la mesure de grosses quantités de liquides fournissent des prestations à l'industrie, et surtout l'industrie pétrolière, sous la forme de jaugeages de réservoirs, étalonnage des ensembles de comptage et des tubes étalons. Elles ont généralement des liaisons directes avec les autorités de métrologie légale, en particulier en ce qui concerne le raccordement aux étalons primaires.

De la discussion qui a suivi cet exposé il ressort que l'exactitude des étalonnages effectués sur le tas dépend en fin de compte dans beaucoup de pays de l'exactitude et de l'étendue de mesure des étalons primaires dont dispose le laboratoire central du service national de métrologie. Ces installations peuvent en fait être très coûteuses mais elles sont nécessaires bien que la fréquence de leur utilisation soit souvent faible.

9 — *Vérification des ensembles de mesure de GPL en Australie*

par T.J. Buca, National Standards Commission, Australie

Plusieurs méthodes de vérification des distributeurs routiers de gaz de pétrole liquéfié sont utilisées en Australie comprenant des jauges volumétriques, compteurs pilotes et méthodes gravimétriques. Il s'est avéré que le système volumétrique, pour des raisons diverses, ne convient pas bien aux mesures sur le tas. La difficulté majeure avec la méthode gravimétrique, qui autrement est relativement commode, se rapporte à la mesure ou l'appréciation de la masse volumique des différents mélanges de GPL. Le compteur pilote constitue également une méthode facile à employer mais demande cependant l'accès fréquent à un dispositif de vérification de l'étalonnage.

La combinaison d'un compteur turbine avec un tube étalon ayant une capacité de 245 litres est une solution assez universelle qui a trouvé faveur auprès des autorités de vérification de quelques Etats d'Australie. Elle permet également l'extension aux débits plus importants de façon à rendre possible l'étalonnage de compteurs montés sur camion-citerne. L'auteur a conclu qu'il y a certainement un besoin d'intercomparer les différents systèmes d'étalonnage avec un étalon primaire au laboratoire central national.

10 — *Panorama des moyens utilisés en Europe pour la vérification des distributeurs routiers de GPL*

par J. Goellner, Sous-direction de la Métrologie, Paris

Cet exposé résume les résultats d'une intercomparaison de différentes méthodes d'étalonnage, entreprise en 1982 dans le cadre de la Communauté Européenne.

Des distributeurs routiers de GPL installés à quatre endroits différents en Europe ont été étalonnés en même temps par un tube à piston et un des quatre moyens suivants : jauge volumétrique fermée (bombola), jauge à double déplacement d'eau, jauge simple à déplacement d'eau et compteur pilote.

Des discussions qui ont suivi cet exposé et d'autres sur le même sujet il apparaît que les autorités de vérification doivent s'efforcer d'améliorer l'exactitude des installations primaires de vérification de volume de GPL. Les compteurs de GPL installés dans les distributeurs ou sur les camions citernes ont en effet aujourd'hui des caractéristiques telles que les limites d'erreurs de ± 0,5 % peuvent être maintenues pour un rapport de débit de 1 : 10. Les jauges à piston qui ont été spécialement construites pour la vérification de ces compteurs s'avèrent donner des résultats très reproductibles mais l'incertitude des moyens disponibles pour leur étalonnage initial est élevée et atteint parfois les erreurs maximales tolérées des ensembles modernes de comptage de GPL.

Quelques intervenants ont suggéré que l'OIML élabore d'abord une Recommandation sur les méthodes d'étalonnage de compteurs de GPL avant de conclure le travail qui vient de commencer sur une Recommandation spéciale pour les ensembles de mesure de GPL.

11 — *Etalonnage des compteurs volumétriques de GPL installés sur camion-citerne*

par S. Miraucourt, Sous-direction de la Métrologie, Paris

En France, le nombre de compteurs de GPL installés sur camion-citerne est d'environ 1 200. Le contrôle légal de ces compteurs a débuté en 1965. Il existe actuellement deux installations fixes d'étalonnage utilisant des jauges à double déplacement d'eau.

L'autre méthode couramment employée comporte l'utilisation d'unités mobiles équipées de tubes étalons. L'auteur a passé en revue les différents problèmes pratiques inhérents aux compteurs tels que cavitation, présence de vapeur, étanchéité interne et, plus spécifiquement, les problèmes d'étalonnage liés aux variations de température, réglage de la pression d'essai et montage de l'émetteur d'impulsion lorsqu'on utilise un tube étalon, ainsi que des problèmes d'usure.

Une étude statistique des résultats d'étalonnage effectués sur des camions citernes pendant plusieurs années a mis en évidence une dérive importante des compteurs, ce qui nécessite une vérification et un réajustage au moins une fois par an. Certaines compagnies de pétrole préfèrent même refaire une vérification (et si nécessaire un ajustage) 6 mois après chaque vérification réglementaire.

12 — *Vérification d'un compteur GPL monté sur camion-citerne*

par O.K. Warnlof, National Bureau of Standards, U.S.A.

L'auteur de cet exposé a décrit les étapes de vérification habituellement effectuées aux Etats-Unis des compteurs GPL installés sur camion. La procédure est décrite dans le guide « Examination Procedure Outline » publié par NBS (Handbook 112 actuellement en cours de révision) qui se réfère, en ce qui concerne les spécifications techniques et métrologiques, à la publication NBS Handbook 44.

13 — *Vérification des compteurs de gros débit en France*

par C. Rey, Direction Régionale de l'Industrie et de la Recherche de Provence-Alpes-Côte d'Azur

Cet exposé décrivant brièvement les systèmes centralisés et mobiles utilisés en France pour l'étalonnage de gros compteurs, avait surtout pour but de servir d'introduction à l'exposé suivant et aux visites techniques.

14 — *Amélioration de la précision de comptage du pipe-line Sud-Européen (SPSE)*

par Y. Barriol et J.L. Convert, Direction technique de la Société du Pipeline Sud-Européen, Fos-sur-Mer, France

Le mesurage de la quantité de pétrole brut transporté par le pipeline sud-européen est effectué à l'aide de compteurs turbine. Des capteurs mesurant la masse volumique sont également installés, ce qui permet d'obtenir la quantité transportée en unités de masse. Les compteurs turbine sont périodiquement étalonnés à l'aide d'un gros tube étalon installé à Fos-sur-Mer, qui permet d'effectuer des essais jusqu'à un débit de 4 000 m^3/h et que les participants du séminaire ont pu voir en fonctionnement.

Bien que tous les compteurs du pipeline soient étalonnés à la même station d'étalonnage, il est nécessaire de prendre en considération les écarts systématiques qui peuvent résulter du fait que la configuration géométrique des tuyauteries n'est pas identique d'une station de mesurage à l'autre. Ces écarts sont atténués par les parties droites et tranquilliseurs d'écoulement qui sont installés en amont de chaque compteur et qui sont prescrites dans les normes. Ces dispositifs sont tous identiques et forment un ensemble avec le compteur. Cependant en vue de diminuer encore les écarts résiduels et mieux faire coïncider les résultats de comptage des différentes stations, la SPSE a mis au point un conditionneur (ou mélangeur) d'écoulement qui est installé en amont du tuyau droit précédant chaque compteur. L'exposé décrit les résultats obtenus avec ce dispositif qui a été agréé par les services de métrologie légale concernés.

15 — *Mesure de GPL pour la distribution au détail*

par J.J. Françoijs et A. Kooiman, Dienst van het IJkwezen, Pays-Bas

Les auteurs ont, dans un bref exposé, décrit la jauge volumétrique utilisée aux Pays-Bas pour la vérification des distributeurs routiers de GPL. Grâce à quelques modifications introduites dans la construction mécanique, un système amélioré de la prise de température et un procédé de calcul par mini-ordinateur, cette méthode constitue, selon les auteurs, un étalon de haute qualité en même temps qu'elle a les mérites de ne produire qu'une faible perte de pression et évite l'emploi d'eau qui pourrait donner lieu à corrosion dans les compteurs à vérifier.

16 — *Vérification des distributeurs routiers de GPL au Royaume-Uni*

par C.S. Cornwall, National Weights and Measures Laboratory, Teddington, Royaume-Uni

Cet exposé présenté par Mr W.D. Jones comportait la description de l'unité mobile d'étalonnage récemment conçue par le National Weights and Measures Laboratory pour location aux autorités locales de vérification au Royaume-Uni.

Cet équipement qui peut être utilisé pour la vérification des distributeurs routiers, et au besoin des compteurs montés sur camion-citerne, consiste en une remorque sur laquelle deux jauges de 200 et 100 litres peuvent être installées. L'étalonnage de ces jauges est effectué au laboratoire central à Teddington en utilisant de l'eau et des jauges étalons de 2 × 50 litres qui sont étalonnées par pesée sur une balance ayant une capacité de 125 kg.

17 — *Mesurage direct de débit massique*

par B.R. Hoover, Micromotion Inc., Boulder, U.S.A.

Le mesurage massique direct suscite un grand intérêt depuis quelques années. L'effet Coriolis paraît être le principe de mesure qui est le plus en faveur et il y a au moins huit constructeurs qui ont développé, ou sont en train de développer, des compteurs basés sur ce principe.

L'auteur qui représente une marque répandue de compteurs massiques de ce type, a d'abord passé en revue quelques-unes des constructions anciennes pour ensuite décrire des essais effectués à la PTB sur des constructions récentes.

Ces essais furent également commentés par le Dr Mencke, représentant la PTB, qui a mentionné que des travaux sur une Recommandation pour ces compteurs sont envisagés par l'OIML et qu'on attend le résultat d'une enquête à ce sujet. Aux Etats-Unis on propose d'appliquer des erreurs maximales tolérées de ± 0,2 % à la vérification primitive et ± 0,3 % en service et ceci pour un rapport de débit de 1 : 5.

Des étalons mobiles pour le débit massique doivent être mis au point et avoir une exactitude suffisante pour permettre l'étalonnage de compteurs massiques déjà installés.

18 — *Mesure directe de débit massique - principes, équipement et caractéristiques principales*

par W. Steffen et W. Stumm, Krohne Messtechnik, Massametron GmbH, Rép. Féd. d'Allemagne

Cet exposé présenté par M. Stumm a débuté aussi par une revue historique des méthodes de mesure de débit massique utilisant la conductibilité thermique ou le moment d'inertie pour ensuite rentrer plus dans les détails des constructions basées sur l'effet Coriolis. L'exposé a notamment analysé les différents types de systèmes oscillants, les signaux de sortie et les caractéristiques métrologiques en général.

Les moyens pour supprimer le bruit provenant de chocs et vibrations extérieures en utilisant un filtrage digital, ont également été décrits ainsi que les résultats d'étalonnage obtenus lorsque le compteur est soumis à des variations de température et de pression.

L'exactitude de ce type de compteur est à des débits faibles limitée par le bruit thermique et à débits élevés par la perte de pression et effets de cavitation. Les résultats d'étalonnage dans des différentes conditions montrent néanmoins que les limites d'erreurs de ± 0,2 % pour un rapport de débit de 1 : 5 peuvent aisément être atteintes comme cela avait déjà été précisé par le conférencier précédent.

L'utilisation de ce type de compteur pour la mesure de produits séparés en plusieurs phases est possible en ce qui concerne du gaz finement injecté ou des particules sous forme de grains fins, mais cela devient difficile dans un système gaz-liquide lorsque le volume de gaz représente plus de 4 % du total.

19 — *Comparaison des méthodes de jaugeage de réservoirs de stockage*

par I. Chren, Institut Tchécoslovaque de Métrologie

Comme l'auteur n'a finalement pas pu venir au séminaire, cet exposé a simplement été distribué (en français et en anglais). L'article compare les erreurs d'étalonnage des réservoirs cylindriques verticaux lorsqu'on utilise la méthode de mesure des rayons internes et la méthode de la mesure des circonférences.

20 — *Jaugeage interne des réservoirs par théodolite laser dimensionnel*
par P. Canavaggio et P. Demany, Sous-direction de la Métrologie, Paris

Cet exposé qui était accompagné d'une démonstration du matériel, décrit le nouveau système utilisé par le service français pour le jaugeage des réservoirs.

Précédemment, une méthode utilisant deux théodolites était employée mais elle s'est avérée difficile à appliquer pour le jaugeage de réservoirs de bateaux à cause des mouvements de ceux-ci joints à la nécessité de maintenir une distance fixe entre les deux instruments.

Le nouveau système n'emploie qu'un théodolite mais qui est équipé des systèmes de lecture électronique des angles horizontaux et verticaux, et sur lequel le tube de visée est pourvu d'un laser permettant les mesures directes de distances. Lorsqu'il est utilisé à l'intérieur d'un réservoir, l'instrument permet d'obtenir une répétabilité de la mesure de l'ordre de 3 mm pour des distances de 2 à 10 m et ne nécessite pas l'emploi d'un réflecteur pour de courtes distances, ce qui rend son emploi très commode.

Le théodolite est relié à un micro-ordinateur permettant l'évaluation directe et l'impression du volume du réservoir (barème) à partir d'un certain nombre de pointés sur les différentes surfaces du réservoir.

Ces surfaces sont, pour les besoins du calcul, divisées en éléments individuels (plan, cylindre, virole, coupe sphérique, etc.). Le mode de calcul utilise la méthode des moindres carrés afin de calculer à partir des mesures effectuées, les coordonnées du modèle théorique de chacun de ces éléments.

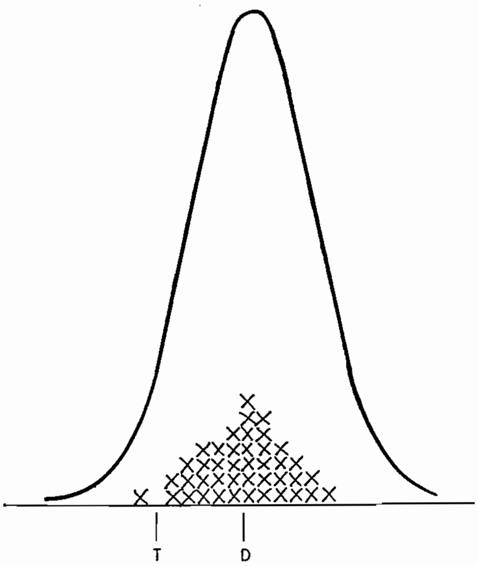
Conclusions

D'après la satisfaction exprimée par de nombreux participants, il semble que ce séminaire a atteint les buts que nous nous étions fixés.

Sur le plan technique, et comme cela a été indiqué ci-dessus sous certaines rubriques des exposés, la réunion a conclu que
— les services nationaux doivent œuvrer pour améliorer l'exactitude des étalons de référence de volume de forte capacité et fort débit,
— des efforts doivent plus particulièrement être faits pour développer de meilleurs étalons de référence pour les compteurs de gaz de pétrole liquéfié,
— l'utilisation croissante dans l'industrie de débitmètres massiques exige la mise au point de dispositifs d'étalonnage facilement transportables.

Nous tenons à remercier les services français de métrologie, sur le plan national et régional, ainsi que les industriels participants, pour leur coopération technique et logistique.

Nos remerciements chaleureux s'étendent bien entendu également à la Chambre de l'Industrie et du Commerce, à Monsieur le Maire d'Arles et aux responsables et techniciens de l'Institut de Régulation et d'Automation, qui ont bien voulu accueillir le séminaire et assurer son succès.



PROGRESS of OIML WORK on CONTROL of NET CONTENT in PACKAGES and STATISTICAL TESTING

Many metrology services have shown great interest for OIML activities in the field of control of net content in packages and statistical test methods in general. This has induced the reporting secretariats within SP 20 dealing with these matters to accelerate the work during the last years. The discussions and decisions at the recent meetings in Göteborg, Sweden in June 1987 seem to have finalized the most important phase of the work programme. The purpose of these notes is to very briefly review the drafts and other publications related to these activities.

Labelling (SP 20-Sr 1 - U.S.A.)

The control of net content of packages requires first that there is sufficient information on the labels of the packages to allow such control. The nominal content must thus be indicated in a clearly legible form and without possible confusion. The name of the packed commodity and the name of the responsible manufacturer, packer or distributor must also be stated. General prescriptions for net content label information are the subject of the draft International Recommendation « Information on Package Labels » elaborated by SP 20-Sr 1, which will be submitted for sanction by the International Conference of Legal Metrology in October 1988.

Net content (SP 20-Sr 2 - Switzerland)

The requirements for net content of packages are laid down by the draft « Net content in packages » elaborated by SP 20-Sr 2. This draft has now been sent to all CIML members for a preliminary vote correspondence before being submitted to the Conference in 1988.

The requirements contained in this draft are based on the so-called « average system » whereby the average net content conveyed by any lot of packages shall equal or exceed the nominal content indicated on the label. The tested lots shall each consist of a sufficiently great number of units so as to reflect the actual production. Individual packages shall not show variations from the declared net content by more than a negative tolerance which is accepted on condition that it corresponds to normal fluctuations in the packaging process.

The Appendix to this draft Recommendation contains a tolerance table and advice to legal metrology services how to execute control of the above requirements using statistical methods. It is worth noting that the reporting secretariat agreed to specially recommend the use of a sampling plan with a sample size of 32 units as an economical solution for such tests*.

The indicated tests assume that random sampling can be applied, which is unfortunately not always the case in shops or warehouses.

The secretariat also stresses in a Note to the introduction to the draft that the described test methods are not sufficient for use by manufacturers.

Products difficult to test

Tolerance tables

In the early days of package control, several legal authorities applied different tolerance tables for individual packages depending on whether the products were « easy » or « difficult » to pack in constant quantities. Later it was found better to consider that most products were difficult to pack and only one tolerance table was retained which, in most countries, is in line with that indicated in the Appendix to the OIML draft « Net content in packages ».

This table applies in particular to products which are fully enclosed in containers with no exchange to the environment.

Moisture loss

A number of problems arise with products that are affected by moisture and not hermetically enclosed in the packing material. Frozen food is a subject of special consideration as it may contain a great amount of water. The list of such « difficult » products is rather long. The net content, however, is not the only factor to be considered as the quality of the product may also be affected by moisture content variations and this is sometimes more important for the consumer than the net quantity.

As the problems concerned depend very much on local conditions and are product-specific it has been found rather difficult to deal with them generally and strictly on a legal metrology basis. However the draft « Net content in packages » mentions that changes of the average content caused by ordinary and customary exposure to conditions which normally occur shall be recognized by the inspection authority.

Yarn

A special situation concerns yarn and textile fibers when sold by weight. In this case, each type of fiber may be estimated to have a standardized percentage of water content (in standard ambiance of 20 °C and RH = 65 %). Tests of samples taken in the field can then be conducted in the laboratory by full drying in an oven (at more than 100 °C), followed by weighing, after which an allowance can be applied from a conventional table established according to the known composition of the fiber. This procedure common in textile testing, is for instance used by enforcement authorities in the Federal Republic of Germany and was briefly described at the OIML seminar « Prepackaged products » in Berne, 6-8 June 1983.

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* Testing procedures using this sample size are included in the Directives to Swedish verification officers, published in the Bulletin de l'OIML No. 84, Sept. 1981.

Drained weight

Another problem is drained weight indications and how to verify them. The drained weight depends on the time at which the tests are carried out after the production.

Drained weight is thus also somewhat too product-specific to be dealt with from the general metrology point of view and it was decided by majority vote within SP 20-Sr 1 at the recent meeting in Göteborg not to maintain it on any immediate work programme.

Let us mention however that Codex Alimentarius has established test rules in this field concerning fruits and vegetables (Preserves in CAC RM 36, 37, 44 and 45 and quick frozen in CAC RM 34). Methods are also described in NBS Handbook 133. The methods used in the Federal Republic of Germany will be subject to a future note in the OIML Bulletin.

Products declared in volume - Density measurements

It is in many cases easier to determine the actual content of a container by weighing than to measure the volume. However, estimating that for a number of products the volume is the main factor of interest to the consumer, several legal authorities have prescribed volume indications for products such as aerosols, ice-cream, paints and lacquers, putties, etc.

To test such products it is generally customary, at least in Europe, to make density determinations on a few representative samples and thereafter proceed by weighing on the other samples. The volume is then calculated from the ratio of mass to density.

Products filled in containers under pressure (so-called aerosol products) are particularly difficult to test especially if they are declared by volume. This difficulty in testing is increased by the fact that the SP 20-Sr 1 draft « Information on package labels » requires that the net content declaration shall apply to the expelled quantity of the product, which is of course of main interest to the consumer. A solution to the difficulty of testing would be to declare exceptionally such products, even when mainly liquid, by weight of expelled product rather than by volume. This seems to be frequently the case in the U.S.A. but is not European practice. Presently some aerosol products indicate statements in both volume and weight.

The problems of density measurement on difficult products were also treated at the OIML seminar in Berne in 1983 and these presentations were subsequently published in the OIML Bulletin No. 94 (paper by L.A. van Driel) and No. 96 (paper by J. Rüssing).

Some countries have elaborated special instructions to the inspectors on how to conduct density measurements on various more or less difficult products. At the SP 20-Sr 1 meeting in St-Gallen, Switzerland, in 1986, it was decided to translate into French and English the guidelines elaborated by J.A. Dalm and P. Hogervorst of the Dutch metrology service. This work was entrusted to Mr P. Degavre of the Belgian metrology service for the French version. The English version was then prepared by BIML. The result is an illustrated brochure which now is available from BIML : DENSITY MEASUREMENT - Guidance for Inspectors, March 1987.

Future work of SP 20

The work on labelling and on net content testing can now be said to have reached a stage of accomplishment subject to the usual future revisions.

The subject of products difficult to test, treated within SP 20-Sr 1, has as mentioned encountered numerous difficulties. However, a number of test methods have been published in the OIML Bulletin, the BIML brochure « Density measurements » and in various national publications (see BIML Bibliography). It was decided at the meeting in Göteborg that this matter will now continue to be handled through correspondence and if possible be subject to a draft International Document of informative nature.

Application of statistical methods in verification procedures

(SP 2-Sr 5 - Switzerland)

Net content package control is only one application of statistical test methods. Other applications constitute the general work programme of SP 2-Sr 5, the activity of which was resumed two years ago.

Here again, several metrology services show a great interest but it has been found hard to clearly define the subjects to be treated. It is in fact difficult to propose applicable and useful test methods without knowing the characteristics of the test items as to their design, use, population, location, etc. Items such as length measures, thermometers, electricity and flow meters, etc. would typically require direct technical cooperation with the respective OIML reporting secretariats dealing with these instruments.

Though there exists a very exhaustive literature on the subject and in particular the ISO Handbook No. 3 « Statistical methods », there is definitely a need for guidance in selecting and applying methods and sampling plans to specific metrology problems.

It was finally decided at the meeting of SP 2-Sr 5 in Göteborg in June 1987 that a predraft International Document should be elaborated containing a catalogue of short descriptions of test methods while referring to ISO standards and other publications for details. It would however be necessary to list typical applications for each method. This Document would thus have a similar form and purpose as the International Document No. 11 elaborated by SP 2-Sr 6 for the testing of electronic instruments.

Literature on net content package control

SP 20-Sr 1 draft : Information on Package Labels, August 1986

SP 20-Sr 2 draft : Net Content in Packages, July 1987

BIML brochure : Density Measurements - Guidance for Inspectors, by J.A. Dalm and P. Hogervorst, March 1987

BIML : Bibliography on the control of net quantity of prepackaged goods, November 1983

This bibliography which was originally prepared for the 1983 OIML seminar in Berne should be completed by the following papers presented at the seminar and subsequently published in Bulletin de l'OIML :

Strecker A. — Legal requirements and enforcement of prepackage control in the Federal Republic of Germany.
Bulletin de l'OIML No. 93, December 1983

Vadelund E. — Packaging and Labelling in the USA,
Bulletin de l'OIML No. 93, December 1983

Brickenkamp C.S. — Net contents requirements and their application in the USA,
Bulletin de l'OIML No. 93, December 1983

Zankevitch D. — Expérience française dans le contrôle des préemballages,
Bulletin de l'OIML No. 93, December 1983 (English translation available)

van Driel L.A. — Methods of quantity control of prepackages,
Bulletin de l'OIML No. 94, March 1984

Rüssing J. — Special methods for testing of certain types of prepackages such as sparkling beverages, aerosols, ice-cream,
Bulletin de l'OIML No. 96, September 1984

Bolchover S.P., Harris F. — Use of measuring container bottles in the prepackaging industry,
Bulletin de l'OIML No. 96, September 1984

PROGRÈS des ACTIVITÉS de l'OIML CONCERNANT le CONTROLE du CONTENU NET des PRÉEMBALLAGES et des TESTS STATISTIQUES

De nombreux services de métrologie sont intéressés par les travaux de l'OIML dans le domaine du contrôle du contenu net des préemballages ainsi que dans les tests statistiques d'une façon générale. Ceci a incité les secrétariats-rapporteurs du SP 20 à accélérer les travaux pendant ces dernières années. Les discussions et décisions lors des dernières réunions à Göteborg, Suède, en juin 1987, semblent avoir permis de terminer la phase la plus importante de ces travaux. Le but de ces notes est de passer en revue les projets et autres publications relatives à ces activités.

Etiquetage (SP 20-Sr 1 - U.S.A.)

Le contrôle du contenu net des préemballages suppose d'abord qu'il y ait des informations suffisantes sur les étiquettes des préemballages pour permettre ce contrôle. Le contenu nominal net doit par conséquent être indiqué sans ambiguïté et de façon clairement visible. Le nom du produit et celui du fabricant, emballeur ou distributeur responsable doivent également y figurer. Les prescriptions générales pour ces informations font l'objet du projet de Recommandation Internationale « Etiquetage des préemballages » élaboré par SP 20-Sr 1 et qui sera soumis pour sanction à la Conférence Internationale de Métrologie Légale en octobre 1988.

Contenu net (SP 20-Sr 2 - Suisse)

Les prescriptions en ce qui concerne le contenu net font l'objet du projet « Contenu net des préemballages » élaboré par SP 20-Sr 2. Ce projet a maintenant été adressé à tous les membres du CIML pour vote préliminaire par correspondance avant d'être soumis pour sanction par la Conférence en 1988.

Ces prescriptions sont basées sur le système dit « de la moyenne » par lequel le contenu net moyen d'un lot de préemballages doit être égal ou supérieur au contenu nominal indiqué sur l'étiquette. Les lots soumis aux tests statistiques doivent comprendre un nombre suffisant d'unités afin de refléter la production réelle. Les variations individuelles des préemballages dues aux fluctuations du remplissage ne doivent pas dépasser une tolérance spécifiée par l'autorité de contrôle.

Ce projet de Recommandation contient en son Annexe une table type de tolérances et des conseils aux services de métrologie sur la façon d'exécuter des contrôles par des méthodes statistiques. On peut noter en particulier que le secrétariat recommande spécialement l'utilisation d'un plan d'échantillonnage économique comportant des échantillons de 32 unités*.

Les tests indiqués supposent, bien entendu, que les sondages peuvent s'effectuer au hasard, ce qui n'est malheureusement pas toujours le cas dans les magasins ou les entrepôts.

Le secrétariat souligne également dans une note à l'introduction que les méthodes de tests décrites ne sont pas suffisantes pour le contrôle de qualité de la fabrication.

Produits difficiles à contrôler

Tables de tolérances

Dans les débuts des contrôles de préemballages plusieurs pays utilisaient des tables de tolérances différentes selon que le produit était « facile » ou « difficile » à conditionner à quantité constante. Plus tard on a trouvé qu'il était plus simple de considérer que la plupart des produits sont difficiles à conditionner et par conséquent de n'utiliser qu'une table de tolérances qui pour la plupart des pays est alignée sur celle figurant dans l'annexe au projet de l'OIML « Contenu net des préemballages ».

Cette table s'applique en particulier aux produits qui sont complètement enfermés dans leur emballage sans communication avec l'environnement.

Pertes d'humidité

Les produits qui sont affectés par l'humidité et dont l'emballage n'est pas hermétique créent certains problèmes. Les produits congelés doivent également être considérés en ce qui concerne leur teneur en eau. La liste de ces produits « difficiles » est relativement longue. Le contenu net n'est cependant pas le seul facteur à prendre en compte pour défendre le consommateur car la qualité du produit peut également être fortement affectée par les variations d'humidité.

Puisque ces problèmes dépendent beaucoup des conditions locales et sont spécifiques aux produits concernés, il est difficile de les traiter d'une façon générale et du point de vue purement métrologique. Dans le projet « Contenu net des préemballages » il est cependant indiqué que des dérives de la moyenne, qui peuvent être dues aux conditions normales de stockage et de distribution, doivent être prises en compte par les autorités de contrôle.

Fils textiles

Les fils textiles tels que laines à tricoter, lorsqu'ils sont vendus au poids, constituent un cas particulier. Chaque type de fibre de textile peut en effet être considéré contenir un pourcentage moyen d'eau qui peut être normalisé (pour un environnement de 20 °C et une humidité relative de 65 %). Des échantillons pris sur le tas peuvent alors être pesés au laboratoire après séchage complet (dans un four à plus de 100 °C). Le poids total dans les conditions normalisées peut ensuite être déterminé en ajoutant la quantité d'eau obtenue en utilisant un tableau conventionnel établi en fonction de la composition des fibres. Cette méthode, qui est d'usage courant pour l'essai de textiles, est par exemple utilisée par les services de métrologie en République Fédérale d'Allemagne et a été décrite brièvement lors du séminaire OIML sur les produits préemballés à Berne, 6-8 juin 1983.

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* Ce plan d'échantillonnage est notamment utilisé en Suède et décrit dans le Bulletin de l'OIML N° 84, Sept. 1981.

Poids égoutté

Un autre problème est l'indication de poids net égoutté et la façon de la vérifier. La détermination du poids égoutté dépend en fait dans la plupart des cas du temps écoulé depuis la production.

Le poids égoutté est ainsi également trop spécifique au produit concerné pour être traité du point de vue purement métrologique et il a été décidé par vote majoritaire lors de la récente réunion du SP 20-Sr 1 à Göteborg de ne pas maintenir ce problème sur le programme de travail.

On peut noter cependant que des méthodes d'essais ont été établies par Codex Alimentarius en ce qui concerne des légumes et fruits (Conserves dans CAC RM 36, 37, 44 et 45, et produits congelés dans CAC RM 34). Des méthodes sont également décrites dans NBS Handbook 133. Les méthodes utilisées en République Fédérale d'Allemagne seront décrites prochainement dans le Bulletin de l'OIML.

Produits déclarés en volume - Mesures de la masse volumique

Il est dans bien des cas plus facile de déterminer le contenu d'un récipient par pesage que de mesurer le volume. Cependant, considérant que pour un certain nombre de produits, le volume est d'intérêt majeur pour le consommateur les autorités légales ont souvent prescrit des indications de volume plutôt que poids pour des produits sous forme d'aérosols, crème glacée, peintures et laques, mastics, etc.

Pour contrôler ces produits, il est souvent usuel, du moins en Europe, de déterminer la masse volumique sur quelques échantillons et ensuite procéder par pesage pour les autres échantillons. Le volume est ensuite calculé du rapport masse à masse volumique.

Des produits contenus dans des récipients sous pression (souvent appelés produits aérosols) sont particulièrement difficiles à contrôler. Cette difficulté est accrue par le fait que le projet de SP 20-Sr 1 « Etiquetage des préemballages » exige que la déclaration du contenu net doit se référer à la quantité expulsée du produit ce qui évidemment est le facteur le plus important pour le consommateur. Une solution à la difficulté de contrôle serait d'indiquer sur l'étiquette le poids expulsé de ces produits même lorsqu'ils sont à l'état liquide. Ceci semble être le cas aux U.S.A. mais pas en Europe. Certains fabricants de produits aérosols indiquent en même temps le volume et le poids.

Les problèmes de détermination de la masse volumique des produits « difficiles » étaient également sujet à des exposés lors du séminaire de l'OIML à Berne en 1983, qui ont été publiés dans le Bulletin de l'OIML : exposé de L.A. van Driel dans le N° 94 et celui de J. Rüssing dans le N° 96.

Certains pays ont élaboré des instructions pour leurs agents de vérification en ce qui concerne les méthodes de déterminations de la masse volumique. Lors de la réunion du SP 20-Sr 1 à St-Gall, en Suisse, en 1986, il a été décidé de traduire en français et en anglais les instructions du Service néerlandais de métrologie qui ont été rédigées par MM. J.A. Dalm et P. Hogervorst. Ce travail fut confié à M. P. Degavre du Service belge de la métrologie pour la version française. La version anglaise fut ensuite préparée par le BIML. Cette brochure illustrée est maintenant disponible au BIML : MESURE de la MASSE VOLUMIQUE - Guide pour agents de vérification, mars 1987.

Travaux futurs du SP 20

Les travaux sur l'étiquetage et sur le contrôle du contenu net peuvent maintenant être considérés comme terminés en attendant d'éventuelles révisions à l'avenir.

Les produits difficiles à contrôler, sujet traité par SP 20-Sr 1, ont, comme cela a été indiqué, soulevé de nombreux problèmes. Un certain nombre de méthodes d'essai ont cependant été publiées dans le Bulletin de l'OIML, dans la brochure du BIML « Mesure de la masse volumique » et dans différentes publications nationales (voir la bibliographie du BIML). Il fut décidé à la réunion de Göteborg que ces problèmes doivent continuer à être traités par correspondance et si possible faire l'objet d'un projet de Document International ayant un caractère d'information.

Application des méthodes statistiques à la vérification (SP 2-Sr 5 - Suisse)

Le contrôle du contenu net des préemballages ne constitue qu'une application des méthodes statistiques. Les autres applications font en principe partie du programme général de travail du secrétariat-rapporteur SP 2-Sr 5 qui a repris son activité il y a deux ans.

Les services de métrologie ont, ici encore, montré un grand intérêt pour les travaux mais il n'a pas été aisé de bien délimiter les sujets à traiter. Il est en fait difficile de proposer des méthodes d'essai valables sans connaître les caractéristiques des objets à contrôler quant à leur conception, utilisation, nombre, localisation, etc. L'application aux objets tels que mesures de longueur, thermomètres, compteurs d'électricité et de débit, etc. nécessite en pratique une coopération étroite avec les autres secrétariats-rapporteurs de l'OIML s'occupant de ces instruments.

Bien qu'il existe une littérature abondante sur les méthodes statistiques et en particulier le Manuel ISO N° 3, il y a un besoin évident de conseils pour choisir et appliquer les méthodes et plans d'échantillonnage pouvant convenir aux problèmes spécifiques de la métrologie.

Il a finalement été décidé lors de la réunion du SP 2-Sr 5 à Göteborg en juin 1987 d'élaborer un avant-projet de Document International contenant un catalogue des brèves descriptions de méthodes de contrôle statistique tout en se référant aux normes ISO et autres publications pour les détails. Il sera cependant nécessaire de mentionner des applications typiques pour chaque méthode. Ce Document International sera par conséquent de forme et d'utilisation similaires au Document International N° 11 élaboré par SP 2-Sr 6 pour l'essai d'instruments électroniques.

Littérature sur le contrôle du contenu des préemballages

Projet du SP 20-Sr 1 — Etiquetage des préemballages, août 1986

Projet du SP 20-Sr 2 — Contenu net des préemballages, juillet 1987

Brochure du BIML : Mesure de la masse volumique - Guide pour agents de vérification, par J.A. Dalm et P. Hogervorst, mars 1987

Brochure du BIML : Bibliographie sur le contrôle du contenu des préemballages, novembre 1983

Cette bibliographie qui était à l'origine préparée pour le séminaire de l'OIML en 1983 à Berne doit être complétée par les exposés suivants présentés à ce séminaire et par la suite publiés dans le Bulletin de l'OIML :

Strecker A. — Legal requirements and enforcement of prepackage control in the Federal Republic of Germany.
Bulletin de l'OIML N° 93, décembre 1983

Vadelund E. — Packaging and Labelling in the USA,
Bulletin de l'OIML N° 93, décembre 1983

Brickenkamp C.S. — Net contents requirements and their application in the USA,
Bulletin de l'OIML N° 93, décembre 1983

Zankevitch D. — Expérience française dans le contrôle des préemballages,
Bulletin de l'OIML N° 93, décembre 1983 (English translation available)

van Driel L.A. — Methods of quantity control of prepackages,
Bulletin de l'OIML N° 94, mars 1984

Rüssing J. — Special methods for testing of certain types of prepackages such as sparkling beverages, aerosols, ice-cream,
Bulletin de l'OIML N° 96, septembre 1984

Bolchover S.P., Harris F. — Use of measuring container bottles in the prepackaging industry,
Bulletin de l'OIML N° 96, septembre 1984

REPUBLIQUE DEMOCRATIQUE ALLEMANDE

REPRESENTATION and TRANSFER of the UNITS of VIBRATION QUANTITIES in the GDR

by H.-J. v. MARTENS and P. ROGAZEWSKI

1. Introduction

Advanced vibration measuring instruments and transducers require the use of suitable methods for calibration.

The new standard ISO 5347 describes suitable methods for calibrating vibration measuring instruments and transducers [1] as well as for examining their behaviour [2]. Most of these methods are already applied in the GDR to assure quality of vibration measuring equipment produced and ensure accuracy in the course of its use.

However, the system of standard methods, standard equipment and regulatory documents established in the GDR for representation and transfer of the units of vibration quantities, goes to a certain extent beyond the recommended methods and procedures. Thus, for low frequencies new methods and equipment have been designed to enable the frequency response of acceleration measuring instruments down to 0.1 Hz to be measured at a sufficient acceleration level. For high frequencies, above 1 kHz, improved interferometric amplitude measuring methods are applied in order to keep the preferred acceleration range for calibration 1 to 100 $m \cdot s^{-2}$ up to 20 kHz. A hierarchy scheme as well as technical requirements on standard measuring instruments and exciters have been established to transfer the units of vibration quantities with an overall uncertainty permissible.

This paper is intended to present the new (national) regulations [3], [4], [5], adequate standard equipment and methods for representing and transferring the units.

2. Representation of the units of vibration quantities

Calibrations, verifications, tests, and examinations of measuring instruments and transducers for periodic rectilinear vibration are based on the units represented by three standard devices which are operated in different frequency ranges and constitute the state measurement standard of the GDR - see GDR Standard TGL 31 542/23, [3]. This GDR Standard provides that the representation of units has to be based on the generation of sinusoidal rectilinear vibration by means of electrodynamic vibration exciters with high-precision straight-line mechanism and on the absolute measurement of the displacement amplitude $\hat{s}$ by laser interferometer. The acceleration amplitude $\hat{a}$ and the velocity amplitude $\hat{v}$ are calculated by using the relations

$$\hat{a} = (2\pi f)^2 \hat{s}, \quad (1)$$

$$\hat{v} = 2\pi f \hat{s}. \quad (2)$$

The value of the vibration frequency, necessary for this purpose, is measured with the aid of an electronic counter.

The new edition of TGL 31 542/23, compared with the former edition of 1980, takes account of the latest requirements on the representation of units, particularly by

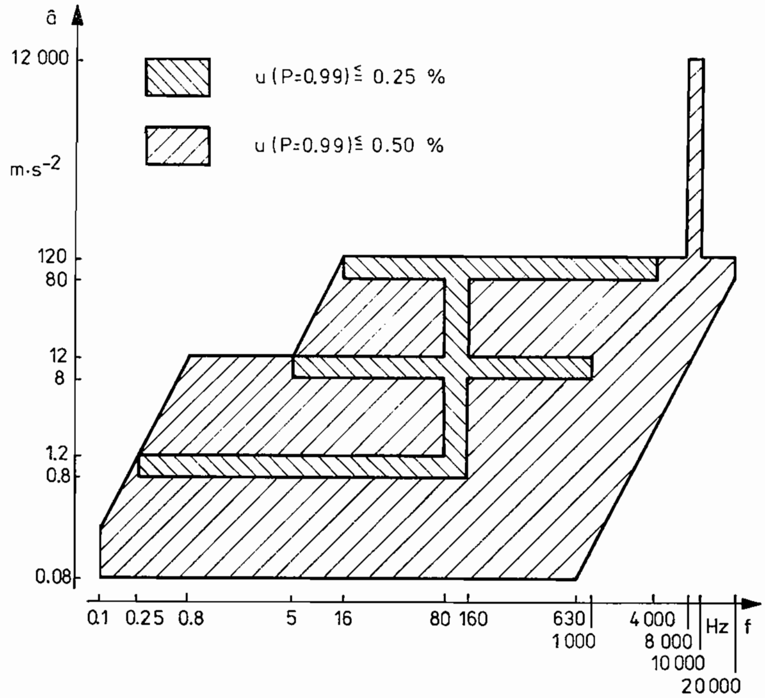


Fig. 1 — Domain of frequencies and acceleration amplitudes as well as overall uncertainty of the state measurement standard as given in [3].

TABLE 1 — Metrological characteristics of the state measurement standard of the GDR specified in GDR Standard TGL 31 542/23

Characteristic	Value of characteristic
frequency	0.01 Hz to 20 kHz
lower frequency limit f_u 1) for vibration acceleration a for vibration velocity v for displacement s	 0.1 Hz 0.03 Hz 0.01 Hz
acceleration amplitude $\hat{a}$ 2)	8×10^{-2} to 1.2×10^{-4} m·s^{-2}
velocity amplitude $\hat{v}$ 2)	1×10^{-5} to 2.4 m·s^{-2}
displacement amplitude $\hat{s}$ 2)	5×10^{-9} to 0.5 m
overall uncertainty u (P = 0.99) for $\hat{a}$, $\hat{v}$, $\hat{s}$ for $\hat{u}_l$, $\hat{q}_l$ 3)	 ≤ 0.25 % or ≤ 0.5 %, assignment see fig. 1 ≤ 0.25 % for 100 mV ≤ $\hat{u}_l$ ≤ 1 V or 10 pC ≤ $\hat{q}_l$ ≤ 1 nC ≤ 0.5 % for 10 mV ≤ $\hat{u}_l$ < 100 mV or 1 pC ≤ $\hat{q}_l$ < 10 pC
distorsion factor k for a, v, s	≤ 2 % for f < 10 Hz ≤ 1 % for 10 Hz ≤ f ≤ 10 kHz ≤ 3 % for 10 kHz < f ≤ 20 kHz
rel. transverse vibration amplitude $\hat{s}_{90°}/\hat{s}$	≤ 0.5 % for f ≤ 10 Hz ≤ 1 % for 10 Hz < f ≤ 10 kHz ≤ 5 % for 10 kHz < f ≤ 20 kHz
max. mass m of the object to be tested	5 kg for f ≤ 20 Hz (horizontal direction) 2 kg for f ≤ 20 Hz (vertical direction) 1 kg for 20 Hz < f ≤ 10 kHz 500 g for 10 kHz < f ≤ 20 kHz

1) if overall uncertainty u (P = 0.99) ≤ 0.5 % is kept.

2) the upper and lower limits established for a determined frequency are specified in [3].

3) amplitude of the fundamental wave of voltage and charge respectively.

— extending the frequency range to 0.01 Hz to 20 kHz,

— increasing the maximum acceleration amplitude to 12 000 $m \cdot s^{-2}$ (at discrete frequencies, to be used for linearity tests),

— extending the range of (interferometric) absolute measurement to the entire domain of frequency and intensity (i.e. $\hat{s} = 5 \times 10^{-9}$ to 0.5 m),

— decreasing the maximum permissible overall uncertainty (*) to 0.5 % (in preferred ranges 0.25 %, see fig. 1).

Fig. 1 refers to the vibration acceleration. Domains of frequency and amplitude have also been fixed for velocity and displacement [3]. However, with regard to the uncertainty 0.5 % which has to be kept, the lower frequency limit has been set on the value 0.1 Hz for vibration acceleration, 0.03 Hz for vibration velocity and 0.01 Hz for vibration displacement. These restrictions do not apply when the state measurement standard is used to perform any experimental examinations in order to study the behaviour of vibration measuring instruments and transducers.

In accordance with the requirements established in [3] and summarized in table 1, the medium frequency vibration standard [8] was improved in its metrological characteristics and complemented by a low-frequency vibration standard [2], [9] and a high-frequency vibration standard [10]. These three measuring standards (see figures 2, 3, 4) constitute the set of state measurement standards of the GDR.

3. Transfer of the units of vibration quantities

In connection with the revision of the GDR Standard [3] for the state measurement standard, the GDR Standard for the hierarchy scheme was revised too and replaced by the 1987 edition [4]. In the following, the most important new regulations are outlined which are intended to better assure proper tests of vibration measuring instruments and transducers as well as accurate vibration measurements to be carried out by the producers and users.

a) The hierarchy scheme (see fig. 5) regulates the transfer of the acceleration unit. When the unit is transferred, the amplitude of the fundamental wave of acceleration is used as characteristic parameter. The requirements on overall uncertainty refer to this parameter. To test ordinary instruments for vibration velocity and displacement respectively, the value of the acceleration amplitude $\hat{a}$ indicated by the used standard and the value of frequency are employed to determine the desired input quantity $\hat{v}$ or $\hat{s}$ - see eq. (1) and eq. (2).

b) The transfer of the acceleration unit through reference and working standards is limited to a domain of frequencies 0.5 Hz to 4 kHz and acceleration amplitudes 0.8 to 120 $m \cdot s^{-2}$. If calibrations or tests of ordinary vibration measuring instruments or transducers have to be performed outside this domain or if the highest accuracy has to be achieved, the state measurement standard is directly used.

c) As the representative error characteristic of reference or working standards, the overall uncertainty referring to the conditions of use of this standard is fixed. This uncertainty includes, in addition to the uncertainty of calibration, the disturbing effects from the fixed conditions of use (see sect. 4). This rather unconventional approach has been applied to spare the user time-consuming calculations and ensure consistent, reliable uncertainty statements.

(*) Data on overall uncertainty are calculated according to [6] [7]. To obtain an overall uncertainty, the combined uncertainty is multiplied by a factor k = 2.58 which results from t (P = 0.99, $n = \infty$) [7]. Data on uncertainty refer to the measurement of the fundamental wave amplitude concerned.

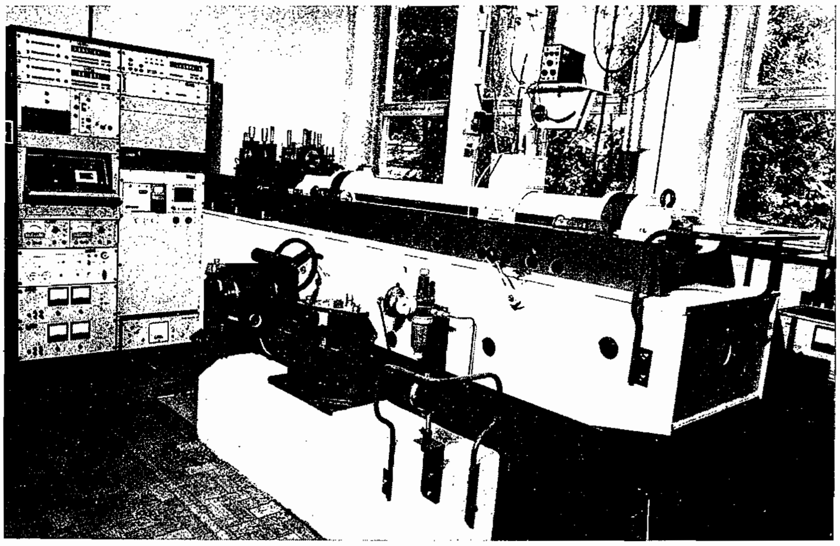


Fig. 2 — Low-frequency vibration standard.
Frequency 0.01 Hz to 20 Hz, displacement amplitude 0.5 m to 1 $\times$ 10^{-4} m.

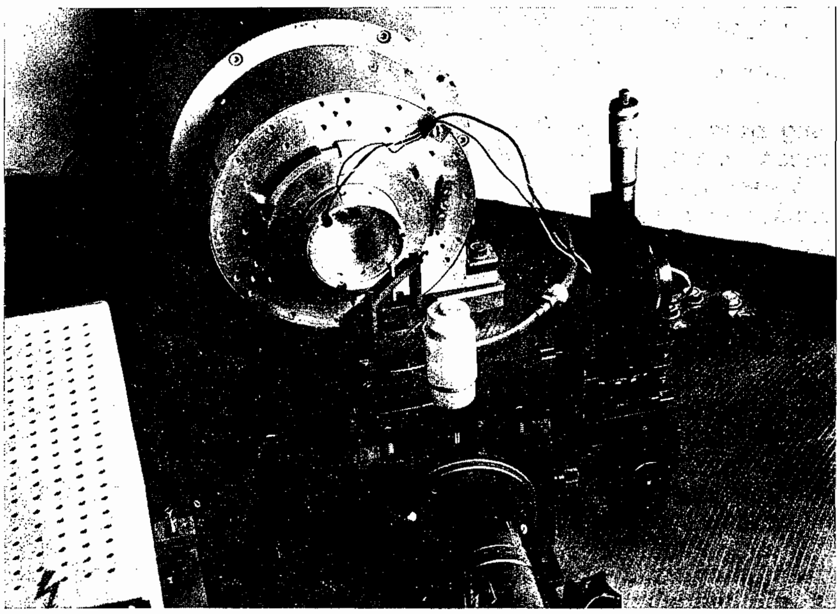


Fig. 3 — Medium-frequency vibration standard.
Frequency 10 Hz to 20 kHz (above 10 kHz discrete frequencies), displacement amplitude 1 $\times$ 10^{-2} m to 5 $\times$ 10^{-9} m.

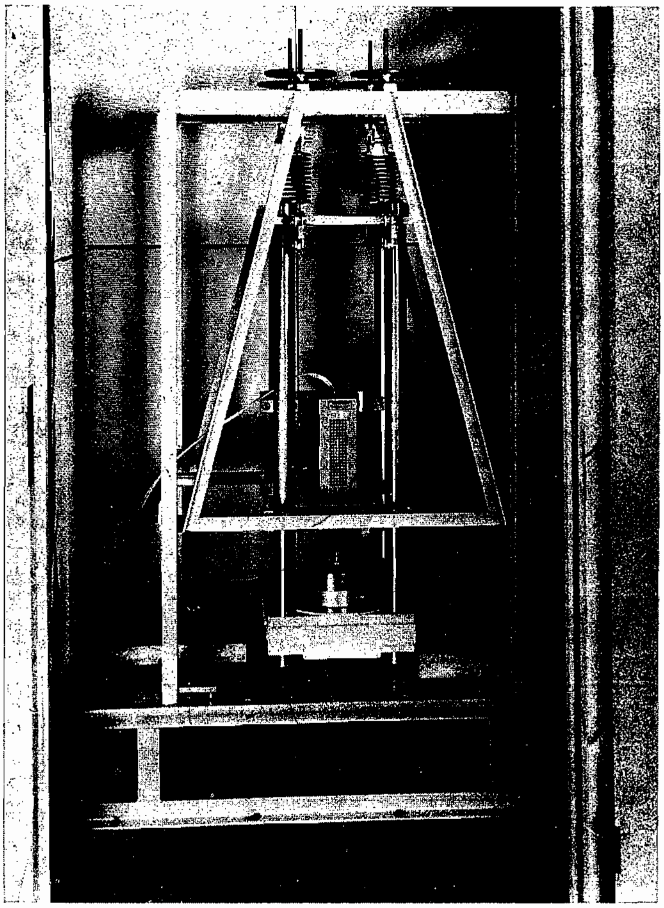


Fig. 4 — High-frequency vibration standard.
Frequency range 0.5 kHz to 20 kHz, displacement amplitude 1×10^{-5} m to 5×10^{-9} m.

When going from level 1 of the hierarchy scheme down to level 2 (see fig. 5), the ratio of these overall uncertainties shall not be larger than 1 : 2. The ratio 1 : 2 is also fixed on each level of the hierarchy scheme between the maximum permissible overall uncertainty in a range of higher accuracy (16 Hz to 1 kHz) and that in a range of lower accuracy (below 16 Hz down to 0.5 Hz and above 1 kHz up to 4 kHz ; for more details of the assignment see [4]). Details of error analysis and uncertainty estimation will be given in sect. 4 and in the appendix.

d) The ratio between the overall uncertainty of the testing standard and the sum of the maximum permissible intrinsic error of the tested ordinary instrument and its maximum permissible complementary error due to the frequency response shall not be larger than 1 : 4.

e) The overall uncertainties of reference and working standards include the error components caused by the state measurement standard.

f) The transfer of units is performed by the comparison method. As in case of the reference and working standards, technical requirements have also been fixed for the exciters [5] in order to achieve a permissible overall uncertainty. To meet these requirements e. g. the exciter for transferring the unit from a reference standard to a working standard has to be fitted out with air bearing (see fig. 5), the standard has to be equipped with a back-to-back quartz accelerometer and the indicating device shall provide r.m.s. measurement of the output voltage of the charge amplifier.

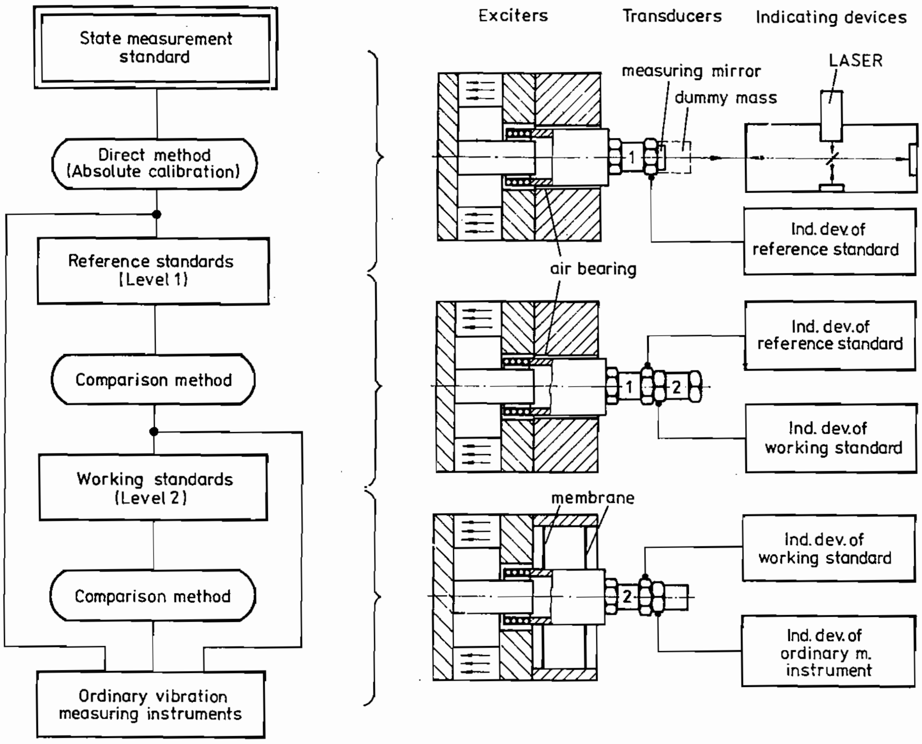


Fig. 5 — Hierarchy scheme demonstrating the acceleration measuring instruments and exciters used for the transfer of the units.

4. Uncertainties in the steps of transferring the acceleration unit

Combined and overall uncertainties were estimated in order to choose suitable technical requirements for the new ASMW-VM 1273 Document [5] and, if these requirements are fulfilled, to verify that the fixed permissible overall uncertainties are kept. According to [5], when using a reference standard (in fig. 6 standard 1) the overall uncertainty has to be $\leqslant$ 1 % in the range of higher accuracy and $\leqslant$ 2 % in the whole range of the unit transfer. For using a working standard (standard 2) the double values are permitted.

The estimation of the resulting uncertainties - see fig. 6 and tables 2, 3 - has been based on evaluating and summing up the variances of the different uncertainty components [6], [7]. However, in connection with vibration measurements - as in general in the measurement of dynamic quantities - remarkable obstacles arise due to the lack of validity of several assumptions usually applied to the evaluation and combination of uncertainty components [11].

Thus,

— not only scalar quantities but also vector quantities exist,

— several quantities are functions of time, and the dynamic behaviour of the measuring system has to be accounted for,

— the relation between the resulting quantity y and the influence quantities $x_1, \ldots, x_m$,

$$y = f(x_1, \ldots, x_m), \qquad (3)$$

is not known because of an unacceptable effort to determine the dependences,

— a number of error components are correlated,

— the Taylor series expansion results in significant nonlinear terms (*).

(*) The reader should remember the cosinusoidal dependence of the error component due to cross motion on the angle between the direction of this cross motion and the direction of cross sensitivity ; as the measurement of this angle is impracticable the latter is indefinite in the whole interval [— π ; π].

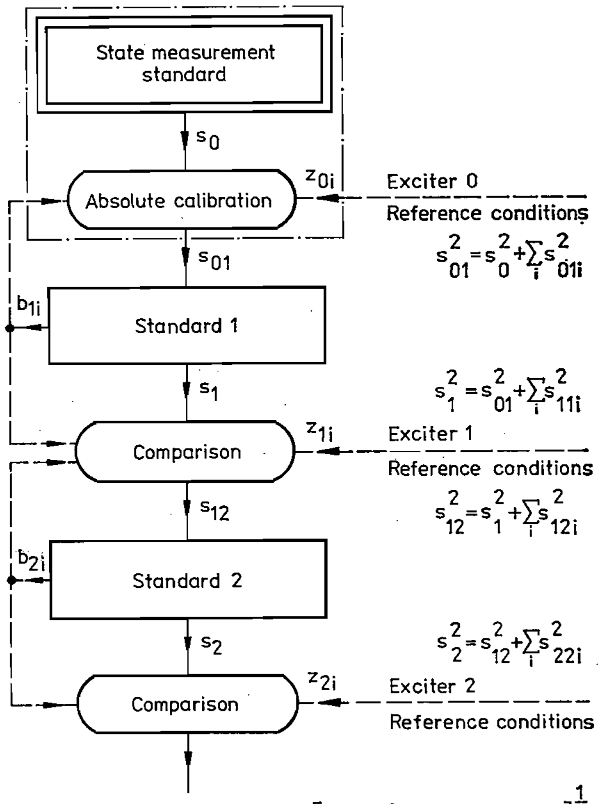
To overcome these obstacles the procedures proposed in [7] and [11] have been implemented. The corrected result y_c (e. g. the corrected indication of the standard concerned) has been expressed in terms of

$$y_c = \hat{a}\prod_{\nu}(1 + e_\nu) \qquad (4)$$

where the error components** $e_\nu \ll 1$, hence eq. (4) can be written as

$$y_c = \hat{a}\,(1 + \sum_{\nu} e_\nu). \qquad (5)$$

The error model demonstrated in fig. 6 generally presumes that each error component e_ν results from the effect of an influence quantity z_ν on the vibration measuring instrument (standard 1 or 2) which responds with the sensitivity. b_ν. The influence quantities come from the exciter or from the environment and are principally the same on all levels of the hierarchy. Also, the behaviour (e. g. the sensitivities b_ν) of standard 1 is essentially the same as that of standard 2. Hence, the variety of error components e_ν can be classified with regard to the error sources i = 1 to 8 (see table 2***). Thus, one can distinguish between error components



Combined uncertainty $\quad s_{n+1} = \left[s_n^2 + \sum_i s_{n,n+1,i}^2 + \sum_i s_{n+1,n+1,i}^2\right]^{\frac{1}{2}}$

Basic requirements $\quad \dfrac{s_{n+1}}{s_n} \geq q_{n,n+1}$

Fig. 6 — Effects of influence quantities in the process of transferring the unit.

** In this paper, error characteristics (such as error e, standard deviation s, overall uncertainty u) are expressed as relative quantities, e.g. divided by the (conventional) true value of the measurand.

*** This classification refers to the error sources occuring when the unit is transferred. Additionally, a number of error components e_{00l} with l = 1, 2, ..., m_l from the representation of the acceleration unit have to be taken into account. The error analysis for representing the acceleration unit and the estimation of the resulting combined uncertainty s_0 is not subject of this paper (see [12]).

TABLE 2 : Estimated standard deviations s_{kji} of the errors e_{kji} (range of higher accuracy)

Error index i	Source of error	Estimated standard deviations*		
		s_{11i}	s_{12i}	s_{22i}
1	cross motion	0.99×10^{-3}	1.98×10^{-3}	1.98×10^{-3}
2	base strain	0.35×10^{-3}	0.70×10^{-3}	0.70×10^{-3}
3	magnetic fields	0.18×10^{-3}	0.35×10^{-3}	0.35×10^{-3}
4	temperature	0.63×10^{-3}	1.26×10^{-3}	1.26×10^{-3}
5	supply	0.35×10^{-3}	0.70×10^{-3}	0.70×10^{-3}
6	dispersion of indications	1×10^{-3}	2×10^{-3}	2×10^{-3}
7	residual error	2×10^{-3}	2×10^{-3}	2×10^{-3}
8	long-term drift	2×10^{-3}	—	4×10^{-3}
	$\sum_{i=1}^{8} s^2_{kji} =$	10.65×10^{-6}	14.61×10^{-6}	30.61×10^{-6}

*The method of estimating the standard deviations is given in the appendix.

TABLE 3 — Combined and overall uncertainties in the different steps of transferring the acceleration unit

Resulting uncertainties for	Combined uncertainties	Overall uncertainties 1)
representation of acceleration by state measurement standard	$s_0 = 0.10$ %	$u_0 = 0.25$ %
calibration of reference standard (standard 1) by state measurement standard with exciter 0	$s_{01} = 0.19$ %	$u_{01} = 0.5$ %
application of standard 1 with exciter 1	$s_1 = 0.38$ %	$u_1 = 1$ %
calibration of working standard (standard 2) by standard 1 with exciter 1	$s_{12} = 0.54$ %	$u_{12} = 1.4$ %
application of standard 2 with exciter 2	$s_2 = 0.77$ %	$u_2 = 2$ %

1) The overall uncertainties were calculated with the factor $k = 2.58$ corresponding t ($P = 0.99$, $n = \infty$).

e_{kji} where i is the i-th error source, j is the respective standard ($j = 1, 2$) and k is the level of measurement ($k = 0, 1, 2$, see fig. 6). Especially one has to distinguish the error $e_{j-1,j}$ of the j-th standard when calibrated with the (j-1)-th exciter in the presence of the influence quantities $z_{ki} = z_{j-1,i}$, from the error e_j of this j-th standard when used with the j-th exciter in the presence of the influence quantites $z_{ki} = z_{ji}$. This approach leads to the following error expressions

— error of representation of acceleration by state measurement standard :

$$e_0 = \sum_{l} e_{00l} \qquad (6a)$$

— error of calibration of reference standard (standard 1) by state measurement standard with exciter 0 :

$$e_{01} = \sum_{l} e_{00l} - \sum_{i} e_{01i} \qquad (6b)$$

— error of application of standard 1 with exciter 1 :

$$e_1 = \sum_{l} e_{00l} - \sum_{i} e_{01i} + \sum_{i} e_{11i} \qquad (6c)$$

— error of calibration of working standard (standard 2) by standard 1 with exciter 1 :

$$e_{12} = \sum_{l} e_{00l} - \sum_{i} e_{01i} + \sum_{i} e_{11i} - \sum_{i} e_{12i} \qquad (6d)$$

— error of application of standard 2 with exciter 2 :

$$e_2 = \sum_{l} e_{00l} - \sum_{i} e_{01i} + \sum_{i} e_{11i} - \sum_{i} e_{12i} + \sum_{i} e_{22i} \qquad (6e)$$

Concerning the representation and the transfer of the units, the results of measurements are presupposed to be corrected. The remaining errors e_{00l} and e_{kji} in equations (6a) to (6e) are assumed to be random variables and are described by estimated standard deviations - see eq. (7).

The approach of breaking down the error components to influence quantities and sensitivities has been modified as follows. If the influence quantity and the sensitivity are vectors a direction factor $\cos\alpha_{kji}$ is additionally introduced (see appendix, table A1). If the quantity having an effect on the measuring system is time-dependent, a phase factor $\cos\varphi_{kji}$ is additionally applied. In each case, the breaking down process is performed as long as all of the constitutents can reliably be evaluated separately. For this reason, the errors resulting from the sources $i = 6$ to 8 are evaluated as a whole (see table A1).

As mentioned above, several error components are correlated. Equations (6c) to (6e) show that positive correlation of error components due to the same (i-th) error source, in general effects a partial error compensation. This effect does not occur if a reference standard (standard 1) is calibrated - see eq. (6b) - because the error sources l from the acceleration measurement by laser interferometer are, in principle, different from the error sources i which exist if the acceleration is measured by an accelerometer.

A perfect error compensation takes place as far as the distortion of the exciter is concerned when applying the comparison method. In this case, the correlation coefficient is 1 as the distortion influences in the same way the indications of both compared r.m.s. measuring instruments. Therefore, the distortion from the exciter is not mentioned as error source*.

* When applying the absolute method a (very small) distortion influence exists. The latter is included in the combined uncertainty s_0 of representation of the acceleration unit and in the residual error characteristic s_{117}.

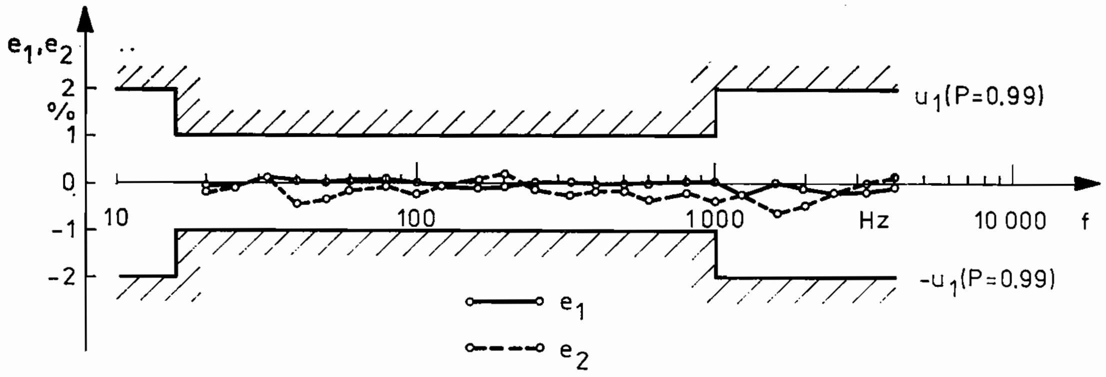


Fig. 7 — Experimentally obtained errors e_1, e_2 of a reference standard and a working standard, respectively, compared to the maximum permissible overall uncertainty u_1 of reference standards.

Detailed examinations have shown that, given these measurement conditions, positive correlation coefficients are more likely to occur than negative ones. The latter lead to the undesired effect of addition of the errors. Keeping in mind the objective to find an appropriate estimate of the combined and overall uncertainties « on the safe side » the correlations, except the distortion influences discussed above, have been neglected. Moreover, to avoid underestimation of the errors and uncertainties, rather pessimistic assumptions have been introduced with respect to the distributions of error components and their constituents, respectively.

In this way, the error components in equations (6b) to (6e) can be described by standard deviations and the combined uncertainties can be determined by adding the variances. The generalized expression is

$$s_n^2 = s_0^2 + \sum_{i=1}^{m_i} \sum_{j=1}^{n} \sum_{k=j-1}^{j} s_{kji}^2 \qquad (7)$$

where s_0 is the combined uncertainty of representation of the acceleration unit.

In order to prove the accuracy of transferring the acceleration unit, an experimental determination of the errors e_1 and e_2 - see equations (6c) and (6e) - and their comparison with the maximum permissible overall uncertainties u_1 and u_2 respectively would be useful. However, as the true value of the acceleration amplitude is not exactly known it is only possible to get rough estimates of e_1 and e_2. Thus, the error curve e_1 in fig. 7 was determined as deviation of the individual frequency-dependent results of an absolute calibration of a given standard 1 by the state measurement standard of the GDR from corresponding « reference » values. The latter were determined by regression of the results of an absolute calibration of this standard 1 by the state measurement standard of Czechoslovakia, performed in the Czechoslovak Metrological Institute in Prague six months before. The error curve e_2 in fig. 7 expresses the deviations of the results of a comparison calibration of a standard 2 from the results of its absolute calibration by the state measurement standard of the GDR. Obviously, these estimates of e_1 and e_2 do not exactly correspond to the definitions of these errors. However, the experimentally determined error values are well within the maximum permissible uncertainties. As mentioned before, the module of the error e_2 should lie below $u_2 = 2\ u_1$ with good probability (e. g. P=99 %).

5. Conclusions

The state measurement standard presented in its new set-up in sect. 2 of this paper, supplies absolute calibrations of vibration measurement instruments and transducers in the extended frequency range 0.01 Hz to 20 kHz. The applications of this standard equipment go far beyond the legal representation of units. Especially it is used to carry out metrological investigations which are a prerequisite for the design and production of vibration measuring instruments of a high quality.

The new regulations [3] to [5] and the error analysis according to sect. 4 and the appendix have made it possible to choose as main error characteristic that overall uncertainty which is expected to be kept when the reference or working standard is used. Thus, the user is given that information involving a minimum effort in estimating the accuracy of his measurement.

The estimation of the overall uncertainty is based on the INC-1 (1980) recommendation [6]. This concept in connection with the assumptions and procedures introduced to obtain estimates of the variances of the individual error components and allow for correlations have proved as a useful approach of error description for the transfer of the units of vibration quantities.

A number of experiments have been performed, which confirm that the requirements defined in [3] to [5] are already met.

Acknowledgement

The authors are grateful to Dr. K. Hasche and Dr. E.-E. Pippig for valuable discussions of details of this paper.

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Appendix

TABLE A1 — Relations for calculating the uncertainties of transfer of the acceleration unit

Error index	Technical requirements on		Error components	Error distribution models 1)	Estimated limits of standard deviations
	influence quantities	sensitivities			
i	z_{ki}	b_{ji}	e_{kji}	$p(e_{kji})$	s_{kji}
1	$\lvert z_{k1}\rvert \leqslant Z_{k1}$	$\lvert b_{j1}\rvert \leqslant B_{j1}$	$z_{k1}b_{j1} \cos \alpha_{kj1} \cos \varphi_{kj1}$	Arcsin $(s = E/\sqrt{2})$	$0.71\ Z_{k1}B_{j1}$
2	$\lvert z_{k2}\rvert \leqslant Z_{k2}$	$\lvert b_{j2}\rvert \leqslant B_{j2}$	$z_{k2}b_{j2} \cos \alpha_{kj2} \cos \varphi_{kj2}$	convex with $s = 0.35\ E$	$0.35\ Z_{k2}B_{j2}$
3	$\lvert z_{k3}\rvert \leqslant Z_{k3}$	$\lvert b_{j3}\rvert \leqslant B_{j3}$	$z_{k3}b_{j3} \cos \alpha_{kj3} \cos \varphi_{kj3}$	convex with $s = 0.25\ E$	$0.25\ Z_{k3}B_{j3}$
4	$\lvert z_{k4}\rvert \leqslant Z_{k4}$	$\lvert b_{j4}\rvert \leqslant B_{j4}$	$z_{k4}b_{j4}$	convex with $s = 0.35\ E$	$0.35\ Z_{k4}B_{j4}$
5	$\lvert z_{k5}\rvert \leqslant Z_{k5}$	$\lvert b_{j5}\rvert \leqslant B_{j5}$	$z_{k5}b_{j5}$	convex with $s = 0.35\ E$	$0.35\ Z_{k5}B_{j5}$
6	$s_{kj6} \leqslant S_{kj6}$	$b_{j6} = 1$	e_{kj6}	(normal)	S_{kj6}
7	$s_{kj7} \leqslant S_{kj7}$	$b_{j7} = 1$	e_{kj7}	(normal)	S_{kj7}
8	$\lvert e_{kj8}\rvert \leqslant E_{kj8}$	$b_{j8} = 1$	e_{kj8}	binomial $(s = E)$	E_{kj8}

The error distribution models (probability density functions) for e_{kj2} to e_{kj5} were computed by randomization of the error constituents. The resulting density function is similar to a symmetrical exponential function but it does not exceed the limits $\pm E = \pm Z_{ki}B_{ji}$.

The quantities z_{ki}, b_{ji}, α_{kji}, φ_{kji} were assumed to be randomly distributed with the following probability densities as models :

— rectangular densities for z_{k2}, z_{k3}, z_{k4}, z_{k5}, b_{j2}, b_{j3}, b_{j4}, b_{j5}, α_{kj1}, α_{kj3} within $[-Z_{ki}\ ;\ Z_{ki}]$, $[-B_{ji}\ ;\ B_{ji}]$, $[-\pi\ ;\ \pi]$

— singular densities (worst case assumption) for z_{k1}, b_{j1}, α_{kj2}, φ_{kj1}, φ_{kj2}, φ_{kj3} with $z_{k1} = Z_{k1}$, $b_{j1} = B_{j1}$, $\alpha_{kj2} = \varphi_{kj1} = \varphi_{kj2} = \varphi_{kj3} = 0$

— binomial density for e_{kj8} with $-E_{kj8}$, E_{kj8}

The supposition of normal densities of e_{kj6} and e_{kj7} has no effect on the uncertainty statements because the standard deviations are given a priori.

TABLE A2 — Values of the technical requirements stipulated in ASMW-VM 1273, ref [5]

i	Z_{1i}	Z_{2i}	B_{1i}	B_{2i}	$S_{kji}\ ;\ E_{kji}$
1	$10^{-1}\ \hat{a}$	$1.4 \times 10^{-1}\ \hat{a}$	$1.4 \times 10^{-2}/\hat{a}$	$2.0 \times 10^{-2}/\hat{a}$	$S_{116} = 10^{-3}$
2	$10^{-1}\ \dfrac{\mu m/m}{m \cdot s^{-2}}$	$10^{-1}\ \dfrac{\mu m/m}{m \cdot s^{-2}}$	$10^{-2}\ \dfrac{m \cdot s^{-2}}{\mu m/m}$	$2 \times 10^{-2}\ \dfrac{m \cdot s^{-2}}{\mu m/m}$	$S_{126} = S_{226} = 2 \times 10^{-3}$
3	$10^{-5}\ T/(m \cdot s^{-2})$	$10^{-5}\ T/(m \cdot s^{-2})$	$70\ m \cdot s^{-2}/T$	$140\ m \cdot s^{-2}/T$	$S_{117} = S_{127} = S_{227} = 2 \times 10^{-3}$
4	3 K	3 K	$6 \times 10^{-4}/K$	$1.2 \times 10^{-3}/K$	$E_{118} = 2 \times 10^{-3}$
5	$5 \times 10^{-2}\ U_N$	$5 \times 10^{-2}\ U_N$	$2 \times 10^{-2}/U_N$	$4 \times 10^{-2}/U_N$	$E_{228} = 4 \times 10^{-3}$

To save space, only the values for the limited range 16 to 1 000 Hz (range of higher accuracy) are given in the table above.

ROYAUME-UNI

ACTIVITIES of INDEPENDENT CALIBRATION COMPANIES in the METROLOGY of BULK LIQUIDS *

by **A.T.J. HAYWARD**
Moore, Barrett & Redwood Ltd. (SGS Redwood)

SUMMARY. — The paper surveys the entire field of activities in which independent calibration companies participate, in relation to the metrology of liquids in bulk. They are mainly concerned with liquids of high intrinsic value, and especially with the petroleum, petrochemicals, and alcoholic beverage industries. The activities include the calibration of storage tanks of all sizes, ranging from vats for wine and whiskey, through the cylindrical tanks of various sizes used for oil storage, to the tanks of irregular shape used in both land and marine transport. They also include the calibration of liquid meters of all types and sizes and the calibration of devices such as volumetric standard tanks and pipe provers. A number of peripheral activities are also mentioned in the paper but not discussed.

The credibility of independent calibration companies is directly related to the closeness of their links with legal metrology authorities, because of the necessity for all accurate measurements to have full traceability to national standards. Two case studies are described in detail, to illustrate the benefits of close interaction between the two types of body.

1. Introduction

This paper attempts to give a broad picture of the activities of independent calibration companies, which operate extensively in the field of bulk liquid metering. It is obviously impossible to give a perfect picture of the activities of many independent companies operating within a large number of different countries, and there are doubtless many exceptions to the broad generalisations made in this paper. Even so, it is hoped that what follows will provide a reasonably accurate guide to the activities of companies of this kind.

2. Definitions

The first problem is the question of definition : it is difficult to say exactly what an independent calibration company is, because such companies may take different forms in different countries. It is, in fact, easier to say what an independent calibration company is *not*. Perhaps the simplest procedure will be to begin by listing all the various types of organisation that operate calibration facilities in the field of large-scale liquid measurement. The following list may not be exhaustive, but it probably covers all the more important types :

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* Presented at the OIML seminar on Calibration of Liquid Volume Measuring Installations, Arles, France, 11-15 May 1987.

(1) National Legal Metrology Authorities.
(2) Other national government bodies, including National Research Laboratories.
(3) Local government bodies, such as Local Legal Metrology Authorities.
(4) Other publicly-owned organisations, such as gas, water and electricity suppliers in countries where these are state owned.
(5) Universities and other educational institutions.
(6) Trade associations.
(7) Oil and pipeline companies.
(8) Meter manufacturers.
(9) Privately funded research institutions.
(10) Independent calibration companies.

Only the last two categories in this list could be regarded as « independent », that is to say, not owned either by governement or by any sectional industrial interest. And although the last but one on the list contains laboratories that have liquid volume calibration facilities, such calibration is generally not their main activity and the calibration facility is generally for research purposes rather than for carrying out calibrations on a routine basis.

That leaves only the last category in the list, with which this paper is exclusively concerned. These are companies (or, perhaps, separately managed departments of larger companies) which have been set up for the express purpose of « selling » calibrations, tests, analyses, inspections, and similar facilities. With some of the larger companies, liquid volume calibrations may form only a minor part of the total activities of the company, whereas some of the smaller companies may be totally occupied with this one activity.

It is worth noting that whereas the calibration of large tanks can only be done on the site, flowmeters may be calibrated either in their installed position or at some central facility to which they may be taken when necessary. There is a significant difference between independent companies and all the other bodies mentioned in the above list, in that the independents generally calibrate flowmeters in their installed position whilst the other bodies are much more likely to calibrate flowmeters in their central, static installations.

3. Activities of independent calibration companies

Independent calibration companies range in size from one-man firms to large multi-national corporations. Only the larger independents are likely to engage in all or most of the activities listed below.

3.1 Industries Served

The services of independent calibration companies are mainly sought in areas where liquids of high intrinsic value are being measured for the purposes of sale or taxation. In practice this means that such companies are mainly concerned with either the petroleum and petrochemicals industry, or with the alcoholic beverage industry. Only in these industries is the economic benefit of highly accurate measurement likely to be sufficient to justify the costs of calibration by independents.

The possession of independence is of crucial importance in these industries, since both parties to a transaction (buyer and seller ; or government revenue collector and payer of duty) need to have complete confidence in the impartiality and integrity of the organisation carrying out the calibration. This is not to say that independent calibration companies work simultaneously for both parties in a transaction. On the contrary, like lawyers, in any given case they appear either for one side or the other. But, also like lawyers, they are in principle available to be hired by anybody and everybody, and are therefore regarded as being as nearly unbiassed as it is possible to be in this imperfect world.

3.2 **Calibration of Tanks**

A widely used method of measuring the volume of liquids consists of determining the volume of a tank in which the liquid is contained. In large tanks it is usual for the horizontal cross-section of the tank to be determined at many different heights, and for the volume of a given depth of liquid to be derived from the combination of a calibration table for the tank and a depth measurement (which may be obtained either by manual dipping or by some form of mechanical or electronic depth gauge). With a very small tank the situation may be simplified by the use of only two positions, « full » and « empty ».

Tanks requiring calibration may be divided into five main categories.

(1) Small tanks. These include vats to contain wines or spirits, and very small tanks for the storage of petroleum products.

(2) Large cylindrical tanks. These are used for the storage of crude oil, petroleum products and their derivatives at oil refineries, distribution depots, and elsewhere.

(3) Large spherical tanks. These are used for the storage of petroleum products, petro-chemicals and liquefied gases.

(4) Large irregular tanks. Examples of irregular tanks are caverns blasted out of rock. These are used for the storage of crude oil, products and liquefied gases. Special arrangements are made to ensure that the liquid is contained within the confines of the cavern.

(5) Ships' tanks. Tanks in ships can either use the hull as the containment or have especially constructed tanks which are fitted in the hull. They are rarely of a regular cross-section except in the main body of the ship.

Calibration companies have at their disposal a wide variety of methods with which to calibrate tanks. These include the following.

(1) Strapping. This is probably the oldest method of calibrating cylindrical tanks, and is still probably the most accurate if carried out correctly. It consists of measuring the circumference of the tank at many different horizontal planes, by placing a measuring tape around the outside. Attention must be paid to the effect of thermal expansion on the tank wall, to the geometry of the tank bottom, and to any internal structures in the tank.

(2) Optical calibration methods. The most used of the newer methods of calibration is the optical reference line method which uses an « optical plummet » to establish an « optical plumbline » or truly vertical line of sight close to the tank side. A simple trolley, to which is attached a horizontal, translucent scale, is run up the tank side and, by means of the plummet, the distances between the tank side and the « optical plumbline » are measured at various heights.

Other optical methods include single-station and two-station triangulation techniques which are derivatives of normal cartographic triangulation routines. These methods are used internally. External methods include three-station triangulation, again derived from standard cartographic techniques.

(3) Photogrammetry. This technique is also developed from cartographic methods. It is based on photography using stereo cameras of very high quality and definition. Photographs of the tank are taken, usually externally for land tanks and internally for ship tanks, although prismatic ship tanks are more likely to be photographed externally. Included in the photograph is a measurement scale, such as an Invar tape, to enable tank dimension to be scaled off the photograph when placed in a stereo plotter/viewer.

Photogrammetry is also used in the calibration of large caverns as the technique allows the calibrator to use computer technology to make the necessary adjustments for the unevenness of the cavern walls.

(4) Macrometrological methods. Macrometrology is the science of the measurement of large objects. Basically when applied to the calibration of tanks, be they land or ship tanks, the term implies measurements derived from a secondary measurement from which the required measurement can be obtained. An example of this technique is that used in optical reference line measurements described above.

However, the term is most used when referring to the calibration of ships' tanks. Methods of calibration have been developed using laser beams as reference lines, and offset measurements taken from the laser beam to the tank side are used to calculate the required dimensions.

(5) Water calibration. This consists of filling a tank with a liquid, usually water, through a reference meter which has itself been calibrated against a volumetric tank. Special care must be taken to allow for thermal expansion and contraction of the water ; the larger the tank the greater the thermal expansion effects are likely to be. For this reason the method is best suited for use with small tanks and especially small tanks of irregular or complex shape.

3.3 Meter Calibration

There are many fields where regular recalibration of meters in their installed position is required. Of these, the area with the greatest economic importance is that of liquid fuel distribution depots, where (mainly) gasoline, kerosene and gas oil are loaded through displacement meters, typically operating at around 2 000 litres per minute, into road tank vehicles for delivery. Such meters are generally recalibrated at six-monthly intervals, by one of the following methods.

(1) Reference meter. Placing a reference meter of the displacement type in series with the meter to be calibrated is the simplest and most convenient method of calibrating distribution depot meters, and is regarded as of sufficient accuracy for this particular purpose. Its main disadvantage is that it imposes a significant additional pressure drop upon the metering system.

(2) Mobile volumetric tanks. The use of a mobile volumetric tank in series with the meter to be calibrated is less convenient, largely because it creates a disposal problem. It is probably no more accurate than the use of a reference meter, because it introduces additional errors through thermal expansion and, in the case of volatile fuels such as motor spirit, through heavy evaporation losses. But it does have the important advantage of creating very little additional pressure drop.

(3) Mobile pipe provers. Their main use hitherto has been for calibrating large turbine meters used for custody transfer metering. They have been used only rarely for calibrating the loading meters referred to above, because of their great size and initial cost. They provide a higher level of accuracy than the previous two methods, but this extra accuracy is generally regarded as unnecessary for the calibration of loading meters. However, with the gradual introduction of pipe provers of the new compact design, it is possible that they may be used for this purpose rather more frequently in future.

3.4 Calibration of Pipe Provers

Pipe provers are used extremely widely in connection with the large scale metering of crude oil. In most countries (France being the most notable exception, where the alternative method of « central proving » is preferred) a typical crude oil metering installation consists of a battery of large turbine meters in parallel, built on to a skid which also carries a large pipe prover, which is dedicated to the sole purpose of calibrating these meters one at a time. Provision must be made for regular recalibration - typically at yearly intervals - of such a prover Figure 1 illustrates such a metering skid, where some of the turbine meters can be glimpsed in the background, and where the main dedicated prover dominates the foreground. Also in the foreground is a small « master pipe prover », whose sole purpose is to recalibrate the main pipe prover, and a small volumetric tank whose only use is to recalibrate the master pipe prover.

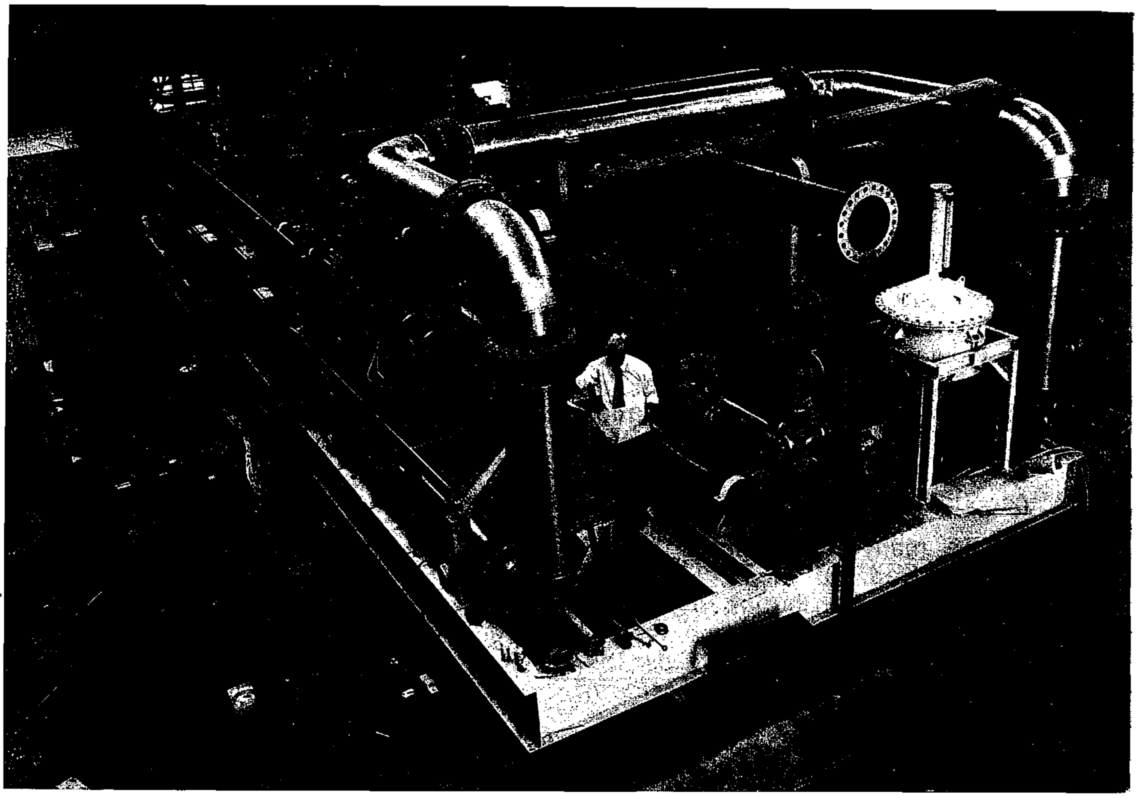

Fig. 1 — Crude oil metering skid, with provision for prover recalibration by dedicated master prover, which can itself be recalibrated against the volumetric tank shown.
(Photo by courtesy of Jordan Kent Metering Systems Ltd.)

Three methods are available to independent calibration companies for the on-site recalibration of dedicated (and other) pipe provers.

(1) Water draw. In this, the oldest and most fundamental method of calibrating pipe provers, water is expelled from the calibrated portion of the prover between its detectors, and the volume of the expelled water is measured in a volumetric tank. The method is highly accurate, provided that appropriate corrections for thermal expansion of both water and metal are made, but is slow in operation, especially with very large provers.

(2) Reference meter linked to volumetric tank. The calibration of very large provers can be expedited considerably if a small volumetric tank is first used to calibrate a reference meter with water, then the reference meter is used with water to calibrate the pipe prover, and finally the reference meter is calibrated anew against the volumetric tank. As with the previous method, the use of water imposes an obligation to drain and thoroughly clean the pipe prover of crude oil before it can be calibrated.

(3) Reference meter linked to master prover. This is a variation of the previous method in which the volumetric tank is replaced by a highly accurate master prover. This is a much more expensive device, but it has the great advantage that it will operate on crude oil, so that the whole calibration operation can be carried out on the normal fluid within the prover, thus eliminating the need for draining and thorough cleaning.

Extensive comparative tests have shown that comparable accuracies can be obtained with all three of these methods.

3.5 **Peripheral Activities**

The larger independent calibration companies also engage in various peripheral activities connected with liquid volume metering. These include reconciliation of conflicting measurements (for example, tank gauge measurements which disagree with meter measurements), loss control, technical auditing of metering systems, maintenance of metering systems, design of metering and production allocation systems, arbitration between parties in dispute. Unfortunately there is no space here to discuss these topics.

4. Interaction with legal metrology authorities

Although in some countries independent calibration companies and legal metrology authorities may be partially in competition, this is not a common situation. More usually, they operate in clearly defined and separate spheres, with the independent calibration companies taking over exactly at the point where legal metrology authorities leave off. Nevertheless, it is very much in the interest of independent calibration companies for them to work in close association and harmony with their national legal metrology authorities, for reasons which will be made clear in the examples that follow.

4.1 **Traceability**

Traceability is the concept by which any accurate measurement must be linked to national standards, and hence to international standards, by an unbroken chain of successive calibrations. A portion of such a chain is illustrated schematically in Figure 2. A bullion balance is used to calibrate gravimetrically one or more standard measures, using water. These measures are subsequently used to calibrate a volumetric tank, and the volumetric tank is in turn used to calibrate other calibration devices such as pipe provers and reference meters. Because this is only a portion of a chain, the diagram could be extended in both directions. Behind the bullion balance at the left lies a chain of gravimetric calibrations leading to the international standard kilogramme, in Sèvres ; whilst the two calibration devices at the right are used to calibrate ordinary working meters.

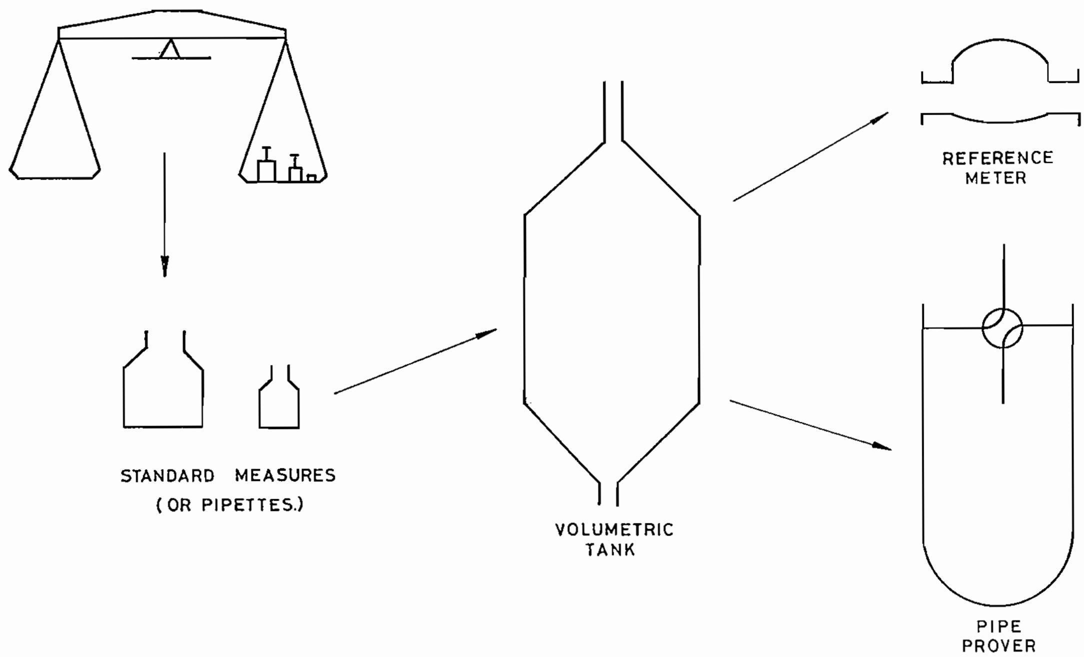

Fig. 2 — A traceability chain of successive calibrations

At the higher end of any traceability chain (the left hand end in this diagram) must always stand a national metrological laboratory. An independent calibration company may choose to break into such a calibration chain at any one of a number of different points. For example, a very small independent may possess no calibration equipment except one or more reference meters, which he needs to take to his local or national legal metrology authority for recalibration against a volumetric tank at regular intervals.

Larger companies, however, are likely to break into the chain at a much higher level. For example, Moore, Barrett & Redwood Ltd operate not only reference meters but also mobile pipe provers and mobile and static volumetric tanks. They therefore find it convenient to possess their own standard measures which are calibrated against the bullion balance in the British National Weights and Measures Laboratory at yearly intervals. They then use these in their own laboratories to calibrate their own volumetric tanks, one of which is subsequently used to calibrate their pipe provers and their reference meters.

Thus, whatever its size and competence, every independent calibration company is compelled to be linked at some stage in its cycle of operations to its national legal metrology authority. Without such a link the independent would have no credibility in the eyes of his discerning clients.

4.2 A Case Study

This study concerns seven dedicated crude oil pipe provers belonging to a single client, which were recalibrated by Moore, Barrett & Redwood Ltd in 1968, and then at yearly intervals from 1971 or 1972 until 1978, when the calibration contract ceased. The results of the calibrations of the four unidirectional provers are plotted against date in Figure 3, with the volumes shown in non-dimensional form. Similar data for the three bidirectional provers are given in Figure 4.

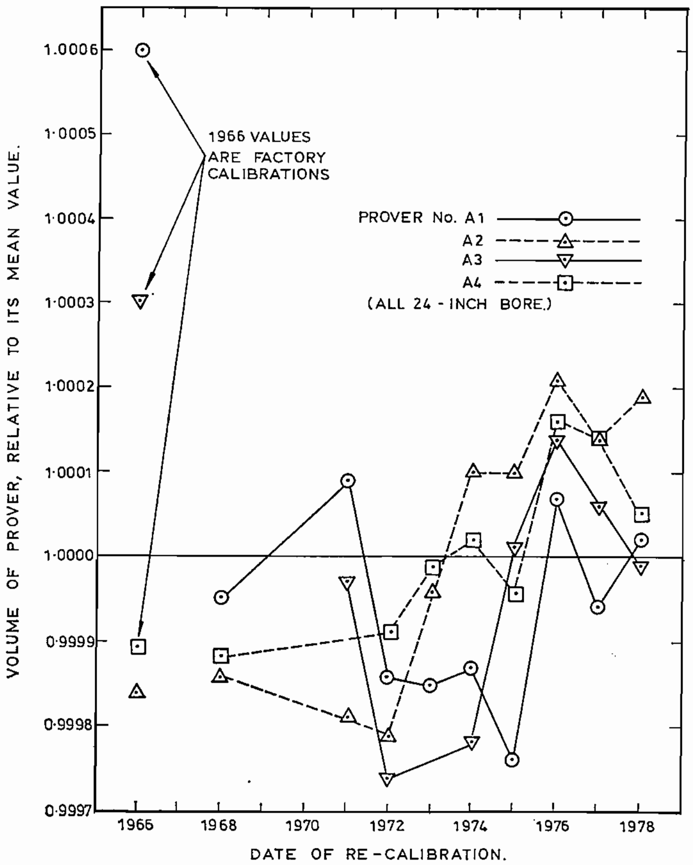

Fig. 3 — Results of recalibrations of a group of four unidirectional pipe provers

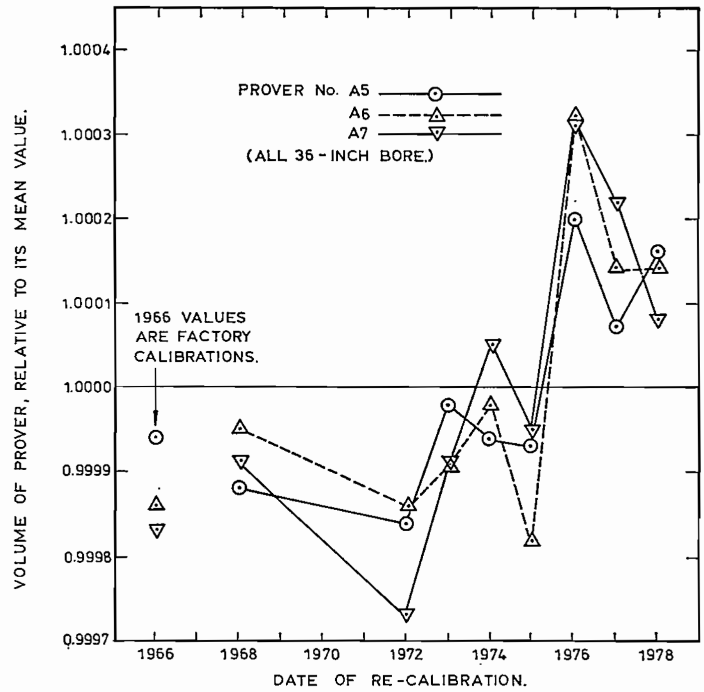

Fig. 4 — Results of recalibrations of a group of bidirectional pipe provers.

Careful examination of Figure 3 reveals that all four volumes appeared to increase in unison between the calibrations of 1975 and 1976. A similar movement is exhibited - only much more obviously - by the three provers in Figure 4. It was therefore thought desirable to plot the mean line for all seven provers, and to plot the volume variation in the master prover over the same period ; this has been done in Figure 5.

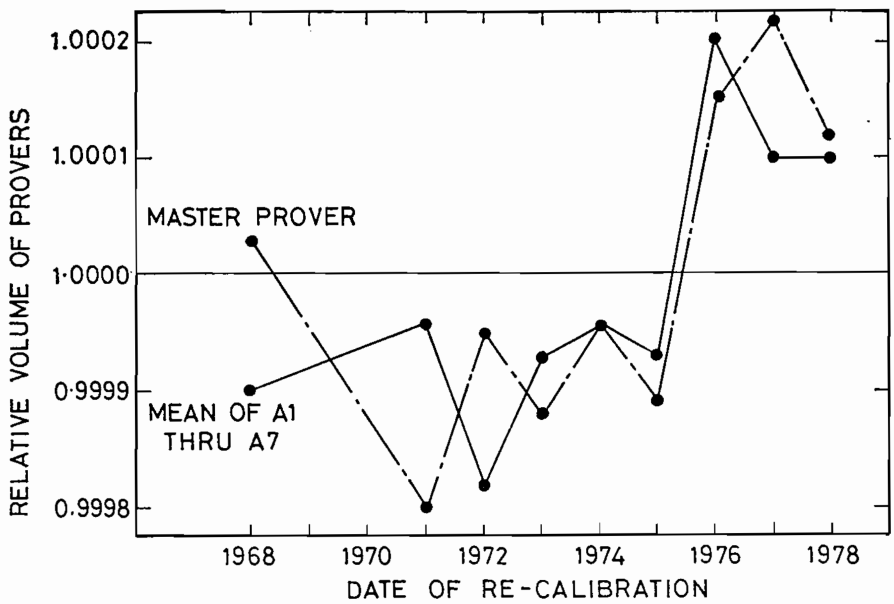

Fig. 5 — Mean of results for all seven provers, from figs. 3 and 4.

This demonstrates quite clearly that the experimental results are the consequence of the normal amount of experimental scatter combined with a systematic shift of approximately 0.02 per cent in the volume of the master prover, which has propagated a similar systematic shift in the volumes of the provers being recalibrated.

The size of this shift was not alarming, being much less than the claimed absolute accuracy of recalibration of the service provers, which is ± 0.05 per cent. Nevertheless, Moore, Barrett & Redwood Ltd expended a great deal of effort in searching for the cause of the shift, and in this they received the close and helpful cooperation of the National Weights and Measures Laboratory, who was responsible for the calibration of their primary standard measures. Despite this intensive activity it proved impossible to identify positively the cause of this small but noticeable shift. It was, however, observed that the claim for « best measurement accuracy » of the national laboratory when calibrating primary measures is only ± 0.01 per cent. Consequently, if the 1975 calibration of the primary measure happened to be at the bottom of this tolerance, and the 1976 calibration at the top of this tolerance, this would account for the systematic shift that was observed. It was therefore concluded that there was nothing to worry about, and consequent recalibrations have borne out this conclusion.

This small incident from calibration history, which is described fully in [1], illustrates how important it is for an independent calibration company to maintain close and friendly relations with its national legal metrology authority.

4.3 **Another Case Study**

The National Engineering Laboratory at East Kilbride, near Glasgow, is a British government institution that has been charged with holding the national standards of flow in oil, water and air. Thus it is complementary to the National Weights and Measures Laboratory, which holds the national standard of volume.

In 1980 a detailed intercomparison exercise was carried out, between the largest pipe prover owned by Moore, Barrett & Redwood Ltd and four of the large flow calibration rigs installed at the National Engineering Laboratory. The mobile prover was taken to NEL and connected in turn to each of the four NEL rigs, and at the same time to one of several flowmeters which could then be calibrated in immediate succession by both the NEL rig and the Moore, Barrett & Redwood Ltd rig.

The results of these tests, which are given in detail in [2], are summarised in Table 1 and Figure 6. These results reflect great credit on all five of the rigs. Table 1 shows that all have excellent repeatability (the marginally better repeatability of the pipe prover may not be significant). Figure 6 shows that any systematic shift between any two of the rigs is considerably less than the accuracy claim for all five rigs, of ± 0.1 per cent.

TABLE 1

Mean overall combined percentage repeatabilities of each standard with transfer package

<table>
<tr><th rowspan="2">Weightank</th><th rowspan="2">Liquid</th><th rowspan="2">Transfer Package</th><th colspan="2">Mean repeatability, per cent</th></tr>
<tr><th>Gravimetric standard</th><th>Pipe Prover standard</th></tr>
<tr><td>3-tonne</td><td>Water</td><td>Two 4-inch turbines</td><td>± 0.050</td><td>± 0.032</td></tr>
<tr><td>30-tonne</td><td>Water</td><td>7-inch turbine</td><td>± 0.047</td><td>± 0.045</td></tr>
<tr><td>1-tonne</td><td>Kerosine</td><td>Positive displacement</td><td>± 0.078</td><td rowspan="2">± 0.035</td></tr>
<tr><td>3-tonne</td><td>Kerosine</td><td>Positive displacement</td><td>± 0.045</td></tr>
</table>

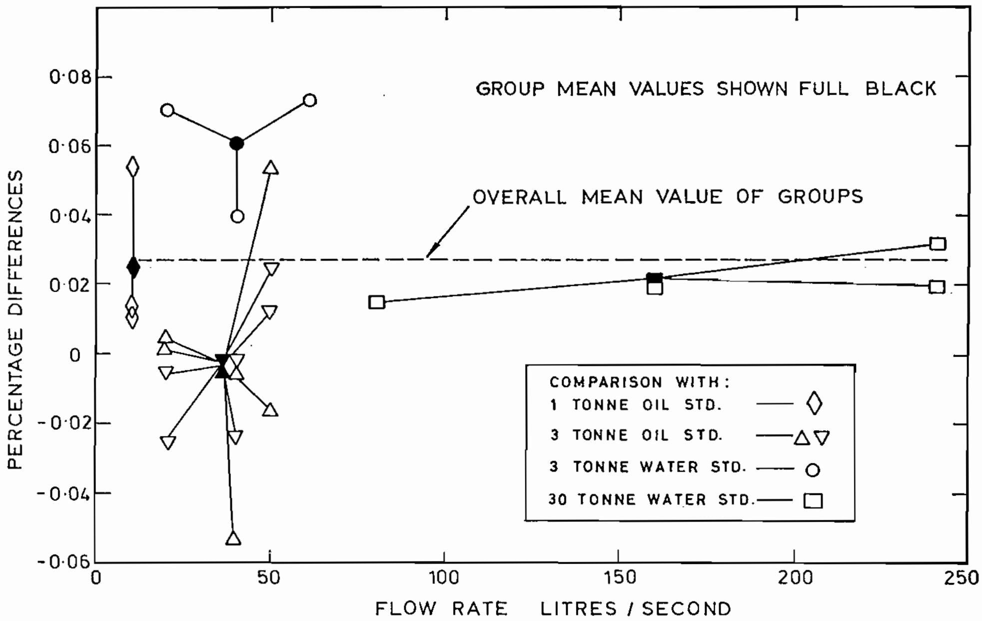

Fig. 6 — Differences between pipe prover and four static weighbridge standards used over a range of 24:1 in flow rate.

These results were of considerable importance to the calibration company, as showing that not only did it possess static traceability of calibration to the volumetric standards of the National Weights and Measures Laboratory, but that there was also excellent dynamic correlation between its own calibration rig and the national standard flowmeter calibration rigs. This strengthening of the company's credibility again illustrates the importance of maintaining close relationships between an independent calibration company and its national government bodies working in the same field.

5. Conclusion

This survey has shown that independent calibration companies do have a fairly well defined and important responsibility in the field of economic metrology of liquids in bulk. If it might be permitted to close with an analogy, legal metrology authorities are the manufacturers of measurement accuracy, independent calibration companies are the wholesale distributors of such accuracy, and their clients are its retailers.

References

[1] A.T.J. Hayward and P.A.M. Jelffs, « Long-term Variations in the Base Volume of Pipe Provers ». Proceedings of the International Flow Measurement Conference at Washington DC, 1986, American Gas Association, Washington DC, 1987.

[2] E.A. Spencer and A.T.J. Hayward, « The relative Accuracies of a Pipe Prover and Four Gravimetric Flow Standards ». IP Paper No. 83-006, Institute of Petroleum, London, 1983.

ACTIVITES DU BUREAU COMMUNAUTAIRE DE REFERENCE (BCR)

Les activités du BCR s'étendent aux mesures physiques (métrologie), mesures dans l'industrie et à l'analyse chimique.

Des informations détaillées sur les matériaux de référence sont données dans un catalogue disponible à l'adresse ci-dessous.

Dans le domaine de la métrologie appliquée, environ 90 sujets de recherche ou développement ont été mis en chantier. Nous donnons ci-dessous les titres de rapports publiés sur ces travaux.

ACTIVITIES OF THE EUROPEAN COMMUNITY BUREAU OF REFERENCE

The BCR programme covers physical measurements (metrology), technological measurements and chemical analyses.

Detailed information on reference materials can be found in the catalogue available at the address indicated below.

In the field of applied metrology about 90 projects have been started. A number of reports have been published on the results. The following publications are available and can be purchased from :

Office for Official Publications of the European Communities — 2, rue Mercier, L-2985 Luxembourg — Telex : PUBLOF Lu 1322.

EUR 6662	E.A. Spencer, E. Eujen, H.H. Dijstelbergen, G. Peignelin, Intercomparison campaign on high-pressure gas flow test facilities (1980).
EUR 8312	H.L. Eschbach, Intercomparison of vacuum measurement with an ionization gauge in the range of 10^{-4} Pa to 10^{-1} Pa (1982).
EUR 8324	L. Silvert, J. Verdonck, Intercomparison of the means of calibration relating to the measuring assemblies used in the refuelling of motor vehicles with liquefied petroleum gases (1982).
EUR 8325	D. Gould, Intercomparison of the calibration of helium leaks for use in leak detection.
EUR 8326	M. Withers, Interlaboratory comparison of the calibration of small volumetric measures (1982).
EUR 8359	J.E. Daborn, G. Kuhlbörsch, Report on the second BCR viscosity audit (1983).
EUR 9767	R. Paton, W. Pursley, Report of the intercomparison of large volumetric measures (1985).
EUR 10167	E. Delany, Pressure sensitivity calibration of 1-inch microphones by the reciprocity technique (1985).
EUR 10027	J.H. Hobbs, Experimental data for the determination of basic 100 mm orifice meter discharge coefficients (European programme) (1985) (Microfiche).
EUR 10100	A. Harvie, The intercomparison of three dimensional measurements taken from coordinate measuring machines (CMMs) (1985).
EUR 10101	M.V. Chattle, R.L. Rusby, Intercomparison of gallium sealed cells (1985).
EUR 10175	B. Cretinon, J. Merigoux, Réalisation d'un système d'étalonnage de transfert d'hygrométrie dans la gamme — 21 °C + 60 °C (1985) (Microfiche).
EUR 10178	T.A Deacon, Intercomparison measurement of the ratios of a 100 kilovolt DC voltage divider (1985).
EUR 10193	A. Braun, H. Richter, Intercomparison of the calibration of a voltage transformer (1985).
EUR 10228	A.K. Michell, The design and construction of a transfer standard dewpoint hygrometer (1985).
EUR 10229	C. Ferrero, C. Marinari, E. Martino, Analysis and calibration of IMGC six component dynamometer (1985) (Microfiche).
EUR 10233	A.E. Drake, Precise magnetic measurements on electrical sheet steels (1985).
EUR 10234	P.J. Key, D.H. Nettleton, Deuterium lamps as transfer standards for spectral radiance measurements (1985).

EUR 10288	M. Peters, A. Sawla, G. Wilkening, EC comparison measurements for forces up to 1 MN (1985) (Microfiche).
EUR 10322	M. Cretinon, J. Merigoux, Development of a hygrometer calibration facility for dew point temperatures from — 20°C to + 60°C (1985).
EUR 10349	B.C. Moss, J.M. Milne, Calibration of ultrasonic transducer sensitivity and power by laser interferometry (1980) (Microfiche).
EUR 10372	A. Peuto, A. Sacconi, R. Balhorn, M. Kochsiek, Density determination of Zerodur spheres and cubes by measuring the mass and the dimension (1985).
EUR 10371	H. Bayer, International intercomparison of high attenuation values (60 dB, 100 dB) in coaxial line at 30 MHz (1985).
EUR 10351	L. Crovini, Intercomparison of noble metal thermocouples between 1000°C and 1600°C (1985) (Microfiche).
EUR 10554	G. de Jong, R. Kaarls, Time synchronization via OTS-2 (1986).
EUR 10562	L.R. Rusby, E.A. Opie-Smith, Improvements of standards for industrial temperature measurements above 1500°C (1986).
EUR 10573	L. Brendel, G. Ludwig, Preliminary investigation of two types of hydrophones up to 15 MHz (1986).
EUR 10574	D. Förste, G. Sauter, The determination of the ratio of luminous flux of discharge lamps to the luminous flux of reference incandescent lamps (1986).
EUR 10575	M.S. Shipton, Intercomparison of measurements on ear protectors by subjective and objective test methods (1986).
EUR 10667	J.F Magana, Turbine meters as hot water transfer standard (1986) (Microfiche).
EUR 10690	G. Bonnier, Cellule scellée de référence de température au point de fusion du sodium (1986) (Microfiche).
EUR 10691	H. Canton, The comparison of European laboratories dealing with middle frequency accelerometer calibration (1986).

INFORMATIONS

MEMBRES DU COMITE

ETATS-UNIS d'AMERIQUE — Monsieur D.E. EDGERLY, représentant des Etats-Unis au Comité et second Vice-Président du CIML, a été nommé Directeur de « Office of Research and Technology Applications » au National Bureau of Standards. Aux termes de la Convention OIML, ce changement de situation implique que Monsieur EDGERLY abandonne ses fonctions au sein du Comité. Monsieur EDGERLY participait aux travaux de l'OIML depuis 1972, d'abord comme collaborateur de Mrs ANDRUS et McCOUBREY, anciens Membres du Comité, puis comme représentant des USA à compter de 1982. Sous l'autorité de Monsieur EDGERLY, la participation des USA aux travaux OIML s'est considérablement accrue et généralisée à des domaines aussi importants, par exemple, que le pesage électronique, les pollutions, ou les principes de la métrologie légale. Nous souhaitons un complet succès à Monsieur D.E. EDGERLY dans le cadre de ses nouvelles et importantes fonctions, et nous sommes heureux d'accueillir Monsieur S.E. CHAPPELL comme nouveau Membre du CIML représentant les USA.

MONACO — Monsieur A. VEGLIA, du Centre Scientifique de MONACO, remplace Monsieur A. VATRICAN dont nous avions annoncé le décès dans notre numéro de mars 1987. Nous souhaitons à Monsieur VEGLIA la meilleure des bienvenues.

PORTUGAL — Le Gouvernement Portugais a désigné son représentant au Comité en la personne de Monsieur A. CRUZ, Directeur du Service de la Métrologie à l'Institut Portugais de la Qualité. Nous sommes heureux de l'accueillir comme premier représentant d'un tout nouvel Etat membre.

TCHECOSLOVAQUIE — Monsieur T. HILL, Président de l'Office de Normalisation et des Mesures, quitte le CIML où il est remplacé par Monsieur M. CIBAK, Directeur de l'Institut Métrologique Tchécoslovaque, à qui nous souhaitons chaleureusement bienvenue. Monsieur HILL, Membre du Comité depuis 1978, aura largement contribué aux liaisons entre ISO, ILAC et OIML. Nous le remercions vivement pour sa longue et importante participation aux travaux OIML.

BIPM

Le BIPM va faire paraître prochainement une plaquette intitulée « Le BIPM et la Convention du Mètre ». On trouvera dans cette plaquette un exposé des activités présentes du BIPM et une brève description des divers organes issus de la Convention du Mètre.

Cette brochure (de 45 pages environ) est illustrée en couleurs et publiée en version bilingue, français et anglais. Elle pourra être obtenue gratuitement auprès du BIPM, Pavillon de Breteuil F-92312 SEVRES Cedex, France.

GRECE

Une importante exposition sur la métrologie était organisée à Athènes du 29 mai au 14 juin 1987 par le secrétariat général de la recherche et de la technologie du Ministère de l'Industrie, de l'Energie et de la Technologie. Cette exposition embrassait les aspects historiques des poids et mesures, les plus récentes définitions des unités SI ainsi que les applications de la métrologie aux essais industriels et à la protection du consommateur et de l'environnement.

L'exposition a reçu un soutien financier de l'UNESCO et fait l'objet d'un catalogue bien illustré, en langue grecque.

APMP

Le Programme de Métrologie pour l'Asie et la région de l'Océan Pacifique a été lancé en 1977 à l'initiative du Conseil Scientifique du Commonwealth (CSC) et avec un support financier substantiel du Fonds de coopération technique du Commonwealth. Ce programme, qui a été, et est toujours, un grand succès, a reçu le soutien financier ou technique d'un nombre d'autres organisations internationales (surtout de l'UNESCO) et nationales (voir Bulletin de l'OIML N° 87, juin 1982).

Le APMP est progressivement devenu une organisation pratiquement autonome qui dépend maintenant financièrement à un moindre degré du CSC, l'accueil des réunions et le secrétariat technique étant assurés par différents pays à tour de rôle (Australie, Inde, Chine, etc.). Une évaluation des résultats a été effectuée dans le rapport de Rogers W'O Okot-Uma, CSC Publication Series No. 207, CSC (86) ISP-19, mars 1986.

Les possibilités d'étalonnage des 21 pays participants à l'APMP sont indiquées en détail, pays par pays, dans APMP Directory of the National Measurement System, CSC Technical Publication Series No. 224, CSC (87) ISP-26, 274 pages, avril 1987. Cette nouvelle et très complète édition a été compilée par Wen Shanlin et Yang Xiaoren de l'Institut national de métrologie de Beijing, R.P. de Chine.

Un séminaire sur l'étalonnage et la vérification joint à la 8ème réunion du Comité directeur de APMP a récemment eu lieu à Beijing du 20 au 31 juillet 1987. Le Directeur du BIML a assisté à ce séminaire et fait un exposé sur les activités de l'OIML.

IFCC

En plus du livre contenant les principales Recommandations de la Fédération Internationale de Chimie Clinique (voir Bull. de l'OIML N° 100, Sept. 1985), l'IFCC vient de publier les Recommandations suivantes qui peuvent avoir un intérêt pour les services de métrologie concernés par les mesures physico-chimiques :

IFCC 1987/4 Guidelines (1987) for Classification, Calculation and Validation of Conversion Rates in Clinical Chimistry

IFCC 1987/5 Approved Recommendation (1985) on Names, Symbols, Definitions and Units of Quantities in Optical Spectroscopy

IFCC 1987/6 Approved Recommendation (1986) on the Theory of Reference Values (Part 1. The Concept of Reference Values)

IFCC 1987/7 Approved Recommendation (1984) on Physico-Chemical Quantities and Units in Clinical Chemistry.

ISO

La troisième édition de KWIC INDEX of International Standards a été publiée par ISO en 1987. Cette publication permet au lecteur de trouver le numéro de référence d'une norme en utilisant un système à mot-clef comportant les mots les plus importants du titre de la norme. L'Index a 577 pages et comprend les publications de 29 organisations internationales, y compris l'OIML.

INFORMATION

COMMITTEE MEMBERS

UNITED STATES of AMERICA — Mr. D.E. EDGERLY, United States representative on the Committee and Second Vice-President of CIML, has been appointed Director of the Office of Research and Technology Applications at the National Bureau of Standards. Under the terms of the OIML Convention this change of circumstances requires that Mr. EDGERLY give up his activities within the Committee. Mr. EDGERLY has participated in the work of OIML since 1972, first as a colleague of Mr. ANDRUS and Mr. McCOUBREY, former Members of the Committee, then as the representative of the USA from 1982. Under Mr. EDGERLY's authority the USA's participation in the work of OIML has grown considerably and broadened into fields as important as, for example, electronic weighing, pollution, or the principles of legal metrology. We wish Mr. EDGERLY complete success in his new and important responsibilities, and we are pleased to welcome Mr. S.E. CHAPPELL as the new Member of CIML representing the USA.

MONACO — Mr. A. VEGLIA, of the Centre Scientifique de Monaco, replaces Mr. A. VATRICAN, whose death we announced in our Bulletin of March 1987. We warmly welcome Mr. VEGLIA.

PORTUGAL — The Portuguese Government has appointed Mr. A. CRUZ, Director of the Metrological Service of the Portuguese Institute of Quality, as its representative on the Committee. We are happy to welcome him as a new Member State's first representative.

CZECHOSLOVAKIA — Mr. T. HILL, President of the Office of Standards and Measurement, leaves the CIML and is replaced by Mr. M. CIBAK, Director of the Czechoslovak Institute of Metrology, to whom we extend a warm welcome. Mr. HILL, a Committee Member since 1978, will have largely contributed to liaison between ISO, ILAC and OIML. We express our keen appreciation and thanks for his important contribution to the work of OIML.

BIPM

A new BIPM publication is shortly to appear under the title « Le BIPM et la Convention du Mètre ». It has been prepared to give an up to date account of the activities of the BIPM and an outline of the organizational structure now existing under the Convention du Mètre.

This colour brochure (c. 45 pp.) is published in a bilingual French/English version and is available free of charge from the BIPM, Pavillon de Breteuil, F-92312 SEVRES Cedex, France.

GREECE

An important exhibition on Weights, Measures and Standards was organised in Athens May 29 - June 14, 1987 by the General Secretariat of Research and Technology, Ministry of Industry, Energy and Technology. The exhibition covered historical weights and measures, the most recent definitions and measurement standards for the SI-units as well as the metrology aspects of testing in industry or for the environment and consumer protection.

The exhibition was financially supported by UNESCO and subject to a well illustrated catalogue in Greek language.

APMP

The Asia Pacific Metrology Programme was originally launched in 1977 through the initiative of the Commonwealth Science Council and with substantial financial support from the Commonwealth Fund for Technical Cooperation. It has been very successful and received financial or technical support from a number of other international (mainly UNESCO) and national bodies (see OIML Bulletin No. 87, June 1982).

Through the years APMP has become almost an independent organization financially less dependent on CSC and hosted by various countries in turn (Australia, India, China, etc.). An evaluation of the results is made in a report by Rogers W'O Okot-Uma, CSC Technical Publication Series No. 207, CSC (86) ISP-19, March 1986.

The calibration facilities of 21 countries participating in the Asia Pacific Metrology Programme are listed in detail, country by country, in the APMP Directory of the National Measurement System, CSC Technical Publication Series No. 224, CSC (87) ISP-26, 274 pages, April 1987. This new very complete edition has been compiled by Wen Shanlin and Yang Xiaoren of the National Institute of Metrology, Beijing, China.

A training seminar on calibration and verification together with the 8th APMP Steering Committee meeting was organized in Beijing 20-31 July 1987. The Director of BIML was invited to attend this seminar and given the opportunity to deliver a lecture about the activities of OIML.

IFCC

The International Federation of Clinical Chemistry has in addition to the collection of IFCC Recommendations and Related Documents which was announced in OIML Bulletin No. 100, Sept. 1985 now published the following documents which may be of interest to metrology services concerned with physico-chemical measurements.

- IFCC 1987/4 Guidelines (1987) for Classification, Calculation and Validation of Conversion Rates in Clinical Chemistry
- IFCC 1987/5 Approved Recommendation (1985) on Names, Symbols, Definitions and Units of Quantities in Optical Spectroscopy
- IFCC 1987/6 Approved Recommendation (1986) on the Theory of Reference Values (Part 1. The Concept of Reference Values)
- IFCC 1987/7 Approved Recommendation (1984) on Physico-Chemical Quantities and Units in Clinical Chemistry.

ISO

The third entirely revised edition of the convenient KWIC INDEX of International Standards has been published by ISO in 1987. The index enables the reader to find the reference number of an international standard by using a key-word system which incorporates the most important words in the title of the standard. The index has 577 pages and covers publications issued by 29 international organizations including OIML.

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

RI 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)

3 — Réglementation métrologique des instruments de pesage à fonctionnement non automatique
Metrological regulations for non automatic weighing instruments

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 — Prescriptions générales pour les compteurs de volume de gaz
General specifications for volumetric gas 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
Optical pyrometers of the disappearing filament type

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

28 — Réglementation technique des instruments de pesage à fonctionnement non-automatique
Technical regulations for non-automatic weighing machines

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

64 — Exigences générales pour les machines d'essai des matériaux
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
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72 — Compteurs d'eau destinés au mesurage de l'eau chaude
Hot water meters

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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 (*)

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

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(*) Projet à sanctionner par la Huitième Conférence Internationale de Métrologie Légale - octobre 1988
Draft to be sanctioned by the Eighth International Conference of Legal Metrology - October 1988.

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
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Guidelines for bi- or multilateral arrangements on the recognition of : test results - pattern approvals - verifications

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Principles of selection of characteristics for the examination of measuring instruments

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