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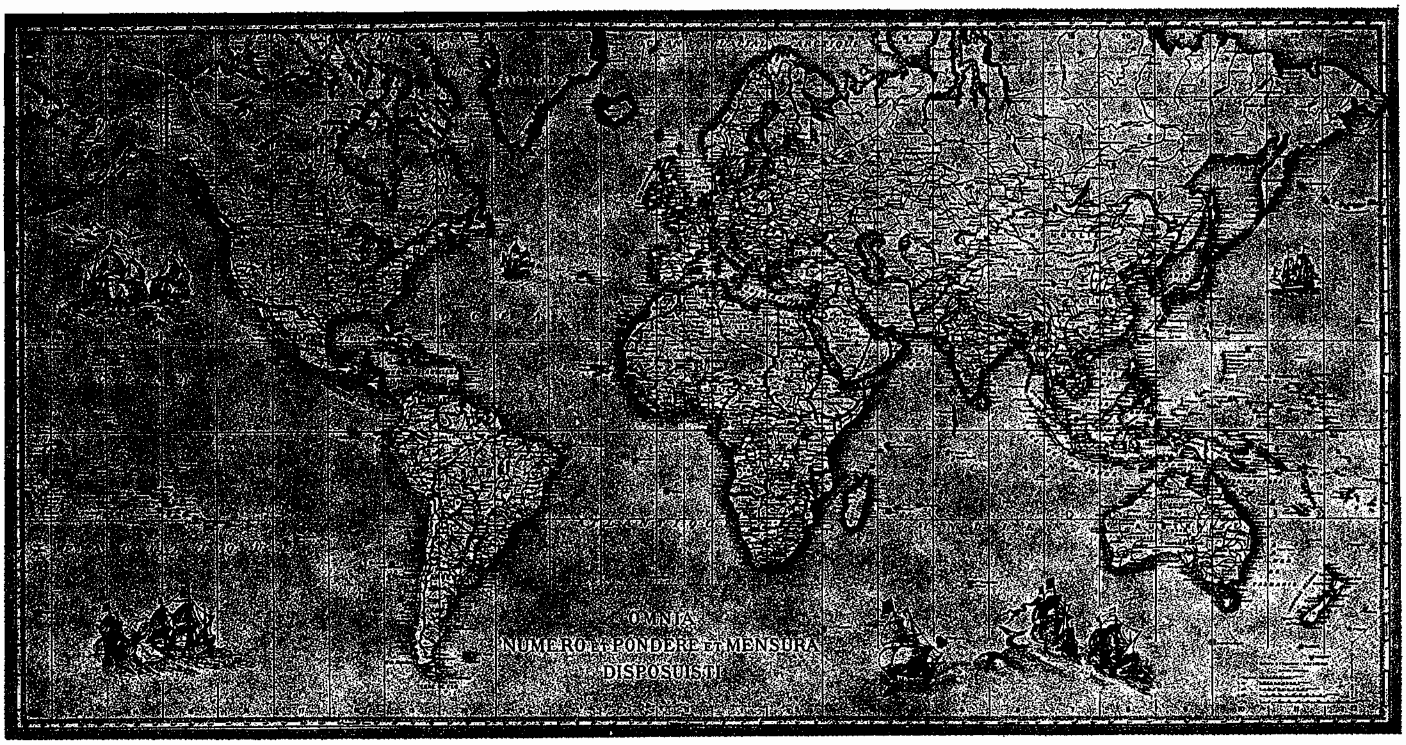

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CONSEIL de DEVELOPPEMENT de l'OIML
SEMINAIRE et REUNIONS du SP 31

La Havane, 11-15 avril 1988

Ce printemps a été marqué par un événement important : la réunion du Conseil de Développement à CUBA jointe à un séminaire pour les pays en développement ainsi que des réunions du Secrétariat-Pilote SP 31 et ses secrétariats-rapporteurs s'occupant de l'enseignement de la métrologie.

Le nombre de participants à ces manifestations était très important grâce aux invitations de CUBA qui ont permis, à titre exceptionnel, à des pays non-membres de l'OIML, d'envoyer des délégués. L'OIML a également, comme cela est l'habitude, pris à sa charge trois participants des pays en développement. Les pays représentés par un ou plusieurs délégués étaient les suivants :

R.D. Allemande, R.F. d'Allemagne, Bolivie, Bulgarie, Brésil, Canada, R. Pop. Dém. de Corée, Cuba, Espagne, France, Guinée, Hongrie, Maroc, Mexique, Nicaragua, Panama, Pérou, Royaume-Uni, Tanzanie, Tchécoslovaquie, Tunisie, Uruguay, URSS, Venezuela et Viet-Nam.

L'Instituto Centro Americano de Investigacion y Tecnologia Industrial (ICAITI), un institut régional de conseil industriel créé avec l'aide de l'ONUDI et installé au Guatemala était également représenté. Il y avait au total plus de 50 participants.

Les réunions ont eu lieu à La Havane au Palacio de las Convenciones, un grand ensemble architectural présentant toutes les installations modernes que l'on peut souhaiter pour une conférence internationale y compris pour la traduction simultanée qui dans notre cas comprenait l'anglais, le français et l'espagnol. Dans l'ensemble l'organisation, à laquelle nos amis cubains avaient pourvu, était parfaite aussi bien en ce qui concerne la conférence, que l'hôtel, le transport et les réceptions.

Une visite de l'Institut de Recherches Métrologiques INIMET fut également organisée. Cet institut, dont le Directeur est M. GOMEZ-ROSELL, est pourvu d'un équipement moderne et adapté aux besoins du pays (voir Bulletin de l'OIML N° 105, Décembre 1986). En attendant la construction de nouveaux bâtiments, les diverses sections de cet Institut sont installées dans la vieille ville de La Havane ainsi que dans les quartiers résidentiels de Miramar.

En liaison avec les réunions de l'OIML, un cours de métrologie était également organisé par INIMET pour certains pays participants. Ce cours avait essentiellement le même programme que celui qui été décrit dans le Bulletin de l'OIML N° 103, Juin 1986.

Les réunions ont débuté par deux journées de séminaire traitant divers aspects de la métrologie, en particulier la formation des ingénieurs et techniciens et les systèmes de vérification des instruments. La métrologie à Cuba y était également présentée et illustrée par un vidéo film. Les titres des exposés sont donnés à la fin de la version anglaise de cet article. Le séminaire a été animé par des discussions auxquelles ont pris part les pays non-membres de l'OIML qui ont ainsi pu s'informer sur le fonctionnement de notre organisation. Ceci laisse prévoir de nouvelles demandes d'adhésion en tant que membres correspondants.

Le séminaire a été suivi des réunions du SP 31 et de ses secrétariats-rapporteurs : SP 31-Sr 1 « Formation d'ingénieurs » dont l'URSS est responsable et SP 31-Sr 2 « Formations de techniciens » dont la responsabilité incombe à la France. Ces réunions ont permis d'une part de réviser les programmes de travail des secrétariats et de mettre au point d'une façon définitive les deux projets : « Cours de métrologie générale pour ingénieurs » et « Formation initiale des techniciens en métrologie légale ». Ce dernier texte qui était au stade de 4e avant-projet sera prochainement soumis au vote de l'ensemble des membres du CIML et il est prévu que les deux projets seront ensuite imprimés dans un même Document International.

Deux premiers avant-projets rédigés par le SP 31-Sr 1 concernant un cours de métrologie mécanique et un cours de métrologie électrique firent également l'objet de débats. On peut prévoir que les sujets de ces deux avant-projets seront largement modifiés pour tenir compte des observations relativement importantes communiquées au secrétariat-rapporteur lors de la réunion.

Du fait que certains aspects de formation et d'assistance bilatérale aux pays en développement ont pu être traités lors du séminaire et au cours des réunions de SP 31, les débats sur certains points de l'ordre du jour du Conseil de Développement ont pu être accélérés.

Le rapport présenté par le BIML sur les activités de l'OIML pour les pays en développement est reproduit dans ce numéro du Bulletin.

Les participants à la réunion ont regretté le peu d'intérêt manifesté par des pays en développement, probablement pour des raisons financières, en ce qui concerne la poursuite de l'enquête sur la formation à l'étranger lancée par le Président du Conseil de Développement, mais ont salué l'initiative qui consiste à organiser des cours de métrologie pour étrangers à Cuba. Ces félicitations vont également à la France et à la RFA pour leurs nouvelles écoles de métrologie, ainsi qu'au Royaume-Uni pour les cours pratiquement annuels qu'il organise. L'URSS, bien qu'accueillant déjà des étrangers dans ses écoles de métrologie à Odessa et à Tachkent, envisage également d'organiser un cours de métrologie pour étrangers dans le cadre du SP 31 et cherche le soutien de l'ONUDI ou de l'UNESCO, organisations dont nous avons malheureusement regretté l'absence de représentation lors de ces discussions.

Le délégué du Royaume-Uni a attiré notre attention sur une brochure « Directory of metrology education and training in the United Kingdom » publiée par le Department of Trade and Industry qui contient des informations sur les différentes écoles et cours existants au Royaume-Uni dans le domaine de la métrologie et de l'assurance de la qualité.

Au sujet de la publication par le BIML de brochures visant à aider les pays en développement, les participants à la réunion ont approuvé ces activités et félicité Cuba pour les travaux de traduction en espagnol.

Un nouveau programme de travail a été établi par le Conseil de Développement comportant pour le BIML la demande de traduire en français certaines brochures et de terminer la brochure en cours intitulée « Guide d'étalonnage » comportant en particulier des conseils et renseignements pour l'étalonnage des étalons nationaux à l'étranger.

L'événement principal décidé par le Conseil de Développement pour l'année à venir est l'organisation d'un séminaire sur la planification et l'équipement de laboratoires de métrologie. Le BIML a été chargé d'examiner les possibilités en ce qui concerne le lieu et la date convenant à cette manifestation.

L'Assemblée présente a exprimé son entière satisfaction et ses remerciements à M. J. GOMEZ-ROSELL pour l'efficacité avec laquelle il a conduit la Présidence du Conseil de Développement pendant la période de 1984 à 1988 et l'a remercié chaleureusement ainsi que ses collaborateurs pour tous les efforts accomplis afin de rendre agréables les réunions à Cuba.

Monsieur Mohammed BENKIRANE, membre du CIML représentant le Maroc a ensuite été élu à l'unanimité Président du Conseil de Développement pour la période 1988-1990.

Rapport sur les activités de l'OIML pour les pays en développement avril 1986 - mars 1988

Publications

Comme prévu dans le Programme de Travail pour 1986-1988 le BIML a pu effectuer une révision complète des deux brochures suivantes qui sont d'un grand intérêt pour les pays en développement :

— Fournisseurs d'équipement de vérification (bilingue, mars 1987)

— Formation en métrologie, synthèse et bibliographie (bilingue, mars 1987).

Par ailleurs, le Président du Conseil de Développement a pris l'initiative de faire traduire en espagnol par son institut les brochures publiées en anglais en 1986 concernant d'une part l'équipement d'un service de métrologie et d'autre part la planification des laboratoires de métrologie et d'essais. Ces publications, qui peuvent être obtenues du Centre d'Information Scientifique-technique de l'Institut de Métrologie du Comité de Normalisation de Cuba, ont pour titres :

— Equipos de verificacion para los servicios nacionales de metrologia

— Planificacion de los laboratorios de metrologia y ensayo.

Comme cela avait été demandé par certains membres du CIML, les informations contenues dans la brochure sur la planification des laboratoires ont pu être complétées par des descriptions de deux laboratoires récemment construits en Finlande et en Espagne. Ces articles ont été publiés dans les Bulletins de l'OIML N° 105, décembre 1986 et N° 109, décembre 1987.

Les Pays-Bas ont attiré notre attention sur une publication de l'Instrument Society of America : ISA RP 52.1 - 1975 - Recommended Environments for Standards Laboratories. Le Brésil nous a adressé une brève description de son laboratoire d'acoustique. Un séminaire très intéressant sur les laboratoires de mesures dimensionnelles a eu lieu en R.F.A. en avril 1986. Les dix exposés présentés sont publiés dans le GMR-Bericht 10-Messräume publié par VDI-Gesellschaft Mess- und Regelungstechnik, Postfach 1139, 4000 Düsseldorf 1.

La brochure du BIML sur la planification des laboratoires a en général suscité un grand intérêt et nous avons reçu plusieurs commandes émanant des pays même très industrialisés. La traduction en français a été retardée mais nous pensons qu'elle pourra être effectuée avant fin 1988 et en prévision d'un séminaire traitant le même sujet.

Le travail de rédaction d'une brochure « guide sur les étalonnages » a commencé et nous avons sollicité la collaboration du BIPM et de plusieurs grands laboratoires nationaux afin de pouvoir inclure des chapitres sur les possibilités d'étalonnage à l'étranger d'étalons primaires ou secondaires en indiquant des renseignements pratiques sur les démarches à effectuer dans ce cas. Le projet sera soumis à l'examen de ces laboratoires et éventuellement à l'ensemble du CIML avant reproduction.

Cours et séminaires de métrologie

Le Président du Conseil de Développement a pris l'initiative d'organiser dans son pays en 1986 et en 1988 des cours de métrologie auxquels les pays membres et les membres correspondants de l'OIML ont été invités à assister. Le programme de ces cours a été indiqué dans le Bulletin de l'OIML N° 103, juin 1986.

Les cours de formation et les nouvelles écoles de métrologie mentionnés par la R.F.A., la France, le Japon et le Royaume-Uni à la réunion du Conseil de Développement en 1986 ont fait l'objet de publication dans le Bulletin de l'OIML N° 104, septembre 1986.

Le BIML a organisé un séminaire technique sur la vérification des installations de mesure de liquides à Arles, France, du 11 au 15 mai 1987. Nous avons eu le plaisir de constater que 10 des 63 participants ont pu venir de pays en développement, ce qui constitue un net progrès par rapport aux séminaires précédents. Les exposés à ce séminaire sont publiés progressivement dans le Bulletin de l'OIML à partir du N° 107, juin 1987.

Le BIML a pu participer activement en donnant des conférences lors de deux séminaires de métrologie, l'un organisé par ASMO à Amman du 24 au 26 novembre 1986 (voir Bulletin de l'OIML N° 106, mars 1987) et l'autre organisé dans le cadre de l'APMP à Beijing, R.P. de Chine en juillet 1987.

L'action entreprise par le BIML pour faire suite à l'enquête présentée à la dernière réunion du Conseil de Développement en ce qui concerne la formation à l'étranger ne semble pas avoir abouti à des résultats satisfaisants. En fait seulement 7 pays (*) sur 18 de l'enquête préliminaire ont fourni au BIML des indications détaillées concernant les besoins spécifiques de formation pour la période 1987-1988. Le BIML a transmis ces informations aux membres du CIML et au moins deux pays (**) ont selon les informations reçues par le BIML répondu favorablement à ces demandes.

Autres actions

Le BIML a continué de fournir des renseignements aux divers pays en développement en ce qui concerne la formation et le matériel de vérification. Ainsi nous avons effectué une estimation du coût d'équipement pour l'Algérie et nous avons pu obtenir de la part du Royaume-Uni une aide en équipement pour l'Ouganda.

Aspect financier

Prise en charge par l'OIML de frais de participation au Conseil

Quatre Etats-membres avaient été invités à envoyer des représentants à la réunion d'avril 1988 aux frais de l'OIML. L'un d'entre eux a indiqué qu'il ne pouvait pas participer, mais cette annulation a été trop tardive pour que l'on puisse contacter un autre pays.

La prise en charge par l'OIML des frais de participation à la réunion du Conseil 1988 a donc concerné trois pays seulement, mais il faut remarquer que le total des dépenses engagées pour les deux réunions de 1986 et 1988 a atteint environ 190 000 francs-français alors que les crédits votés par la Conférence s'élevaient à un peu moins de 160 000 francs-français. Ce dépassement, qui correspond à un vœu exprimé lors de la 7e Conférence, a été rendu possible par l'état relativement sain des finances de l'OIML.

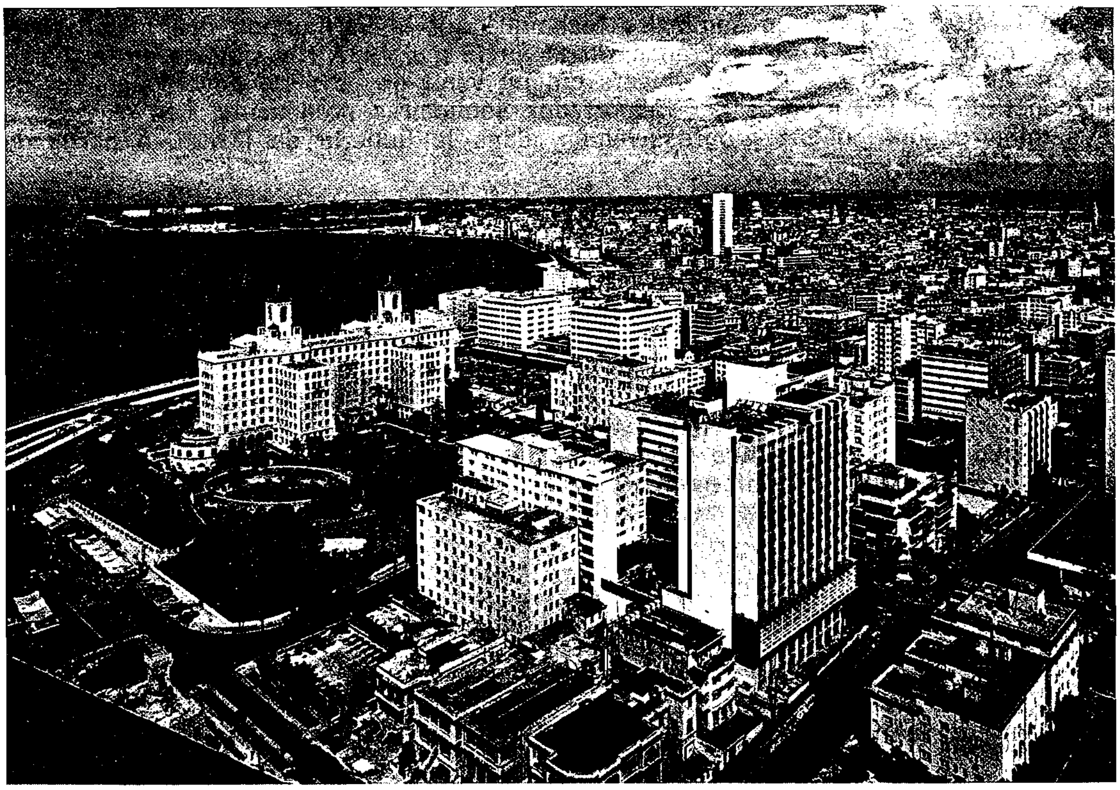
Coût du programme « pays en développement »

Pour la période 1985-1988 ce coût représente 13 % du budget de l'OIML. Il faut cependant considérer qu'environ un tiers du travail du BIML inclus dans le programme « informations » est d'intérêt immédiat pour les pays en développement. Ce programme représentant 19 % du budget de l'OIML, on peut par conséquent, estimer à environ 20 % la part du budget de l'OIML consacrée aux pays en développement.

Etant donné que les pays en développement assurent 23 % du budget de l'OIML, on voit que à 90 % leurs contributions sont utilisées à leur profit exclusivement. Les autres travaux de l'OIML, élaboration des RI et DI en particulier, peuvent donc être considérés comme presque entièrement financés par les pays industrialisés.

(*) Cuba, Pérou, R.P. Chine, R.P.D. Corée, Indonésie, Kenya et Tanzanie.

(**) Australie et Tchécoslovaquie.



OIML DEVELOPMENT COUNCIL, SEMINAR and SP 31 MEETINGS

Havana, 11-15 April 1988

This spring was marked by an important event : the meeting of the OIML Development Council in CUBA combined with a seminar for developing countries and meetings of the Pilot Secretariat SP 31 and its reporting secretariats dealing with metrology training.

The participants in these meetings were numerous thanks to the invitations by CUBA which allowed, as an exceptional measure, countries which are non-members of OIML to send delegations. The OIML had also, as is usual, covered the travelling costs of three participants from developing countries. The countries represented by one or more delegates were the following :

German Democratic Republic, Federal Republic of Germany, Bolivia, Bulgaria, Brazil, Canada, People's Dem. Republic of Korea, Cuba, Spain, France, Guinea, Hungary, Morocco, Mexico, Nicaragua, Panama, Peru, United Kingdom, Tanzania, Czechoslovakia, Tunisia, Uruguay, USSR, Venezuela and Viet-Nam.

The Instituto Centro Americano de Investigacion y Tecnologia Industrial (ICAITI), a regional institute for industrial consultant services created by assistance from UNIDO and established in Guatemala, was also represented. On the whole there were more than 50 participants.

The meetings took place in Havana in the Palacio de las Convenciones, a large architectural compound which has all the modern facilities that can be desired for an international conference including those for simultaneous interpretation which in our case comprised English, French and Spanish. On the whole the organisational facilities provided by our Cuban friends were perfect concerning the conference as well as hotel, transportation and receptions.

A visit to the Institute of Metrological Research INIMET was also organized. This Institute directed by Mr. GOMEZ-ROSELL is provided with modern equipment adapted to the needs of the country (see OIML Bulletin N° 105, December 1986). Pending the construction of new building the various sections of the Institute are installed partly in the old city of Havana and partly in the residential area of Miramar.

In connection with the OIML meetings a metrology course was also organized by INIMET for some of the participants. This course has essentially the same programme as that described in OIML Bulletin N° 103, June 1986.

The meetings started by a two days seminar comprising lectures on various metrology topics, in particular on training of engineers and technicians and on instrument verification systems. The metrology in Cuba was also described and illustrated by a video film. The titles of the presentations are given at the end of this article. The seminar was animated by discussions in which the participants from non-member countries took part and thus could inform themselves about the functionning of OIML. This may lead to future requests for admissions as corresponding members.

The seminar was followed by the meetings of SP 31 and its reporting secretariats : SP 31-Sr 1 « Training of metrology engineers » under the responsibility of the USSR and SP 31-Sr 2 « Training of metrology technicians » for which France is responsible. These meetings enabled on the one hand to revise the work programmes of the secretariats and on the other hand, to finalize the two drafts : « Basic course for metrology engineers » and « Training of legal metrology technicians ». The latter document which was at the stage of 4th predraft will shortly be submitted for voting by all CIML members and it is planned that the two drafts will then be printed together in one International Document.

Two first predrafts provided by SP 30-Sr 1 concerning a course in mechanical metrology and another in electrical metrology were also discussed. It may be expected that these two pre-drafts will be largely modified so as to take into account the rather important comments conveyed to the reporting secretariat at the meeting.

As some of the aspects of training and bilateral assistance to developing countries were already covered during the seminar and in the SP 31 sessions it was possible to accelerate the discussions on certain points of the agenda of the Development Council.

The report presented by BIML on the OIML activities for developing countries is reproduced in this issue of the Bulletin.

The participants regretted the rather low interest shown by the developing countries, probably for financial reasons, concerning the follow-up of the enquiry on training abroad launched by the Chairman of the Development Council but they welcomed the initiative of organizing training courses in metrology in Cuba. Congratulations were also extended to France and the Federal Republic of Germany for their new metrology schools and to the United Kingdom for the annual metrology courses for foreigners. The USSR which already receives foreigners at the metrology shools in Odessa and Tachkent also plans to organise a special course within the framework of SP 31 and is seeking support from UNIDO and UNESCO, organizations which were unfortunately not represented during these discussions.

The representative from United Kingdom draw our attention to the brochure « Directory of metrology education and training in the United Kingdom » which is published by the Department of Trade and Industry and which contains information on the various schools and courses existing in the United Kingdom in the field of metrology and quality assurance.

Concerning the publication of BIML brochures intended to guide developing countries, the meeting approved these activities and congratulated Cuba for all the translations made into Spanish.

A new work programme has been drawn up by the Development Council including a request to BIML to translate some of these brochures into French and to finalize the brochure « Guide to Calibration » comprising in particular advice and information for calibration abroad of national measurement standards.

The main event decided the Development Council for the coming year is the organization of a seminar on planning and equipping of metrology laboratories. The BIML was instructed to examine the possibilities as regards suitable place and date for this event.

The participants expressed their full satisfaction to Mr. J. GOMEZ-ROSELL for the effectiveness with which he has conducted his task as Chairman of the Development Council during 1984 to 1988. They also expressed their gratitude to him and his colleagues for all the efforts accomplished to make the meetings in Cuba pleasant and successful.

Mr. Mohammed BENKIRANE, CIML member of Morocco was unanimously elected Chairman of the Development Council for the period 1988-1990.

List of papers presented at the international seminar on legal metrology

Havana, April 11-12, 1988

1. Metrological ensuring of the National Economy of the P.R. Bulgaria
   by V. Gavrailov, Bulgaria
2. Role of metrology in scientific and technical progress and in contemporary education
   by A.S. Vishenkov, USSR
3. The national service of time and frequency in the Republic of Cuba
   by Eng. Silvia Iglesias Valcarcel, Cuba
4. Training in metrology for national and foreign students at the Ecole Supérieure de Métrologie in Douai, France
   by P. Bertran, France
5. Metrology for reliable verification of measuring instruments
   by Dr. Seton Benett, United Kingdom
6. The study of metrology as general and engineering subject at higher and secondary specialized institutions
   by V.P. Lukjancev, USSR
7. National Technical Training Program. Phase 1 and 2
   by C. Burningham, Canada
8. The implantation of the International System of Units in the Republic of Cuba
   by Eng. Eugenio Rodriguez Tapia, Cuba
9. Training concepts and activities in the F.R. of Germany as part of technical co-operation with developing countries
   by Dr. Christian Ulrich Volkmann, F.R. of Germany
10. Automation of the verification of measuring means
    by V. Gavrailov, Bulgaria
11. Metrological assurance of international trade weighing machines
    by Eng. José Suarez Rivero, Cuba
12. How can developing countries benefit from OIML activities and implement International Recommendations
    by S.A. Thulin, BIML
13. Evolution of the metrology in Spain
    by Dr. Manuel Cadarso, Spain
14. Metrological control of electronic weighing instruments and petrol pumps as adapted to developing countries
    by Dr. Christian Ulrich Volkmann, F.R. of Germany
15. Metrology assurance in Cuba
    by Eng. Luis Revuelta Formoso, Cuba

Report on OIML activities for developing countries

April 1986 - March 1988

Publications

As foreseen in the Work Programme for 1986-1988 BIML has completely revised the following two brochures which are of great interest to developing countries :

— Suppliers of verification equipment (bilingual, March 1987)

— Metrology training, synthesis and bibliography (bilingual, March 1987)

On the initiative of the Chairman of the Development Council his Institute has translated into Spanish the two brochures published in 1986, one on « Equipment of a National Metrology Service » and the other on « Planning of Metrology and Testing Laboratories ». These publications, which can be obtained from the scientific-technical Information Centre of the Metrology Institute of Cuba, have the following titles :

— Equipos de verificacion para los servicios nacionales de metrologia

— Planificacion de los laboratorios de metrologia y ensayo.

As requested by some CIML members the information contained in the brochure on laboratory planning has been extended by descriptions of two recently built laboratories in Finland and in Spain. These descriptions have been published in the OIML Bulletins No. 105, December 1986, and No. 109, December 1987.

The Netherlands have drawn our attention to a publication of the Instrument Society of America : ISA RP 52.1 - 1975 - Recommended Environments for Standards Laboratories. Brazil has sent us a short description of their acoustic laboratory. A very interesting seminar on laboratories for dimensional measurements took place in the Federal Republic of Germany in April 1986. The ten papers then presented have been published in the report GMR-Bericht 10 - Messräume, edited by VDI-Gesellschaft Mess- und Regelungstechnik, Postfach 1139, 4000 Düsseldorf 1.

The BIML brochure on planning of laboratories has aroused great interest and we have even received several orders from some highly industrialized countries. The translation into French has been delayed but we hope it can be done before the end of 1988 in view of a planned seminar on the same subject.

Work has started on the brochure « Guide to calibration » and we have sought the cooperation of BIPM and several national laboratories in order to include chapters on the possibilities of calibration abroad of primary and secondary standards, with practical information concerning the administrative and other steps to take. The draft brochure will be submitted to these national laboratories for comment and possibly also to the CIML members, before publication.

Metrology courses and seminars

The Chairman of the Development Council took the initiative in organizing metrology courses in his country in 1986 and 1988 for OIML Member States and Corresponding Members. The programme of these courses is reproduced in OIML Bulletin No. 103, June 1986.

The courses and new metrology schools described by the Federal Republic of Germany, France, Japan and the United Kingdom at the meeting of the Development Council in 1986 have been subject to publication in the OIML Bulletin No. 104, September 1986.

The BIML organized a technical seminar on the calibration of liquid volume measuring installations in Arles, France 11-15 May 1987. We were happy to see that

10 of the 63 participants came from developing countries which represents a much better score than at preceding seminars. The papers presented at this seminar are progressively being published in the OIML Bulletin starting with No. 107, June 1987.

The BIML participated actively by delivering lectures at two metrology seminars, one organized by ASMO in Amman, 24-26 November 1986 (see OIML Bulletin No. 106, March 1987) and the other organized within the framework of APMP in Beijing, China in July 1987.

The actions undertaken by BIML as a follow-up of the enquiry reported at the last meeting of the Development Council and concerning training abroad has unfortunately not yielded very satisfactory results. In fact only seven countries (*) out of the eighteen of the preliminary enquiry have supplied BIML with details of the specific training needs for the period 1987-1988. The BIML has transmitted this information to the CIML members and at least two (**) have responded favourably.

Other actions

The BIML has continued to supply information to developing countries about training and verification equipment. We have thus made an equipment cost estimate for Algeria and we have been able to obtain an equipment grant from the United Kingdom for Uganda.

Financial aspects

OIML Contribution to costs of participation in the Development Council

Four Member States were invited to participate at the expense of OIML in the Development Council meeting in April 1988. One of them announced that it could not participate but this cancellation took place too late to arrange contacts with another country. The expenditure on behalf of OIML at the Development Council meeting in 1988 is thus limited to that of three participants. However, it must be noted that the total expenditure for the two meetings in 1986 and 1988 amounts to about 190 000 French francs whereas the corresponding budget voted by the Conference amounts to slightly less than 160 000 French francs. This over-run, suggested during the 7th Conference, was possible due to the fair financial situation of OIML.

Cost of the programme « developing countries »

For the period 1985-1988 this expenditure represents 13 % of the OIML budget. It must however be borne in mind that about one third of the BIML activities included in the programme « information » is of direct interest to developing countries. This programme represents 19 % of the OIML budget ; one may thus estimate that roughly 20 % of the OIML budget is devoted to special activities for developing countries.

Taking into account that the developing countries contribute about 23 % of the budget of OIML, we can see that about 90 % of their contributions is used exclusively for their profit. The other activities of OIML and in particular the production of International Recommendations and International Documents may thus be considered to be almost fully financed by the industrialized countries.

(*) Cuba, Perou, P.R. of China, P.D.R. of Korea, Indonesia, Kenya and Tanzania.

(**) Australia and Czechoslovakia.

LIQUID FLOW CALIBRATION USING A LOAD CELL WEIGHING MACHINE *

by **J.S. PAIK**

Korea Standards Research Institute
P.O. Box 3, Taedok Science Town
Taejon, Chungnam 300 - 31

SUMMARY — The author describes 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.

RESUME — L'auteur 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.

Introduction

In the course of a continuing research effort for the establishment of national measurement standards, several small and a medium scale primary liquid standard facilities [1] have been constructed at KSRI. Due to its high potential accuracy, a gravimetric method was employed. In the gravimetric standard facility, liquid flow is generated by either direct pumping or a constant head tank and passed through the meter, control valves and then into a weighing tank.

When a steady state flow condition is established, the fundamental accuracy of a gravimetric flow standard system depends on accuracy of the weighing machine [2, 3, 4]. In order to keep the over all uncertainty within ± 0.2 %, any systematic or random errors in the mass measurement have to be reduced to less than ± 0.1 % [2]. In fact, according to ISO-4185-80 [4], the maximum permissible systematic weighing error is restricted to ± 0.05 % of the mass registered on the weighing machine. The uncertainty due to random weighing errors has to be less than ± 0.1 %.

Recent development of load cell technology [5, 6] has achieved remarkable improvement in sensitivity and accuracy of load cell weighing machines. Performance characteristics of these machines are not only comparable with those of the best mechanical ones but also convenient to interface with a computer and available at a relatively low price. Because of these advantages, load cell weighing machines tend to be preferred to mechanical weighing machines.

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

Performance characteristics of load cell weighing machines were verified by a deadweight test method and then compared with deadweight/water ballast test results. Tests have been repeated at the regular base over a year to evaluate the long term stability and then a calibration interval was determined. The design of the weighing machines and the selection of load cell associated closely with the final measurement accuracy were also reviewed.

Gravimetric liquid flow standard facilities at KSRI

For liquids, five different gravimetric standard systems are in commission. Among them four systems are employing load cell weighing machines. In order to determine the mass of liquid in a static way, the liquid flowing out from the testline is collected either by a standing start and finish method or by a flying start and finish method. Continuous efforts have been made [1] to reduce overall uncertainty of each system to less than ± 0.2 %. The water flow standard facility at KSRI is schematically illustrated in figure 1. The type of flow meters which may be calibrated with this system is limited to the bore size of 200 mm or the maximum flow rate of 0.1 m^3/s. At present this is the largest one, however, construction of a larger scale flow standard facility is at the stage of planning.

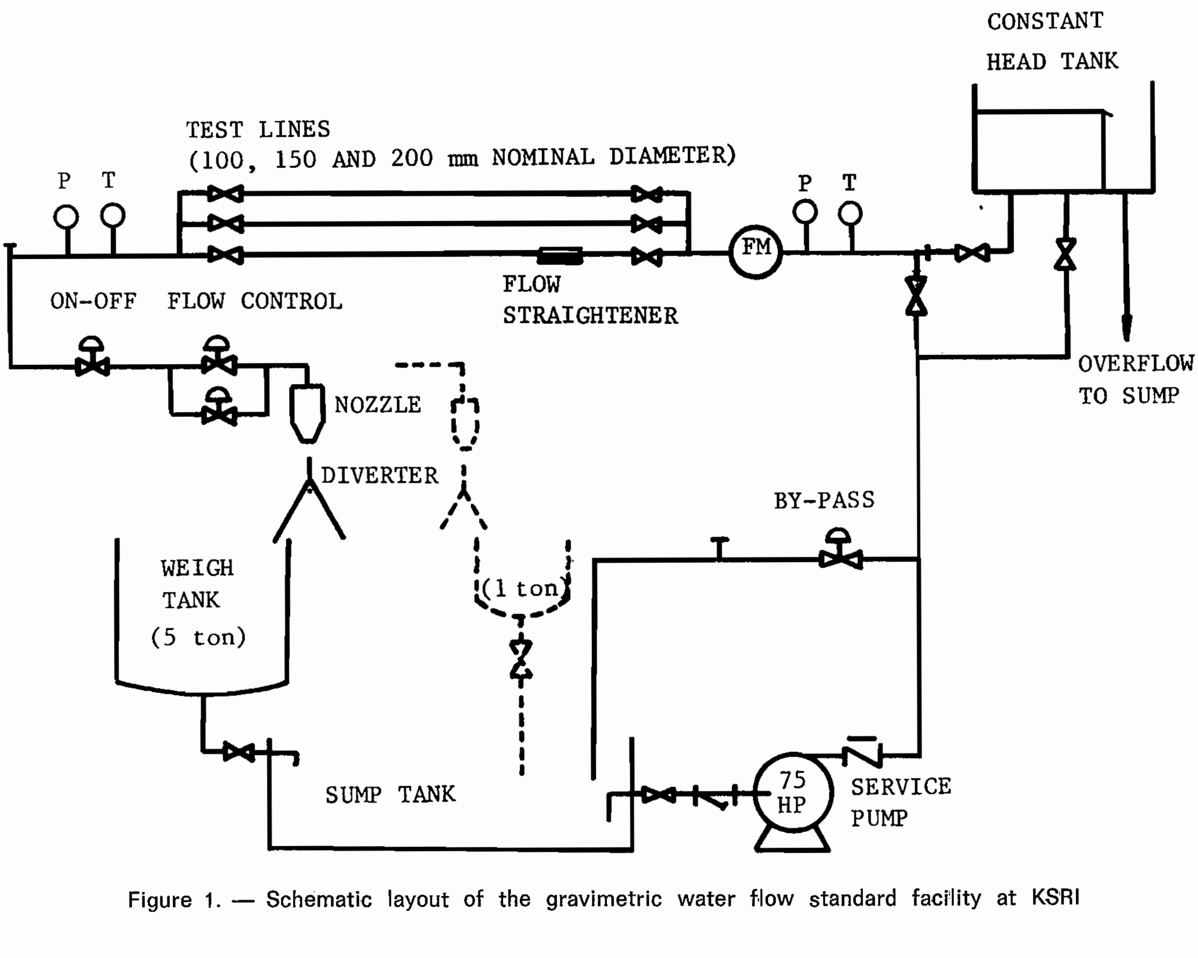


Figure 1. — Schematic layout of the gravimetric water flow standard facility at KSRI

Essential parts of the flow standard systems are a sump tank, a pump, a constant head tank, a testline and a load cell weighing system. Water stored in the sump tank may be pumped to the constant head tank or to the testline directly. The constant head tank is located at the top of the hill of 17 m high. Water flows from the tank under a constant head through the testline and control valves. Water is then issued as a jet from a nozzle of a fish tail shape situated at the end of the pipeline. For a measured interval, the jet can be diverted into a weighing tank during the test.

The uncertainty of flow measurement depends on a combination of uncertainties of separate measurement results of mass, time, length and temperature. Among these mass is the most difficult to determine with accuracy level required for the primary flow standards. Therefore, the accuracy of a gravimetric standard system is heavily dependent upon performance characteristics of the load cell weighing machine installed.

Load cell weighing machine

As long as a weighing machine offers the required sensitivity, accuracy and reliability, it can be used for the gravimetric flow standard system. Mechanical weighing machines of conventional design, equipped with beam and counter poise have been recommended traditionally for the large capacity facilities [7]. For smaller capacities, a straight lever or even the equal arm system can be used.

Performance characteristics of mechanical machines, however, may be affected seriously by the damage on their knife edges. The damage may be caused by wear, corrosion, or shock loading and alters the sensitivity as well as load transmission ratio to increase the weighing error. Furthermore, automation of data logging and processing is not convenient. When automation is essential, load cells have to be fitted additionally at corners of the support structure for the weighing tank [3] as a means of providing electrical signals unless other special arrangements are available. Depending on the required accuracy level and capacity as well as functions, therefore total expenses for the installation and the maintenance of a mechanical weighing machine may be much higher than that of a load cell weighing machine. Nowadays, load cell weighing machines tend to be recommended instead of mechanical ones. In the following sections, the experience of KSRI on load cell weighing machines will be discussed in detail.

1. Structure

In a load cell weighing machine, the weighing tank or the container is supported by several interconnected load cells. The load cells convert the load acting on them into an analog electrical signal. For weighing machines of 300 kg and 600 kg three load cells of a shear type are arranged in such a way to distribute total load as uniformly as possible and the weighing tank is positioned upright on them. This requirement is fulfilled by locating three load cells at the same distance from the vertical centerline of the weighing tank and have them spaced at 120° from one another. When constructing the designed weighing machine, leveling operations were carried out carefully to adjust the supporting surface for the load cells horizontally, position the weighing tank vertically and bring the loading points of load cells to the same level.

In the case of the 6 t weighing machine, three load cells of a column type are used in a tension mode instead of a shear type and the weighing tank is suspended. The load cells are arranged in the identical way as smaller capacity weighing machines and the same amount of attention was paid for levelling operation during the construction period. The weighing tank is connected with load cells by using knuckle eyes to minimize the effects of lateral forces on load cells caused by wind forces, vibrations, etc.

2. Load cell selection

The accuracy of a load cell weighing machine is limited by performance characteristics of each load cell supporting the weighing tank. Before making the selection of load cells, therefore, the meanings of specifications which represent load cell characteristics such as repeatability, non-linearity, hysteresis, temperature effects on zero point and output of the load cell, creep, etc. have to be understood clearly.

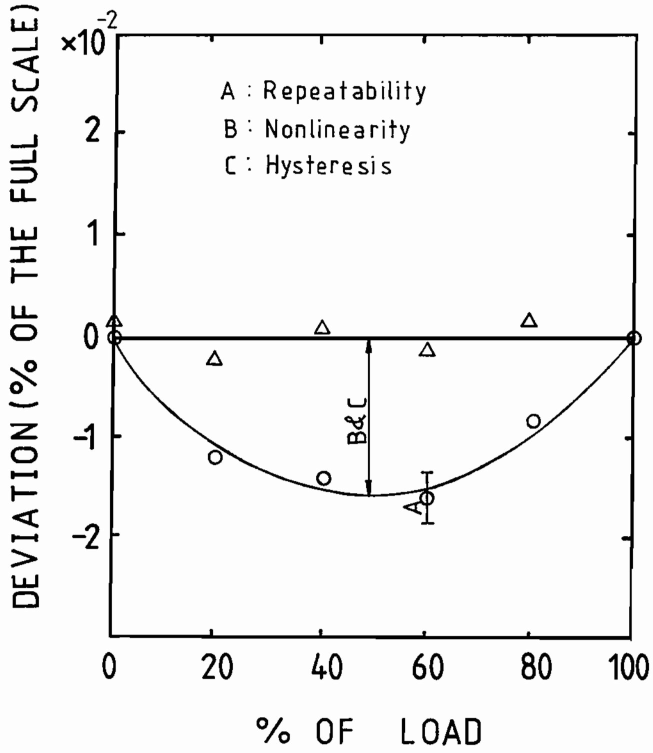


Figure 2. — Performance characteristics of the 20 kN load cell.

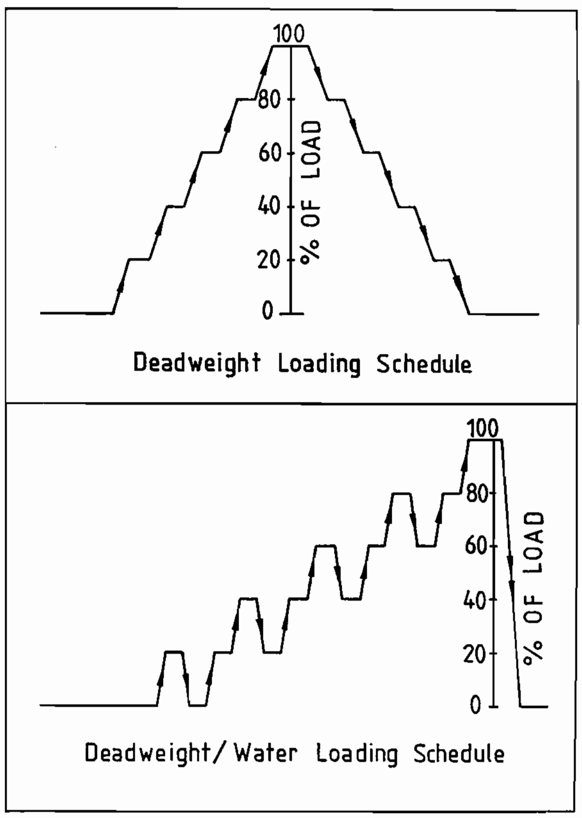


Figure 3. — Loading schedules for the deadweight method and the water method.

In figure 2, test results of a 20 kN load cell are summarized as an example. In this figure, deviations from the straight line passing through the output at zero and the maximum loading point are shown as a function of the applied force and the relative magnitude of the maximum deviation is indicated as the non-linearity. Each data point represents the mean value of three measurement results and the scattering of the data is associated with the repeatability of the load cell. The hysteresis of a load cell is usually defined as the difference between the measurement of load cell output for the same applied force during loading and unloading procedure. In figure 2, the maximum difference between the loading and unloading curve is the hysteresis of this load cell.

Temperature effects on zero and output [5] at each loading point, over a temperature range of about 60 °C, can be adjusted to a very small magnitude by using compensation gages. Within the range — 10 °C to 60 °C, this load cell was found to change its zero point less than ± 0.002 % of the full scale per °C and output less than ± 0.0015 % of the load per °C.

The creep of a load cell is specified by most manufactures as the maximum change of output over a specified time after increasing the force from zero to the maximum capacity of the load cell. This is a complicated phenomenon [6] with several different factors contributing to the overall effect. More detailed discussion is out of scope of this paper, but for high accuracy calibration of a weighing machine it is recommended to follow carefully a timed loading sequence and take readings of the output of the load cell at well defined points in the sequence. Usually a high precision load cell such as the one used in this test does not change its output at the maximum load more than 0.02 % of the full scale during an hour.

Three load cell weighing machines of 300 kg, 600 kg and 6 t have been constructed. Two different types of load cells were purchased for these machines. Beam type load cells using the shear principle of load sensing were chosen for the two smaller weighing machines. These load cells are compact and insensitive to the positioning of the applied load along the beam. The ease of installation without need for a complicated supporting structure and mounting accessories was also considered seriously during the selection period. For the 6 t weighing machine, three 20 kN load cells of column type were chosen and mounted in a tension mode to have a suspended weighing tank for the reason of stability. The main performance specifications of the selected load cells are summarized in Table 1.

Table 1. Performance specifications of selected load cells

<table>
<tr><th></th><th>Beam type load cell
(for 300 kg and 600 kg weighing machines)</th><th>Column type load cell
(for 6 t weighing machine)</th></tr>
<tr><td>Rated Output (RO)</td><td>2.0 mV/V ± 0.01 %</td><td>2.0 mV/V ± 0.1 %</td></tr>
<tr><td>Zero Balance % RO</td><td>1.0</td><td>1.0</td></tr>
<tr><td>Non-linearity % RO</td><td>0.03</td><td rowspan="2">0.025</td></tr>
<tr><td>Repeatability % RO</td><td>0.01</td></tr>
<tr><td>Creep % RO</td><td>< 0.02 (20 minutes)</td><td>< 0.025 (30 minutes)</td></tr>
<tr><td>Temp. Effect :
Zero Balance % RO
Output % Reading</td><td>
0.003/K
0.0015/K</td><td>
0.002/K
0.0015/K</td></tr>
</table>

3. Performance characteristics of the weighing machines.

For the full characterization of the load cell weighing machines, a deadweight method and a water method were applied [2, 3]. Depending upon the capacity of a weighing machine, deadweights of 20 kg, 100 kg and 500 kg have been combined to apply the required load in stepwise.

1) Procedure of the deadweight method.

   i) For weighing machines of 300 kg and 600 kg, a wood platen was laid inside the weighing tank to position the deadweights. However, for the machine of 6 t two I-beams were placed across the tank.

   ii) Up to the maximum capacity from the zero of the weighing machine, it was preloaded several times until the load indication was stabilized. Special care was taken to load the tank symmetrically.

   iii) Zero and span of the indicator were adjusted at zero load and at the maximum load respectively. This procedure was repeated until the zero and the maximum load indication deviated from the nominal value by not more than the discrimination of the indicator. Indicators having been used in this study can discriminate at least 1/10000 of the full scale, and display the load directly in kg.

   iv) During the calibration, the loading and unloading procedures were conducted according to a schedule as in figure 3. Experiments have been repeated at least 3 times over the full range and a least 5 equally spaced loading steps were taken.

2) Procedure of the water method.

   i) A wood platen or I-beams were laid across the weighing tank

   ii) Before starting the calibration procedure, the weighing machines were preloaded several times until the indicator reading was stabilized.

   iii) A test-deadweight unit was placed on the weighing tank and the indicator reading was noted. Different unit loads were applied depending upon the capacity of weighing machines. For the 6 t weighing machine, the test-deadweight unit of 500 kg was used. The loading schedule followed during the test is illustrated schematically in figure 3.

   iv) The test-deadweight unit was removed from the weighing tank and water was added until the indicator display become identical to the deadweight reading.

   v) Steps iii) and iv) were repeated up to the maximum capacity of the weighing machine. The full experimental procedure was repeated three times.

3) Calibration results and discussion

   i) Preloading effects.

   In order to eliminate the warm-up effect which might give unreliable indicator readings, the electrical supply to the load cell weighing system is always kept on. However, preloading cycles usually consisting of 3 and 6 loads to the maximum capacity still have to preceed the actual loading cycles as, in practice, a small residual temperature rise exists [6] after the completion of each loading cycle. The magnitude of this rise falls with the number of cycles until a stable condition is reached. In figure 4, the variation of the weighing indication at the maximum load of each loading cycle is indicated. In the case of the 300 kg weighing machine, it reached a stable condition after the third loading cycle while the 600 kg one established a stable condition only after the sixth loading cycle. The number of loading cycles required for the best performance of weighing machines appears to be different depending upon the individual load cells. However according to

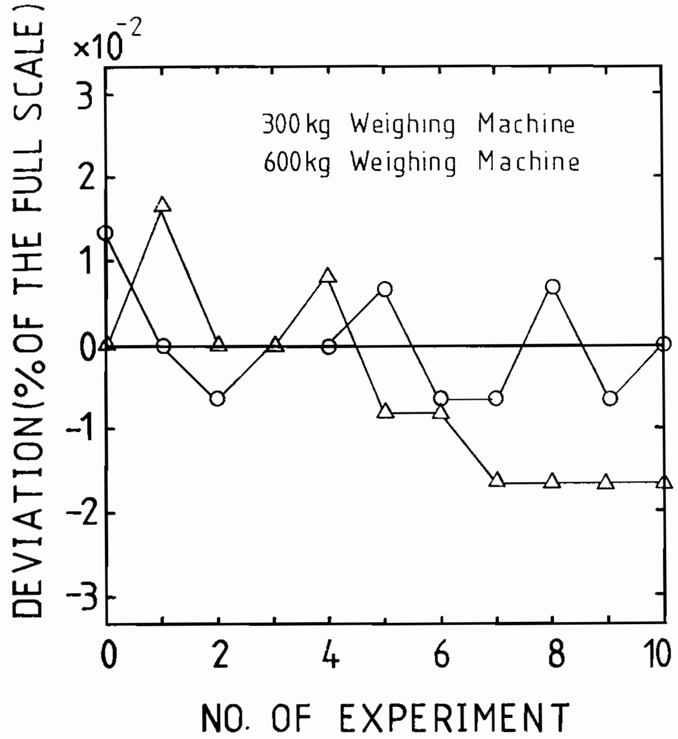


Figure 4. — Variation of weight indications at the maximum load as a function of the number of preloadings.

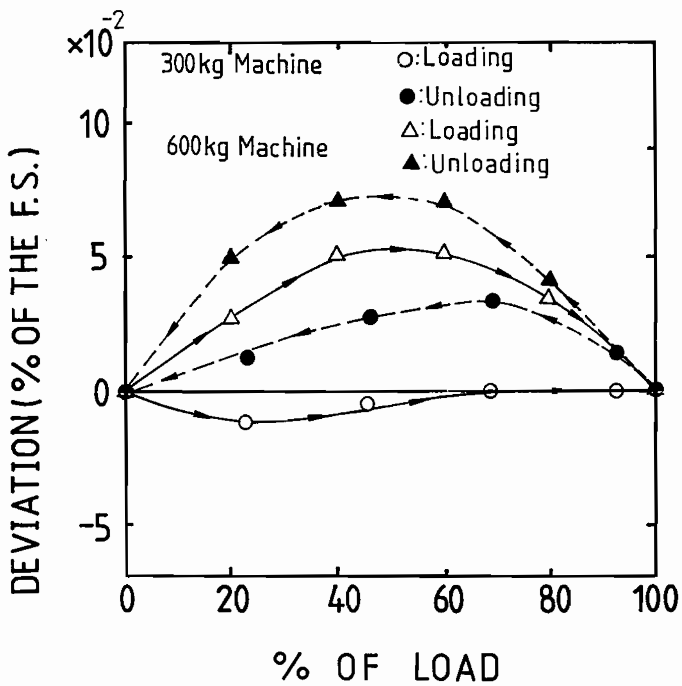


Figure 5. — Calibration results of small capacity weighing machines.

our experience obtained during a routine calibration of various load cells, the best measurement accuracy required for the load cell weighing may be ensured by having not more than 6 preloading cycles before actual data acquisition.

ii) Small capacity weighing machines

The load cell weighing machines of 300 kg and 600 kg have been tested according to the test procedure as described in the previous section. The loading schedules in figure 3, were followed during the deadweight test and the deadweight/water ballast test. The normal deadweight test results obtained by stacking test deadweight units one by one inside of the weighing tank are summarized in figure 5 for both weighing machines. While the 300 kg weighing machine shows a non-linearity of 0.03 % of the full scale, the 600 kg one shows a non-linearity of 0.07 % of the full scale.

Beam type load cells are installed in both of 300 kg and 600 kg weighing machines. On the surface of the shear web spring element of a beam type load cell is a strain gage bridge arrangement to detect the shear stress. Since strain gages are bonded at the neutral axis where the bending stress is zero, in the ideal loading situation [7], these load cells are insensitive to the position of the applied load along the beam. However, a slight rotation of the load cell around the longitudinal axis of the beam might introduce a complex bending stress field to the strain gage bonding area. The increased non-linearity of the 600 kg weighing machine, therefore, appears to be associated with the rotational misalignment of the load cells.

Since a rather large non-linear behavior of the 600 kg machine is not acceptable for the accurate determination of the weight change, it is necessary to draw a best fit curve through the individual data points and correct the measured value. According to ISO-4185-80, the maximum permissible systematic weighing error is restricted to ± 0.05 % of the load. Therefore, even the 300 kg weighing machine can not satisfy the above requirement when it is operated at 50 % of the full load. Non-linearity of 0.03 % of the full scale actually means 0.06 % error at the 50 % of full load. In order to guarantee the reliability for the non-linearity correction and to determine a calibration interval by evaluating the long term stability, deadweight tests have been repeated at the regular base over a long period of time. During a year, test results revealed an output change of less than 0.02 % of the full scale at the maximum load. It is well within the permissible weighing error so that a calibration interval of 12 months appears to appropriate.

Calibration results obtained by applying a water method (water test I), however, showed deviation from the deadweight results by about 0.05 % of the full scale at the maximum load as shown is figure 6. This much of deviation might be possible as a result of simple rounding off effect [2]. In fact, when the smallest weight which can be distinguished by the indicator is 20 g and the test deadweight-unit of the water method is 20 kg, a cumulative error of 0.05 % of the full scale is possible for the 300 kg weighing machine during the substitution operation of the test-deadweight unit with water. In order to confirm the hypothesis, the water method was repeated with an indicator of which the discrimination is 10 times higher than the previous one (water test II). Contrary to the expectation, however, both of water test results (water I and II) agreed very well and did not decrease the deviation from the deadweight results.

The loading sequence of the deadweight method is always incremental but that in the water method load increasing steps alternates with load decreasing steps. Hysteresis effects due to difference in loading procedure might have caused deviation between two methods. Using a 20 kN load cell of 1/5 000 class, the respective loading sequence of both methods was simulated by a deadweight machine to find less than 0.01 % difference. It

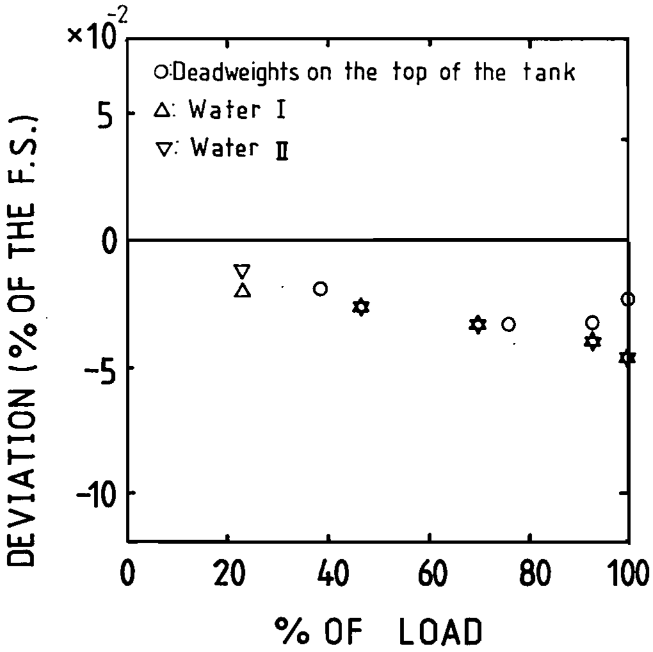


Figure 6. — Water calibration results in comparison with deadweight calibration results.

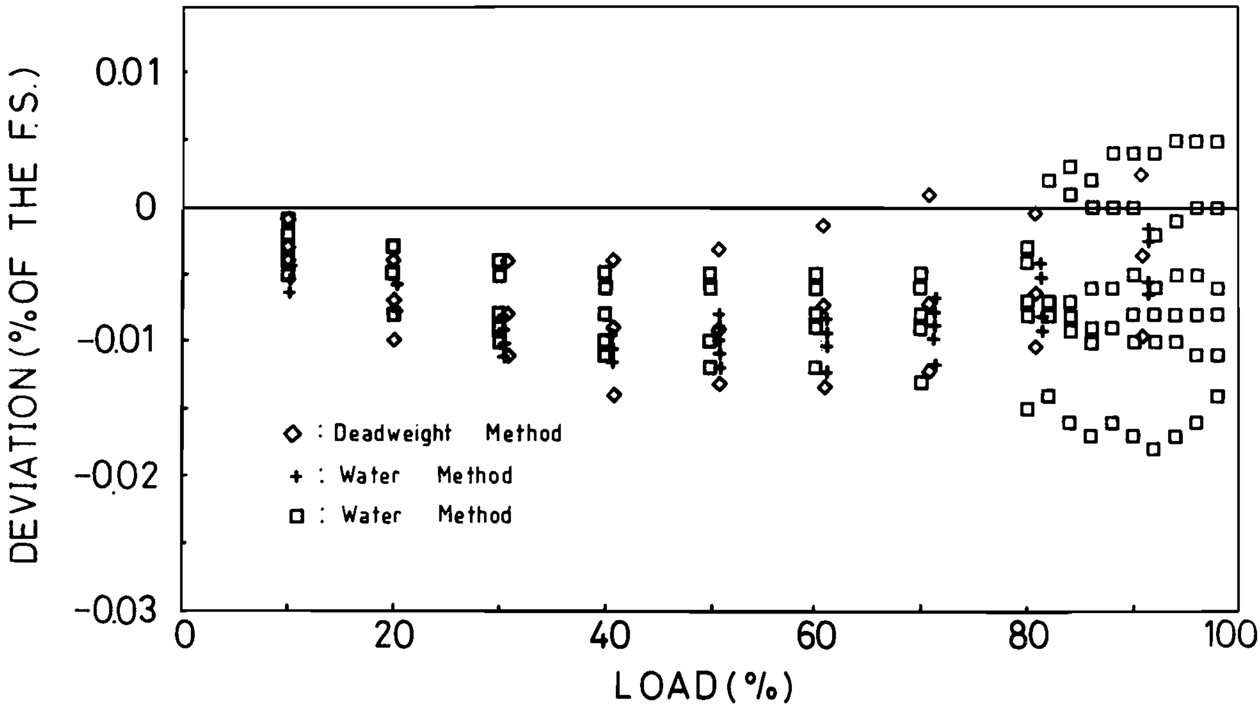


Figure 7. — Calibration results of the 6t weighing machine.

is again too small to explain the deviation between the deadweight test results and the water test results.

Deadweight tests were repeated by stacking deadweights on the wood platen which was laid across the tank rather than inside of the tank. In figure 6, new deadweight test results are compared with the water test results. These deviate from the normal deadweight test results about 0.04 % of the full scale at the maximum load but agree very well with the water test results. In the weighing machines of 300 kg and 600 kg, since the center of gravity is higher than the load cell plane when weights are stacked on the wood platen across the tank, reaction of force components perpendicular to the axial force might have occured due to deflection of the wood platen and the tank. The same phenomena might have happened during the water tests. During the water test, as test-deadweight unit is positioned on the wood platen across the tank while water is put into the tank, side load effects are believed to have caused the calibration error.

iii) 6 t weighing machine

The performance characteristics have been tested by applying the deadweight method and the water method over a year. The discrimination of the indicator used in this test is about 1/100 000 of the full scale. As shown in figure 7, the non-linearity is less than 0.02 % of the full scale so that this machine can be used without non-linearity correction for the standard flow-rate determination as long as it is operated over the range above 50 % of the full load. Test results of two calibration methods, the deadweight method and the water method, agree within 0.01 % of the full scale. This excellent agreement between two methods is believed to be due to the design of the weighing machine. For the 6 t machine, the distance between the center of gravity and the load cell plane is designed to be about the same whether deadweights are stacked inside the tank or on the I-beam across the weighing tank.

In order to evaluate temperature effects on the weighing accuracy and the long term stability, performance tests of the weighing machine have been repeated at different surrounding temperatures over a year. Since load cells used for the construction of the weighing machine were compensated to be insensitive to the change of the surrounding temperature, the test results obtained in summer agreed very well with the results of late fall. In fact, the temperature difference between two tests was about 30 °C. Furthermore, the calibration results did not change significantly for about a year. A calibration interval of 12 months thus looks appropriate for this weighing machine too.

Accuracy of the water flow standard facility at KSRI

In addition to the weighing error, errors in the measurement of diversion time may be introduced into the uncertainty of the flow rate determination as a major systematic error source. The systematic diverter timing error of the water flow standard facility is shown as a function of flow rate in figure 8. This error was evaluated by following the recommendation of ISO-4185-1980 [4] and was within a ± 0.05 % envelope over the flow rate 10 to 70 kg/s when about 5 000 kg of water was diverted into the weighing tank.

The scatter of the measurement data of flow rate is shown in figure 9 as a function of flow rate. During the test, the diversion time was varied from 30 s to 120 s. The uncertainties due to random error sources in mass flow rate determination was found less than ± 0.12 % over the flow rate 10 to 70 kg/s.

The overall uncertainty of the water flow standard facility at KSRI [1], therefore, is believed to be less than ± 0.2 % in mass flow rate determination when the weighing system is operated at about its full capacity.

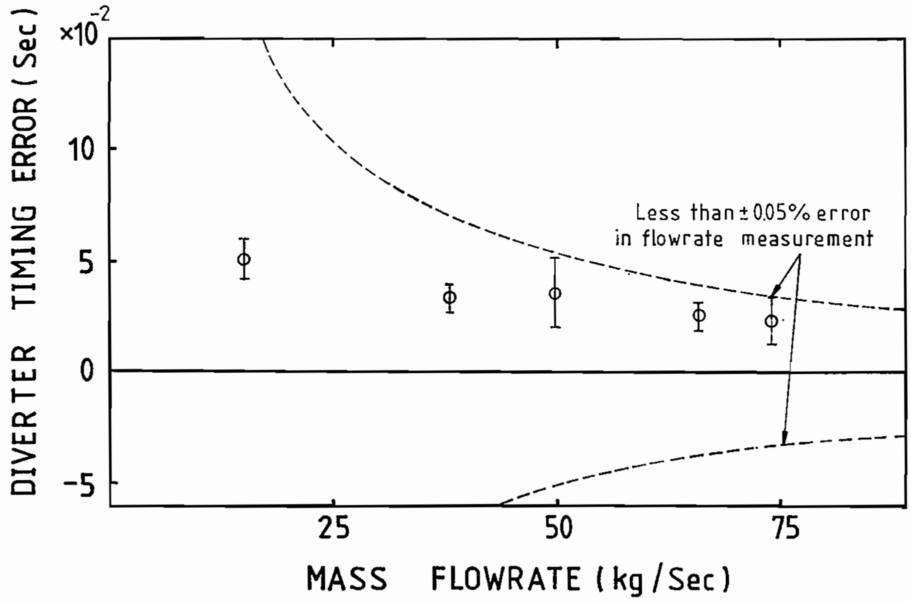


Figure 8. — Diversion time error as a function of flow rate.

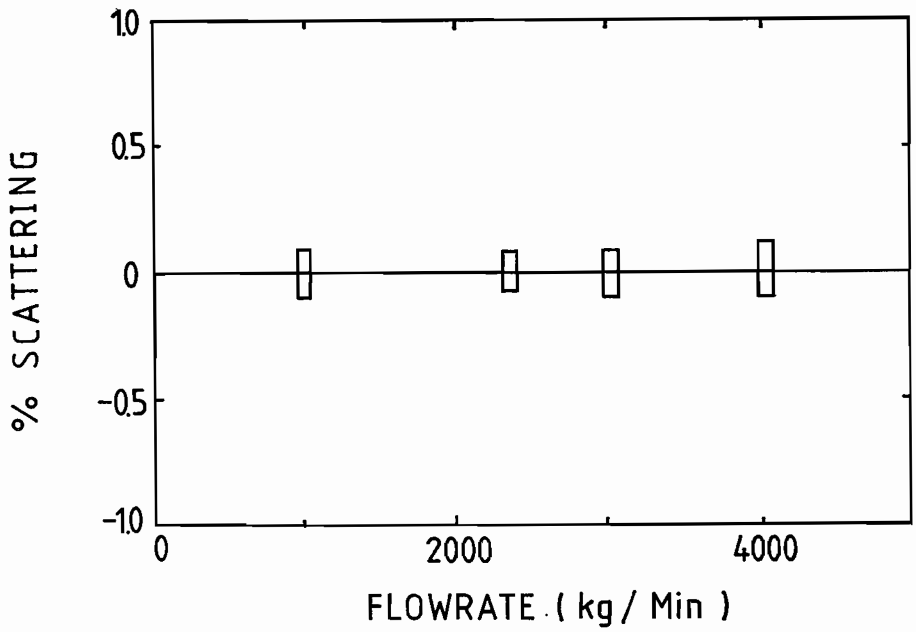


Figure 9. — Scattering of the flowrate measurement data.

Conclusions

By performing repeated tests of load cell weighing machines, installed at KSRI as a part of the gravimetric flow standard facilities, the following experimental results have been obtained :

1) The basic performance characteristics of a load cell weighing machine such as repeatability, non-linearity, hysteresis etc., as well as number of preloadings required before actual data acquisition are determined by the characteristics of the individual load cells and the structural design of each weighing machine.

2) The performance of the load cell weighing machines did not change by more than 0.02 % of the full scale over a year. A calibration interval of 12 months seems to be appropriate for maintaining the accuracy level of load cell weighing machines.

3) When the non-linearity of the load cell weighing machines are corrected on the basis of the actual calibration data, a systematic weighing error of less than 0.05 % of the mass registered on the weighing machine was obtained as required in ISO-4185-80.

4) Side load effects introduced during the water calibration of the small capacity weighing machines by positioning a test-deadweight unit on the wood platen across the tank are believed to have caused a significant magnitude of calibration error.

5) The overall uncertainty of the water flow standard facility at KSRI including errors in the measurement of diversion time is believed to be less than ± 0.2 % in mass flowrate determination.

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ROYAUME-UNI

BULK MEASUREMENT of LIQUID FUEL in the UNITED KINGDOM *

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SUMMARY — 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 reviews the principles and procedures of verification including meter tests, system performance, accuracy, etc and highlights the problems encountered in particular as regards correct operation of the gas extractor and associated devices.

RESUME — 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.

1. Introduction

Legal metrological control over weighing and measuring equipment, in use for trade purposes, has existed in various forms in the UK for many hundreds of years. Indeed, references to the control of the measures used for the sale of alcoholic drinks — obviously an early English priority — can be found in the Magna Carta of 1215 a.d.

Although beer and wine can be regarded as a form of liquid fuel, it is only in the last 30 years or so that the UK has given significant consideration to the use of its legal machinery to control the design and accuracy of equipment used for the bulk measurement of liquid fuels (of the more conventional type !).

The various Weights and Measures Acts, which have been produced this century in the UK, have controlled the weighing of solid fuel, its carriage on the highway and its delivery, to a condiderable extent. In a similar way, the equipment used to measure liquid fuel and lubricants has traditionally been subject to metrological controls, but here the legislation imposed a limit — only equipment used for measuring quantities of less than 100 litres was covered. Certainly, the general provisions of the Acts meant that other liquid fuel measuring instruments should not be « false or unjust » but, in general, there were no detailed Regulations concerning bulk liquid fuel measuring instruments, and in particular instruments mounted onto road tankers and used for domestic or small industrial deliveries.

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

In 1951 a report was presented to Government recommending that legal metrological controls were needed in this area of trade. Not much action resulted from this, however, — presumably the House of Commons was heated by gas ! In the early 1970's the price of oil rose dramatically and the situation changed radically. As the value of the product rose, Industry's attention became sharply focussed on the need to upgrade its measurement capabilities as margins in the petroleum distributive industry came under pressure. Consumer awareness of the cost penalty of short measure deliveries simultaneously arose, and of course with a sharp rise in product value, the motivation for individuals to fraudulently deprive either the buyer or seller of the fuel (or both) of some of it also increased.

In the late 1970's, the Community adopted Directives [1] regarding measuring systems for liquids other than water, and by that time the UK Government had already set up a Working Party, embracing Industry, Government and enforcement agencies to prepare proposals for legislation.

The result was that, in 1979, Regulations [2] were enacted under UK domestic Weights and Measures legislation, applying metrological controls to bulk fuel measuring equipment. This brought within the legal framework, equipment used to deliver liquid fuels from road tankers in quantities exceeding 100 litres. Certain types of equipment such as LPG meters, and ship and aircraft bunkering instruments were exempted, as were certain classes of product such as heated oils, lubricating oils and black products.

In 1980, further Regulations [3] were enacted implementing the requirements of the EC Directives [1] in the UK and so we were faced with two regimes, UK and EC, applied to the same classes of measuring equipment.

Further control was exercised in 1985 by an Order [4] made under the Weigths and Measures Act 1985, regulating the documentation which must accompany liquid fuel deliveries on the highway, with the primary objective of enabling enforcement agencies to carry out an audit of the tanker contents at any stage during its deliveries, and thereby detecting the commission of fraud.

The legislation enacted to control truck-mounted measuring instruments deals with three generic types of equipment, two of which are in common use at the present time — (1987).

A. Dipstick Measuring Systems

The use of multi-compartment road tankers, each compartment having its own sub-divided dipstick, is widespread in the UK particularly for deliveries of petrol and diesel fuel to garages.

The calibration and verification of these dipstick measuring systems is a specialist operation requiring purpose-built facilities, one of which was operated by my own Authority, Buckinghamshire. The individual nature of these Calibration Centres varied considerably but in all cases water was used as the transfer medium. Traceability to National Standards of measurement was ensured by the use of volumetric proving tanks, calibrated by National Weights and Measures Laboratory.

The workload dealt with by the eleven Calibration Centres was considerable with over 20 000 tankers, many having seven compartments being verified in the period July 1980 - July 1984, a task which required considerable co-operation between Central and Local Government and the Oil Industry.

Metrologically the traditional wooden dipstick is a crude measuring device and it is hoped that its days of use are numbered.

B. Meter Measuring Systems

Fitted to road tankers, these systems are used for the delivery of fuels such as gas oil, derv and kerosene to domestic and industrial consumers and the purpose of this paper is to examine the ways in which legal controls over their design and accuracy have been applied.

TYPICAL PRE-REGULATION METER SYSTEM

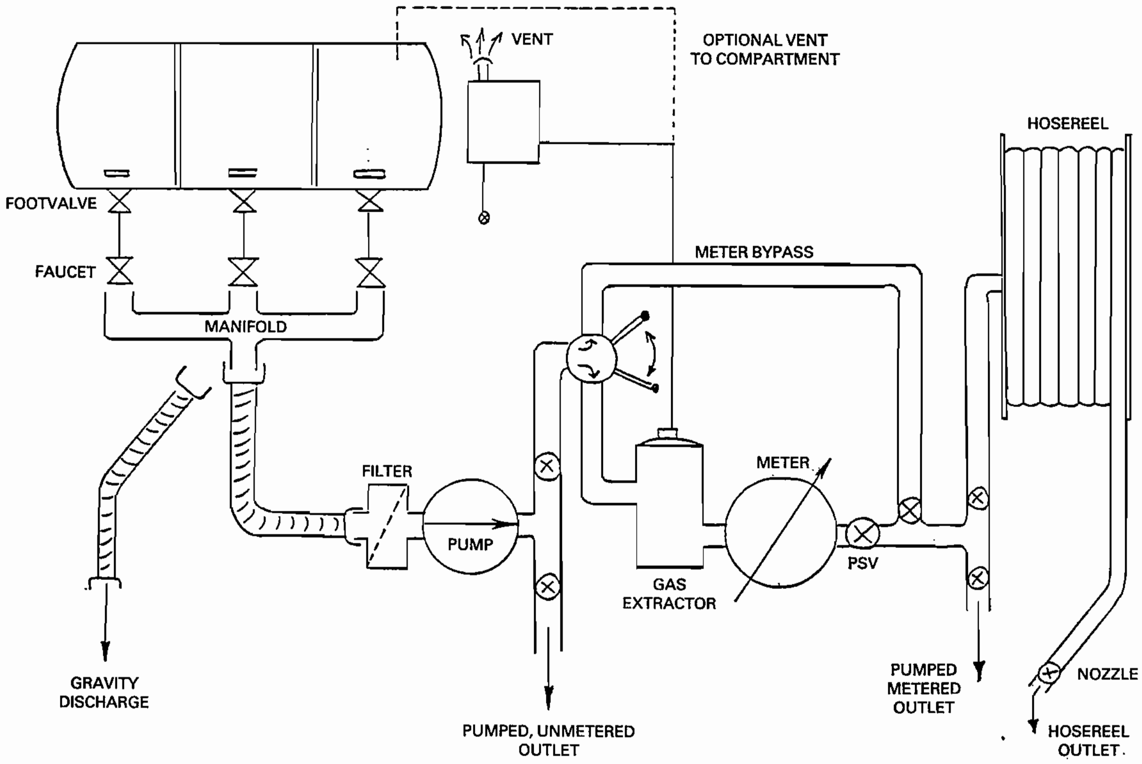


Fig. 1

EEC WET-LINE SYSTEM

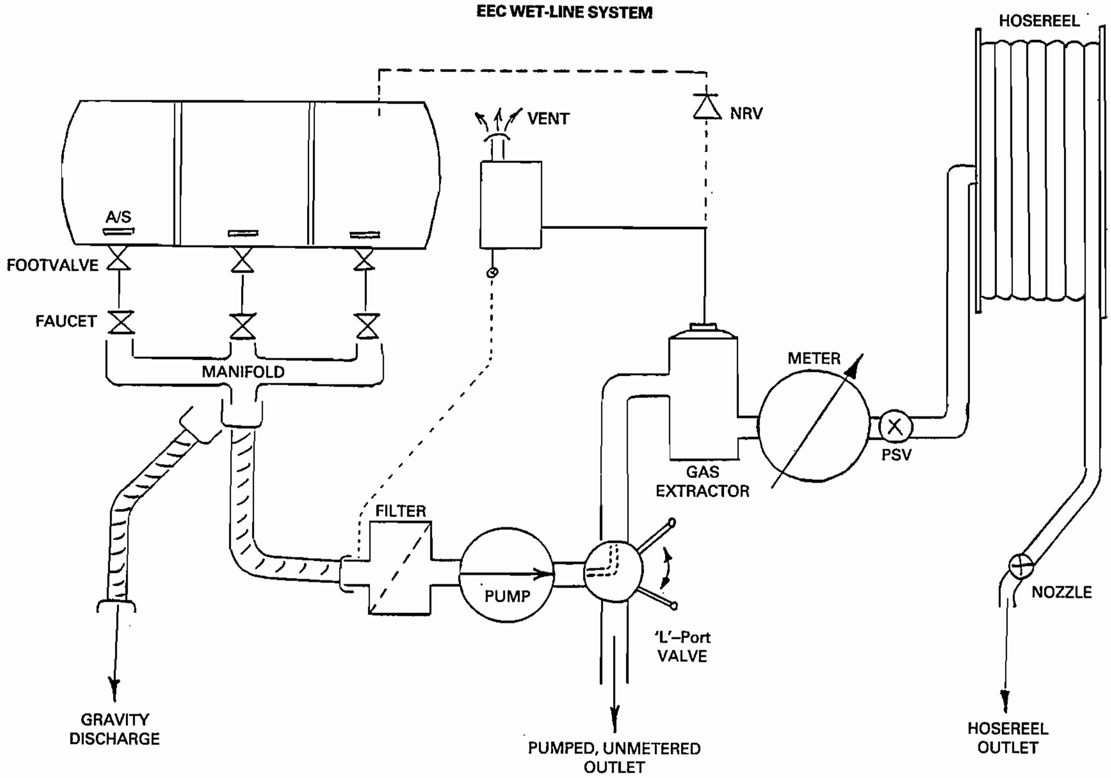


Fig. 2

C. Contents Gauging Systems

Systems involving electronic gauging of tank compartments using, for exemple, transducers to detect the liquid level are under development. Such systems will provide enhanced metrological accuracy and can be used, via software control, to provide full product information to customer and distributor.

Combined with other developments such as bottom loading of compartments, vapour recovery and unattended site deliveries, Contents Gauging Systems represent the next generation of measuring systems for bulk liquid fuel in the UK.

2. The UK Situation prior to 1979

The equipment used by the petroleum distributive trade at the end of the 1970's had developed over a considerable period of time in a haphazard fashion dictated by the particular demands of individual operators and their customers.

Consequently, as the enforcement authorities, Trading Standards Officers were faced with a considerable variety of features embodied in meter measuring systems. A typical system is shown in Figure 1.

There was a mixture of wet hose and dry hose measuring systems. Often the same measuring system could be operated in wet and dry hose mode by making use of the meter bypass system.

The same meter bypass allowed product to be discharged from the vehicle without registering on the meter totaliser. In this way, product fraudulently obtained by, for example, manipulation of the gas extractor, could be dispensed unlawfully.

Many meter systems were equipped with a variety of outlets including gravity discharge, pumped metered and unmetered ports and hosereel outlets. Consequently, whether the contents of the hosereel reached the intended consumer was in the control of the driver !

Manifolds were also a common feature of delivery systems, the benefits being based on the ease of product or compartment champing during deliveries. They also readily facilitate fraudulent use.

Last, but by no means least, there is no doubt that a great deal of fraud was perpetrated by making use of the ability of the positive displacement meter to measure and dispense air instead of liquid fuel.

Aided by the British Goverment, who kindly produced a half-penny coin which was a precise fit in the vent pipes of most gas extractor systems, many drivers modified their meter systems to defraud customers in this way and dispose of the product for cash to receivers who were happy to pay half the market price for illicit product.

3. Legal Metrological Controls

The dual regimes of legal metrological controls introduced in the UK sought to control this situation in several ways.

(a) Approval of the Design Pattern

By requiring that all meter measuring systems be constructed in accordance with an approved Pattern, the range of design features can be reduced and standardised. Those features which facilitate fraud can be eliminated, or at least minimised.

An approval procedure under UK National or EEC regimes is available. The natural benefits of obtaining EEC Approvals were recognised by Industry and have been widely taken up. New systems have had to be constructed on this basis since 1984 and by 1st July 1987 all meter measuring systems will have to comply with a Pattern Approval Certificate.

(b) Verification and Sealing

From July 1984 in the UK all meter measuring systems in use for trade have had to bear stamps indicating that the equipment has been checked by an Inspector for conformity to an Approved Pattern and has been subjected to verification tests to establish its measurement accuracy.

These requirements are enforced by the provisions of the Weights and Measures Act which creates criminal offences for the use of unstamped measuring equipment.

(c) Inspection

Trading Standards Officers have powers to examine and test meter measuring systems in trade use to establish that, at any time, they are still in conformance with the Pattern and are operating within prescribed limits of accuracy. If the equipment is found to be inaccurate it can be put out of use until repaired and reverified.

4. Consequences for truck operators

Following the introduction of Regulations relating to meter measuring systems, the great majority of operators decided to adopt the wet-hose method of measurement where the hosereel remains full of product at all times, even though this is operationally more complicated where multi-product deliveries are made.

Such systems are recognised by the « standard schemes » of the EEC and a typical system which has received Pattern Approval is as shown in Figure 2.

The philosophy behind the system is that all product dispensed through the meter must go through the hosereel. No meter bypass is acceptable.

The system retains a pumped, unmetered discharge, but this cannot be dispensed through the hosereel. An L-Port valve prevents simultaneous connection of this outlet with the meter system.

Dry-hose systems are not prohibited, although their format differs from the traditional system in that no meter bypass is allowed, which would permit liquid to by pass the meter.

Several ingenious systems have received approval and are in use in UK. Usually the hosereel is blown dry with compressed air, introduced by automatic control valves from a separate reservoir, or from an expansion box charged by the cargo pump. These are depicted in Figure 3.

The deterrent as far as operators are concerned is that the enforcement authorities are adamant that no closure *of any kind* is acceptable on the end of the hosereel of a dry hose system. This means that the hose contents must go to the consumer who has paid for them, but problems arise in the event of frustrated deliveries and spillages are likely.

Dry hose systems are consequently fairly uncommon in the UK.

5. Enforcement

The duty of verification of road tanker measuring systems lies with the Trading Standards Service operated by Local Authorities throughout the UK.

The fact that there are a considerable number of Authorities, each autonomous in its provision of equipment and personnel to discharge this duty, meant that some coordination of activity was essential if the Petroleum Industry was to receive uniform standards of enforcement.

EEC DRY-LINE SYSTEMS

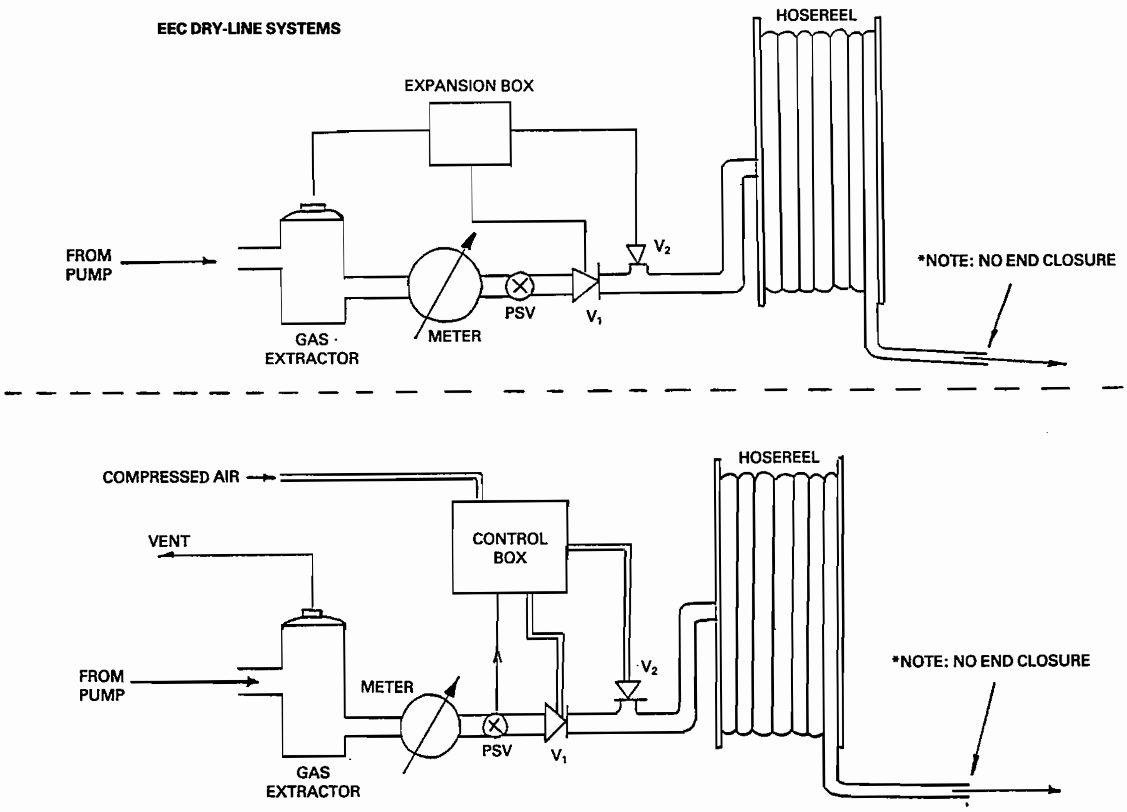
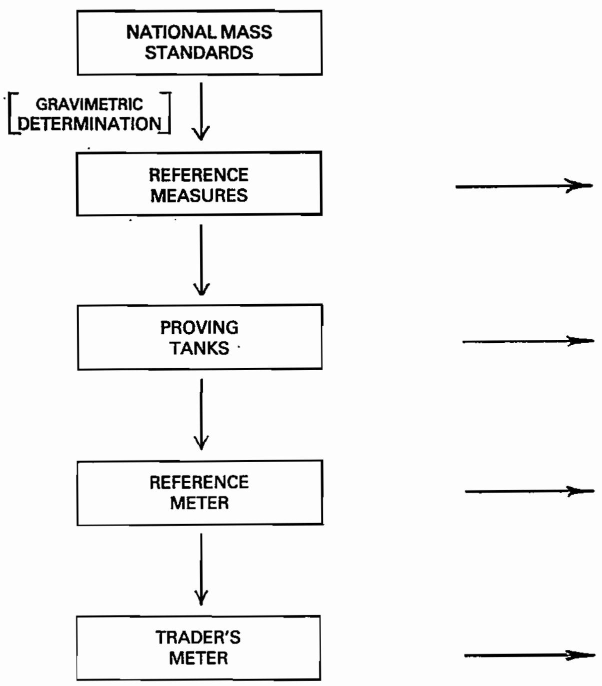


Fig. 3

HIERARCHY OF STANDARDS AND TRACEABILITY



UNCERTAINTY OF MEASUREMENT	TOLERANCE
0.01%	0.01%
0.01%	STATED ERRORS
0.05%	STATED ERRORS
0.2%	0.5%

Fig. 4

A co-ordinating body for Trading Standards activities (LACOTS) was already in existence and issued guidance to all Trading Standards officers on the equipment and techniques recommended for the verification of meter systems, and uniform procedures are now in operation.

6. Principles of Verification

The first objective in the metrological control of meter systems was to ensure the traceability of measurement back to UK National Standards.

LACOTS considered various methods of verification and came up with two realistic alternatives :

(1) Proving Tanks

It was recognised that this was the most accurate method of assessing the accuracy of the system under test. In practice, however, the range of tank sizes necessary, transportation difficulties and the need for additional pumping equipment meant that this option is unattractive to enforcement agencies and has not, to my knowledge, been adopted.

(2) Reference Meter

The use of a reference meter as the verification standard, lends itself to the production of readily portable test rigs which enable the system under test to be assessed in conditions which simulate normal operating practices.

This verification technique has become the norm for verification of meter measuring systems in the UK. It also meets the requirement that the uncertainty on the reference standard should not exceed one-fifth of the tolerance on the measuring system under examination.

The hierarchy of traceability linking reference meters back to UK National Standards is as shown in Figure 4.

Intercomparison exercises have been held to monitor the performance effectiveness of Laboratories which certify the accuracy and traceability of reference meters, both in UK and Europe.

Reference meters are required by law [5] to be maintained within certain limits of accuracy which are depicted here in Figure 5.

At present these requirements are :

Overall accuracy of measurement	± 0.25 %
Linearity	0.1 %
Reproducibility	0.05 %

The sign convention normally used in UK is shown in Figure 6.

In addition, the National Weigths and Measures Laboratory of the Department of Trade and Industry issues specifications [6] governing the form of reference meters and ancillary equipment used by Trading Standards Officers.

The layout of individual reference meter rigs varies between Authorities. The unit operated in Buckinghamshire is depicted in Figure 7.

REFERENCE METER ERROR ALLOWANCES

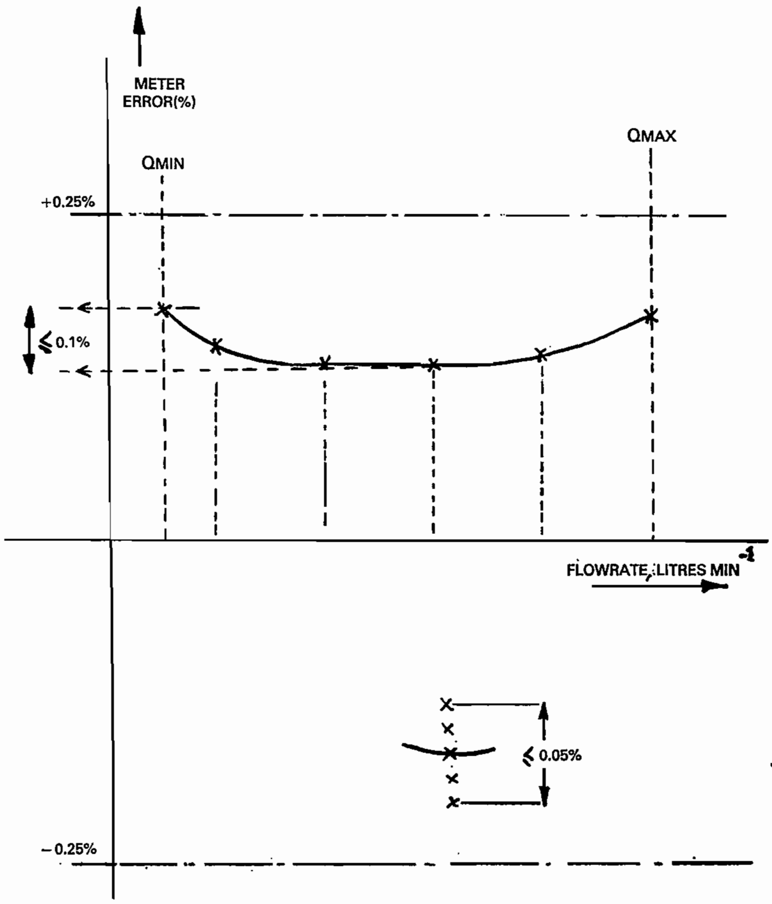


Fig. 5

SIGN CONVENTION

A **MINUS ERROR** MEANS THE METER IS:

"OVER-INDICATING" : INDICATING MORE THAN THE TRUE DELIVERED QUANTITY

OR

"UNDER-DELIVERING" : DELIVERING SHORT-MEASURE

Fig. 6

MOBILE REFERENCE METER TESTING RIG

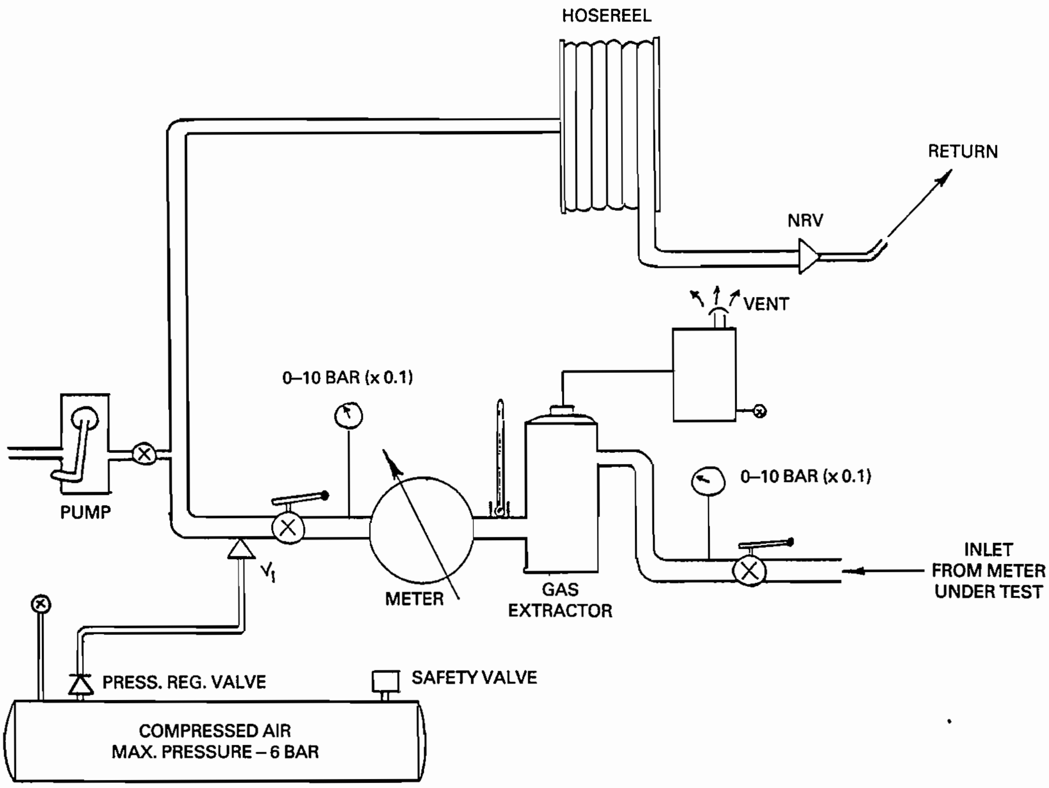


Fig. 7

7. Verification Procedure

Faced with the requirements of the Directives and of UK domestic law, LACOTS set up a Working Group which produced guidance to Trading Standards Officers on how to go about testing meter measuring systems in ways which give a realistic assessment of their performance.

The tests which were devised attempt to simulate, as far as is practicable, the conditions under which the measuring system will be used for trade purposes, and fall into three main sections.

(A) The meter test : this is essentially a direct comparison of the metering element of the measuring system with the reference standard.

(B) The system test : this examines the characteristics of the measuring system as a whole and, in particular, the ways in which the system can legitimately be used to produce a short measure delivery situation.

(C) Ancillary equipment : this tests the function of the ancillary equipment, such as preset counter, ticket printer and gas extractor, fitted to the measuring system.

When a road tanker meter measuring system is submitted for verification, the first stage of the process, after examining the system for conformity, is to test the effectiveness of some of the ancillary equipment.

In particular, the Trading Standards Officer will carry out tests on the gas extractor, since if this is not functioning adequately, there is little point in proceeding with the rest of the testing.

Gas extractors are tested by the practical method of introducing air to the suction side of the cargo pump — either by opening the jumper hose connection or, when a manifold is fitted, opening to an empty compartment.

Once the line up to the gas extractor is cleared, it should not be possible to advance the meter indication by the passage of air.

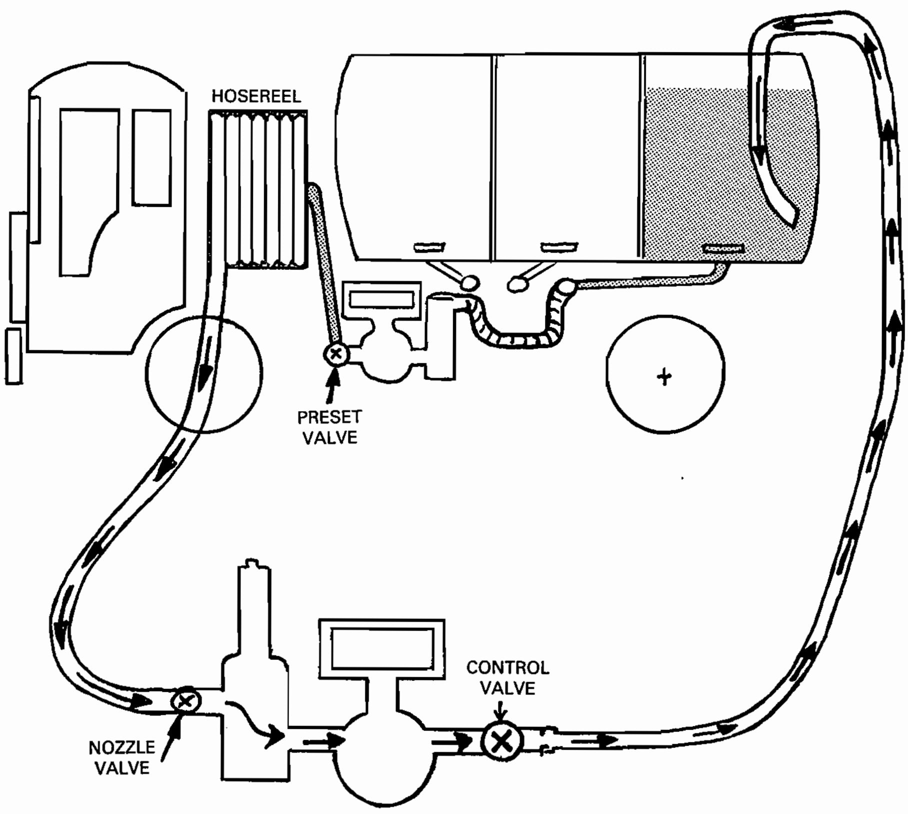
Unless a gas separator (as opposed to a gas extractor) is fitted the Directive requires an interlock of some kind to prevent simultaneous use of two or more compartments. Where this is not the case, a test will be conducted in which an empty compartment is opened to suction whilst pumping from a full compartment. The overall measuring accuracy should not be affected. Such a test only applies to vehicles equipped with manifolds and in practice many systems fail to cope with the air entrainment produced. Most operators seem to opt for the expedient solution and discard the manifold.

At this stage, the verifying officer would check for the presence and effectiveness of an anti-milking valve in the nose-end nozzle and then proceed to the metrological stage of the verification.

Tests for measurement accuracy are carried out with the reference meter connected in series with the truck meter and forming a closed loop with a reservoir of test medium which would be contained in the truck compartments. Two test fluids are used, normally kerosene and gas oil, representing the extremes of the viscosity range on which the measuring system is to be used. A sufficient volume of product to ensure temperature stability during test is necessary - normally at least 1 000 litres.

The verification arrangement is as shown in Figure 8.

TESTING A ROAD TANKER METER MEASURING SYSTEM



METER TEST: TEST RUNS STARTED AND TERMINATED USING THE SAME VALVE. (USUALLY THE PRESET)

SYSTEM TEST: TEST RUN STARTED BY OPENING PRESET VALVE (i.e. HOSE UNPRESSURISED) AND TERMINATED WITH REFERENCE METER CONTROL VALVE (i.e. HOSE DILATED)

RUN-DRY TEST: DELIVERING A PRE-DETERMINED VOLUME FROM A COMPARTMENT, EMPTYING IT.

Fig. 8

Product is circulated around the loop for a sufficient period to ensure temperature stability, taking this opportunity to determine the flowrate characteristics of the system and the relevant meter factors of the reference meter.

The following procedures are then implemented :

A. The Meter Test

Test runs aimed at comparing the indications of the meter under test with those of the reference meter may then be commenced. Normally flow is controlled using the preset mechanism for the following reasons :

1. It provides an opportunity to test the preset device.
2. It should provide more repeatable conditions than manual valve closure.
3. It avoids unnecessary pressurisation of the reeling hose.

However, any control valve in the system can be used providing the same valve is used to start and stop the test. I prefer to use the downstream reference meter valve as the control, since both meters are then subject to similar pressure conditions and there is no risk of over-run on the reference meter. I consider myself lucky not to have burst a hose (yet !).

The above procedure would normally be repeated at least five times at each of two subtantially different flowrates within the stated range of the system, and further tests at other flowrates could be conducted if desired.

B. The System Test

To test the system performance as a whole, rather than just the characteristics of the metering element, flow is interrupted using the preset valve and a test run carried out which is then terminated using the reference meter control valve. In this way the reeling hose starts in an unpressurised state, but finishes in a dilated state, resulting in a short-measure situation due to hose-dilation. This effect is most marked when using the product of highest density (normally gas-oil) at maximum flowrate and the test would be done under those conditions. This test simulates the operating situation where the road tanker is used on a « top-up » style of delivery, where the delivery is controlled by the tanker driver at the consumer's tank using the hose-end nozzle.

C. Other Fluids

The meter test described above will then be repeated using the second test fluid. Experience has shown that the effect of viscosity differences on a positive displacement meter may be considerable but, more importantly, will vary between individual units. There is no predictable quantification of the effect and so systems are tested at the extremes of the usable viscosity range.

During any of the above test runs, the verifying officer will test the system ancillary equipment, such as zeroiser, printer, preset device.

D. The « run-dry » test

For this test a known quantity of liquid is metered into a wetted, drained compartment on the truck and is then pumped off again through the reference meter. This test simulates the situation where a compartment runs dry either during or at the end of a delivery and is a measure of the gas extractor's ability to deal with the arrival of a product/air interface.

All the above tests would be carried out using a nominal delivered quantity in excess of the stated minimum delivery of the system, at flowrates between the stated minimum and maximum. In reality, the structuring of permitted tolerances suggests that measurement errors become critical at a quantity equal to twice the minimum delivery (normally therefore 1 000 litres) and most tests will be conducted at that quantity.

A suggested test programme is given in Figure 9.

SUGGESTED TEST PROGRAMME

1. NOZZLE ANTI-MILKING VALVE
2. GAS EXTRACTOR TEST
3. **METER TESTS** AT TWICE MINIMUM DELIVERED QUANTITY – ANY FLOWRATE BETWEEN QMIN and QMAX
4. **SYSTEM TEST** AT MAXIMUM FLOWRATE, DELIVERING TWICE MINIMUM DELIVERY QUANTITY OF THE MOST VISCOUS LIQUID (GAS OIL)
5. RUN-DRY TEST
6. ANCILLARY EQUIPMENT: ZEROISING DEVICE
   PRESET COUNTER
   TICKET PRINTING MECHANISM
7. TEST ON A DIFFERENT FLUID

Fig. 9

ERROR ALLOWANCE ON ROAD TANKER METER

a) BETWEEN MINIMUM DELIVERY → 2 x MINIMUM DELIVERY, ERROR IS 1% OF THE MINIMUM DELIVERY QUANTITY.

b) THEREAFTER ERROR IS 0.5% OF THE MEASURED QUANTITY.

c) IF ALL ERRORS ARE OF THE SAME SENSE, AT LEAST 1 MUST BE ≤ 0.3%.

TYPICAL EXAMPLE: MINIMUM DELIVERY 500 L

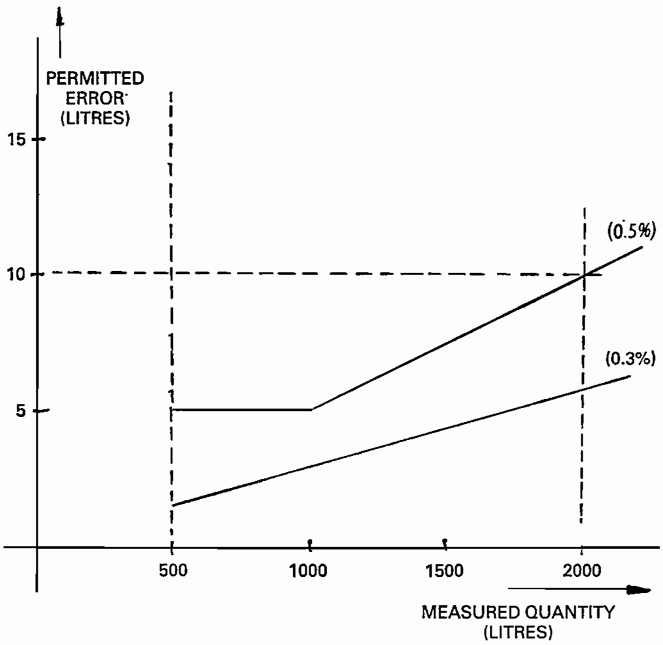


Fig. 10

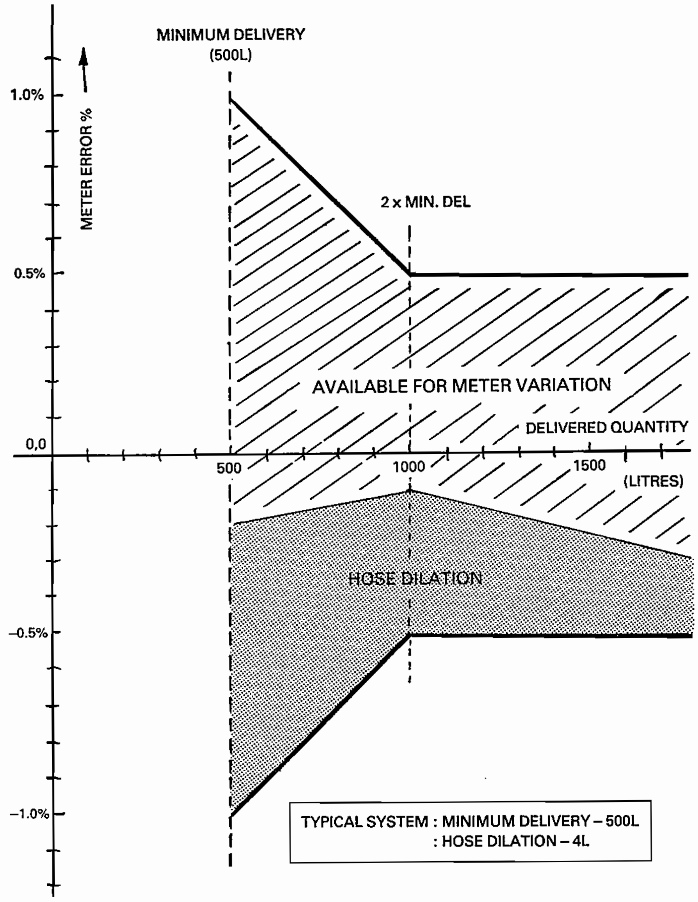


Fig. 11

8. Application of Results

When using the reference meter to determine the true delivered quantity produced by the measuring system the following corrections may be made :

1. Variation of meter factor as a function of flowrate.

   The characteristic curve of the reference meter is known and the meter factor at any given flowrate on the relevant test medium can be calculated and applied.

2. Pressure of test.

   The difference between the line pressure at the time of use and the line pressure when the reference meter was calibrated is known. An empirical correction of 0.015 % bar can be applied but is generally not significant for small pressure variations.

3. Temperature.

   By using a reference meter as the verification standard and taking trouble to ensure temperature stability during the tests it is not thought that corrections based on the *difference* in cubical expansion of the two meters is relevant. However it is critical that temperatures should not vary significantly during any given test run.

9. Permissible Errors

The limits of error, applicable on verification to bulk fuel meter measuring systems are laid down by Directive [1] and are as follows :

1. Maximum permissible error — within 0.5 % of the measured quantity, except : —
2. Between the minimum delivery and twice the minimum delivery an error of a value equivalent to 1 % of the minimum delivery is allowed.

and

3. If all errors are the same sense, at least one value must be within 0.3 % of the measured quantity.

The effects of these limits, applied to a system having a minimum delivery of 500 litres is shown graphically in Figure 10.

When hose dilation is taken into account, and for this example it is assumed to represent a fixed volumetric value, it can be seen from a plot of meter % error against flowrate, as in Figure 11, that the most effective quantity to select for test purposes is equal to twice the minimum delivery.

10. Problems areas encountered

1. Gas extractor Performance

This is the most difficult aspect of the metrological verification of meter systems. Most UK systems are fitted with gas extractors, which are really designed only to remove large slugs of air from the flow. Few systems are built to incorporate the more sophisticated gas separators. However, it is considered that the measurement of air is the most likely potential cause of short measure deliveries to consumers and so Trading Standards Officers pay particular attention to the functioning of this component, to minimise the risk of fraudulent manipulation by the driver.

The problems encountered include the following :

(a) Performance of the cargo pump

Although this unit does not form part of the Pattern Approval, the rating and condition of the pump can have a marked effect on the performance of the measuring system, both when measuring fuel and when pumping air. Many operators fit high capacity 3" pumps to 2" systems in an attempt to reduce discharge times. Such pumps deliver sizeable flowrates of air which often exceed the venting capacity of the gas extractor even using both ports where available.

(b) Hand-throttle control settings

The speed of the truck engine, and hence that of the cargo pump, is usually controlled by a hand-throttle linkage which is adjustable. This is not a sealing point on the system. Generally testing of the gas extractor will be confined within the limits of this control but, where it is felt that the adjustment is unreasonably slow, or the use of the foot-throttle will cause the system to meter air, these limits may be exceeded by the verifying officer — caution must be exercised though, as the pump may be operated both unlubricated and at excess speed during such tests.

(c) Manifolds

When fitted, manifolds permit the introduction of air into the flow while pumping product, conditions which a gas extractor finds difficulty in dealing with. The implementation of EEC systems in UK provides the opportunity to require an interlock device to prevent this.

In general, the tests on gas extraction equipment simulate conditions which either apply in the course of routine delivery operations or which can be created by a dishonest operative to facilitate fraud. Our justification is that the equipment should not only be capable of accurate use but should be reasonably incapable of inaccurate use to commit fraud.

Hardware such as biased check-valves (which close the preset valve when air reaches the gas extractor vent) and foot-throttle isolators are available to solve these problems, and the UK will continue with a hard enforcement strategy.

2. Contamination

The use of two products for testing purposes and the problems caused to operators by the contamination of, say, kerosene with gas oil, means that extra care is taken when changing fuels during verification. Normally the product interface colour change can be used but if in doubt all lines are cleared between liquids.

3. Health and Safety

Particular attention is paid to :

(a) Fire prevention and control

(b) Prevention of accumulation of static charge by earth-bonding during verification.

4. Fraud

Even when correctly verified and sealed, meter measuring systems can be readily manipulated to commit fraud by, for example, recycling product on the tanker and then delivering through the bulk unmetered outlet.

Verification alone, therefore, is only part of the legal metrology machinery and must be supported by inspection enforcement activity.

It would be regrettable if the major effect of legal metrology in this field was to enable fraud to be committed more accurately !

11. Sealing

The following points are normally sealed on meter measuring systems :

Meter covers.

Meter calibrator.

Register (including preset and ticket printer).

Meter to gas extractor.

All joints in the gas extractor venting system.

EEC data plate.

The breakage of any seal during service renders the whole system unlawful for use except that :

(a) The seal protecting the ticket printer may be broken to free a stuck ticket.

(b) The seal between the gas extractor and its vent pipe may be broken to fit a *previously stamped* meter and gas extractor assembly.

In these cases further use for 28 days and 7 days respectively before resealing is lawful.

12. The Future

The legal metrological controls introduced in UK dealing with bulk fuel measuring equipment have involved Weights and Measures Authorities and their Trading Standards Officers in an unfamiliar sector of volume measurement and has led to the development of a new range of measurement techniques. A further impact of the legislation has been to reduce the range of patterns of equipment in use and to standardise on a range of uncomplicated, reasonably fraud-resistant systems.

Industry, however, will continue to look for advances in technology to refine its measurement and stock control capabilities. The most likely developments in the near future involve the use of electronic fuel management systems to replace the mechanical hardware currently in use.

In the case of dipstick systems, contents gauges, based on vibratory transducers, with full product control systems, are a realistic possibility and in my view the sooner we see the end of the wooden dipstick as a measuring device used with a high value product, the better.

For meter measuring systems the replacement of mechanical indicators with pulse-driven electronics is inevitable. The advantages include the ability to linearise the indications of the system over the product and flowrate range using software, thereby enhancing the overall measuring capability considerably. Reduction of register load on the meter improves its inherent linearity and repeatability, and sophisticated product security and documentation systems can readily be incorporated.

Developments such as these show that bulk liquid measurement in the petroleum distribution business is a dynamically changing activity which will continue to hold the interest of legal metrologists in the UK for some time to come.

References

[1] Meters for liquids other than water 71/319/EEC
Ancillary Equipment for meters for liquids other than water 71/348/EEC
Measuring Systems for liquids other than water 77/313/EEC
Measuring Systems for liquids other than water 82/625/EEC

[2] The Measuring Equipment (Liquid Fuel Delivered from Road Tankers) Regulations 1979 as amended, and subsequently revoked by :
The Measuring Equipment (Liquid Fuel Delivered from Road Tankers) Regulations 1983, amended by
The Measuring Equipment (Liquid Fuel Delivered from Road Tankers) (Amendment) Regulations 1986.

[3] The Measuring Instruments (EEC Requirements) Regulations 1980 as amended by :
The Measuring Instruments (EEC Requirements) (Amendment) Regulation 1984.
and
The Measuring Instruments (EEC Requirements) (Amendment) Regulations 1985.

[4] The Weights and Measures (Liquid Fuel carried by Road Tanker) Order 1985.

[5] The Working Standards and Testing Equipment (Testing and Adjustment) Regulations 1987.

[6] National Weights and Measures Laboratory Specification No. 7330.

SUEDE

EXPERIENCE from FIELD CALIBRATION with a MOBILE PISTON PROVER *

by **Kerstin MATTIASSON**
Swedish National Testing Institute, Borås

SUMMARY — 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 %.

RESUME — 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 %.

1. Background

We have for a number of years calibrated hydrocarbon meters in our central laboratory in Boras. For safety and practical reasons we dispose only of two kinds of kerosene, one which is similar to gasoline and the other similar to diesel oil. The flow capacity of this fixed installation is limited and the metering assemblies have to be disassemblied for the tests.

These disadvantages, and an increasing demand for calibration at higher flowrates, made us look for a new idea.

The requirements were : a mobile equipment for all kinds of liquid petroleum products, cold and hot water and condensed gas. It should be used in hazardous areas (zone 1), with flowrates up to 30 000 L/min and with both turbinemeters and volumetric meters with mechanical counter. This equipment should be calibrated, checked and maintained by ourselves. It all pointed at a development of an equipment using a piston prover.

At the time, there were two well experienced types, both American : Brooks (formerly made by Flow Technology) and Waugh. In the Waughprover, the piston seal has to pass openings at the cylinder surface during every run, which is undesirable since one cannot check possible leaks along the cylinder by putting the piston at different positions (we were not convinced that the built-in dynamic sealcontrol works in thick liquids). On top of that, our bad experience with valves, made us choose as few as possible, and we therefore chose the Brooks prover.

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

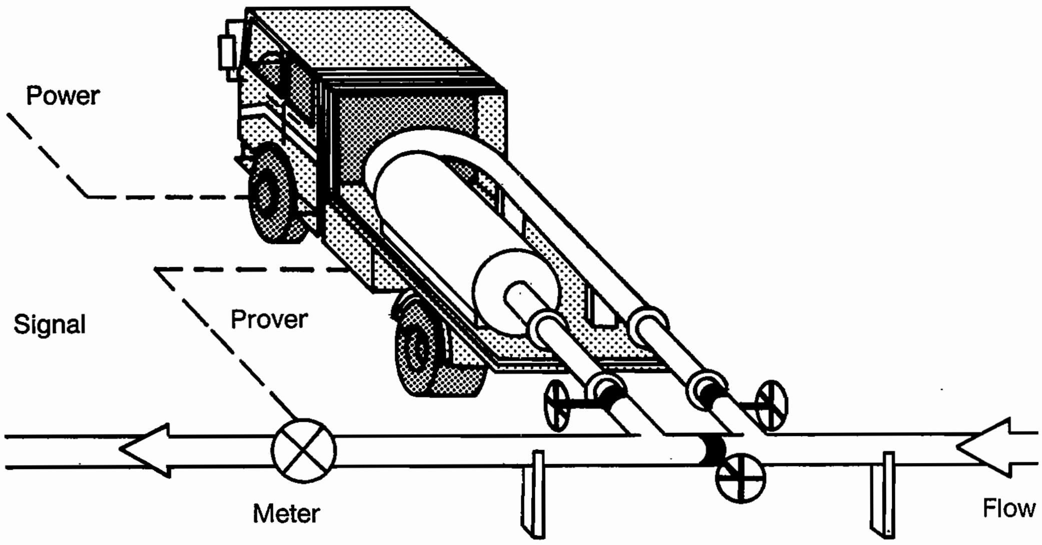


Fig. 1. — Connection of the prover. Very high requirements on the valve closing the main pipeline.

2. General description

The volume standard consists of a cylinder with a well defined displacement (Brooks Compact Prover). The prover is connected with the pipe, upstream or downstream the meter to be calibrated (fig. 1). The piston acts like a displacer and moves with the fluid (fig. 2). When the piston has travelled this well defined displacement, the same amount of fluid passes the meter. By reading the meter indication at the beginning and at the end of a displacement it is possible to calibrate the meter.

There is a poppet valve in the piston to allow flow through the prover when not calibrating a meter. The piston is connected by the poppet valve, to an actuator cylinder, which is activated by hydraulic pressure and a nitrogen pneumatic spring plenum.

The position of the piston is detected by optical switches. When the piston moves, a « flag » passes three light beams, indicating standby, start and stop. These three signals operate data collection and valves. The distance between the start and stop position defines the displaced volume, and is kept constant by an invar rod. Temperature and pressure sensors are located at the prover inlet.

2.1. **Double chronometry**

Conventional pulse counting has an accuracy of $\pm$ 1 pulse. To reduce uncertainty to 0,01 %, you need at least 10 000 pulses. That corresponds to a volume far larger than that of the prover, for most large meters.

The use of double chronometry allows high resolution with reduced prover volume. This equipment consists of two clocks and a pulse counter (fig. 3). When the piston passes the « startbeam » a clock measuring the time of test (A) starts. At the same time the counter is ready to count the first pulse from the meter. When the pulse arrives, a second clock starts, measuring the time of a whole number of pulses (B).

When the piston passes the « stopbeam » and the displacement volume (D) has passed the meter, the counter (C) and the first clock is stopped (time A). When the next pulse from the meter arrives the second clock stops (time B). With this arrangement, it is possible to detect parts of pulses. To achieve a good result every pulse has to correspond to the same amount of volume.

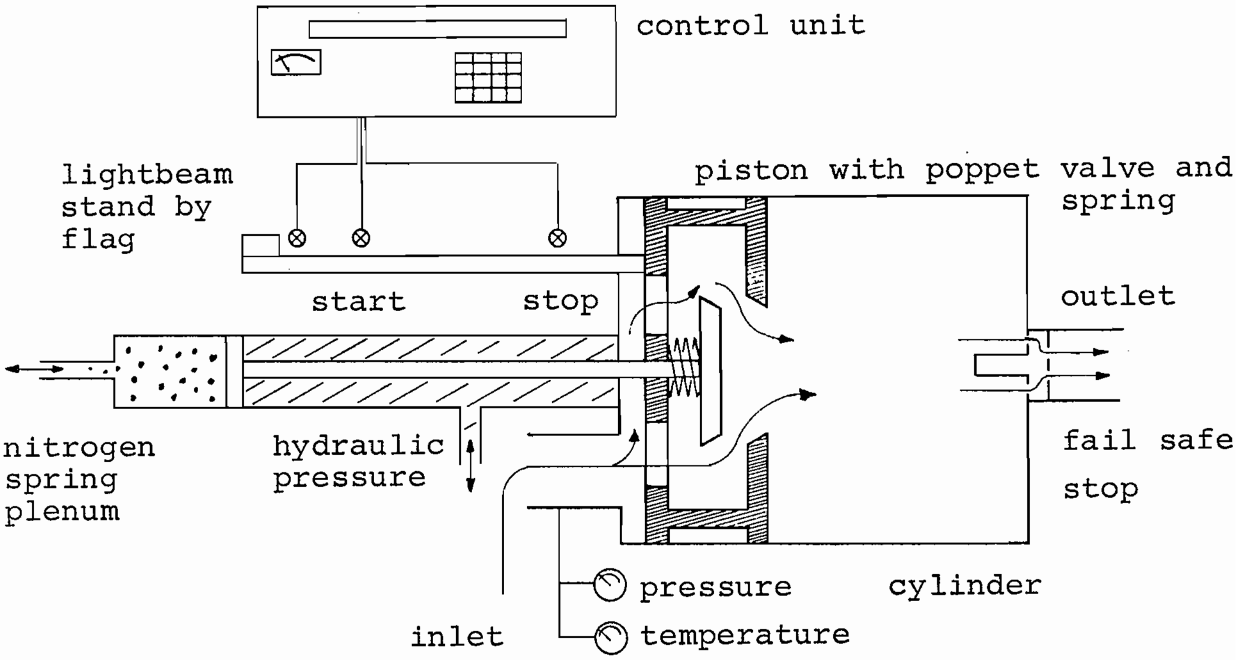
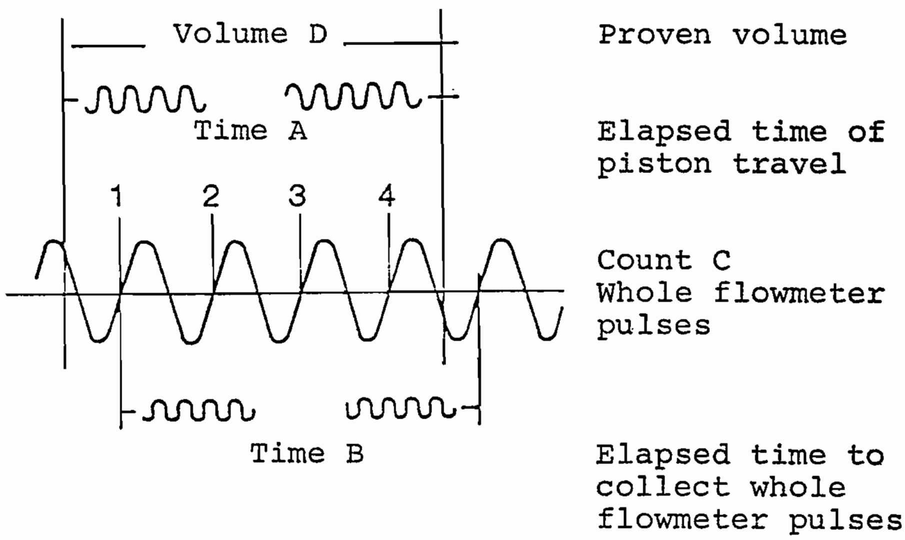


Fig. 2. — Principle of measurement



Meter factor $K = \frac{C \times A}{D \times B}$ pulses per litre

Fig. 3. — Double chronometry

2.2. **Operation of the prover** (fig. 2)

— The prover is in its standby mode when the calibration piston is at its upstream position with the poppet valve open, by the hydraulic pressure. The liquid passes unrestricted through the poppet valve.

— Upon issue of a start command, the hydraulic pressure is vented from the downstream face of the actuator piston. The spring and pressure from the pneumatic spring plenum applied to the upstream face of the actuator piston, allows the poppet valve to close. The fluid moves the calibration piston downstream. The pneumatic spring pressure insures that no pressure drop occurs at the calibration piston. When the piston passes the « startbeam », the measurement starts.

— Eventually the piston passes the « stopbeam » and the measurement is completed. The hydraulic pressure opens the poppet valve and forces the calibration piston through the fluid, to the upstream standby position. If the hydraulic pressure fails, a mechanical fail-safe stop, at the downstream end of the cylinder, opens the poppet valve.

2.3. **Mastermeter and camera**

A mastermeter (turbine) is situated downstream of the prover (fig. 4). It is used when the resolution at the meter to be calibrated is limited. If the output from the meter is less than 1 pulse per litre, or if it is irregular, the output is compared with the mastermeter during a longer period of time, with the help of two counters. If the meter does not have an electrical output, a photo is taken of its mechanical counter. Simultaneously, pulses from the mastermeter is counted. When the next photo is taken, the counter stops. During this measurement, the mastermeter is calibrated with the prover, to get an accurate K-factor (pulses per liter).

2.4. **Water draw**

When calibrating the prover, the liquid downstream of the piston during one run, is collected and measured. This is the volume that passes a meter downstream of the prover. If the meter is situated upstream of the prover, another (due to the piston shaft) smaller volume passes the meter during one run. The volume upstream of the piston is obtained by multiplying the downstream volume with a fixed factor.

2.5. **The truck**

The prover is mounted on a truck Volvo F613 (fig. 5). The cabin is made higher and longer than standard, to make space for the instruments. At the rear end of the platform, a crane powered by the power supply of the truck, is mounted.

Connection to the meter pipework is made at the rear end with hoses or spool pieces.

2.6. **Power supply**

The prover needs electrical energy for both the control unit and the hydraulic pump. All parts, except the control unit, has US approvals for use in hazardous areas (Class 1, Group 1, Div 1).

To avoid having long cables between the prover and the control unit (and placing the control unit outside the hazardous area) the following solution was chosen (fig. 6).

The plug at the main power supply is approved EEx d (3 phases 32 A). The power supply cable ends at an electrical panel at the truck, containing switches and fuses. The power is distributed to the different units ; hydraulic pump, draining pump, light and instruments. A switch for the light and the instruments in the cabin, is placed at the electrical panel.

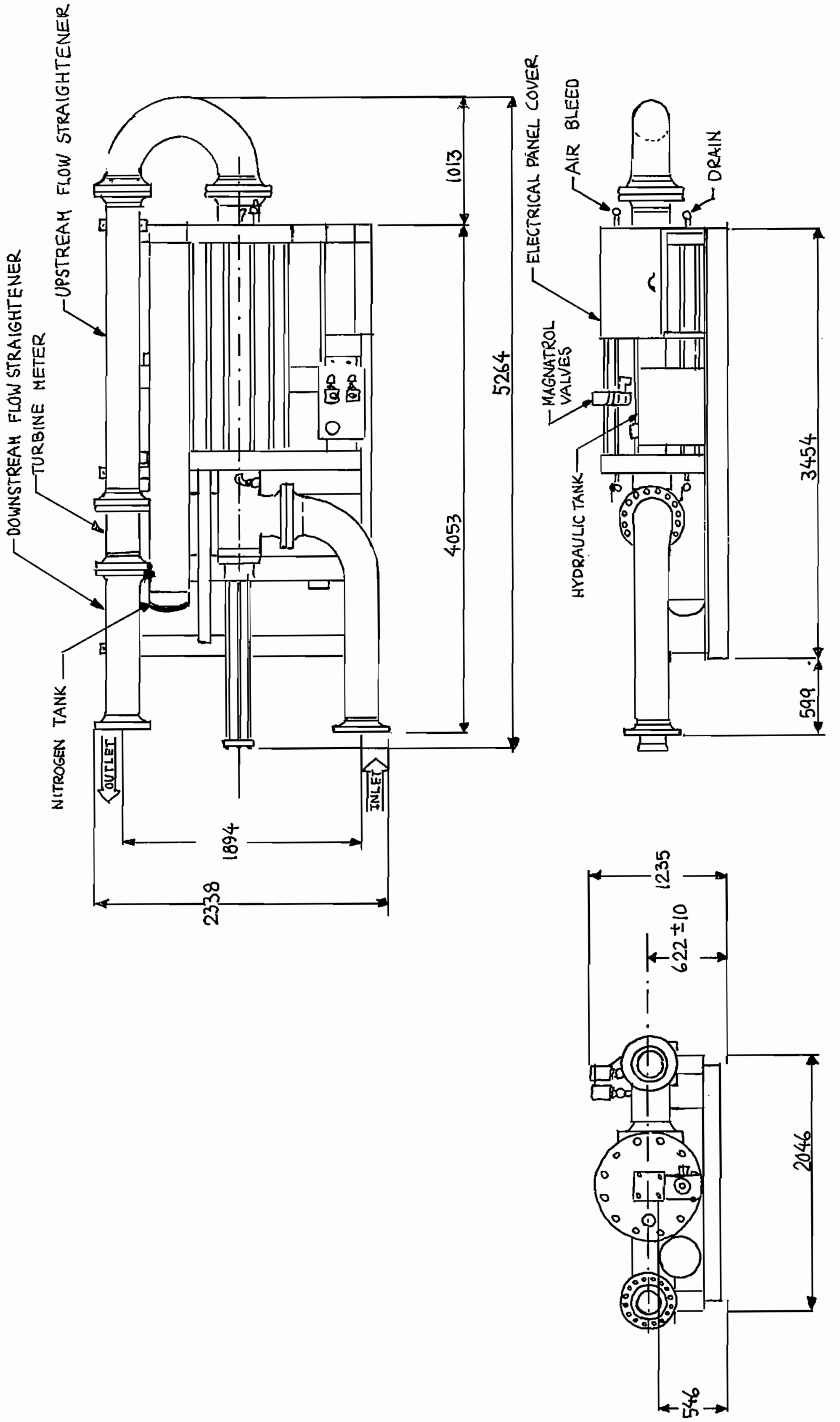


Fig. 4. — Prover and mastermeter

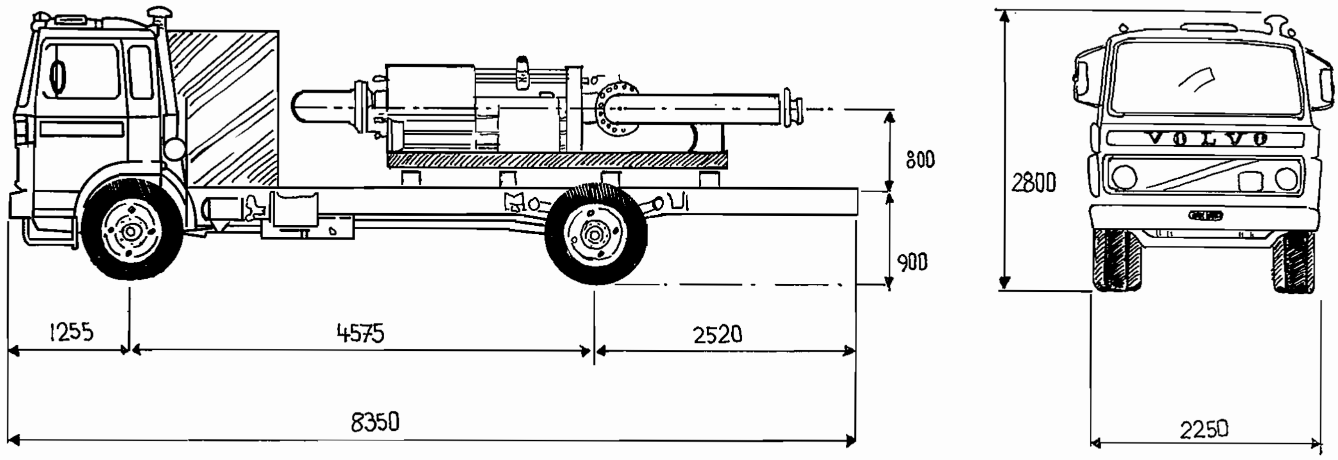


Fig. 5. — Truck with prover

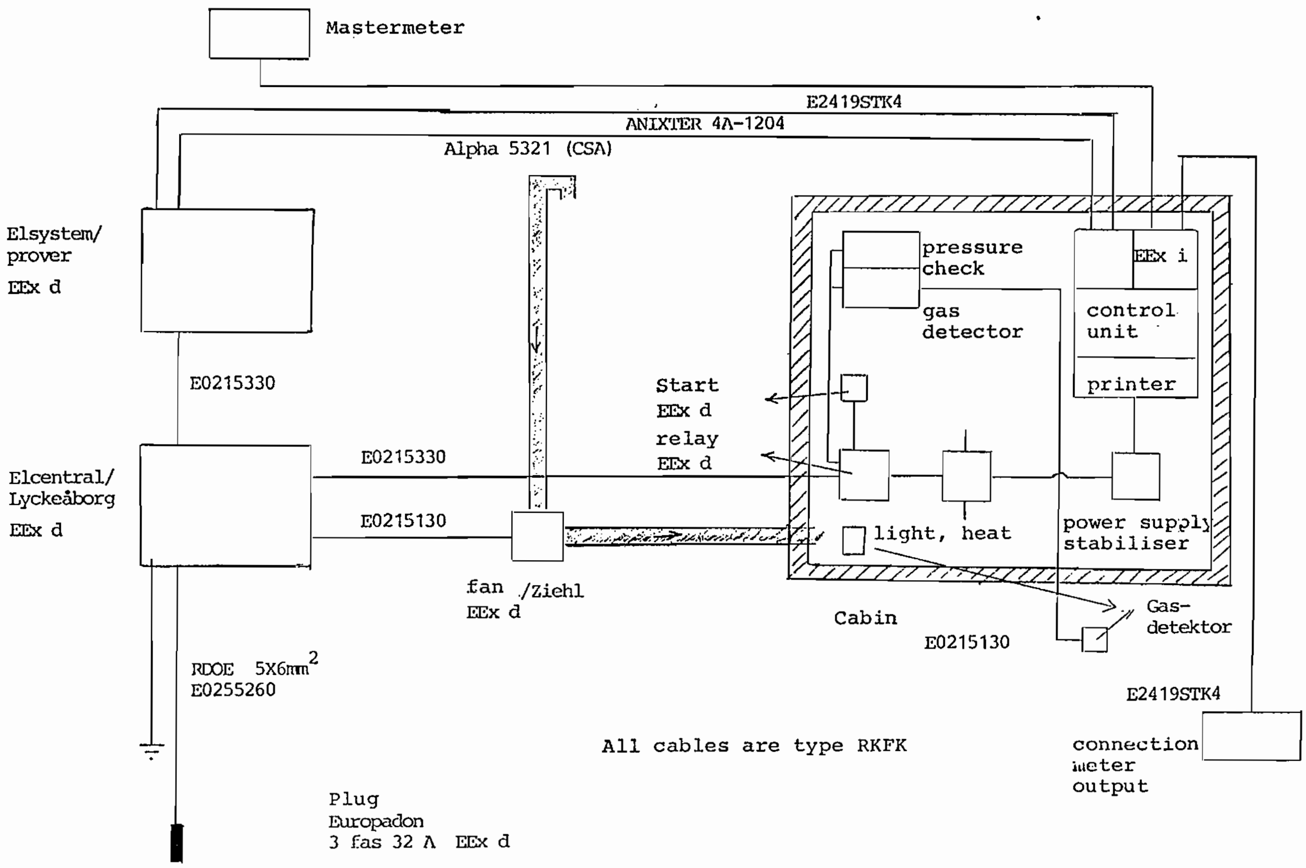


Fig. 6 — Power supply

To supply the instruments a relay has to be activated. To prevent the cabin from being a hazardous area, a supervising system, consisting of two parts, has to be working and activates this relay :

1. Outside the cabin a fan blows air from the top of the truck (3 meter above ground) into the cabin, to create a pressure above ambient. A pressure check releases the relay, if the pressure in the cabin drops.

2. Two gas detectors check if the air in the cabin consists of any explosive gas. If that occurs, the relay is released.

With a switch in the cabin, it is possible to choose between two operating conditions :

1. Operation in zone 1 (hazardous area) The supervising system is operating. The cabin has to be closed.

2. Operation in zone 2 or lower.

The pressure check is not operating and the gas detectors give an alarm, instead of cutting the power supply to the cabin.

As a complement, a portable explosimeter can be used before connecting the main power supply.

The electrical supply of the truck itself (24 volt), can be switched off at the battery.

2.7. **Control unit**

In the original Brooks control unit, the calibrated displacement volume, dimensions and material of the prover is programmed. Since temperature and pressure is measured at the prover inlet, the valid displacement volume can be calculated.

PROVING RUN 5 OF 5

P NO.	FREQ	GROSS F RATE	GROSS K	AVG GROSS K	TDVOL	TFMP	NO. - FMP
1	128.13	515.47	14.9139	14.9139	1.74825	1.74825	224
2	128.13	515.48	14.9139	14.9139	1.74822	1.74822	224
3	128.13	515.48	14.9139	14.9139	1.74822	1.74822	224
4	128.13	515.48	14.9139	14.9139	1.74822	1.74822	224
5	128.13	515.49	14.9139	14.9139	1.74819	1.74818	224

===

COMPENSATION DATA:

	MODE	START VALUE	FINAL VALUE	AVG VALUE	
PROVER FLUID TEMP	MAN	85.0			DGF
PROVER FLUID PRESS	MAN	100.0			PSI
METER FLUID TEMP	MAN	92.0			DGF
METER FLUID PRESS	MAN	110.0			PSI

TEMP-INVAR = 60.0 DGF
EQUILIBRIUM VAPOR PRESSURE = 14.7 PSI
REFERENCE TEMP = 60.0 DGF　　REFERENCE PRES = 14.7 PSI

CTL-P = 0.99936	CTS-P = 1.00031	CTL-M = 0.99918	TCOEF = 0000255/DGF
CPL-P = 1.00236	CPS-P = 1.00003	CPL-M = 1.00260	PCOEF = .0000235/PSI

BASE K = 15.0000 C/GAL

$$\text{AVG NET K} = \frac{\text{(AVE GROSS K) (CTL-M) (CPL-M)}}{\text{(CTL-P) (CPL-P) (CTS-P) (CPS-P)}} = \text{14.9097 C/GAL}$$

$$\text{METER FACTOR} = \frac{\text{BASE K}}{\text{AVG NET K}} = 1.006054$$

Fig. 7 — Protocol of five tests.

One meter can be tested at a time, and it is possible to connect pressure and temperature gauges at the meter to the prover.

The location of the meter (upstream or downstream of the prover), if temperature or pressure compensation of the liquid is desired, and the number of tests, are specified at every occasion. The control unit monitors the test and calculates the K-factor (fig. 7, 8).

METER PROVING REPORT

DATE. . . . . LOCATION. . . . .

METER NO.. . . . . MAKE & MODEL . . . . S/N . . . .

PRODUCT. . . . . COMMENTS . . . .

==

PROVER DATA:

PROVER DIAMETER = 12.235 IN   WALL THK = .369 IN   MATL = CS

PROVER VOLUME   UPSTREAM = 15.0188 GAL   DOWNSTREAM = 15.0195 GAL

BASE TMP = 60.0 DGF   BASE PRS = 0.0 PSI

==

METER DATA:

BASE K = 15.0000 C/GAL

POSITION = DOWNSTREAM

==

PROVING DATA:

RUN NO.	METER FACTOR	AVG NET K	RUN NO.	METER FACTOR	AVG NET K
1	1.006054	14.9097	2	1.006054	14.9097
3	1.006054	14.9097	4	1.006054	14.9097
5	1.006054	14.9097			

AVG NET K = 14.9097

AVERAGE METER FACTOR = 1.006054

$$\text{METER FACTOR REPEATABILITY} = \frac{(\text{MF MAX} - \text{MF MIN})}{\frac{(\text{MF MAX} + \text{MF MIN})}{2}} = 0.002\%$$

==

SIGNED BY. . . . . CHECKED BY. . . . .

WITNESSED BY. . . . .

FOR. . . . . FOR. . . . .

Fig. 8 — Summary of five runs with calculated K-factor.

We had to design a unit to compare the meter to the mastermeter, and another unit to adjust the meter output, before putting it into the control unit.

3. Application

The prover is designed to test meters in closed conduits (fig. 9). There have to be pumps in the system, since the prover is passive. The equipment is designed for both cold and hot liquids, and for high pressures.

The overall advantage with the prover is, that the meter can be tested, on site, with the proper liquid. Connection of the prover and calibration of the meter can be performed without stopping the flow and disturbing the production.

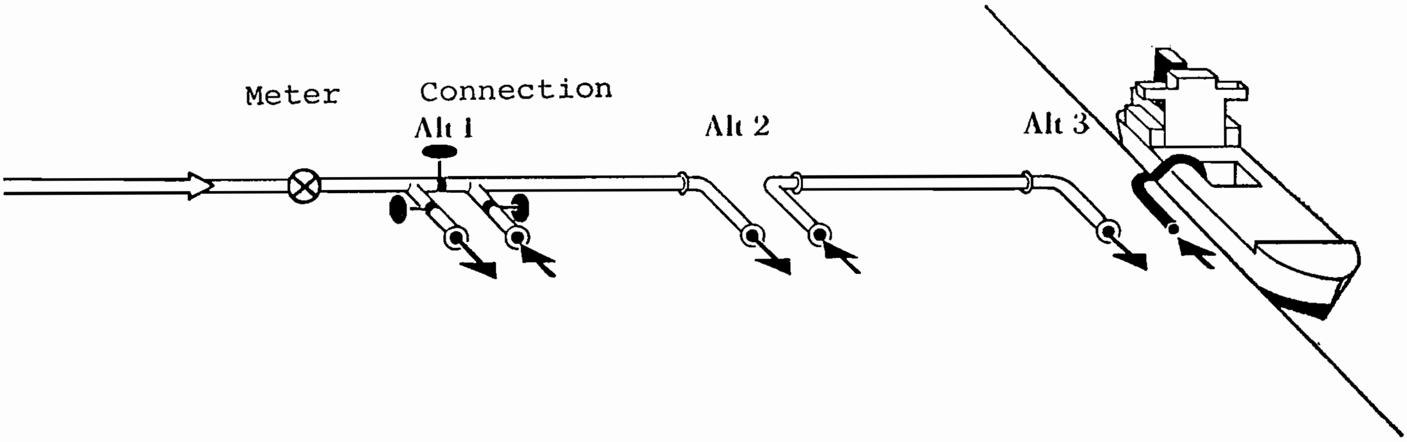


Fig. 9. — Connecting the prover to the pipeline

When using the prover with liquified propane, some precautions have to be taken :

— The prover has to be dry, to prevent valves from freezing, if the pressure drops.

— The prover has to be free of oxygen (to prevent explosion) and is filled with nitrogen, before letting in the propane.

— The pressure must not drop, thereby preventing the temperature from dropping.

— The prover is emptied by evacuation of the propane to a flare, and at the same time filling the prover with nitrogen.

4. Technical data

Maximum flow rate	26 000 L/min
Minimum flow rate	26 L/min
Maximum flow rate for mastermeter	32 000 L/min
Maximum pressure	5 MPa
(pressure class	300 lb ANSI)
Maximum temperature	+ 120 °C
Minimum temperature	— 30 °C
Connection, flange, maximum	10" ANSI
Power supply	220/300 V, 50 Hz
(apprx. current	10 A)
Meter output, sine or square wave	40 000 Hz
Displaced volume	250 L
Total inaccuracy at meter calibration	0,1 %
Liquids	Water, petrol, oil, LPG etc

5. Delivery test

The equipment was tested both at Brooks, Georgia, USA and at our laboratory in Boras, Sweden.

5.1. Tests at Brooks, Georgia, USA

The waterdraw, with a volume standard calibrated by NBS, gave the result 249,89 L at 15,6 °C and ambient pressure. This is an average of 3 measurements with a range of dispersion of 0,01 L.

To test the repeatability, two turbine meters were mounted in series (OIML International Document no. 7). These were calibrated at the same time with two control units connected to our prover. Our prime interest was in high flow rates, since the capacity at our laboratory is limited to 6 000 L/min.

The meters were calibrated several times at the same flow rate. At each test, the result was plotted in a diagram, (fig. 10, 11) with one K-factor on the x-axis, and the other on the y-axis (correlation analysis).

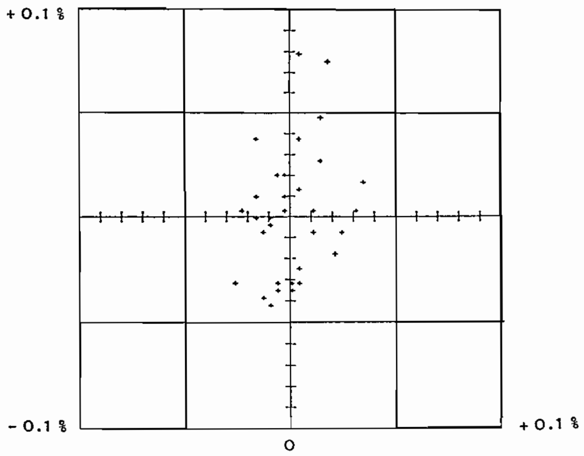


Fig. 10

Correlation analysis 24 500 L/min at Brooks. Correlation value = 0.270, mean x = 2.9640, mean y = 2.8918, standard deviation x = 0.00044, standard deviation y = 0.00090.

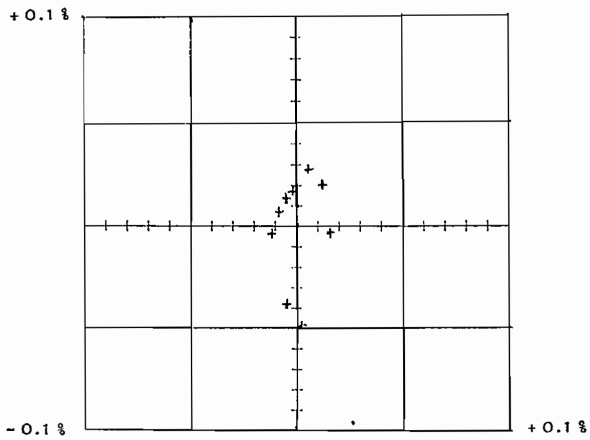


Fig. 11

Correlation analysis, 10 100 L/min at Brooks, Correlation value = 0,219, mean x = 2.9628, mean y = 2.8901, standard deviation x = 0.00028, standard deviation y = 0.00076.

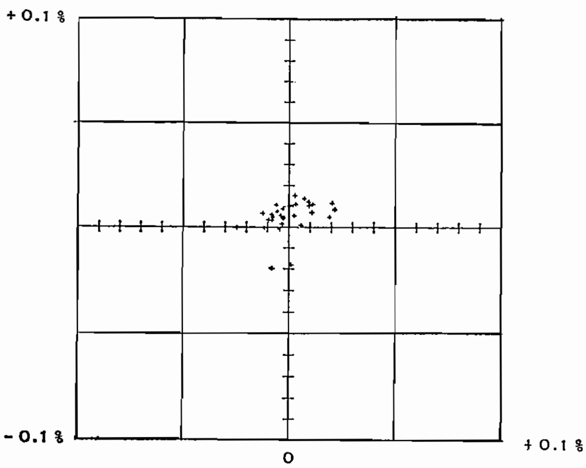


Fig. 12

Correlation analysis, 630 L/min, in Borås, Correlation value = 0.087, mean x = 94.1016, mean y = 88.1246, standard deviation x = 0.01011, standard deviation y = 0.01858.

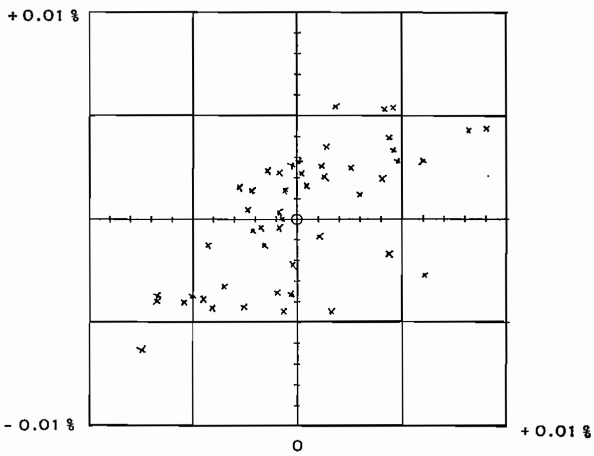


Fig. 13

Correlation analysis, 420 L/min, in Borås, Correlation value = 0.083, mean x = 94.1539, mean y = 86.1513, standard deviation x = 0.00351, standard deviation y = 0.00283.

If the repeatability of the prover is worse than that of the meters, the result will be a curve with the slope + 1. If the repeatabilities of the two meters are the same, and much worse than the repeatability of the prover, the result will be a circular pattern. The result was satisfactory.

5.2. **Continuation of the tests at our laboratory in Borås**

When the equipment arrived, we borrowed an extra control unit and the test continued, with further correlations analysis (fig. 12, 13).

5.3. **Waterdraw tests**

	Test 1	Test 2	Test 3	
Mass, empty	147,384	147,404	147,412	kg
Mass, full	396,996	397,025	397,030	kg
Water temp. at scale	22,0	22,0	22,1	°C
Ambient temperature	22,5	22,5	22,5	°C
Ambient pressure	739	739	739	mm Hg
Relative humidity	54	54	54	%
Displacement volume (*)	250,40	250,41	250,41	L
Water temp. at prover	22,0	22,1	22,2	°C
Water pressure at prover	204	203	204	kPa

This test was performed after a longer period of test. Before making the waterdraw, the water was circulated for 12 h to establish a constant temperature (fig. 14).

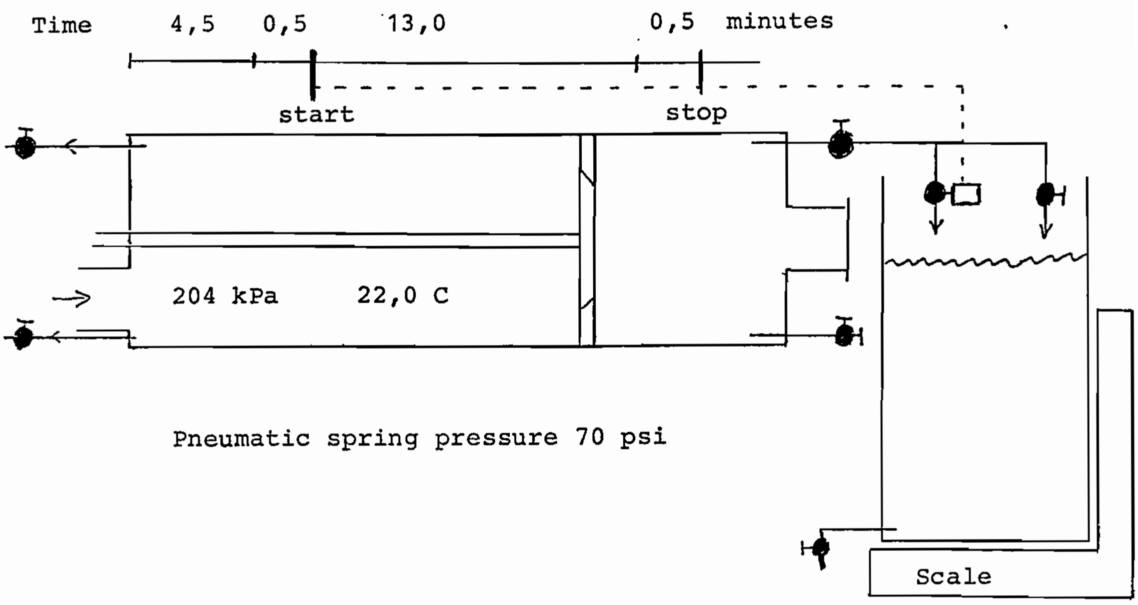


Fig. 14 — Water draw tests.

5.4. **Time measurement**

To check the clock in the control unit, another calibrated clock was connected to start and stop. This time was compared with « TD VOL » and an error of about — 0.005 % was detected.

(*) This volume is valid at 20 °C, ambient pressure, too.

5.5. **Double chronometry**

To check the operation of the double chronometry (fig. 3), a known frequency was connected to the control unit, instead of a meter. The prover made a couple of runs at constant flowrate (± 0,03 %).

Frequency (Hz)	Error with double chron. (%)	Error without double chron. (%)	One pulse equals (%)
2 500	0,00	0,00	0,002
25	+ 0,02	+ 0,05	0,2
0,25	+ 0,01	— 6,33	20

5.6. **Comparison between different equipments**

Comparisons were made between our different volume standards, by determining the K-factor of an electromagnetic flowmeter. The liquid was water and the tests were performed at about 22 °C ambient temperature.

Volume standard	Flowrate (L/min)	Pressure (kPa)	Temperature (°C)	K-factor (pulses/L)
Ball prover 3 500 L	760	170	20,1	57,562
Piston prover 250 L	760	180	20,3	57,583
			Difference 0.04 %	
Ball prover 3 500 L	3 170	170	21,1	57,334
Piston prover 250 L	3 230	80	20,7	57,371
			Difference 0,06 %	

One week, and 1 000 shaking kilometers later, the test was repeated.

Volume standard	Flowrate (L/min)	Pressure (kPa)	Temperature (°C)	K-factor (pulses/L)
Ball prover 3 500 L	693	100	22,8	57,560
Piston prover 250 L	695	100	22,6	57,590
			Difference 0,05 %	
Test measure 3 500 L	705	120	22,9	57,590
Piston prover 250 L	695	100	22,6	57,590
				Difference 0

Conclusions

During the time the prover has been in our laboratory, it has been used with hot water meters. Some of the new electromagnetic flowmeters, have outputs with very short pulses. The control unit of the prover requires a pulse length of at least 50 µs, which is too long for these meters.

The control unit is somewhat old fashionned and we have had to supplement it with other units, in order to adjust the meter output before putting it into the control unit, and for the use of a mastermeter.

Since we were not satisfied with this arrangement, and the presentation of the results from the control unit, we designed a completely new control unit, based on an IBM PC.

With this new unit, it will be possible to calibrate four meters at a time, one of them having a 20 mA output. The maximum frequency is raised from 5 to 40 kHz. Three meters can be tested with the mastermeter.

All the results can be presented in a report, or in a diagram. If two meters are tested at the same time, correlation analysis can be performed. The equipment will be ready during 1987-88.

In comparison with the ball prover (3 500 L) at flowrates from 100 to 6 000 L/min, the piston prover is certainly faster. We have used the prover down to 15 L/min, with water.

The prover has been used in field calibrations, with water, petrol, diesel, bunker C oil, LDF (Light distillated fraction), solvent and liquified propane, without any problems.

The air vents and draining valves are connected to a tank, and the prover can also be drained by pumping or by filling it with nitrogen.

The flow tube is made out of stainless steel, but the rest is made out of carbonised steel. In the beginning the paint prevented corrosion, but last winter we had to zinc the pipes.

Finally, we are, despite the problems mentioned on the whole satisfied with the prover as we are able to calibrate meters in the best way possible : IN-LINE.

References

[1] Meter Provning with the Brooks Compact Prover. Brooks Instrument Division, Technical Bulletin, August 1982.

[2] Theory and Application of Double Chronometry. Brooks Instrument Division, Technical Bulletin, March 1982.

[3] The evaluation of flow standards and facilities used for testing water meters. OIML International Document no. 7.

INFORMATIONS

MEMBRE DU COMITE

URSS — Le Docteur Anatoly I. MEKHANNIKOV, Vice-Président du Gosstandart, a été nommé comme nouveau Membre du Comité International de Métrologie Légale pour l'URSS.

Rappelons que le Dr MEKHANNIKOV avait été élu Membre du Comité International des Poids et Mesures lors de la dernière Conférence Générale des Poids et Mesures en octobre 1987.

Nous souhaitons au nouveau Membre de notre Comité la meilleure des bienvenues.

MEMBRE CORRESPONDANT

BANGLADESH — Le Bangladesh a été admis comme Membre Correspondant de notre Organisation au début de l'année 1988.

INFORMATION

COMMITTEE MEMBER

USSR — Dr Anatoly I. MEKHANNIKOV, Vice-President of Gosstandart, has been nominated the new Member of the International Committee of Legal Metrology representing the USSR.

We remind you that Dr MEKHANNIKOV was elected Member of the International Committee of Weights and Measures at the last General Conference of Weights and Measures in October 1987.

We are pleased to welcome our new Member.

CORRESPONDING MEMBER

BANGLADESH — The Bangladesh was admitted as Corresponding Member of our Organisation at the beginning of 1988.

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
Fixed storage tanks. General requirements

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

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

74 — Instruments de pesage électroniques (*)
Electronic weighing instruments (*)

75 — Compteurs d'énergie thermique (*)
Heat meters (*)

DOCUMENTS INTERNATIONAUX

INTERNATIONAL DOCUMENTS

DI N°

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
Guidelines for the determination of recalibration intervals of measuring equipment used in testing laboratories

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

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

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

14 — Qualification du personnel en métrologie légale
Qualification of legal metrology personnel

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

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

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

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

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