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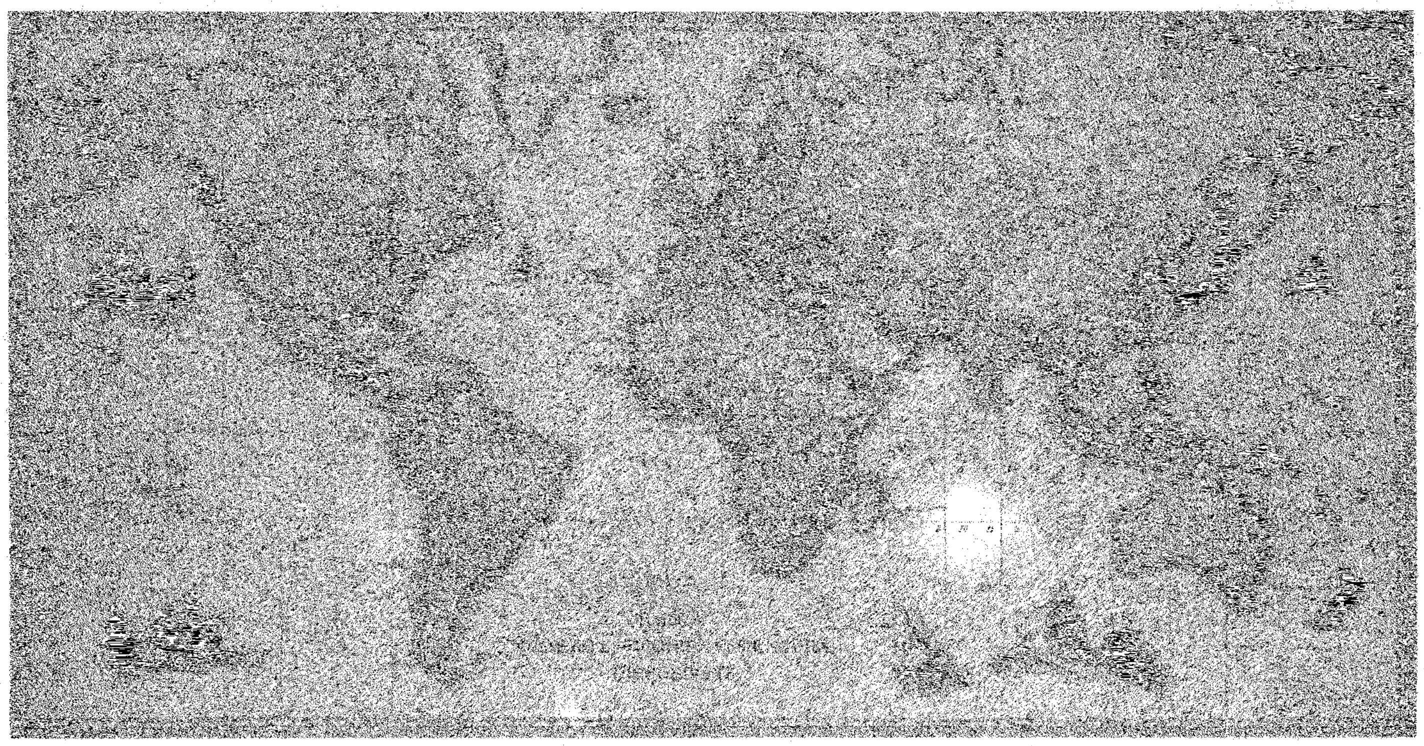

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11, Rue Turgot – 75009 PARIS – France

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TRAINING COURSE IN VERIFICATION OF WEIGHING INSTRUMENTS

Munich, 22 June-3 July 1992

This second course in metrology of weighing instruments conducted in English and organized by PTB and OIML at the Deutsche Akademie für Metrologie (DAM) was very successful according to the reactions of the participants.

The experience of the first course which was held in 1991, inspired the organizers to limit the number of subjects that were covered. This allowed more time for practical training which was carried out in small groups of participants.

Course content

One of the main aims of the course in 1991 was to sensibilize testing authorities on problems of bulk weighing and the necessity for using proper verification methods and equipment. The second aim was to update the knowledge of testing retail scales in light of the new OIML Recommendation R 76.

The experience of the course held in 1991 was used to significantly improve this year's course. The practical training was thus divided into smaller groups, the amount of testing on the mechanical weighbridge was reduced (to 40 t in two steps) and the practical testing of an electronic vehicle scale was added. The testing of class III shop scales was extended and largely improved as well. The time gained was used to include practice in testing of class II scales (mainly electronic) such as those used for pharmaceutical dispensing and jewellery trade.

Participation

There was a total of 19 participants who had been selected from a much larger number of applications based on replies to a questionnaire.

The theoretical training during the first week was, in addition, also attended by three metrologists from developing countries who were granted longterm practical training in Germany.

The entire course was almost fully sponsored by the German authorities, as was the case in 1991. There were however, two participants from more industrially developed countries whose travel costs were fully or partly covered by their respective employing organizations.

Due to financial constraints, the travel of only one participant and one BIML staff member could be sponsored by OIML this year.

The discussions showed that, in general, the participants had a very good background and important technical responsibilities in their home countries within the fields covered by the course.

Lecturers

Information about the general outline and the practical arrangements of the course was given by Dr Wallerus, Director of DAM, followed by a lecture on Legal Metrology in Germany and in the European Community which was delivered by Mr Breuer, Director of the Bavarian Verification Administration.

The requirements concerning nonautomatic weighing instruments were explained by Prof. Volkmann of PTB who has actively participated in the development of the OIML Recommendation R 76. He also delivered lectures on the pattern approval of these instruments and on load measuring devices comprising strain-gauge load cells.

As the scope of the course this year had been extended to include class II weighing instruments the course organizers were fortunate to count on a lecture on electromagnetic compensation devices by Mr Reber from the development section of the firm Mettler. Furthermore Mr Wolff,also from Mettler, assisted the participants in the practical training for verification of class II electronic balances.

The construction of electronic class III weighing instruments used for direct selling to the public was reviewed by Mr Biermann of the Bizerba company, using background material from the chapter on this subject that he wrote for Handbuch des Wägens (ed. Prof. Kochsiek).

Basic weighing principles concerned such as weighing in air, influence of *g* and fundamental terminology were explained by Dr Thulin, of BIML, who also reviewed the various types of verification equipment of vehicle scales.

For the part of the course concerned with the practical training in verification, the facilities provided by DAM had been improved and extended using a model electronic weighbridge specially constructed by the Pfister factory and class II electronic balances supplied on loan by manufacturers. The lecturers on these subjects were Mr Rank, head of the training for foreigners and his colleague Mr Seidl.

In addition to the lecturers from DAM and so as to extend the international character of the course, the practical training was assisted by Mr Källgren, head of the mass department of the Swedish National Testing Institute. Mr Källgren has also actively participated in the drafting of OIML R 76 and was thus fully qualified to further explain and relate his experience of testing weighing instruments.

Similar to last year, the subject of automatic weighing was reviewed by Mr Barten during a visit to the Pfister factory in Augsburg.

Conclusions

In general, the completed questionnaires by the participants at the end of the course showed that the programme was well balanced and that they were very satisfied with it. The time period, however, was generally considered too short for a full review of OIML R76 and for discussions with the lecturers as to their experience in pattern approval testing.

These remarks should be taken into account for future courses. In fact, a majority of the participants considered that the course should be repeated so as to make it available to more participants from each country. They also suggested that similar courses should be organized for subjects such as calibration of precision weights, testing of prepackages, automatic weighing instruments, statistical metrological supervision, flowmeters, calibration of storage tanks, etc.

Acknowledgements

The participants were also grateful for the extensive social programme arranged that was including a welcome dinner and a special evening at DAM which proved that many Bavarian metrologists are also excellent musicians. A city tour of Munich was also offered as well as a Sunday excursion to visit the castle of Linderhof and other interesting sites in the Bavarian mountains.

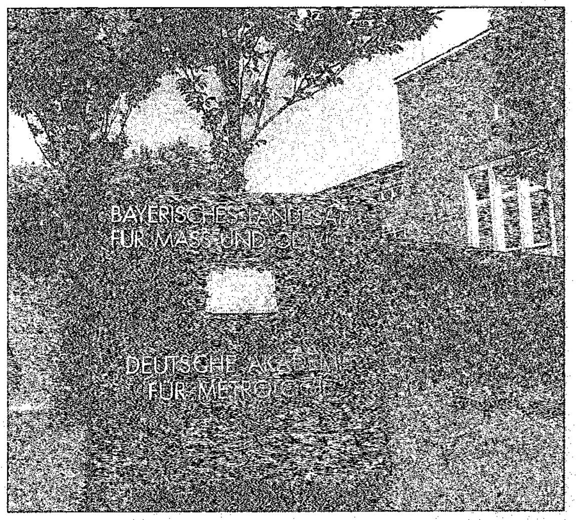
In addition, the important contributions of the firms Bizerba, Mettler and Pfister must not be forgotten.

We express once more our warmest thanks to the course administrators at PTB, Mr Apel and Mr Schaaf, and to Mr Breuer, Director of the Bavarian Verification Administration, to Mr Märkl, Director of the Munich Verification Office and especially to Dr Wallerus, Director of DAM and Mr Rank, Mr Seidl and the other staff at DAM responsible for the practical arrangements which contributed to the success of the course.

A. T.

GERMAN ACADEMY of METROLOGY

by **H. WALLERUS***



1. Legal metrology in Germany

The Bundesrepublik Deutschland (BRD) is a federal republic with a government situated in Bonn/Berlin and with sixteen separate Federal States. In the field of legal metrology the tasks and competencies are divided between several authorities.

The Verification law is issued by the Government. The execution of this law is the task of the responsible authorities in the Federal States, e.g. in Bavaria: Bavarian State Office for Weights and Measures (Landesamt für Maß und Gewicht - LMG) and its verification offices.

The Verification law refers to measures and weights, which are used in business, for pollution control, in medicine and for official supervision.

The Federal Institute of Physics and Metrology (Physikalisch-Technische Bundesanstalt - PTB) is responsible all over Germany for pattern approval of measuring equipment which is acceptable for verification, for the national standards and for the representation of the units.

Measuring instruments for industrial measuring technique are normally checked by the departments of the German Calibration Service (Deutscher Kalibrierdienst - DKD), which is supervised by the PTB.

2. The German Academy of Metrology (DAM)

The German Academy of Metrology (Deutsche Akademie für Metrologie - DAM) is a common institution for basic and advanced training of the technical staff of the verification authorities of all federal States of the Republic of Germany. It was established in Munich with the Bavarian State office for Weights and Measures (Landesamt für Maß und Gewicht, LMG) on the basis of an agreement concluded by the federal states more than thirty years ago. A survey of the historical development of the legal metrology training in Germany is given in section 4.

(*) Dr.-Ing. Heinz Wallerus is the head of the German Academy for Metrology (DAM) and the head of the division Metrology and Verification in the Bavarian State Office for Weights and Measures (LMG).

TABLE 1 – THE VERIFICATION OFFICER - A JOB OUTLINE

Careers	Advanced technical service (Gehobener Dienst)	Intermediate technical service (Mittlerer Dienst)
Admission requirements	graduate engineer (higher technical college)	certified technician, master craftsman
Branches	electrical or mechanical or related branches	
Training centers	verification boards and verification offices of the Federal States; DAM in Munich	
Practical training **Theory (DAM)** **Total training***	6 - 18 months 6 months 12 -24 months	9 - 15 months 3 months 12 - 18 months
Conclusion of training	examination qualifying candidates for employment - at DAM in Munich -	
Career advancement	advancement within the framework of the career structure change of career for especially proven officers	

* The duration is specific for the Federal States

3. Activities of the DAM

3.1. Training of technical staff

The Academy's main task is the basic and advanced training in the field of Legal Metrology of the technical staff of the verification authorities.

The two main careers of verification staff are shown in Table 1.

Certain prerequisites must be fulfilled before a candidate is admitted to the preparatory training (= practical and theoretical professional training) for one of these careers. The relevant prescriptions as

- Civil Service Code
- admission regulations
- training regulations

are similar in all Federal States and include the conditions given in Table 2.

TABLE 2 – CONDITIONS FOR ADMISSION TO A CAREER

Advanced technical service	Intermediate technical service
Legal requirements to be met prior to appointment as civil servant (e.g., according to the Bavarian Civil Service Code)	
• age of 32 years not yet reached • final examination passed at a a) higher technical college or b) a university offering study courses equivalent to those of a higher technical college, in mechanical engineering, electrical engineering or similar branches	• age of 30 years not yet reached • final examination passed at a) a technical academy b) a technical college c) master craftsman's examination qualifying in a trade relevant to the technical service d) journeyman's examination and practical experience of 5 years

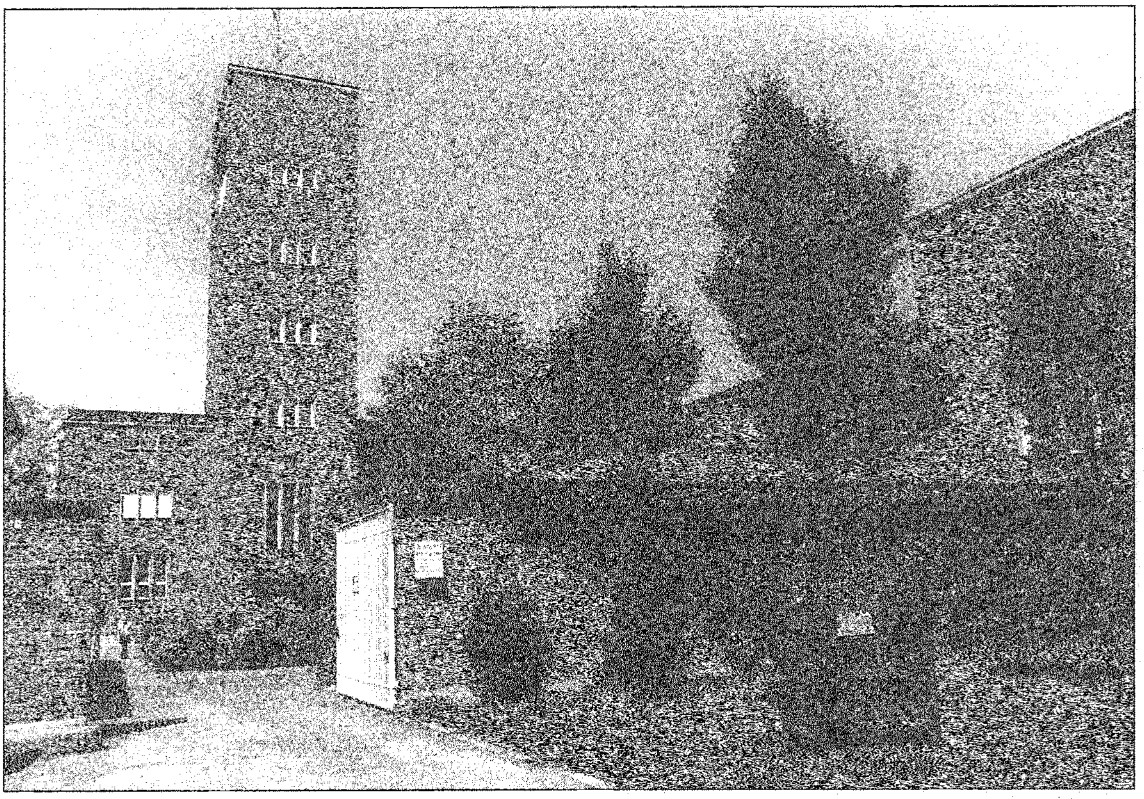


Fig. 1 – Entrance to the main buildings of the Bavarian Weights and Measures Administration and to the DAM

Candidates for the civil services are trained in practical skills in the verification offices of their states. The DAM does the theoretical education for careers in the advanced and intermediate technical services.

The courses for the higher intermediate technical service last from the beginning of January to the end of May. The courses for the intermediate technical service take place from September to the end of November each year.

The contents of the curriculum for the advanced and the intermediate service are shown in Table 3.

Immediately after the courses the candidates have to undergo an examination.

The fields of the examinations are

- methods of verification of different kinds of measuring instruments and control of the filling quantities of prepackaged goods
- mathematics and physics with special respect of applications in the field of metrology
- legal prescriptions as Verification Act, Verification Ordinance, Units Act, technical rules and standards etc.
- basic concepts of public and private law, administrative offenses and legal proceedings

The examination comprises written and oral parts. The written examination for the intermediate technical service comprises six questions to be answered in two hours each; for the advanced technical service there are eight questions to be answered in ten hours.

TABLE 3 – CONTENTS OF THE CURRICULUM FOR THE ADVANCED AND THE INTERMEDIATE TECHNICAL SERVICES

1. Legal regulations
(Advanced technical service: 52 hours
Intermediate technical service: 39 hours)

- Verification Act
- Verification Ordinance and verification instructions, technical rules and standards
- State approved test centers

2. Mathematical and physical bases of metrology
(Advanced technical service: 118 hours
Intermediate technical service: 56 hours)

- General aspects of algebra and geometry
- Integral and differential calculus
- Fundamentals of statistics
- Introduction to error calculus and observation calculus
- Data processing, control of data processing units
- Physical quantities
- Mechanics of solids, liquids and gases
- Thermodynamics
- Brief review of atomic physics, radiation of radioactive substances, acoustics, optics
- Electricity, electrical measurement of non-electrical quantities

3. Basic concepts of public and private law
(Advanced technical service: 69 hours
Intermediate technical service: 49 hours)

- The basic Law of the Federal Republic of Germany
- Brief survey of the development of the German State
- Administrative law
- Public service law
- Budget, accounting and invoicing
- Administrative offenses and legal proceedings
- Administrative procedures act
- Brief review of the tasks of the police and the regulatory authorities
- Brief review of the content of the German Civil Code
- Official correspondence

4. Supplementary lectures
(Advanced technical service: 29 hours
Intermediate technical service: 22 hours)

- Dealing with the citizen
- Drawing up test records
- Test evaluation
- Radiation Protection Ordinance
- X-Ray Ordinance
- Historical development of metrology and verification

5. Measuring instruments
(Advanced technical service: 416 hours
Intermediate technical service: 249 hours)

- Length measuring instruments
- Area measuring instruments
- Instruments for measuring the volume of non-liquid products
- Instruments for measuring the volume of liquids at rest
- Instruments for measuring the volume of flowing liquids other than water
- Instruments for measuring the volume of flowing water
- Instruments for measuring gas
- Weights
- Non-automatic weighing machines
- Automatic weighing machines
- Measuring instruments for the grading of cereals and oilseeds
- Volume measuring instruments for laboratory use
- Density and content measuring instruments
- Temperature measuring instruments
- Medical measuring instruments
- Pressure gauges
- Measuring instruments for examinations in dairies
- Measuring instruments used in road traffic (including exhaust carbon monoxide meters, radars, wheel load measuring instruments, tire gauges)
- Hour meters, stop watches
- Measuring instruments for electricity
- Sound level meters
- Instruments for measuring the thermal energy, warm and hot water meters for heat exchanger circulation systems
- Radiation protection measuring instruments
- Control of the filling quantities of prepackages and measuring container bottles

6. Working in groups
(Advanced technical service: 86 hours
Intermediate technical service: 25 hours)

- Technical reports on given subjects to be elaborated by the trainees

3.2. Technical seminars for the staff of the German verification authorities

Besides the regular courses, the academy holds technical seminars for the advanced training of verification officers from all parts ot the country to prepare them for tasks and fields of work, see Fig.2.

In view of the rapid technical development of measuring instruments and the changing tasks to be performed by the new Verification Act and Verification Ordinance in view of the common market in Europe, the DAM offers a steadily increasing number of technical seminars with typical subjects in this field, such as

- New legal prescriptions (national and European)
- New technical developments of measuring instruments
- Training courses for verification officers in leading position
- Intensive courses in technical English
- Didactic courses for the lecturers at the DAM
- Qualification in the field of Quality Assurance and Auditor for Quality Systems

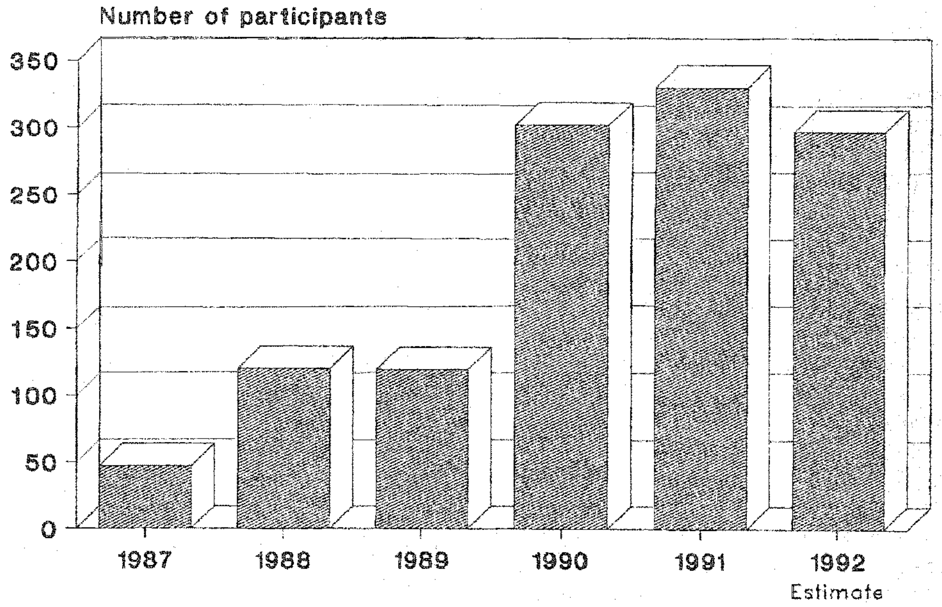


Fig. 2 – Technical seminars for Verification Authorities

3.3. Seminars for participants from trade and industry

In the field of legal metrology special state-approved test centers certify measuring instruments for gas, water, electricity and thermal energy. In order to be accredited , executive staff of these test centers must furnish proof of the required expertise. To attain uniformity of knowledge of verification prescriptions, the DAM holds, since 1989, courses and examinations for the heads of test centers in all Federal States.

Lecturers from the DAM also held technical lectures at other institutes, e.g.

- Academy of Public health, Bavarian Ministry of the Interior
- Technical college for the brewery trade "Doemens-Technikum"
- Bavarian Pharmacists Association
- Bavarian Hospitals Association
- Master craftsmen's school of the Bavarian Millers Association.

Fig. 3 – The DAM lecturer Mr Rank explains the verification of an electronic road weighbridge to foreign participants. On the blackboard: samples of the international vocabulary in metrology

Fig 4 – Concluding discussions at the PTB-DAM-OIML international training course on verification of weighing instruments

3.4. Courses for foreign experts in the field of legal metrology

The DAM collaborates in technical cooperation projects of the Physikalisch-Technische Bundesanstalt (PTB) and the Organisation Internationale de Métrologie Légale (OIML) in the fields of metrology, standardization, testing and quality assurance (MSTQ) that are financed by the Federal Ministry for Economic Cooperation (BMZ) and by the European Community.

The workshops on "Verification of Weighing Equipment" have been held in 1991 and 1992 in English language for participants from Central and South-America, Africa, Europe and Asia (Fig. 3 and 4).

The objective of the workshops is to familiarize in particular verification inspectors of national metrology and calibration services with the measuring principles, the technical standards and verification procedures for weighing instruments. Lectures on physical principles, measuring methods, types of weighing instruments, international and national standards, in combination with practical test and verification work, provide an excellent opportunity to become acquainted with the metrological aspects of nonautomatic weighing instruments (self-indicating and non-selfindicating weighing instruments class III and class II, e.g. retail scales, road vehicle scales, scales for pharmaceutical and jewellery trade, and mass comparison of heavy test weights.

The seminars "Medical Measuring Instruments" in 1991 and 1992 in English language concern measuring principles, the technical standards and test procedures for clinical thermometers and blood-pressure measuring instruments. The combination of lectures and practical test and verification work ensures the success.

In addition to these courses there are numerous foreign scholarship holders who are being trained in the practice of verification of different measuring instruments. A prerequisite for participation in this training is a working knowledge of the German language, since the training is done by verification officers in outdoor work.

Based on the agreement of 1988 on cooperation between the provinces of Shantung and Beijing, Peoples Republic of China, and the Free State of Bavaria, there are activities of lecturers from the DAM on tours in China and visits of Chinese experts to study special fields of metrology in Bavaria.

Statistics of the international contacts and cooperation of DAM is given in Fig. 5.

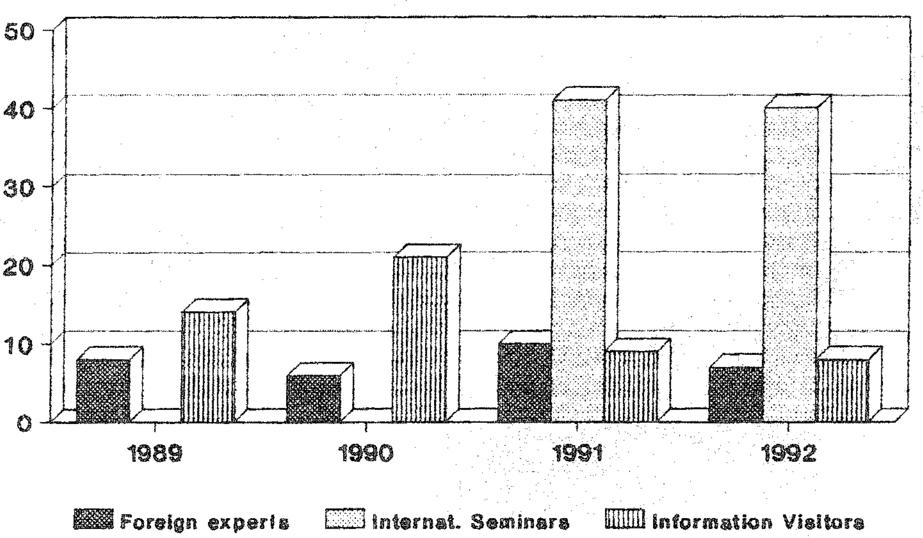


Fig. 5 – International contacts of DAM, numbers of participants from abroad

3.5. Central services for the verification authorities

Recent legal regulations tend no longer to establish technical rules but to refer to accepted rules of technique. The Academy as an institution supported by all Federal States provides them with technical rules as standards (national and European), PTB-reqirements and legal prescriptions.

3.6. Organization of the DAM

The legal base is the agreement of 25.5.1961, which was renewed in 1992 including the States of the former GDR. This agreement regulates such points as uniform practical and theoretical training of candidates for employment, responsibilities of the DAM, appointment of the examination board and financing of the DAM. Once a year, the representatives of the Federal States meet in Munich to decide upon the budget and questions of training.

As the DAM is affiliated to the Landesamt für Maß und Gewicht (LMG), the Academy has the organizational status of a section and is subordinated to the head of division responsible. The whole infrastructure of the LMG is at the DAM's disposal.

As the number of tasks has increased, a permanent executive and a secretariat is established. The permanent staff of the DAM consists of six persons. The Academy's lecturers, about 20, are practitioners from the technical service. As such, they are able to instill life into theoretical subjects and show their relevance to practice.

Depending on the subject and the demand, lecturers from PTB, OIML and trade and industry are invited to give lectures.

Global statistics of the services supplied by DAM are shown in Fig. 6.

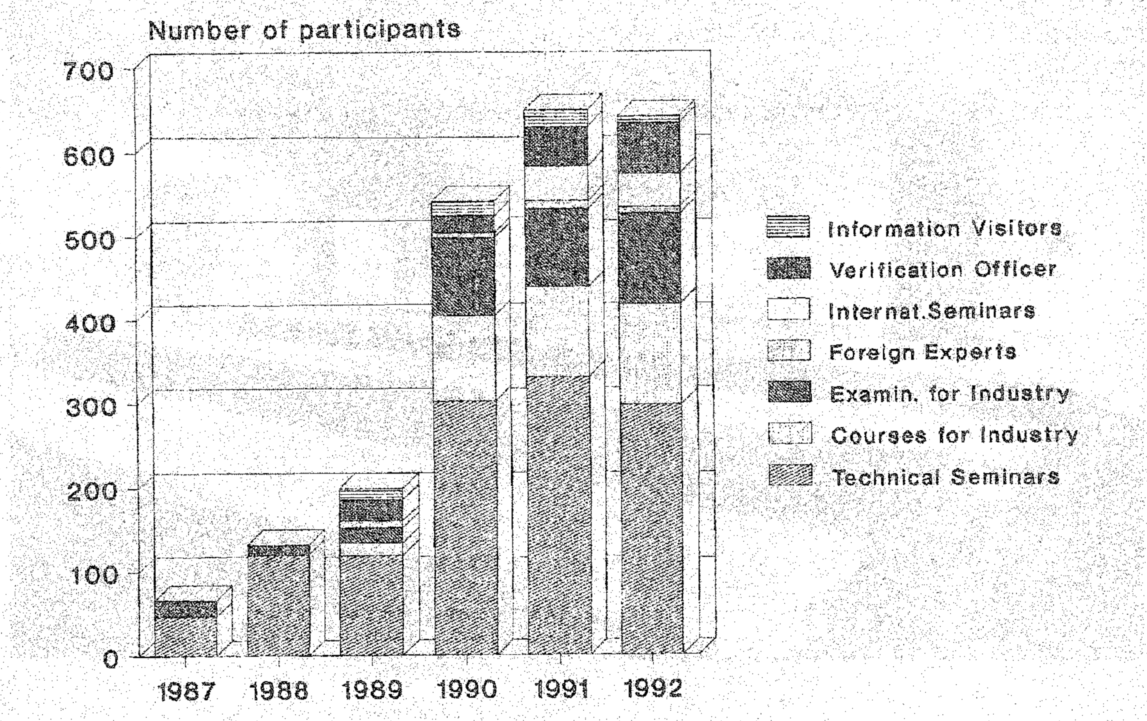


Fig. 6 – Global statistics of the services of DAM

3.7. Facilities available

The DAM is accommodated in the building of the Bavarian Weights and Measures Administration in immediate vicinity of the Munich verification office, Germany's largest verification office. The equipment allows all kinds of metrological tests to be carried out, such as

- Determination of mass, pressure and volume and tape measures
- Verification of velocimeters used by the police
- Verification of clinical measuring instruments
- Verification of dosimeters and sound level meters
- Support of state-approved test centers for gas, water, electricity and thermal energy located in Munich

Two lecture rooms, one room for practical training, several offices and one storage room for instruction materials are at the disposal of the DAM. Modern equipment as overhead projectors, flipcharts, videorecorders, technical books, cutaway models and graphs of measuring instruments and a collection of historical instruments complete the facilities, see Fig. 7 and 8.

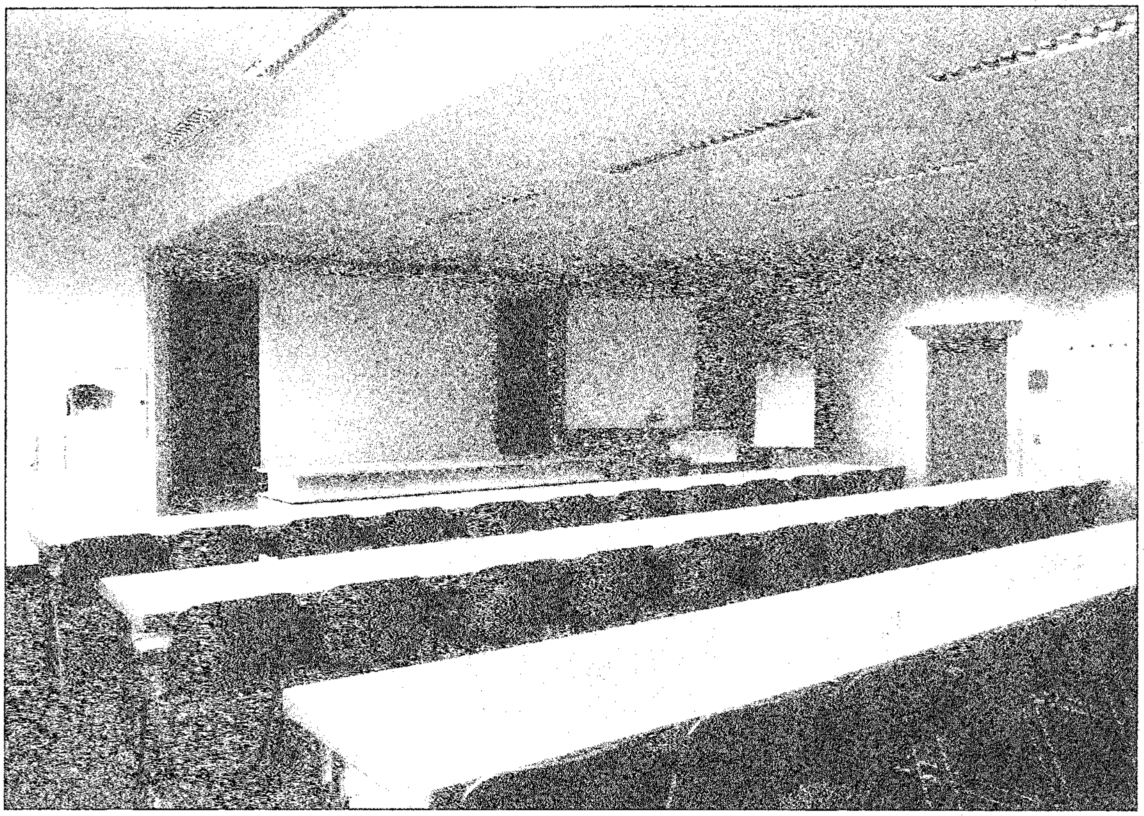


Fig 7 – One of the lecture rooms at DAM

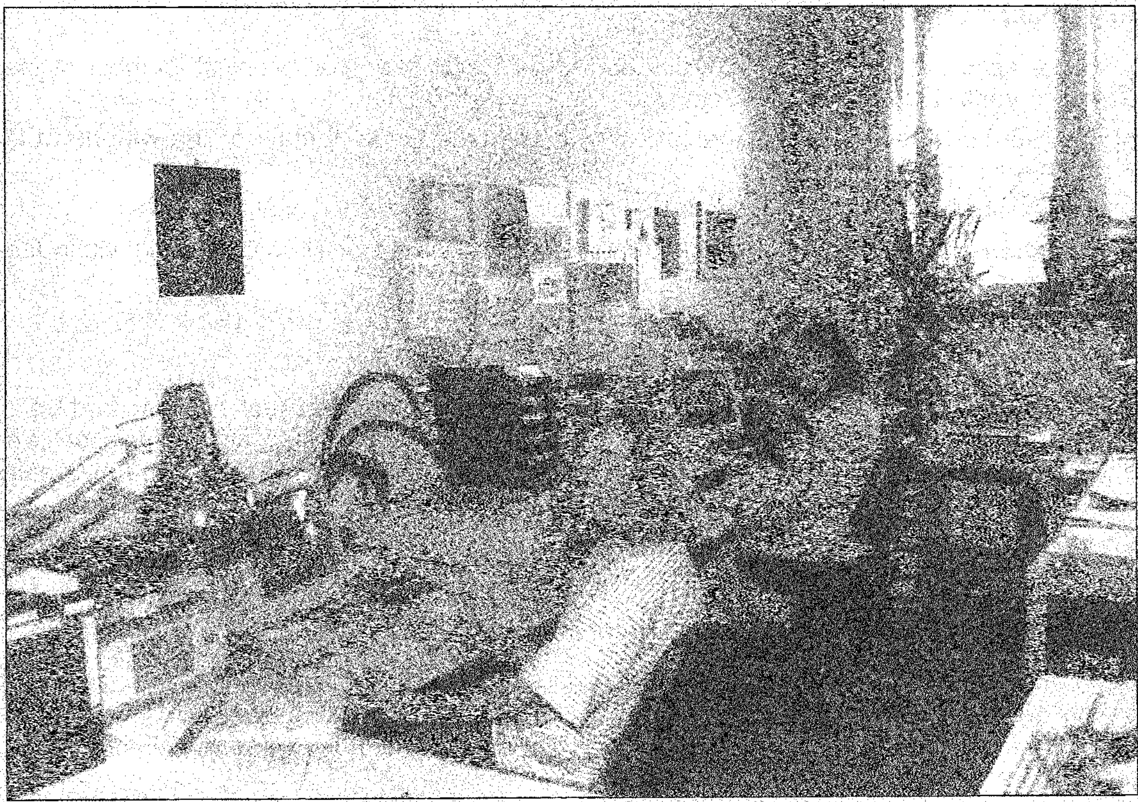


Fig. 8 – View of the DAM secretariat

4. Survey of the historical development

Uniform training everywhere in all Federal States started only in 1941, which is why training prior to this had state-specific characteristics. The development in Bavaria up to 1941 is given as an example.

1869

By decree of His Majesty the King, dated November 23, 1869, related to the Standard Verification Commission, the verifiers (the verification officers at that time), the stamps and verification marks, the verification fees and the weights and measures inspections and the requirements to be met by the verifiers are stipulated.

From 1870 to 1934

Training of Bavarian verification officers (verifiers).

Requirements for verifiers:

- they must have attained the age of 30,
- they must be in possession of the required personal guarantees,
- and they must have furnished proof of their qualification by an examination to be taken at the Standard Verification Commission.

Examination of verifiers

The examination of verifiers, which had to be conducted by a technical member of the Standard Verification Commission, covered

- The required theoretical, mathematical and physical fundamentals of the weights and measures system,
- the provisions on weights and measures fixed by Bavarian laws and ordinances, and
- the required familiarity with the exact technical performance of all tasks arising within the framework of the verification system.

Courses for verifiers

Courses for the training of verifiers were held at irregular intervals at the Standard Verification Commission. The first examination was held on February 7, 1870, after completion of a course. Additional courses and examinations were held when required. A course at a particularly large scale with more than 100 participants followed in 1903.

From 1913 to 1941

Bavarian Examination regulations of April 25, 1913:

Only candidates who had passed the final examination of a school of mechanical engineering or candidates from the military forces who had successfully attended the ordnance technicians' school or the school of fortification construction were admitted to the examination to qualify them as verification inspectors.

Regular courses for the qualification of verification inspectors (since 1934).

From 1934, courses for inspectors were held regularly every year, and their duration was extended to more than 4 weeks. These courses were completed by a written and oral examination taking several days, which, until 1941, was held on the basis of the examination regulations for the national service of legal metrology of April 25, 1913.

1941

From 1941 careers of technical verification officers followed uniform training everywhere in Germany.

On 01.01.41, the examination regulations of 1913 were replaced by the regulations for the careers of technical verification officers laid down by the Minister for Economics of the German Reich in close cooperation with the Landesamt. The training and examination regulations, which were uniform for the whole Reich, fixed the requirements to be met by technical officers of the advanced and the intermediate service and ensured uniform training and examinations.

- The career of "senior verification inspector" was established for the advanced service,
- the career of "verification inspector" for the intermediate service
- and the career of "verification assistant" for the lower service.

This classification still exists today.

After 1945

After the second world war, two courses (including final examination) were held, at first only for participants from Bavaria (1948 and 1949). As the other Federal States had no training facilities or institutions where examinations could be taken, and as there was a general desire to continue the tradition of the verification school of the Reich, participants from outside Bavaria were from 1950 admitted too on the condition that the costs were shared. From then on, one course for the advanced technical service and one course for the intermediate technical service were held regularly every year.

From 1961

On 25.05.1961, an agreement on the uniform training and examination of the advanced and the intermediate technical service was concluded with the other Federal States; this agreement forms the basis of the activities of the Bavarian Verification school. The training and examination regulations were adapted to recent developments in the field of metrology.

1988

On the occasion of the Verification School meeting on 20.04.1988, a new name "Deutsche Akademie für Metrologie" (DAM, German Academy of Metrology) was decided on as being better suited to the wider field of activities.

1990

The new examination regulations for the advanced and the intermediate technical service came into force on January 1, 1990. The subjects set for the examination can be brought up to date to take into account technical developments in the measuring instruments sector and to allow for structural changes in the legal metrology system, without the examination regulations having to be changed. In coordination with the verification authorities of the Federal States, the Academy lays down the subjects for the examination.

1992

The States of the former GDR join the renewed agreement. The DAM is the only one education center in the field of legal metrology for all states in Germany.

5. Conclusions

The German Academy for Metrology (DAM) was founded by the community of the Federal States thirty years ago. Its tasks are

- uniform training of technical staff of verification authorities
- advanced training of experienced verification officers in the fields of new legal prescriptions and new technical developments
- organization of information workshops for industry and
- organization of seminars for employees of foreign offices and metrological institutes
- supplying the verification authorities with publications of the technical/legal rules.

The DAM will offer adequate services for the future of legal metrology in the European Community.

Further information can be obtained from

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ALLEMAGNE

TRANSPORT MEASURING CONTAINERS AND THEIR CALIBRATION

by E. SCHÄFER

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Introduction

The character of the German State of Rhineland-Palatinate is formed, in part, by its vast wine-growing areas. Cultivation of wine and large wine-processing companies are substantial factors of the economy of our State. Consequently, trading and transshipment of the products is significant within the State as well as with other wine-producing countries such as Italy, Spain and France. For this purpose, road tankers whose containers are volumetric measuring instruments for liquids were found to be very suitable. In the following pages, these containers will be referred to as "transport measuring containers".

Transport measuring containers may form part of the truck or may be removable. Construction requirements and types of containers to be used are usually governed by national regulations.

The following types may be used:

- Transport measuring containers for liquids which are measured at atmospheric pressure (wine, milk, oil, alcohol)
- Transport measuring containers for liquids which are measured under pressure (beer, sparkling wine)

Regulations

According to regulations, the body of the containers shall be manufactured from metal or fibre-reinforced plastic. The volume of the container or of individual compartments should be at least 100 L. The section may be a circle, an elipse, a form with curved sides or any similar form.

The container volume is defined by a valve at the lowest part and by marks inside the dome or in the viewing glass at the upper part.

For reasons of measuring sensitivity a mark in the dome was prescribed as the upper limitation with, possibly, a subsidiary scale which should not protrude into the container (Fig. 1).

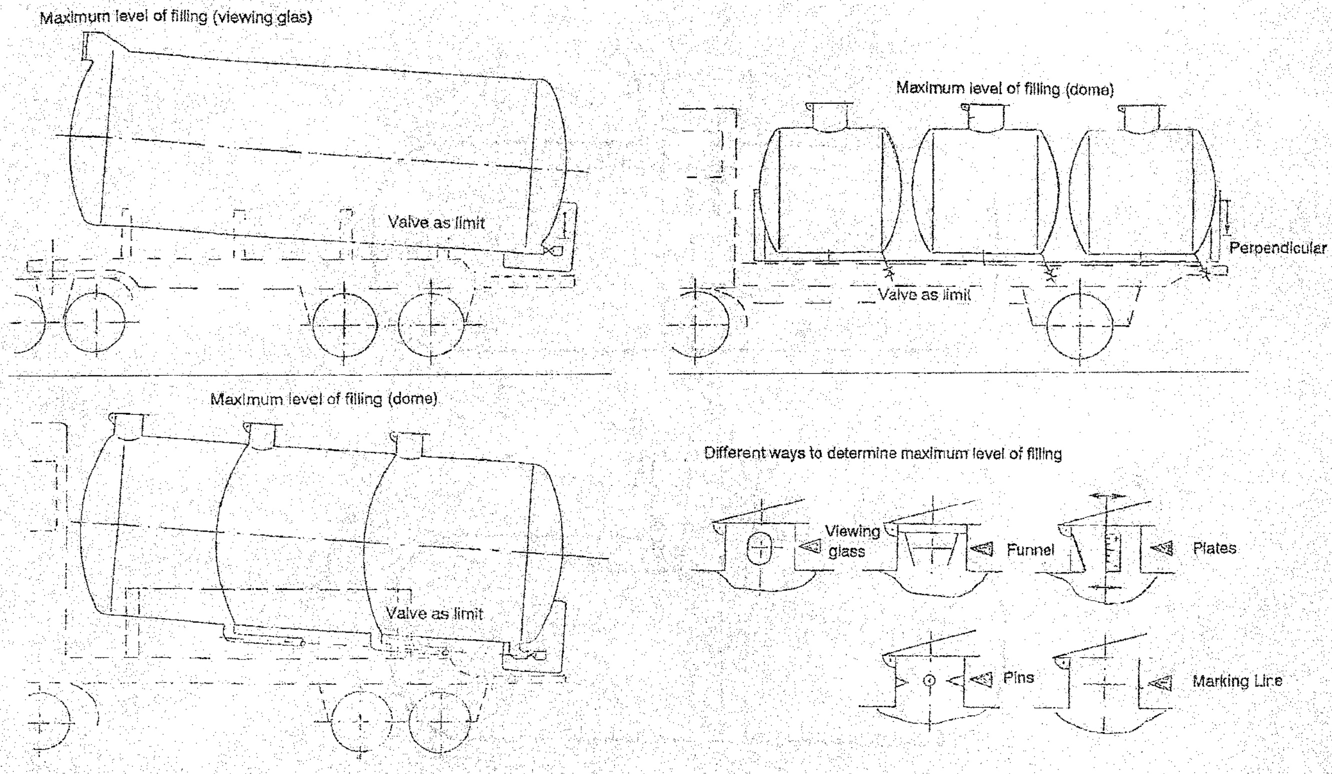


Fig. 1 - Examples of transport measuring containers

Regulations for the transport of dangerous products on roads, however, specify a lower maximum filling level for certain liquids. Requirements for the maximum filling level were therefore adapted. This means that the maximum level for measuring transport containers filled with dangerous material may be inside the measuring chamber provided that specific metrological requirements are met (Fig. 2).

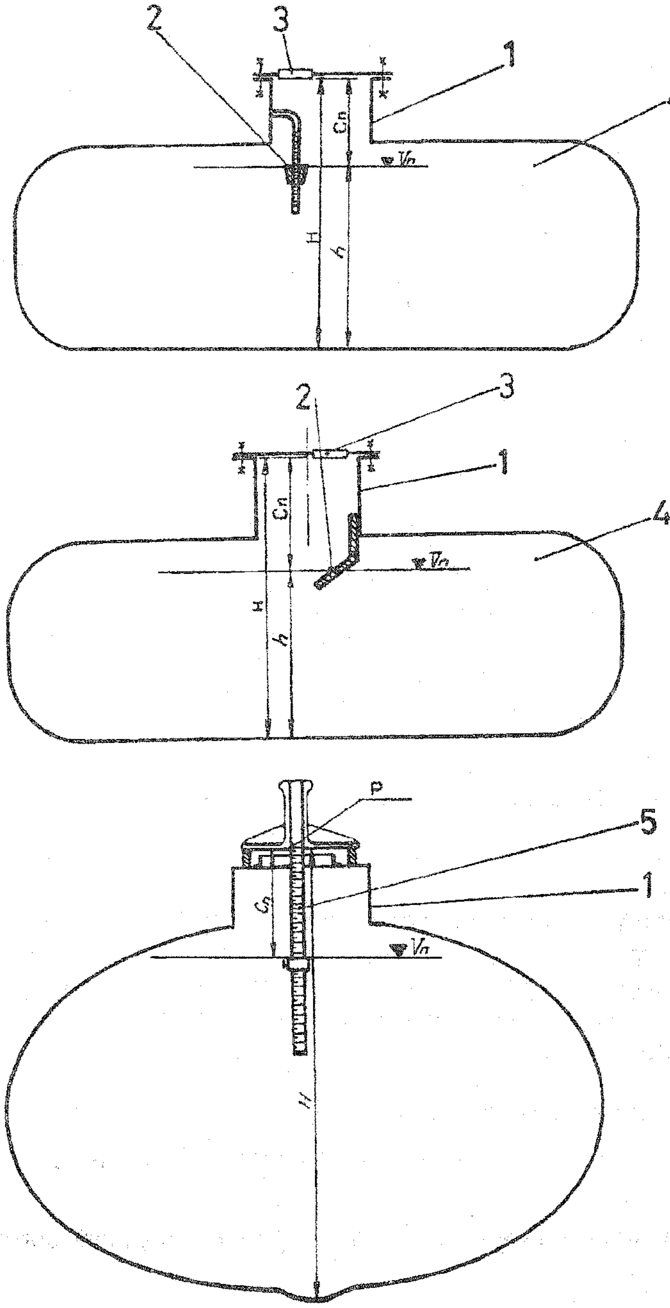
It is the responsibility of the verification authority

1. to verify that legal construction requirements are met by means of an external administrative examination and
2. to determine the volume between the bottom valve and the mark corresponding to the maximum level.

Complete filling of the container without air pockets as well as complete drainage of the liquid are important.

Measuring equipment

The Bad Kreuznach Verification Office provides the metrological supervision for about 360 vehicles equipped with transport measuring containers with a varying number of compartments. When new test laboratories were planned and constructed, great care was taken to provide optimal measuring equipment for metrological control of transport measuring containers. Since the formal opening of the new laboratories, this task can be performed effectively.



1 Dome
2 Mark for maximum filling level
3 Observation window
4 Container
5 Graduated measure

Fig. 2 – Examples of measuring containers for dangerous liquids (according to OIML International Recommendation R 80 "Road and Rail Tankers")

During the planning phase it was necessary to decide whether to use the gravimetric or the volumetric method and the latter was chosen. The volumetric method with provers guarantees a high measuring accuracy as well as an efficient measuring stability over a long period of time. The range of uncertainty with this method is 0.08 % to 0.1 %.

The equipment is installed in a hall with large, electrically-operated doors at both ends which permit the passage of a complete truck (tractor with trailer). It is therefore possible for the vehicle to enter via one door, and exit via the other door upon completion of the measurements. (Fig. 3).

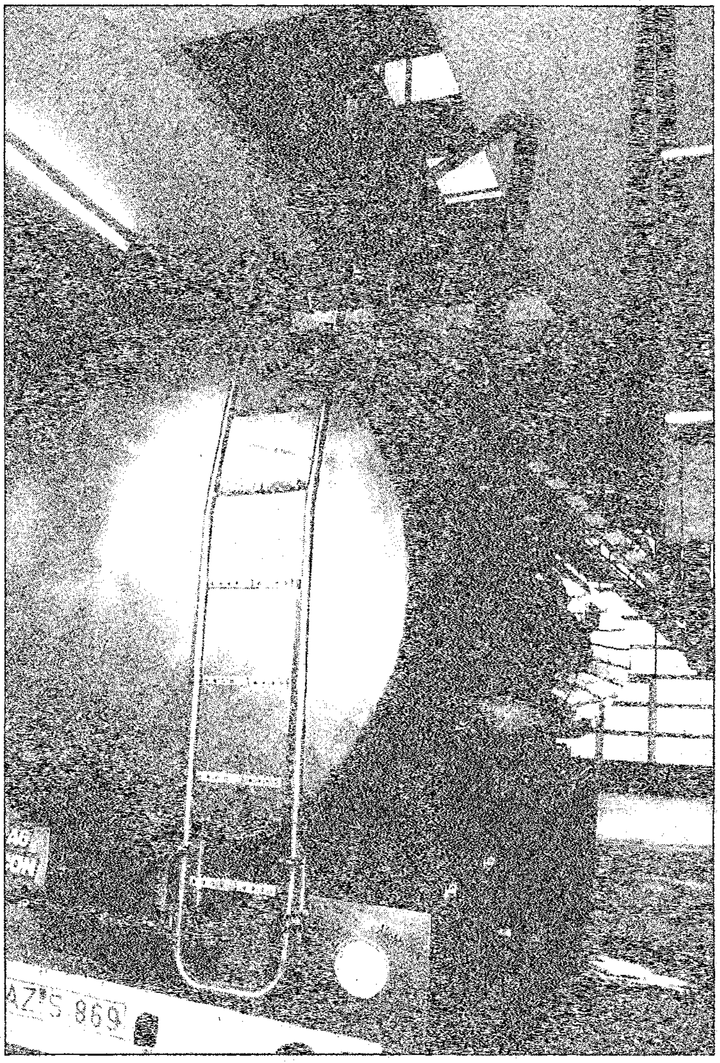


Fig. 3 – Road tanker parked in the indoor test stand

Upper floors with stairway access provide the space for the installation of the necessary standard instruments as well as a working platform that permits the verification officers safe and easy access to the top of the containers via lowering bridges (Fig. 4 and 5).

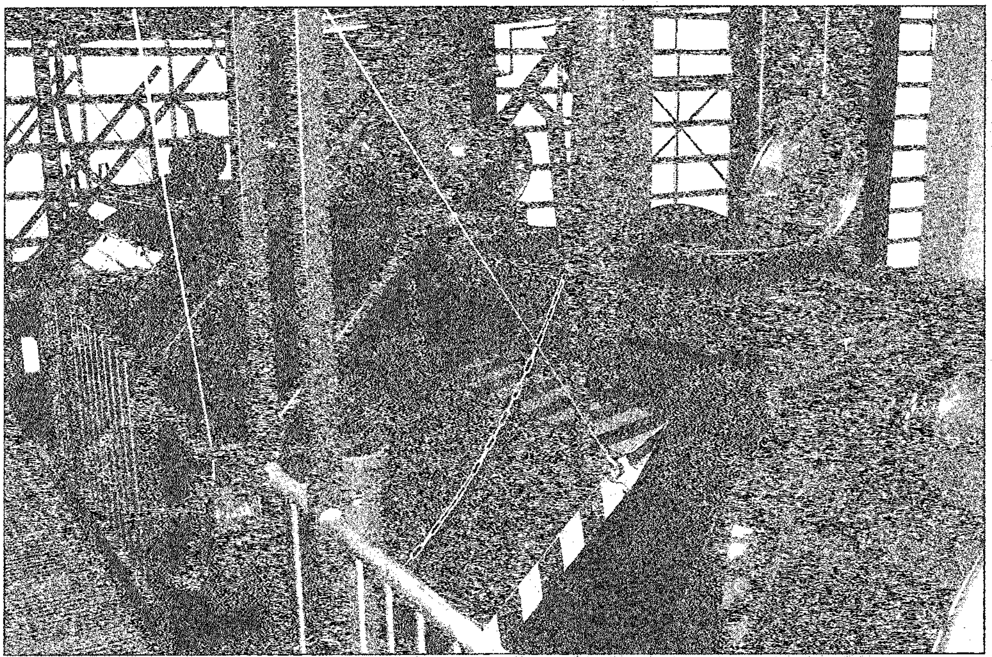


Fig. 4 – View of the transport measuring container from working platform

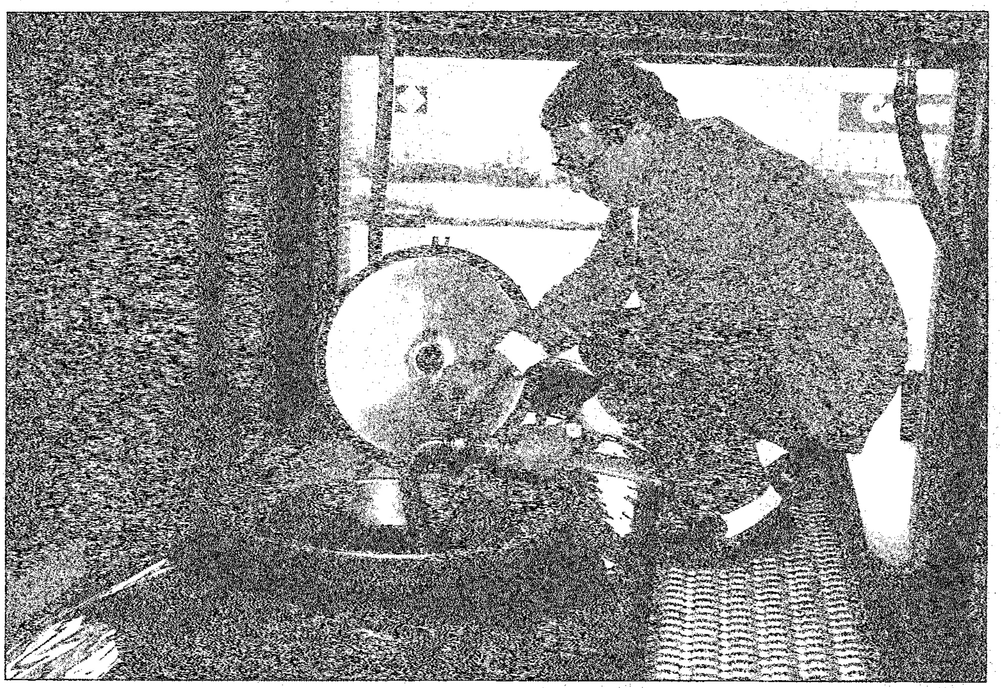


Fig. 5 – Verification officer filling a measuring container to determine the volume

This set-up ensures that the metrological examination can be carried out regardless of seasonal and weather conditions and without any change in the vehicle position during the procedure.

In applying the volumetric method, predominantly classical overflow provers of 1 000 L, 500 L and 200 L are used. The maximum surface level of the provers is delimited with a sliding glass plate (Fig. 6 and Fig. 7).

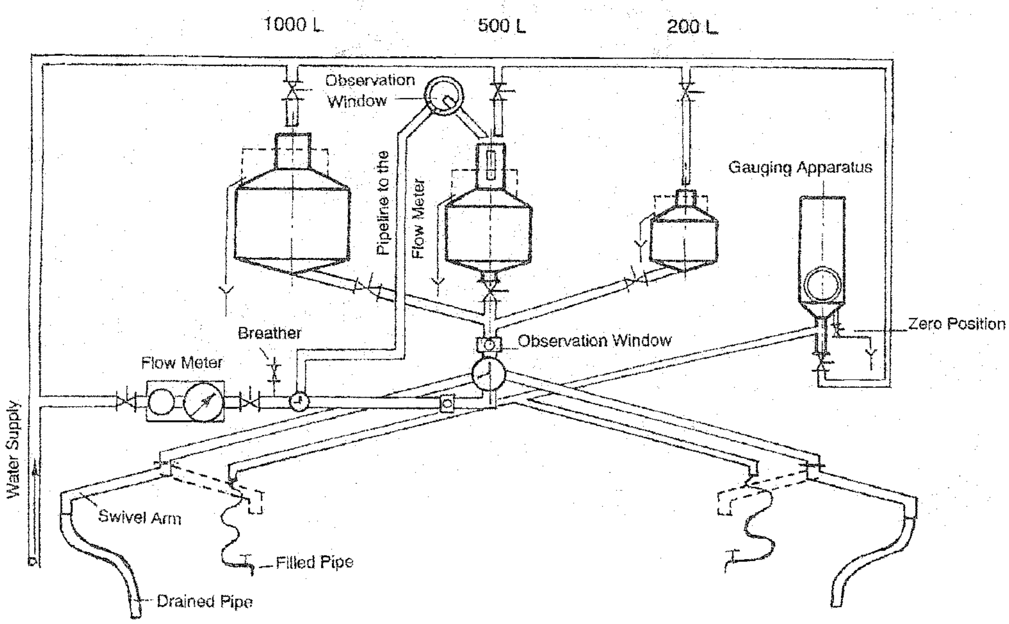


Fig. 6 – Diagram of the measuring systems

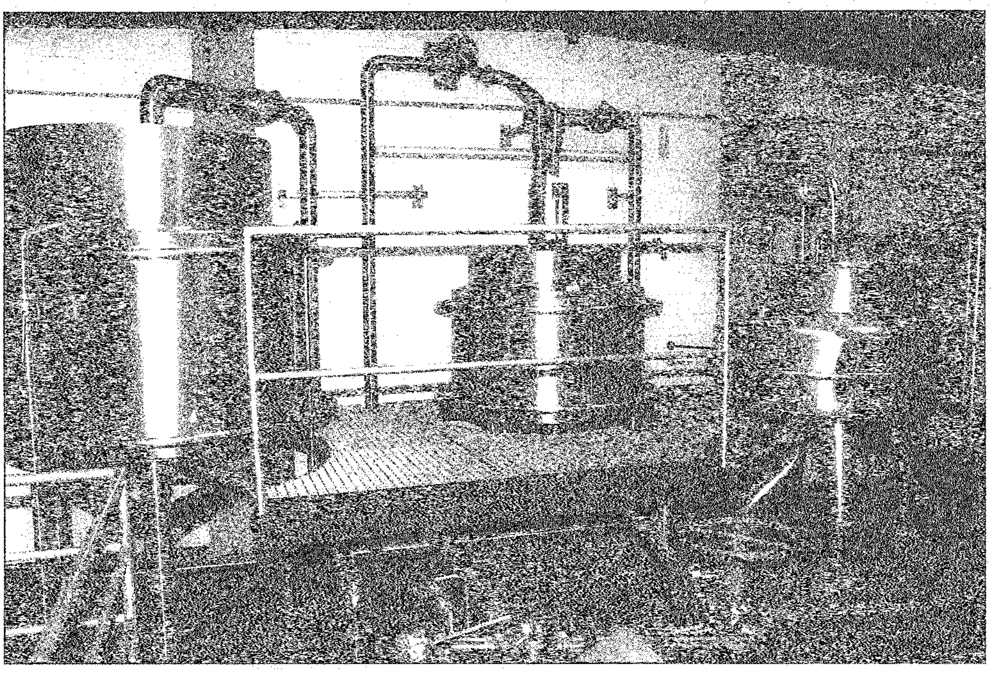


Fig. 7 – Overflow provers

To determine remaining quantities, a gauging apparatus is used. This is a cylindrical container in which the surface level of the contents is determined by a floating element and the value is transferred to a wheel with a graduated scale with 0.1 L scale intervals (Fig. 8).

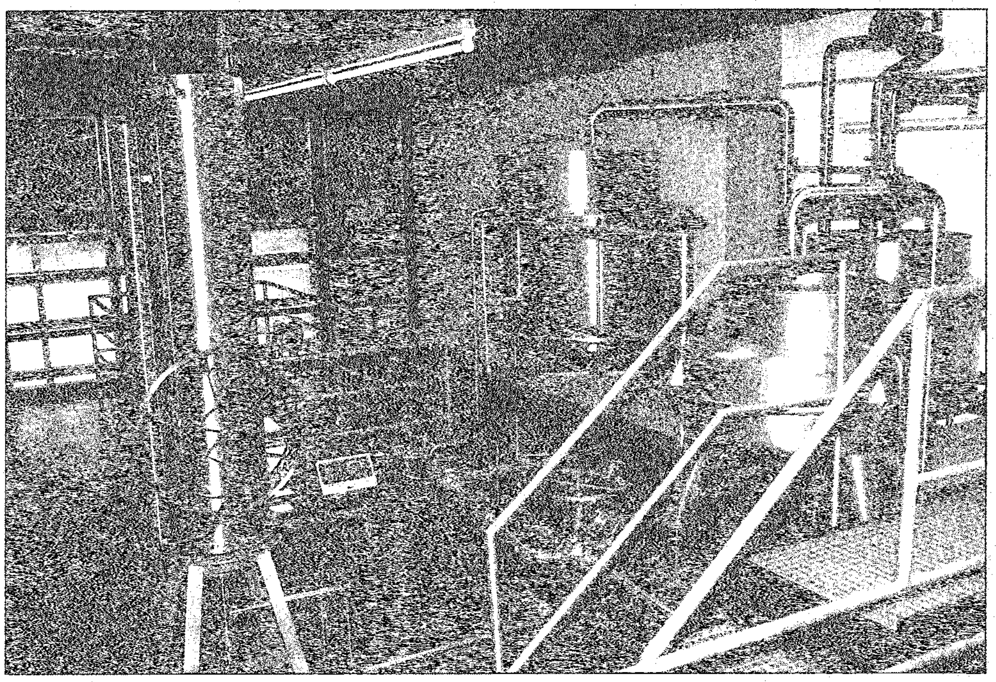


Fig. 8 – Gauging apparatus and overflow provers

The provers are stationary. Their defined contents are drained into the compartments of the transport measuring container to be tested. This drainage is accomplished through a pipe system which is connected to the provers.

The main pipes end in swivel arms with short draining hoses beneath the working platform so that the domes of all compartments can be reached easily.

The material of the provers and the distribution system is stainless steel.

This rigid distribution system with a sharp decline is used to avoid additional errors due to unknown liquid residues. Use of a hose would be simpler and less expensive but not safe enough due to the risk of possible liquid traps.

Provers and the distribution system work as a drained pipe system.

The gauging apparatus is connected to the filled pipe distribution system.

In addition to the system described above, a standard flowmeter is also available. A stainless steel oval piston flowmeter (nominal bore 65 mm), is installed on the working platform and connected to the public water supply system. This is also an integral part of the abovementioned distribution system. A combination of valves for limiting flow and for ventilation is installed between the main water supply and the flowmeter (Fig. 9).

Working with a flowmeter requires much attention and work and depends on the quality of the water. Hard water may change the friction conditions due to residues, especially after long periods of inactivity.

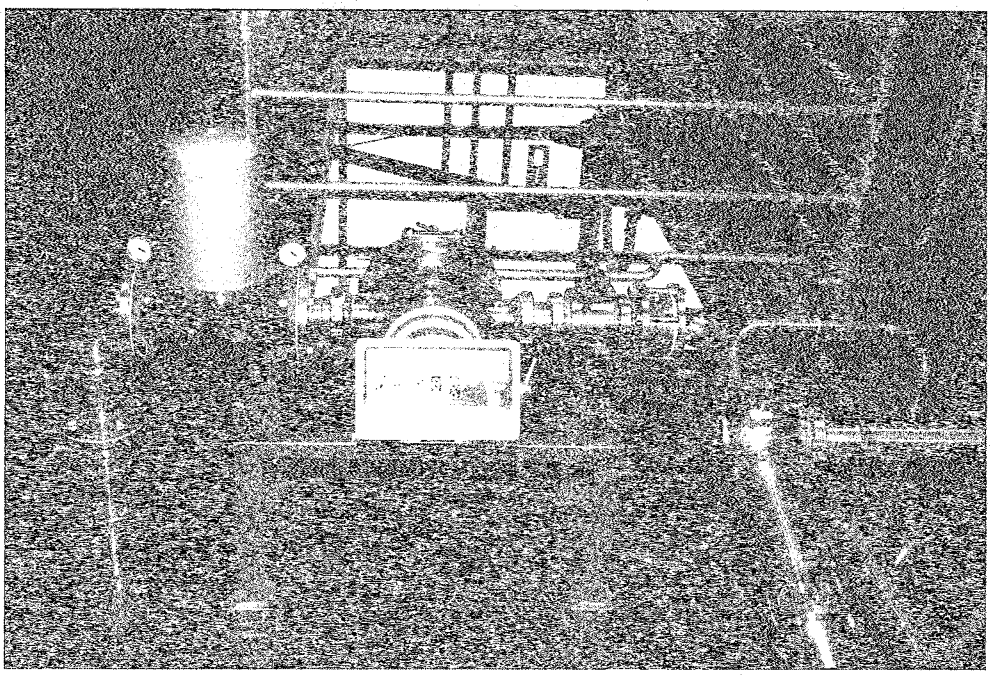


Fig. 9 – Flowmeter

Special attention must be given to errors arising from the variations in flowrate.

The flowmeter should therefore be tested with the reference standard before it is used as a working standard. With the measuring equipment described here, the test can be conducted easily by using the existing provers as the reference standard. For this purpose, a viewing glass with a graduation from 492.5 L to 498.5 L with a scale interval of 0.1 L has been positioned in the neck of the 500 L prover.

With a two-way valve it is possible, without any reassembly, to directly connect the flowmeter to the standard; the test can be performed with little effort. This convenient means of control guarantees that the meter can be used with an uncertainty of 0.1 %.

Meters with a nominal bore of 65 mm, as used here, usually have a larger error at small flowrates. To deliver the final filling or small volumes for the graduation of the scale, even smaller flowrates are necessary.

In addition, frequent opening and closing of the shut-off valve may have negative effects.

To avoid these disadvantages, the flowmeter is used only for the main volume, the water flow being shut off only once. To measure the remaining quantity of liquid, the gauging apparatus is used.

Comparison of both systems

1. Provers

The handling of the provers is relatively simple and guarantees an efficient measuring accuracy and measuring constancy over a long period of time. Air contained in the water supply system has no negative effect.

2. Flowmeter

The flowmeter must be checked before starting each test. This entails increased work load and effort during preparation time.

During operation, the flow must be constantly monitored.

Air passing through the pipes is registered as volume and therefore has a detrimental effect.

A possible advantage may be the time-saving aspect of this system due to the rapid filling operation.

ALLEMAGNE

MEASUREMENT OF GASEOUS AND PARTICULATE POLLUTANTS IN VEHICLE EXHAUST EMISSION SURVEILLANCE IN GERMANY*

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Introduction

Exhaust emission surveillance was introduced in Germany in 1985. Since then the concentration of CO in the exhaust gases of cars with spark-ignition engines (petrol engines) is periodically measured (once a year) at idling speed as a component representative of the pollutant emission. The measuring instruments used for this purpose must pass pattern approval at PTB, and initial and subsequent verification (every year), carried out by the verification authorities of the federal Laender. About 40 000 verified CO meters are in use at present in Germany. With these means of quality assurance a high degree of reliability of the CO emission surveillance has been achieved.

With a new exhaust emission surveillance ordinance, which is expected to be put into force in 1992, vehicles with petrol engines equipped with catalytic converters (catalysts), and diesel-engine vehicles, will be included in the emission surveillance programme. The aim is to keep the vehicles in use as close as possible to their initial low emission level by timely adjustments or repairs of the devices relevant to the pollutant emissions. The tests are to be carried out by approved garages and test organisations.

In the case of the catalyst vehicles with fuel/air ratio control systems it is intended to evaluate the performance of this system indirectly via a measurement of the concentrations of the exhaust gas components CO, CO_2, hydrocarbons (abbreviated HC), and O_2 downstream of the catalyst and a calculation of the air ratio λ (amount of air provided/amount of air necessary for complete combustion) using these concentrations. Though CO_2 and O_2 are not pollutants, their determination is necessary for this diagnostic purpose. In addition, the conversion performance of the catalyst is to be tested at elevated idling speed using the final CO concentration as an indicator. Vehicles without catalysts and those with catalysts but without λ control systems are dealt with in a simpler way. Only the CO from the exhaust gas components is measured.

For the surveillance of diesel-engine vehicles it is intended to measure the soot emission (particulate emission) as the specific pollutant emission, via opacity measurements of the exhaust gas. The environmental importance of the diesel particulate emission is due to the carcinogenic potential attributed to the soot particles. Individual opacity values determined at the time of the type approval of the vehicles are to be used as references to assess the emission behaviour. The test method of free acceleration of the engine is to be applied.

(*) Presented at the OIML seminar CLEAN AIR MEASUREMENT, Interlaken, 28 Sept-1 Oct. 1992.

For these purposes new measuring instruments which must meet the requirements of legal metrology are necessary. In the following, the metrological and technical requirements adequate to the measurement task, the state of the art of exhaust emission measurement and the performance tests of the instruments are described.

1. Measuring instruments for petrol engines

1.1 Requirements

Exhaust emission surveillance and maintenance of petrol-engine vehicles require measuring instruments of high sensitivity to be used for the low concentrations of some of the components behind the catalyst which at the same time have measuring ranges large enough to cover also the higher pollutant levels of vehicles without a catalyst or with a defective one. Instruments constructed according to the International Recommendation OIML R 99 are suitable for this purpose, although this recommendation is not explicitly designed to describe instruments for measurements downstream of the catalyst. The R 99 does not, however, take into account the need for an O_2 measuring channel, which is a special requirement for the λ calculation.

Table 1 contains the most important metrological requirements, the error limits, laid down in the draft of the relevant chapter of the verification ordinance (Eichordnung) which will be put into force simultaneously with the above-mentioned emission surveillance ordinance.

TABLE 1 – MAXIMUM PERMISSIBLE ERRORS UNDER OPERATING CONDITIONS ON INITIAL AND SUBSEQUENT VERIFICATION

CLASS I	CLASS II
± 5 % of indication but not less than	± 10 % of indication but not less than
± 0.06 % vol for CO,	± 0.2 % vol for CO
± 0,5 % vol for CO_2,	(here only CO channel necessary).
± $12 \cdot 10^{-6}$ vol for HC,	
± 0.1 % vol for O_2.	

Class I instruments will be used for the exhaust emission surveillance of λ-controlled catalyst vehicles and for general maintenance purposes. Class II instruments (with CO channel only) are sufficient for petrol-engine vehicles without λ-controlled catalysts. The need for these latter instruments, which have already been used since 1980 with slightly less stringent requirements, will decrease in future.

The error limits in service of many instruments subject to regulations are in general larger by a factor of 1.5 or 2 to allow for wear and tear. In the case of the class I instruments such an increase is not tolerable due to the high accuracy necessary for the air fraction λ calculated from the measurement results. The requirement is $\Delta\lambda \leq 0.02$ at $\lambda = 1$. The error limits in service are in Germany therefore equal to those on initial and subsequent verification for class I instruments. This shows that these instruments will be used at the limit of their performance. For class II instruments the error limits in service are 1.5 times higher than those on verification.

Further requirements, not included in R 99, concerning the modalities of carrying out the emission tests (e.g. connection of a printer, format of record, calculation of λ) will be laid down in a separate guideline of the Ministry of Transport. As an additional means of quality assurance, training courses for workshop staff are included in the programme.

1.2 State of the art of exhaust emission measurement

Measuring instruments in accordance with OIML R 99, including in addition the O_2 channel, are already available. In anticipation of the pattern approval, PTB has tested several types of these instruments with the preliminary result that compliance with the metrological and technical requirements can be expected. All the instruments tested up to now operate according to the non-dispersive infrared-absorption (NDIR) principle of measurement [1,2] as far as CO, CO_2 and HC are concerned. Mainly two kinds of realisation (Fig. 1) of this principle have been encountered from at least four basic setups possible [3].

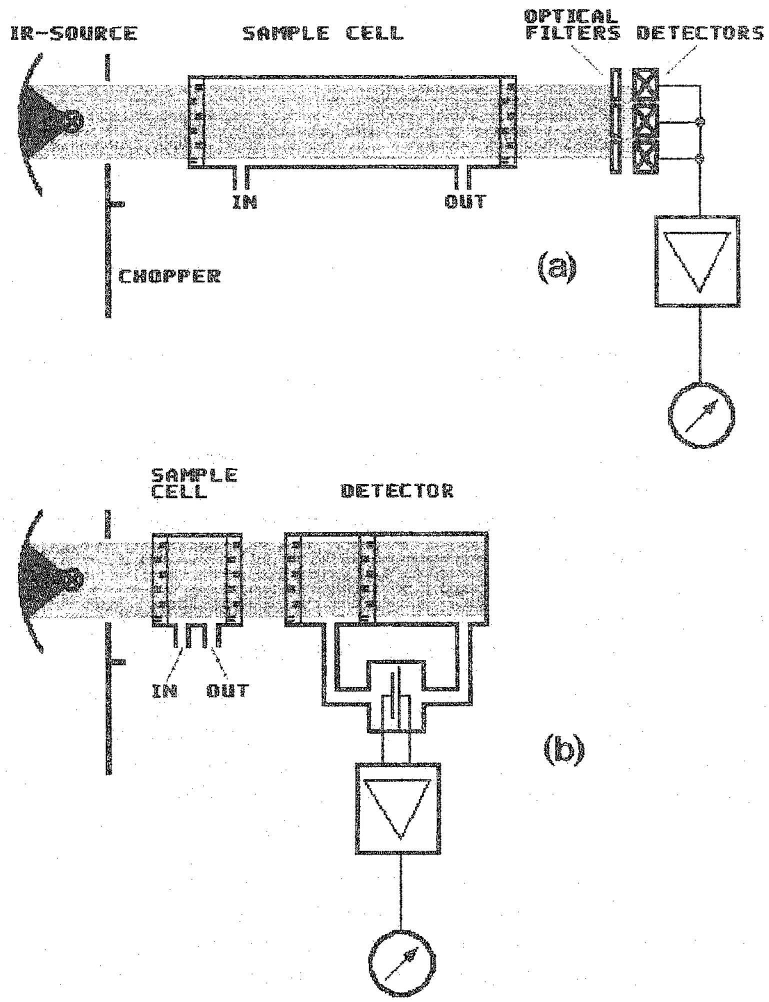


Fig. 1 – Two kinds of realisation of the non-dispersive infrared-absorption (NDIR) principle of gas concentration measurement, schematic, (a) using broad-band detection with optical filters, (b) using opto-pneumatic detection. Instead of the capacitor, a flow sensor is often used to detect pressure differences between the detector chambers.

Fig. 2 shows the infrared absorption spectrum of a gas mixture of CO, CO_2 and propane in N_2 with the assignment of the vibrational-rotational absorption bands to these molecules, in order to illustrate the measurement task. The double band centered at 2150 cm^{-1} ($\approx$ 4.7 μm) is used for determining CO, the band around 2900 cm^{-1} ($\approx$ 3.4 μm) usually for hydrocarbons. CO_2 is determined using the intense absorption band centered at 2350 cm^{-1} ($\approx$ 4.3 μm) with short optical paths or the two double bands (or one of them) between 3550 cm^{-1} ($\approx$ 2.8 μm) and 3 800 cm^{-1} ($\approx$ 2.6 μm) when longer optical paths are applied.

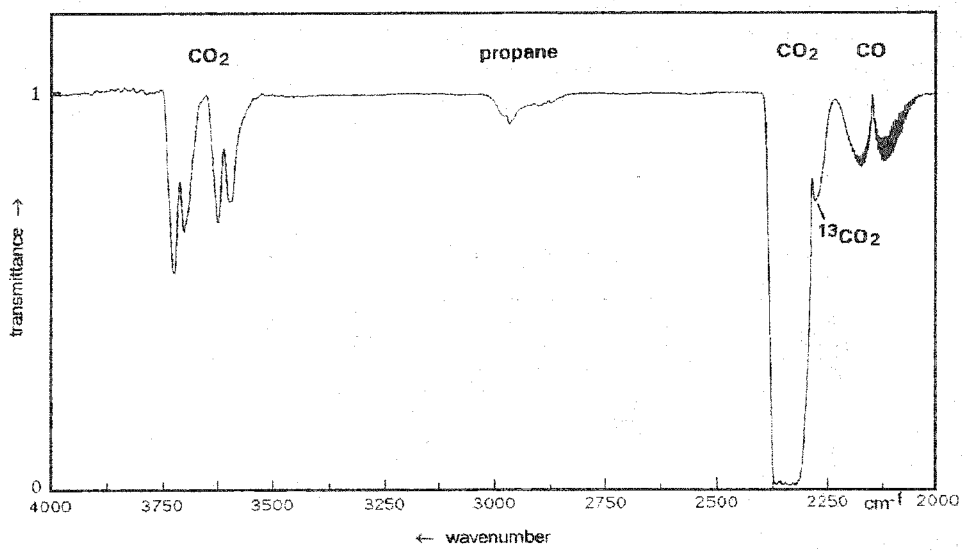


Fig. 2 – Absorption spectrum (displayed as transmittance) of a mixture containing 3.40 % vol CO, 8.90 % vol CO_2 and 1340 ppm vol propane in N_2.

Due to their low molar absorption coefficients in the selected spectral regions, aromatic hydrocarbons and some of the olefins are indicated less sensitively by NDIR instruments. This will be taken into account by an empirical correction for the calculation. The HC channel according to OIML R 99 is designed and calibrated to determine n-hexane. The requirements are valid for this purpose only. The instruments are frequently calibrated using a propane-containing calibration gas which has less restrictive storage requirements. A factor, slightly different for each instrument, is used for converting the indications into each other.

In the set-up (a) of Fig. 1 three broad-band detectors with optical filters, one combination for each channel, are used to measure CO, CO_2 and HC simultaneously. The length of the absorption cell common to all three channels can only be a compromise between the different optical path requirements due to the different absorption intensities. A chopper modulates the incident radiation for optimum electronic processing conditions.

Set-up (b) shows an opto-pneumatic detector, the particular feature of which is a high substance selectivity. The two chambers arranged behind each other in the beam direction are filled with the substance to be determined (in an inert gas mixture) and have some kind of connection, e.g. via a narrow drilling containing a flow sensor or a pressure-sensitive capacitor as shown schematically in the figure. Pulsating (due to the chopper) pressure differences between the chambers resulting from differences in the amounts of radiative power absorbed by the gas content can thus be sensed and processed into a measuring signal.

In the first chamber radiative power is absorbed mainly in the centers of the spectral lines resulting in a high attenuation (high absorption), whereas in the second chamber the remaining power is absorbed mainly in the wings of the lines. The latter effect is much smaller than the former if the chambers are not very different in length, resulting in a high output signal when the sample cell is empty. This is diminished by the presence of the sample in the sample cell thus making concentration measurements possible.

This unbalanced version of the opto-pneumatic detection principle has the advantage that the high signal with the empty sample cell can be used as a reference to reduce the effects of source intensity changes and cell window contamination.

The new instruments have already been developed to the high level of performance which is necessary to meet the class I requirements. The most important measures taken for achieving the necessary accuracy and long-term stability are

- stabilisation of the radiative power output of the infrared source,
- temperature stabilisation of the detector and filter units (if available),
- sensitive temperature and pressure measurement in the sample cell,
- automatic correction of the measurement result for temperature and pressure changes (in order to use the instrument at different local altitudes, recalibrations are necessary),
- using ratio rather than difference methods (as was done earlier when microprocessors were not available) for obtaining the result from a zero and a sample measurement.

The corrections for pressure variation (due to weather conditions as well as gas flow dynamics) are of particular importance and have resulted in a substantial improvement of the instruments' performance. The influence of pressure is twofold, (i) via the molecule density in the sample cell and (ii) via the width of the spectral lines. The measuring instruments designed according to Fig. 1 (b) are particularly stable allowing long gas calibration intervals, and this is of great practical importance.

Cross sensitivity, a general analytical problem, is also present with these instruments. We distinguish between two kinds, (i) direct: positive indication without measurand due to absorption effects of other exhaust gas components, (ii) indirect: via change of line widths due to intermolecular interactions. CO_2, for example, has a considerable indirect effect on the CO indication. In some instruments corrections are also made for these influences.

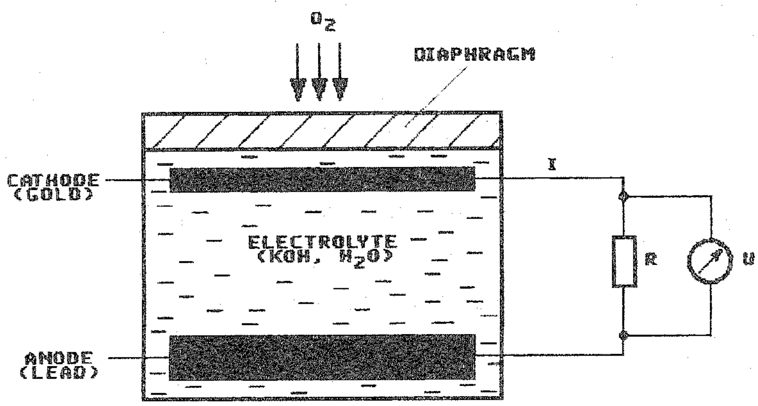


Fig. 3 – Electrochemical oxygen sensor with alcaline electrolyte, schematic.

The oxygen concentration, which plays a key role in the λ calculation is measured using electrochemical methods an example of which is shown schematically in Fig. 3. A gold and a lead electrode are placed in a KOH solution of high concentration in a small polyethylene container and are externally connected via a load resistor. The O_2 molecules diffuse through the diaphragm which separates the cell from the exhaust gas sample, and take part in the overall reaction

$$O_2 + 2Pb \rightarrow 2PbO,$$

which generates an electrical current proportional to the O_2 entering rate which in turn is a measure of the O_2 concentration in the exhaust gas. The gold electrode acts as the cathode, the lead electrode as the anode in this process which involves the reduction of O_2 to OH^- at the cathode and correspondingly the oxidation of Pb to Pb^{2+} at the anode. The measuring signal is the voltage across the load resistor which is approximately proportional to the O_2 concentration. The cell is calibrated at the oxygen concentration of air at each self check.

Due to the conversion of the lead to lead oxide and the formation of lead carbonate (high CO_2 concentration in the exhaust gas), the lifetime of these electrochemical sensors is limited, but in general longer than six months. When they need to be changed, this is indicated by a drop in the full scale voltage (air measurement) below a specified threshold.

A particular problem which now seems to have been solved was the formation of solid K_2CO_3 close to the gold electrode forming a barrier to oxygen diffusion. The accuracy in the low concentration region of importance was particularly affected by this process [4].

1.3 Tests for pattern approval

So far about 70 patterns of CO meters have been approved by PTB. About 20 types of the new four-component instruments have recently been under test at PTB in anticipation of the new exhaust emission surveillance regulations, in order to keep the time necessary for making verified instruments available as short as possible.

The tests of the new four-component measuring instruments are carried out in cooperation with two test organisations, the Rheinisch-Westfählischer Technischer Überwachungsverein (RWTÜV) and the Deutscher Kraftfahrzeug-Überwachungsverein (DEKRA).

PTB is chiefly concerned with the physical and metrological concepts and the metrological behaviour under laboratory conditions, including disturbance tests, whereas the test organisations mainly take care of aspects of practical application to the vehicle, endurance of the exhaust gas pre-treatment facilities, most of the environmental tests, and measurements under realistic conditions with the exhaust gas of a representative selection of vehicles. Further tests covering the requirements of the additional guideline will also be performed by these test organisations.

The basis for the tests is ANNEX A of OIML R 99. Deviations from this Recommendation and supplements are necessary on the following points:

1) Additional tests are required to evaluate the measuring performance of the O_2 measuring device. The following items are checked:

- calibration curve,
- stability of zero indication, using 15 % vol CO_2 in N_2,
- response time,
- CO_2 loading capacity,
- functioning of the checking facility for undue ageing.

2) Electronic interfaces for the connection of peripheral instruments (e.g. printers) are tested according to special PTB requirements which have proved useful in the whole of legal metrology in Germany.

3) If the equipment under test is too large for the limited capacity of the PTB facilities for the electromagnetic disturbance tests, these are given into the responsibility of the applicant. Approval is made on the basis of an examination of the test results submitted.

4) The measurements under realistic conditions with exhaust gases of a representative selection of in-use vehicles carried out by the test organisations have proved to be a very important part of the test procedure and a desirable supplement to OIML R 99.

Although not much experience with the OIML Recommendation has yet been had in Germany, practice has already shown that the test A.6, "damp heat, steady state", is unnecessarily time-consuming. The time of exposure can be substantially reduced without any loss of information content of this test.

For pattern approval and later on for verification, calibration gas mixtures are required, the composition of which must be traceable to national or regional or international standards. Only traceability to reference materials is possible in Germany at present. This is provided by Bundesanstalt für Materialprüfung und -forschung (BAM). In future PTB will provide national standards of gas composition.

2. Measuring instruments for diesel particulate emission

The physical quantity most closely related to environmental pollution by diesel particulate exhaust emission is the mass concentration of soot particles in the exhaust gas (or the mass emission per driven distance). This is determined using the elaborate direct gravimetric method in order to check compliance with the legal emission limit in the type approval tests of the vehicle.

For field measurements indirect methods are in use which require less effort and outlay. Among these the optical methods of blackening a filter paper and light attenuation (opacimetry) are most widely used. The latter exists in two variants: as a full-flow and a partial-flow measuring method. This partial-flow opacimetry technique is to be used mainly for the surveillance of the particulate emission of diesel-engine vehicles according to the draft exhaust emission ordinance. Full-flow opacimeters may be used in special cases.

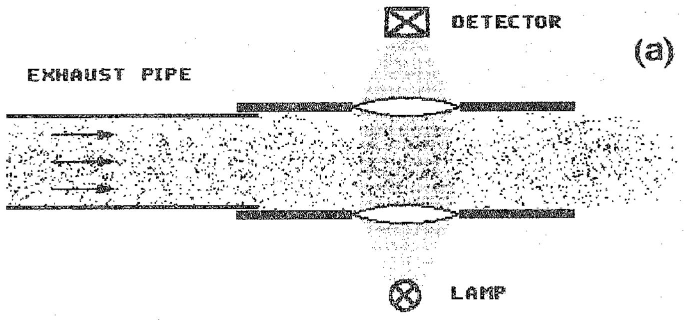
These kinds of measuring instruments are adequate for the test method involving free acceleration of the engine, intended to be used irrespective of the size of the vehicle, in accordance with a regulation planned by the Commission of the European Communities. The opacity of the exhaust gas and/or the light absorption coefficient (light attenuation coefficient) are the physical quantities to be measured.

Correlations exist between these optical quantities and the mass concentration. These depend, however, on the particle size distribution and the chemical composition of the (complex) particles which vary from engine to engine, and also with the conditions under which the engine is operated.

Since the emission behaviour is to be followed during the use of the vehicles relative to the initial emission level at the time of type approval the optical properties are sufficiently suited as an auxiliary means. They are defined as follows:

Opacity in %:	$N = 100\,(1-\tau)$, τ transmittance (as fraction); this definition holds for an effective optical path length of 430 mm.
Absorption (attenuation) coefficient in m^{-1}:	$k = (1/\ell)\ \ln\,(1/\tau)$, ℓ effective optical path length.

Fig. 4 shows the principle of operation of the measuring instruments.



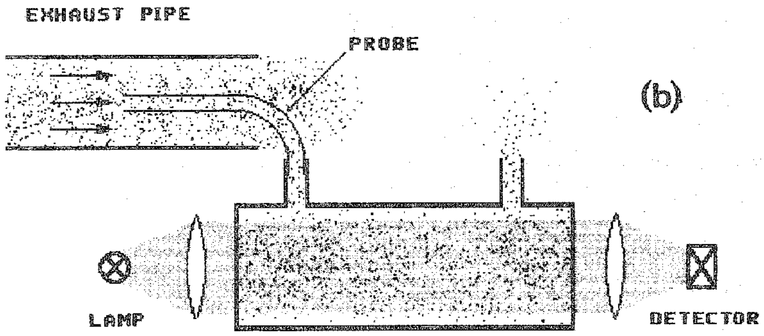


Fig. 4 – The full-flow (a) and the partial-flow (b) version of the diesel smoke meters according to the opacimetric principle, schematic.

The calibration of these instruments is a particular problem. In contrast to the gas analysers used for the petrol-engine exhaust emission measurement where calibration gas mixtures are used as standards, there are no means of calibrating diesel smoke meters which are suitable for testing all aspects of their metrological behaviour. At present only the optical part of the instrument can be calibrated using transmittance (opacity) standards in the form of optical filters.

In view of this, additional measures have been taken to secure reliable measurements in diesel-engine exhaust emission surveillance. A two-step approach is made [5]:

1) the optical measuring system of the instruments is calibrated using grey (neutral) filters which are traceable to national standards,

2) the patterns of the instruments are compared with reference instruments using exhaust gas from a representative selection of in-use diesel-engine vehicles.

Verification is restricted to step 1. Step 2 is carried out by the test organisations RWTÜV and DEKRA instead of a pattern approval by PTB, which is not possible at present due to the lack of experience with these instruments. The reference instruments are defined according to the draft revision of ISO 3173 of March 1992. Particular attention is paid to the response time of the measuring system with regard to the measurement of transient quantities. Two different response times are required, assigned to two different modes of measurement: one, solely representing the exchange time of the gas content in the measuring cell for nearly real-time measurements of the smoke peak to correctly determine the maximum opacity and a second response time of (1 ± 0,1) s for measurements according to the regulation ECE R 24 of the United Nations Commission for Europe.

A few instruments which meet these requirements and are highly similar to one another in their metrological behaviour have been selected from the opacimeters available to serve as reference instruments. Only partial-flow opacimeters have been considered up to now. Instruments under test must give the same measurement result as such a reference instrument within the maximum permissible errors of verification, when used to measure the exhaust gas of a representative selection of diesel-engine vehicles.

The maximum permissible errors on initial and subsequent verification (under operating conditions), laid down in the draft of the verification ordinance, are:

± 5 % for the opacity,

± 0,3 m^{-1} for the absorption (attenuation) coefficient.

The corresponding values in service are 1.5 times higher.

In this way the problem of the overall calibration has been shifted to the comparison test under realistic conditions. No other possibility at present exists.

A calibration with a diesel smoke of known optical properties (and mass concentration of soot) as a standard would be metrologically more satisfactory, generated, for example, by some kind of standard engine. Such a standard is, however, not yet available with sufficient reproducibility and stability. Another possibility, the laboratory-generated soot aerosol based on compact flame soot using a particle dosage system, has not yet been developed to a level high enough to be used as a standard. This latter project will be pursued further at PTB.

More than ten patterns of diesel smoke meters of the partial-flow opacimeter type have been tested up to now and meet the metrological and technical requirements. It can therefore be expected that a sufficient number of verified measuring instruments will be available for diesel particulate emission surveillance. As with the gas analysers, further technical requirements related to the way of carrying out the emission tests will be laid down in the additional guideline of the Ministry of Transport and compliance with these must still be checked.

References

[1] K.F. Luft, Z. techn. Physik **24** (1943), 97

[2] K.F. Luft, G. Kesseler, K.H. Zörner, Chem.-Ing.-Techn. **39** (1967) 937

[3] W. Richter, D. Schiel, PTB-Mitt. **91** (1981) 421

[4] Chr. Mengersen, private communication

[5] M. Schumann, Chr. Mengersen, W. Richter, PTB-Mitt. **101** (1991) 425

AUTRICHE

LABORATORIES FOR PRESSURE MEASUREMENT*

by **R. LEWISCH**

former Director of the Austrian Metrology Service

SUMMARY – This paper gives an overview of the basic operating principles of the most common pressure measuring instruments and the equipment necessary for their verification.

RÉSUMÉ – Cet article passe en revue les principes de fonctionnement des instruments les plus courants utilisés pour la mesure des pressions et indique l'équipement nécessaire pour leur vérification.

General considerations

Effective work in legal metrology does not always require the instruments of the highest hierarchic rank. In most cases simpler instruments will do. At purchase it must be considered that costs are rising exponentially with a higher hierarchic rank and that therefore the demands on the qualification of the staff are rising too.

It is essential that above all the planned laboratory rooms are big enough since experience has shown that within short time the space required may increase considerably. A pressure measurement laboratory should be installed free from vibrations and as far away as possible from disturbing sound sources. The constancy of temperature is generally sufficient with ± 1 °C. Fresh air ventilation or air-conditioning must be provided and the floor covering must be jointless and be laid up on the wall especially when mercury filled instruments are used.

Sufficient room must be reserved for instruments to be verified and for the already verified instruments. There must be proper rooms where the staff can do their office work which should not be carried out in the laboratories.

Depending on the national legislation the laboratory must be able to examine and to verify barometers, manometers, piston gauges, tyre pressure gauges and sphygmomanometers.

We will in the following sections review the most common pressure measuring instruments and the equipment required for their verification.

The U-tube-manometer

Already at fundamental school level we make acquaintance with the most simple pressure measuring instrument, namely with the U-tube-manometer.

$$\Delta p = p_2 - p_1$$

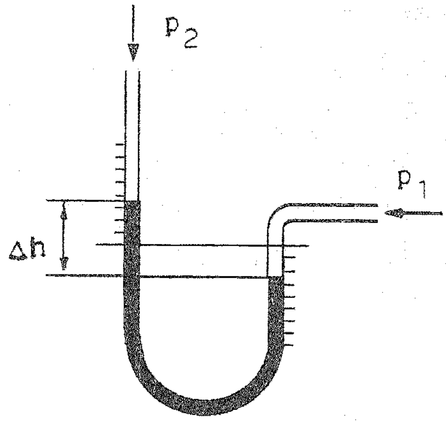


Fig. 1

(*) Abridged and updated version of a paper presented at the OIML Seminar on Planning and Equipping Metrology and Testing Laboratories, Paris, 25-26 September 1989.

This measuring instrument is so important, for it permits the measurement of pressure in a fundamental way. The U-tube contains a manometric liquid which keeps equilibrium with the pressure to be measured according to the following equation:

$$p = \rho \times g \times h,$$

were in this equation between quantities, p means the pressure to be measured, ρ the density of the liquid, h the height of the level difference between the upper and the lower miniscus, and g the local acceleration of free fall. It seems that here really very simple conditions are existing when we will measure the pressure. In reality it is necessary to consider many influences also in the case of this simple measuring instrument when the measurement shall be executed with high precision.

Let us consider the following:

For the measurement of the atmospheric pressure, which amounts to about 100 kPa, a height of the manometer of at least 75 cm is necessary when mercury is used as manometric liquid. For a pressure of 1 000 kPa = 1 MPa a height of 7.50 m is necessary, and at a pressure of 10 MPa, which is a pressure often used in technology, a height of the manometer of 75 m would be necessary. It is clear that the handling of such instruments is by no means a simple one.

At the end of the last century experiments were carried out to install a highpressure manometer in the Eiffel tower in Paris. As everybody knows the Eiffel tower is 300 m high, and therefore it would have been possible to measure a pressure of about 40 MPa. The expectations that were placed in this instrument did not come true by far. The reason is evident. Temperature variations along the manometer tube make the measurements useless since mercury is a good thermometric liquid.

Moreover one has tried to install such big mercury manometers in vertical mine shafts. Also in these cases the results did not come up to expectations since the great increase of temperature with the depth of the mine is greatly disturbing the measurements.

Nowadays it is possible to construct liquid manometers with a maximum height of approximately 35 m which seems to be the optimum with respect to maximum pressure and accuracy. The order of accuracy is in the case of these manometers at about $1.5 \cdot 10^{-5}$. The expenses necessary for the construction of the instrument and for the measurement are extremely high.

The pressure in a mercury-U-tube-manometer is more accurately described by the following equation between quantities:

$$p = \int_{Z_1}^{Z_2} \rho_{\,\mathrm{Hg}}\, g\,(z)\, dz$$

were ρ_{Hg} is the density of the mercury as a function of pressure and temperature, and $g\,(z)$ is the acceleration of free fall as a function of height z.

The standard density of mercury at 20 °C and 101 325 Pa is $\rho'_{\mathrm{Hg}} = 13.545\,867$ g/cm^3.

This value was determined by Cook at the National Physical Laboratory at Teddington in 1961. It seems to be correct within $3 \cdot 10^{-6}$. The density of the mercury at other presures and temperatures may be calculated approximately by means of the following relation:

$$\rho_{\mathrm{Hg}} = \frac{\rho'_{\mathrm{Hg}}}{[1 + A(t-20) + B(t-20)^2]\,[1 - \chi\,(p - 101\,325)]}$$

where $A = 18\,115 \times 10^{-8}$ °C^{-1}
$B = 0.8 \times 10^{-8}$ °C^{-2}
$\chi = 4 \times 10^{-7}$ Pa^{-1}

The compressibility of the mercury is a function of pressure and temperature too. Up to about 5 MPa it can however be considered as a constant value.

In order to be able to calculate accurately the pressure, the knowledge of the relation of the acceleration of free fall as a function of the height is also necessary. This is given by the following equation:

$$g(z) = g(z_0) - 3.086 \cdot 10^{-6} \cdot (z - z_0)$$

where it is essential to know the local acceleration of free fall at height $z = 0$ with sufficient accuracy. It can be determined by means of gravimeters. It is generally not necessary to make an absolute determination of g but may prove sufficient to measure the acceleration with a relative gravimeter at the place of installation of the mercury manometer starting from a point of known absolute acceleration.

When there is no such point available one may get a good approximate (to 10^{-4}) by the following equation*

$$g = 9.780\,318\,(1 + 0.005\,3024 \sin^2 \varphi - 0.000\,0058 \sin^2 2\varphi) - 2 \cdot 10^{-6} H \qquad \text{m/s}^2$$

where φ is the latitude and H the altitude in metres above sea level.

For the exact determination of pressures the following effects have moreover to be considered:

- the surface tension of the mercury (capillary depression),
- the difference of the heights of the two mercury levels, in which case the temperature influence on the length measuring installation for the heights must be considered.

The light refraction of the glass windows of the optical sighting telescopes may sometimes also have to be considered.

For the determination of the heights various methods are in use, from the simple vernier to the laser interferometer. In addition the counter pressure of the gas column in the tube has to be considered for exact measurements. Besides mercury, water may also be used a manometric liquid. In practice this liquid however causes considerable difficulties due to its property of wetting the walls of the tube. There exist however liquids, e.g. nonane, which have good wetting qualities for manometry, the density determination however gives some troubles.

For the measurement of the ambient pressure barometers are used, which are quite complicated for highest accuracy. However, a verification laboratory may be equipped with simpler and cheaper instruments as described below [ref. 1]:

a) Standard-mano-barometer for connection to external test chamber accuracy ± 5 Pa (0.05 mbar) or approaching, range 0 to 110 kPa (1 100 mbar) suitable for calibration of other barometers or manometers. Two-position reading on precision scale of upper and lower mercury level to ± 0.05 mm, inner diameter of tube at least 11 mm. Certified by official institute.

b) Barometer test chamber for connection to item a) comprising chamber for installation of mercury barometers and horizontal and vertical aneroid type precision barometers and low pressure gauges. Equipped with vacuum and overpressure pumps, pressure regulating valves, all required supplies, such as oil, fuses etc.

c) Secondary standard barometer, accuracy ± 20 Pa (0.2 mbar), or approaching, suitable for connection to test chambers, range 2.5 to 120 kPa (1 200 mbar). Transportable electronic digital type or equivalent.

(*) For more details see S.A. Thulin - The local value of g, Bulletin de l'OIML N° 94, mars 1984, p. 23-26 and N° 127, juin 1992, p. 45.

d) Mercury column vacuum tester with scale graduated in mm and second scale graduated in kPa.

To be delivered with hand pump or with electrical vacuum pump and regulating needle valves. The connection to external vacuum system should be possible through suitable connector.

c) Mercury column pressure tester, range 0 to 150 kPa (1.5 bar) to be delivered complete with pump and the following connections (1/4" - 3/8" - 1/2" BSP - M 20 × 1.5 and angle connector).

The pressure balance

An almost ideal instrument for pressure measurement is the pressure balance. It can be used in the range of technical vacuum, and in special modifications for overpressures up to 1 000 MPa.

It functions according to the definition of the pressure: $p = \frac{F}{A}$.

In principal a pressure balance is consisting of a cylinder in which a piston is moving. The piston is loaded with mass pieces, resulting in force *F*. If the sectional area *A* of the piston is known, the pressure can be calculated which keeps equilibrium with the loaded piston. In order to avoid friction as much as possible during the measurement, the piston or the cylinder is kept rotating.

In practice various modifications of pressure balances are available, as may be gathered from Fig. 2.

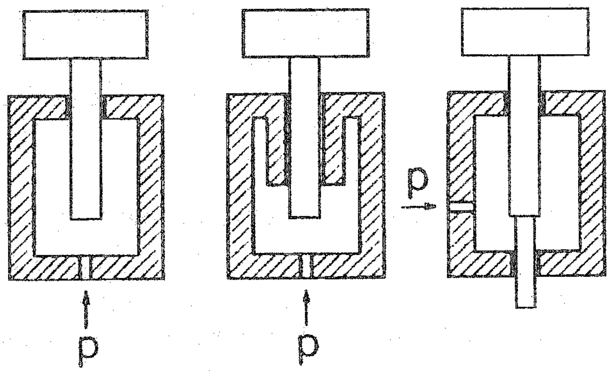


Fig. 2 – Various types of pistons and cylinders

For the most simple case, namely that of a piston with constant diameter in a cylindrical bore as shown in fig. 2, the pressure can be calculated according to the following equation:

$$p = \frac{[M_M(1 - \frac{\rho a}{\rho m}) + M_F(1 - \frac{\rho a}{\rho F})]\, g + \gamma C}{A_0\,[1 + (\alpha_c + \alpha_p)\,(t - t_{20})]\,(1 + \lambda_p)}$$

here is: p the pressure to be measured,

M_M the mass of piston and load pieces (weights)

M_F the mass of the pressure medium contributing to the mass of piston,

ρa density of the air,

ρm density of the masses,

g acceleration of free fall,

A_0 effective cross-section of the piston at pressure $p = 0$,
α_c and α_p linear expansion coefficient of the piston and cylinder material,
t prevailing temperature,
λ coefficient of compression of the cylinder and piston material,
c circumference of the piston,
γ surface tension of the pressure medium.

λ can be calculated by means of the following formula:

$$\lambda = \frac{1}{2E} [(3\,\mu - 1) + \frac{a}{b} (\frac{D^2 + a^2}{D^2 - a^2} + \mu)]$$

if piston and cylinder are of the same material.

The symbols have the following meaning:

a inner diameter of the cylinder,
b diameter of the piston,
D external diameter of the piston,
E module of elasticity of the employed material,
μ Poisson-number.

Pressure balances are capable of high accuracy. With the best of them an accuracy of about 3×10^{-5} may be attained in the range up to 3 MPa.

The main difficulties are lying in the effective cross-section of the piston. The piston is a three-dimensional object; for this reason a simple determination of the diameter in one plane is not sufficient in order to determine the cross section.

The effective cross-section may approximately be calculated from

$$A = \frac{(a^2 + b^2)\,\pi}{8}$$

where a is the inner diameter of the cylinder and b is the diameter of the piston.

The theory of the pressure balance is rather complicated, therefore the effective cross-sections are rarely determined by computation. As a rule the effective cross-section is found by means of comparison measurement with another pressure balance having known characteristics.

Cylinder and piston of pressure balances are produced from highgrade steel. Today, however, pistons made from hard metal (tungsten carbide) are very often employed.

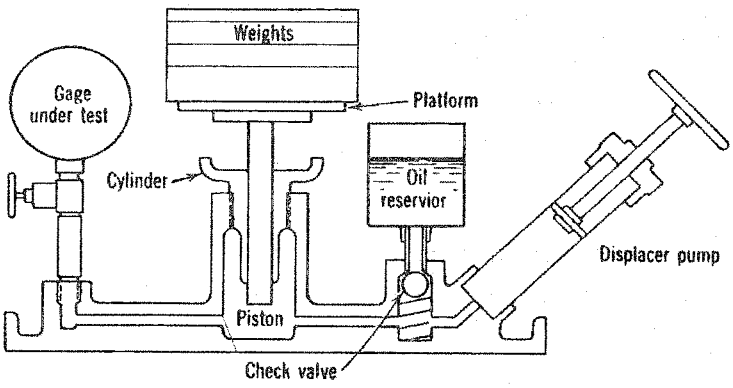


Fig. 3 – Pressure balance

The basic equipment of a laboratory for calibration of pressure gauges may typically consist of the following instruments [ref. 1]:

f) Single rotating piston dead-weight pressure gauge calibrator *for air*, accuracy ± 0.03 % range 10 kPa to 1 000 KPa (0.1 bar to 10 bar) or approaching values, to be delivered with official certificate from recognized national laboratory and all adaptors as follows (1/8" - 1/4" - 3/8" - 1/2" BSP and angle connector 1/4" - 1/2" NPT and M 12 × 1.5 and M 20 × 1.5 as well as triplicate sets of gaskets).

g) Rotating piston dead-weight pressure gauge calibrators *for oil*, accuracy ± 0.03 % consisting of two single piston testers with range 0.1 MPa to 6 MPa (1 bar to 60 bar) and 1 MPa to 60 MPa (10 bar to 600 bar) or approaching values,
(A combined dual piston tester covering the total range is also acceptable)
To be delivered with official certificate from recognized national laboratory (piston mass and diameter), connectors and gaskets as for item f).

h) Oil to water separator for use with item g) in particular for testing of oxygen gauges, to be delivered with all suitable connectors. Range of use to 40 MPa (400 bar).

i) Portable on-site piston dead-weight tester complete in transport box, range 20 kPa to 1 000 kPa (0.2 bar to 10 bar), accuracy 0.1 %, to be delivered with official certificate from recognized national laboraroty, for tests *using air*, including suitable connections (for 1/8" - 1/4" - 3/4" - 1/2 BSP - M 20 × 1.5 and sets of gaskets).

j) Portable on-site piston dead-weight tester complete in transport box for testing *using oil*, range 100 kPa to 6 000 kPa (1 bar to 60 bar), accuracy 0.1 %. To be delivered with official certificate from recognized national laboratory, including connections (for 1/8" - 1/4" - 3/8" - 1/2" BSP - M 20 × 1.5 and sets of gaskets).

Pressure gauges with elastic sensing elements

In practice U-tube manometers and pressure balances are only used in special cases. The pressure measuring instrument for technical use is the pressure gauge with elastic sensing element.

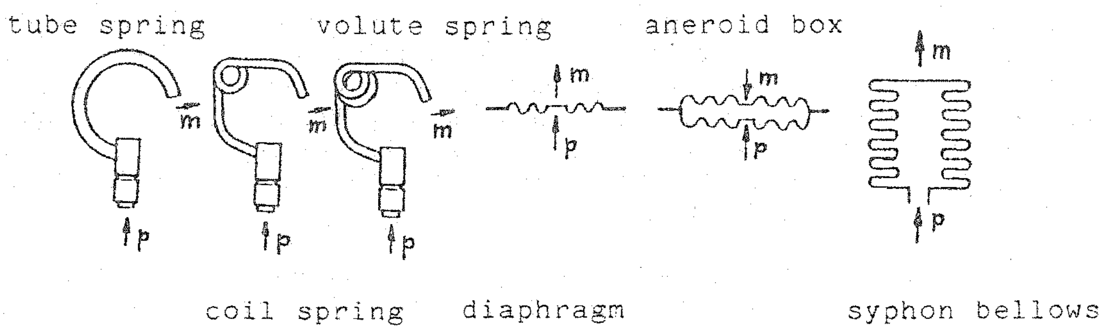


Fig. 4 – Different types of elastic sensing elements

There exist various types of pressure gauge (Fig. 4). Prevailing is nevertheless the tubal spring pressure gauge in which the pressure to be measured is conducted into a circularly bent tube with oval cross-section (Fig. 5).

One end of this tube is firmly connected with the pressure inlet. The other end of the tube is acting by means of a mechanical gear on a pointer playing over a scale. Under the influence of the pressure the tube tries to get a circular cross-section, whereby the free end is making a movement which is transferred to the pointer. A very great pressure range may be covered with pressure gauges having elastic sensing elements. With tubal spring pressure gauges it is possible to measure pressures from 5 kPa up to 1 000 MPa.

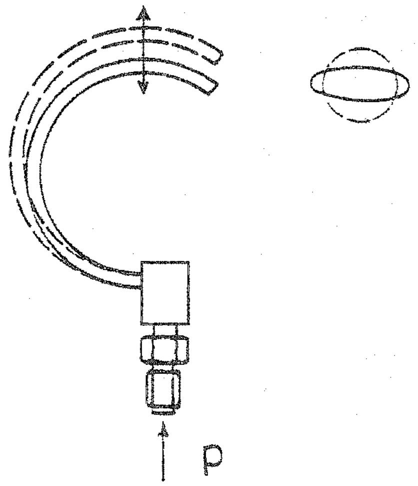


Fig. 5 – Principle of operation of a tubular elastic sensing element

Diaphragm pressure gauges have a range from 10 Pa to 2.5 MPa. These instruments are preferably used in the chemical industry, because it is very easily possible to protect an elastic diaphragm with a chemically resistant coating.

Moreover, syphon bellows pressure gauges are in use which have a measuring range from 500 Pa to 60 kPa. Aneroid boxes are suitable for pressures from 1 kPa to 0.1 MPa. Pressure gauges with elastic sensing elements can also be employed for the measurement of technical vacua. Technical vacuum is very often called under-pressure. We are speaking of physical vacuum, when the mean free path of the molecules is within the order of the dimensions of the measuring apparatus. Nevertheless it must be pointed out that there are also a number of other criteria for the classification of the vacuum.

The theory of manometers with elastic sensing elements is extremely complicated. Even for the tubal spring pressure gauge there exists no perfect theory. It is rather necessary to apply different methods of calculation depending upon the dimension of the tubal spring.

The production of good manometers is not easy and the technological procedures are considered by the producers as manufacturing secrets. Especially the choice of the material of the elastic sensing elements and its structure are most essential for its metrological qualities, if one tries to get small hysteresis and good time constancy of accuracy.

The assignment of the scales to the movement of the pointer as a function of pressure is not calculted according to a complicated theory, it is determined by experiment.

As concerns the metrological qualities which tubal spring pressure gauges have to respond in the field of legal metrology, the necessary information may be found in the OIML Recommendation R 101.

For the basic equipment of a pressure measurement laboratory the following standard test manometers are recommended [Ref. 1]:

2 sets of secondary test gauges, accuracy 0.25 %, diam. 150 mm consisting of

0 – 400 kPa (0 – 4 bar) for use on *air,* connection 1/2" BSP
0 – 1 MPa (0 – 10 bar) for use on *air,* connection 1/2" BSP
0 – 2.5 MPa (0 – 25 bar) for use on *oil,* connection 1/2" BSP
0 – 6 MPa (0 – 60 bar) for use on *oil,* connection 1/2" BSP
0 – 10 MPa (0 – 100 bar) for use on *oil,* connection 1/2" BSP
0 – 60 MPa (0 – 600 bar) for use on *oil,* connection 1/2" BSP

All manometers to be delivered without mounting flange in suitable transport boxes.

Pressure transducers

For many technical applications the just mentioned instruments cannot be used for practical reasons. In such cases so-called transducers are employed. With these pressure measuring instruments the physical quantity pressure is converted into an electric quantity (Fig. 6). This is done in such a way that changes of inductivity, capacity or electric resistance of suitable elements as a function of pressure are taken as measuring principle.

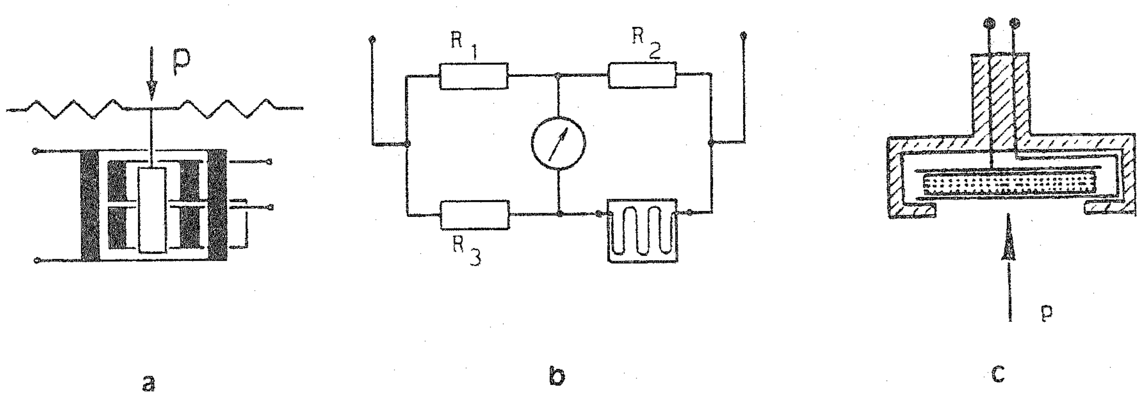


Fig. 6 – Different types of pressure transducers
a – differential transformer
b – strain gauge bridge
c – piezoelectric

The most modern instruments of this kind are working according to the semi-conductor principle or with the aid of strain gauges.

The piezoelectric effect, which e.g. occurs with quartz crystals, is also used for pressure measurement in particular for rapid pressure variations. If a quartz crystal is subjected to a suitable force (pressure) it is charged positively or negatively according to the electric axis. The electric charge can be measured and this is proportional to the acting pressure.

It is common to all pressure transducers that they do not constitute fundamental methods of pressure measurement, but they have to be calibrated with the aid of an U-tube, pressure balances or other precision pressure gauges.

Pressure measuring instruments for special purposes

From the point of view of legal metrology some other pressure measuring instruments have to be mentioned here for the sake of completeness:

TYRE PRESSURE GAUGES

In Austria and in many other countries, tyre pressure gauges are subject to obligatory verification if they are used in garages, at filling stations and in workshops. The life span of a tyre on a motor vehicle is essentially depending upon the use of the correct tyre pressure.

In order to slow down a car of e.g. 1 000 kg from a velocity of 120 km/h with a deceleration of 4 m/s^2, the breaks have to be able to create a power of 150 kW. Likewise the tyres must be in the position to bring this power onto the road. On account of the extensive grade of motorization it is therefore extremely important for the safety in traffic that the tyre pressure can be measured with verified tyre pressure gauges, and that the tyres of the vehicles are in order.

There are various kinds of tyre pressure gauges:

- Hand-held pressure gauges from vehicle tool-kits.
  They are rather intended as indicators of tyre pressure than real measuring instruments. They are not subject to verification.
- Tyre pressure gauges used in service station, garages and workshops. Here we distinguish among hand-held gauges and pressure gauges in fixed installations, and tyre pressure gauges with pressure vessel.
  Hand-held pressure gauges are connected to a compressor by a long hose. They must be especially shock resistant since they are subjected to extreme shocks in use when the instruments are thrown onto the floor.

Pressure gauges in fixed installations are connected by a long hose to the compressor, but they are much heavier and less subject to shocks. Some of those instruments are rigidly mounted to walls or pillars.

There are also gauges attached to pressure vessels which are not firmly connected with the compressor. They consist of a small vessel which is filled up with compressed air. Afterwards the complete instrument can be carried to the tyres to be tested without a hose-connection to the compressor.

On account of the just mentioned situation if is necessary that mobile tyre pressure gauges have to be subjected to shock tests. In Austria the tyre pressure gauges have to sustain 10 000 shocks without loosing their accuracy of measurement. Another important circumstance to be considered are the temperature changes between winter and summer which the instruments have to suffer.

The maximum permissible errors at the verification of tyre pressure gauges are

Range	Maximum permissible error
0 - 400 kPa (4 bar)	8 kPa (0.08 bar)
400 kPa - 1 000 kPa (4 bar - 10 bar)	16 kPa (0.16 bar)
above 1 000 kPa (10 bar)	25 kPa (0.25 bar)

The requirements for tyre pressure gauges are stipulated in the OIML Recommendation R 23 (in revision).

Tyre pressure gauges can be verified with an equipment consisting of a manometer with 16 bar upper limit of the measuring range, class 0.6 and with an air-tank of 2 to 3 litre content.

SPHYGMOMANOMETERS

Other important measuring intruments being subject to verification in many countries are instruments for measuring human blood pressure (sphygmomanometers). On account of the most modern findings of medical science the human blood pressure is a very essential quantity for the individual person as well as for public health.

For the measurement of blood pressure the method Riva-Rocci-Korotkoff is applied according to the state of knowledge of school medicine. For this purpose an inflatable rubber cuff is put, e.g., over the upper arm, and it is inflated so long until no blood is streaming through the arteria brachialis, that is the artery of the upper arm. Now the pressure in the cuff is decreased, and controlled by a manometer. The medical doctor makes an auscultation with a stethoscope in the bend of the elbow. At a certain pressure, the systolic pressure, a typical sound may be heard, the so-called Korotkoff-sound, which disappears again at the diastolic pressure. The doctor notes both values. They give concrete medical indications concerning the blood circulation of the person examined. Standard instruments for pressure measurement are in this case the mercury manometer (Fig. 7) and the manometer with elastic sensing element (Fig. 8).

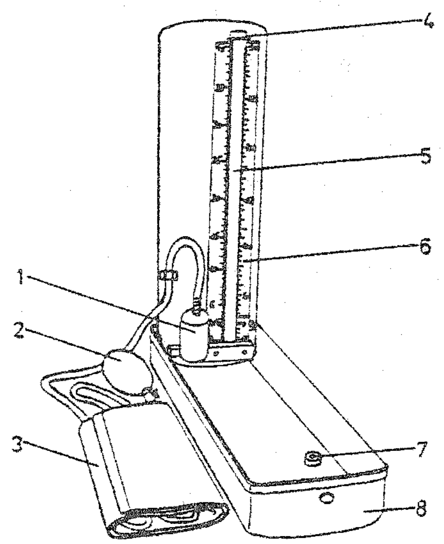


Fig. 7 – Mercury shygmomanometer

1 mercury cistern
2 pump
3 cuff
4 protection cap
5 tube
6 scale
7 bubble level
8 housing

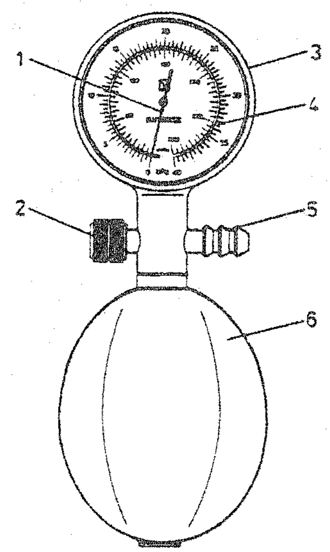


Fig. 8 – Shygmomanometer with elastic sensing element

1 pointer
2 bleed valve
3 housing
4 scale
5 pressure connection
6 pump

According to medical experience sphygmomanometers must not have an error greater than 0.5 kPa. These permissible limits of error are obeyed by the just mentioned instruments when produced by reliable manufacturers.

But also in this field, electronics is in progress and therefore various models with electronic appliances are offered for sale (Fig. 9). As far as these instruments have an analogue indication, that means scale and pointer, additional electronic devices are making no special problems, since the doctor measure still according to the classical method.

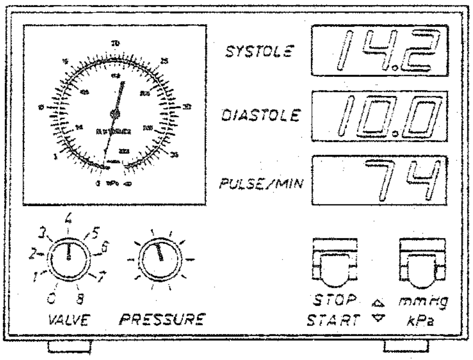


Fig. 9 – Electrical sphygmomanometer with both analogue and digital display

But difficulties will arise especially with digital indication, since in this case the doctor has hardly a possibility to follow the indication of the pressure variation accordingly. For the verification of such instruments artificial arms are needed which are simulating the blood pressure phenomena in the human body more or less well.

The OIML Recommendation R 16 gives the technical requirements for instruments for measuring blood pressure, but it must be stressed that this Recommendation is now being revised on the ground of the most modern developments.

For the verification of sphygmomanometers air-supplied piston gauges with an upper limit of 40 kPa have proved quite useful, but it is also possible to verify them with mercury manometers. U-tube mercury manometers with two scales are not useful. Mercury-manometers with a reservoir and a single column are more useful as they also transportable.

References

[1] "Verification Equipment for National Metrology Services", March 1986, BIML.

(References to literature for further reading can be found in the publication "Metrology Training - Synthesis of facilities and bibliography", March 1987, BIML).

COOMET

COOMET is an organization of national metrological institutions of the States of Central and Eastern Europe. It is open to national metrological institutions of countries of other regions to join as Associate Members.

COOMET was established in Warsaw in June 1991 when representatives of five metrological institutions of Bulgaria, Czechoslovakia, Poland, Roumania and the Confederation of Independant States (ex-Soviet Union) signed the **Memorandum of Understanding.** Representatives of metrological institutions from Germany and Cuba signed the Memorandum as Associate Members in November 1991. The State Committee for Standardization, Metrology and Certification of Ukraine joined COOMET in June 1992.

The basis for COOMET was the declared intention of its members to cooperate in the fields of standards of physical quantities, legal metrology and calibration services. COOMET offers its members a forum for discussing cooperative projects in these fields.

The objectives of COOMET are:

– to contribute to an effective resolution of problems of uniformity of measures and to the required accuracy of measurements,

– to contribute to the development of a closer cooperation between national economies and to the elimination of technical barriers to international trade,

– to bring into closer contact the activities of metrological services of the States of Central and Eastern Europe to the activities of corresponding services in Western Europe and, particularly, to cooperate as far as the mutual interest exists with EUROMET, WECC and WELMEC.

COOMET is not a continuation of the corresponding sector within the former Council of Mutual Economic Assistance which was disbanded in 1991. However, in establishing COOMET, members of this organization took into consideration the results of their previous bilateral and multilateral cooperation, their accumulated experience, the advantages of the territorial proximity of their States, their mutual economic relations and the similarity of structures of their national metrological services.

It should be emphasized that COOMET does not have any independent financial means of its own.

COOMET intends to make the best use of the results of the work of international metrological organizations - the Metre Convention and the International Organization of Legal Metrology, as well as other organizations of interest for metrology, such as ISO and IEC. In addition, COOMET will follow the recommendations of these organizations in the course of its activities.

The principles of collaboration within COOMET are similar to those developed in the Organizations of Western Europe: EUROMET, WECC, and WELMEC. The procedures for the COOMET Committee and for the projects follow closely the EUROMET rules and it was assumed that the analogy of principles and forms may facilitate possible common actions, bring the partners from the two European regions closer together and contribute to the expected integration.

The COOMET Committee consists of the Directors of national metrological institutions which are members of COOMET and is responsible for initiating and supporting mutual cooperation. The Committee meets at least once a year; the President of the Committee is elected for a three-year period with the possibility of only one additional consecutive term of office.

The Secretariat is provided by the Institution of the President.

In their respective countries, Committee members appoint the contact persons for the specified subject fields. In each subject field, the contact persons propose candidates for Rapporteur and the Committee appoints the Rapporteur.

A collaborative project may be placed in one of the following subject fields: Mass, Force and Pressure; Electricity; Length and Angle; Time and Frequency; Thermometry and Calorimetry; Ionizing Radiation and Radioactivity; Photometry and Radiometry; Flow Measurements; Acoustics and Vibration; Physical Chemistry; Reference Materials; General Metrology; Legal Metrology; Calibration Services.

English and Russian are the languages of the COOMET Committee meetings and of the documents received and sent by the Secretariat.

COOMET has already defined its intentions and working method and is ready to begin activities. Sixty project proposal forms have been received thus far by the Secretariat and the majority of them concern comparisons of national and reference standards.

Zbigniew Referowski
President of the COOMET Committee

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PUBLICATION of the PROCEEDINGS
of
the FIRST EUROLAB SYMPOSIUM
on
"Quality Management and Assurance in Testing Laboratories"

Strasbourg, France, January 28-30, 1992

The first large scale manifestation of EUROLAB, the Organisation for testing in Europe, created in Brussels on April 27, 1990, has been an important milestone in the development of the Europe of Testing.

500 participants from 25 countries met in Strasbourg (France) to exchange views and experience on Quality Management and Assurance in Testing and Analytical Laboratories.

This topic, chosen by EUROLAB as the theme of its first Symposium, is of particular relevance considering the contribution expected from laboratories both to provide expert back-up to the improvement of quality and safety of products and the control of the environment and to facilitate the international acceptance of their results.

The symposium was divided into three parts:

- a *first plenary session* consisting of the description of the present state of the European scene in matters connected to Quality Assurance in testing,
- five *technical sessions* where real life experience and opinions were presented and discussed by laboratory practitioners and their partners. Some 60 papers have been selected out of more than 120 and have been organized for presentation around five aspects of quality management of interest to laboratories:
  - organizational factors,
  - technical factors,
  - human factors,
  - quality assurance requirements and customer relationship,
  - laboratory accreditation.
- a *second plenary session* for the presentation of summaries of the technical sessions and EUROLAB reports and also for a round table on future trends, where all the economic partners were represented.

EUROLAB has decided to publish the Proceedings of the Symposium on a large scale. They constitute *a unique reference document* on the state of the art concerning Quality Assurance and Management in testing in Europe.

The Proceedings are published in two volumes:

- Volume 1 contains the papers presented in the technical sessions,
- Volume 2 contains the papers presented in the plenary sessions.

The Proceedings (760 pages; 168 ECU, VAT included) are available at the:

EUROLAB Secretariat
1, rue Gaston Boissier
75015 PARIS
FRANCE
Phone: (33) (1) 40 43 38 33 - Fax: (33) (1) 40 43 37 37

INFORMATIONS

NOUVEL ÉTAT MEMBRE – NEW MEMBER STATE

La ZAMBIE a été admise comme nouvel État Membre de l'OIML.

ZAMBIA has joined OIML as new Member State.

NOUVEAUX MEMBRES du COMITÉ – NEW CIML MEMBERS

BULGARIE/*BULGARIA* - M. Y. YORDANOV, Président, Comité de Normalisation et de Métrologie.

ÉTHIOPIE/*ETHIOPIA* - M. TAFESSE MULUNEH, head of Metrology Department, Ethiopian Authority for Standardization.

FINLANDE/*FINLAND* - M. Martti RANTALA, Assistant Director of Legal Metrology, Technical Inspection Centre.

HONGRIE/*HUNGARY* - Dr Péter PAKAY, President, Országos Mérésügyi Hivatal.

ITALIE/*ITALY* - Dott. Gennaro VISCONTI, Direttore Generale del Commercio Interno e dei Consumi Industriali del Ministero dell'Industria, del Commercio e dell'Artigianato.

PAYS-BAS/*NETHERLANDS* - M. G.J. FABER, Directeur général, Nederlands Meetinstituut N.V.

ZAMBIE/*ZAMBIA* - M. L.N. KAKUMBA, Head of the Assize Department, Weights and Measures Office, Ministry of Commerce and Industry.

ARABIE SAOUDITE / *SAUDI ARABIA* – Le nouveau catalogue de normes de l'Organisation de normalisation de l'Arabie Saoudite (SASO) vient de paraître en deux versions: arabe et anglaise. Il comporte la liste de normes publiées jusqu'en mai 1991.

The new catalogue of standards of the Saudi Arabian Standards Organization (SASO) covering standards issued up to May 1991 in both Arabic and English is now available. For the convenience of its users, it has an alphabetical subject index. It also includes two separate parts: the list of the Gulf standards and that of the international standards which have been adopted as Saudi standards.

AUSTRALIE / *AUSTRALIA* – Les documents ci-dessous publiés par la National Standards Commission ont récemment été révisés.

The following documents of the National Standards Commission have recently been revised and published.

- *Document 100, Pattern Approval Specifications for Non-automatic Weighing Instruments for Trade Use* which is now based on *OIML R 76-1, Nonautomatic Weighing Instruments. Part 1: Metrological and Technical Requirements-Tests;*
- *Document 114, Pattern Approval Specifications for Milk Tanks for Trade Use;*
- *Document 116, Pattern Approval Specifications for Load Cells for Trade Weighing Instruments* has been revised to include the latest modifications to *OIML R 60, Load Cells;*

– *Document 111, Procedures for the Submission and Testing of Load Cells and Indicators;* and

– *Interim Specifications and Procedures for Testing Weighing-in-motion Systems* which are based on OIML draft recommendations. The Interim Specifications include changes to the maximum permisisible errors and test procedures and are incorporated in the following documents:

  Document 117, Pattern Approval Specifications for Weighing-in-motion Systems for Trade Use;

  Document 113, Procedures for the Submission and Testing of Weighing-in-motion Systems; and

  Test Procedure N° 20, Weighing-in-motion Weighing Instruments.

ÉTATS-UNIS / *U.S.A.* – Une nouvelle édition de la publication spéciale N° 250 de NIST donne sur 200 pages les détails de plus de 500 services d'étalonnage offerts par NIST et comporte également sous chaque chapitre des renseignements précieux sur ces possibilités et sur les incertitudes de mesures. Il y a également une bibliographie à la fin de chaque chapitre.

More than 500 different calibration services, special test services, and measurement assurance programs (MAPs) are listed on 200 pages in the NIST Calibration Services Users Guide 1991 (SP 250). The Guide also gives very valuable information on calibration possibilities in general and on the accuracies which may be expected. Services are listed in the following seven areas: dimensional; mechanical (including flow, acoustic, and ultrasonic); thermodynamic quantities; optical radiation, ionizing radiation; electromagnetic (including direct current, alternating current, radio frequency, and microwave) and time and frequency measurements. Bibliographic references are given in each of these chapters.

Copies of the guide are available from the Calibration Program, A104 Building 411, NIST, Gaithersburg, MD 20899.

ROYAUME-UNI / *UNITED KINGDOM* – Les exposés de la 2e conférence sur la métrologie de masses, organisée par South Yorkshire Trading Standards les 12-13 mai 1992, ont été publiés sous forme d'un livre qui peut être obtenu à l'adresse ci-dessous.

The proceedings of the 2nd conference "Weighing, Calibration and Quality Standards in the 1990's", 12-13 May 1992 may be obtained from the organizer:

Mr M.J. Buckley
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EOTC – Une brochure d'information sur les buts et le fonctionnement de l'organisation européenne d'essais et de certification a été publiée récemment et peut être obtenue à l'adresse ci-dessous.

A booklet describing the mission and operation of the European Organization for Testing and Certification has recently been published and may be obtained from:

EOTC Office
Rue de Stassart 33
B-1050 Brussels
Belgium

PUBLICATIONS

		Edition
	Vocabulaire de métrologie légale *Vocabulary of legal metrology*	1978
	Vocabulaire international des termes fondamentaux et généraux de métrologie *International vocabulary of basic and general terms in metrology*	en révision *being revised*
	Dictionnaire des essais de dureté (français, anglais, allemand, russe) *Hardness testing dictionary (French, English, German, Russian)*	1991

RECOMMANDATIONS INTERNATIONALES
INTERNATIONAL RECOMMENDATIONS

R 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)*	1973
R 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)*	1973
R 4 —	Fioles jaugées (à un trait) en verre *Volumetric flasks (one mark) in glass*	1970
R 5 —	Compteurs de liquides autres que l'eau à chambres mesureuses *Meters for liquids other than water with measuring chambers*	1981
R 6 —	Dispositions générales pour les compteurs de volume de gaz *General provisions for gas volume meters*	1989
R 7 —	Thermomètres médicaux (à mercure, en verre, avec dispositif à maximum) *Clinical thermometers (mercury-in-glass, with maximum device)*	1978
R 9 —	Vérification et étalonnage des blocs de référence de dureté Brinell *Verification and calibration of Brinell hardness standardized blocks*	1970
R 10 —	Vérification et étalonnage des blocs de référence de dureté Vickers *Verification and calibration of Vickers hardness standardized blocks*	1970
R 11 —	Vérification et étalonnage des blocs de référence de dureté Rockwell B *Verification and calibration of Rockwell B hardness standardized blocks*	1970
R 12 —	Vérification et étalonnage des blocs de référence de dureté Rockwell C *Verification and calibration of Rockwell C hardness standardized blocks*	1970
R 14 —	Saccharimètres polarimétriques *Polarimetric saccharimeters*	1978
R 15 —	Instruments de mesure de la masse à l'hectolitre des céréales *Instruments for measuring the hectolitre mass of cereals*	1970
R 16 —	Manomètres des instruments de mesure de la tension artérielle (sphygmomanomètres) *Manometers for instruments for measuring blood pressure (sphygmomanometers)*	1970

R 18	—	Pyromètres optiques à filament disparaissant *Visual disappearing filament pyrometers*	1989
R 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*	1973
R 21	—	Taximètres *Taximeters*	1973
R 22	—	Tables alcoométriques internationales *International alcoholometric tables*	1975
R 23	—	Manomètres pour pneumatiques de véhicules automobiles *Tyre pressure gauges for motor vehicles*	1973
R 24	—	Mètre étalon rigide pour agents de vérification *Standard one metre bar for verification officers*	1973
R 25	—	Poids étalons pour agents de vérification *Standard weights for verification officers*	1977
R 26	—	Seringues médicales *Medical syringes*	1973
R 27	—	Compteurs de volume de liquides (autres que l'eau). Dispositifs complémentaires. *Volume meters for liquids (other than water). Ancillary equipment*	1973
R 29	—	Mesures de capacité de service *Capacity serving measures*	1973
R 30	—	Mesures de longueur à bouts plans (calibres à bouts plans ou cales-étalons) *End standards of length (gauge blocks)*	1981
R 31	—	Compteurs de volume de gaz à parois déformables *Diaphragm gas meters*	1989
R 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*	1989
R 33	—	Valeur conventionnelle du résultat des pesées dans l'air *Conventional value of the result of weighing in air*	1973
R 34	—	Classes de précision des instruments de mesurage *Accuracy classes of measuring instruments*	1974
R 35	—	Mesures matérialisées de longueur pour usages généraux *Material measures of length for general use*	1985
R 36	—	Vérification des pénétrateurs des machines d'essai de dureté *Verification of indenters for hardness testing machines*	1977
R 37	—	Vérification des machines d'essai de dureté (système Brinell) *Verification of hardness testing machines (Brinell system)*	1977
R 38	—	Vérification des machines d'essai de dureté (système Vickers) *Verification of hardness testing machines (Vickers system)*	1977

R 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)*	1977
R 40	—	Pipettes graduées étalons pour agents de vérification *Standard graduated pipettes for verification officers*	1977
R 41	—	Burettes étalons pour agents de vérification *Standard burettes for verification officers*	1977
R 42	—	Poinçons de métal pour agents de vérification *Metal stamps for verification officers*	1977
R 43	—	Fioles étalons graduées en verre pour agents de vérification *Standard graduated glass flasks for verification officers*	1977
R 44	—	Alcoomètres et aréomètres pour alcool et thermomètres utilisés en alcoométrie *Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry*	1985
R 45	—	Tonneaux et futailles *Casks and barrels*	1977
R 46	—	Compteurs d'énergie électrique active à branchement direct (de la classe 2) *Active electrical energy meters for direct connection (class 2)*	1978
R 47	—	Poids étalons pour le contrôle des instruments de pesage de portée élevée *Standard weights for testing of high capacity weighing machines*	1978
R 48	—	Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques *Tungsten ribbon lamps for calibration of optical pyrometers*	1978
R 49	—	Compteurs d'eau (destinés au mesurage de l'eau froide) *Water meters (intended for the metering of cold water)*	1977
R 50	—	Instruments de pesage totalisateurs continus à fonctionnement automatique *Continuous totalising automatic weighing machines*	1980
R 51	—	Trieuses pondérales de contrôle et trieuses pondérales de classement *Checkweighing and weight grading machines*	1985
R 52	—	Poids hexagonaux. Classe de précision ordinaire de 100 g à 50 kg *Hexagonal weights. Ordinary accuracy class, from 100 g to 50 kg*	1980
R 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*	1982
R 54	—	Échelle de pH des solutions aqueuses *pH scale for aqueous solutions*	1981
R 55	—	Compteurs de vitesse, compteurs mécaniques de distance et chronotachygraphes des véhicules automobiles - Réglementation métrologique *Speedometers, mechanical odometers and chronotachographs for motor vehicles. Metrological regulations*	1981
R 56	—	Solutions-étalons reproduisant la conductivité des électrolytes *Standard solutions reproducing the conductivity of electrolytes*	1981
R 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*	1982

R 58	—	Sonomètres *Sound level meters*	1984
R 59	—	Humidimètres pour grains de céréales et graines oléagineuses *Moisture meters for cereal grains and oilseeds*	1984
R 60	—	Réglementation métrologique des cellules de pesée *Metrological regulations for load cells*	1991
R 61	—	Doseuses pondérales à fonctionnement automatique *Automatic gravimetric filling machines*	1985
R 62	—	Caractéristiques de performance des extensomètres métalliques à résistance *Performance characteristics of metallic resistance strain gauges*	1985
R 63	—	Tables de mesure du pétrole *Petroleum measurement tables*	1985
R 64	—	Exigences générales pour les machines d'essai des matériaux *General requirements for materials testing machines*	1985
R 65	—	Exigences pour les machines d'essai des matériaux en traction et en compression *Requirements for machines for tension and compression testing of materials*	1985
R 66	—	Instruments mesureurs de longueurs *Length measuring instruments*	1985
R 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*	1985
R 68	—	Méthode d'étalonnage des cellules de conductivité *Calibration method for conductivity cells*	1985
R 69	—	Viscosimètres à capillaire, en verre, pour la mesure de la viscosité cinématique *Glass capillary viscometers for the measurement of kinematic viscosity*	1985
R 70	—	Détermination des erreurs de base et d'hystérésis des analyseurs de gaz *Determination of intrinsic and hysteresis errors of gas analysers*	1985
R 71	—	Réservoirs de stockage fixes. Prescriptions générales *Fixed storage tanks. General requirements*	1985
R 72	—	Compteurs d'eau destinés au mesurage de l'eau chaude *Hot water meters*	1985
R 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*	1985
R 74	—	Instruments de pesage électroniques *Electronic weighing instruments*	en révision *being revised*
R 75	—	Compteurs d'énergie thermique *Heat meters*	1988

R 76	—	Instruments de pesage à fonctionnement non automatique *Nonautomatic weighing instruments*	
		Partie 1 : Exigences métrologiques et techniques - Essais *Part 1 : Metrological and technical requirements - Tests*	1992
		Partie 2 : Rapport d'essai de modèle *Part 2 : Pattern evaluation report*	(*)
R 77	—	Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Dispositions particulières relatives à certains ensembles *Measuring assemblies for liquids other than water fitted with volume meters. Provisions specific to particular assemblies*	1989
R 78	—	Pipettes Westergren pour la mesure de la vitesse de sédimentation des hématies *Westergren tubes for measurement of erythrocyte sedimentation rate*	1989
R 79	—	Étiquetage des préemballages *Information on package labels*	1989
R 80	—	Camions et wagons-citernes *Road and rail tankers*	1989
R 81	—	Dispositifs et systèmes de mesure de liquides cryogéniques (comprend tables de masse volumique pour argon, hélium, hydrogène, azote et oxygène liquides) *Measuring devices and measuring systems for cryogenic liquids (including tables of density for liquid argon, helium, hydrogen, nitrogen and oxygen)*	1989
R 82	—	Chromatographes en phase gazeuse pour la mesure des pollutions par pesticides et autres substances toxiques *Gas chromatographs for measuring pollution from pesticides and other toxic substances*	1989
R 83	—	Chromatographe en phase gazeuse équipé d'un spectromètre de masse et d'un système de traitement de données pour l'analyse des polluants organiques dans l'eau *Gas chromatograph/mass spectrometer/data system for analysis of organic pollutants in water*	1990
R 84	—	Capteurs à résistance thermométrique de platine, de cuivre ou de nickel (à usages techniques et commerciaux) *Resistance-thermometer sensors made of platinum, copper or nickel (for industrial and commercial use)*	1989
R 85	—	Jaugeurs automatiques pour le mesurage des niveaux de liquide dans les réservoirs de stockage fixes *Automatic level gauges for measuring the level of liquid in fixed storage tanks*	1989
R 86	—	Compteurs à tambour pour alcool et leurs dispositifs complémentaires *Drum meters for alcohol and their supplementary devices*	1989
R 87	—	Contenu net des préemballages *Net content in packages*	1989
R 88	—	Sonomètres intégrateurs-moyenneurs *Integrating-averaging sound level meters*	1989
R 89	—	Électroencéphalographes - Caractéristiques métrologiques - Méthodes et moyens de vérification *Electroencephalographs - Metrological characteristics - Methods and equipment for verification*	1990
R 90	—	Électrocardiographes - Caractéristiques métrologiques - Méthodes et moyens de vérification *Electrocardiographs - Metrological characteristics - Methods and equipment for verification*	1990

R 91	—	Cinémomètres radar pour la mesure de la vitesse des véhicules *Radar equipment for the measurement of the speed of vehicles*	1990
R 92	—	Humidimètres pour le bois - Méthodes et moyens de vérification: exigences générales *Wood-moisture meters - Verification methods and equipment: general provisions*	1990
R 93	—	Frontofocomètres *Focimeters*	1990
R 95	—	Bateaux-citernes - Prescriptions générales *Ships' tanks - General requirements*	1990
R 96	—	Bouteilles récipients-mesures *Measuring container bottles*	1990
R 97	—	Baromètres *Barometers*	1990
R 98	—	Mesures matérialisées de longueur à traits de haute précision *High-precision line measures of length*	1991
R 99	—	Instruments de mesure des gaz d'échappement des véhicules *Instruments for measuring vehicle exhaust emissions*	1991
R 100	—	Spectromètres à absorption atomique pour la mesure des polluants métalliques dans l'eau *Atomic absorption spectrometers for measuring metal pollutants in water*	1991
R 101	—	Manomètres, vacuomètres et manovacuomètres indicateurs et enregistreurs *Indicating and recording pressure gauges, vacuum gauges and pressure-vacuum gauges*	1991
R 102	—	Calibreurs acoustiques *Sound calibrators*	1992
R 103	—	Appareillage de mesure pour la réponse des individus aux vibrations *Measuring instrumentation for human response to vibration*	1992
R 104	—	Audiomètres à son pur *Pure-tone audiometers*	1992

DOCUMENTS INTERNATIONAUX
INTERNATIONAL DOCUMENTS

D 1	—	Loi de métrologie *Law on metrology*	1975
D 2	—	Unités de mesure légales *Legal units of measurement*	en révision *being revised*
D 3	—	Qualification légale des instruments de mesurage *Legal qualification of measuring instruments*	1979
D 4	—	Conditions d'installation et de stockage des compteurs d'eau froide *Installation and storage conditions for cold water meters*	1981

D 5	—	Principes pour l'établissement des schémas de hiérarchie des instruments de mesure *Principles for the establishment of hierarchy schemes for measuring instruments*	1982
D 6	—	Documentation pour les étalons et les dispositifs d'étalonnage *Documentation for measurement standards and calibration devices*	1983
D 7	—	Évaluation 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*	1984
D 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*	1984
D 9	—	Principes de la surveillance métrologique *Principles of metrological supervision*	1984
D 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*	1984
D 11	—	Exigences générales pour les instruments de mesure électroniques *General requirements for electronic measuring instruments*	en révision *being revised*
D 12	—	Domaines d'utilisation des instruments de mesure assujettis à la vérification *Fields of use of measuring instruments subject to verification*	1986
D 13	—	Conseils pour les arrangements bi- ou multilatéraux de reconnaissance des résultats d'essais, approbations de modèles et vérifications *Guidelines for bi- or multilateral arrangements on the recognition of test results, pattern approvals and verifications*	1986
D 14	—	Formation du personnel en métrologie légale - Qualification - Programmes d'étude *Training of legal metrology personnel - Qualification - Training programmes*	1989
D 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*	1986
D 16	—	Principes d'assurance du contrôle métrologique *Principles of assurance of metrological control*	1986
D 17	—	Schéma de hiérarchie des instruments de mesure de la viscosité des liquides *Hierarchy scheme for instruments measuring the viscosity of liquids*	1987
D 18	—	Principes généraux d'utilisation des matériaux de référence certifiés dans les mesurages *General principles of the use of certified reference materials in measurements*	1987
D 19	—	Essai de modèle et approbation de modèle *Pattern evaluation and pattern approval*	1988
D 20	—	Vérifications primitive et ultérieure des instruments et processus de mesure *Initial and subsequent verification of measuring instruments and processes*	1988

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

D 22 — Guide sur les instruments portatifs pour l'évaluation des polluants contenus dans l'air en provenance des sites de décharge de déchets dangereux — 1991
Guide to portable instruments for assessing airborne pollutants arising from hazardous wastes

D 23 — Principes du contrôle métrologique des dispositifs utilisés pour les vérifications — (*)
Principles for the metrological control of devices used for verification

(*) Publication en cours d'impression/*Publication being printed.*

Note — Ces publications peuvent être acquises au / *These publications may be purchased from* Bureau International de Métrologie Légale, 11, rue Turgot, 75009 PARIS.

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