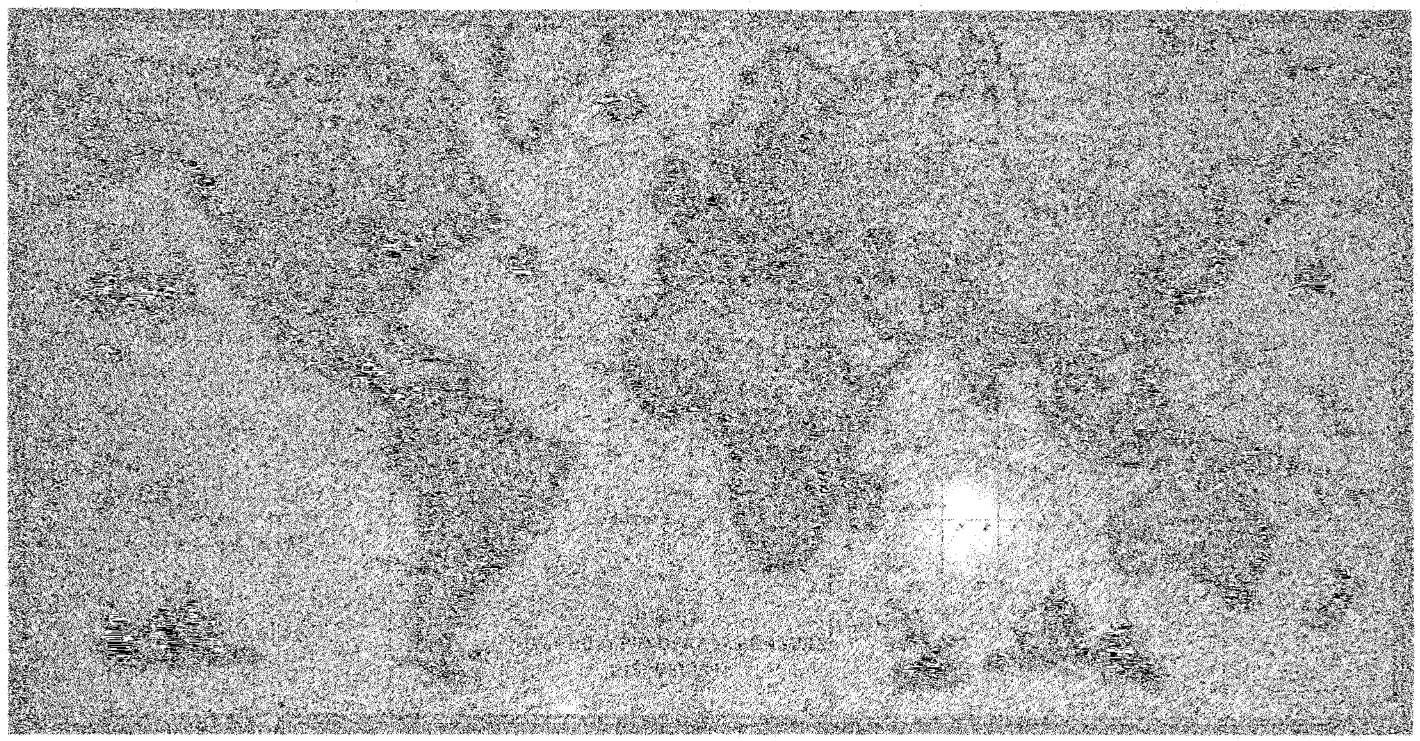
Bulletin OIML n° 131
Juin 1993

ISSN 0473-2812

BULLETIN

DE

L'ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE



BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE
11, Rue Turgot – 75009 PARIS – France

Bulletin OIML n° 131
Juin 1993
Trimestriel
ISSN 0473-2812

BULLETIN
de
l'ORGANISATION INTERNATIONALE de MÉTROLOGIE LÉGALE

SOMMAIRE

Abonnement pour 1993 : Europe : 200 FRF
Autres pays : 250 FRF
Chèques postaux : Paris 8 046-24 X
Banque de France : B.P. 140-01 - 75049 Paris Cedex 01
Comptes Courants, Banques Étrangères, Compte n° 5051-7

BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE
11, Rue Turgot – 75009 Paris – France
Tél. 33 1 48 78 12 82
et 42 85 27 11
Le Directeur : Mr B. ATHANÉ
Téléfax : 33 1 42 82 17 27
Télex : 234 444 SVP SERV F ATTN OIML

NORVÈGE

APPROVAL OF AN AUTOMATIC WEIGHING INSTRUMENT FOR ROAD VEHICLES

by Thor MYKLEBUST
National Measurement Service

SUMMARY

This paper deals with automatic weighing instruments for road vehicles and different influences on such instruments are evaluated. The OIML Recommendation R 106 on automatic rail-weighbridges is mentioned as well as how this recommendation is applied for road vehicles. The last sections describe the test methods and the results from the pattern approval tests.

1 GENERAL

This is the first approval of an instrument used for dynamical weighing of road vehicles in Norway and as far as we know, it is the very first approved pattern for legal use. Since there does not exist any international standard for such instruments, we had to develop both requirements and test procedures before we could start the pattern approval process. We used the OIML Recommendation for rail weighbridges as a basis for these requirements [6].

The advantages with a dynamical weighing system are as follows:

- It is more efficient than a nonautomatic weighing instrument. This is important since in the worst case, in Norway, a driver may have to stop for a weighing control up to four times in only one day.
- It is not as easy for the drivers to influence the weighing result by using their brakes when the vehicles are weighed dynamically.
- It is also possible to measure the length of the vehicle with this weighing instrument. This is an advantage since there are requirements on the lengths of the vehicles.

The disadvantages are as follows:

- It is not as accurate as a weighbridge that can weigh the vehicle in one weighing operation.
- The test of the instrument takes more time and demands more resources.

2 DESCRIPTION OF THE WEIGHING INSTRUMENT

2.1 Electronic and mechanical parts

Maximum capacity is 20 t and the verification scale interval is 20 kg.

The pattern consists of a weighbridge with four loadcells. The dimensions of the weighbridge are 3 m × 0,8 m.

The indicator was approved earlier as part of a nonautomatic weighing instrument a few years ago. This indicator has been modified so it can also handle dynamical weighing.

A PC has been connected to the indicator and works as a slave. This weighing system works in only one direction.

In addition there are light signals that inform the driver whether he has to stop, to start, etc.

2.2 Aprons

The dimensions of the aprons are 10 m × 4 m on both sides of the instrument. It has warming cables on both aprons, temperature and humidity sensors to avoid problems as a result of low temperatures, rain, and snow.

The top surface of the aprons are vertically aligned to ± 8 mm along the weigh zone which has a length of 40 m. Within 17 m on both sides the vertical alignment is ± 6 mm.

2.3 Description of the separate control instrument

The separate control instrument is situated 20 km from where the automatic weighing instrument is located. The maximum capacity is 60 t. The verification scale interval is 10 kg from 0 t to 30 t, and 20 kg from 30 t to 60 t.

The length of the weighbridge is 18 m. This permits a single weighing.

3 THEORETICAL ESTIMATES OF THE DIFFERENT INFLUENCES ON INSTRUMENTS USED FOR DYNAMICAL WEIGHING OF VEHICLES

Before we decided whether we should be willing to put so much work into the approval of such an instrument, we screened the literature, consulted different test institutes, and performed mathematical calculations on different problems. We wanted to see how good the chances were to succeed and this was also a tool to develop correct requirements and good test procedures.

There existed no literature on dynamical weighing of road vehicles. But there existed a few articles on dynamical weighing of trains which are to some degree comparable to this problem [3], [5], [7] and [8]. In addition there was one article about static axle and bogie weighing of vehicles that was of interest [1]. The institutes we consulted did not have experience with such instruments.

3.1 Problems resulting from height differences between the weighing instrument and the aprons

In all the calculations it is assumed that the weighbridge is levelled.

If we only look at the difference between the aprons and the weighbridge, we may have four different cases:

- Weighbridge at the highest place.
- An apron higher at one side of the weighbridge and an apron lower at the other side.
- An apron higher or lower, and the other apron at the same level.
- Weighbridge at the lowest place. This will lead to opposite results to the first case.

From this we see that it is sufficient to mathematically treat the vehicle in one position and generalize from that example.

Fig. 1 schematically shows an example: vehicle and static forces that the vehicle acts on the ground and on the weighbridge.

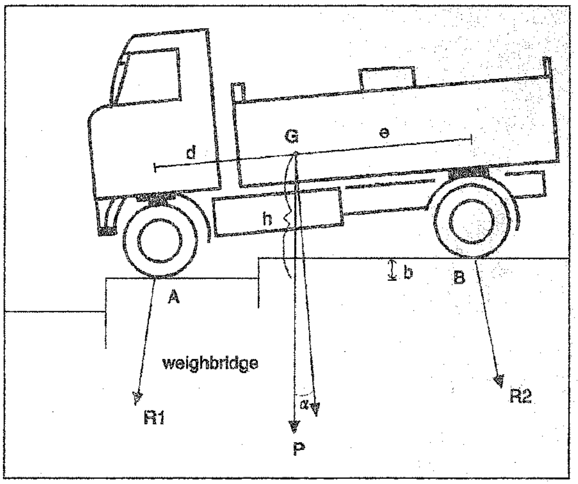


Figure 1 – Truck with one axle on the weighbridge.

P: weight of the vehicle - marked at the center of gravity
R1: representing the action at the front wheels
R2: representing the action at the rear wheels
α: angle with the horizontal plane, due to the height difference b
a: length between the rear and front wheels (a = d + e)
b: height difference between the weighbridge and the apron (or rear and front wheels)
e: length between the rear wheels and the center of gravity
d: length between the front wheels and the center of gravity
h: height between the weighbridge and the center of gravity G

The problem of the vehicle weighed statically as indicated in fig. 1 will now be considered and some comments on the dynamical influence are made at the end of this section.

Static weighing

Internal forces and moments may be omitted since they occur in pairs of equal and opposite forces and moments.

By expressing that the system of the external forces (moments) is equivalent to the system of the effective forces (moments), the resulting external forces R1 and R2 are finally given by:

$$R1 = (P/a)\,(e + h \tan\alpha)$$
$$R2 = (P/a)\,(d - h \tan\alpha)$$

If the center of gravity is in the middle of the vehicle ($d = e = a/2$) and the angle α is different than zero,

$$R1 = P/2 + P\,(h/a) \tan\alpha$$
$$R2 = P/2 - P\,(h/a) \tan\alpha$$

R1 will, as expected, be higher than P/2 and R2 will be lower than P/2; when the rear wheels are on the weighbridge, the opposite will be the case. This implies a systematic error when weighing axle and bogie weights.

Nevertheless, a well-designed weighbridge is able to measure correctly even though the directions of R1 and R2 are not really vertical.

EXAMPLE:

The error for the front wheels (with d = e) is:

$$\text{Error} = R1 - (P/2)$$

If we allow an error of 1 % of the load (as for class 2 rail-weighbridges that conform with OIML R 106 requirements):

$$\text{Error} = R1 - (P/2) \leq 0.01\ P/2$$

and

$$\tan\alpha \leq 0.005\ a/h$$

With real values

P = 500000 N
a = 4 m
e = d = 2 m
h = 1 m

this means that

$$\tan\alpha \leq 0.02$$

and that the maximum angle α is equal to 0.02 rad and the maximum b value is equal to 8 cm; such value is relatively easy to obtain since the aprons are much better.

As concerns the sum R1 + R2, it is

$$R1 + R2 = P$$

This indicates that in this theoretical example the sum will be correct but the axle weights will have a small, but systematical error.

Similar calculations may be made for the other possible weighbridge/aprons configurations with similar results:

- small systematic errors for axle weights
- no error (theoretically), or small systematic errors for total weights.

Dynamical effects

In addition, there will be errors due to the dynamical effects. We may think of three different cases since it is only allowed to drive in one direction:

- The weighbridge is at the same level as the apron. This should not be a problem at low speeds for a modern weighing instrument.
- The weighbridge is higher than the apron. This is a problem because this will result in shocks on the sides of the weighbridge that would certainly have a negative effect on the instrument, especially in the long run.
- The weighbridge is lower than the apron. This may cause additional problems since the vehicle will "fall" on the weighbridge and this will be taken as an additional load. To some extent, this additional force can be taken care of, for example, by software.

Dynamical weighing also causes vibrations. There will be vibrations both on the weighbridge and on the vehicle. The most difficult part is the vibrations on the vehicle since it is difficult to reduce these vibrations.

The vibrations on the weighbridge may be solved by high stiffness and with electronics. Software is a tool to deal with vibrations both from the vehicle and the weighbridge.

Nevertheless, the dynamical errors are expected to be low since the maximum speed is only 5 km/h.

3.2 Height differences and moment

As mentioned earlier it is known that torques and moments may cause problems in the determination of axle and bogie weights.

Fig. 2 schematically shows a truck and a coupled trailer, and the torque and moment caused by the special kind of spring system of the trailer.

The result of the torque indicated in fig. 2 is a moment that the weighbridge will take as a load.

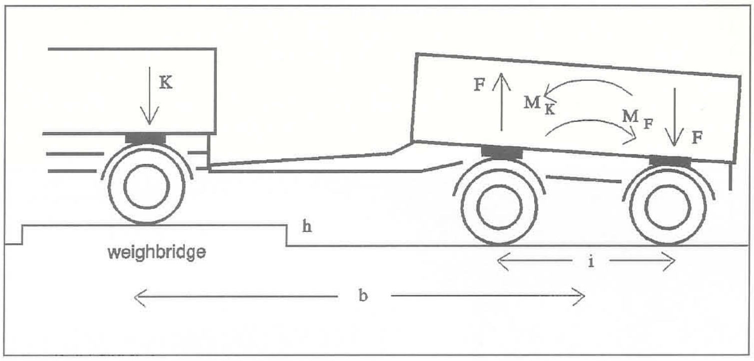
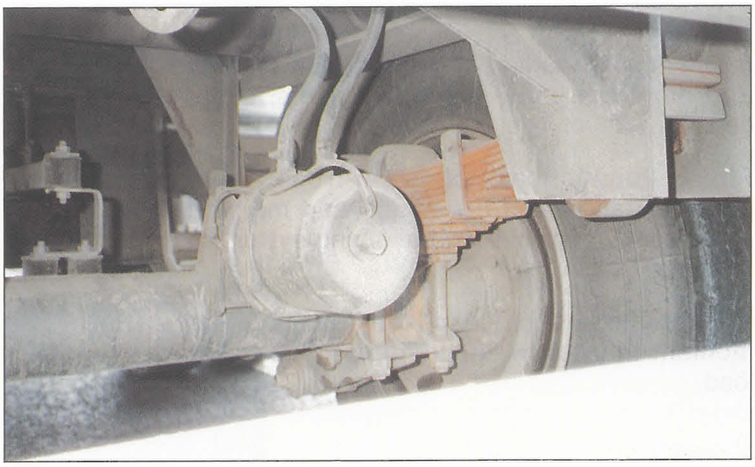


Figure 2 – Trailer that exerts a moment on the weighbridge.

M_K: moment caused by the spring system and the height difference
M_F: torque of the moment
F: two forces that are resulting in a moment M_k
K: force at the connection between the trailer and the truck
i: length between the two wheels axles
c: spring constant
x: displacement of the spring
h: height difference between weighbridge and apron
b: distance between the middle of the trailer and the connection point

Trailer



Part of the spring system (trailer)

Connection between the truck and the trailer

The torque exerted by the spring system is as follows:

$$M_F = F\ i = c\,x\,i$$
$$M_F = M_K = K \times b$$

Assuming that the connection point is on the vertical line above the rear wheel axle of the truck, the force exerted on the weighbridge is as follows:

$$K = \frac{M_F}{b} = \frac{c\,x\,i}{b} = \frac{c\,h\,i^2}{2\,b^2}$$

EXAMPLE:

Normal values for the different parameters are as follows:

$c = 10.4$ kN cm^{-1}
$x = 0.2$ cm
$b = 3{,}65$ m
$i = 1{,}15$ m

As a result we have the following error:

K = 0.653 kN corresponding to 67 kg, for a height difference h equal to 1.27 cm.
This example shows that small height differences may result in large errors.
If b increases, this will result in an increase in x. The spring system is also such that the spring is stretched more with additional load on the trailer. Because Hooke's law [4] is only correct (linear) for a very limited interval, there is also reason to believe that c will increase both with b and with increasing load on the vehicle.
In addition, x is larger if the trailer is loaded at the end and if there is no load on the truck.

This suggests that we should test the weighbridge with vehicles that are loaded with more than which is allowed according to the requirements for vehicles. This to see how much effect the increase in c has on the weighing result. It also suggests that we have to distribute the load in different ways during the tests.

This means that the error increases both with c and x. And that both c and x may increase from several factors. This may result in a very drastic increase in the error.

The error formula also shows that the lengths i and b are very important. Only a small increase in the length i and a smaller value of the length b would have resulted in a much larger error.

Another problem which must be considered is the following case: the weighbridge is lower than the aprons and the trailer consists of a truck with a bogie at the rear and a trailer with the above mentioned spring system: in this case, even smaller height differences will result in a very low value for the total weight. This will be the result because the last axle on the truck and the first axle on the trailer would then be "lifted off" the weighbridge.

Dynamical effects

In this case, the dynamical effects may cause larger problems than those mentioned in section 3.1 since the moment may increase as a result of the dynamical effects. It is also easily seen that the front wheels on the trailer may be lifted as a result of the spring system. The result will be that the trailer will appear to be lighter than it really is.

4 REQUIREMENTS

4.1 General

It is important to have in mind, before we mention the requirements, that the instrument can only be used for determining the axle weight, bogie weight, and total load of vehicles. The weighing results determine penalties for overload.

We have based our requirements on the OIML Recommendation R 106 on automatic rail-weighbridges, sanctioned by the Ninth International Conference of Legal Metrology in October 1992; the accuracy class 2 was considered appropriate (see 4.2).

Most of our requirements are similar to those of the OIML Recommendation on automatic rail-weighbridges, but the following differences must be considered:

- In the Terminology,
  - "trailer" is substituted by "vehicle";
  - "rail-weighbridge" is substituted by "weighbridge";
  - everything that has to do with train weighing is deleted; we only had to include "trailer" and "coupled trailer weighing".
- We decided that in all cases they have to use a separate control instrument for the comparison with the total load. It is not acceptable to use it as its own control instrument. One of the main reasons for this is the problem mentioned earlier in section 3.2.
- We did not allow 10 % of the coupled trailer weighing results to exceed the error limits (point 2.2.1.1 in R 106). The reason for this being that a person then might have to pay for an incorrect weighing result.
- When we discussed this problem, we only had the draft recommendation. This draft stated that the minimum wagon weight was 5 t. As a result of this, we still have a minimum vehicle weight equal to 5 t. This was changed in the last version of R 106 (this minimum is now equal to 50 d). We may change this to be in accordance with the Recommendation but more tests would have to be performed.
- We deleted point 2.6 with regard to axle or bogie weights since the instrument shall be used for determining the axle and bogie weight.
- In point 3.1 in the Recommendation, there is a list of devices that an instrument shall include. We deleted vehicle-type device from this list as this is not necessary for weighing road vehicles.
- In point 3.6.2.1 in the Recommendation, markings with regard to the number of trailers are deleted.
- In point 3.6.3 with regard to "supplementary markings", we have included a sentence as follows: "Only to be used for determining the overload of axles, bogies, and total load of vehicles".
- With regard to the section "metrological controls" in the Recommendation, we have modified it slightly (see the description of the test in point 5).
- Chapter VI in the recommendation was deleted. It is not appropriate for weighing vehicles.
- Annex B was deleted as we required a separate control instrument.
- Annex C was deleted as we do not want to give practical instructions before we have approved several instruments. But we do refer to the OIML R 106.

4.2 Metrological requirements

It was agreed between the Road Department and the National Measurement Service that the instrument could be approved as a class 2 instrument.

4.3 Aprons

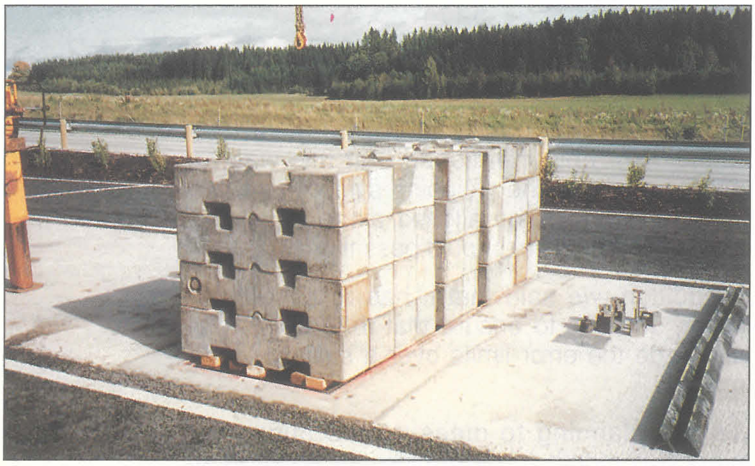
We did not have any requirement on the aprons. We only mentioned that this was an important part of the weighing system and that the aprons had to be aligned extremely well if the weighing system should pass the tests.

In addition, we said that it has to have long-lasting qualities to ensure that the instruments are inside the error limits over a sufficient time interval.

We are planning to measure the alignment every two month to determine the qualities of the aprons.

Truck and trailer

Semi-trailer



Static test of the weighbridge

4.4 Requirements for vehicles in Norway

The Road Department has requirements on the axle weight, the bogie weight, and the total weight of a vehicle. These requirements are more severe during the winter due to the spring thaw.

5 DESCRIPTION OF THE TESTS

5.1 Introduction

We performed only tests in situ, since all the different parts of the weighing instrument were approved earlier. As shown in section 3, it is very important to use different vehicles and include at least one vehicle with a special spring system (see section 3.2).

We chose the vehicles as follows:

- Vehicle A: Truck (with bogie)
- Vehicle B: Trailer (This trailer had a special spring system.)
- Vehicle C: Semi-trailer

As a result of the calculations in section 3, preliminary tests and the principle that one shall perform tests as close as possible to normal working conditions, it was decided that we had to overload the trailer during some of the tests. This was done to see the effect of the spring system in such cases. This was a problem, and we had to get authorization from the Road Department before we could start the tests.

We decided to overload vehicle B which was the most difficult vehicle to be weighed. This vehicle was loaded up to the limit guaranteed by the manufacturer of the vehicle to cause no damage to the vehicle. This corresponds to an overload of approximately 8 t. This would have led to a penalty of 18200 NOK (1800 £).

5.2 Static tests

We performed static tests with weights on the weighbridge in question and the control instrument. After we tested the instruments with weights we weighed the vehicles on the same instruments statically.

5.2.1 Test of the instruments in static mode

We performed the static tests according to OIML R 76 on both instruments.

All the different tests mentioned in point 8.2.2 in R 76 was performed. The test included:

- Weighing test: On the automatic weighing instrument we had to put something between the weights and the weighing instrument because the weights were wider than the weighbridge. This was to ensure that the weights did not touch the aprons during the test.
- Eccentricity test: On the automatic weighing instrument this test was performed only at the ends of the weighbridge since it was impossible to do it on each corner.
- Mobility
- Repeatability
- The accuracy at zero: Both of the instruments has a zero tracking device, so this test was performed at 60 kg.

5.2.2 Static weighing of the vehicles

All the vehicles were weighed empty on the control instrument since we loaded the vehicles with OIML class M2 weights.

On the control instrument, the vehicles were weighed in one weighing operation, one by one. Every vehicle was weighed three times.We checked the zero-setting between each weighing.

On the automatic weighing instrument, we had to weigh each axle. The truck was weighed statically both with and without the trailer. In addition to this, we weighed the trailer uncoupled. On this instrument we also weighed the vehicles when they were loaded.

These tests were performed on the same day as those of the dynamical tests.

5.3 Dynamical tests

All the final dynamical tests were performed in one day. We performed tests with the three different vehicles

- at different velocities between minimum (1 km/h) and maximum velocity (5 km/h),
- at different loads,
- with different distribution of the loads between the trailer and the truck.

We performed at least five weighings for every different situation.

6 RESULTS

6.2 Static tests

6.2.1 Test of the control instrument

All the different tests mentioned in point 8.2.2 in R 76 were performed and the error was within ± 10 kg for all the different tests.

6.2.2 Test of the automatic weighing instrument

All the different tests mentioned in point 8.2.2 were performed and the error was within ± 8 kg in the whole weighing range.

6.2.3 Static weighing of the vehicles

The different vehicles were weighed empty three times on the control instrument. The repeatability of the results was within ± 6 kg for all the vehicles. The mean values from these weighings were used as the reference values for the vehicles.

On the automatic weighing instrument, the static error was within 50% of the error limits given in OIML R 106. The repeatability error was within ± 50 kg for all the different vehicles and different loads. The range was between + 60 kg to - 160 kg.

The repeatability of the axle and bogie weighings was within 50% of the repeatability of the total error of the vehicle (25 kg).

6.3 Dynamical tests

All the results for the total weight in the final test were within 50% of the error limits for dynamical weighing for class 2 instruments in R 106. A high percentage, 99%, of the results were within 25% of these error limits. There was no significant difference in the result for different velocities.

The distribution of the loads had a significant influence on the total mass but it was well within the error limits.

As expected, the error for the trailer was greater than the errors for the semi-trailer and the truck.

For the trailer, the errors were within +120 kg and – 40 kg for all the tests. The errors for the semi-trailer and the truck were within +30 kg and –70 kg for all the tests.

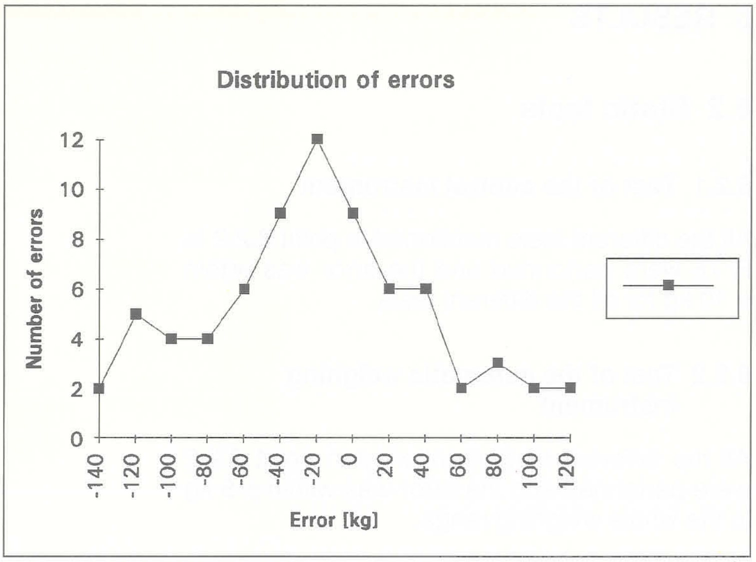


Figure 3 – Error curve

Fig. 3 shows that the errors are distributed as a Gauss curve. This was expected since many of the error components involved are random.

The result from the axle and bogie weighings are of course difficult to judge but the difference between the dynamical and static results was well within the error limits. There was no significant difference between the errors for the total weight when determined static or dynamically. This indicates that there is good reason to believe that dynamical determination of axle and bogie weights is not worse than when it is performed statically.

If the driver passed the instrument too slowly or too fast, this resulted in an error message.

7 CONCLUSIONS

The results of the pattern approval tests showed that all the results were within the error limits for class 2 instruments. This and the technical evaluations of the weighing system led to an approval of the weighing instrument.

This approval indicates that the weighing industry has taken another step forward. Performing dynamical weighing of road vehicles has been considered to be extremely difficult.

In the future, we will also consider approving such instruments for loads below 5 t since there is no reason to believe that this would be worse than weighing heavy trailers.

Since this is the first approval, we are planning to do a follow-up study. We will measure the height difference several times and a complete verification will be performed within half a year after this approval.

References

[1] Baumgarten Dieter: Wagen+dosieren 1/1987: Gravierende Fehlmessungen beim achsweisen Wagen moderner Sattelfahrzeuge.

[2] Beer, Ferdinand and Russel Jonston Jr: Mechanics for engineers, Statics and dynamics; McGraw-Hill Company, 1987.

[3] Ferguson,A.C.: Weighing Vehicles in motion; Measurement and control, December 1969.

[4] Gere and Timoshenko: Mechanics of Materials; Chapman and Hall 1991.

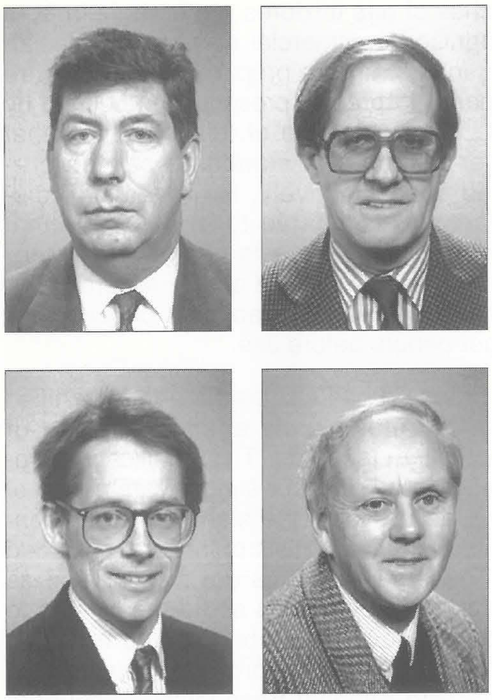
[5] Myklebust, Thor: Test av automatisk jernbanevekt; NJV 1988.

[6] OIML R 106 on automatic rail-weighbridges, sanctioned by the Ninth International Conference of Legal Metrology in October 1992.

[7] Robinson, R; Testing of automatic rail-weighbridges. Bulletin OIML No. 101, December 1985.

[8] Robinson, R; Automatic rail-weighbridges. Bulletin OIML No. 118, Mars 1990.

CLEAN AIR MEASUREMENT Interlaken 28 Sept - 1 Oct 1992



Pictured clockwise from top:
P.T. Woods, R.H. Partridge, A.J. Davenport, M.J. Milton.

GAS STANDARDS AND MONITORING TECHNIQUES FOR MEASUREMENTS OF VEHICLE AND INDUSTRIAL EMISSIONS, WORKPLACE EXPOSURE AND AIR QUALITY

by **P.T. WOODS, R.H. PARTRIDGE, M.J. MILTON** and **A.J. DAVENPORT**

Division of Quantum Metrology, NPL, Teddington

1 INTRODUCTION

The National Physical Laboratory (NPL) is the main focus of the United Kingdom's National Measurement System for physical measurements, and as such provides nationally-traceable standards to which UK measurements of air quality, workplace exposure and air pollution source emissions can be referenced. This work is one component of the UK's Valid Analytical Measurement (VAM) initiative. The VAM programme is part of the Government's wider responsibility which aims to ensure that UK measurements of all kinds are accurately made through the framework of a "National Measurement System".

Research is also being carried out on the development, validation and exploitation of new open-path and remote monitoring techniques which will supplement conventional atmospheric monitoring methods. In addition, NPL is involved in the development and utilisation of new sensitive spectroscopic techniques for monitoring stratospheric ozone and other trace gases, and understanding the impact of anthropogenic emissions on stratospheric ozone depletion.

Two of the research areas (those related to the development and dissemination of an expanding range of gas concentration standards, and to the validation and utilisation of new remote and open-path monitoring techniques) are discussed below.

2 GAS CONCENTRATION STANDARDS

2.1 Procedure for preparing and validating primary and secondary standards

A National Facility has been established at the National Physical Laboratory (NPL) for over fifteen years, where primary gas concentration standards are prepared and maintained. Primary standards of a range of different gases with widely differing concentrations are prepared by absolute gravimetric techniques in carefully-passivated containers. The concentrations of the gas standards, which are expressed in absolute molar units, are traceable to the primary standard of mass.

Rigorous quality control and quality assurance protocols ensure the accuracy of these primary standards. Initially, all the parent gases are analysed comprehensively for impurities using a set of sensitive gas chromatographic and spectroscopic instruments. These parent gases are then used to prepare the primary standards employing a range of different methodologies and gravimetric facilities. One such methodology is to prepare sets of three or more gas standards with nearly equal concentrations at about 10 % by molar value by accurately weighing the parent gases consecutively into an appropriate container. Then, in a similar manner, these 10 % standards are diluted gravimetrically to produce a further set of standards with concentrations of about 1 %. This dilution procedure is repeated to develop a hierarchy of sets of accurate gravimetric standards with concentrations ranging from greater than 10 % to a few parts per million or less. Each set of standards prepared at a given concentration is then intercompared using precise analytical instrumentation to demonstrate their self-consistency. Several hierarchies of gas standards are prepared *independently* for each gaseous species. Members of the different hierarchies with similar concentrations are also intercompared to verify the self-consistency of the complete range of standards. Whenever new standards are prepared to replace depleted ones, a stringent intercomparison procedure is followed to confirm its consistency with the existing standards.

In addition, alternative independent microweighing methods are also employed to prepare standards, which enable dilutions in concentration of considerably greater than a factor of ten to be carried out with the required accuracy. These are compared with the standards which have been diluted consecutively. All the standards are also analysed regularly to ensure that no significant chemical reactions have taken place and that no impurity gases have been desorbed from the container walls. A more detailed description of the preparation procedures used and an analysis of the uncertainties which are ascribed to the concentrations of the primary standards has been given [1]. Some of the results obtained when these standards were intercompared with those of other national laboratories are outlined in Section 2.4.

Secondary Standards are also produced which are certified with respect to these primary standards. These are prepared by two methods:

(i) Gas mixtures are prepared in-house using the analytical instrumentation, blending facilities and parent gases which are used to produce the primary standards. The advantage of this method is that the preparation procedure is quality controlled and it is unlikely that significant impurities will be entrained or that unforeseen chemical reactions will occur during or after the preparation process.

(ii) Batches of gas mixtures are brought in from recognised commercial companies specialising in gas mixture preparations. These are prepared to precise prescriptions defined by NPL. The advantage of this method is that larger numbers of standards can be prepared cost effectively. However, one disadvantage (compared to (i) above) is that these mixtures have to be more comprehensively analysed and quality assured, and their concentration stabilities checked for longer period, before use.

These prepared gas mixtures are then certified directly and individually against a range of NPL's primary standards. This certification procedure is carried out over a significant period of time in order to verify the stability in their concentrations. Further details of this are published [1, 2]. These gas mixtures are then utilised as Secondary Gas Standards and disseminated to UK industry, government bodies and research organisations in order to provide measurement accuracy and national traceability. Secondary standards are also disseminated to other countries to provide them with the ability to carry out accurate measurements. In addition, previous and ongoing intercomparisons are carried out to establish the international uniformity of gas concentration measurements in Europe and elsewhere (see Section 2.4).

2.2 Gas standards available

A range of different gas concentration standards have already been developed, validated and disseminated by NPL. These include:

(i) Gas standards for measurements of gaseous pollutants emitted by vehicles and aircraft. These comprise binary mixtures of carbon monoxide, carbon dioxide and nitrogen monoxide in a diluent gas of nitrogen, hexane in air, and propane in nitrogen or air. The concentrations available depend on application, with some covering the range 15 % to a few parts per million by molar value. Most standards for this application have been intercompared with similar standards abroad in order to demonstrate the international uniformity of such measurements (Section 2.4).

(ii) Multicomponent gas standards are also available to provide traceable measurements in the UK's vehicle emissions testing programme (Section 2.3). These comprise specific concentrations of mixtures of carbon monoxide, carbon dioxide and propane in a diluent gas of nitrogen.

(iii) Gas standards containing methane in diluent gas of air or nitrogen are available to provide traceable, accurate flammability measurements.

(iv) Multicomponent standards are available to provide accurate calibration of instruments (generally gas chromatographs) being used to monitor the concentrations of a wide range of volatile organic hydrocarbon compounds (VOCs) in ambient air. These measurements are required to understand the effects of VOCs and nitrogen oxides on the formation of photochemical ozone and other secondary pollutants near ground level in the boundary layer, and in the free troposphere. These standards currently contain 26 different hydrocarbon species (Table 1), important to photochemical ozone formation, with known concentrations ranging from 10 to 100 parts per billion (10^9) by molar value. They are disseminated in the UK to underpin and audit laboratories making air quality measurements (Section 2.3) and throughout the EC to determine the accuracy of such measurements in member countries (Section 2.4).

A *wider* range of gas concentration standards and calibration facilities are now under development at NPL for measurement of source emissions, workplace exposure and air quality. These are outlined in Section 2.5.

2.3 Examples of applications of traceable gas standards

2.3.1 Vehicle and aircraft emission measurements

As noted previously, one application of gas standards is in ensuring the internationally acceptability and accuracy of exhaust emission measurements carried out on vehicles and aircraft. Following intercomparisons carried out between the National Institute of Standards and Technology (NIST) in the USA and NPL (Section 2.4), the US Environmental Protection Agency accepted NPL's gas standards as a substitute for those of NIST for appropriate motor vehicle emission measurements. Measurements made on aircraft engine emissions on behalf of the UK government by the Royal Aircraft Establishment, Pystock, are now also traceable to NPL standards and these have been used to investigate the uniformity of aircraft emissions measurements made in some European countries.

A further example concerns the recent implementation in the UK of annual exhaust emission tests for all vehicles two years old or greater. These tests are now being carried out by instruments that were type-approved before use, according to OIML R99. Several commercial laboratories carried out these type approvals, and they had to be accredited beforehand by the UK's National Accreditation and Measurement Service (NAMAS), the Executive of which is based at NPL. Nationally-traceable multicomponent and binary gas standards were supplied to these laboratories in order to underpin these type-approval measurements. A number of different makes of instruments are now in service in UK garages (about 20,000 instruments). Figure 1 shows an example.

Figure 1

TABLE 1

Composition of the Hydrocarbon Mixture			
Ethane	1-Butene	Isoprene	Ethyl benzene
Ethylene	trans-2-Butene	n-Hexane	o-Xylene
Acetylene	cis-2-Butene	2-Methyl pentane	m-Xylene
Propane	n-Pentane	3-Methyl pentane	1.2.4-Trimeth. benzene
Propene	i-Pentane	n-heptane	1.3.5-Trimeth. benzene
n-Butane	trans-2-Pentene	Benzene	
i-Butane	cis-2-Pentene	Toluene	

The accuracy of *all* instruments in service is checked at three monthly intervals, by NAMAS-approved engineers, who use nationally-traceable reference gas mixtures (carbon monoxide, carbon dioxide, and propane in a nitrogen balance gas). These mixtures are prepared by NAMAS-accredited commercial specialist gas preparation companies, using NPL Secondary Standards to underpin their calibration procedures. Stringent quality control procedures are also employed to ensure the validity of the NAMAS-accredited standards. These include analyses of the parent gases for significant trace impurities (for example, 10 ppm of gaseous N_2O as an impurity in the mixture will produce a 1 % relative error in the measurement of the concentration of carbon monoxide, for some exhaust monitoring instruments).

2.3.2 Ethanol standards for breath-alcohol testing

A further example where national traceability is required is in breath-alcohol measurements. Currently, evidential breath-alcohol instruments in UK police stations are checked for accuracy using a device known as a liquid simulator before and after each test on the human subject. This employs a mixture of liquid ethanol and water maintained at a constant temperature, through which ambient air is bubbled to produce a known concentration of ethanol vapour in air. However, this liquid needs regular replacement and the unit is easily damaged. Research has been carried out at NPL for several years on the preparation and validation of an alternative calibration method. This uses stable, ethanol/air or ethanol/nitrogen gas standards. This work resulted in standards accurate to ± 0.5 % relative and stable for greater than two years. The prescription for preparing these standards was then transferred to commecial specialist gas-preparation companies. These companies have produced trial batches of gas mixtures which are calibrated with respect to NPL standards, and they are now in the process of seeking NAMAS-accreditation for the supply of accurate, nationally-traceable gas calibration mixtures. The commercially-prepared standards will be employed to carry out calibration checks on the new generation of breath-alcohol measuring instruments which are to be introduced soon into police stations for evidential breath-alcohol tests. These instruments will be type-approved before use to ensure that they conform to OIML requirements. This type-approval will include a number of tests for interference arising from other gaseous chemical species. In addition, it will involve sets of tests of the instruments, responses to alcohol, carried out by a dynamic breath-simulator developed by NPL. This instrumentation (Figure 2) emulates the dynamic breath-flow and alcohol-concentration exhalation profiles which will be encountered in practice. It will be used to measure the accuracy with which breath-alcohol measurements are made by the different instruments in order to determine whether they conform to the OIML Recommendation.

Figure 2

2.3.3 Hydrocarbon standards for air quality measurements

A new monitoring initiative is underway to establish a network of ambient hydrocarbon monitoring stations in urban locations throughout the UK. These stations employ automated gas chromatographic instruments to provide hourly measurements of a range of hydrocarbons in the ambient atmosphere. These measurements are calibrated regularly using NPL's multicomponent standards which, as noted previously, contain 26 species important to the issue of photochemical ozone production. These are all at known concentrations similar to those in ambient air. Other multicomponent VOC standards with concentrations known to NPL but not to the monitoring stations, will be used to audit the ambient air measurements.

2.4 International collaborations

NPL has been involved for a number of years with international intercomparisons and other collaborative activities with other laboratories in Europe and elsewhere, with a view to determining and improving the international uniformity of gas concentration measurements. These collaborations include:

(a) Participation in round-robin exercises organised by the European Commission's Community Bureau of Reference (BCR) [2]. These involved batches of a few selected commercially-prepared gas mixtures which were circulated to a number of EC research laboratories where they were "certified" in concentration against each laboratory's in-house standards.

(b) A series of intercomparisons have been carried out between NIST in the USA and NPL, with the aim of establishing the uniformity of vehicle emission measurements in the two countries. This work entailed exchanging standards, the exact concentrations of which were unknown to the recipient, and certifying them using the in-house standards of the analysing laboratory [3]. Intercomparisons were carried out on carbon monoxide, carbon dioxide, nitrogen monoxide and propane standards. Results obtained for some of these are shown in Figures 3 and 4. The overall mean difference between the values assigned by the supplying laboratory and those determined by the analysing laboratory was 0.1 % relative of value with a sample standard deviation of ± 0.15 %. These results indicate a high degree of consistency between the standards in the two organisations and showed that measurements using these can be directly compared.

(c) Gas standards containing 26 hydrocarbon species with known concentrations at near ambient levels were distributed to 18 laboratories in eight EC countries, and one further laboratory from Norway which is involved in atmospheric monitoring under the EMEP project. Valid comparisons were obtained for only 15 different hydrocarbon species, due to difficulties with the stability of certain species in the batch of passivated cylinders used. The results, which are summarised in Figure 5 *(see page 16)*, are discussed in detail elsewhere [4]. They indicate that improvements in the quality of current ambient hydrocarbon measurement procedures are necessary if the results are to be harmonised between different countries and if valid comparisons are to be made.

(d) A number of standards laboratories, including NPL, are involved in collaborations under the EUROMET initiative. This comprises a series of collaborative projects within EC and EFTA countries, in the field of measurement standards. Its objective is to promote coordination of metrological activities to achieve higher efficiency by, for example, pursuing collaboration in research and by sharing access to measurement services. In this context, collaborative research and intercomparisons of gas standards has been continuing for some time between the National Measurement Institute (NMI/VSL) in the Netherlands and NPL.

Figure 3

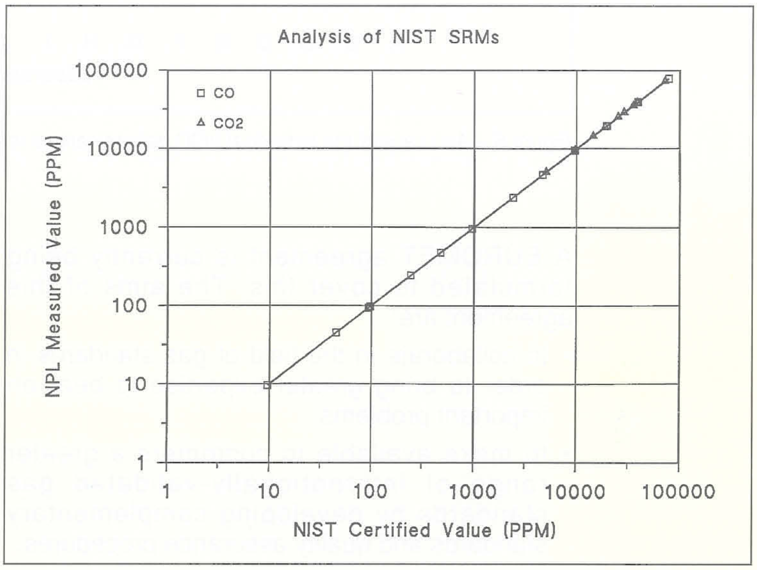
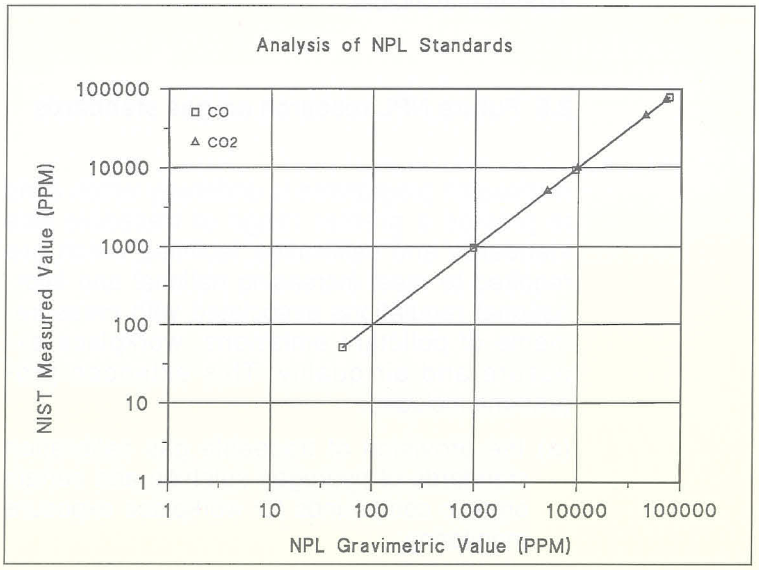


Figure 4



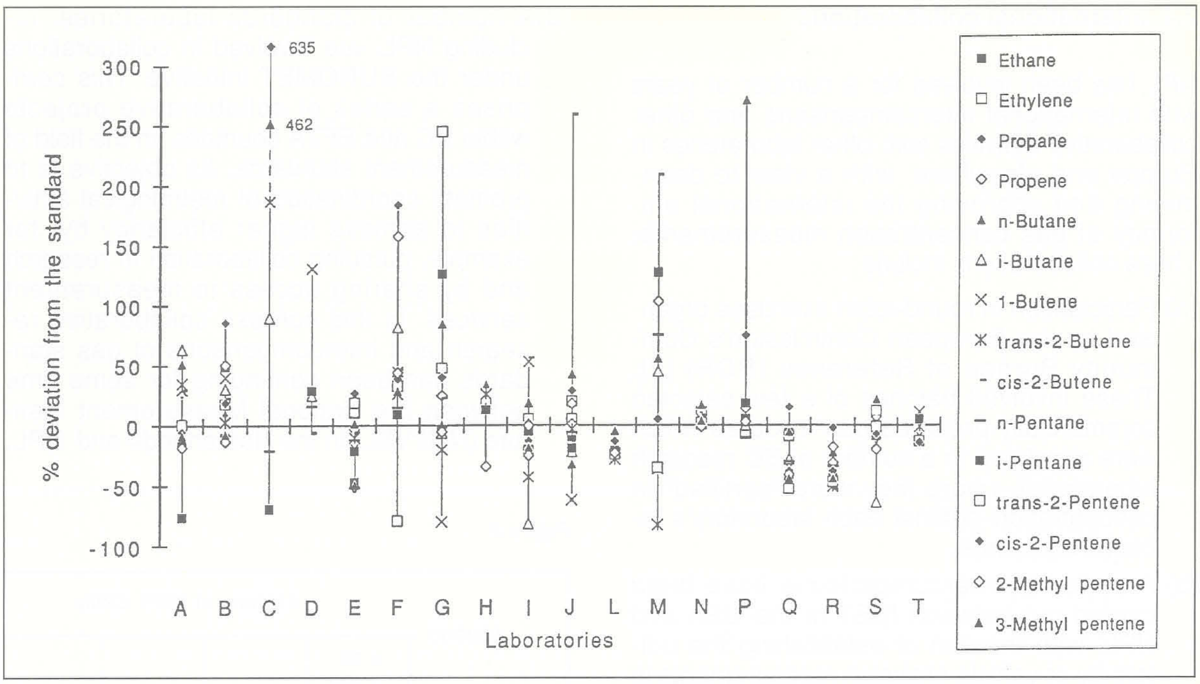


Figure 5 – Accuracy of the individual VOC determinations in each laboratory

A EUROMET agreement is currently being formulated to cover this. The aims of this agreement are:

- to collaborate in the field of gas standards in order to bring greater expertise to bear on important problems;
- to make available to customers a greater range of internationally-validated gas standards by developing complementary standards and quality assurance procedures.

It is anticipated that, in the future, other recognised national standards laboratories will join the project in order to broaden still further the range of gas standards and measurement expertise available.

2.5 Future NPL research on gas standards

A research programme is underway which aims to provide a greater range of traceable gas standards and calibration facilities which are required to meet increasing national and international regulations associated with measurements of pollutant emissions, workplace exposure and air quality. This extended programme includes:

(a) the provision of traceable gas calibration standards of hydrogen sulphide and certain organic compounds for workplace exposure monitoring;

(b) the provision of SO_2 and NO_x standards for urban air quality measurements (in collaboration with NMI, Holland);

(c) the establishment of an absolute calibration facility for instruments measuring a range of gases too reactive to hold in containers with known concentrations for extended periods.

3 OPEN-PATH AND REMOTE MEASUREMENT TECHNIQUES

3.1 Background to remote sensing technology

Gas detection is generally carried out using what is known as "point monitoring" – ie, a measurement is made at a single location in space. This is suitable for very localised gas measurements or for measurements where the gas concentration is homogeneous over the area being monitored. However, point monitoring, is inadequate for measuring, for example, poorly mixed gases in industrial or urban areas. Examples of this include fugitive emissions from industrial plant, and leakages from chemical storage tanks, since in these cases it will be a matter of chance whether or not a particular gas cloud intersects the measuring point.

Open-path and remote optical gas detection techniques are particularly suitable on these large area monitoring applications. These techniques operate using spectroscopic principles and rely on the fact that most pollutant gases have unique characteristics spectroscopic features. They generally employ a beam of infrared or ultraviolet radiation to sense the gas directly in the atmosphere and this beam is directed along a path which can be a few metres to several kilometres in length. The wavelength of the radiation is chosen so that it selectively addresses the gas of interest and is not sensitive to other gases which may be present.

Remote monitoring techniques offer a range of advantages over conventional point-sensing methods. For example:

(i) The measured concentrations are averaged over extended paths (1 m – 1 km) and are therefore much less affected than point sensors by local, possibly unrepresentative, fluctuations in gas concentration.

(ii) There is much greater probability of intersecting a leak from an industrial area with a remote sensor than with a point sensor.

(iii) Measurements of a wide range of species can be made with one system, with a minimum interference from other species which may be present.

(iv) Measurements of multiple sources can be made non-intrusively from one location.

(v) Gas detection is by means of a beam of radiation, with no physical equipment needed in the area, so that measurement can be made in regions where physical access is difficult, especially above ground level, or in hazardous areas where the equipment would constitute a risk.

(vi) There is no physical contact between the gas and the sensor. This eliminates "poisoning" of the sensor; it also allows reactive gases to be monitored, which may be difficult to detect with conventional methods.

(vii) The measurements can be made traceable to absolute spectrometric data.

(viii) The measurements can have a rapid time response which allows fluctuations and surges to be detected.

(ix) The fluxes of emitted gases can be measured directly (see Section 3.3), thereby determining the total emissions of gases from a particular site.

(x) One type of these techniques can be used to provide two or three-dimensional maps of the concentrations of the selected gas at the site in real time, and this enables toxic or flammable hazards to be detected rapidly.

These remote techniques often operate using tunable lasers as their sources. Lasers interact with gases in a variety of ways which arise from processes such as Raman scattering, molecular or atomic fluorescence, and molecular absorption. However, for most applications, the most sensitive and specific process is gaseous absorption discussed by Partridge [5], and therefore, the new techniques under development generally involve this process. As indicated above, they rely on the fact that industrially-important gases and pollutants all have unique, characteristic, spectroscopic absorption features, and a light source may be selected so that the wavelength it emits coincides with one feature of this spectrum. Then, tuning or modulating this wavelength rapidly on and off this feature, and measuring the difference in the intensities of the radiation at the two or more wavelengths after it has passed through the gas, allows the concentration of the gas to be determined.

Tunable lasers are used as the radiation sources since they have several outstanding characteristics important to gas detection and pollution monitoring:

(i) They can generate radiation over a wide spectral range, which enables a range of gases to be addressed with one system.

(ii) They emit radiation with high intensities in narrow spectral bandwidths, and this allows very specific and sensitive detection of the selected gases.

(iii) They produce well-collimated beams of radiation that can propagate with little divergence through the atmosphere or through a gas stream, and this provides a compact measurement volume even at distances up to several kilometres.

(iv) Some lasers emit very short, high intensity, pulses which, as discussed below, are essential for range-resolved measurements of gas concentration.

Lasers operating in the infrared, visible and ultraviolet regions have all been used for the remote detection of gases. However, there are some wavelength limitations which are imposed either because of atmospheric absorption or because the species present in the gas stream being monitored absorb all the radiation. For example, radiation at ultraviolet wavelengths shorter than about 220 nm is considerably attenuated by molecular oxygen present in the atmosphere, whilst in the infrared region the presence of carbon dioxide and water vapour prevents measurements in spectral regions around 1.8 μm and 4.2 μm, and between 5 and

8 µm. However, these are not serious limitations since a wide range of industrially-important gases have absorption features in spectral regions where the commonly-occuring atmospheric gases do not absorb significantly. Table 2 gives examples of these.

TABLE 2
Example of atmospheric Gases with Characterised Absorption Spectra Measurable with the NPL Remote Monitoring Facilities

220-500 nm Spectral Region	3-5 µm Spectral Region	8-13 µm Spectral Region
SO_2	H_2S	NH_3
NO	CO	HNO_3
NO_2	N_2O	H_2S
O_3	NO_2	
Hg	HC1	C_2H_2
Benzene	HBr	C_2H_4
Toluene	HF	C_6H_6
Xylenes	HCN	
NH_3	CH_4 (+ Isotopes)	
N_2O	C_2H_2	
$C1_2$	C_2H_4	O_3
O_2		
Aldehydes	C_2H_6	SO_2
Ketones	C_3H_8	SF_6
	Higher Alkanes	
	Higher Alkenes	
	Higher Alkynes	
	HCHO	CH_3C1
	HCOOH	C_2H_3C1
	CH_3OH	$COC1_2$
	C_2H_5OH	
	C_2HC1_3	
	COS	C_2H_4O
	CO_2 (+ Isotopes)	
	H_2O	

The NPL optical techniques are implemented in three different configurations:

(a) The radiation produced by the tunable source is directed into the atmosphere, or across the gas stream being monitored, towards a reflector (usually a "cube-corner" mirror) placed at any distance between a few metres and 500 metres away. This reflector returns the radiation identically along its original path to a detector situated, for convenience, close to the source. Then, tuning the wavelength of the source as outlined above allows measurement of the gas concentration. This arrangement enables the total amount, or the average concentration of the selected gas between the source/detector and the reflector, to be measured. This configuration ensures that a large fraction of the radiation emitted by the source is directed back onto the detector and hence, in contrast to the other two configurations outlined below, requires only a low energy source.

(b) If the laser radiation is directed towards a solid object such as a building, vegetation, or the ground, a small fraction of this is reflected back along the direction of propagation and this may be collected and focused onto a detector. Then, if the system is operated in the manner outlined in (a), the total amount, or average concentration, of the selected gas between the source and the target can be measured. However, since only a small fraction of the transmitted energy is received back at the detector, a source with a larger intensity than that in configuration (a) is required.

(c) If laser radiation is transmitted into the atmosphere or through a gas stream, a very small fraction will be scattered out of the beam by any particulates and aerosols present, and by the gaseous medium itself. Some fraction of this will be reflected back along the direction of propagation, and this may be measured by a detector close to the source. If, in addition, a short duration pulse or radiation is transmitted, and the amount of backscattered radiation is measured as a function of time from when the pulse is launched, the distance of the scattering species from the laser can be determined. This technique is known as LIDAR (light detection and ranging). In practice, the atmosphere will scatter the transmitted radiation at *all* distances away from the source. Thus, tuning the laser wavelength on and off the spectral absorption allows the gas concentration to be measured as a function of distance from the source. However, since the atmosphere acts as a very inefficient reflective medium, a high-intensity source is required to produce measurable signals on the detector.

3.2 Remote monitoring facilities at the national physical laboratory

Several versatile different facilities which utilise the principles outlined above are being developed at NPL [6].

3.2.1 Long-path infrared tunable diode-laser facility

A double-ended system has been constructed which utilises a tunable diode laser to measure the average or integrated concentration of the target gas between the laser located in a mobile laboratory and a reflector which may be mounted from a few metres to a kilometre away. Diode lasers are capable of being tuned across the entire infrared spectral region (2-20 µm) and operate with very narrow spectral linewidths. The system can thus measure a wide range of gases (for example, see Table 2) with very high specificity and sensitivity. The facility, the operating principles of which have been discussed by Partridge [7], has been designed to provide rapid, realtime measurements of the target gas concentrations directly, with the results being unaffected by any changes in laser energy, or by fluctuations caused either by atmospheric turbulence or other meteorological conditions. The system is calibrated on-line by inserting gas cells containing accurately-known concentrations of the target gas in the beam. The sensitivity of the system can be better than one part in 10^8 by volume (a few μg/m^3), depending on the particular gas. However, the diode lasers currently used to achieve this operate at cryogenic temperatures (10-77 k), and this requires a relatively expensive, non-portable, cooling system. For field measurements, therefore, the NPL facility is mounted in a specially-modified vehicle, and the laser radiation is directed by means of a moveable periscope to give 360° geographic coverage. This can be used to monitor several paths in quick succession with suitably-placed reflectors.

3.2.2 Portable, low-cost, monitor

A portable, low cost, infrared, long-path, monitor has been developed. This unit operates on similar principles to those used in the diode laser facility outlined above, except that it does not utilise an expensive cryogenically-cooled laser system as its source. It is portable, and can be tuned in wavelength to measure a large number of industrially-important gases with good sensitivity. However, the sensitivity is not, in general, as good as the diode-laser system discussed above. Nevertheless, it is capable of monitoring hydrocarbons at both flammable and fugitive levels, and monitoring toxic gases at occupational exposures levels. Following completion of this development, the instrumentation will be marketed commercially (see Section 3.6). Work is underway to extend the operation of this monitor into the ultraviolet and visible regions where a wider range of gases is measurable.

3.2.3 Multi-wavelength differential-absorption lidar (DIAL)

A single-ended facility, based on the DIAL principle outlined above, is being developed for remote, range-resolved measurements of atmospheric gases. It currently has a range resolution between 3 and 10 metres and a sensitivity of a few parts in 10^8. Ranges of a few kilometres [6] are achievable with some species. The transmitted laser beam, the collecting telescope and the detection system can be scanned together to provide full horizontal and vertical coverage in the atmosphere, and this allows two and three-dimensional concentration profiles of the target gases to be obtained remotely from a single location.

The facility was first constructed to operate in the ultraviolet and visible regions of the spectrum and this enabled a number of gases to be monitored (Table 2) including SO_2, NO, NO_2, O_3 and aromatic hydrocarbons. More recently, however, a major development programme has been completed which has extended the operation of the facility into the infrared region where a much broader range of industrially-important gases can be monitored (Table 2).

There are two intrinsic disadvantages in operating a DIAL system in the infrared rather than the ultraviolet or visible spectral regions. These are that the aerosol backscatter coefficients are smaller and that the spectroscopy is significantly more complicated because of atmospheric interference caused by, for example, carbon dioxyde and water vapour. These two problems, together with the comparitively poor performance of detectors in the infrared demand that a high energy pulse be required to perform effective DIAL measurements. In addition, the complexity of the spectra of light hydrocarbons (< C_3) and atmospheric gases in the 3.3 to 3.5 μm region imposes a maximum linewidth of 0.1 cm^{-1} and the necessity for the source to be continuously tunable. The complete facility developed with these characteristics has been integrated into a dedicated mobile laboratory which also contains all the electronics and computer control systems necessary to operate the facility and compute the results.

3.2.4 Detection sensitivities achievable

The detection sensitivities achievable with the long-path and DIAL facilities are summarised in Table 3.

TABLE 3 – Examples of Detection Sensitives Attainable with NPL Remote Monitoring Facilities

Tunable diode-laser system		Ultraviolet/visible DIAL system		Infrared DIAL system	
CO	0.5 ppb	NO	5 ppb	CH_4	50 ppb
CH_4	1 ppb	NO_2	10 ppb	C_2H_2	40 ppb
NH_3	5 ppb	SO_2	10 ppb	C_2H_4	40 ppb
C_2H_4	5 ppb				
C_2H_6	1 ppb	O_3	5 ppb	C_2H_6	20 ppb
C_2H_2	2 ppb	Hg	0.5 ppb	High Alkanes	40 ppb
		Benzene	10 ppb	HC1	50 ppb
H_2S	0.5 ppb	Toluene	10 ppb	N_20	100 ppb
N_2O	0.2 ppb	Xylenes	20 ppb		
NO_2	20 ppb				
COS	0.5 ppb				
HC1	1 ppb				
H_2CO	1 ppb				
HNO_3	1 ppb				

3.3 Measurements of spatial concentration and emitted gas flux using remote monitoring techniques

3.3.1 Long-path gas monitor

Although a double-ended long-path system measures only the average concentration of gas between the source and the reflector, it can nevertheless be used to indicate variations of gas concentration with position on a large site, while retaining the advantage of averaging out local concentration fluctuations. This is achieved through a series of measurements in the horizontal plane along a set of lines radiating out from the laser system. Each line has several reflectors spaced along it and positioned so that a "concentrations multiplied by pathlength" measurement can be made to each retroflector in turn by slight adjustments in beam direction. Subtraction of the results between pairs of adjacent reflectors, together with knowledge of the reflector distances from the laser, then yields the average concentration between each pair. Such values can then be displayed on a map of the site to indicate the variations of gas concentration over the site as a whole. Data on wind speed and direction are monitored continuously during the measurement sequence.

Measurements of gas flux across a boundary are made in the vertical plane as shown in Figure 6. The mast nearer to the monitoring system carries two plane mirrors which can slide up or down the mast. The far mast carries reflectors which are set at the same heights as the plane mirrors on the near mast. Selection of a path of a particular height is then made by directing the optical beam at the appropriate plane mirror.

The gas flux values are obtained on the basis that the flux is the gas concentration multiplied by the wind speed integrated over both spatial dimensions of the measuring plane. The vertical measuring plane is set up downwind of the site to be investigated and, as far as possible, perpendicular to the prevailing wind direction. When the plane extends beyond the boundaries of the site, the gas flux derived will be the total flux of gas leaving the entire site. If, furthermore, there is known to be a negligible amount of gas entering the site upwind, then the observed gas flux will also represent the total emission rate of gas from the site from all sources. This quantity is extremely difficult to measure by any technique other than an open-path optical one, and the technique has proved valuable in evaluating both fugitive emissions and gas leakages from industrial sites, and gas generated from landfill sites.

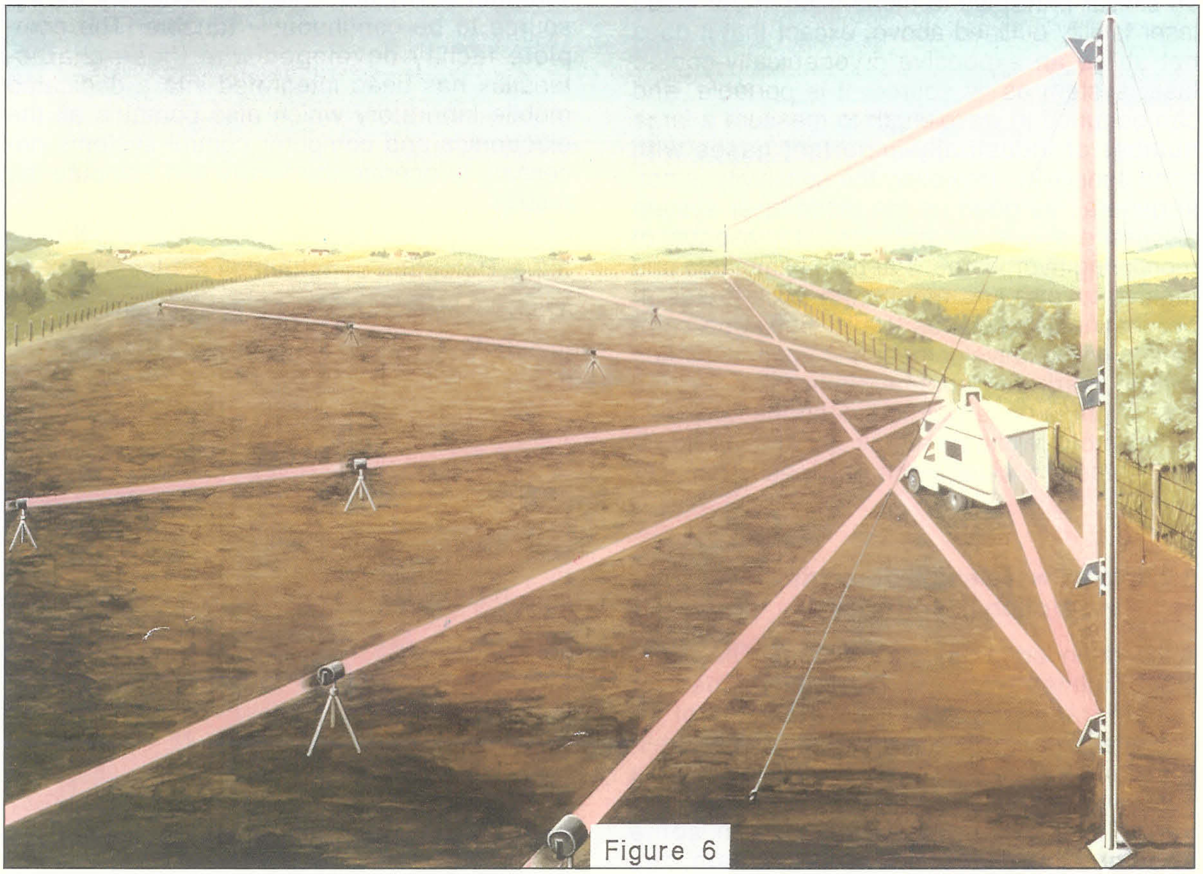
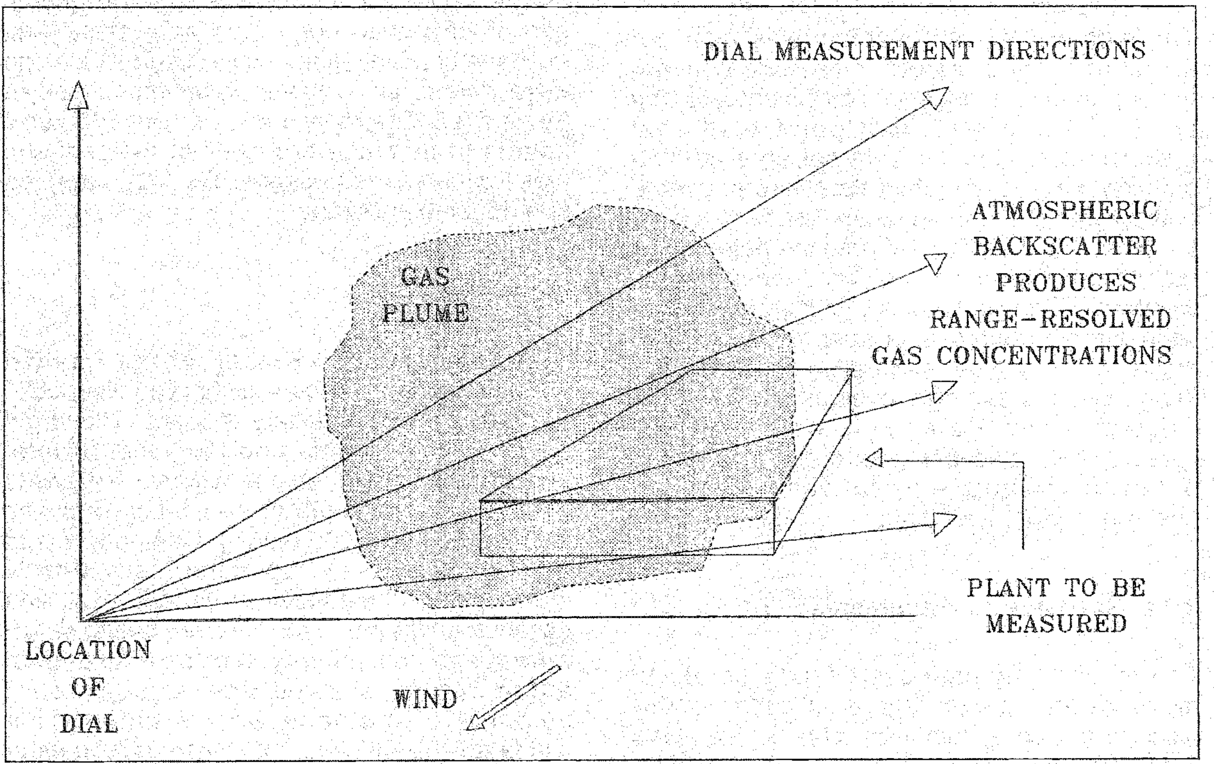


Figure 6

Figure 7 – Arrangement for flux measurement using DIAL



3.3.2 DIAL measurements

The DIAL technique measures directly the concentration of the selected gas as a function of range up to the maximum range along the selected line-of-sight direction.

Thus, by scanning this line-of-sight the spatial concentration profile of the gas is obtained.

The total amount of gas between any two distances in the measurement direction can also be determined. If this measurement direction is then scanned in a plane downwind of an industrial plant, in the manner similar to that shown in Figure 7, the total amount of gas passing through the plane can be measured. This can then be combined with data on wind speed and direction obtained simultaneously, to produce directly the total flux of gas passing through the measurement plane. If similar measurements are carried out upwind, the total flux of gas emitted by the site can be determined.

3.4 Field measurements using the remote monitoring facilities

A range of field measurement exercises have been carried out using the NPL facilities in order to illustrate the flexibility and advantages of the techniques and to show some of their unique monitoring capabilities [8]. Examples of these are outlined below.

3.4.1 SO_2 measurements

Three-dimensional profiles of atmospheric sulphur dioxide concentrations at various distances downwind of power plant and oil refineries have been measured with the DIAL facility. In an alternative mode of operation, the laser beam can be made to scan the emitted plume close to the stack exit. This allows the total SO_2 emissions of different stacks to be measured non-intrusively from one location.

3.4.2 NO_x measurements

DIAL measurements of NO and NO_2 were carried out around selected industrial and urban areas as part of a programme to demonstrate UK compliance with the European Community Directive on NO_2 air quality. Simultaneous remote measurements of NO and NO_2 have been made at the exits of industrial stacks and further work has also been carried out to investigate the dispersion and chemical reactions occuring in industrial plumes and urban atmospheres.

3.4.3 Coal processing plant

The mobile long-path system was used for measurements of carbon monoxide concentrations *within* an industrial plant manufacturing solid fuel bricketts from pulverised coal granules. Optical paths were set up inside the building whilst the mobile facility was located outside with the infrared beam first directed into the plant and then steered onto the paths being monitored. Carbon monoxide concentrations were measured continuously, in the presence of considerable quantities of dust and fume, and the results provided information on the fluctuations and the average levels of carbon monoxide to which the workers were exposed; these results also demonstrated correlations between variations in concentration and changes in plant operation.

3.4.4 Roadside measurements

The mobile long-path system was set up to measure the concentrations of carbon monoxide produced by motor vehicles driving along a double-level road system in London. The objective was to obtain path-integrated concentrations of carbon monoxide at different distances away from the road in order to test theoretical models which predict the dispersion of the gases from the vehicles. The facility was set up to monitor paths parallel to the road system, at different distances from the road. These paths were acquired in rapid succession, thereby operating the long-path system in a manner similar to a "boundary fence" industrial monitor.

The results provided the concentrations of carbon monoxide as a function of distance from the road and demonstrated that, contrary to theory, the moving vehicles were not themselves the dominant mechanism of gas dispersion, and that carbon monoxide concentrations in the different paths depended strongly on wind speed and direction.

3.4.5 Landfill site measurements

Landfill sites generate a number of waste gases through chemical reactions in the soil, one of the emitted gases being methane. This can give rise to problems and has caused explosion. It is therefore necessary to locate the major gas-emitting areas in landfill sites, and to quantify the total amount of methane emitted. Current methods are unable to provide accurate data on this.

One example of a landfill site surveyed by the mobile diode-laser facility was a gravel quarry, part of which had been filled with refuse. The methane concentrations emitted across the site were measured in the manner discussed in Section 3.3. The measured flux was 160 cubic metres of methane per hour at atmospheric pressure which represented the total emission rate from the entire site.

3.4.6 Coke ovens

Measurements were made of the fugitive emissions produced by a plant producing coke by heating coal in a battery of ovens. The target gases were ammonia and methane. Several optical paths were set up at different elevations along the entire length of the battery of ovens which were about 200 m long. One path was at the same level as the top of the ovens, directly in the path of the plumes of hot grit, dust, and gaseous emissions. The measurements, which were made continuously over path lengths of about 240 m, showed that no significant amounts of methane were emitted. This validated the efficiency of the gas extraction system attached to the ovens. However, significant concentrations of ammonia were measured in an adjacent area of the plant. The leaks were identified and their emission rates measured.

3.4.7 Fugitive methane emissions

Both the portable monitor and the mobile infrared DIAL facility have been employed to determine the methane fluxes produced by grazing cattle and during other agricultural practices. Cattle make significant contributions to the global budge of methane, an important greenhouse gas, and previous methods may have underestimated this contribution. The infrared DIAL facility also has been used to monitor the total flux of methane emitted fugitively by north-sea natural gas terminals.

3.4.8 Oil refinery measurements

The mobile DIAL facility was employed, in collaboration with BP, to monitor the total fluxes of volatile hydrocarbons which are emitted fugitively by oil refineries. As indicated previously, infrared measurements were used to monitor aliphatic compounds, whereas ultraviolet measurements provide greater sensitivity for certain aromatic compounds. One measurement exercise was carried out at a BP-owned oil refinery in Europe. DIAL measurements were made (following the form discussed in Section 3.3) on four separate areas – the crude oil storage tanks, the process area, the product storage tanks and the water-effluent plant. In each area the infrared DIAL system scanned spectrally to identify the major hydrocarbon constituents present. The spatial concentration distribution was determined by scanning the laser beam in the selected area.

Table 4 gives the time-weighted hourly mean values of the hydrocarbon fluxes measured during all the periods in each area. These results were taken in summer conditions and were not therefore representative of the annual emissions. The NPL results were therefore combined by BP with API calculations to estimate the variations in emissions with time of year. These calculations took account of, for example, variations in windspeed and ambient temperature, and allowed for solar heating of the tankage in summer. The DIAL measurements were then scaled to derive the estimated annual values of the total fluxes of fugitive hydrocarbons, as shown in table 4.

TABLE 4

Example of DIAL Oil Refinery Measurements

	Mean Measured Flux (kg/hr)	Analyzed Flux (tonnes/ year)
Crude Tankage 9 tanks- 35 000 m^3 each)	238	570- 970
Product Tankage (40 tanks- 2 000 to 21 000 m^3)	402	1 130-1 700
Water Treatment	36	280- 310
Process Area	250	1 970-2 190
TOTALS	**926**	**3 950-5 200**
(Refinery design throughput 5 x 10^6 tonne/year)		

3.4.8 Measurements of aromatic hydrocarbons

The DIAL facility was used to monitor the atmospheric concentrations and concentration profiles of toluene in the atmosphere close to terminals where road tankers transporting petrochemical products were loaded. The same facility can also monitor benzene and other aromatic hydrocarbons, and the fluxes of these gases emitted by industrial sites haves been determined.

Care must be taken when monitoring aromatic hydrocarbons in the ultraviolet region in the presence of other spectrally-interfering pollutant species. Laboratory measurements have been carried out to determine the sensitivity of DIAL measurements of benzene and toluene measurements to the presence of atmospheric ozone, nitrogen dioxide, sulfur dioxide and xylene [8]. Examples of the results are given in Table 5. These cross interferences in DIAL measurements are small. However, significantly worse interference effects are possible with other instruments which have lower spectral resolution.

TABLE 5

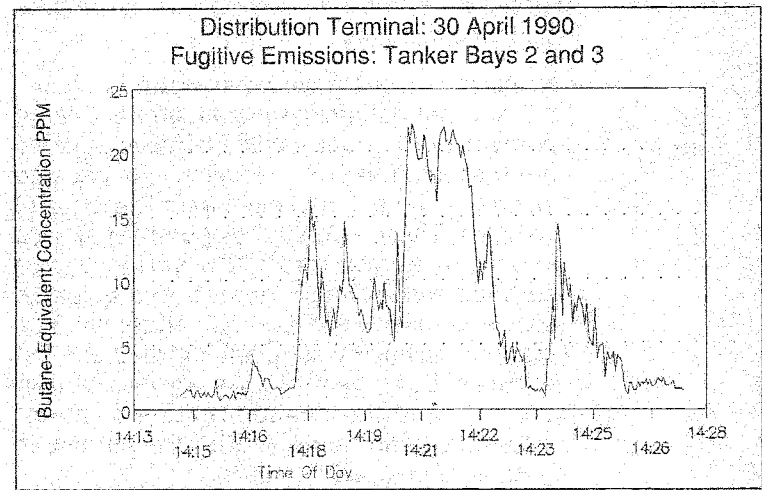
Differential absorption coefficients (base e) at the wavelengths chosen for measuring toluene and benzene at $atm^{-1}cm^{-1}$. Entries shown 0 indicate that the interference has been calculated using the data available and is less than 0.1 % of the toluene or benzene values.

Interferent	Toluene Wavelengths [$atm^{-1}cm^{-1}$]	Benzene Wavelengths [$atm^{-1}cm^{-1}$]
Toluene	29.5	0
Benzene	0	60.8
o-xylene	– 2.3	0.8
m-xylene	– 0.6	0
p-xylene	27.0	0
Ozone	– 13	– 3.8
Nitrogen dioxide	0.04	– 0.06
Sulfure dioxide	– 0.09	0.1

3.4.9 Long-path measurements at loading terminal

Measurements were made at various locations in a road-tanker loading terminal to assess the ambient levels of hydrocarbons using the portable long-path monitor. Figure 8 shows an example of the measured fugitive hydrocarbon concentrations produced downwind of the loading bays, when road tankers were being loaded with petroleum spirit.

Figure 8



The measurements outlined above demonstrate the diverse applications of these open-path and remote techniques in evaluating, controlling and reducing toxic, flammable, and environmentally damaging emissions from industrial plants and other sources such as landfill sites.

3.5 Validation of remote monitoring techniques

A number of diagnostic techniques are built into the NPL remote monitoring facilities as part of the protocol used for checking the validity of their measurements in the field. For example:

- the wavelengths of the transmitted DIAL radiation are monitored on line using a calibrated wavemeter and a set of calibration gas cells. These cells are filled with known mixtures of the gases being monitored, and their concentrations are traceable to gas standards held in the NPL primary gas standards facility. These allow the accuracy of the atmospheric measurements to be checked by monitoring the absorption of the DIAL radiation which occurs through the gas cells;
- similar gas cells with a range of concentrations are inserted regularly into the return beam in the receiving telescope of the DIAL system prior to the detection system to confirm the linearity and accuracy of the complete detection system;
- the NPL long-path monitor also uses cells containing known-concentration mixtures which are inserted regularly into the optical beam to check the linearity and accuracy of the instrumental response, and a "zero-path" measurement is performed to check its zero.

In addition to these calibration checks, which are performed automatically during field measurements, a number of field validation exercises have been carried out. Examples include the following:

- Intercomparisons have been made in chemical and petrochemical plants where a large number of different volatile organic species are present. The DIAL radiation was directed along the same line-of-sight as a line of point samples. These operated by pumping air at a known rate time through a series of absorption tubes which absorb hydrocarbon species in the range $C_2 - C_8$ efficiently. The results obtained by the point samples and the infrared DIAL techniques agreed within ± 15 %, and the concentrations of atmospheric toluene measured by the ultraviolet DIAL agreed to within ± 20 %;
- As noted previously, the ultraviolet DIAL facility was used to monitor the fluxes and concentrations of sulfur dioxide emitted by industrial combustion stacks. These stacks were also instrumented with calibrated in-stack sampling instruments. The results of the two sets of measurements agreed to within ± 10 %.
- Field trials have been carried out in collaboration with British Gas and BP. These have utilised an instrumental facility which enables known fluxes of methane and other gases to be emitted from a 1 metre diameter stack. Measurements were made downwind of the source using the infrared DIAL facility. These were supplemented by an array of meteorological sensors to determine the wind field. The DIAL flux measurements agreed with the emitted fluxes to within ± 12 %.

3.6 Commercial exploitation of remote monitoring techniques

Several avenues are being pursued for commercial exploitation of the techniques being developed by NPL. These include:

3.6.1 Portable, low-cost monitor

This instrumentation is being manufactured by the Siemens Plessey Company under licence from the UK Government. Technical personnel from the Company have worked closely with NPL scientists to assimilate the technology and ensure rapid production of commercial prototypes. Commercial instruments are now available. The commercial products should be cost effective by comparison with *in situ* monitors, be flexible enough to measure accurately a number of industrially-important gases, be useful in industrial diagnostic and control, and have application in monitoring a wide range of industrial toxic and flammable hazards.

3.6.2 Multi-wavelength differential-absorption lidar

The NPL multi-wavelength DIAL facility was developed partly in collaboration with the British Petroleum Company. As a first step, NPL has provided technology transfer to enable BP scientists to construct their own mobile facility. This was designed to incorporate some of the features needed for a commercial prototype. Present research at NPL is aimed at developing reliable, autonomous, multiwavelength sources and detection systems for incorporation into commercial instrumentation, and discussions are underway with UK manufacturers with the aim of commercialising the DIAL technology further.

3.7 Validation and utilisation of open-path and remote monitoring technology

- NPL offers a measurement service, where open-path techniques are applicable, to industrial and government customers. These are being used, for example, to measure fugitive losses of hydrocarbons produced by the chemical and petroleum industries, with a view to improving the UK national emission inventory;
- A specification standard is being prepared by BSI with a view to its uptake as a CEN standard. This work is being carried out in consultation with interested organisations in Germany.
- Open-path and remote measurements techniques, once developed commercially, will need to be accepted by the regulatory authorities in the appropriate countries. To this end, discussions are underway in the UK on methods required for validating and assessing the quality of these techniques, and with organisations responsible for regulating emissions of industrial pollution. It is anticipated that this will lead to these techniques becoming part of the "best available technology" for monitoring industrial emissions. It is also anticipated that this kind of technology will be taken up by industry to prevent emissions which may be hazardous, environmentally damaging or economically undesirable.
- NPL is now developing a National Calibration Facility which will employ long path-length gas cells and accurate nationally-traceable gas standards to calibrate and validate the performance characteristics of different remote open-path and range-resolved measurement techniques as they become available commercially.

References

[1] A.J. Davenport and P.T. Woods, The Preparation and Certification of Certified Reference Mixtures by the National Physical Laboratory, NPL Report QU 81, December 1989.

[2] A.J. Davenport, F. Freshwater, J. King, D. Merrifield, R.H. Partridge and P.T. Woods. Analyses of Reference Gas Mixtures for the Community Bureau of Reference, CEC, NPL Quantum Metrology Report, December 1985.

[3] E.E. Hughes, A.J. Davenport, P.T. Woods and W. Zielinski, Intercomparison of a Range of Primary Gas Standards prepared by the National Institute of Standards and Technology USA, and the National Physical Laboratory UK, J. Environ. Science and Technology **25**, 671-676, 1991.

[4] E. De Saeges and E. Tsani-Bazaca, EC Intercomparison of VOC Measurements, Report of Central Laboratory of Air Pollution, Joint Research Centre, Commission of the European Communities, 1992.

[5] R.H. Partridge, Long-path Monitoring of Atmospheric Pollution, J. Measurement and Control **23**, 293-298, 1991.

[6] P.T. Woods and R.H. Partridge, New Techniques for Gas Detection and Air Pollution Monitoring, NPL Report QU 88, January 1991.

[7] R.H. Partridge and I.H. Curtis, Monitoring of Gaseous Pollutants by Tunable Diode Lasers, ed R. Grisay, G. Smidtke, H. Tacke and G. Restelli, Kluwe Academic Publishers, London 1989.

[8] P.T. Woods, R. H. Partridge, M. J. Milton, B.W. Jolliffe and N. R. Swann, Remote Sensing Techniques for Gas Detection, Air Pollution and Fugitive Loss Monitoring, J. Air & Waste Management Association – to be published 1992.

[9] M. J. Milton, P. T. Woods, B. W. Jolliffe, N. R. Swann and T. J. McIlveen, Appl. Phys. **B55**, 41-45, 1992.

NEW STRUCTURES AND PROCEDURES FOR THE DEVELOPMENT OF OIML INTERNATIONAL RECOMMENDATIONS AND DOCUMENTS

Foreword

The need to re-examine the OIML Pilot and Reporting Secretariats' working methods was first expressed and discussed during the Eighth International Conference of Legal Metrology, held in Sydney (Australia) from 24 to 28 October 1988; the International Committee of Legal Metrology was instructed to study this matter in detail and the Bureau was requested to review the working methods and to see how its complete application by the Secretariats might be better assured.

At the Committee meeting in 1989, more radical changes were proposed (based, whenever possible, on the IEC/ISO Directives) and it was decided to elaborate a brand-new document, *Directives for the technical work* in two parts:

- Part 1: Structures and Procedures for the Development of OIML International Recommendations and Documents
- Part 2: Guide to the Drafting and Presentation of OIML International Recommendations and Documents

The International Committee of Legal Metrology (CIML) approved Part 2 at its meeting in 1991, and Part 1 at its meeting in 1992. The final version of these documents is now widely diffused and the essential sections of Part 1 are explained in this paper.

The new work structure that has been established (technical committees) is also given at the end of this paper; the list of the subcommittees should be available in the near future and will be published later in the OIML Bulletin.

Why new structures and procedures?

Living in a changing world, legal metrology is evolving and OIML must adapt to these developments and even try to anticipate them to be able to respond immediately to the new needs. In addition to the creation and development of the *OIML Certificate System*, two main directions of change were proposed:

- To redefine the programs of activities

OIML must concentrate its activities on matters that are specifically in the domain of legal metrology; these activities concern instruments that are used in essential fields such as trade, health, safety, and preservation of the environment, and which may be subject to legal control.

- To improve the work methods

It was necessary to find work methods that provide both excellent technical quality and a broad international participation in the development of drafts so that they could be approved quickly by the International Committee of Legal Metrology (CIML), without extending the time scale and possibly even shortening it. To summarize, we should produce better Recommendations and Documents more quickly, rendering more effective the participation of all interested parties.

The previous working methods were nearly twenty years old and although they had given a decisive thrust to the work, there existed some deficiencies and situations that were not acceptable, for example:

- Countries or regional organizations would develop their own regulations because OIML had not been able to produce the corresponding Recommendations in sufficient time; it would be very difficult for such countries or organizations to adapt their national or regional regulations later to OIML's Recommendations; *producing Recommendations more quickly is therefore a priority.*
- A draft produced and accepted by a reporting secretariat would wait one or two years before being accepted by the pilot secretariat and then approved by CIML; *OIML shall make its work methods less bureaucratic.*
- A reporting secretariat may have worked for several years on a subject which has no priority and no international interest; *the work topics shall be screened and clearly defined a priori.*

The main advantages of the new work methods will be explained section by section in the following paper and the significant differences will appear in italics.

Terminology and abbreviations

Since some of our readers are not fully acquainted with OIML terminology, some of the terms and abbreviations used in this paper are given below.

An **OIML International Recommendation** (hereafter Recommendation) dealing with a given category of measuring instruments is a model for establishing national or regional regulations *concerning the metrological characteristics required of the measuring instrument concerned, the methods and equipment for checking the conformity of instruments with the established requirements, and the format of the test reports.*

An **OIML International Document** (hereafter Document) is *a text of informative nature to help and improve the work of the metrology services.*

A **field of technical activity** is *any part of the OIML general field of work that may be covered by, in general, one technical committee; it may concern a quantity (mass, temperature,...) or an application (pollution, medical instruments,...) or a general subject (terminology, control of instruments,...).*

A **project** is *any approved item of work entering into a field of technical activity and intended to lead to the publication of a new or revised Recommendation or Document.*

An **internal body** is, *in relation to a given OIML technical committee or subcommittee, any other OIML technical committee, subcommittee, technical advisory group or other technical body.*

An **external organization** is *any international or broadly based regional organization that has activities in fields connected with those of OIML.*

Main abbreviations:

TC: *technical committee*
SC: *subcommittee*
WG: working group
CD: *committee draft (TC or SC)*
DR: draft Recommendation
DD: draft Document

Structures and responsibilities for the technical work

The **International Conference of Legal Metrology** is the highest authority of OIML; it meets every four years and one of its responsibilities is to sanction OIML Recommendations; **the International Committee of Legal Metrology** ***(CIML)*** *is authorized by a decision of the Conference, to approve Recommendations* at its annual meetings for immediate publication; it also approves Documents by correspondence.

Other tasks and responsibilities of **CIML** related to the technical work are, in brief: definition of OIML's general technical program, planning of work in new fields of legal metrology, establishment and disbandment of TCs and SCs, allocation of secretariats of TCs and SCs, acceptance of proposals for new projects, allocation of priorities and monitoring the progress of the work.

The **Presidential Council** has an important role in monitoring the work of TCs, SCs, and BIML.

The International Bureau of Legal Metrology (BIML) is the permanent secretariat of OIML and is responsible for the preparation of meetings of the Conference and CIML; BIML shall therefore *participate in the development of Recommendations and Documents once they have reached the CIML or Conference* level. BIML is also responsible for the dissemination of information and uses the OIML Bulletin to announce that a working draft has reached the committee stage (1st CD), the issuance of new OIML publications, etc.

The **technical committees (TCs) and their subcommittees (SCs)** are responsible for the development of Recommendations and Documents falling within the scopes of the technical fields allocated to them by CIML on the basis of approved projects. *A given project may be developed either by the TC itself or by one of its SCs;* this is an important difference between the new and the former working methods. The TCs also have the following responsibilities:

- *long-term programming of their work and that of the SCs attached to them*
- *coordination of their activities and meetings with those of such SCs*
- *monitoring the activities of such SCs*
- *reporting these actions to CIML*

All **Member States** have the right and are encouraged to participate actively in the work of TCs and SCs (as P-members) or to be informed of the progress of their work (as O-members). *P-members are obliged to comment and vote on committee drafts and whenever possible, to attend meetings; O-members have the right to submit comments and to attend meetings.*

In addition to volunteering Member States, TCs or SCs include **liaison internal bodies and external organizations** concerned; it is particularly important to associate external organizations in the work to insure a beneficial cooperation and to avoid duplication of work; *the TCs and SCs are responsible for maintaining liaisons.*

Proposals for work in new fields of technical activity

The new procedures clearly define *who has the right to make a proposal for work in a new field of technical activity, how this proposal should be submitted to BIML, the approval by CIML (a proposal supported by a majority of CIML Members is accepted), and the extension of the scope of a TC to include this new field (approved with a two-thirds majority of the TC P-members), or the creation of a new TC (if appropriate).*

Establishment or disbandment of technical committees and subcommittees

The new procedures specify the reasons and procedures for establishing or disbanding a TC or SC, or for changing the scope of an existing TC; the rules are clearly defined to increase the general efficiency of the working system.

- Establishment or change of the scope of a technical committee

This may be decided by CIML for the following reasons: *in response to a proposal for work in a new technical activity, excessive or too widely diffused work load, or to change an existing SC into a new TC.*

Procedure in brief:

- Proposal sent to BIML in a specified form
- *Consultation of the different interested parties (3 months)*
- *Establishment if*
  - *either at least 10 Member States have expressed their intention to participate as P-members, the number of CIML Members not supporting the proposal being less than half the total number of CIML Members,*
  - *or at least 5 Members States have expressed their intention to participate as P-members, the proposal being, in addition, supported by a two-thirds majority of CIML Members, and*
  - *a Member State volunteers to undertake the work of the secretariat.*

The same procedure applies for the establishment of a new SC: proposal is submitted by the secretariat of the parent TC with the support of a two-thirds majority of the TC P-members.

- Disbandment of technical committees and subcommittees

CIML may decide to disband a TC when its scope no longer corresponds to the general working policy of OIML, *when projects may be developed more efficiently within another technical committee,* or when the number of P-members falls below the limit specified; CIML may decide to dissolve a SC *upon recommendation of the parent TC or for other specific reasons; however, it may not be disbanded until its responsibility for developing and maintaining Recommendations and Documents has been transferred to another TC or SC, or until such existing Recommendations and Documents have been withdrawn by CIML.* This last rule is an important new safeguard clause.

Discipline and efficiency

To avoid long periods of apparent inactivity of TCs or SCs, the deadlines, timetables and obligatory participation in activities by the P-members must be respected. The complete description of the working rules that must be considered by the secretariats of the TCs and SCs are not in the scope of this paper; nevertheless, two examples are given to highlight the new means for increasing the discipline and efficiency:

- A P-member of TCs or SCs has *the obligation to participate actively in the work (to contribute in meetings, to comment on drafts, and to vote when requested by the TCs or SCs); if it fails, a reminder is sent and in the absence of a satisfactory response, the status is changed to that of O-member. After 12 months, a request to regain P-membership may be made.*

- A TC may propose, by a majority vote of the P-members, that the responsibility for a subcommittee should be reassigned to another Member State.

Flexibility

To increase the flexibility, *working groups may be established by the TCs or SCs for the accomplishment of specific tasks that require a limited number of experts: the decisions of a working group do not constitute a commitment for the P-members and bodies or organizations that are represented by these experts.* There are no formal rules of procedure for working groups other than those established by the parent TC or SC, and:

- *the convener is appointed by the TC or SC;*
- *the work and the target dates are specified;*
- *the working group is disbanded when the assigned task is completed.*

Development of Recommendations and Documents

The five stages

The five stages in the development of OIML Recommendations and Documents are summarized in the following table.

When applicable, the allowed delays are specified and an analysis of such delays clearly indicates that the production or the review of Recommendations and Documents may be completed more quickly than in the past. *In fact, the preparatory stage shall be completed in less than 2 years and the committee stage in less than 3 years.*

Stage of development	Procedure in brief	Allowed delays (in months)
1 Proposal stage	Proposal for a project within the scope of a TC or a SC (if not in the scope, the procedure must be supplemented by the acceptance of the new field of activity and the eventual creation of a new TC)	
	Vote by the TC (unless it is the proposer)	3
	Acceptance by CIML	3
2 Preparatory stage	The secretariat prepares the first committee draft or proposes to the P-members to constitute one or more working groups to complete this work (decision made by a majority vote)	
	Submission of the first committee draft to the TC or SC	Varies according to the nature and the complexity of the work
3 Committee stage	The secretariat circulates the first committee draft for comment	3 to 6
	The secretariat circulates copies of comments received and indicates its intentions	1
	a) to prepare a 2nd CD taking into account the comments and to circulate it for vote, or	3
	b) to prepare a 2nd CD taking into account the comments and to circulate it for comments, followed by procedure a), or	3
	c) to discuss the 1st CD and the comments received at a meeting.	
	Decision to register a CD as a draft Recommendation or Document, subject to two conditions: 1) approval by at least a two-thirds majority of the total number of P-members, and 2) conclusion by the secretariat that either: - there is little or no prospect of obtaining wider acceptance of the CD, or - it is in the general interest of the Organization's Member States that discussion of the CD should not be further prolonged.	
	The secretariat sends the draft to BIML, accompanied with an explanatory note	4

Stage of development	Procedure in brief	Allowed delays (in months)
4 Approval stage	Draft Recommendation or Document sent by BIML to CIML Members for comment and vote, and to external organizations concerned for comment BIML sends the results of the votes and copies of the comments and indicates the subsequent action, i.e. 1) DD either approved with a simple majority of favorable votes and no objections of principle to its publication, or returned to the TC or SC for reconsideration 2) DR either submitted at the next CIML meeting for approval (or Conference for direct sanction), or returned to the TC or SC for reconsideration.	4 or less
5 Publication stage	BIML conducts a final verification of the text in close cooperation with the secretariat of the TC or SC concerned. After its publication, a Recommendation approved by CIML shall be sanctioned by the next Conference.	

Meetings of technical committees or subcommittees

A meeting must be called when the work (to discuss and/or vote on a CD or a draft, to discuss and approve a program of activities) may be accomplished more expeditiously than by correspondence. The secretariat must inform its members if possible one year in advance of the estimated dates and location of the meeting. The TCs or SCs coordinate their meetings to facilitate a large participation of delegates.

PhD

The technical committees and their fields of activity

TC 1	Terminology	POLAND
TC 2	Units of measurement	AUSTRIA
TC 3	Metrological control	USA
TC 4	Calibration and verification devices	SLOVAK REPUBLIC
TC 5	Electronic instruments	NETHERLANDS
TC 6	Prepackaged products	USA
TC 7	Measuring instruments for length associated quantities	UK
TC 8	Instruments for measuring quantities of fluids	SWITZERLAND
TC 9	Instruments for measuring mass and density	USA
TC 10	Instruments for measuring pressure, force, and associated quantities	USA
TC 11	Instruments for measuring temperature and associated quantities	GERMANY
TC 12	Instruments for measuring electrical quantities	GERMANY
TC 13	Measuring instruments for acoustics and vibration	GERMANY
TC 14	Measuring instruments used for optics	HUNGARY
TC 15	Measuring instruments for ionizing radiations	RUSSIA
TC 16	Instruments for measuring pollutants	USA
TC 17	Instruments for physico-chemical measurements	RUSSIA
TC 18	Medical measuring instruments	GERMANY

NOUVELLES STRUCTURES ET PROCÉDURES POUR L'ÉLABORATION DES RECOMMANDATIONS ET DOCUMENTS INTERNATIONAUX DE L'OIML

Introduction

C'est à l'occasion de la Huitième Conférence Internationale de Métrologie Légale qui s'était tenue à Sydney (Australie) du 24 au 28 octobre 1988 qu'avait été évoqué pour la première fois le besoin de réexaminer les méthodes de travail des Secrétariats Pilotes et Rapporteurs de l'OIML; le Comité International de Métrologie Légale avait été chargé d'étudier cette matière en détail et il avait été demandé au Bureau de revoir les méthodes de travail et de voir comment leur complète application par les Secrétariats pourrait être mieux assurée.

Lors de la réunion du Comité de 1989, des changements plus radicaux furent proposés (fondés, si possible, sur les Directives CEI/ISO) et il fut décidé d'élaborer un tout nouveau document *Directives pour les travaux techniques* en deux parties:

- Partie 1: Structures et Procédures pour l'élaboration des Recommandations et Documents Internationaux de l'OIML
- Partie 2: Guide pour la rédaction et la présentation des Recommandations et Documents Internationaux de l'OIML

Le Comité International de Métrologie Légale (CIML) a approuvé la Partie 2 lors de sa réunion de 1991 et la Partie 1 lors de sa réunion de 1992. La version finale de ces documents est maintenant largement diffusée et cet article explique les points essentiels de la Partie 1.

La nouvelle structure qui est établie au moment où nous imprimons ces lignes (les comités techniques) est également donnée en fin d'article; la liste des sous-comités techniques devrait être disponible prochainement, et sera publiée dans un prochain Bulletin OIML.

Pourquoi des nouvelles structures et procédures?

Dans un monde mouvant, la métrologie légale évolue, et l'OIML doit s'adapter à ces changements et même s'efforcer de les anticiper afin de donner une réponse immédiate aux nouveaux besoins au moment où ceux-ci apparaissent. C'est pourquoi, en plus de la création et du développement du *Système de Certificats OIML* qui n'est pas l'objet de cet article, deux axes principaux de changements furent proposés:

- Redéfinir les programmes d'activité

L'OIML doit concentrer ses activités dans des matières spécifiques du domaine de la métrologie légale; ces activités concernent les instruments qui sont utilisés dans des domaines essentiels tels que le commerce, la santé, la sécurité et la préservation de l'environnement, et qui peuvent être soumis à un contrôle légal.

- Améliorer les méthodes de travail

Il importait de trouver les méthodes de travail permettant à la fois une excellente qualité technique et une large participation internationale pour élaborer des projets qui puissent être approuvés rapidement par le Comité International de Métrologie Légale (CIML), c'est-à-dire sans allonger les délais, mais même en les raccourcissant, si possible. En bref, il faudrait produire de meilleurs Recommandations et Documents plus vite, en s'efforçant de rendre effective la participation de toutes les parties intéressées.

Les anciennes méthodes de travail avaient près de 20 ans et, bien qu'elles eussent donné une impulsion décisive au travail, elles ont, depuis, montré certaines déficiences et certaines situations n'étaient plus acceptables, par exemple:

- Des pays ou organisations régionales développant leurs propres réglementations parce que l'OIML n'a pu produire à temps les Recommandations correspondantes ; il peut être très difficile pour ces pays et organisations d'adapter par la suite leurs réglementations nationales ou régionales aux Recommandations de l'OIML; *produire des Recommandations plus rapidement est donc une priorité.*
- Un projet terminé et accepté par un secrétariat rapporteur attendant un ou deux ans avant d'être accepté par le secrétariat pilote, pour être alors approuvé par le CIML; *l'OIML doit rendre ses méthodes de travail moins bureaucratiques.*
- Un secrétariat rapporteur travaillant plusieurs années sur un sujet sans priorité ni intérêt international; *les sujets de travail doivent être sélectionnés et clairement définis a priori.*

Les principaux avantages des nouvelles méthodes de travail seront expliqués point par point dans cet article et les différences significatives seront mises en évidence par le mode italique.

Terminologie et abréviations

Etant donné que certains de nos lecteurs ne sont pas parfaitement familiarisés avec le vocabulaire de l'OIML, nous donnons ci-après plusieurs termes et abréviations utilisés dans cet article.

Une **Recommandation Internationale OIML** (dénommée ci-après Recommandation) se rapportant à une catégorie donnée d'instruments de mesure, constitue un modèle pour établir des réglementations nationales ou régionales *traitant des caractéristiques métrologiques exigées des instruments de mesure concernés, des méthodes et des équipements du contrôle de la conformité des instruments avec les exigences définies, et de la présentation des rapports d'essais.*

Un **Document International OIML** (dénommé ci-après Document) constitue un texte *à caractère informatif destiné à aider et à améliorer le travail des services de métrologie.*

Un **domaine d'activité technique** *définit toute partie du domaine général de travail de l'OIML pouvant être couverte généralement par un comité technique; il peut s'agir d'une grandeur (masse, température, etc.) ou d'une application (pollution, instruments médicaux, etc.) ou d'un sujet de portée générale (terminologie, contrôle d'instruments, etc.).*

Un **thème** *définit tout sujet de travail approuvé s'inscrivant à l'intérieur d'un domaine d'activité technique et susceptible d'aboutir à la publication d'une Recommandation ou d'un Document nouveaux ou révisés.*

Un **organe interne** *définit, par rapport à un comité technique ou sous-comité donné, tout autre comité technique ou sous-comité technique de l'OIML, groupe ad-hoc ou autre organe technique.*

Une **organisation externe** *définit toute organisation internationale ou fortement implantée au niveau régional, ayant des activités dans des domaines connexes à ceux de l'OIML.*

Abréviations principales:

TC: *comité technique*
SC: *sous-comité*
WG: groupe de travail
CD: *projet de comité (TC ou SC)*
DR: projet de Recommandation
DD: projet de Document

Structures et responsabilités pour le travail technique

La **Conférence Internationale de Métrologie Légale** est la plus haute autorité de l'OIML; elle se réunit tous les quatre ans et une de ses responsabilités est la sanction des Recommandations OIML; le **Comité International de Métrologie Légale (CIML)** *a été habilité par une décision de la Conférence à approuver, lors de ses réunions annuelles, les Recommandations pour les publier immédiatement;* il approuve également les Documents, par correspondance.

D'autres tâches et responsabilités du **CIML** concernant les travaux techniques sont en bref: définition du programme général des travaux techniques de l'OIML, planning de travail dans les nouveaux domaines de métrologie légale, établissement et suppression des TC et SC, établissement des secrétariats des TC et SC, acceptation des propositions de nouveaux thèmes, détermination des priorités et contrôle de l'avancement des travaux,etc.

Le **Conseil de la Présidence** a un rôle important dans la supervision du travail des TC, SC et du BIML.

Le **Bureau International de Métrologie Légale (BIML),** secrétariat permanent de l'OIML, est responsable de la préparation des réunions de la Conférence et du CIML et *doit donc participer au développement des Recommandations et Documents dès qu'ils ont atteint le stade de la Conférence ou du CIML;* le BIML est aussi responsable de la dissémination de l'information et utilise le Bulletin de l'OIML pour annoncer qu'un projet a atteint le stade de comité (1er CD), les nouvelles publications de l'OIML, etc.

Les **comités techniques (TC)** et les **sous-comités (SC)** sont responsables du développement des Recommandations et Documents qui relèvent du domaine technique dont ils sont chargé par le CIML sur la base des thèmes approuvés. *Un thème donné peut être développé soit par le TC lui-même, soit par un des SC;* c'est une différence fondamentale par rapport aux anciennes méthodes de travail. Les TC ont également les responsabilités suivantes:

- *programmation à long terme de leur travail et de celui de leurs SC rattachés*
- *coordination de leurs activités et réunions avec celles de leurs SC*
- *supervision des activités de leurs SC*
- *rapport de ces activités au CIML*

Tous les **Etats Membres** ont le droit et sont encouragés à participer activement aux travaux des TC et SC (comme membres-P) ou d'être informés sur l'avancement de ces travaux (comme membres-O). *Les membres-P sont tenus de commenter et de voter sur les projets de comité et de participer aux réunions dans la mesure du possible; les membres-O ont le droit de soumettre des commentaires et d'assister aux réunions.*

En plus des Etats Membres volontaires, les TC et SC incluent des **organes de liaison internes** et des **organisations extérieures** concernés; il est particulièrement important d'associer des organisations extérieures aux travaux pour assurer une coopération bénéfique et pour éviter que les travaux ne soient faits en double; *les TC et SC sont responsables du maintien des liaisons.*

Propositions de nouveaux domaines d'activité

Les nouvelles procédures définissent clairement *qui a le droit de faire des propositions de travail dans des nouveaux domaines d'activité, dans quelle forme ces propositions doivent être soumises au BIML, la procédure d'approbation par le CIML (une proposition doit être soutenue par la majorité des Membres pour être acceptée), ainsi que l'extension du domaine d'activité d'un TC (approuvée avec la majorité des deux-tiers des membres-P), ou la création d'un nouveau TC (si approprié).*

Etablissement et suppression des comités techniques et des sous-comités

Les nouvelles procédures spécifient en détail les raisons et procédures pour l'établissement ou la suppression d'un TC ou SC, ou la modification du domaine d'activité d'un TC existant; les règles sont clairement définies afin d'accroître l'efficacité du système de travail.

- Etablissement ou changement du domaine d'activité d'un comité technique

Il est demandé au CIML d'en décider pour les raisons suivantes: *en réponse à une proposition de travail dans un nouveau domaine d'activité; une charge de travail excessive ou trop dispersée; ou pour changer un SC existant en un nouveau TC.*

Procédure en bref:

- Proposition envoyée au BIML *au moyen du formulaire spécifié*
- *Consultation des différentes parties intéressées (3 mois)*
- *Etablissement si*
  - *soit au moins 10 Etats Membres ont exprimé leur intention de participer comme membres-P, le nombre de Membres du CIML ne soutenant pas la proposition étant inférieure à la moitié du nombre total de Membres,*
  - *soit au moins 5 Etats Membres ont exprimé leur intention de participer comme membres-P, la proposition étant soutenue par la majorité des deux-tiers des Membres du CIML,*
  - *et si un Etat Membre est volontaire pour se charger du secrétariat.*

La même procédure s'applique pour l'établissement d'un nouveau SC: la proposition est soumise par le TC parent si elle est soutenue par une majorité des deux-tiers des membres-P du TC.

- Suppression des comités techniques et des sous-comités

Le CIML peut décider de supprimer un TC quand son domaine d'activité ne correspond plus à la politique générale de travail de l'OIML, *quand les thèmes peuvent être développés plus efficacement au sein d'un autre TC,* ou quand le nombre de membres-P tombe en dessous de la limite spécifiée; le CIML peut décider de supprimer un SC *sur recommandation du TC parent ou pour d'autres raisons précises; cependant il ne pourra être supprimé tant que sa responsabilité de développer et de maintenir les Recommandations et Documents n'aura pas été transférée à un autre TC ou SC, ou que de ces Recommandations et Documents n'auront pas été supprimés par le CIML.* Cette règle constitue une nouvelle clause de sauvegarde importante.

Discipline et efficacité

Afin d'éviter les longues périodes d'apparente inactivité des TC et SC, les dates limites, plannings et participations obligatoires des membres-P aux activités doivent être respectés. La description détaillée des règles à suivre par les secrétariats des TC et SC sort du cadre de cet article; néanmoins, deux exemples sont donnés pour mettre en exergue les nouveaux moyens utilisés pour augmenter la discipline et l'efficacité:

- Un membre-P d'un TC ou SC *a l'obligation de participer activement aux travaux (contribuer aux réunions, envoyer des commentaires et voter, quand cela est requis par les TC ou SC); s'il ne le fait pas, un rappel lui est envoyé et, en l'absence d'une réponse satisfaisante, son statut est modifié en membre-O. Après 12 mois d'attente, une demande peut à nouveau être faite pour redevenir membre-P.*
- Un TC peut proposer, à la suite d'un vote à la majorité simple des membres-P, que la responsabilité d'un sous-comité soit assignée à un autre Etat Membre.

Flexibilité

Afin d'augmenter la flexibilité, *des groupes de travail peuvent être établis par les TC et SC pour l'accomplissement de tâches spécifiques qui requièrent un nombre limité d'experts: les décisions d'un groupe de travail ne constituent en aucun cas un engagement pour les membres-P ou organismes et organisations qui sont représentés par ces experts.* Il n'y a pas de règles formelles et procédure applicable par les groupes de travail sinon celles fixées par les TC ou SC parents, ainsi que:

- *le président est désigné par le TC ou SC;*
- *le travail et les délais sont spécifiés;*
- *le groupe de travail est supprimé dès que sa tâche est terminée.*

Développement des Recommandations et Documents

Les cinq stades

Les cinq stades dans l'élaboration des Recommandations et Documents OIML sont résumés au tableau ci-dessous; quand ils sont applicables, les délais autorisés sont indiqués; en les analysant, il apparaît clairement que la production ou la révision des Recommandations et Documents pourra être faite plus rapidement que dans le passé.

En fait, le stade de préparation doit être terminé en moins de 2 ans et le stade de comité en moins de 3 ans.

Stade de développement	Procédure en bref	Délais autorisés (en mois)
1 Stade de proposition	Proposition d'un nouveau thème entrant dans le domaine d'activité d'un TC ou SC (sinon, la procédure doit être adjointe à celle de l'acceptation du nouveau domaine d'activité et de création d'un nouveau TC)	
	Vote par le TC (sauf s'il fait lui-même la proposition)	3
	Acceptation par le CIML	3
2 Stade de préparation	Le secrétariat prépare lui-même le premier projet de comité ou propose aux membres-P de constituer un ou plusieurs groupes de travail pour accomplir cette tâche (décision à la majorité simple)	
	Soumission du premier projet de comité au TC ou SC	Variable en fonction de la nature et de la complexité de la tâche
3 Stade de comité	Le secrétariat fait circuler le 1er CD pour commentaires	3 à 6
	Le secrétariat fait circuler des copies des commentaires reçus et indique ses intentions	1
	a) préparer un 2e CD tenant compte des commentaires et le faire circuler pour vote,	3
	ou b) préparer un 2e CD tenant compte des commentaires et le faire circuler pour commentaires, suivi de la procédure a),	3
	ou c) discuter le 1er CD et les commentaires reçus à une réunion.	
	Décision d'enregistrer un CD comme projet de Recommandation ou Document, soumise à 2 conditions: 1) approbation par une majorité d'au moins deux-tiers du nombre total des membres-P, et 2) conclusion par le secrétariat que soit: - il y a peu ou pas de chances d'obtenir une acceptation plus large du CD, soit - l'intérêt général des Etats Membres de l'Organisation est de ne pas poursuivre plus longtemps la discussion du CD.	
	Le secrétariat envoie le projet au BIML, accompagné d'une note explicative	4

Stade de développement	Procédure en bref	Délais autorisés (en mois)
4 Stade d'approbation	Le projet de Recommandation ou de Document est envoyé par le BIML aux Membres du CIML pour commentaires et votes, et aux organisations extérieures concernées pour commentaires Le BIML envoie les résultats des votes et les copies des commentaires et indique la phase suivante, c'est-à-dire 1) DD soit approuvé avec une majorité simple de votes positifs et aucune objection de principe à sa publication, soit retourné au TC ou SC 2) DR soit soumis à la réunion suivante du CIML (ou à la Conférence pour sanction directe), soit retourné au TC ou SC	4 ou moins
5 Stade de publication	Le BIML procède à une vérification finale du texte en étroite coopération avec le secrétariat du TC ou SC concerné. Après sa publication, une Recommandation approuvée par le CIML doit être sanctionnée par la Conférence suivante.	

Réunions des comités techniques et des sous-comités

Une réunion doit être convoquée quand le travail (discuter et/ou voter sur un CD ou un projet, discuter et approuver un programme d'activités) peut être accompli plus rapidement que par courrier. Le secrétariat doit informer les membres si possible un an à l'avance des dates et lieux probables de la réunion. Les TC et SC coordonnent leurs réunions afin de faciliter une large participation des délégués.

PhD

Les comités techniques et leurs domaines d'activité

TC 1	Terminologie	POLOGNE
TC 2	Unités de mesure	AUTRICHE
TC 3	Contrôle métrologique	ETATS-UNIS D'AMERIQUE
TC 4	Dispositifs d'étalonnage et de vérification	REPUBLIQUE SLOVAQUE
TC 5	Instruments électroniques	PAYS-BAS
TC 6	Produits préemballés	ETATS-UNIS D'AMERIQUE
TC 7	Instruments de mesure des longueurs et grandeurs associées	ROYAUME-UNI
TC 8	Instruments de mesure des quantités de fluides	SUISSE
TC 9	Instruments de mesure des masses et masses volumiques	ETATS-UNIS D'AMERIQUE
TC 10	Instruments de mesure des pressions, forces et grandeurs associées	ÉTATS-UNIS D'AMERIQUE
TC 11	Instruments de mesure de la température et grandeurs associées	ALLEMAGNE
TC 12	Instruments de mesure des grandeurs électriques	ALLEMAGNE
TC 13	Instruments de mesure pour l'acoustique et les vibrations	ALLEMAGNE
TC 14	Instruments de mesure utilisés en optique	HONGRIE
TC 15	Instruments de mesure pour rayonnements ionisants	RUSSIE
TC 16	Instruments de mesure des polluants	ETATS-UNIS D'AMERIQUE
TC 17	Instruments pour mesurages physico-chimiques	RUSSIE
TC 18	Instruments de mesure médicaux	ALLEMAGNE

WESTERN EUROPEAN CALIBRATION COOPERATION SCHEME TO BUILD AND DOCUMENT MUTUAL CONFIDENCE IN ACCREDITATION

by **J.M. VIRIEUX**
Swiss Federal Office of Metrology, Head of the Swiss Accreditation Service

1 Introduction

As soon as serious consideration was given to signing agreements on the equivalence of calibration certificates between many calibration services, WECC recognized the necessity to base the necessary mutual confidence on hard facts and not on papers. It was deemed necessary to make an objective evaluation of each other's accreditation activities, using the same criteria to evaluate each scheme.

At the beginning, when only a few countries were concerned, it was possible to make bilateral visits of each service concerned and thus gather all the information needed to have full confidence in each other's accreditations. However, this way of working would have proven very cumbersome with the increasing number of countries having fully operational calibration services. It was then decided to set up a system in which each service would be visited by an international team of WECC experts which would elaborate a report on their findings. WECC would then make a recommendation to its members for acceptance in the multilateral agreement based on this report. There would be no need for a higher authority.

On December 13th, 1990, the following countries signed a Multilateral Agreement on mutual confidence in calibration certificates: Denmark, Finland, France, Germany, Italy, The Netherlands, Sweden, Switzerland, and the United Kingdom.

The operation of this scheme is documented in WECC document 16.

2 Aims of an international evaluation scheme of technical bodies

The first aim on an international evaluation scheme of technical bodies is the opportunity for all participating bodies to gain confidence in the operations performed by others. A well thought-out scheme will provide many other advantages as well:

- It will give a material and objective basis to justify for third parties the decision to place full confidence in the operations of the body in question.
- It will allow the evaluated body to correct any mistake identified by the evaluating team.
- Il will permit evaluating experts to learn from the evaluated body and generally to exchange expertise and information with all experts involved.
- It will help everyone involved by better knowledge of what help and assistance can be, or cannot be, expected from whom.

Usually, the final aim of an international evaluation scheme is the opportunity to sign a multilateral agreement on equivalence based on a sound material basis.

3 The general features of the WECC evaluation scheme

The WECC scheme has been set up in order to ensure the best factual basis for mutual confidence, the best possible exchange of information and expertise, comprehensive information from all members together with minimal administration, good transparency, minimal disturbance of the visited laboratories and the possibility for adaptation to the local conditions (language, distances, number of accredited laboratories, fields of activity, etc.).

This scheme operates in the following way:

The WECC Committee elects several conveners; one of them is changed every year. The convener has the task of leading a team of experts, possibly delegated from different countries, during the visit to the calibration service wishing to be evaluated.

The head of a calibration service wishing to be visited announces his intention to the WECC chairman. The WECC Executive Committee appoints a convener if certain prerequisites are met. The convener chooses the calibration laboratories to be visited in collaboration with the head of the service concerned and asks all WECC members to propose experts in accordance with the fields of activities of the chosen laboratories.

After the visit has been completed, the team prepares a report with a conclusion which is submitted to the visited service. This service then decides whether it wants the report to be sent to each WECC delegate or not. If the report is not sent, then the service cannot ask to be admitted in the multilateral agreement.

4 Rules and criteria

A prerequisite for considering to send a team to a given calibration service is that this service:

- participates actively in the activities of WECC such as committee meetings, meetings of expert groups and task forces, establishing documents, exchanging experts if appropriate, and having accredited laboratories taking part in WECC interlaboratory comparisons;
- establishes a yearly report on its activities which is sent to all WECC members.

The main criteria to be fullfilled by the calibration service are given in the EN 45000 series standards. Since these criteria have been elaborated for testing laboratories, WECC has completed them for calibration laboratories, putting special emphasis on:

- traceability;
- estimation of the uncertainty of the different measurements;
- control over the various influence factors;
- metrological competence of the staff of the laboratory;
- pertinence of the measurements methods;
- participation in intercomparisons, evaluating the quality of the results and taking appropriate measures whenever necessary.

The absolute rule of the scheme is the fact that the visiting team shall collect only objective and material evidence - only hard facts so to speak. This evidence shall be recorded in the report in such a way as to be clearly understood by experts who did not participate in the visit. The complete compliance with the abovementioned criteria or the differences will be specially highlighted. In order to ensure a uniform application of the scheme and also to facilitate the work of the visiting team, a list of pertinent questions for both headquarters and accredited laboratories has been worked out.

5 Execution of the evaluation

Before visiting the evaluated calibration service, the convener and the mandated experts receive all pertinent documentation available about the service itself and the laboratories to be visited. The most relevant documents have to be provided in English. The convener designates which experts are going to visit which laboratories so that each visit can be well-prepared. The convener may assign special review tasks to experts.

When preparing the visit, the convener must choose, in collaboration with the head of the service concerned, the accredited laboratories to be visited by the team; several factors must be taken into consideration:

- The laboratories must be located at a reasonable distance from headquarters so as not to lose too much time travelling.
- Laboratories should represent the main field of activities of the service in terms of the physical quantities concerned and of the values of accredited uncertainties.
- The availability of experts for the team in given fields of measurements.
- If at all possible, the specialists responsible for the laboratories and the laboratories' key staff should have working knowledge of English.

The visit begins with one day at the headquarters of the service where the documents and rules of accreditation are reviewed and discussed with the staff. The dossiers of the laboratories to be visited are also examined. All the documents are compared to the requirements of the EN 45000 series standards and of the relevant WECC documents.

Two days are usually taken to visit the chosen laboratories to evaluate how the accreditation work has been done. For this activity, the team is usually split into two sub-teams.

On the fourth day of the visit, the results are discussed at the headquarters with the responsible experts of the visited service. The report draft is written at this time, with each visiting experts reporting on the laboratories that were visited; one of the experts writes a report on the headquarters.

6 Report

Typically, a report will have the following chapters:

- **Visit to headquarters**

  Information on accreditation policy, accreditation criteria, quality manual and compliance of the service with the appropriate criteria is given. Usually, a list of the documentation available and the language used is included.

- **Visits to the chosen laboratories**

  Special emphasis is placed on the compliance of the actual accreditation with the documents and rules of the service.

- **A conclusion of the team**

  A report is made as to the degree of compliance of the service with the pertinent international standards.

- **Annexes**

  Interesting documents, for example, calculations of uncertainties or examples of calibration certificates.

The visited service may give its own views at the end of the report.

7 Experiences acquired

Up to now, more than ten such visits have been completed and the experience thus gained allows to confirm the effectiveness and practicability of the scheme.

The services that did not participate in a given visit found useful information in the report and those who wished to do so could ask precise questions to the visited service in order to get a more complete picture. They also could place full confidence in the conclusions of the visiting team. The shortcomings, if any, and the points on which a visited service disagreed with explicit WECC policy were always clearly indicated, proving that the visiting teams were factual and impartial.

For all announced visits, the conveners were offered a sufficiently wide choice of experts to cover all the fields of accreditation. Except for the first visit, there were no language problems because this was taken care of by the conveners in the choice of the laboratories and of the experts.

Not one single accredited laboratory was unwilling to be visited by foreign experts. In cases where tight security precautions were imposed, for example, for armament laboratories, the national service concerned could always solve the problem smoothly. The visiting team, the experts of the national calibration service and the specialists of the laboratories have worked in good cooperation and there has never been unpleasantness or embarrassment even when pointed or very precise questions had been asked. In several cases, some questions highlighted difference of opinion between national services, for instance on the accreditation of three coordinates' measuring laboratories. It proved very useful and necessary to have discussions on such topics in the relevant expert groups and the WECC Committee in order to achieve an agreement.

The exchange of expertise between all concerned experts has proved tremendous, especially on the practical side of the accreditation and calibration work. This could never be accomplished so efficiently in any other way. Despite all the exchange of expertise, know-how and information, there has been no leak of confidential information.

Pre-evaluation visits may be necessary to ensure that a service to be evaluated is prepared accordingly, especially if the service is a newcomer to WECC... A simpler procedure is used for re-evaluations.

8 Advantages, disadvantages, problems

The practical use of the described scheme has highlighted the following advantages:

- No need for a permanent evaluation committee.
- No need for a permanent staff, no salaries, no budget.
- No durable bias of judgement because the experts are different each time.
- The administration is kept to a minimum and equally distributed among all members.
- Complete transparency from beginning to end. The visits are announced to every member who has the possibility to participate.
- Considerable exchange of expertise to the benefit of the visiting experts, assessors of the visited calibration service, and specialists of the laboratories. The discussions together with practical problems allow the clarification of many questions.

- The experts of the calibration services can progressively know the other services and therefore gain full confidence in them. They will also be able to give correct and exact advice about them.
- The reports will allow any service to justify and document the confidence placed in other services if permitted by the concerned service.

On the other hand, problems might arise which are as yet difficult to estimate:

- The scale or the severity of the evaluation by the visiting team may vary with different teams without anyone being aware of that. This is particularly sensitive in the formulation of the conclusion; a consensus between past, present, and future conveners should be aimed at. The way in which reservations are expressed or the wording chosen to highlight differences between national policies and European or WECC standards must be given careful consideration.
- Services with ample staff will have a tendency to always offer experts while understaffed services will tend to offer none. Therefore, some services will gain much more influence than others.
- Regarding the increasing number of evaluation and re-evaluation visits, it is becoming difficult to find a sufficient number of experts and conveners able to undertake the work.
- The present scheme might give outsiders the impression of a closed club where everyone must know everyone. This is not so but it hinges on the fairness of the experts involved.

9 Updating and revision of the scheme

The experiences gained in the practical use of the scheme have shown it to be very sound and the basic ideas will certainly remain unchanged for the present time. However the conveners and experts have come up with new practical and efficient ideas which will be included in the revision work under way at present.

The conveners and appointed experts shall study in future the evaluated service's documentation (ie quality manual) and any relevant information from other sources in advance of the visit. This has been made possible by the WECC decision to ask for these documents in an English translation. Only those points not considered satisfactory or clear need then be studied in depth during the visit.

As a rule, the convener will pay a pre-evaluation visit to the service.
The attendance by the visiting team at assessment or surveillance visits to observe the visited service's staff and/or assessors at work has been attempted with success.

A coordinated WELAC-WECC evaluation visit has also been successfully done which should encourage the coordination of the policies of both organizations.

Re-evaluation visits will be simplified and concentrated on items where changes occurred since the previous evaluation. In addition, the quality aspects of accreditation bodies shall be further addressed now that the necessary standards have been or are being fully developed.

Conclusion

The WECC scheme guarantees a fair, factual, comprehensive and widely spread evaluation done in an efficient and economical way by a balanced team of the best experts available. The frame allows the convener to adapt the evaluation to local particularities for maximum efficiency.

HABANA/HAVANA, CUBA
METROLOGIA 93
Palacio de las Convenciones
23 al 26 de marzo de 1993
International Conference Center
23-26 March 1993

2nd International Symposium and OIML developing countries meeting

Havana, Cuba 23-26 March 1993

The State Committee for standardization (CEN) of Cuba together with Cuban Academy of Sciences and Chamber of Commerce organized a series of metrology events for "Metrology 93" which included: the 2nd International Symposium on metrological assurance, Exhibition of metrological equipment: "Advances in Metrology", OIML consultative meeting of developing countries, meetings of SIM (Sistema Interamericano de Metrologia), Ibero-American Metrology Cooperation, COPANT (Comisión Panamericana de Normas Téchnicas) technical committee TK 142 on metrology, and the national Cuban conference on metrology.

The participants in these meetings were 270 delegates from 18 countries and international and regional institutions: OIML, IMEKO, WELMEC, SIM, COPANT, Ibero-American cooperation. The countries represented at the meetings were the following: Argentina, Brazil, Canada, Chile, China, Costa-Rica, Colombia, Cuba, Dominican Republic, Germany, Libya, Morocco, Mexico, Russia, Spain, Uruguay, Venezuela.

The meetings took place in the Palace of Congress - a large building which has all the modern facilities for international symposia, congresses, seminars. It was here, in April 1988, that meetings of the OIML Development Council, metrology seminar, and SP 31 "Training in metrology" were held successfully. The organizing committee of Metrology 93, headed by Mr Ramon Darias Rodes, CEN President, provided all the necessary facilities to delegates for the meetings as well as hotel, transportation and receptions.

The main topics of the Symposium dealt with metrology and scientific research, legal metrology, testing, verification, calibration, and the development of measuring instruments. During the symposium, 42 papers were presented pertaining to metrology application in the fields of biotechnology, medicine, physics, chemistry, electronics, developments of medical diagnostic equipment, photometry, measurement of lasers parameters, magnetism, and the use of certified reference materials. Current trends and future objectives of legal metrology were also the topics of a number of round table discussions. The OIML certificate system, implementation of OIML International Recommendations and Documents, and the interaction between metrology and quality assurance were also discussed.

The OIML consultative meeting of developing countries was attended by 24 delegates from 12 countries; participants from non-member countries also took part in the meeting and received therefore useful information about OIML. The meeting was conducted by Mr M. Benkirane, Chairman of the OIML Development Council, and Mr A. Vichenkov, Assistant Director of BIML.

The main issues of the meeting were basic needs and requirements of national metrology services, problems associated with training personnel, rendering financial and technical assistance to developing countries in the framework of international, regional, and bilateral cooperation. Another aim of the discussions was to establish principal stages for a new cooperation program of the OIML Development Council which is to be prepared for the next official meeting of the Council on 30 september - 1 October 1993 in Berlin.

Information was given by participants as to training courses, seminars, technical visits in 1993 - 1995 including courses on verification of weighing equipment in Germany, international seminar in Mexico, congress on quality and metrology in Brazil and other events. The German delegate, Dr Seiler (PTB), requested proposals on themes for future courses and seminars. Some subjects were proposed for individual fields of measurements (volume, flow, etc.) as well as for general aspects of legal metrology (prepackaged products, planning and equipping of laboratories, general concepts of legal metrology, certification of OIML).

Training in metrology is one of the most urgent needs of developing countries. Possible facilities in this field were discussed, and some delegations (Canada, Germany, Cuba, Russia) would inform the Bureau to this end. Programs for some training courses were received from delegates of Canada, Costa-Rica, Brazil. The German delegate requested the Cuban party to translate some training manuals from German into Spanish, and this proposal was accepted by the Cuban delegation. It was proposed to include in the draft agenda of the next Development Council meeting an item concerning the reestablishment of a technical body dealing with subjects related to training (instead of SP 31).

OIML representatives had contacts with many delegates of national and international institutions that attended the meetings. A report on OIML activities was given by the BIML representative at the opening of the Symposium. Discussions and consultations were held at the request of some delegations, in particular those from Latin American states. There were given OIML booklets and the "List of publications" for general information concerning OIML activities. Delegates of some non-member countries expressed interest in cooperation with OIML and in joining OIML in the future. They may wish to contact BIML to receive relevant information as to the conditions of joining OIML. Information related to activities of some national and regional organizations (Cuba, Spain, Brazil, SIM, COPANT etc.) and technical prospects and catalogues of the Exhibition were available. A few papers were proposed for possible publication in OIML Bulletin.

The president of CEN emphasized his wish to hold the next International Conference of Legal Metrology in 1996 in Cuba. A guided tour of the Palace of Congress was organized for the OIML representatives and a newly published prospectus and a list of international events were given to the Bureau to demonstrate all the technical facilities of the Palace. Information concerning the organizational aspects of the future conference may be presented by the Cuban delegation for the 28th CIML meeting in October 1993 in Berlin.

The participants of Metrology 93 expressed their full satisfaction and numerous thanks to Cuban hosts for the invitation and perfect organization of all the events held in Havana.

AV

New OIML Publications

Nouvelles publications OIML

A pattern evaluation report for nonautomatic weighing instruments

The second part of the R 76 is now available in French and English, on paper and diskette (Wordperfect 5.1).

This is a tool that can be used directly by legal metrology services, laboratories, and constructors that seek to verify that a given weighing instrument conforms to OIML requirements. The principal metrological requirements are first presented in tables that can be directly filled in at the time of the conformity tests; once completed, a study of the tables immediately permits one to determine whether or not the instrument conforms to the requirements.

Additional pages are reserved for the description of the instrument and the equipment used for the pattern test.

The report is concluded by a "checklist" which includes all the requirements of R 76-1: boxes are provided in order to indicate whether the tests were conclusive, therefore signifying that the instrument fully satisfies the OIML requirements.

Use of this test report is obligatory for the issuance of OIML certificates; the test report is given back to the constructor with the certificate. The constructor can submit the certificate and the report to the approval authorities of the various countries in which marketing of the product is desired; these authorities can accept the results of the tests in order to accelerate the approval process.

Use of the test report is also recommended when a national authority grants a type approval based on the regulations in conformity to the OIML Recommendation (which is for example, the case of the 16 countries of the European Economic Area that apply the EC/384 Directive and the accompanying European Standard EN 45501).

Un rapport d'essai de modèle pour les instruments de pesage à fonctionnement non automatique

La deuxième partie de la R 76 est maintenant disponible en français et en anglais, sur papier et sur disquette sous le logiciel WordPerfect 5.1.

Il s'agit d'un outil directement utilisable par les services de métrologie légale, laboratoires et constructeurs qui souhaitent s'assurer de la conformité d'un instrument de pesage aux exigences OIML. Les principales exigences métrologiques sont tout d'abord rassemblées sous forme de tableaux pouvant être remplis directement lors des essais de conformité; une fois remplis, l'examen des tableaux permet immédiatement de conclure si, pour les exigences en question, l'instrument est conforme.

Des pages additionnelles sont réservées à la description de l'instrument et à l'équipement utilisé pour l'essai de modèle.

Le rapport se termine par une "liste de contrôle" rassemblant toutes les exigences de R 76-1: des cases permettent d'indiquer si les examens et essais ont été concluants et donc si le modèle satisfait pleinement aux exigences OIML.

L'utilisation de ce rapport d'essai est obligatoire pour la délivrance de certificats OIML; le rapport d'essai est remis au constructeur en même temps que le certificat. Le constructeur peut communiquer certificat et rapport d'essai aux autorités d'approbation des divers pays où il souhaite commercialiser sa production; ces autorités peuvent accepter de prendre en considération les résultats d'essai pour accélérer l'approbation.

L'utilisation du rapport d'essai est également recommandée chaque fois qu'une autorité nationale effectue une approbation de modèle sur la base d'une réglementation conforme à la Recommandation OIML (ce qui est par exemple le cas des 16 pays de l'espace économique européen qui appliquent la Directive CEE/384 et la Norme Européenne d'accompagnement EN 45501).

Other recent publications

The Recommendations R 105, *Direct mass flow measuring systems for quantities of liquids*, and R 106, *Automatic rail-weighbridges*, that were sanctioned by the OIML Conference in 1992 are also available in French and English. They should be supplemented soon by test methods and test reports that will permit OIML certificates to be granted for these instruments. The rail-weighbridges may be the subject of a recognition agreement of the approvals given according to R 106 through WELMEC.

Autres publications récentes

Les Recommandations R 105 *Ensembles de mesurages massiques directs de quantités de liquides* et R 106 *Ponts-bascules ferroviaires à fonctionnement automatique* sanctionnés par la Conférence de l'OIML en 1992, sont également disponibles en français et en anglais. Elles devraient être ultérieurement complétées par des méthodes et rapports d'essai permettant à ces instruments de recevoir des certificats OIML. Les ponts-bascules ferroviaires pourraient faire l'objet d'un prochain accord de reconnaissance des approbations faites selon la R 106 dans le cadre de WELMEC.

The United States National Conference on Weights and Measures seeks "Excellence Through Standards"

"Excellence Through Standards" will be this year's theme for the 78th annual meeting of the US National Conference on Weights and Measures to be held in Kansas City, Missouri USA July 18 through 22, 1993. Between 300 - 500 delegates from the 50 States, Puerto Rico, Virgin Islands, Canada, Mexico, and other Caribbean nations are expected to attend as well as representatives from foreign companies and organizations.

OIML will participate in the Conference and will be represented by BIML Director Bernard Athané and Kristine French, responsible for the Bureau's communications. A lecture will be given highlighting OIML's pursuit of excellence in its Recommendations including the organization's long-term policies and strategies for responding to the new trends in legal metrology. A complete report of the Conference as well as OIML's presentation will be published in the OIML Bulletin which will be a double issue: September/December numbers 132 - 133.

"L'excellence par les normes", thème de la Conférence Nationale des Poids et Mesures des Etats-Unis d'Amérique

"L'excellence par les normes" sera le thème de la 78e réunion annuelle de la Conférence Nationale des Poids et Mesures des Etats-Unis d'Amérique, qui se tiendra à Kansas City, Missouri, du 18 au 22 juillet 1993. De 300 à 500 délégués représentant les 50 Etats américains, Puerto Rico, les Iles Vierges, le Canada, le Mexique et d'autres pays des Caraïbes sont attendus ainsi que les représentants des entreprises et institutions étrangères.

L'OIML participera à cette Conférence, représentée par le Directeur du BIML, Bernard Athané, et par Kristine French, chargée de la Communication au BIML. Un exposé soulignera la poursuite par l'OIML de l'excellence dans ses Recommandations, y compris les politiques et stratégies à long terme pour répondre aux nouvelles évolutions de la métrologie légale. Un rapport complet de cette Conférence et la présentation de l'OIML seront publiés dans le prochain Bulletin OIML qui sera un numéro double: septembre/décembre 1993, n^os^ 132 - 133.

New OIML Member State: Republic of Slovenia

Republic of SLOVENIA has joined OIML as new Member State.

Pending the appointment of the CIML Member, correspondence may be sent to the following address:

Nouvel Etat Membre de l'OIML: la République de Slovénie

La République de SLOVENIE a été admise comme nouvel Etat Membre de l'OIML.

Dans l'attente de la nomination du Membre du CIML, le courrier peut être envoyé à:

The Director
Ministrstvo za znanost in tehnologijo
Urad za standardizacijo in meroslovje
Slovenska cesta 50
61000 Ljubljana
Republic of SLOVENIA

TP 38 - 61 - 111 107   Fax 38 - 61 - 124 288

Training course in the verification of weighing instruments, Munich, 3 - 13 August 1993

In view of the success of the 1991 and 1992 training courses organized by PTB at the German Academy for Metrology (DAM) in Munich and co-sponsored by OIML, a similar course will be given on 2-13 August 1993. A short paper on these activities will be published in the next OIML Bulletin.

Cours de formation à la vérification des instruments de pesage

Suite au succès des cours de formation organisés par le PTB, à l'Académie Allemande pour la Métrologie (DAM) à Munich, et également sponsorisés par l'OIML, un cours similaire sera donné du 2 au 13 août 1993. Un article résumant ces activités sera publié dans le prochain Bulletin de l'OIML.

OIML meetings

TC 9/SC - (SP 7 Sr 5) Automatic weighing instruments

Teddington, UK
22 - 24 June 1993

TC 8 Instruments for measuring quantities of fluids

Wabern, Switzerland
28 - 29 June 1993

TC 4 (SP 23) Calibration and verification devices

Bratislava, Slovak Republic
13 - 17 September 1993

TC 7/SC - (SP 10 - Sr 2) Instruments for the measurement of speed and distance fitted in vehicles

BIML, Paris
25 - 27 October 1993

TC 18/SC - (SP 26 - Sr 4) Bioelectrical measuring instruments

Berlin, Germany – dates to be announced later

OIML Development Council

Berlin, Germany
30 Sept - 1 Oct 1993

Twenty-eighth Meeting of the International Committee of Legal Metrology

Berlin, Germany
4 - 6 Oct 1993

Réunions OIML

TC 9/SC - (SP 7 Sr 5) Instruments de pesage à fonctionnement automatique

Teddington, Royaume-Uni
22 - 24 juin 1993

TC 8 Instruments de mesure des quantités de fluides

Wabern, Suisse
28 - 29 juin 1993

TC 4 (SP 23) Dispositifs d'étalonnage et de vérification

Bratislava, République Slovaque
13 - 17 septembre 1993

TC 7/SC - (SP 10 - Sr 2) Instruments de mesure de vitesse et distance installés dans les véhicules

BIML, Paris
25 - 27 octobre 1993

TC 18/SC - (SP 26 - Sr 4) Instruments de mesure bioélectriques

Berlin, Allemagne – les dates seront annoncées plus tard

Conseil de Développement de l'OIML

Berlin, Allemagne
30 sept. - 1 oct. 1993

Vingt-huitième Réunion du Comité International de Métrologie Légale

Berlin, Allemagne
4 - 6 octobre 1993

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 (sphygmomano-mètres) *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 — 1984
Sound level meters

R 59 — Humidimètres pour grains de céréales et graines oléagineuses — 1984
Moisture meters for cereal grains and oilseeds

R 60 — Réglementation métrologique des cellules de pesée — 1991
Metrological regulations for load cells

R 61 — Doseuses pondérales à fonctionnement automatique — 1985
Automatic gravimetric filling machines

R 62 — Caractéristiques de performance des extensomètres métalliques à résistance — 1985
Performance characteristics of metallic resistance strain gauges

R 63 — Tables de mesure du pétrole — 1985
Petroleum measurement tables

R 64 — Exigences générales pour les machines d'essai des matériaux — 1985
General requirements for materials testing machines

R 65 — Exigences pour les machines d'essai des matériaux en traction et en compression — 1985
Requirements for machines for tension and compression testing of materials

R 66 — Instruments mesureurs de longueurs — 1985
Length measuring instruments

R 67 — Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Contrôles métrologiques — 1985
Measuring assemblies for liquids other than water fitted with volume meters. Metrological controls

R 68 — Méthode d'étalonnage des cellules de conductivité — 1985
Calibration method for conductivity cells

R 69 — Viscosimètres à capillaire, en verre, pour la mesure de la viscosité cinématique — 1985
Glass capillary viscometers for the measurement of kinematic viscosity

R 70 — Détermination des erreurs de base et d'hystérésis des analyseurs de gaz — 1985
Determination of intrinsic and hysteresis errors of gas analysers

R 71 — Réservoirs de stockage fixes. Prescriptions générales — 1985
Fixed storage tanks. General requirements

R 72 — Compteurs d'eau destinés au mesurage de l'eau chaude — 1985
Hot water meters

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 — 1985
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

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

R 75 — Compteurs d'énergie thermique — 1988
Heat meters

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*	1993
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 — 1990
Radar equipment for the measurement of the speed of vehicles

R 92 — Humidimètres pour le bois - Méthodes et moyens de vérification: exigences générales — 1990
Wood-moisture meters - Verification methods and equipment: general provisions

R 93 — Frontofocomètres — 1990
Focimeters

R 95 — Bateaux-citernes - Prescriptions générales — 1990
Ships' tanks - General requirements

R 96 — Bouteilles récipients-mesures — 1990
Measuring container bottles

R 97 — Baromètres — 1990
Barometers

R 98 — Mesures matérialisées de longueur à traits de haute précision — 1991
High-precision line measures of length

R 99 — Instruments de mesure des gaz d'échappement des véhicules — 1991
Instruments for measuring vehicle exhaust emissions

R 100 — Spectromètres à absorption atomique pour la mesure des polluants métalliques dans l'eau — 1991
Atomic absorption spectrometers for measuring metal pollutants in water

R 101 — Manomètres, vacuomètres et manovacuomètres indicateurs et enregistreurs — 1991
Indicating and recording pressure gauges, vacuum gauges and pressure-vacuum gauges

R 102 — Calibreurs acoustiques — 1992
Sound calibrators

R 103 — Appareillage de mesure pour la réponse des individus aux vibrations — 1992
Measuring instrumentation for human response to vibration

R 104 — Audiomètres à son pur — 1992
Pure-tone audiometers

R 105 — Ensembles de mesurage massiques directs de quantités de liquides — 1993
Direct mass flow measuring systems for quantities of liquids

R 106 — Pont-bascules ferroviaires à fonctionnement automatique — 1993
Automatic rail-weighbridges

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

R 108 — Réfractomètres utilisés pour mesurer la teneur en sucre des jus de fruits — (*)
Refractometers for the measurement of the sugar content of fruit juices

R 109 — Manomètres et vacuomètres à élément récepteur élastique - Instruments étalons — (*)
Pressure gauges and vacuum gauges with elastic sensing elements - Standard instruments

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 *Secondary standard dosimetry laboratories for the calibration of dosimeters used in radiotherapy*	1990
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 *Guide to portable instruments for assessing airborne pollutants arising from hazardous wastes*	1991
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.

ÉTATS MEMBRES

ALGÉRIE
ALLEMAGNE
ARABIE SAOUDITE
AUSTRALIE
AUTRICHE
BELGIQUE
BRÉSIL
BULGARIE
CAMEROUN
CANADA
RÉP. POP. DE CHINE
CHYPRE
RÉP. DE CORÉE
RÉP. POP. DÉM. DE CORÉE
CUBA
DANEMARK
ÉGYPTE
ESPAGNE
ÉTATS-UNIS D'AMÉRIQUE
ÉTHIOPIE
FINLANDE
FRANCE
GRÈCE
HONGRIE
INDE
INDONÉSIE
IRLANDE
ISRAËL
ITALIE
JAPON
KENYA
MAROC
MONACO
NORVÈGE
PAKISTAN
PAYS-BAS
POLOGNE
PORTUGAL
ROUMANIE
ROYAUME-UNI DE GRANDE-BRETAGNE ET D'IRLANDE DU NORD
RUSSIE
RÉPUBLIQUE SLOVAQUE
RÉPUBLIQUE DE SLOVÉNIE
SRI LANKA
SUÈDE
SUISSE
TANZANIE
RÉPUBLIQUE TCHÈQUE
TUNISIE
YOUGOSLAVIE
ZAMBIE

MEMBRES CORRESPONDANTS

Albanie - Bahrein - Bangladesh - Barbade - Botswana - Burkina Faso - Colombie - Costa Rica - Équateur - Fidji - Ghana - Hong Kong - Islande - Jordanie - Koweit - Libye - Luxembourg - Malaisie - Malawi - Mali - Maurice - Mexique - Mongolie - Népal - Nouvelle-Zélande - Oman - Ouganda - Panama - Pérou - Philippines - Sénégal - Seychelles - Syrie - Trinité et Tobago - Turquie - Venezuela - Yemen

MEMBRES
du
COMITÉ INTERNATIONAL de MÉTROLOGIE LÉGALE

ALGÉRIE

Membre à désigner par son Gouvernement
Correspondance à adresser à
Office National de Métrologie Légale
1, rue Kaddour Rahim Hussein Dey
ALGER

ALLEMAGNE

Mr M. KOCHSIEK
Directeur
Physikalisch-Technische Bundesanstalt
Bundesallee 100 - Postfach 3345
3300 BRAUNSCHWEIG
TP 49-531-592 80 10 FAX 49-531-592 40 06
TX 9-52 822 PTB d
TG Bundesphysik Braunschweig

ARABIE SAOUDITE

Mr KHALED Y. AL-KHALAF
Director General
Saudi Arabian Standards Organization
P.O. Box 3437
11471 RIYADH
TP 966-1-479 33 32 FAX 966-1-479 30 63
TX 40 16 10 saso sj
TG giasy

AUSTRALIE

Mr J. BIRCH
Executive Director
National Standards Commission
P.O. Box 282
NORTH RYDE, N.S.W. 2113
TP 61-2-888 39 22 FAX 61-2-888 30 33
TX OTCD AA 100200
(MAIL BOX 6007:NSC001)

AUTRICHE

Mr R. GALLE
Director of the Metrology Service
Gruppe Eichwesen
Bundesamt für Eich- und Vermessungswesen
Postfach 20
Arltgasse 35
A-1163 WIEN
TP 43-222-49 11 01 FAX 43-222-49 20 875

BELGIQUE

Mr H. VOORHOF
Inspecteur Général
Inspection Générale de la Métrologie
24-26, rue J.A. De Mot
B-1040 BRUXELLES
TP 32-2-233 61 11 FAX 32-2-230 83 00
TX 20 627 COM HAN

BRÉSIL

Eng° ARNALDO PEREIRA RIBEIRO
Président, INMETRO
Rua Santa Alexandrina, No. 416 - Rio Comprido
CEP.: 20 261-232 - RIO DE JANEIRO RJ. Brasil
TP 55-21-273 90 02 FAX 55-21-293 09 54
TX 30672 IMNQ BR

BULGARIE

Mr Y. YORDANOV
Président
Comité de normalisation et de métrologie
21, rue du 6 Septembre
SOFIA 1000
TP 359-2-8591 FAX 359-2-801402
TX 22 570 DKS BG

CAMEROUN

Mr S. NOUMSI
Sous-Directeur des Poids et Mesures
Direction des Prix, Poids et Mesures
Ministère du Développement Industriel et Commercial
BP 501
YAOUNDÉ
TP 237-22 31 16 et 237-23 26 17 FAX 237-230069
TX 82-68 à Yaoundé

CANADA

Mr R.G. KNAPP
Director, Legal Metrology Branch
Consumer and Corporate Affairs
301, Laurier Avenue West, 5th floor
OTTAWA, Ontario K1A OC9
TP 1-613-952 0655 FAX 1-613-952 1736
TX 053 3694

RÉPUBLIQUE POPULAIRE DE CHINE

Mr LI CHUANGQING
Deputy Director General
State Bureau of Technical Supervision
4, Zhi Chun Lu, Hai Dian
BEIJING 100088
TP 86-1-202 58 35 FAX 86-1-203 10 10
TX 210209 SBTS CN
TG 1918 Beijing

CHYPRE

Mr G. TSIARTZAZIS
Controller of Weights and Measures
Ministry of Commerce and Industry
NICOSIA
TP 357-2-40 34 41 FAX 357-2-36 61 20
TX 2283 MIN COMIND
TG Mincommind Nicosia

RÉPUBLIQUE DE CORÉE

Mr Young-Chang KIM
Director of Metrology Division
Bureau of Standards
Industrial Advancement Administration
2, Chungang-dong
KWACHON-CITY, Kyonggi-Do 427-010
TP 82-2-503 79 28 FAX 82-2-503 79 41
TX 28456 FINCEN K

RÉPUBLIQUE POP. DÉM. DE CORÉE

Mr DJEUNG KI TCHEUL
Directeur de l'Institut Central de Qualité
et de Métrologie auprès du Comité National
de la Science et de la Technologie
Arrondissement de Sadong
PYONGYANG
TG standard

CUBA

Membre à désigner par son Gouvernement
Correspondance à adresser à
Mr J. Acosta Alemany
Director, International Relation Division
Comite Estatal de Normalizacion
Egido 610 e/Gloria and Apodaca
HABANA Vieja
TP 53-7-62-1503 or 61-2068 FAX 53-7-33 82 12
TX 512245 CEN CU 53-7 33 80 48

DANEMARK

Mr P.C. JOHANSEN
Assistant Head
Secretariat for Metrology
National Agency of Industry and Trade
Tagensvej 135
DK-2200 COPENHAGEN N
TP 45-31-85 10 66 FAX 45-31-81 70 68
TX 15768 INDTRA DK

ÉGYPTE

Mr M. HILAL
Président
Egyptian Organization for Standardization
and Quality Control
2 Latin America Street, Garden City
CAIRO
TP 20-2-354 97 20 FAX 20-2-355 78 41
TX 93 296 EOS UN
TG TAWHID

ESPAGNE

Membre à désigner par son Gouvernement
Correspondance à adresser à
Centro Espanol de Metrologia
c/ del alfar 2
28760 TRES CANTOS (Madrid)
TP 34-1-803 33 03 FAX 34-1-803 11 78
TX 47254 CEME E

ÉTATS-UNIS D'AMÉRIQUE

Mr S.E. CHAPPELL
Chief, Standards Management Program
Office of Standards Services
National Institute of Standards and Technology
Admin. 101, A625
GAITHERSBURG, Maryland 20899
TP 1-301-975 40 24 FAX 1-301-963 28 71
TX 197674 NBS UT

ÉTHIOPIE

Mr TAFESSE MULUNEH
Head of Metrology Department
Ethiopian Authority for Standardization
P.O. Box 2310
ADDIS ABABA
TP 251-1-15 04 00 et 15 04 25
TX 21725 ETHSA ET
TG ETHIOSTAN

FINLANDE

Mr M. RANTALA
Assistant Director on Legal Metrology
Technical Inspection Centre
Technical Department/Weights and Measures
P.O. Box 204, Lönnrotinkatu 37
SF-00181 HELSINKI
TP 358-0-61 67 489 FAX 358-0-60 54 74

FRANCE

Mr J. HUGOUNET
Sous-Directeur de la Métrologie
Ministère de l'Industrie, des Postes et Télécommunications
et du Commerce extérieur
22, rue Monge
75005 PARIS
TP 33-1-43 19 51 40 FAX 33-1-43 19 51 36

GRÈCE

Mr A. DESSIS
Technical Officer
Directorate of Weights and Measures
Ministry of Commerce
Canning Sq.
10181 ATHENS
TP 30-1-36 14 168 FAX 30-1-364 26 42
TX 21 67 35 DRAG GR et 21 52 82 YPEM GR

HONGRIE

Mr P. PÁKAY
Président
Országos Mérésügyi Hivatal
P.O. Box 19
H-1531 BUDAPEST
TP 36-1-1567 722 FAX 36-1-1550 598
TG HUNGMETER Budapest

INDE

Mr N.S. PANGTEY
Deputy Director
Weights & Measures
Ministry of Civil Supplies
Weights and Measures Unit
12-A, Jam Nagar House
NEW DELHI 110 011
TP 91-11-38 53 44
TX 31 61962 COOP IN
TG POORTISAHAKAR

INDONÉSIE

Mr G.M. PUTERA
Director of Metrology
Directorate General of Domestic Trade
Departemen Perdagangan
Jalan Pasteur 27
40171 BANDUNG
TP 62-22-50 597 et 50 695
TX 28 176 DITMET BD

IRLANDE

Mr S. MORAN
Assistant Secretary
Department of Industry and Commerce
Frederick Building, Setanta Centre,
South Frederick Street,
DUBLIN 2
TP 353-1-61 44 44 FAX 353-1-67 95 710
TX 93478
TG TRADCOM Dublin

ISRAËL

Mr. A. RONEN
Controller of Weights, Measures and Standards
Ministry of Industry and Trade
P.O.B. 299
JERUSALEM 91002
TP 972-2-27 241

ITALIE

Mr G. VISCONTI
Direttore Generale del Commercio Interno
Ufficio Centrale Metrico
Via Antonio Bosio, 15
I-00161 ROMA
TP 39-6-841 68 25 FAX 39-6-841 41 94

JAPON

Mr Y. KURITA
Director General
National Research Laboratory of Metrology
1-4, Umezono 1-Chome, Tsukuba
IBARAKI 305
TP 81-298-54 41 49 FAX 81-298-54 41 35
TX 03652570 AIST
TG KEIRYOKEN TSUCHIURA

KENYA

Mr P.A. AYATA
Director of Weights and Measures
Weights and Measures Department
Ministry of Commerce
P.O. Box 41071
NAIROBI
TP 254-2-50 46 64/5
TG ASSIZERS, Nairobi

MAROC

Mr M. BENKIRANE
Chef de la Division de la Métrologie Légale et Industrielle
Direction du Commerce et de l'Industrie
5, rue Errich, Immeuble A, Quartier Tour Hassan
RABAT
TP 212-7-72 45 65 FAX 212-7-76 06 75
TX 36872

MONACO

Mr A. VEGLIA
Ingénieur au Centre Scientifique de Monaco
16, Boulevard de Suisse
MC 98000 MONTE CARLO
TP 33-93-30 33 71

NORVÈGE

Mr K. BIRKELAND
Directeur Général
Service National de Métrologie
Postbox 6832 St. Olavs Plass
0130 OSLO 1
TP 47-22-20 02 26 FAX 47-22-20 77 72

PAKISTAN

Mr M. ASAD HASAN
Director
Pakistan Standards Institution
39-Garden Road, Saddar
KARACHI-74400
TP 92-21-772 95 27 FAX 92-21-772 81 24
TG PEYASAI

PAYS-BAS

Mr G.J. FABER
Directeur général
Nederlands Meetinstituut nv
Hugo de Grootplein 1
3314 EG DORDRECHT
TP 31-78 33 23 32 FAX 31-78 33 23 09
TX 38 373 IJKWZ NL

POLOGNE

Mr Z. REFEROWSKI
Vice-Président
Polski Komitet Normalizacji, Miar i Jakosci
ul. Elektoralna 2
00-139 WARSZAWA
TP 48-22-20 54 34 FAX 48-22-20 83 78
TX 813 642 PKN
TG PEKANIM

PORTUGAL

Mr J.N. CARTAXO REIS
Directeur du Service de la Métrologie
Instituto Português da Qualidade
Rua Prof. Reinaldo dos Santos
Lote 1378
1500 LISBOA
TP 351-1-778 61 58 FAX 351-1-778 19 80
TX 65744 METROQ P

ROUMANIE

Mr P.G. IORDACHESCU
Directeur Général
Bureau Roumain de Métrologie Légale
21, Boulevard Nicolae Balcescu
70112 BUCAREST
TP 40-1-613 16 54 FAX 40-1-312 05 01
TX 11 355

ROYAUME-UNI

Mr S. BENNETT
Chief Executive
National Weights and Measures Laboratory
Stanton Avenue
TEDDINGTON, Middlesex TW 11 OJZ
TP 44-81-943 72 72 FAX 44-81-943 72 70
TX 9312131043 (WM G)

RUSSIE

Mr L. K. ISSAEV
Vice-President
Gosstandart of Russia
Leninsky Prospect 9
117049 MOSCOU
TP 7-095-236 40 44 FAX 7-095 237 60 32
TX 411 378 GOST
TG Moskva-Standart

RÉPUBLIQUE SLOVAQUE

Membre à désigner par son Gouvernement
Correspondance à adresser à
Mr Lubomír SUTEK
Président
Úrad pre Normalizáciu
Metrológiu a Skúšobníctvo SR
Štefanovičova 3
814 39 BRATISLAVA
TP 42-7-491 085 FAX 42-7-491 050

RÉPUBLIQUE DE SLOVÉNIE

The Director
Ministrstvo za znanost in tehnologijo
Urad za standardizacijo in meroslovje
Slovenska cesta 50
61000 Ljubljana
TP 38 - 61 - 111 107 Fax 38 - 61 - 124 288

SRI LANKA

Mr H.L.R.W. MADANAYAKE
Deputy Commissioner of Internal Trade
Measurement Standards and Services Division
Department of Internal Trade
101, Park Road
COLOMBO 5
TP 94-1-83 261
TX 21908 COMECE CF

SUÈDE

Mr R. OHLON
Ingénieur en Chef
Statens Provningsanstalt
P.O. BOX 857
S-501 15 BORÅS
TP 46-33-16 50 00 FAX 46-33-11 77 59
TX 36252 TESTING S

SUISSE

Mr O. PILLER
Directeur
Office Fédéral de Métrologie
Lindenweg 50
CH- 3084 WABERN
TP 41-31-963 31 11 FAX 41-31-963 32 10
TG OFMET

TANZANIE

Mr A.H.M. TUKAI
Commissioner for Weights and Measures
Weights and Measures Bureau
Ministry of Industries and Trade
P.O. Box 313
DAR ES SALAAM
TP 64046/64797/64808
TX 41 689 INDIS

RÉPUBLIQUE TCHÈQUE

Membre à désigner par son Gouvernement
Correspondance à adresser à
Monsieur le Président
Czech Office for Standards
Metrology and Testing
Vaclavské nám. 19
113 47 PRAHA 1
TP 42-2-26 14 23 FAX 42-2-263 187
TX 121948 FUNM C
TG Normalizace Praha

TUNISIE

Mr Ali BEN GAID
Président Directeur Général
Institut National de la Normalisation
et de la Propriété Industrielle
Boîte Postale 23
1012 TUNIS BELVEDERE
TP 216-1-785 922 FAX 216-1-781 563
TX 13 602 INORPI

YOUGOSLAVIE

Mr Z.M. MARKOVIC
Deputy Director
Federal Bureau of Measures and Precious
Metals
Mike Alasa 14
11000 BEOGRAD
TP 38-11-18 37 36 FAX 38-11-620 134
TX 11 020 YUZMBG

ZAMBIE

Mr L.N. KAKUMBA
Superintendent Assizor, Assize Department
Weights and Measures Office
Ministry of Commerce and Industry
P.O. Box 30 989
LUSAKA
TP 260-1-21 60 62
TG Assize, LUSAKA

TP = téléphone FAX = télécopie (téléfax)

Les numéros sont en général indiqués pour le régime automatique international à l'exception des numéros qui sont précédés d'un trait.

The call numbers are generally indicated for international automatic dialling except where the local number is preceded by a dash.

TG = télégramme TX = télex

Pour tout télex ou télégramme, il est nécessaire d'indiquer le nom de la personne et sa qualité.

For all telex or telegrams it is necessary to indicate name of person and occupation.

PRÉSIDENCE

Président	K. BIRKELAND, Norvège
Vice-Président	S.E. CHAPPELL, U.S.A.
Vice-Président	M. KOCHSIEK, Allemagne

CONSEIL DE LA PRÉSIDENCE

K. BIRKELAND, Norvège, Président
S.E. CHAPPELL, U.S.A., V/Président
M. KOCHSIEK, Allemagne, V/Président
J. BIRCH, Australie
R.G. KNAPP, Canada
BAI JINGZHONG, Rép. Pop. de Chine
S. BENNETT, Royaume-Uni
L. K. ISSAEV, Russie
Le Directeur du Bureau International de Métrologie Légale

BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE

Directeur	B. ATHANÉ
Adjoint au Directeur	A. VICHENKOV
Adjoint au Directeur	P. DEGAVRE
Ingénieur	E. WEBER
Responsable de la Communication	K. FRENCH
Administrateur	Ph. LECLERCQ

MEMBRES D'HONNEUR

V. ERMAKOV, Russie – Vice-Président du Comité
A.J. van MALE, Pays-Bas – Président du Comité
A. PERLSTAIN, Suisse – Membre du Conseil de la Présidence
W. MUEHE, Allemagne – Vice-Président du Comité
H.W. LIERS, Allemagne – Membre du Conseil de la Présidence

ADRESSES DES SERVICES DES MEMBRES CORRESPONDANTS

ALBANIE

The Director
Drejtoria e Standardeve dhe e Mjeteve
Matëse (DSMA)
në Komisionin e Planit të Shtetit
TIRANA

BAHREIN

The Responsible of Metrology
Standards and Metrology Section
Ministry of Commerce and Agriculture
P.O. Box 5479
MANAMA

BANGLADESH

The Director General
Bangladesh Standards and Testing Institution
116-A Tejgaon Industrial Area
DHAKA 1208

BARBADE

The Director
Barbados National Standards Institution
Culloden Road
St. Michael
BARBADOS W.I.

BOTSWANA

The Permanent Secretary
Division of Weights and Measures
Department of Commerce and Consumer Affairs
Private Bag 48
GABORONE

BURKINA FASO

Direction Générale des Prix
Ministère du Commerce
et de l'Approvisionnement du Peuple
BP 19
OUAGADOUGOU

COLOMBIE

Superintendencia de Industria y Comercio
Centro de Control de Calidad y Metrologia
Cra. 37 No 52-95, 4° piso
BOGOTA D.E.

COSTA RICA

Oficina Nacional de Normas y Unidades
de Medida
Ministerio de Economia y Comercio
Apartado 10 216
SAN JOSE

ÉQUATEUR

Director General
Instituto Ecuatoriano de Normalizacion
Baquerizo Moreno No. 454 y Almagro
Casilla 17-01-3999
QUITO

FIDJI

The Chief Inspector of Weights and Measures
Ministry of Economic Development, Planning
and Tourism
Government Buildings
P.O. Box 2118
SUVA

GHANA

Ghana Standards Board
Kwame Nkrumah Conference Centre
(Tower Block - 2nd Bay, 3rd Floor)
P.O. Box M-245
ACCRA

HONG KONG

Commissioner of Customs and Excise
(Attn. Trading Standards Investigation Bureau)
Tokwawan Market & Government Offices
165, Ma Tau Wei Road
11/F., Kowloon
HONG KONG

ISLANDE

The Director
Icelandic Bureau of Legal Metrology
Löggildingarstofan
Sidumuli 13
P.O. Box 8114
128 REYKJAVIK

JORDANIE

Directorate of Standards
Ministry of Industry and Trade
P.O. Box 2019
AMMAN

KOWEIT

The Under Secretary
Ministry of Commerce and Industry
Department of Standards and Metrology
Post Box No 2944
KUWAIT

LIBYE

The Director General
National Centre for Standardization
and Metrology (N.C.S.M.)
P.O. Box 5178
TRIPOLI

LUXEMBOURG

Le Préposé du Service de Métrologie
Administration des Contributions
Rue des Scillas
2529 HOWALD

MALAISIE

The Director of Standards
Standards and Industrial Research Institute of Malaysia
P.O. Box 7035
40911 Shah Alam
SELANGOR DARUL EHSAN

MALAWI

The Principal Assizer
Assize Department
P.O. Box 156
LILONGWE

MALI

Le Directeur Général des Affaires Économiques
(Service des Poids et Mesures)
BP 201
BAMAKO

MAURICE

The Permanent Secretary
Ministry of Trade and Shipping
(Division of Weights and Measures)
New Government Centre
PORT LOUIS

MEXIQUE

Direccion General de Normas
Secretaria de Comercio y Fomento Industrial
Sistema Nacional de Calibracion
Ave. Puente de Tecamachalco no. 6 - Planta Baja
Lomas de Tecamachalco, Seccion Fuentes
53950 NAUCALPAN DE JUAREZ

MONGOLIE

Mongolian National Institute
for Standardization and Metrology
Peace Str.
ULAANBAATAR 51

NÉPAL

The Chief Inspector
Nepal Bureau of Standards and Metrology
P.B. 985
Sundhara
KATHMANDU

NOUVELLE-ZÉLANDE

The Manager
Trade Measurement Unit
Ministry of Consumer Affairs
P.O. Box 1473
WELLINGTON

OMAN

The Director General
for Specifications and Measurements
Ministry of Commerce and Industry
P.O. Box 550
MUSCAT

OUGANDA

Commissioner for Weights
and Measures
Weights and Measures Department
Ministry of Commerce
P.O. Box 7192
KAMPALA

PANAMA

Le Directeur
Comision Panamena de Normas Industriales
y Tecnicas
Ministerio de Comercio e Industrias
Apartado 9658
PANAMA 4

PÉROU

The Director General
ITINTEC Instituto de Investigacion Tecnologica
Industrial y de Normas Tecnicas
Av. Guardia Civil No. 400
LIMA 41

PHILIPPINES

Bureau of Product Standards
Department of Trade and Industry
3rd floor DTI Building
361 Sen. Gil J. Puyat Avenue
Makati, Metro Manila
PHILIPPINES 3117

SÉNÉGAL

Le Directeur
Institut Sénégalais de Normalisation
Ministère du Plan et de la Coopération
DAKAR

SEYCHELLES

The Director
Seychelles Bureau of Standards
P.O. Box 648
VICTORIA

SYRIE

The General Director
The Syrian Arab Organization
for Standardization and Metrology
P.O. Box 11836
DAMASCUS

TRINITÉ ET TOBAGO

The Director
Trinidad and Tobago Bureau of Standards
P.O. Box 467
PORT OF SPAIN

TURQUIE

Le Directeur Général
Service du Contrôle de la Qualité et des Mesures
Sanayi ve Ticaret Bakanligi
Ölçüler ve Kalite Kontrol Genel
Müdürlügü
ANKARA

VENEZUELA

Le Directeur
Direccion General de Tecnologia
Servicio Nacional de Metrologia
Ministerio de Fomento
Av. Javier Ustariz, Edif. Parque Residencial
Urb. San Bernardino
CARACAS

YEMEN

The Director General
Yemen Standardization & Metrology
Organisation
P.O. Box 19213
SANA'A

Grande Imprimerie de Troyes, 130, rue Général de Gaulle, 10000 TROYES
Dépôt légal n° 8738 - Juin 1993