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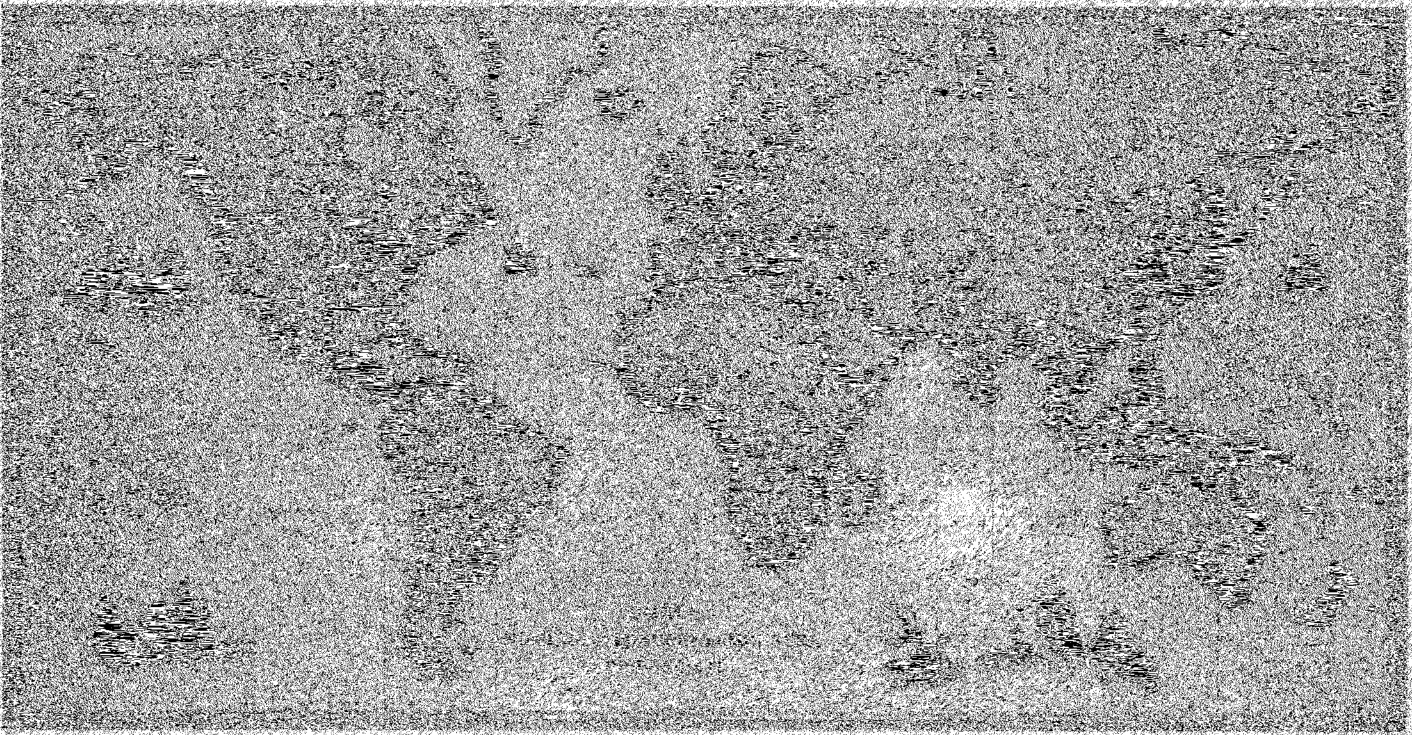

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SOMMAIRE

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CLEAN AIR MEASUREMENT
Interlaken 28 Sept - 1 Oct 1992

ALLEMAGNE

GAS ANALYZERS WITH EXCELLENT LONG-TERM STABILITY FOR THE MEASUREMENT OF EXHAUST GASES FROM OTTO ENGINES AND OPACITY MEASURING EQUIPMENT FOR DIESEL ENGINES.

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GAS ANALYSIS BY INFRARED ABSORPTION MEASUREMENT

By using the specific property of gases to absorb infrared radiation at well defined wavelengths, rugged analyzers for operation in the field can be built to measure gases such as CO_2, CO, C_nH_m and other components in vehicle exhaust.

The oxygen concentration of interest in the exhaust gases too, especially when calculating the air-to-fuel ratio (or Lambda value) cannot be determined by infrared spectroscopic methods, this component is analyzed by electrochemical cells or paramagnetic analyzers.

IR spectroscopy

Molecules that are formed of different atoms can show either a permanent or an inducible electric dipole momentum. If such molecules are exposed to electromagnetic radiation, they will interchange with the electric field (Fig. 1).

Depending on the mass of the atoms building the molecule and on the strength of binding forces between them, we have spatial structures that show typical resonant frequencies when stimulated for vibrations. The resonant frequency gives an information about the sort of molecule present in the gas sample. The amount of energy that is absorbed by the molecules from the radiation at a fixed frequency is dependent on the number of molecules of that species within the considered volume.

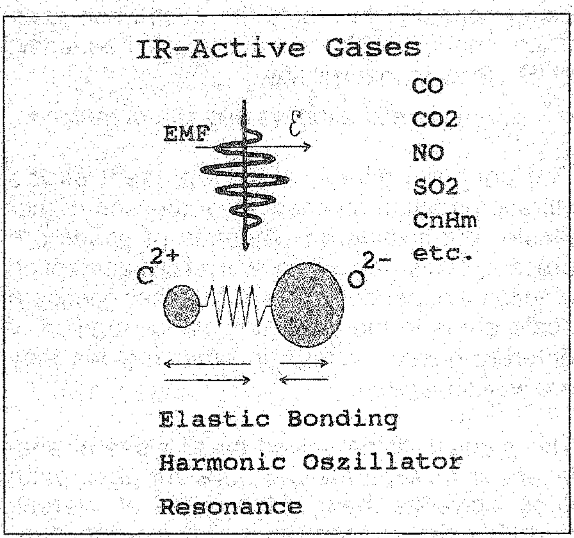

Fig. 1 – IR Absorption

It shall be pointed out that molecules consisting of identical atoms have no electrical dipole momentum and therefore cannot interfere with radiation to provoke vibrations. Such molecules are said to be infrared-inactive. Monoatomar molecules like He and Ar (inert gases) do not absorb IR radiation.

The explanations given above are a bit too simple to be useful for interpreting infrared absorption spectra. Pure bonding vibrations on molecules do not exist. Molecules that are stimulated for vibrations are simultaneously stimulated for rotating. Quantum mechanics state certain selection rules depending on the symmetry of molecules by which the structure of rotational vibration spectra can be understood. In the records of absorption spectra, the typical rotation structure can be seen.

The quantitative relation between absorption of energy and the concentration of gas within a thin layer permeated by IR radiation is given by a proportion. The absorbed energy, dI, is proportional to the incident intensity of radiation I, to the thickness of the layer dx, and to the concentration of gas:

$dI = \alpha\ I\ c\ dx$ or $dI/I = -\alpha\ c\ dx$ with the value α as the factor of proportion.

Integration renders the well known Lambert-Beer relation

$I = Io \exp(-\alpha\ c\ L)$

where c is the gas concentration
L the length of the gas cell
and α is the absorption coefficient.

This relation given above is only valid for one very sharp section of the gas spectrum, where the absorption coefficient can be considered as being constant. In reality the absorption coefficient changes with the wavelength (frequency) of IR radiation that will say

$\alpha = \alpha(\lambda)$ where λ is the wavelength of radiation.

The equation given has to represent all the vibration-rotation resonances of one sort of molecule. When different varieties of gases are present, every gas will show such an absorption function independently from the other gases. In some areas in the spectrum, the absorption of different gases overlap; in other regions they are well separated.

The problem to be solved by all types of analyzers is to separate the different absorption lines, correlate them to the gases of interest, and give the concentration value without remarkable cross-sensitivity.

Some known spectrometer types that will do this are listed here:

Dispersion **T**ype **S**pectrometer (**DTS**) working sequentially in a wide spectral range from 4 000 cm^{-1} to 200 cm^{-1} (2.5 µm to 50 µm).

Fourier **T**ransform **I**nfra **R**ed (**FTIR**) spectrometer working in a parallel mode over the entire spectral range by using interference methods (Michelson Interferometer).

Non-**D**ispersive **I**nfra **R**ed (**NDIR**) analyzers picking out the regions of interest out of the entire spectrum. Mainly two principles are in use today: Filter Correlation or Gas Correlation.

With a DTS, it takes from at least 2 minutes to 30 minutes or more to get a spectrum. The signal to noise ratio and the stability of the measured values is not so good that for small concentrations of CO or HC e.g. a resolution of 100 ppm CO or 2 ppm HC respectively can be achieved. The long period for one measurement of the spectrum is one of the factors associated with; using this type of instrument in the field of exhaust analysis; the main field of application of a DTS is in the laboratory.

FTIR spectrometers have gained an appreciable market share for exhaust measurement. These instruments can record the complete spectral range of interest within a few seconds with a good wavelength resolution (e.g. 1 cm^{-1}) and sufficient signal to noise ratio. With fast fourier transformation modules and special computer techniques, one can do the calculations for excluding cross sensitivity effects, correct for drift, and pick out the spectral lines that are affected most by the changes in concentration of the gases to be measured. This last point is not as trivial as it appears: As the complete gas sample passes only one gas cell, this cell must be as long (e.g. 700 mm) as necessary to have enough absorption signal for the gas with the lowest concentration and the smallest absorption coefficient. When measuring gases with high concentrations and high absorption strength, the lines will be saturated, i.e. there will be no changes in the signal, even though the gas concentration is changing. Other parts of the absorption lines have to be chosen. Many parts of a spectrum may be blocked when high concentrations of additional gases (CO_2 and/or H_2O) are present besides with components in a low ppm concentration of interest (hydrocarbons). The FTIR systems are mostly used in research departments and for acceptance tests where a high number of components has to be certified. Elaboration and adaption of the software to the individual measuring problem often takes an appreciable part of the development costs.

Construction principles of NDIR analyzers

NDIR analyzers are of a rather simple construction when compared with Dispersion Type Spectrometers or FTIR spectrometers. They include optical systems that normally work without any imaging devices (no lenses or imaging mirrors), using just a radiation source, a cell through which sample passes, and a selective sensing detector. For selectivity, two mainly methods are used: either interference filters are put into the optical path, or the detector is built in such a way that it only detects infrared radiation in the spectral region of interest. To extract the small absorption signal out of the whole infrared intensity of radiation, certain principles are used and will be explained below.

Standard construction principles

As the absorption signal to be resolved can be 1/1 000th of the primary radiation intensity for concentration values of some 10 ppm HC e.g., devices to determine small differences in big measured values are realized.

Four standard principles are usual, i.e. either a comparison of optical beams that transmit different materials from separated reference and measuring cells or a comparison of IR beams influenced by absorption from different wavelengths within the same sample cell. As shown in the schematic drawing (Fig. 2), the modulation of the IR radiation can be done inphase or in a reversed mode, depending on whether the detector is generating the difference or the sum of the incoming signals.

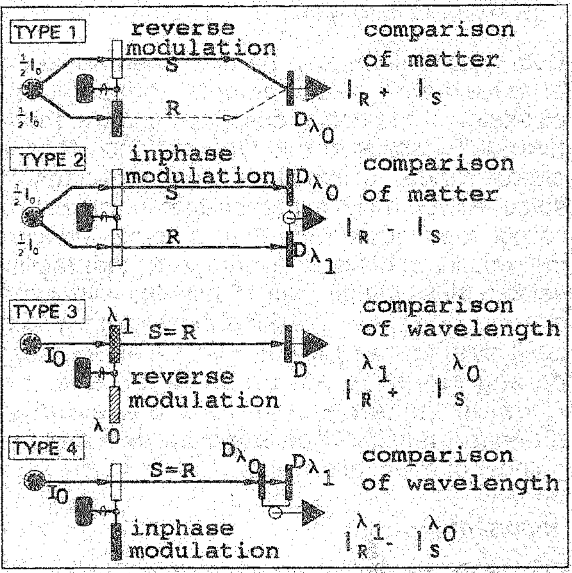

Fig. 2 – Basic principles of NDIR analyzers

Combination of principles

It should be pointed out that for high performance in stability and selectivity in the development of industrial analyzers the combination of fundamental arrangements are used.

Most producers of process analyzers favor the so-called optopneumatic detecting system with two detector cells, one behind the other, both being irradiated by the infrared beam. This construction represents a special form of a wavelength comparison because the irradiation to the second gas layer is pre-filtered by the first layer. Therefore, the spectral response of the second layer is more sensitive in the outer regions of the absorption bands whereas the first layer is more sensitive in the center. Within the detector cells, the modulated radiation is absorbed, the pulsation amplitudes of both cells are led to a tiny anemometer (or membrane condenser microphone) and the difference of the pneumatic modulation is converted to give the electrical output. The first layout of such benches is tended to design the front and rear cell of the detector so that both signals cancel simultaneously when there is no pre-absorption in the sample cell. Since the optical length of the rear cell has to be longer than that of the first cell, complicated shapes of the cells had to be realized. An additional disadvantage was the fact that complete balancing could not be afforded as the pneumatic timing was different from both cells when they had different volume.

The solution for these problems was a construction using the double layer detector combined with the principle of the comparison of two gases - the reference gas enclosed in the reference cell and the sample gas passing through the measuring cell (Fig. 3).

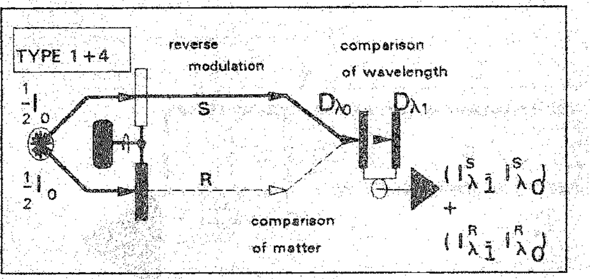

Fig. 3 – Combination type of NDIR analyzer

The modulation is inphase when looking at the comparison of wavelengths and it is reverse for the two spatially separated beams of radiation. For the two different IR beams, the detector forms the sum of both signals. However, one signal follows the other and no alternating output will be detected when both are equal in absorption, for the two layers in series the difference is generated. By using these techniques, an especially high selectivity is obtained and a stability in the zero that is much better than for the pure design of one of the standard principles. Measuring ranges of 10 ppm CO f.s. with resolutions down to 0.1 ppm can be realized.

One remaining problem is that the sensitivity can only be checked with additional means, e.g. test gases with known concentrations. In particular, when measuring near zero concentration, there is no information as to whether or not the analyzer shows this small signal because of a fault in the bench or because the gas concentration is near zero. Even the usually applied 4 mA elevated electrical output current does not give the desired information because it is not a survey of an optically living zero.

Here a new design of the optical bench combines some of the advantages of the sketched principles with an optically live zero which, in combination with microprocessor techniques, useful internal testing can be accomplished. Consequently, a high reliability and faultless operation can be expected.

New single beam design - Physics of the design and electronics

The new design represents principally a single beam bench with an optopneumatic double layer detector. The scope of development was to establish an easy to handle and cost effective analyzer.

Single beam bench

For generating the IR radiation, a coiled wire is electrically heated to about 600 °C and the beam is slightly focused to pass the sample cell (Fig. 4). By a sectorized wheel, the beam is periodically interrupted so that the intensity is modulated at a rate of about 8 Hz. A gas-filled detector gives a signal proportional to the intensity of radiation for specific wavelengths.

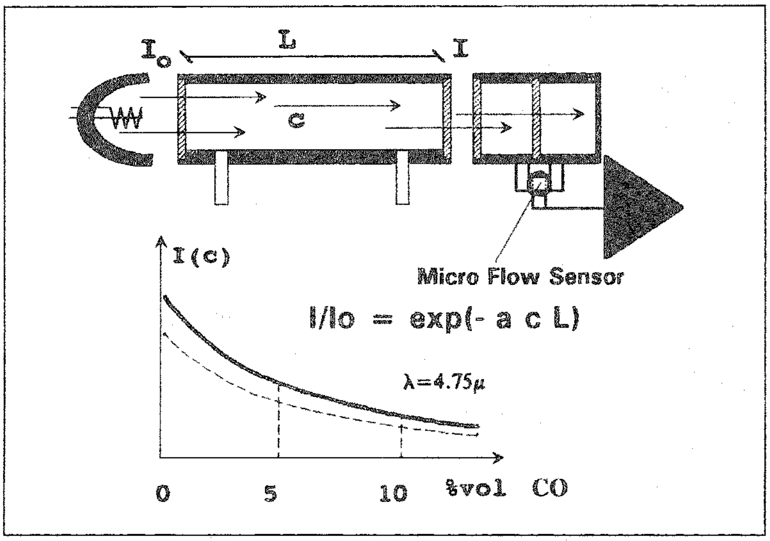

Fig. 4 – Single beam NDIR analyzer

The interrelation between the detector signal and the gas concentration is that given above by the Lambert-Beer formula. It is self explanatory and it can also be seen from the equation that for zero absorption, we have the maximum of radiation intensity at the detector. When the detector is constructed for best selectivity and not for zero compensation, we will have the maximum AC signal at the detector output for zero concentration in the gas cell. As the transmitted infrared energy for every concentration of gas is proportional to the primary intensity, I_0, we can calculate the ratio $I/I_0 = \exp(-\alpha\ c\ L)$, which is independent of I_0 and for a given cell length, L, and a given gas only depends on the concentration c of that gas. I and I_0 must not fall below a certain limit so that there will be no complications for the division and signal to noise considerations. Tolerated limits are set for the I_0 level to ensure that the transmission is good enough for the accuracy to be in given ranges. If this I_0 value is within the fixed range, then the transmission line from the source to the detector and the complete signal processing will work as desired.

One question remains: Where do we get the zero signal when we have only one sample cell? Two things must be postulated.

- First: The bench has to be stable for more than one cycle of measurement
- Second: A valve can be put into the gas path so that ambient air (filtered if necessary) can be used as zero gas.

Both requirements can be met when speaking of car exhaust measurements. Industrial applications of the bench described show a short-term drift stability of this type of bench for the critical ranges of small HC concentrations of some 100 ppm HC full range that is within 1 % f.s. for a period of more than 3 hours. Measuring vehicle exhaust in a garage or test facility seldom takes longer than 15 minutes with some minutes of pause. Checking the sensitivity and zero setting can be done when an exhaust measurement is not being taken and the I_0 value (taken just before the exhaust measurement) will be used up to a certain number of hours afterwards.

Important:

The exact transmission path for the sample cell is examined with a detector which contains the gas filling that has the same absorption lines as the gas to be measured. Changes of transmission caused by dust, smoke, condensed material on the windows, aging of the source, etc are screened exactly in all the spectral lines (not only in the area of some or all of the lines) of the gas to be measured.

The sealed gas filling of the detector itself works as a test gas and the stability of the signal generated is checked again against an internal electrical reference so as to exclude leakage.

Gas correlation detector

The spectral response of this arrangement has to be calculated from the absorption of energy by the filling gases in the first and the second layer. One has to take into account that the radiation input to the second layer is pre-filtered by the first cell. The result is shown in the diagram (Fig. 5).

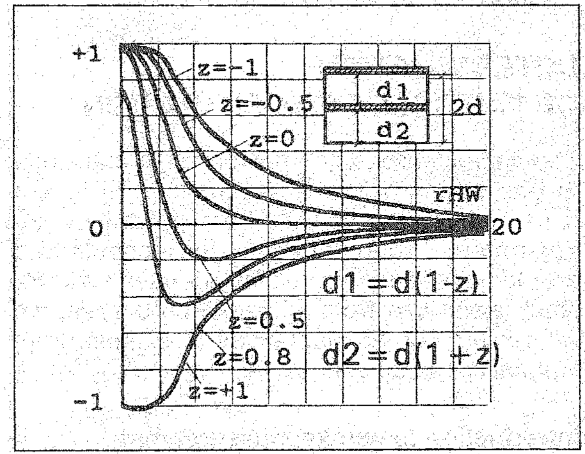

Fig. 5 – Bandwidth of NDIR detector

As the lengths of the detector cells are changed, a different spectral selectivity is obtained; in particular, the bandwidth of the detector is changed as shown. From this, one can see that with equal dimensions of the two detector cells, there is a detection bandwidth of about half the width of a single cell detector. With the same type of gas filling inside the detector as the gas to be measured, a spectral sensitivity is generated which is an exact image of the rotation-vibration band of the gas to be measured. Measuring by this method represents a correlation analysis between sample gas and detector filling.

Data processing

With the high AC signal always being present as detector signal, the precision rectifier works as an automatically synchronizing login amplifier and a good noise reduction is achieved.

In addition to the rectified and A/D converted signals from the infrared channels, the signal from the oxygen sensor and information from temperature sensing devices and the barometric pressure sensor are digitized. The internal hardware does all the linearizing and corrections for influences from cell temperature and pressure. Other parameters such as oil temperature and engine speed are screened and limits of operation are given.

In addition to the measurements mentioned above, a calculation for the LAMBDA (or A/F) value according to BRETTSCHNEIDER (BOSCH TECHN.BER: 6/1979/9) is executed. Determination of the oxygen content is of particular importance for this calculation. Since the electrochemical oxygen sensors are, to some extent, temporarily poisoned by high CO_2 concentrations and the recovery time for exact zero indication of O_2 depends on the duration and the level of CO_2 present in the oxygen sensor, a recovery timer is realized which integrates the % minutes CO_2 and controls the purging period so that the pump will only stop when a sufficient amount of clean air has passed the sensor. This procedure assures a good zero stability of the oxygen sensor.

Advantages

With the analytical techniques and data processing described here, rugged and reliable equipment for gas analysis in car I&M programs and in industrial applications have been established. By utilizing processor techniques, operation is simplified and the user is guided by the equipment for easy handling.

As explained theoretically and confirmed by tests from an independent legal certification institution, the long term stability of the analyzer is so good that there is **no need for online calibration gases** at the site of the analyzer.

It is sufficient to look for right calibration twice a year and this should be done with a standard gas by authorized personnel for all analyzers that are in action within a legal inspection program to have identical reproducible accuracies within this set of analyzers.

Realization

The main technical data can be seen from this list.

Ranges for the gas components

0 ...... 10.000 ppm HC
resolution: 1 (10) ppm HC
0 ...... 10.00 % vol CO
resolution: 0.001 (0.01) % vol CO
0 ...... 18.0 % vol CO_2
resolution: 0.1 % vol CO_2
0 ...... 25.0 % vol O_2
resolution: 0.01 (0.1) % vol O_2

LAMBDA calculation

0.5 .... 1.8 resolution: 0.001

In addition, the analyzer comprises:

- ignition clamp sensor for the measurement of revs
  0 ...... 9990 mn^{-1} resolution 10 mn^{-1}
- oil temperature measurement
  0 ...... 160 °C resolution 1 °C
- internal protocol printer
- features for data communication

View of decomposed bench

A perspective view of the bench shall give a realistic impression (Fig. 6).

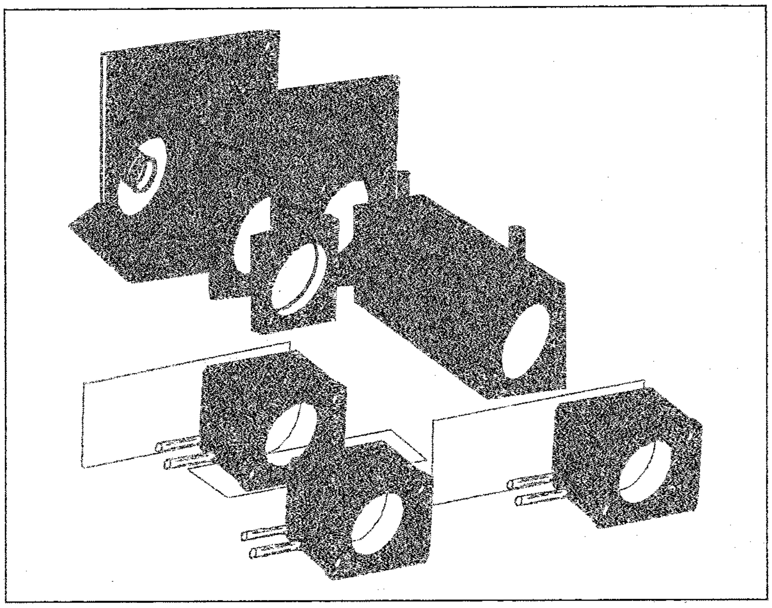

Fig. 6 – Decomposed bench

Radiation source, chopper, sample cell, and detectors are shown. One can see that for the more sensitive HC channel, a longer sample cell (100 mm) is used to have a stronger absorption signal. For higher concentrations like CO and CO_2, the shorter cell is chosen to get enough resolution at full scale in the CO_2 channel. You must not be confused: This is not a double beam bench; it consists of two single beam benches using one chopper and one suspension mount. For lower precision demands, all the detectors could be mounted to one beam behind one sampling cell in a serial manner.

Test results

To give support to the explanations above, some results are given. These results concern field operation from three units under inspection of the German Eichamt from 3 May 1991 through 25 May 1992. They were installed in three different sites. In addition to the standard hardware, a counter for the number of measurements was installed in order to have an impression of the use that the analyzers are exposed to.

Working out all the data from this run gives a good affirmation of the high accuracies pronounced. For the gases under test, we obtain the following results (see Fig. 7):

DETERMINATION OF PARTICLE CONCENTRATION

The characteristics of small particles contained in gas emissions are remarkably different depending on the process from which they are generated. Though some of the aspects that are addressed in this section are also valid for stack emissions from industrial processes, we will restrict our considerations to exhaust from internal combustion engines.

Introduction to smoke measurement

Smoke in the exhaust from Diesel engines caused by incomplete combustion of fuel mainly consists of coagulations of carbon particles with a high amount of polycyclic hydrocarbons, salts, metals and other additives. These chain to a particle size of 0.05 µm to 0.5 µm and show a maximum of about 0.15 µm in the distribution probability.

For optical measuring techniques, the same basic LAMBERT-BEER equation used for IR analysis is valid. One difference comes from the fact that the specific absorption coefficient is assumed not to be wavelength dependent within the spectral region of interest (green LED). This can only be stated for the black smoke and is not valid for blue smoke (oil dust) and white smoke (water vapor as fog). Therefore, it is not evident to use optical absorption for the measurement of particle emissions. Only from the measurements by DODD et.alt. (MIRA No.10; 1965) and recently

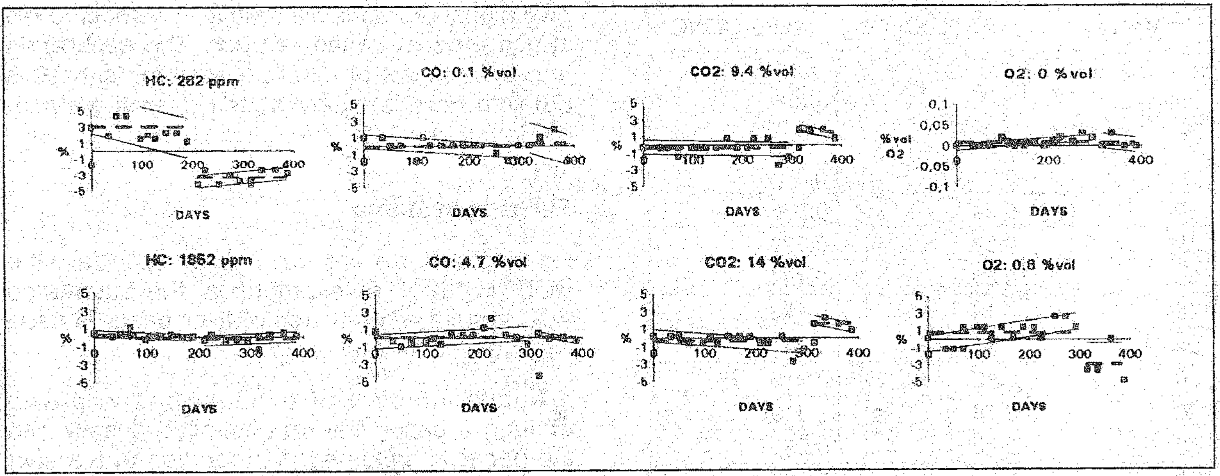

Fig. 7 – Worst case of field test

discussed by HARDENBERG et.alt. (MTZ 48; 1981; 2) one can correlate mass concentration of black smoke from vehicular engines to optical absorption. A specific extinction coefficient for smoke was found to be

$$a = k/c = 6.640\ \mathrm{m^2/g} \pm 2.288\ \mathrm{m^2/g}$$

this value being independent of the smoke concentration. As can be seen, however, the value has a high variance (see Fig. 8).

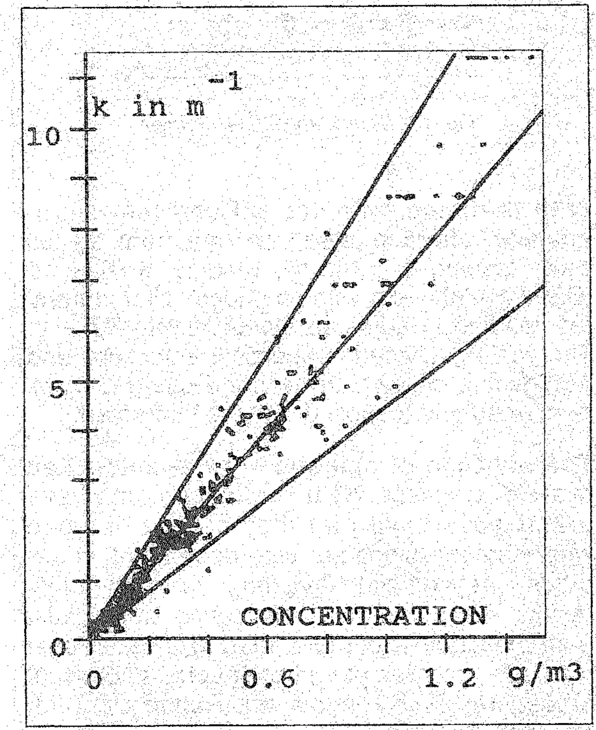

Fig. 8 – Absorption constant versus mass concentration

Therefore, the optical measurement can only be a coarse estimation for the real mass concentration that normally has to be weighed using complicated filter technologies in a steady state operation of the engine.

Remark: To be exact, one should use the word *EXTINCTION* for the intensity that will not reach the detector This is more than the pure absorption: it will include contributions from scattering, refraction, and bending. Usually, the expressions *EXTINCTION* and *ABSORPTION* are used as synonyms in the context of smoke measurement. We shall do the same when referring to the absorption coefficient, k (m^{-1}).

For a simple understanding, one can look to the specific extinction coefficient as being the total cross section per mass of smoke shading the light source when brought into an optical transmission system. From previous considerations for the IR topics, we now obtain the following relations:

From $I = I_o \exp(-a\ c\ L)$ c (g/m^3 mass concentration)

with the proportion $k = a\ c$ for the absorption coefficient

it reads as $k = -1/L \ln(I/I_o)$ k (m^{-1})

The transmission T is

$T = 100\ (I/I_o)$ T (% transmission)

and for the opacity H we get

$H = 100\ (1 - I/I_o)$ H (% opacity)

or $H = 100 - T$

With the knowledge from MIRA we can give the proportion

$c\ a = k = -1/L \ln(1 - H/100)$

In Table 1, for certain distinct values this relation is shown numerically.

OPACITY	ABS:COEFF	MASS:CONC.
L = 432 mm cell length %	m^{-1}	g/m^3
0	0	0
10	0.24	0.036
20	0.52	0.078
30	0.83	0.124
40	1.18	0.178
50	1.60	0.241
60	2.12	0.319
70	2.78	0.419
80	3.72	0.561
90	5.33	0.803

Table 1

As mentioned above, the correlation between the rightmost column and the absorption coefficient is rather weak with a standard deviation of about 20 %.

This is impressively shown in a figure representing this fact from a different point of view (Fig. 9).

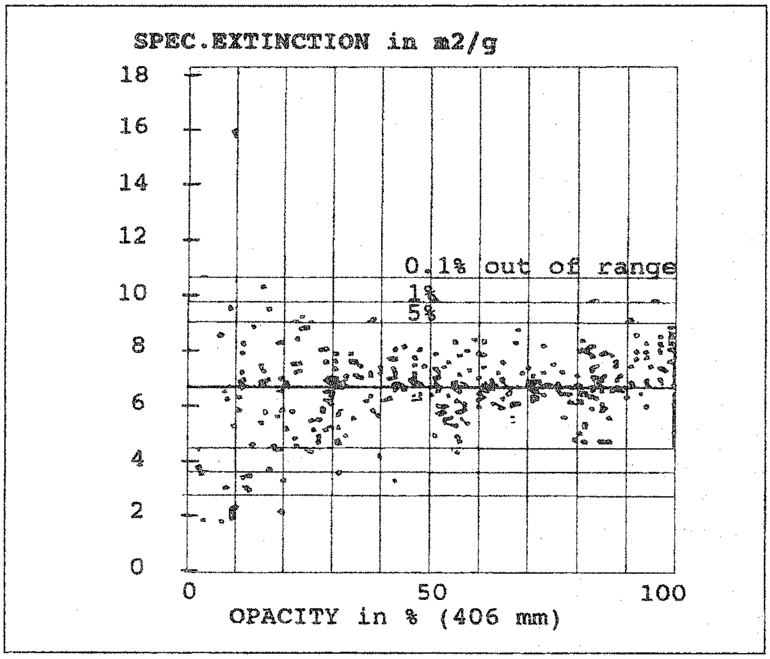

Fig. 9 – Specific mass extinction coefficient

Construction principles of smokemeters

All the different principles of smoke measurement have specific disadvantages. Nevertheless, optical systems are used more and more because they are fast in response and give highly reproducible results in respect to the optical opacity measurement. The calibration and adjustment of different systems can be a problem because there does not exist a standard for smoke.

Filtering systems

Filtering systems are well-known, especially the BOSCH "Spot" smokemeter or the automated AVL system where a roll of filter paper is used instead of individual disks.

A known amount of exhaust gas is drawn through a paper filter of controlled density and the paper is darkened in proportion to the soot particle concentration. Diffuse reflection from the filter paper is measured as shown in the sketched diagram (Fig. 10).

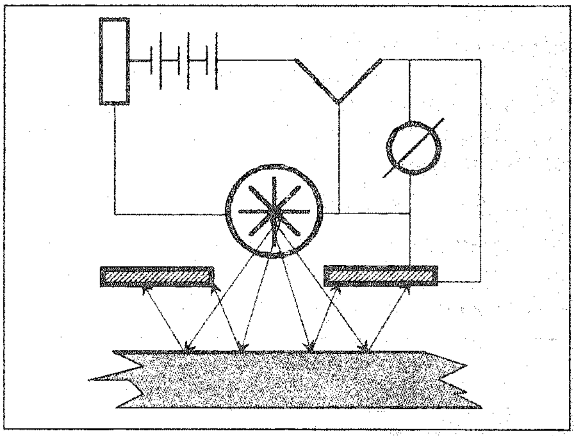

Fig. 10 – Reflectance measurement

With the lamp switched off and the microammeter shortcircuited, the (mechanical) full scale reading is set to the reading of BZ = 10 (BOSCH-Zahl) and with an unused filter in front, the reading is adjusted electrically to BZ = 0. The scale is divided in equidistant sections and a midscale check can be done using a black perforated grid (supplied with the instrument).

The principle of operation of the automated system is similar. All these instruments have the disadvantage that they cannot be used when the emissions are time dependant; in addition, they do not have high reproducibility results. For purposes of estimating smoke/dust from the stack of burners, there exist additional methods, for example, photographic and visual procedures (see Ringelmann Rating US B.M. No. 8333 & 7718).

Optical systems

International standards (ISO 3173) ask that the optical system consist of a light source having a color temperature between 2800 and 3250 K and a light receiver combined with filters (if necessary) with a maximum response in the range of 550 to 570 nm and restricted sensitivity below 430 nm and above 680 nm; or a green LED in conjunction with a photodiode must be used. This last proposal is favored by today's analyzers because it has a lower energy consumption and can be modulated electronically at high rates.

Full-Flow Opacimeters

Full-flow type opacimeters measure the light transmission across the full cross section of the exhaust pipe. End of line as well as in-line opacimeters are discussed below.

End of Line Type

With instruments (i.e. the USPHS [EPA] smokemeter) mounted some inches from the end of the stack, high influences from the form of the smoke "plume" result; the optical path length is not well defined and the results do not have a good reproducibility.

Inline Type

Inline smokemeters (i.e. V.A.G 1543) are adapted directly to the exhaust stack with a rubber cone; the cross section of the duct has to be similar to the shape of the exhaust pipe so that the pneumatics of the exhaust manifold is not disturbed.

Some instruments require compressed air to keep the light source and the detecting unit free from soot. The unit shown in Fig. 11 has a smooth restriction in the gas duct to give a small negative pressure difference at the holes where the light beam passes the wall. A small amount of clean air (from the surroundings) is sucked into the unit and protects the lenses from smoke particulates.

Part Flow Sampling Opacimeter

The HARTRIDGE MK 3 smokemeter is a well-known sampling opacimeter. It is used in engine development and testing departments and therefore, has become a de facto standard for sampling opacimeters.

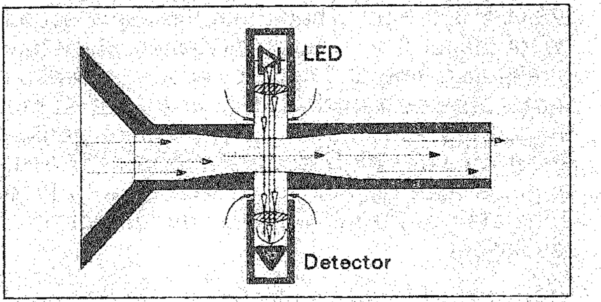

Fig. 11 – Full flow opacimeter

Transient smoke measurements are not recommended with this type of instrument due to the slow response and problems maintaining temperature and pressure conditions within specified limits.

The principle of the HARTRIDGE design is rather simple (see Fig. 12); it consists of two optically identical cells with black cylindrical walls and annular light traps on the inner surfaces in order to avoid reflected light from the light source to reach the photoelectric detector. One cell serves as the measuring cell, where the smoke probe is passed through and the other is used as a reference cell, continuously cleared by clean air from a blower. By means of a control knob, the light source and the detector can be switched simultaneously from the sample path to the reference path to set the zero point for the opacity reading.

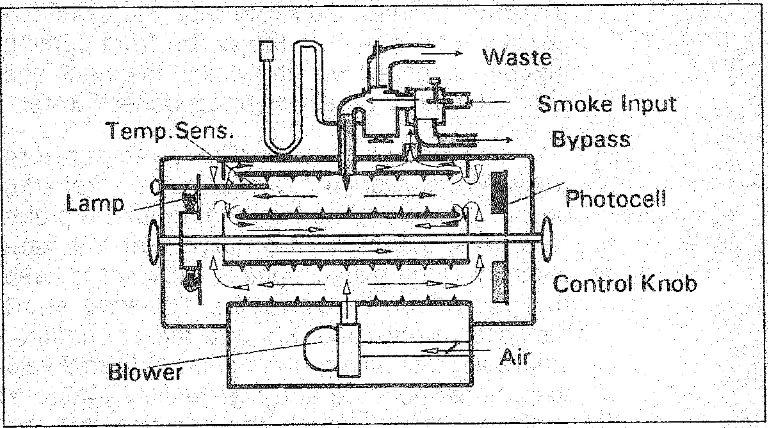

Fig. 12 – Hartridge smokemeter

A bit more complicated seems to be the probe handling techniques with heated sampling tubes, pre-coolers, smoke by-pass valve, pressure relief valve, water drain, etc.

One further disadvantage can be seen in the need for the exhaust of the engine being tested to afford enough pressure for flow through the test unit. The engine can be disturbed by the backpressure generated and the tuning of the exhaust manifold can be altered.

New opacimeter design

Experience and know-how from the described optical systems led to a new design of an optical smokemeter that was developed in cooperation with car manufacturers with the intention of giving a good correlation to the HARTRIDGE results.

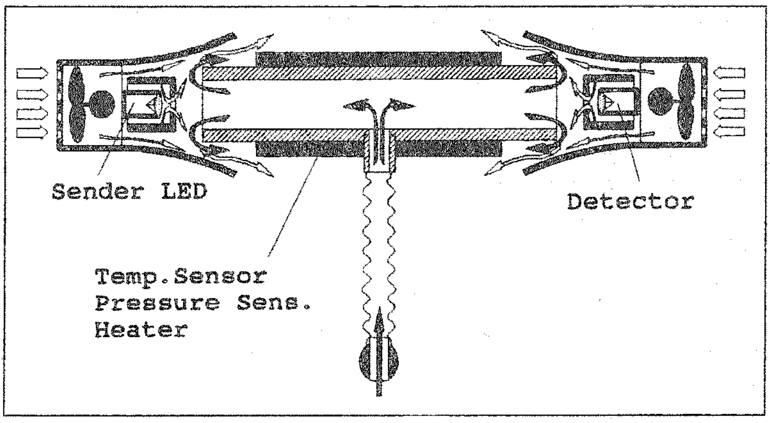

Fig. 13 – Part flow smokemeter

Details (Fig. 13) of this new design will be explained. In agreement with the regulations of the periodical inspection program planned for Diesel vehicles in Germany, the smoke sample from the exhaust is taken with a probe of 10 mm inner diameter (27 mm i.d. for vans) inserted at least 200 mm into the stack. A cruciform fin prevents the probe from coming into direct contact with the wall of the stack and taking in coarse abrasives or condensed water.

The sensor unit is heated to a temperature above 70 °C. Conductive heat transfer from the sensor unit raises the temperature of the probe to a level that is high enough that the heat capacity of the exhaust gas is sufficient to keep the gas above its dewpoint. The very short distance of only 500 mm and the corrugated, stainless steel tubing gives support to maintain the gas temperature at a high level. As there is no force that influences the gas flow into the probehead, we can speak of an "isokinetic" sampling probe.

Measuring cell

After the flow has passed the probe, it separates into two equal parts filling the measuring cell in the same manner as that for the HARTRIDGE analyzer (even the effective cell length is the same as before - 430 mm).

Since the new design uses an LED of small, lateral dimensions as a light source, the beam can be imaged parallel with a very small aperture. Therefore, no light will touch the walls of the cell (even though it is only 40 mm i.d. and the beam has a 20 mm cross section).

Therefore, there is no need for annular light traps to restrict the aperture. The advantage is that gas can pass through the cell without remarkable turbulations and without any pressure difference between gas input and output.

Two small blowers at both ends of the cell generate clean air curtains that keep the lenses in front of the LED and the photo-transistor free from soot.

By means of venturi restrictions in the annular gas outlet of the clean air, a very low negative pressure of approximately 2 mbar is generated so that at the engine's idle, the sample can easily enter the probe. Furthermore, fresh air is taken in from the entrance of the probe when the engine is stopped or when the probe is not inserted into the stack. This accomplishes the method of automatic zeroing of the unit.

The ducts for clean air have been designed very carefully. It has to be pointed out that a "hard" lens of fresh air was built to have only a very small negligible influence on the effective cell length when the flow rates (probe & air) are changing. This gives reproducible results independent from the load and the revolutions of the engine.

The LED is modulated at a pulse rate of 500 Hz. In addition to the pulsation of the LED current, only that part of the signal is picked out of each pulse where the light intensity has become constant - that is, in general the last 20 µs of the pulse. The timing trigger is set by the processor. With this method a good agreement with the HSU is achieved where the measurement is taken under constant light intensity conditions. Furthermore, changes in the dynamic response of the LED are avoided.

If there is a need for cleaning the optics, this can easily be accomplished by opening just one handle and flapping out the cell. All parts are then accessible, and after cleaning, they are clicked in and the unit is ready for operation.

Resolution in time and opacity

The short distance of the exhaust gas from the stack to the cell gives a fast response. In conjunction with the directly-passed cell, the time constant is approx. 100 ms at low engine revs and shrinks down to approximately 10 ms when the engine speed is elevated to a maximum about 6 000 mn^{-1}. That is not the same speed as for the full flow inline smoketester, which has a response time of 5 ms. However, comparison tests between both systems at the same measuring site show that the smoke peaks, even for very high accelerations of Diesel engines, can be monitored exactly with time constants of 20 ms without any loss of time resolution.

The signal to noise ratio for the part flow instrument is at least a factor of 10 times better

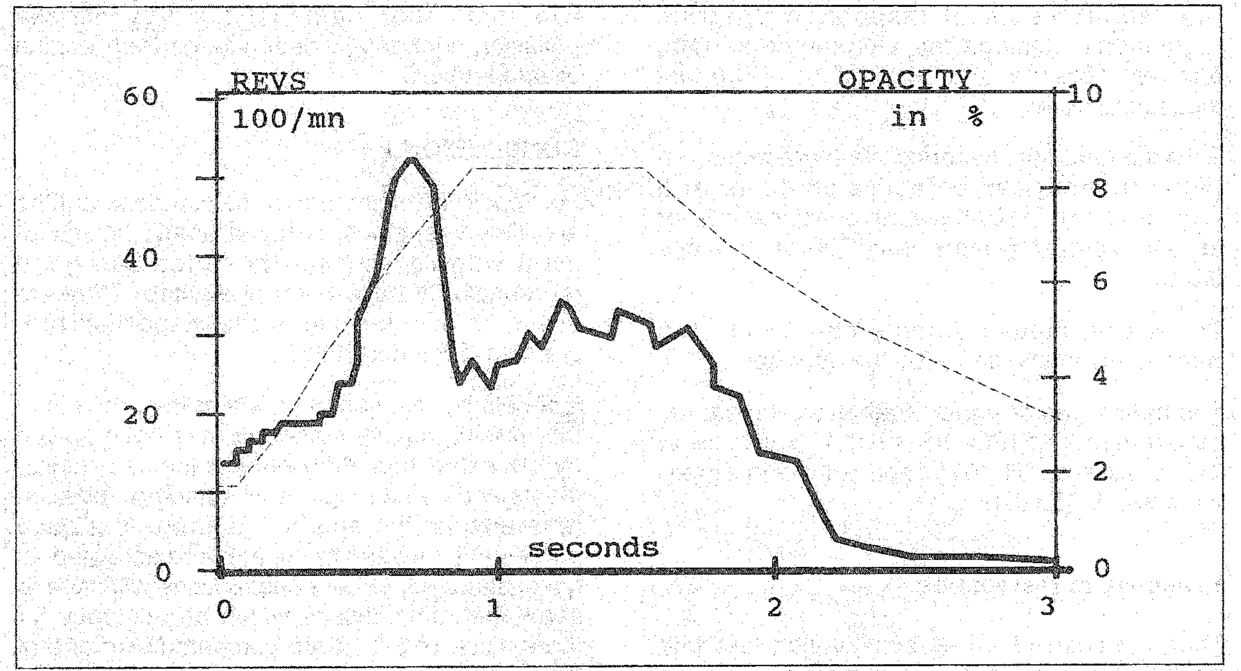

Fig. 14 – Response of inline full flow opacimeter

than with the full flow inline tester due to the longer path length of the light beam. Resolutions in opacity better than $\Delta H \leq 0.3$ % are achieved. This is equivalent to a resolution in k better than $\Delta k \leq 0.01$ m^{-1} for low dust concentrations.

Additional features

It is clear that in comparison to the older generations of smokemeters, many additional features now integrated in the smokemeters are state of the art. For example:

- Sensors and readout for engine speed.
- Top Dead Center marker detection.
- Oil temperature sensor.
- Clamp sensor (injection system clamp).
- Integrated printer.
- Counter for pre-selecting a fixed number of acceleration tests and calculation of mean values including deviations.
- Display units for smoke content can be chosen by the user as opacity (in % for 430 mm optical length); extinction coefficient K (in m^{-1}) or mass concentration (in mg/m^3).
- Internal temperature compensation of results for gas temperatures above 100 °C.
- Monitoring the limits -6 mbar $< p < +7.5$ mbar of gas pressure in the sample cell.

If the user is not so interested in the real peak smoke emission as in a good correlation to some HARTRIDGE Smoke Units, a software time constant of 1 s can be activated which gives an integrating behavior for display and readout.

Additional features, such as settings of time windows for peak detection and special operating sequences, adapt the instrument to

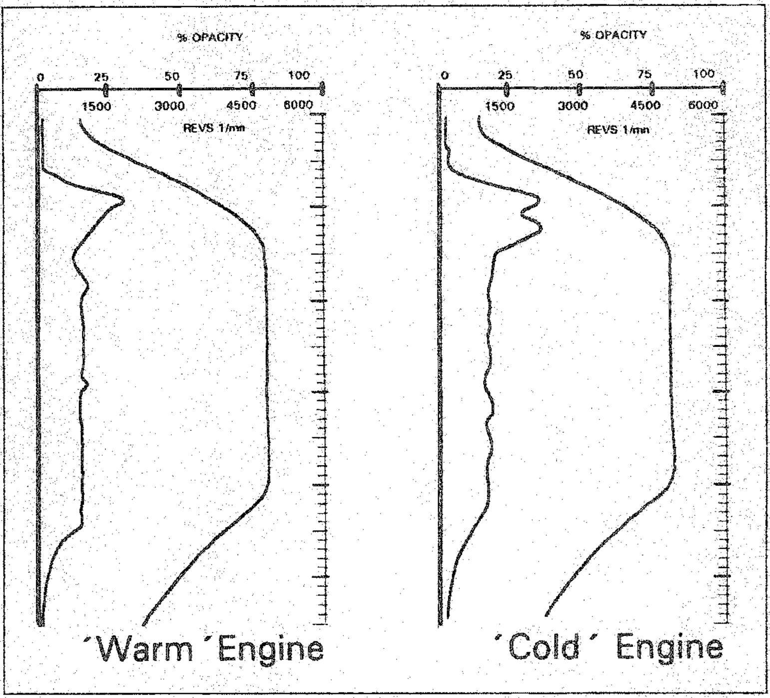

Fig. 15 – Influence of motor temperature

the requirements of inspection program regulations. Besides the alphanumeric data, one can obtain a graphic printout of the last measuring cycle.

To accommodate dynamic measurements, internal triggers can be activated either at a level of opacity 3 % above the opacity at idle, or at revs increasing more than 300 mn^{-1} within 0.5 s.

Therefore, measurements can be started without any manipulation by the operator.

The bench was designed so that it will meet the requirements of ISO/DIS 11 614 (Revision of ISO 3173 and TR 4011) and will be in agreement with ECE R24.

Examples of test results

The time chart of a free acceleration test with an inline smoketester is shown to give an impression of the time resolution needed (Fig. 14).

With the graphics printout feature, some test cycles have been documented. Fig. 15 presents two tests that demonstrate how smoke emission changes in dependence from engine oil temperature.

CONCLUSION

For repair, inspection, and maintenance of Otto and Diesel engines, exhaust analyzing equipment with reliable performance and good reproducibility have been presented. They are available now for use in the inspection programs expected for 1993.

It should be mentioned here that the problem of the missing smoke standards has been solved by choosing four differently designed instruments and measuring the IR standard deviation (one against the others). As there is a good agreement between them, they are accepted as quasi standard. Other constructions will have to show the same results within an accuracy for the k value of 5 % when compared with one of these instruments in operation at a set of ten cars representative for the entirety of Diesel cars in Germany.

There is no hindrance to start measuring now!

ÉTATS-UNIS D'AMÉRIQUE

CLEAN AIR MEASUREMENT Interlaken 28 Sept - 1 Oct 1992

MEASUREMENT TRACEABILITY VS. LEGAL TRACEABILITY IN AIR QUALITY MEASUREMENTS

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Abstract

Traceable, the adjective derived from the verb "to trace," has four distinct definitions with over 12 nuances according to Webster's English Dictionary. Its use in metrology is often in the eye of the beholder. There have been a few notable articles authored during the past 30 years which have given preferred definitions to traceable when used for legal metrology. These include:

- "The ability to relate individual measurement results to an accepted standard or measurement through an unbroken path of measurements."
- "The ability to relate a given standard to a reference standard with rigorous evidence quantitative compatibility within defined error limits."
- "The quantitative expression of a measurement in terms of units that are defined by an accepted reference national or international standard."

We are faced with the same problem today that has confounded the legal community throughout history. Almost without exception, when laws are passed which include the concept of traceability, the exact definition is left for the user community to decide at a later date.

This article will describe a system for traceability useable for air quality measurements and illustrate who is responsible for what portion of the overall traceability system and how it is quantitatively assured.

Introduction

Traceability as a measurement concept has evolved out of the need to understand the sources of and the ambiguity introduced by measurement errors propagated during a series of measurements. In almost all cases, traceability becomes important where secondary or tertiary measurements, related to a standard measurement or artifact, are used to express a relationship in terms of a primary measurement, standard, or standard artifact. This concept has become increasingly important in measurements related to health, safety, and the environment, particularly in situations where issues of compliance with law, government regulations and/or liability litigation are involved.

In air quality measurements, traceability to a primary measurement standard is particularly important because most measurements are made to determine pollution levels regulated by national governments or are measurements made of atmospheric constituents concerned with global climate change. These programs usually involve many countries and large-scale spatial and temporal data sets. In these cases, the understanding of the error propagation throughout the measurement chain from primary standard to secondary laboratory standard to field measurement is often the determinant in whether validity of data and therefore scientific conclusions are the end result of the measurements.

Definition of traceability

Traceable, the adjective, derived from the verb to trace, has four distinct definitions according to Webster's English dictionary. During the past 30 years, there have only been a few articles which attempt to define traceability for use in legal metrology (1,2,3,4), and only one of those dealt with gas measurements (4). Three definitions used in past publications, which are similar but have different subtleties in use are:

- "The ability to relate individual measurement results to an accepted standard or measurement through an unbroken path of measurements." (2)

- "The ability to relate a given standard to a reference standard with rigorous evidence of quantitative compatibility within defined error limits." (3)
- "The quantitative expression of a measurement in terms of units that are defined by an accepted reference, national or international standard." (3)

The definition of traceability used by the International Organization for Legal Metrology (OIML) and derived from the "International Vocabulary of Basic and General Terms in Metrology" is (5):

- The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

For air quality measurements, a variant of the OIML definition, which includes both the property of a measurement result and the propagation of errors, is most useful both for intercomparison of results and for legal use. Therefore, the definition of traceability proposed and adopted for this paper is:

- The property of a result of a series of measurements which gives a quantitative relationship to an accepted reference, national or international standard, with defined error limits derived through an unbroken path of the measurement series.

Primary standards for air quality measurements

Most analytical techniques used for the measurement of gaseous atmospheric species are relative in nature and thus require a calibration standard for routine operation. Exceptions to this are isotope dilution gas mass spectrometry for carbon dioxide in air, absolute ultraviolet photometry for ozone in air, and coulometry for sulfur dioxide. In other cases, primary standards are required to establish the accuracy of atmospheric measurements.

Compressed gas mixtures prepared by gravimetric addition of an analyte gas or gases to a matrix gas of known purity make convenient standards for most atmospheric measurement systems. Such gas mixtures of many nonreactive gases have been shown to be stable over long periods of time and have been used for many years as analytical standards. Some species, however, such as ammonia, change in concentration with time due to chemical adsorption on container materials, and other species, such as ozone, change due to chemical reactivity. The stability of the gas species of interest dictate the type of measurement calibration strategy used and thus dictates the traceability protocol employed.

In this section, two different strategies are described to illustrate the procedures necessary to ensure proper traceability in atmospheric measurements.

Stable gas mixtures

The National Institute of Standards and Technology (NIST) analyzes, certifies and sells Standard Reference Materials (SRMs) in many technical areas. SRMs for gas measurements are described in the NIST SRM Catalog (6). Most of these gas SRMs are stable compressed gas mixtures with one or more analytes included in a matrix gas.

Gas species that are presently sold as NIST SRMs include carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen dioxide, nitric oxide, simple aliphatic hydrocarbons, and some trace organic mixtures. NIST gas SRMs are commercially prepared compressed gas mixtures of specified analytes at a specified concentration in a matrix gas which are compared directly to a set of primary standards gravimetrically prepared at NIST.

The measurement accuracy of these primary standards is directly traceable to the kilogram. SRMs in this category are certified to have a total uncertainty of between 0.1% to 0.2% relative to the concentration of the certified species, depending on the measurement errors encountered during preparation and measurement intercomparison. That uncertainty contains all random and nonrandom errors in the primary gravimetric standard preparation and the random error of the transfer measurement from the primary standard to the SRM gas mixture. Thus, the first step in a traceability statement by an SRM user is the NIST certified value and its stated uncertainty. That measurement value and its uncertainty is promulgated by NIST and is the sole responsibility of NIST.

The next step in a traceable atmospheric measurement is determined by whether the measurement analyst used an NIST SRM or a more available intermediate standard.

Hughes and Mandel published a procedure to ensure traceability in secondary standards in "A Procedure for Establishing Traceability of Gas Mixtures to Certain NIST SRMs" (4). This procedure describes the measurement steps necessary to ensure the proper assessment of the "estimate" of true value and the increase in uncertainty of that value during the measurement comparison of the SRM to the secondary standard.

In the United States, secondary gas standards prepared strictly by the Hughes/Mandel protocol are designated as Certified Reference Materials (CRMs) which is in accord with the internationally accepted usage of the term. These CRMs are legally acceptable to the U.S. Environmental Protection Agency for use in measurements requiring traceability to NIST SRMs.

The individual producers of gas CRMs are legally responsible for the traceability of their CRMs back to the NIST primary standards.

For laboratories making large numbers of atmospheric measurements, there is usually one more step in the traceable chain.

An example is the Environmental Research Laboratory of the U.S. National Oceanographic and Atmospheric Administration (NOAA). They prepare, at their laboratory, many standards similar in nature to NIST SRMs. They also prepare working standards used at many of their worldwide monitoring sites. In this process they intercompare their primary standards to NIST SRMs and determine their own "estimate" of true value and its associated uncertainty to their working standards.

Thus, most of the atmospheric monitoring data published by NOAA are traceable to NIST primary standards and NOAA is legally responsible for the traceability of their published atmospheric data.

Unstable atmospheric gas species

The measurement calibration and its traceability to a national standard for reactive atmospheric gases is, at best, difficult. NIST and the U.S. EPA have developed a national primary standard and traceability protocol for ozone which serves as a model for what can be done and serves as an example for the degree of difficulty of such traceability.

In 1981, Dr. Arnold Bass of the NBS staff and Dr. Richard Parr of the EPA staff collaborated to develop, engineer, and build one prototype of an absolute ultraviolet photometer for ozone (7). This photometer was based on the internationally accepted absolute ultraviolet absorption coefficient of ozone at the 253.8 nm wavelength of mercury light. A dual path photometer was built which compared the absorption of uv light by generated ozone in a cell to that in a second equal cell containing clean air. The concentration of ozone in the standard cell was then calculated using Beer's law.

The uncertainty of the predicted ozone concentration was determined by prediction using the estimates of uncertainty in the path lengths of both cells, the statistics of the photon counts of the difference between cells, and the estimates of the uncertainty of the internationally accepted uv absorption coefficient. A second instrument was built and intercompared with the first. The uncertainty of the intercomparison of absolute ozone concentration was within the predicted uncertainty and the two instruments were designated as national standards, one maintained by NIST and one maintained by EPA. Since their development, the instruments have been directly intercompared at least once every year to maintain their traceability. Following their acceptance by EPA and NIST as national standards, a series of 12 identical instruments have been built by NIST and distributed to 10 U.S. regional environmental laboratories, to one Canadian National Laboratory, and to one Swedish National Laboratory which is part of the European Community ozone monitoring network. All instruments yielded predicted ozone concentrations based on absolute uv absorption within the originally predicted uncertainty.

Instruments in all U.S. laboratories are individually intercompared each year to ensure their continued traceability to the two U.S. national standards. NIST and EPA are jointly responsible for the legal traceability of the ozone standards in place at the U.S. regional laboratories.

The individual regional laboratory managements are responsible for the traceability of the calibration of all transfer ozone standards calibrated at their laboratory for other state or regional laboratories.

The NIST-built photometers in Canada and Sweden are irregularly intercompared using transfer standards. Both instruments have maintained calibration within their certified uncertainty throughout their use to the present.

In these cases, however, the two government laboratories are responsible for the legal traceability of standards and instruments calibrated at their laboratories using the NIST-built absolute photometers.

Summary

In summary, there are three essential elements of measurement which must be followed to reasonably establish traceability.

1) The measurement must be based on a standard, preferably a nationally or internationally accepted standard, which has an estimate of the true value of the concentration of the analyte of interest and has a statistically valid estimate of the total uncertainty of the measurement used to establish the true value.

2) For each step of the measurement traceable chain, there must be a transfer of the estimate of true value and an estimate of the increase in uncertainty of that value incurred during measurement transfer.

3) There must be an individual or organization responsible for maintaining the records which document the transfer measurement and its uncertainty.

Having followed these elements, measurement traceability is established at each measurement transfer step along the measurement chain from primary standard to the measurement being cited and is the responsibility of the individual or organization performing each step.

Legal traceability is the adherence of measurement traceability at each measurement step in the process and is the sole responsibility of the individual or organization citing or using the final measurements.

References

[1] Riordan, J.J. and Brzezinski, C.J., "Current DOD Policies and Problems in Calibrations," Proceedings of the 1966 Standards Laboratory Conference, NBS Special Publication 291, National Bureau of Standards, Washington D.C., pp. 115-118.

[2] Cameron, J.M., "Traceability," Journal of Quality Technology, Vol. 7, No. 4, October 1975, pp. 193-195.

[3] Belanger, B.C., "Traceability: An Evolving Concept," Standardization News, Vol. 8, No. 1, 1980, pp. 22-28.

[4] Hughes, E.E., and Mandel, J., "A Procedure for Establishing Traceability of Gas Mixtures to Certain National Institute of Standards and Technology SRM's," NBSIR 81-2227, NBS, Gaithersburg Md., USA 20899.

[5] ISO/IEC/OIML/BIPM, 1984, "International Vocabulary of Basic and General Terms in Metrology," International Organization for Standardization, Geneva, Switzerland.

[6] NIST Special Publication 260, U.S. Department of Commerce, Technology Administration, NIST, Gaithersburg Md., USA 20899.

[7] Bass, A., and Parr, R., private communication.

SUÈDE

CLEAN AIR MEASUREMENT
Interlaken 28 Sept - 1 Oct 1992

ENVIRONMENTAL CHARGE ON NITROGEN OXIDE EMISSIONS
THE SWEDISH EXPERIENCE

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Introduction

As of January 1992, a charge of SEK 40 000 per tonne is levied on nitrogen oxide emissions from large and medium-sized energy generation plants. It is the first charge in Sweden based on measured emissions. Since the installation of monitoring equipment cannot be required for smaller energy plants, the charge is limited to the two hundred or so plants that have an input of at least 10 megawatts and generate more than 50 gigawatt hours per year.

To avoid unfair competition in relation to companies outside the system and to promote more efficient energy production, the income from the charge is to be refunded collectively to those required to pay the tax, in proportion to the amount of energy produced in each case. This avoids discrimination against large plants, which are often environmentally preferable since they are more energy-efficient and meet higher purification standards.

The level and the scope of the charge on nitrogen oxide emissions cannot be properly understood without some knowledge of the Swedish energy system, the environmental goal concerning nitrogen oxide emissions and the simultaneous changes of other environmental taxes.

This paper attempts to provide:

- a brief overview of other economic instruments used in Swedish environmental policy
- information on the major features of the environmental charge on nitrogen oxide emissions
- comments on the scope of the charge and on the results so far.

Background

Emissions of nitrogen oxides increased rapidly in Sweden in the 1950s and 1960s as the motor car became more and more widely used. Changes in emissions have been fairly small in recent years.

The total Swedish emissions of nitrogen oxides in 1990 were divided among various sources as follows:

1990	(1000 tonnes)
road traffic	182
shipping	63
aviation	7,5
non-road vehicles	79
energy production	54
industrial processes	19
	404,5

There are strong indications that forest soils in southern Sweden are approaching nitrogen saturation, with resultant acidification, nitrogen leaching and nutrient imbalance. Large areas of southern Sweden may suffer from nitrogen saturation within 10-20 years unless nitrogen deposition is reduced.

The Parliament has therefore decided that emissions of nitrogen oxides are to be reduced by 30 per cent by 1995, as compared with 1980. This is a faster reduction rate than that of the international agreement, which stipulates a 30 per cent decrease for the period 1980-1998.

Emissions of nitrogen oxides often originate from small mobile sources which make them difficult to control. Unlike sulphur, which is a constituent of fossil fuels, the emissions of nitrogen oxides mainly depend on the combustion conditions and hence cannot be controlled via the quality of the fuel.

Up to 1992 the main policy instruments used for reducing nitrogen oxides emissions have been traditional permits for stationary sources and mandatory standards for car exhausts. Some special instruments also exist for the farming sector.

Energy supply and demand in Sweden

Residences and services account for approximately 35 per cent of total energy consumed in Sweden. Industry accounts for approximately the same percentage as residences and services, and transport for the remaining 30 per cent or so. Energy intensive processes based on natural resources such as forests and iron ore have traditionally been important within Swedish industry.

In the years following the oil crisis of the 1970's, energy efficiency improved substantially in most parts of the economy. The energy consumption of 1988 was roughly equal to that of 1970. The share of oil in total energy supply has dropped from 70 to 45 per cent in the same period. The use of nuclear power has increased. However, Parliament has decided that the present nuclear reactors are to be phased out. The phase-out is to be completed by the year 2010.

At present, Sweden's electricity production is based almost exclusively on hydropower and nuclear power, each source accounting for approximately half the electricity supply. Fossil fuel installations are used for back up, to ensure adequate production in unusually cold periods etc.

Approximately 45 per cent of total electricity supply is used by industry. The industrial processes using much electric energy can be found in the pulp and paper industry, the metal and steel works and the chemical industry. These processes using electric energy intensively consume about three quarters of the industrial share of electricity consumption.

Economic instruments

In Sweden, as well as in the other Nordic countries, there is a wide range of taxes, charges etc. in the environmental field. Most of these came into being during the 1980's, and are primarily seen as a source of finance.

In the last few years, the government has frequently stressed the need to develop economic instruments. In 1988, a special Environmental Charges Commission was set up to make recommendations on new environmental levies that would reduce use and emissions of environmentally hazardous substances.

Sweden's tax system is currently undergoing a major overhaul. Income tax is being reduced, with money to pay for the cuts coming from a broader tax base for several indirect taxes, including energy and environmental taxes. These changes will transfer almost $ 3 billion per year from taxes on earned income to various types of energy and environmental taxes. In addition to the charge on emissions on nitrogen oxides from large energy conversion plants, carbon dioxide and sulphur taxes have been introduced.

An overview shows that the economic instruments currently in use in Sweden include:

- deposit schemes – e.g. for beverage containers and car hulks;
- subsidies – tax reduction and grants, e.g. for liming, catalytic converters, pollution control technology, and conservation of valuable man- influenced landscapes;
- emission charges – e.g. on sulphur, nitrogen oxides, and carbon dioxide, nitrogen pollutants from agriculture, vehicles and aircraft;
- product charges – e.g. on batteries, artificial fertilizers, pesticides, solvents and oil products;
- exemption fees – charged when emissions contravening regulations are temporarily permitted, e.g. CFCs and vehicle emissions;
- user charges, e.g. for water, sewerage and sanitation;
- administrative charges – e.g. for financing the official supervision and control, permit processing etc. under the Environmental Protection Act;
- sanction charges - fines and penalties charged when emission limits are exceeded without permission.

The economic instruments listed above can be divided into three main types: deposit and recovery systems, charges and taxes, and grants and other subsidies.

It is often difficult to assess the controlling effects of the economic instruments presented here. The main reason for this is that they have seldom been used for the primary purpose of control, in the sense of charges being designed to provide incentives for the polluters to reduce their requisite environmental measures financially viable.

Charges may also perform another function, namely generating income. In practice, the control and financial objectives often coincide, but there are reasons for distinguishing between these two functions as far as possible.

Environmental charges may constitute an alternative to other measures exerting general effects, for example by speeding up a development that is already taking place or making pollution financially unprofitable. Charges may also constitute a supplement to compulsory regulations, e.g. to bring about a continuous decrease in use when a decision to impose a relatively long-term limitation exists.

Environmental charges may also be justified when a regulation for phasing out a chemical exists, but when it is desirable to encourage a more rapid phase-out. Charges may also play an important role in cases where clear or profitable alternatives are still lacking but where the aim is till to reduce consumption by a higher degree of cost benefit assessment by the user.

Obviously, economic instruments have many advantages in that they provide the incentive to reduce emissions and thus stimulate technical development. This also provides the polluter with the flexibility to choose how a pollutant is to be limited and to select the method by which the pollution can be reduced at the lowest possible cost.

Major features of the emission charge

As mentioned before, all small and medium sized energy production plants that have an input of at least 10 megawatts and generate more than 50 gigawatt hours per year are required to pay a charge of SEK 40 000 per tonne of nitrogen oxides emitted.

The emissions can optionally be calculated from the results of continuous monitoring or fixed to 250 mg/MJ for boilers and 600 mg/MJ for gas turbines. Since the actual emissions in most cases are considerably less than 250 mg/MJ, this option is financially preferable.

The monitoring system must meet the following requirements, according to regulations issued by the Swedish Environmental Protection Agency, to ensure sufficient data quality.

Requirements on equipment used for monitoring of SO_2, NO_x, NO, NO_2, O_2, and CO_2

Detection limit ≤ 2 %;

Deviation of zero point ≤ ±2 %
(per period of time between calibrations);

Deviation of observed value ≤ ±4 %
(per period of time between calibrations);

Effect of interfering substances ≤ ±4 %;

Time of response ≤ 200 s.

Requirements on equipment used for monitoring of stack flow

Detection limit ≤ 2 %;

Deviation of zero point ≤ ±2 %
(per period of time between calibrations);

Deviation of observed value ≤ ±4 %
(per period of time between calibrations);

Time of response ≤ 30 s.

There are also additional requirements on data recording and data processing.

The general rule is that as soon as the monitoring system is out of order or does not meet the regulation standards, emissions are set to 250 mg/MJ. During 5 per cent of the monthly operating time, however, the emissions can be estimated on the basis of the response values achieved under similar operating conditions. This exception is made to ensure that there is time to calibrate and maintain the equipment properly.

The income from the charge is refunded collectively to those required to pay the tax according to the amount of energy produced in each case. The energy producers can be

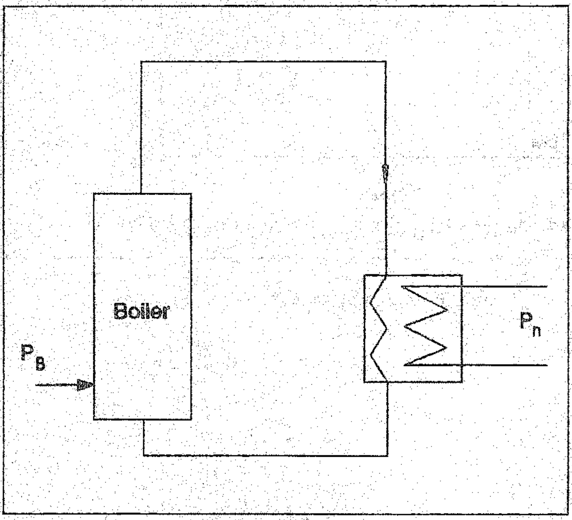


Fig. 1 - District heating

divided into four main categories: district heating, electric power generation, gas turbines, and industrial processes. In fig. 1-3 one can find how the produced energy, P_n, is defined for three of the four categories. The general approach for gas turbines is to define the produced energy as the sum total of the produced electric power and the energy recovered from the gases.

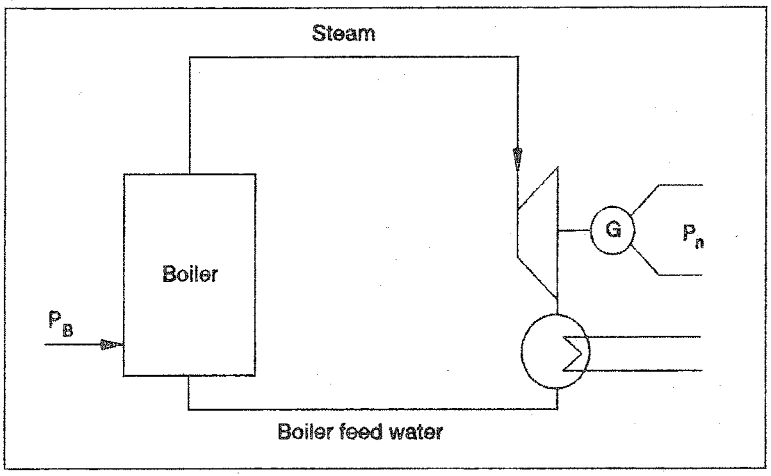
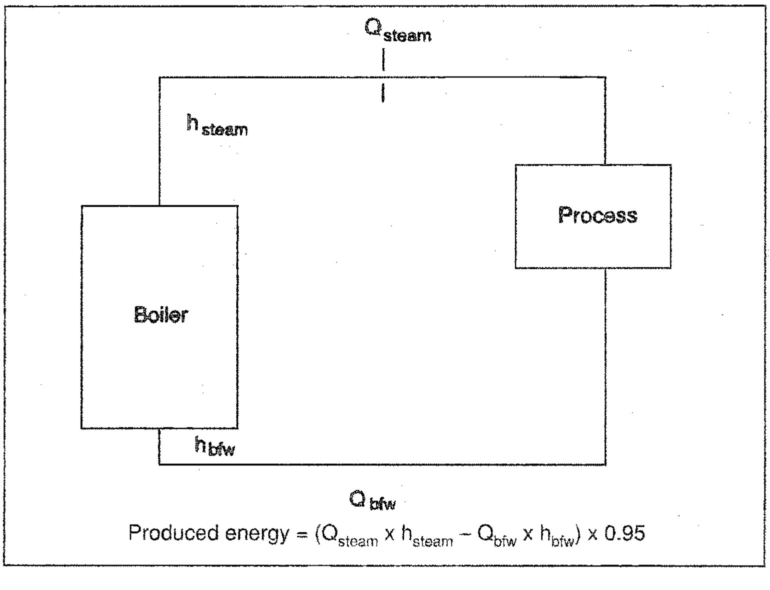


Fig. 2 - Electric power generation



Produced energy = $(Q_{steam} \times h_{steam} - Q_{bfw} \times h_{bfw}) \times 0.95$

Fig. 3 - Industrial boilers

Administration

The tax form is to be handed in by January 25 the following year to the Swedish Environmental Protection Agency. After all tax forms have been scrutinized, the total emission of nitrogen oxides as well as the total amount of energy produced will be known. At this point, the Government, not the Environmental Protection Board, can stipulate the sum of the refund per energy unit produced. The losers, i.e. the plant-owners with high specific emissions, receive an invoice and the winners, i.e. the plant-owners with low specific emissions, receive a refund.

Financial effects

The total emissions of nitrogen oxides from the boilers concerned were estimated at 15-16 000 tonnes during 1992, which corresponds to a turnover amounting to SEK 600 - 650 000 000.

For the same period, the total amount of energy produced was estimated at 37 000 gigawatt hours, which sets the refund to SEK 16 per produced megawatt hour.

Since the average specific emissions of the industry sector is somewhat lower than that of the district heating sector, a transfer of about SEK 17 000 000 will take place.

Concluding remarks

The charge on emissions of nitrogen oxides from energy production plants has been put into force only recently. Reporting as to its long term effects upon the energy system will thus have to be done at a later date. At this point, however, one can tell that the charge has already had a considerable effect in reducing emissions.

A survey, made by the Swedish District Heating Association, shows that the average emissions of nitrogen oxides amounted to 112 mg/MJ in 1990, i.e. just after the law was passed, and that this figure has dropped to 97 mg/MJ during the first three months of 1992. The reduction mainly depends on lower emission figures than expected from boilers within the industrial sector.

SUÈDE

CLEAN AIR MEASUREMENT | Interlaken 28 Sept - 1 Oct 1992

CONTINUOUS MONITORING SYSTEMS FOR SO_2 AND NO_x EMISSION CONTROL

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Sweden is one of the most sensitive areas in Europe to acidification because the bedrock consists of slow-weathering rocks such as granite and gneiss, which offer far less protection against acidification than the readily weatherable sedimentary rocks that predominate elsewhere on the continent. Therefore, to stop the acidification of soil and water in Sweden, the emissions of acidifying substances, especially sulfur dioxide and nitrogen oxides, are to be decreased. In recent years, there has also been growing international awareness of the harmful effects of acidification, resulting in broad agreement to reduce emissions as far as possible.

Actions taken to reduce acidification

To achieve reduction of the emissions of sulfur dioxide and nitrogen oxides in Sweden, different approaches are used:

- emission limits, and
- economical incitements.

To control the emissions from combustion plants, all plants with an effects > 50 MW must perform continuous measurements of sulfur dioxide when burning oil (with desulfurization equipment), coal or peat, and nitrogen oxides (all fuels).

Economical incitements to minimize the emissions of acidifying substances are

- taxes related to the amount of sulfur emitted, and
- an emission fee for nitrogen oxides. The money paid will at the end of the year be repaid in proportion to the contribution of the total energy production. According to the law, all plants with an effect > 10 MW (and an energy production of > 50 GJ per year) must perform continuous measurements of their emission of nitrogen oxides or they must pay a standard charge based on their energy production. Approximately 250 furnaces are affected by this regulation. The mass flow of nitogen oxides (as NO_2) is to be determined and the availability of the measuring system must be ≥ 95 %. If not, the standard charge must be paid for the remaining time.

Requirements for measuring systems and methods

To ensure a minimum quality of the continuous measurements of sulfur dioxide and nitrogen oxides, the Swedish authorities have established regulations as to the performance characteristics that the measuring systems must observe.

Performance characteristics	Numerical value
Lower detection limit	≤ 2 % [1]
Zero drift	≤ ± 2 % [1, 2]
Span drift	≤ ± 4 % [1, 2]
Interferences	≤ ± 4 % [1]
Response time	≤ 200 s

Table 1 – Performance characteristics of automated measuring systems for nitrogen oxides and sulfur dioxide

1) with reference to full scale
2) during the period of unattended operation

There are no demands for suitability tests of automated measuring systems in Sweden. However, it is the responsibility of the plant owner that the equipment used meets the required performance characteristics and that service and maintenance are executed correctly. Once a year, an authorized laboratory must check the installed measuring system and conduct comparative measurements with a reference system.

The Swedish requirements pertaining to performance characteristics and measurement procedures are compatible with German regulations and proposed international standards.

No emission measuring method for sulfur dioxide or nitrogen oxides is recognized by the authorities. All measuring principles can be used as long as it can be proved that the installed measuring system meets the required performance characteristics. Of all the instruments in operation, the most common measuring principle is absorption in IR and UV (extractive and *in situ*); for nitrogen oxides, however, chemiluminescence measurements are also important.

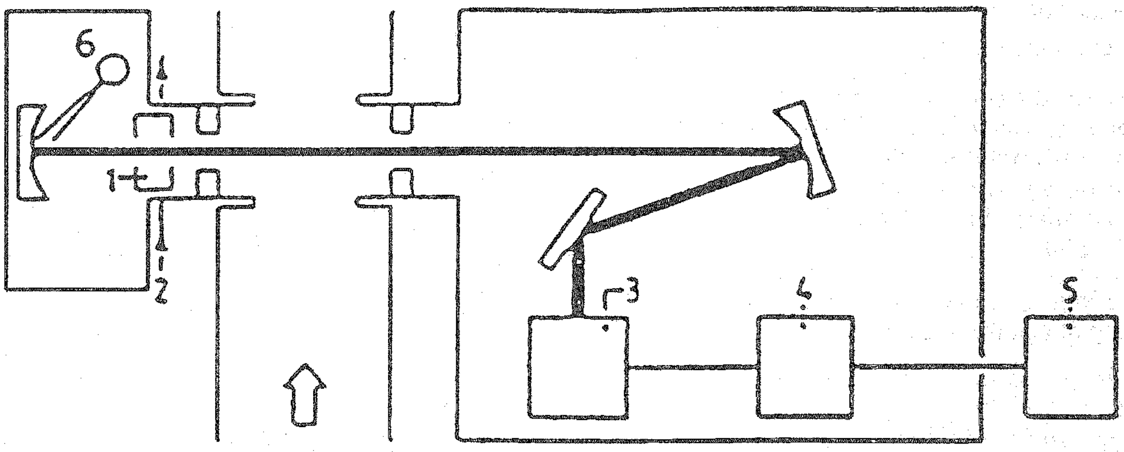
The DOAS technique

In Sweden, significant research and investigation have been focused on the DOAS (Differential Optical Absorption Spectroscopy) technique. This measuring principle (optical, *in situ)* is used in the only emission (and ambient air) instrument manufactured in Sweden, sold under the name OPSIS by Opsis AB. Our laboratory, Air Pollution Laboratory, has done comparative measurements between an OPSIS system and an extractive monitoring system.

The DOAS technique is an optical *in situ* technique. It differs from "conventional" optical techniques in that it scans a specific segment of the spectrum much more frequently during each measuring cycle. Evaluation involves comparing the recorded spectrum with a reference spectrum for the substance being measured. This procedure enables estimation of the error related to the evaluation. It also enables several substances to be measured with the same equipment, provided that the substances to be determined have absorption peaks in the spectral area of the measuring system.

Opsis AB in Furulund, Sweden sells a commercial measuring system under the name of OPSIS. Versions of this system are available for measurement in ambient air or for direct measurement in the gas duct of an emission source. These systems have identical design principles; the only difference is the configuration of certain components. Concentrations are low for ambient air measurements, for which compensation is obtained by a long measurement path. According to the manufacturer, the OPSIS system is calibrated prior to the delivery by measuring a known quantity at specific pressure and temperature. The OPSIS system has been suitability tested for SO_2, NO, and NO_2 in Germany by TÜV Rheinland.

The OPSIS system consists of a light source on one side of the flue-gas duct and a receiver and an analysis unit on the opposite side (cf Fig. 1 and 2). The source of light is a high-pressure xenon arc lamp with an output of 75 W. The light emitted by the lamp is relatively stable in the 200-800 nm wavelength range, with the exception of a few peaks around 500 nm. After passing through the flue-gas duct, the light reaches the receiver where it is then transmitted through a fiber-optic cable to the opto-analyzer.



1. Absorption cell for the reference gas
2. Input for reference gas
3. Detector
4. Electronics
5. Data logger
6. Light source

Fig. 1 – The principle of optical in situ *path measurements*

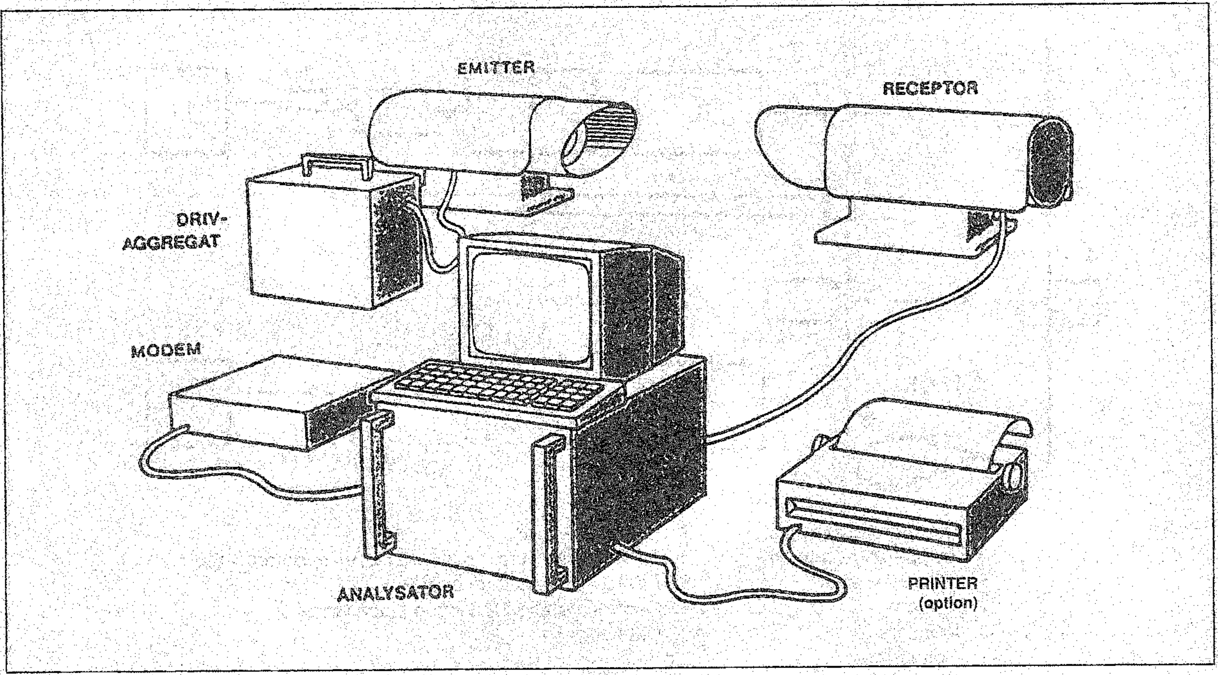


Fig. 2– Configuration of the Differential Optical Absorption System

In the analyzer, the light is spectrally resolved by a grating. A special high-speed scanning technique enables the computer to collect about 100 spectra per second from a specific wavelength range. These spectra are converted to digital signals which are summed and then stored in a multi-channel memory. Subsequent to the end of the measurement periods, the computer compares the spectra collected (wavelength by wavelength) with a reference spectrum for the substance to be determined. As many as 1 000 equations can be used, and each one contributes to the determination of concentrations.

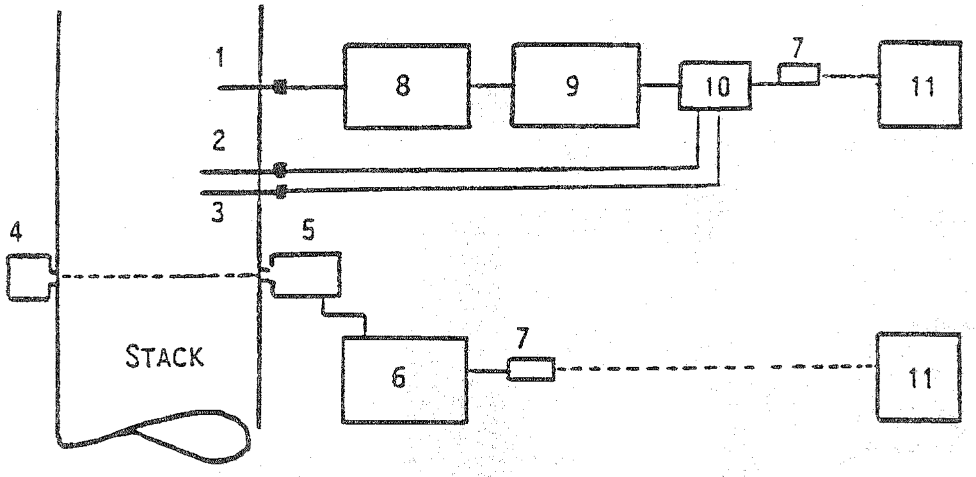
A calculation program computes the concentration of the substance in question. The computer reports the deviation of the measured values and also indicates transmission values, i.e. how large a portion of the light emitted has actually arrived at the receiver. The analyzer operates automatically. The measurement results are stored on a hard disk and can be printed out or sent to another computer over a modem.

Field measurement with a DOAS system

In a field test, the results achieved with a DOAS system (OPSIS) were compared with values collected simultaneously from an extractive measuring system equipped with a chemiluminescence monitor for nitrogen oxides (Monitor Labs, Model 8440E) and a fluorescence monitor for sulfur dioxide (Monitor Labs, Model 8450S). For the sample gas conditioning, a dilution technique was used as an alternative to the sample gas drying. With the dilution technique, the flue gas is diluted with a dilution gas, such as clean air. The dilution gas must be free from nitrogen oxides. The dilution ratio, which must remain constant, must be chosen according to the objectives of the measurement and must be compatible with the range of the analytical unit. After dilution, the water dew point is reduced enough to avoid condensation in the gas loops. The measured values always refer to wet gas.

The arrangement of the equipment for comparative measurements between OPSIS and the extractive system is seen in Figure 3. Before conducting the measurements, the calibration of the systems was checked. The extractive system was controlled by introducing a reference gas and a zero gas (for examples nitrogen) in the probe. The *in situ* system (OPSIS) is more difficult to control, but the recommended procedures are the following:

- **Zero-point calibration:** Performed with a special calibration lamp. The instrument does not have to be dismantled. Calibration requires about 30 minutes. Calibration of the zero-point is recommended once a month or whenever the instrument has been moved.



1. Diluting stack probe
2. Velocity sensor
3. Temperature sensor
4. DOAS light source; high pressure xenon arc lamp
5. DOAS receiver
6. DOAS multi-channel analyzer
7. Modem
8. Control module for diluting stack probe
9. Monitors
10. Datalogger
11. Computers

Fig. 3 – Configuration of the measuring systems

- **Control of the reference point:** This can be obtained by allowing reference gas to flow through the measurement cell between the protective window on the emitter (cf Fig. 1). This cell is 60 mm long, but can be lengthened. Reference gas can be introduced when the instrument is in operation and the boiler is fired. The principle of using reference gases corresponds to practice in other *in situ* instruments for the measurement of gaseous components. Control of the reference point is recommended once a month as a check on performance.

Some results from field measurements with a DOAS system

In Figure 4, results are shown from a measurement performed for three days on an oil-fired power plant. The measurement path across the flue-gas duct was long, 434 cm. The boiler was in service 4-6 hours per day. During the first two days, the boiler was at low output (2 burners out of 18) and on the third day output was increased gradually to the maximum level and maintained for approximately 30 minutes.

In Figure 4, all one-minute mean values for SO_2 and No_x as measured by the DOAS system are plotted against corresponding values for the extractive system. There is a linear relation for SO_2 up to a concentration of about 800 mg/m^3 and for NO_x up to about 300 mg/m^3, until the lines begin to diverge. This divergency from a straight line is traceable to the long measurement path for the DOAS system. Absorption in the radiation path was too high because of the long measurement path. As a result, absorbance was no longer directly proportional to concentration, *i.e.* Beers' law no longer applied. The extrative system measured values approximately 5 % higher than the OPSIS system.

Altogether, measurements with the OPSIS system were performed at three types of plants (coal-dust fired, oil-fired and waste-fired). The tested system showed high availability (> 95 %) for measurements of SO_2, NO, and NO_2. However, the NO_2 concentration measured with the OPSIS system was low at all plants and was independent of the total NO_x concentrations, while the NO_2 portion of the total NO_x concentration as measured with the extractive system was 5 % for the coal-dust fired plant and even higher for the other plants. The reason for these large differences is nonknown, but it has also been observed in other investigations that *in situ* measurements will give a low NO_2 value where extractive systems with converters measure a certain portion of the NO_x as NO_2. An investigation to determine if it is a real difference between the measuring principles has recently started in Sweden. However, the NO_x concentration was not affected; it was only the measured amount of NO_2 that differed.

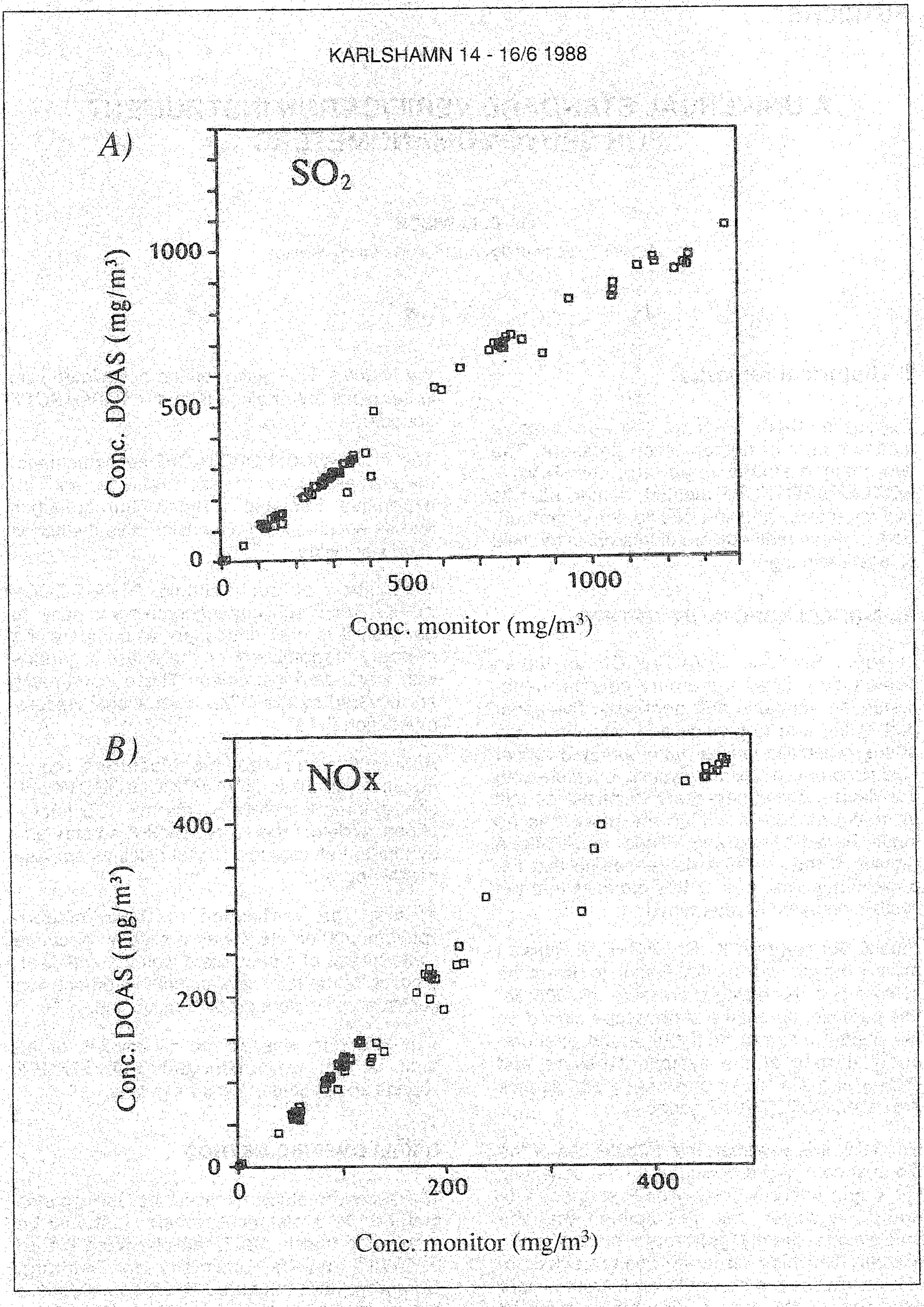


Fig. 4 – Concentrations (mg/m^3) of SO$_2$ (A) and NO$_x$ (B) as measured by the OPSIS system (DOAS) and the extractive system (monitor). 1 minute mean values

AUTRICHE

A UNIVERSAL STANDARD VERIFICATION INSTRUMENT FOR SPHYGMOMANOMETERS

by **R. LEWISCH**
former Director of the Austrian Metrology Service

1 Historical remarks

Various methods exist for the non-invasive measurement of human blood pressure. The two main methods used are: the RIVA - ROCCI/KOROTKOFF method, named after its two inventors, and the oscillometric method. Both of these methods are of interest in the field of legal metrology.

RIVA-ROCCI/KOROTKOFF METHOD

In 1896, Scipione RIVA-ROCCI, an Italian pediatrician, used a mercury column manometer, an inflatable cuff applied to the upper part of the arm to provide an occlusion of the arteria brachialis, and a hand-operated rubber bulb. In order to find the systolic pressure with this device, it was necessary to inflate the cuff up to a pressure at which the pulse can no longer be felt by applying a finger to the arteria radialis. If the pressure decreases so that the pulse reappears, it is at this moment that the systolic pressure is determined.

Nicolai Sergjewitsch KOROTKOFF, a Russian military doctor, was the first person to detect the systolic and the diastolic pressure in 1905; for this purpose, he used a stethoscope placed on the cubital fossa to hear the sound phenomenon starting at the systolic pressure and ending at the diastolic pressure; these sounds are called KOROTKOFF sounds.

Normally, it is assumed that turbulences of the blood-stream in the occluded arteria constitute the origin of the KOROTKOFF sounds. The author, however, has the opinion that the sounds are mainly generated by cavitation effects. The high stream velocity at the occlusion causes a pressure lower than the vapor pressure of the blood. Therefore, bubbles appear. When the pressure increases, the bubbles suddenly collapse and this generates the sounds. The rattle sounds associated with water pipes are analogous to the KOROTKOFF sounds.

The RIVA-ROCCI/KOROTKOFF sphygmomanometers are easy to use, reliable and inexpensive. Because of these characteristics and its epochmaking dimension, this method is used worldwide.

Verification of such simple RIVA-ROCCI/KOROTKOFF sphygmomanometers is easy. In general, it is only necessary to compare the mercury manometers or the aneroid gauges with a standard instrument. These instruments are covered by the OIML International Recommendation R 16.

About 20 years ago, manufacturers began automatizing these RIVA-ROCCI/KOROTKOFF sphygmomanometers by means of a microphone to detect the KOROTKOFF sounds and by modern electronics. Digital displays are also widely applied.

At first, the verification of these modern sphygmomanometers was not easy; because static testing of manometers was not sufficient, a check of the total operational instrument was necessary to ensure proper functioning.

This problem was solved by means of an "artificial arm" which generates KOROTKOFF sounds and at times, pressure pulses.

OSCILLOMETRIC METHOD

The second method is called the oscillometric method. As a historical remark, it should be mentioned that in 1847, the physiologist Carl LUDWIG of the university in Marburg, Germany, had measured the blood pressure oscillations generated by heartbeats by means of an invasive method. He called his device Kymographion. The first information regarding the measurement of blood pressure oscillations by non-invasive means was contributed by ERLANGER in 1903.

In 1906, the German H. von RECKLINGHAUSEN developed a sphygmomanometer which he called oscillotonometer. With this mechanical instrument, it was possible to carry out normal blood pressure measurements and make blood pressure oscillations visible.

About ten years ago, the modern oscillometric sphygmomanometers were introduced. This was the starting point for many problems for metrology services; this statement merits an explanation.

2 Oscillometric sphygmomanometer

The oscillometric method also uses an inflatable cuff for occlusion of the mean arteria; however, no KOROTKOFF sounds are used in this case. If the variation of the pressure from heartbeat to heartbeat is invasively measured (e.g. in the arteria brachialis) and recorded, one will find a curve as seen in Figure 1. This Figure also contains the definitions of diastolic, systolic and mean arterial pressures.

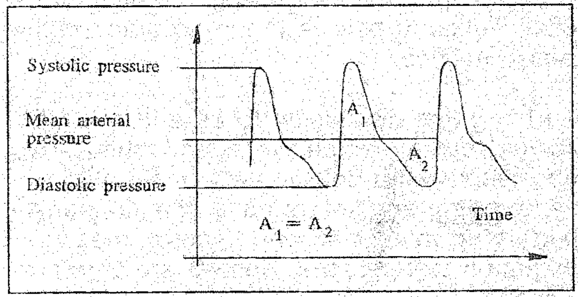


Fig. 1 - Blood pressure variations, e.g. in the arteria brachialis

If, on the other hand, the pressure pulsations in the cuff of a sphygmomanometer are recorded, one obtains a diagram such as that in Figure 2.

It is obvious that in this curve, the shape is not easily comprehensible at first sight; the pressure values of medical interest are hidden.

On this basis, manufacturers began to develop oscillometric sphygmomanometers. They used extensive statistical clinical results from comparisons between the RIVA-ROCCI/ KOROTKOFF and oscillometric methods. They also used sophisticated programs for built-in microcomputers because of the difficulty in detecting characteristics of the diastolic and systolic pressures on an oscillogram.

Furthermore, it was necessary to provide complicated provisions to exclude incorrect oscillation parts created, for example, by unintentional muscle contractions by the patient.

Unfortunately, when the oscillometric sphygmomanometers were available on the market, there existed no possibility for pattern approval and verification. In addition, research work in this field on an international level was not successful. For some models of oscillometric sphygmomanometers, only a static examination exclusive of the real manometers was possible. A positive result of this examination is absolutely necessary but this does not guarantee a proper blood pressure measurement.

Unfortunately also, the manufacturers kept the working algorithm top secret. Otherwise, the problem with oscillometric sphygmomanometers would have been solved more promptly. As it was, it was only possible to decipher the code of algorithm of different sphygmomanometer systems.

After much work, light came into the darkness as M. MACEK, a coworker of Bundesamt für Eich-und Vermessungswesen (BEV), separated in the pneumatic system by means of a rubber membrane, the instrument under test from a pulse generator. This permitted the author to understand the origin of the shape of the oscillations curve shown in Figure 2. After that some different membrane chambers were developed. Unfortunately, it was not possible to adapt the working characteristics of this device to those of the oscillometric sphygmomanometers.

It is well known that physics and therefore, technics are governed by the principle of optimal adaptation. A simple example from everyday life: we know that a normal light bulb is an excellent light source if it is operated at its intended voltage (e.g. 220 V). In the electric network of a car with 12 V, this bulb is useless because it is not adapted to this voltage.

Furthermore it is well known that the human body is not a machine and therefore physiological processes cannot easily be copied in all cases by physical or technical methods.

With knowledge gathered from the membrane chamber, the author designed the tubular chamber. H.TÖMBÖL at BEV succeeded in developing a tubular chamber for practical usage. With this device, it was possible to verify oscillometric sphygmomanometers. TÖMBÖL's paper concerning this subject was published in OIML Bulletin No. 125, p.30-40. This reference

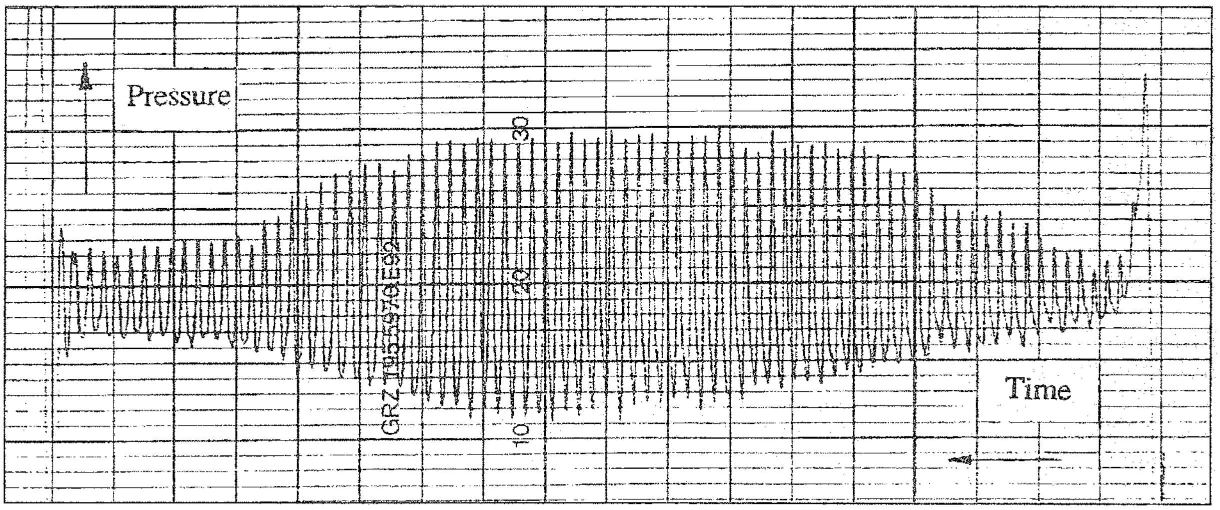


Fig. 2 - Blood pressure oscillations in the cuff of a sphygmomanometer during a measurement

also includes an explanation of the origin of the shape of the curve of oscillations presented in Figure 2.

Despite the practicability and worldwide use of the RIVA-ROCCI/KOROTKOFF method, manufacturers and doctors are seeking new methods to measure blood pressure.

There are several reasons for this search, some of which are the following:

- New methods inspire new knowledge, for example, the possibility to measure the mean arterial pressure (MAP), a value which is important for injured or shocked patients. Until now, it was only possible to measure the MAP invasively.
- The use of microphones in the cuff to pick up the KOROTKOFF sounds has opened the way for automatization and has an advantage against the use of stethoscope. But the microphone must be positioned exactly over the arteria brachialis. Often, this cannot be done easily by self-measuring or adipose patients. Furthermore the microphones are picking up background noise, which sometimes leads to wrong results.
- Oscillometric blood pressure measurements are also advantageous for unconscious patients.
- The commercial considerations must not be forgotten. New instruments with better or new qualities can be more profitable.

Considering all these arguments, the question remains as to whether or not the result measured with oscillometric sphygmomanometers is equivalent to the result obtained by the classic method RIVA-ROCCI/KOROTKOFF and whether or not the maximum permissible errors are exceeded.

This question gave rise to long discussions with doctors and manufacturers. Manufacturers often refuse to believe in the accuracy of the classic method.

To bring this discussion to an end, the BEV carried out an extensive examination. Two observers with a double stethoscope and two separated manometers have simultaneously performed more than one hundred measurements on test-persons. Results are shown in Figure 3.

Practically all points fall inside a range of 0,5 kPa (3,75 mmHg). This convincing result should finally solve this question.

In order to have the possibility to compare, at verification, the results obtained by oscillometric sphygmomanometers with the results obtained by the RIVA-ROCCI/KOROTKOFF method, and also to be able to determine the mean arterial pressure, it was necessary to develop a standard instrument suitable for verification.

3 Solving the problem

As already mentioned, it was not possible to decipher the algorithm of oscillometric sphygmomanometers. The problems arise from the

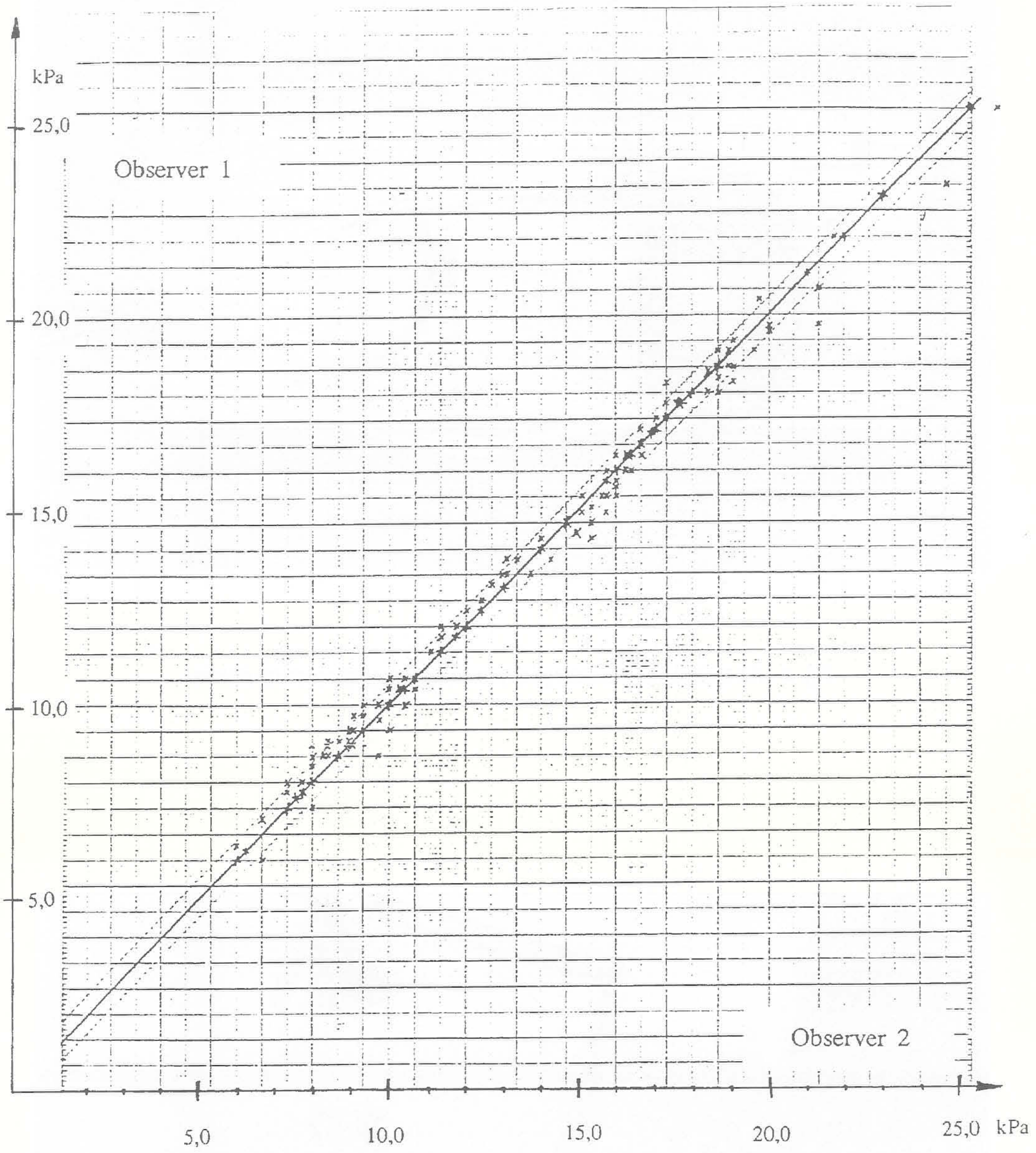


Fig. 3 - Results of two series of measurement performed by two observers

difficulty of artificially copying the hemodynamic behavior, and also from the secret mongers of manufacturers.

After careful analysis of all known facts about oscillometric sphygmomanometers, the author produced a rather mechanical working device. This device aimed at applying variable pressure pulses to the cuff by means of a step-by-step motor, a kinetic gear and a liftmagnet. Unfortunately, unadaptable force characteristics of the liftmagnet prevented a sufficiently good result. In Figure 4, one of these gears is shown.

The next step was the development of a mainly electronic working device, which finally lead to the desired success.

How does the standard instrument work? Figure 5 illustrates the equipment and Figure 6 is a simplified circuit diagram.

To be in conformity with the abovementioned principle of optimum adaptation, the working mode of 12 function groups of this instrument is variable in wide limits.

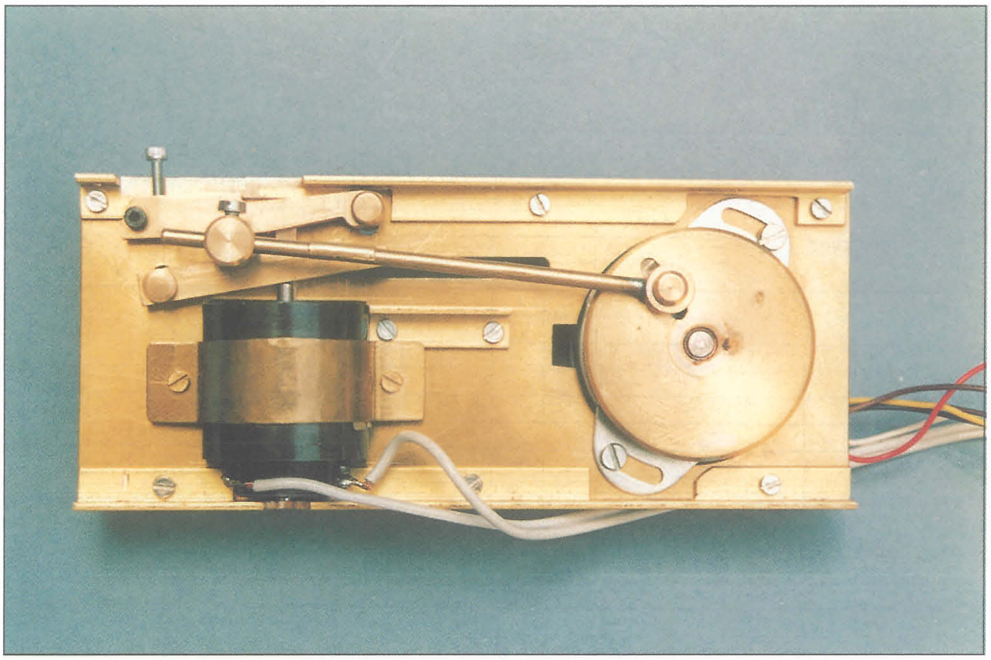


Fig. 4 - An electro-mechanical gear providing variable pressure pulses

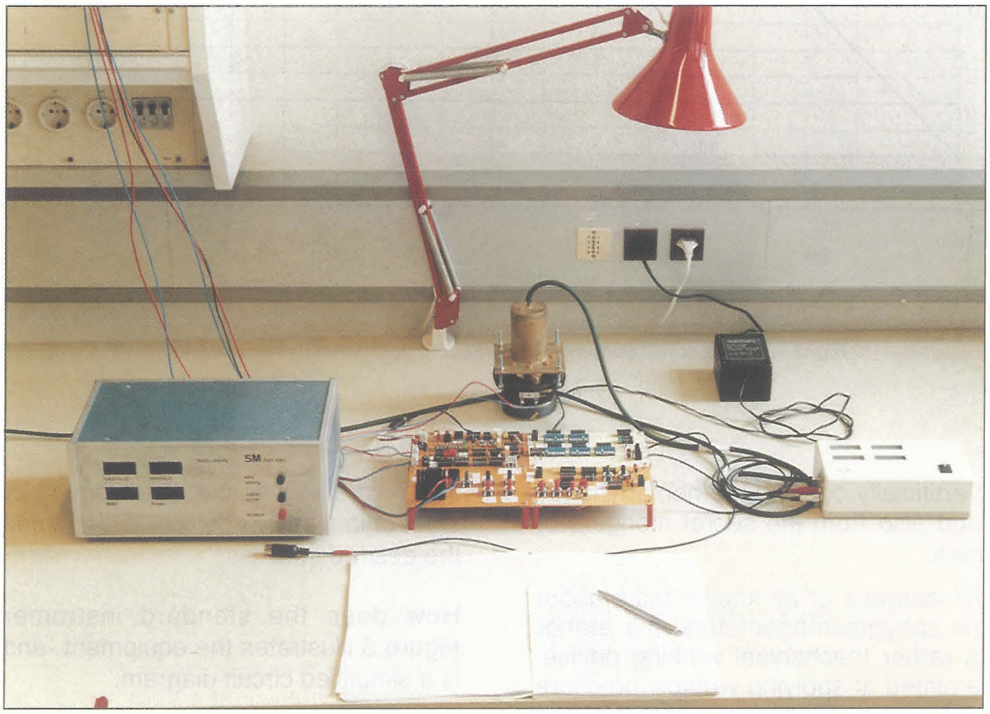


Fig. 5 - The standard instrument in use
Instrument under test – Electronic and pressure generator – Readout device

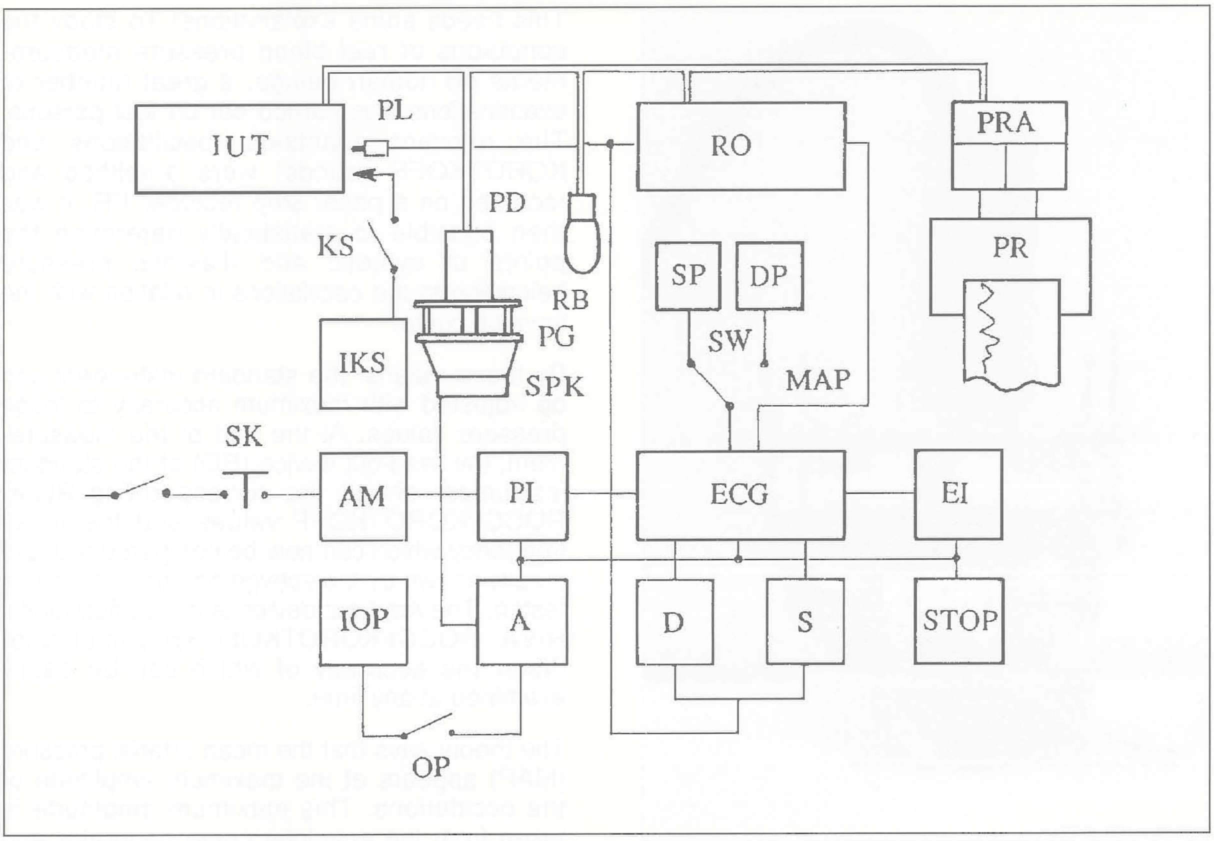


Fig. 6 - Simplified circuit of the standard instrument

IUT	Instrument under test
RB	Rubber bulb
SK	Start key
A	Amplifier
PG	Pressure pulses generator
SPK	Speaker
PD	Pressure dome
AM	Astable multivibrator
PI	Pre-impulse device
ECG	Envelope curve generator
EI	End-impulse device
S	Start device for Korotkoff sounds (systolic pressure)
D	Stop device for Korotkoff sounds (diastolic pressure)
STOP	Automatic total reset device

PRA	Pressure amplifier
PR	Paper strip recorder
RO	Readout device
MAP	Mean arterial pressure
IOP	Inflation oscillations device
IKS	Inflation Korotkoff sounds device
OP	Key for inflation oscillations
KS	Key for inflation Korotkoff sounds
SW	Changeover switch
SP	Single pulse device
DP	Double pulse device
PL	Plug for examination of digital Riva-Rocci/Korotkoff sphygmomanometers

After electrical and pneumatical connections have been made for the instrument being tested as well as the standard instrument, the measurement can start.

The inflation can be done by hand, with the rubber bulb RB or automatically, by the built-in pump of the instrument under test. When the desired pressure has been reached, it decreases again and the start key SK can be pressed. The device now generates electrical pulses in accordance with a special algorithm. They are amplified by A and fed into the pressure pulse generator PG. This contains a normal speaker SPK, which transforms the electrical pulses into mechanical pulses conducted to the rubber membrane of the pressure dome PD as shown in Figure 7. Corresponding pressure pulses are thus produced.

In this case, the use of a cuff is not necessary. An astable multivibrator AM provides an output similar to the shape of pressure pulses from heartbeats. AM is regulating the part PI, which delivers pre-pulses. After the pre-pulses have been converted into pressure pulses, they are similar to the oscillations in the cuff if the arteria brachialis is occluded totally. There may be chosen between one and ten such pre-pulses.

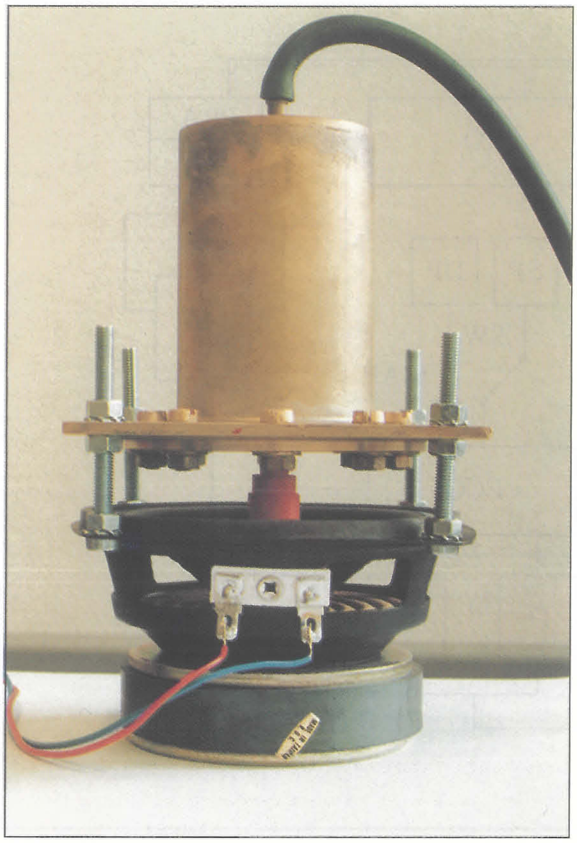


Fig. 7 - The pressure generator

After the last pre-impulse the envelope curve generator ECG starts its work, producing depending from the running time voltage which corresponds to the envelope curve over the oscillations as depicted in Figure 2. With each beat of AM, the match tension will be taken and proportionally converted into a pressure pulse. When the envelope curve is completed, part EI generates an end-pulse as seen on a real oscillogram. The number of end-pulses can also be choosen between one and ten.

In summary, the sphygmomanometer being tested receives oscillations provided by the standard instrument, that are very similar to those obtained during a real blood-pressure measurement on a human being.

How is the comparison of these results with those gathered by the classical RIVA-ROCCI/ KOROTKOFF method conducted?

The standard instrument is able to provide electrically KOROTKOFF sounds. With the parts S and D it is possible to establish the exact relation between the envelope curve and the start and end of KOROTKOFF sounds.

This needs some explanations! To study the conditions of real blood pressure measurements on human beings, a great number of examinations was carried out on test persons. The relevant quantities (oscillations and KOROTKOFF sounds) were amplified and recorded on a paper strip recorder PR. It was then possible to statistically determine the points of systolic and diastolic pressure belonging to the oscillations in relation with the envelop curve.

By these means, the standard instrument can be adjusted with maximum accuracy to those pressure values. At the end of the measurement, the read-out device (RO) of the standard instrument shows the corresponding RIVA-ROCCI/KOROTKOFF values and the pulse frequency which can now be compared with the results shown by the sphygmomanometer being tested. The read-out device is a modified digital RIVA- ROCCI/KOROTKOFF sphygmomanometer the accuracy of which can be easily examined at any time.

The theory says that the mean arterial pressure (MAP) appears at the maximum amplitude of the oscillations. This maximum amplitude is taken from the envelope curve generator and converted into the corresponding pressure. This is shown on the read-out device (RO). Therefore, the MAP can also be examined precisely.

Some sphygmomanometers have a build-in pump to automatically inflate the cuff. They are able to produce a pressure up to 40 kPa (300 mmHg). From a medical standpoint, it makes no sense to expose all patients to such high pressure at the beginning of the measurement; this may even be dangerous. To avoid this problem, some sphygmomanometers have devices, such as switches for different pressure ranges or special sensors. These sensors control the inflation either by pressure oscillations or by KOROTKOFF sounds or both. Some sphygmomanometers do not function well if they do not meet these criteria.

For this reason, the standard instrument is equipped with the devices IOP and IKS as well as with the keys OP and KS. IOP feeds the sphygmomanometer being tested with pressure oscillations, IKS with electrical KOROTKOFF sounds similar to those obtained at inflation during a real blood pressure measurement.

Some sphygmomanometers deflate the cuff pressure in steps during measurement. This is used to prevent an instrument disfunctioning. The built-in microcomputer waits for a second pressure pulse of the same amplitude at each steps. Afterwards, the next pressure step is completed.

In order to examine such sphygmomanometers, the standard instrument has a change-over switch SW. This switch sets the envelope generator from the single pulse mode to the double pulse mode.

For examination of digital RIVA-ROCCI/KOROTKOFF sphygmomanometers, the standard instrument is provided with a plug PL. The plug is to be inserted into the microphone jack of the sphygmomanometer under test.

This paper does not describe the numerous other control devices used to indicate the correct functioning of the standard instrument, since they are not of principal importance.

4 The result

It must be emphasized that it was not in the scope of this work to classify the different sphygmomanometers available on the market. Therefore, trademarks are not mentioned. It is obvious, however, that there are differences in quality. Furthermore, the work was done to show that the standard instrument is able to be used universally.

Most sphygmomanometers indicate not only diastolic and systolic pressures but also the pulse frequency in pulses per minute. This device used for such purpose is normal, but not of mandatory verification. However, it is useful to detect if all pulses delivered by the standard instrument are accepted by the sphygmomanometer under test. Differences of ± 1 pulse per minute may appear for different evaluation algorithms. This is not important for the measurement accuracy.

In general the oscillometric sphygmomanometers meet maximum errors of ± 1 kPa (8mm Hg). However, greater errors are possible. This does not refer negatively to the sphygmomanometer under test. Errors may be a result of an improperly adjusted deflation valve.

In reporting the results concerning errors, it must be mentioned that one of the tested sphygmomanometers has shown (in all ranges of measurement) an error not greater than 0,25 kPa (2 mmHg). This is indeed the best result that may be obtained.

The World Health Organization (WHO) recommends a rate of deflation of between 0.25 kPa/s and 0.5 kPa/s (from 2 mmHg/s to 4 mmHg/s). If the rate of deflation is too high, the error can increase enormously. This is easily understandable: the pressure drop between two pulses may be more than the maximum permissible error, and just one pulse is a signal for measurement. To prevent such misuse, some sphygmomanometers stop functioning or announce an error if the rate of deflation is too high.

The normal pulse frequency is considered to be 72 pulses per minute. However 60 pulses per minute are not seldom. At the same rate of deflation and a lower pulse frequency, a greater error could be expected. To consider this unfavorable case, the standard instrument works at a pulse frequency of 60 pulses per minute. If necessary, this frequency can be adjusted within wide limits.

5 Summary

This paper describes a universally usable standard instrument developed by the author. It is capable of examining oscillometric sphygmomanometers functioning with different algorithms, as well as classic digital RIVA-ROCCI/KOROTKOFF sphygmomanometers.

The measuring result of oscillometric sphygmomanometers are compared with those of the classic method RIVA-ROCCI/KOROTKOFF. It is also possible to examine the mean arterial pressure (MAP) shown by the sphygmomanometer under test.

These properties are gathered by making the working algorithm very close to the relation in a real pressure measurement.

It has been confirmed that a maximum permissible error for oscillometric sphygmomanometers must be twice the error for classic RIVO-ROCCI/KOROTKOFF sphygmomanometers.

The standard instrument contains only inexpensive and easily obtainable electronic components. Only the pressure dome is a simple workshop piece.

For wide use in verification offices, it must be possible to convert the standard instrument into a one-chip computer.

The development of the standard instrument has taken 2 1/2 years.

6 Acknowledgement

I would like to thank Prof.Dr. H. Kirchmayr and Prof. Dr H. Winter from the Technische Universität, Wien, as well as Hofrat Dr. R. Galle, Dipl. Ing. M. Macek, Dipl. Ing. H. Tömböl and Ing. A. Gutruf from the Metrological Service of Bundesamt für Eich-und Vermessungswesen of Austria. Special thanks are extended to Ing. P. Berlinger from the Technische Universität, Wien, for assisting with electronic matters.

Literature

Lehrbuch der medizinischen Physiologie – W. Auerswald Springer Verlag 1979.

Textbook of Physiology – Tuttle and Schottelius 17th Ed. St. Louis. Mosby

Forum hypertonicum, Blutdruckmessung – Heinrich Holzgreve MMW Medium Verlag München 1981

Handbuch der Physik, Band IX Strömungsmechanik III – Springer-Verlag

Arterial hypertension, Report of a WHO Expert Committee – World Health Organization, Technical Report Series 628, 1978

Arterial bloodpressure and its measurement – T. Kenner Basic Res Cardiol 83. 107-121 (1988)

Theorie und Simulation der oszillometrischen Blutdruckmessung – H. Tömböl EVM Nr. 63 1991 (23-31) and OIML Bulletin No. 125 Dec. 1991 (30-40)

Non-invasive bloodpressure measurement – S. Mieke OIML Bulletin No. 125 Dec. 1991 (18-29)

TRAVAUX de l'OIML

OIML ACTIVITIES

1992-1993

Nous indiquons ci-après sous une forme condensée et bilingue l'état de préparation des Recommandations Internationales, Documents Internationaux et autres travaux de l'OIML tel qu'il découle des rapports annuels et autres informations reçus par le BIML.

Dans cette liste ne sont pas inclus les sujets dont les travaux ont donné lieu à des publications définitives parues avant 1992.

Les avant-projets et projets indiqués dans cette liste ne sont disponibles que pour les membres des groupes de travail concernés.

We are hereafter indicating in a condensed and bilingual form the stage of preparation of International Recommendations, International Documents and other work of OIML as it appears from the annual reports and other information received by BIML.

This list does not include work which has been subject to final publication before 1992.

The preliminary drafts and drafts mentioned in this list are available only to the members of the respective working groups.

LEGENDES

AP = Avant-projet
Preliminary draft

P = Projet
Draft

Enquête = *Enquiry*

Préparation = Élaboration d'un avant-projet
Preparation of a preliminary draft

Étude Sr = Observations et nouvelle version étudiée par Sr
Comments and new version studied by Sr

Étude SP = Étude du projet par le Secrétariat Pilote
Study of the draft by the Pilot Secretariat

Vote CIML = Vote par correspondance sur le projet
Vote by correspondence on the draft

CIML = Approbation ou présentation pour approbation par le CIML
Approval by, or presented for approval to CIML

D = Document International
International Document

R = Recommandation Internationale.
International Recommendation

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publication *Status*	État de préparation *Stage of preparation*	
			1992	1993
SP 1	TERMINOLOGIE *TERMINOLOGY*			
Sr 3	Conformité terminologique *Conformity of terminology*		Activité permanente *Permanent activity*	
SP 2	MÉTROLOGIE LÉGALE, GÉNÉRALITÉS *LEGAL METROLOGY, GENERAL*			
Sr 2	Unités de mesure légales (révision D 2) *Legal units of measurement*	D	2 AP	3 AP, P
Sr 6	Exigences générales pour les instruments électroniques (révision D 11) *General requirements for electronic instruments*	D	P	P, Vote CIML
SP 4	MESURES DE LONGUEURS, SURFACES, ANGLES *MEASUREMENT OF LENGTH, AREA, ANGLE*			
Sr 1	Calibres à bouts plans (révision R 30) *End measures of length*	R 30	En attente de la révision de la Norme ISO 3650 *Awaiting revision of ISO Standard 3650*	
Sr 5	Méthodes de reproduction des unités d'angle plan *Methods of reproduction of plane angle units*	D		P
Sr 6	Appareils de mesure de la superficie des peaux *Instruments measuring the area of hides*	R	4 AP	1 P
Sr 7	Terminologie utilisée en métrologie dimensionnelle *Terminology used in dimensional metrology*	D	1 P	
SP 5S	MESURE STATIQUE DES QUANTITÉS DE LIQUIDES *STATIC MEASUREMENT OF QUANTITIES OF LIQUIDS*			
Sr 3	Pipettes automatiques en verre *Glass delivery measures (Automatic pipettes)*	R	Étude SP	P
Sr 4	Seringues médicales *Medical syringes*	R	4 AP	P
Sr 11	Mesure automatique des niveaux de liquides (révision R 85) *Automatic measurement of the level of liquid in tanks*	R 85	Étude Sr	2 AP
Sr 12	Mesurage statique de masses de liquides *Direct static mass measuring for quantities of liquids*	R	3 AP	4 AP, P

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publication *Status*	État de préparation *Stage of preparation*	
			1992	1993
SP 5D	MESURE DYNAMIQUE DES QUANTITÉS DE LIQUIDES *DYNAMIC MEASUREMENT OF QUANTITIES OF LIQUIDS*			
Sr 1	Ensembles de mesurage de liquides autres que l'eau (compilation) *Measuring assemblies for liquids other than water (compilation)*	R	4 AP	1 P, vote CIML
Sr 2	Compteurs et ensembles de mesure de liquides cryogéniques (révision R 81) *Meters and measuring systems for cryogenic liquids*	R 81		Préparation
Sr 3	Compteurs d'eau froide (révision R 49) *Cold water meters*	R 49	3 AP	Étude SP
	Rapport d'essai *Test report*		1 AP	Étude SP
Sr 7	Étalons de volume utilisés pour la vérification des ensembles de mesure *Standard volume measures used for verification of measuring assemblies*	R	1 P	2 P, Vote CIML
	Tubes étalons utilisés pour la vérification des ensembles de mesure *Pipe provers used for verification of measuring assemblies*	R	1 P	2 P, Vote CIML
	Méthodes d'essai de distributeurs routiers de carburant liquide *Testing procedures for liquid fuel dispensers*	R	1 P	2 P, Vote CIML
Sr 9	Compteurs vortex *Vortex meters*	D	1 P	2 P, Vote CIML
Sr 10	Compteurs massiques *Direct mass-flow measuring instruments*	R	CIML	
	Rapport d'essai *Test report*			P
SP 6	MESURE DES GAZ *MEASUREMENT OF GAS*			
Sr 1	Compteurs de gaz à parois déformables (révision R 31) *Diaphragm gas meters*	R 31	Étude Sr	2 AP
Sr 2	Annexe B de R 32 - "Compteurs de volume de gaz à pistons rotatifs" *Annex B to R 32 - "Rotary piston gas meters"*	R 32	Étude Sr	2 P
	Annexe C - Rapport d'essai *Annex C - Test report*			1 P

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publication *Status*	État de préparation *Stage of preparation*	
			1992	1993
SP 6	MESURE DES GAZ (suite) *MEASUREMENT OF GAS*			
Sr 4	Mesure des hydrocarbures gazeux distribués par pipeline *Measurement of hydrocarbon gases distributed by pipeline*	D	4 AP	5 AP
Sr 9	Correcteurs de volume de gaz *Correctors of gas volumes*	R	1 AP	2 AP
Sr 12	Gaz de calibrage pour calorimètres *Calibration gases for gas calorimeters*	R		1 AP
	Instruments de mesure pour la valeur calorifique brute de gaz *Measuring instruments for the gross calorific value of gas*	R		1 AP
SP 7	MESURE DES MASSES *MEASUREMENT OF MASS*			
Sr 2	Instruments de pesage électroniques (révision R 74) *Electronic weighing instruments*	R 74	CIML	P
Sr 4	Instruments de pesage à fonctionnement non automatique (révision R 76), parties 1 et 2 *Nonautomatic weighing instruments, parts 1 and 2*	R 76		1 AP
Sr 5	Instruments de pesage totalisateurs discontinus *Discontinuous totalising weighing machines*	R	CIML	
	Méthodes d'essai et rapport d'essai *Test procedures and test report*		1 AP	2 AP
	Ponts-bascules ferroviaires à fonctionnement automatique *Automatic rail-weighbridges*	R	CIML	
	Méthodes d'essai et rapport d'essai *Test procedures and test report*		1 AP	2 AP
	Instruments de pesage totalisateurs continus (révision R 50) *Continuous totalising weighing machines*	R 50	Étude Sr	5 P
	Méthodes d'essai et rapport d'essai *Test procedures and test report*		1 AP	2 AP
	Trieuses pondérales et groupes d'étiquetage poids-prix (révision R 51) *Automatic catchweighing instruments*	R 51	2 AP	3 AP
	Doseuses pondérales (révision R 61) *Gravimetric filling instruments*	R 61	Étude Sr	5 AP
Sr 8	Réglementation métrologique des cellules de pesée (révision R 60) *Metrological regulations for load cells* Méthodes d'essai et rapport d'essai *Test procedures and test report*	R 60	P	Étude Sr

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publi-cation *Status*	État de préparation *Stage of preparation*	
			1992	1993
SP 8	POIDS *WEIGHTS*			
Sr 1, Sr 5, Sr 6	Spécifications métrologiques pour les poids (compilation) *Metrological specifications for weights (compilation)*	R	2 P, Vote CIML	CIML
SP 9	MESURE DES MASSES VOLUMIQUES *MEASUREMENT OF DENSITY*			
Sr 1	Tables alcoométriques internationales (révision R 22) *International alcoholometric tables*	R 22	Enquête	P
SP 10	INSTRUMENTS DE MESURE POUR VÉHICULES *MEASURING INSTRUMENTS FOR VEHICLES*			
Sr 2	Instruments de mesure de vitesse et distance dans les véhicules (révision R 55) *Speed and distance measuring instruments for vehicles*	R 55	2 AP	1 P
Sr 3	Taximètres électroniques *Electronic taximeters*	R		Étude Sr
SP 11	MESURE DES PRESSIONS *MEASUREMENT OF PRESSURE*			
Sr 3	Manomètres à piston *Pressure balances*	R	4 P	Étude SP
Sr 4	Manomètres pour pneumatiques (révision R 23) *Tyre pressure gauges*	R 23	3 AP	
	Manomètres étalons à éléments élastiques *Reference manometers with elastic sensors*	R	CIML	
	Méthodes et rapport d'essai, supplément à R *Test procedures and report, supplement to R*		2 AP	P
	Manomètres usuels à élément élastique (révision R 101) *Indicating and recording pressure gauges (ordinary instruments)* Méthodes et rapport d'essai *Test procedures and report*	R 101	1 AP	2 AP
	Caractéristiques des éléments récepteurs élastiques (révision R 53) *Characteristics of elastic sensing elements*	R 53	P	Vote CIML
Sr 5	Manomètres pour la pression artérielle (révision R 16) *Manometers for instruments measuring blood pressure*	R 16	Étude Sr	Coordination avec CEN

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publication *Status*	État de préparation *Stage of preparation*	
			1992	1993
SP 12	MESURE DES TEMPERATURES ET DE L'ÉNERGIE CALORIFIQUE *MEASUREMENT OF TEMPERATURE AND HEAT*			
Sr 3	Capteurs à résistance de platine, de cuivre ou de nickel *Resistance-thermometer sensors made of platinum, copper or nickel*	R 84	Préparation	Étude Sr
Sr 5	Thermocouples, tables de f.e.m. et tolérances *Thermocouples, tables of EMF and tolerances*	R		2 AP
Sr 6	Pyromètres à radiation totale *Total radiation pyrometers*	D	Vote CIML	Étude Sr
	Lampes à ruban de tungstène pour l'étalonnage de pyromètres optiques (révision R 48) et rapport d'essai *Tungsten ribbon lamps for calibration of optical pyrometers, revision and test report*	R 48	1 P	Étude Sr
Sr 7	Thermomètres électriques médicaux à maximum *Clinical electrical thermometers with maximum device*	R	2 P	Étude SP
	Thermomètres électriques médicaux pour mesures continues *Clinical electrical thermometers for continuous measurement*	R	2 P	Étude SP
Sr 8	Compteurs d'énergie thermique (révision R 75) *Heat meters*	R 75		Préparation
	Perturbations électromagnétiques influant les compteurs d'énergie *Electromagnetic disturbances influencing heat meters*	D		1 AP
Sr 9	Méthodes de vérification des thermocouples en métaux usuels *Verification methods for thermocouples of common metals*	R	1 AP	Étude Sr
SP 13	MESURES ÉLECTRIQUES ET MAGNÉTIQUES *MEASUREMENT OF ELECTRICAL AND MAGNETIC QUANTITIES*			
Sr 3	Compteurs d'énergie électrique active (révision R 46) *Active electrical energy meters*	R 46	1 AP	Étude Sr
SP 14	ACOUSTIQUE ET VIBRATIONS *ACOUSTICS AND VIBRATION*			
Sr 1	Calibreurs acoustiques *Sound calibrators*	R 102		
	Rapport d'essai *Test report*		1 P	2 P

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publication *Status*	État de préparation *Stage of preparation*	
			1992	1993
SP 14	ACOUSTIQUE ET VIBRATIONS (suite) *ACOUSTICS AND VIBRATION*			
Sr 1	Sonomètres *Sound level meters*	R 58		
	Rapport d'essai *Test report*		2 AP	3 AP
Sr 2	Audiomètres à son pur *Pure-tone audiometers*	R 104		
	Rapport d'essai *Test report*			Préparation
	Audiomètres pour la parole *Speech audiometers*	R	1 AP	1 P
	Rapport d'essai *Test report*			1 P
Sr 3	Instruments de mesure de vibrations *Measuring instruments for response to vibration*	R 103		
	Rapport d'essai *Test report*		1 P (partially)	1 P
SP 15	OPTIQUE *OPTICS*			
Sr 1	Frontofocomètres *Focimeters*	R 93		
	Rapport d'essai *Test report*		Préparation	1 AP
SP 16	RAYONNEMENTS IONISANTS *IONIZING RADIATIONS*			
Sr 3	Mesure des pollutions par radionucléides *Measurement of radionuclide in the environment*	R	1 P	
SP 17	MESURE DES POLLUTIONS *MEASUREMENT OF POLLUTION*			
Sr 1	Instruments de mesure des gaz d'échappement (Révision R 99) *Exhaust emission measuring instruments*	R 99		Préparation
	Rapport d'essai *Test report*			
Sr 2	Spectrophotomètres à absorption atomique pour la mesure des polluants métalliques dans l'eau (révision R 100) *Atomic absorption spectrometers for measuring metal pollutants in water*	R 100		Préparation
	Rapport d'essai *Test report*			
	Spectromètres à plasma couplés inductivement *Inductively coupled plasma emission spectrometers*	R	1 P	P, vote CIML

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publication *Status*	État de préparation *Stage of preparation*	
			1992	1993
SP 17	MESURE DES POLLUTIONS (suite) *MEASUREMENT OF POLLUTION*			
	Chromatographe en phase gazeuse/spectromètre de masse (révision R 83) *Gas chromatograph/mass spectrometer*	R 83		Préparation
Sr 4	Chromatographes à phase liquide de haute performance pour la mesure de pesticides et autre substances toxiques *High performance liquid chromatographs for measuring pesticide and toxic substances pollution (HPLC)*	R	P	Vote CIML
	Chromatographes en phase gazeuse pour la mesure des pollutions par pesticides (révision R 82) *Gas chromatographs for measuring pollution from pesticides*	R 82	P	Étude Sr
Sr 5	Chromatographes en phase gazeuse portatifs pour polluants gazeux *Portable gas chromatographs for gaseous pollutants*	R	Étude SP	Vote CIML
	Spectromètres à fluorescence par rayons X *X-ray fluorescence spectrometers*	R	1 AP	2 AP
	Guide d'instruments portatifs pour le prélèvement des pollutions de l'air *Guide to sampling devices for air born pollutants*	D	1 AP	Étude Sr
SP 18	MESURE DES CARACTÉRISTIQUES DES PRODUITS ALIMENTAIRES *MEASUREMENT OF CHARACTERISTICS OF FOOD PRODUCTS*			
Sr 7	Réfractomètres pour jus de fruits *Refractometers for fruit juice*	R	CIML	
SP 19	MESURE DES CARACTÉRISTIQUES DES MATÉRIAUX *MEASUREMENT OF CHARACTERISTICS OF MATERIALS*			
Sr 2	Exigences pour les machines d'essai des matériaux en traction et en compression (révision R 64 et R 65) *Requirements for machines for tension and compression testing of materials*	R 64 R 65	Préparation	1 AP
Sr 3	Dureté (révision R 9, 10, 11, 12, 36, 37, 38, 39) *Hardness*		Préparation	Prog. trav.
Sr 5	Jauges de contrainte (révision R 62) *Strain gauges*	R 62	Préparation	1 AP

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publication *Status*	État de préparation *Stage of preparation*	
			1992	1993
SP 20	PRODUITS PREEMBALLES *PREPACKAGED PRODUCTS*			
Sr 1	Informations sur l'étiquetage des emballages (révison R 79) *Information on package labels*	R 79	Préparation	Prog. trav.
Sr 2	Contenu net des préemballages (révision R 87) *Net content in packages.*	R 87	Préparation	Prog. trav.
SP 22	PRINCIPES DU CONTRÔLE MÉTROLOGIQUE *PRINCIPLES OF METROLOGICAL CONTROL*			
Sr 4	Méthodes d'assurance de qualité appliquées dans le contrôle métrologique *Quality assurance as applied to initial verification of measuring instruments*	D	P	Étude Sr
Sr 5	Principes d'assurance du contrôle métrologique (révision D 9) *Principles of metrological supervision*	D 9		1 AP
SP 23	ÉTALONS ET DISPOSITIFS UTILISÉS POUR LES ÉTALONNAGES ET LES VÉRIFICATIONS *MEASUREMENT STANDARDS AND DEVICES USED FOR CALIBRATION AND VERIFICATION*			
Sr 1	Caractéristiques métrologiques des étalons et dispositifs d'étalonnage *Metrological characteristics of measurement standards and calibration devices*	D		3 AP
Sr 2	Principes concernant le choix, la reconnaissance officielle, l'utilisation et la conservation des étalons (révision D 8) *Principles concerning choice, official recognition, use and conservation of measurement standards*	D 8		1 AP
Sr 3	Documentation pour les étalons et dispositifs d'étalonnage (révision D 6) *Documentation for measurement standards and calibration devices*	D 6		1 AP
Sr 7	Intervallles de réétalonnage des étalons et dispositifs d'étalonnage (révision D 10) *Recalibration intervals of measurement standards and calibration devices*	D 10	Étude Sr	2 AP
SP 26	INSTRUMENTS DE MESURE UTILISÉS DANS LE DOMAINE DE LA SANTÉ *MEASURING INSTRUMENTS USED IN THE FIELD OF HEALTH*			
Sr 1	Chambres pour numération des cellules sanguines *Blood cell counting chambers*	R	P	Vote CIML

Secrétariat	Titres abrégés des sujets *Abbreviated titles of subjects*	Forme de publication *Status*	État de préparation *Stage of preparation* 1992	1993
SP 26	INSTRUMENTS DE MESURE UTILISÉS DANS LE DOMAINE DE LA SANTÉ (suite) *MEASURING INSTRUMENTS USED IN THE FIELD OF HEALTH*			
Sr 4	Électrocardioscopes (Appendice 1)	R 90	P	Étude SP
	Électrocardioscopes et électrocardiographes numériques (Appendice 2) *Digital electrocardioscopes and electrocardiographs*	R 90	P	Étude SP
	Représentation des caractéristiques des instruments de mesure bio-médicaux *Presentation of metrological characteristics of bio-electrical measuring instruments*	D	P	Étude SP
	Électrodes pour cardiographes et encéphalographes *Electrodes for cardiographs and encephalographs*	R	P	Étude SP
Sr 6	Ergomètres *Ergometers*	R	1 AP	2 AP
Sr 7	Photomètres à absorption *Absorption photometers*	R	1 AP	1 P
SP 30	MESURES PHYSICO-CHIMIQUES *PHYSICO-CHEMICAL MEASUREMENTS*			
Sr 3	Échelle d'humidité relative de l'air utilisant des solutions salines saturées *Scale of relative humidity of air using saturated salt solutions*	R	Étude Sr	P
Sr 9	Liquides étalons pour l'étalonnage de viscosimètres *Standard liquids used for the calibration of viscometers*	R	Vote CIML	CIML
	Viscosimètres à bille. Méthodes d'étalonnage *Falling-ball viscometer. Calibration methods*	R	P	Vote CIML
Sr 10	Méthodes et moyens pour la vérification des instruments de mesure de la teneur pondérale des polluants dans l'air *Methods and means for the verification of instruments measuring the mass concentration of pollutants in air*	R	2 P	Étude SP
	Détermination des erreurs de base et d'hystérésis des analyseurs de gaz (révision R 70) *Determination of intrinsic and hysteresis errors of gas analysers*	R 70	P	Vote CIML
Sr 13	Ethylomètres *Breath analysers*	R	3 AP	

RÉUNION DU CONSEIL DE LA PRÉSIDENCE DE L'OIML

PARIS, 15-16 février 1993

Le Conseil de la Présidence de l'OIML s'est réuni les 15 et 16 février 1993 au BIML à Paris; tous les membres étaient présents; en plus de ces derniers, il fallait compter la participation de M. Z. Referowski (Pologne). M. K. Birkeland (Norvège), Président, a souhaité la bienvenue aux membres du Conseil ainsi qu'aux membres du personnel technique du BIML et a ouvert la discussion, qui devait porter sur un certain nombre de points importants quant au développement de l'OIML.

Les divers points sont repris brièvement ainsi que l'essentiel des décisions qui ont été prises.

1 Situation financière de l'OIML

Le directeur du BIML a fait un rapport sur la situation financière clôturée pour l'année 1992, en rappelant que 20 % des contributions n'ont pas été payées. Une estimation pour 1993 a été présentée et il est à prévoir qu'à nouveau, un pourcentage équivalent des contributions ne sera pas payé. En maintenant les dépenses à un niveau bas comme en 1992, et en refusant certaines dépenses exceptionnelles tant que les liquidités ne sont pas disponibles, l'équilibre financier pourra sans doute être maintenu.

2 Activités des Secrétariats Pilotes et Rapporteurs en 1992 et planifiées pour 1993

M. A. Vichenkov (BIML) a présenté un rapport complet des activités des Secrétariats; il est souligné que douze Secrétariats seulement ont travaillé conformément à leur programme; de très nombreux retards sont constatés; M. S.E. Chappell est d'avis qu'avec l'établissement des nouvelles procédures de travail, ces retards devraient diminuer et même ne plus exister.

3 Directives pour les travaux techniques - Partie 1: Structures et procédures pour le développement des Recommandations Internationales et des Documents Internationaux de l'OIML

Une réunion du groupe ad-hoc chargé de la mise au point rédactionnelle de ce document s'est tenue au BIML les 11 et 12 février 1993 sous la présidence de M. B. Athané. Ce groupe, composé de M. K. Brinkmann (Allemagne), M. S.E. Chappell (Etats-Unis d'Amérique) et M. Z. Referowski, a mis au point la version finale du texte qui a été présenté au Conseil par M. B. Athané: le texte a été simplifié et certains délais dans le déroulement des travaux ont été précisés. Les annexes ont été améliorées en ce qui concerne leur présentation et leur contenu. Le Conseil a approuvé cette version finale et a insisté sur la diffusion la plus rapide et la plus large possible de ces directives. Les points essentiels de ces nouvelles procédures seront présentés dans le prochain Bulletin de l'OIML, au mois de juin.

4 Etablissement des comités techniques et des sous-comités

Les membres du Conseil ont présenté des rapports détaillés relatifs aux enquêtes en cours pour l'établissement des différents comités techniques et sous-comités ainsi que des problèmes non résolus à ce jour.

Il a été décidé que l'établissement des comités techniques et de leurs sous-comités devait se faire le plus rapidement possible, et au plus tard avant la réunion du CIML en octobre de cette année. Des informations sur les nouvelles structures de travail seront données dans le prochain Bulletin de l'OIML.

5 Système de certificats OIML

Un questionnaire détaillé a été envoyé à tous les Etats membres; les réponses déjà parvenues au BIML ont permis à M. A. Vichenkov de présenter au Conseil un rapport sur le Système. Celui-ci doit être développé pour s'appliquer à un nombre croissant de catégories d'instruments, et pour cela, les procédures d'essai doivent être mises au point en priorité par les différents comités et sous-comités pour pouvoir être annexées aux Recommandations; des efforts particuliers doivent être réalisés pour développer la confiance mutuelle dans les résultats d'essais.

6 Stratégie à long terme de l'OIML

Le Président a invité le Conseil a réfléchir sur l'évolution de la métrologie légale qui traverse actuellement une période de changements importants au niveau de son organisation nationale et régionale.

Le rapport "Communications internes et externes au BIML" a été présenté par K. French; ce rapport a été discuté par le Conseil et il a été décidé de poursuivre le travail au niveau des communications externes. Le BIML a commencé le travail de modernisation des publications de l'organisation et une nouvelle brochure expliquant les objectifs et les activités diverses de l'OIML est en préparation.

En ce qui concerne la stratégie à long terme de l'OIML, un projet de document sera préparé sur base d'une enquête auprès des membres du CIML, par un groupe de travail restreint constitué du Président et des Vice-Présidents du CIML, et du directeur du BIML.

7 Vingt-huitième réunion du CIML

La vingt-huitième réunion du CIML qui doit se tenir à Berlin du 4 au 6 octobre 1993 a été préparée par le Conseil, sur base des propositions de M. M. Kochsiek. La réunion sera groupée avec celle du Conseil de Développement ainsi qu'avec des séminaires et visites de laboratoires organisés par le Physikalisch Technische Bundesanstalt (PTB).

8 Copyright

Le Conseil a abordé la question du copyright des publications OIML; cette question sera discutée lors de la prochaine réunion du CIML.

Ph. D.

OIML
PRESIDENTIAL COUNCIL MEETING

PARIS, 15-16 February 1993

The OIML Presidential Council held a meeting on 15-16 February 1993 at BIML in Paris; all members were present with the additional participation of Mr Z. Referowski (Poland). Mr K. Birkeland (Norway), President, welcomed the Council members as well as the BIML technical staff and opened the discussions that would address a number of important subjects relative to the development of OIML.

The items of the agenda and the principal decisions that were made are briefly summarized below.

1 Financial situation of OIML

The Director of BIML delivered a report on the financial situation at the close of 1992, recalling that 20 % of the contributions had not been paid. An estimate for 1993 was presented and it may be anticipated that again, the same percentage of contributions will not be paid. By maintaining a low level of expenditures in 1992 and by refusing certain exceptional expenses, the financial equilibrium can probably be maintained.

2 Activities of the Pilot and Reporting Secretariats in 1992 and plans for 1993

Mr A. Vichenkov of BIML presented a complete report of the Secretariats; it was underlined that only 12 Secretariats had worked in conformity with their work program, therefore demonstrating that many Secretariats have been delayed in their work. Mr S.E. Chappell (USA) is of the opinion that with the establishment of the new work procedures, these delays should be diminished and perhaps even eliminated.

3 Directives for the technical work - Part 1: Structures and procedures for the development of OIML International Recommendations and Documents

A meeting of the ad hoc group charged with the task of editing and finalizing this text met at BIML on 11-12 February under the chairmanship of Mr B. Athané. This group, comprised of Mr Chappell, Mr K. Brinkmann (Germany), and Mr Referowski, succeeded in producing a final draft that was presented to the Council by Mr Athané: the text was simplified and certain deadlines for the development of the work were specified. The annexes were improved in content and presentation. The Council approved this final version and stressed the importance of a rapid and wide diffusion of this text. The essential parts of these procedures will be published in the next OIML Bulletin which will appear in June.

4 Establishment of technical committees and subcommittees

The Council members gave detailed reports relative to the recent inquiries for the establishment of different technical committees and subcommittees as well as the problems that had not yet been resolved.

It was decided that the establishment of technical committees and of their subcommittees should be completed as soon as possible and at the latest, before the next CIML meeting in October of this year. Information on the new work structures will be given in the next OIML Bulletin in June.

5 OIML Certificate System

A detailed questionnaire was sent to all Member States; the responses that have already been received by the Bureau have permitted Mr Vichenkov to present a report on the System to the Council. The System must be developed in order to be applied to a growing number of categories of instruments. To this end, the test procedures must be elaborated in priority by the different technical committees and subcommittees in order to be annexed to the Recommendations and a particular effort must be made to develop the mutual confidence in that which concerns test results.

6 Long-term strategy of OIML

The President invited the Council to reflect on the evolution of legal metrology which is presently facing a period of important changes on international and regional levels.

The report "Internal and External Communications of BIML" was presented by Ms K. French; the Council discussed the report and decided that work should be pursued in the framework of external communications. BIML has undertaken the work involved with modernizing the publications of the organization and a new brochure highlighting OIML's objectives and various activities is being developed.

In that which concerns long-term strategy of OIML, a draft document based on an inquiry among CIML Members will be prepared by a working group comprised of the President and Vice Presidents of CIML and the Director of BIML.

7 Twenty-eighth CIML meeting

Preparations for the twenty-eighth CIML meeting which will be held in Berlin 4 - 6 October 1993 was addressed by the Council based on proposals by Mr M. Kochsiek. The meeting will be held in conjunction with that of the Development Council as well as with seminars and visits to laboratories organized by Physikalisch Technische Bundesanstalt (PTB).

8 Copyright

The Council confronted the matter of copyright for OIML publications; this subject will be discussed during the next CIML meeting.

WELMEC HOLDS ITS FIFTH COMMITTEE MEETING IN BRUSSELS

January 1993 was a symbolic month for the countries of the European Community as they officially opened their doors to the Single Market. It was also a significant month for the legal metrology community as it marked the implementation of the Directive 90/384/EEC, also referred to as the nonautomatic weighing instruments Directive. It was in large part due to these two accomplishments that WELMEC (Western European Legal Metrology Cooperation) chose to hold its Fifth Committee meeting on January 26-27 in Brussels, Belgium.

WELMEC, established in 1990 and based on the signature of a Memorandum of Understanding (MoU), is a committee comprised of delegates from EC and EFTA (European Free Trade Association) national bodies which have signed the MoU, as well as observers from various regional and international organizations. In order to promote communication and cooperation within the sphere of legal metrology in Europe, the committee has established Working Groups whose objective is to pursue progress in areas of mutual interest to the members of WELMEC.

Belgium's General Inspector of Metrology, Dr. H. Voorhof, hosted the WELMEC meeting at the Ministry of Economic Affairs, where the 25 participants met to discuss various issues including the implementation of the Directive 90/384/EEC in the EC countries; a proposed recognition agreement for national type approvals of automatic weighing machines; communication strategies aimed at strengthening the organization's presence; and the advances made in each of its seven working groups.

Dr Seton Bennett, Chief Executive of the National Weights and Measures Laboratory in the UK, chaired the meeting (Dr Bennett is serving his second two-year term as chairman until June 1994) and opened the session with remarks as to the importance of identifying the steps WELMEC can take in 1993 to contribute concretely to its pursuit of becoming an "authoritative organisation at the centre of European Legal Metrology".

EC countries implement Directive 90/384/EEC

As of 1 January 1993, the Directive for the nonautomatic weighing instruments entered in force. This refers to the possibility of introducing such instruments to the market for use throughout the European Community on the basis of a single type approval granted by a notified body in an EC Member State. A report as to its transposition into national law within the countries of the European Community was given by CEC representative E. Jongen. Legal metrology authorities of each EC country indicated that the majority of the countries had indeed trans-

THE MEMBERS OF WELMEC

SIGNATORY BODIES

Austria ▪ Belgium ▪ Denmark ▪ Finland ▪ France ▪ Germany ▪ Greece ▪ Iceland ▪ Ireland ▪ The Netherlands ▪ Norway ▪ Portugal ▪ Spain ▪ Sweden ▪ Switzerland ▪ United Kingdom

▪ *Italy and Luxembourg had not officially joined WELMEC at the time of publication.*

OBSERVER ORGANIZATIONS

CEC (Commission of the European Communities) ▪ EFTA (European Free Trade Association) ▪ EOTC (European Organization of Testing and Certification) ▪ EUROMET (scientific metrology cooperation between Western European countries) ▪ OIML (International Organization of Legal Metrology) ▪ WECC (Western European Calibration Cooperation)

CORRESPONDING ORGANIZATIONS

CECIP (European Committee of Manufacturers of Weighing Instruments) ▪ COOMET (metrology cooperation between Central and Eastern European countries) posed the Directive into national law and that the notification of bodies for type examination, verification, unit verification, and quality assurance assessment was rapidly advancing.

Most EFTA countries are ready to implement the Directive along with other obligations of the EEA agreement; however, with the withdrawal of Switzerland, ratification cannot take place until the agreement is amended (which is unlikely before mid 1993).

In brief...

The OIML report

The International Organization of Legal Metrology (OIML), represented by Mr B. Athané and Ms K. French of the organization's Bureau (BIML), contributed to the Fifth WELMEC committee meeting in Brussels as an Observer organization. Mr Athané delivered a report to the Committee, highlighting the strong liaison between the two organizations and expressing appreciation for WELMEC's contribution in creating a free market within Europe on the basis of OIML Recommendations.

OIML works to develop cooperation with regional organizations such as CEN and CENELEC (*) and encourages joint activities marked by an "international spirit".

Mr Athané also reminded the Committee that OIML attemps to serve as one of the bridges between Eastern and Western European metrology and intends to participate in a COOMET meeting in March.

Underlining the importance of the dissemination of information, Mr Athané indicated that in addition to keeping all OIML Member States generally informed of metrological activities, it would continue to meet the challenge of ensuring bilateral communications between NAFTA (North American Free Trade Association) and Europe, particularly in the domains of certification and conformity applied to measuring instruments.

(*) main joint activities with European standardization bodies: OIML/TC 8 - CEN/TC 237 Gas Meters; OIML/TC 8 - CEN/TC 244 Liquid Meters; OIML/TC 9 - CEN/CENELEC NAWI Weighing instruments; OIML/TC 7 - CENELEC/BTTF 63-4 Electronic Taximeters.

Towards a type approval recognition agreement for measuring instruments

In the absence of a Directive for other measuring instruments, WELMEC members are working to reach an agreement for the recognition of national type approvals, e.g. automatic weighing instruments. During the meeting, there was much discussion on the subject and a revised draft of the agreement is in progress. WELMEC has the intention of having the agreement ready for signing towards the end of 1993, which would result in acceptance by the signatories of national type approvals guaranteeing conformity of an instrument to the set of requirements established in the applicable OIML Recommendations.

WELMEC strives to communicate

With the exchange of information constituting one of WELMEC's principal objectives, a high priority was given to the need for proceeding with the publication of documents pertinent to the organization's progress. During the course of 1993, WELMEC expects to distribute five or six publications including its Memorandum of Understanding, an informational brochure, guidance notes on the implementation of Directive 90/384/EEC, Guidelines on the application of EN 45000 standards in legal metrology, and Guidelines for Computerized Measuring Systems.

During the Committee meeting, the parameters for including Corresponding organizations were discussed, as well as plans for the creation of a type approval database for the members of WELMEC. Representatives from the CEC, EFTA, OIML, and WECC also participated as Observer organizations by presenting reports on their activities.

WELMEC members will assemble in Borås, Sweden for the organization's Sixth Committee meeting to be held late September, 1993.

KF

For additional information,
contact the WELMEC Secretariat:

NWML
Stanton Avenue, Teddington,
Middlesex TW11 0JZ, UK
Tel: +44 81 943 7272
Fax: +44 81 943 7270

INFORMATION

Depuis le 1er janvier 1993 la République Fédérative Tchèque et Slovaque a cessé d'exister, donnant naissance à deux Républiques indépendantes, la République Slovaque et la République Tchèque.

Les deux Républiques ont indiqué leur intention de poursuivre la participation à l'OIML qui était assumée jusqu'à présent par la Tchécoslovaquie.

Dans l'attente de la nomination des Membres du Comité International de Métrologie Légale pour la République Slovaque et la République Tchèque, le courrier peut être envoyé à:

Mr Lubomír SUTEK
Président
Úrad pre Normalizáciu
Metrológiu a Skúšobníctvo SR
Štefanovičova 3
81439 BRATISLAVA
REPUBLIQUE SLOVAQUE
TP 42-7-491 085 FAX 42-7-491050

Since 1 January 1993 the Czechoslovakia has been replaced by two independent Republics: the Slovak Republic and the Czech Republic.

Both Republics have indicated their intent to participate in OIML work which, up to the present, has been carried out by Czechoslovakia.

Pending the appointment of Members of the International Committee of Legal Metrology for the Slovak and the Czech Republics, correspondence may be sent to the following addresses.

Monsieur le Président
Czech Office for Standards
Metrology and Testing
Václavské nám. 19
113 47 PRAHA 1
REPUBLIQUE TCHEQUE
TP 42-2-261423 FAX 42-2-263187
TX 121948 FUNM C
TG Normalizace Praha

PUBLICATIONS

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

RECOMMANDATIONS INTERNATIONALES
INTERNATIONAL RECOMMENDATIONS

R 1	—	Poids cylindriques de 1 g à 10 kg (de la classe de précision moyenne) *Cylindrical weights from 1 g to 10 kg (medium accuracy class)*	1973
R 2	—	Poids parallélépipédiques de 5 à 50 kg (de la classe de précision moyenne) *Rectangular bar weights from 5 to 50 kg (medium accuracy class)*	1973
R 4	—	Fioles jaugées (à un trait) en verre *Volumetric flasks (one mark) in glass*	1970
R 5	—	Compteurs de liquides autres que l'eau à chambres mesureuses *Meters for liquids other than water with measuring chambers*	1981
R 6	—	Dispositions générales pour les compteurs de volume de gaz *General provisions for gas volume meters*	1989
R 7	—	Thermomètres médicaux (à mercure, en verre, avec dispositif à maximum) *Clinical thermometers (mercury-in-glass, with maximum device)*	1978
R 9	—	Vérification et étalonnage des blocs de référence de dureté Brinell *Verification and calibration of Brinell hardness standardized blocks*	1970
R 10	—	Vérification et étalonnage des blocs de référence de dureté Vickers *Verification and calibration of Vickers hardness standardized blocks*	1970
R 11	—	Vérification et étalonnage des blocs de référence de dureté Rockwell B *Verification and calibration of Rockwell B hardness standardized blocks*	1970
R 12	—	Vérification et étalonnage des blocs de référence de dureté Rockwell C *Verification and calibration of Rockwell C hardness standardized blocks*	1970
R 14	—	Saccharimètres polarimétriques *Polarimetric saccharimeters*	1978
R 15	—	Instruments de mesure de la masse à l'hectolitre des céréales *Instruments for measuring the hectolitre mass of cereals*	1970
R 16	—	Manomètres des instruments de mesure de la tension artérielle (sphygmomanomètres) *Manometers for instruments for measuring blood pressure (sphygmomanometers)*	1970

R 18 — Pyromètres optiques à filament disparaissant 1989
Visual disappearing filament pyrometers

R 20 — Poids des classes de précision E_1 E_2 F_1 F_2 M_1 de 50 kg à 1 mg 1973
Weights of accuracy classes E_1 E_2 F_1 F_2 M_1 *from 50 kg to 1 mg*

R 21 — Taximètres 1973
Taximeters

R 22 — Tables alcoométriques internationales 1975
International alcoholometric tables

R 23 — Manomètres pour pneumatiques de véhicules automobiles 1973
Tyre pressure gauges for motor vehicles

R 24 — Mètre étalon rigide pour agents de vérification 1973
Standard one metre bar for verification officers

R 25 — Poids étalons pour agents de vérification 1977
Standard weights for verification officers

R 26 — Seringues médicales 1973
Medical syringes

R 27 — Compteurs de volume de liquides (autres que l'eau). Dispositifs complémentaires. 1973
Volume meters for liquids (other than water). Ancillary equipment

R 29 — Mesures de capacité de service 1973
Capacity serving measures

R 30 — Mesures de longueur à bouts plans (calibres à bouts plans ou cales-étalons) 1981
End standards of length (gauge blocks)

R 31 — Compteurs de volume de gaz à parois déformables 1989
Diaphragm gas meters

R 32 — Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine 1989
Rotary piston gas meters and turbine gas meters

R 33 — Valeur conventionnelle du résultat des pesées dans l'air 1973
Conventional value of the result of weighing in air

R 34 — Classes de précision des instruments de mesurage 1974
Accuracy classes of measuring instruments

R 35 — Mesures matérialisées de longueur pour usages généraux 1985
Material measures of length for general use

R 36 — Vérification des pénétrateurs des machines d'essai de dureté 1977
Verification of indenters for hardness testing machines

R 37 — Vérification des machines d'essai de dureté (système Brinell) 1977
Verification of hardness testing machines (Brinell system)

R 38 — Vérification des machines d'essai de dureté (système Vickers) 1977
Verification of hardness testing machines (Vickers system)

R 39 —	Vérification des machines d'essai de dureté (systèmes Rockwell B, F, T - C, A, N) *Verification of hardness testing machines (Rockwell systems B, F, T - C, A, N)*	1977
R 40 —	Pipettes graduées étalons pour agents de vérification *Standard graduated pipettes for verification officers*	1977
R 41 —	Burettes étalons pour agents de vérification *Standard burettes for verification officers*	1977
R 42 —	Poinçons de métal pour agents de vérification *Metal stamps for verification officers*	1977
R 43 —	Fioles étalons graduées en verre pour agents de vérification *Standard graduated glass flasks for verification officers*	1977
R 44 —	Alcoomètres et aréomètres pour alcool et thermomètres utilisés en alcoométrie *Alcoholometers and alcohol hydrometers and thermometers for use in alcoholometry*	1985
R 45 —	Tonneaux et futailles *Casks and barrels*	1977
R 46 —	Compteurs d'énergie électrique active à branchement direct (de la classe 2) *Active electrical energy meters for direct connection (class 2)*	1978
R 47 —	Poids étalons pour le contrôle des instruments de pesage de portée élevée *Standard weights for testing of high capacity weighing machines*	1978
R 48 —	Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques *Tungsten ribbon lamps for calibration of optical pyrometers*	1978
R 49 —	Compteurs d'eau (destinés au mesurage de l'eau froide) *Water meters (intended for the metering of cold water)*	1977
R 50 —	Instruments de pesage totalisateurs continus à fonctionnement automatique *Continuous totalising automatic weighing machines*	1980
R 51 —	Trieuses pondérales de contrôle et trieuses pondérales de classement *Checkweighing and weight grading machines*	1985
R 52 —	Poids hexagonaux. Classe de précision ordinaire de 100 g à 50 kg *Hexagonal weights. Ordinary accuracy class, from 100 g to 50 kg*	1980
R 53 —	Caractéristiques métrologiques des éléments récepteurs élastiques utilisés pour le mesurage de la pression. Méthodes de leur détermination *Metrological characteristics of elastic sensing elements used for measurement of pressure. Determination methods*	1982
R 54 —	Échelle de pH des solutions aqueuses *pH scale for aqueous solutions*	1981
R 55 —	Compteurs de vitesse, compteurs mécaniques de distance et chronotachygraphes des véhicules automobiles - Réglementation métrologique *Speedometers, mechanical odometers and chronotachographs for motor vehicles. Metrological regulations*	1981
R 56 —	Solutions-étalons reproduisant la conductivité des électrolytes *Standard solutions reproducing the conductivity of electrolytes*	1981
R 57 —	Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Dispositions générales *Measuring assemblies for liquids other than water fitted with volume meters. General provisions*	1982

R 58	—	Sonomètres *Sound level meters*	1984
R 59	—	Humidimètres pour grains de céréales et graines oléagineuses *Moisture meters for cereal grains and oilseeds*	1984
R 60	—	Réglementation métrologique des cellules de pesée *Metrological regulations for load cells*	1991
R 61	—	Doseuses pondérales à fonctionnement automatique *Automatic gravimetric filling machines*	1985
R 62	—	Caractéristiques de performance des extensomètres métalliques à résistance *Performance characteristics of metallic resistance strain gauges*	1985
R 63	—	Tables de mesure du pétrole *Petroleum measurement tables*	1985
R 64	—	Exigences générales pour les machines d'essai des matériaux *General requirements for materials testing machines*	1985
R 65	—	Exigences pour les machines d'essai des matériaux en traction et en compression *Requirements for machines for tension and compression testing of materials*	1985
R 66	—	Instruments mesureurs de longueurs *Length measuring instruments*	1985
R 67	—	Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes. Contrôles métrologiques *Measuring assemblies for liquids other than water fitted with volume meters. Metrological controls*	1985
R 68	—	Méthode d'étalonnage des cellules de conductivité *Calibration method for conductivity cells*	1985
R 69	—	Viscosimètres à capillaire, en verre, pour la mesure de la viscosité cinématique *Glass capillary viscometers for the measurement of kinematic viscosity*	1985
R 70	—	Détermination des erreurs de base et d'hystérésis des analyseurs de gaz *Determination of intrinsic and hysteresis errors of gas analysers*	1985
R 71	—	Réservoirs de stockage fixes. Prescriptions générales *Fixed storage tanks. General requirements*	1985
R 72	—	Compteurs d'eau destinés au mesurage de l'eau chaude *Hot water meters*	1985
R 73	—	Prescriptions pour les gaz purs CO, CO_2, CH_4, H_2, O_2, N_2 et Ar destinés à la préparation des mélanges de gaz de référence *Requirements concerning pure gases, CO, CO_2, CH_4, H_2, O_2, N_2 and Ar intended for the preparation of reference gas mixtures*	1985
R 74	—	Instruments de pesage électroniques *Electronic weighing instruments*	(*)
R 75	—	Compteurs d'énergie thermique *Heat meters*	1988

R 76	—	Instruments de pesage à fonctionnement non automatique *Nonautomatic weighing instruments*	
		Partie 1 : Exigences métrologiques et techniques - Essais *Part 1 : Metrological and technical requirements - Tests*	1992
		Partie 2 : Rapport d'essai de modèle *Part 2 : Pattern evaluation report*	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 *Radar equipment for the measurement of the speed of vehicles*	1990
R 92 —	Humidimètres pour le bois - Méthodes et moyens de vérification: exigences générales *Wood-moisture meters - Verification methods and equipment: general provisions*	1990
R 93 —	Frontofocomètres *Focimeters*	1990
R 95 —	Bateaux-citernes - Prescriptions générales *Ships' tanks - General requirements*	1990
R 96 —	Bouteilles récipients-mesures *Measuring container bottles*	1990
R 97 —	Baromètres *Barometers*	1990
R 98 —	Mesures matérialisées de longueur à traits de haute précision *High-precision line measures of length*	1991
R 99 —	Instruments de mesure des gaz d'échappement des véhicules *Instruments for measuring vehicle exhaust emissions*	1991
R 100 —	Spectromètres à absorption atomique pour la mesure des polluants métalliques dans l'eau *Atomic absorption spectrometers for measuring metal pollutants in water*	1991
R 101 —	Manomètres, vacuomètres et manovacuomètres indicateurs et enregistreurs *Indicating and recording pressure gauges, vacuum gauges and pressure-vacuum gauges*	1991
R 102 —	Calibreurs acoustiques *Sound calibrators*	1992
R 103 —	Appareillage de mesure pour la réponse des individus aux vibrations *Measuring instrumentation for human response to vibration*	1992
R 104 —	Audiomètres à son pur *Pure-tone audiometers*	1992
R 105 —	Ensembles de mesurage massiques directs de quantités de liquides *Direct mass flow measuring systems for quantities of liquids*	1993
R 106 —	Pont-bascules ferroviaires à fonctionnement automatique *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 — 1987
Hierarchy scheme for instruments measuring the viscosity of liquids

D 18 — Principes généraux d'utilisation des matériaux de référence certifiés dans les mesurages — 1987
General principles of the use of certified reference materials in measurements

D 19 — Essai de modèle et approbation de modèle — 1988
Pattern evaluation and pattern approval

D 20 — Vérifications primitive et ultérieure des instruments et processus de mesure — 1988
Initial and subsequent verification of measuring instruments and processes

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

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

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

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