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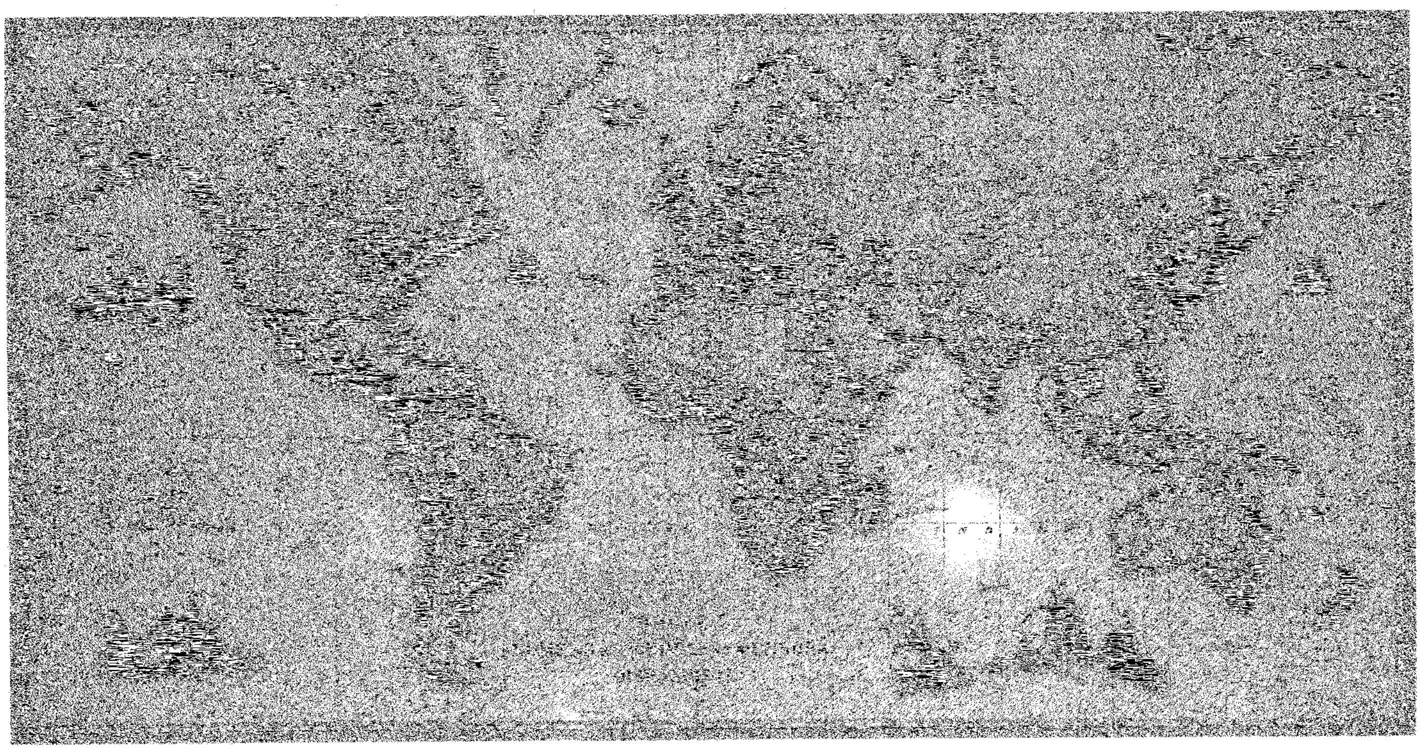

BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE
11, Rue Turgot – 75009 PARIS – France

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A nos lecteurs

Au cours des 14 dernières années, le Bulletin de l'OIML a été l'une des responsabilités de M. Stig Ake Thulin. C'est avec plaisir que je souligne le caractère remarquable du travail de M. Thulin, qui a produit un journal technique couvrant les multiples aspects de la métrologie pratique et légale, et une très efficace source d'informations entre nos membres.

M. Thulin a pris sa retraite en septembre 1992 et le Bulletin sera à partir de maintenant produit par Ms Kristine French et M. Philippe Degavre. Ils ont déjà réfléchi aux modifications potentielles qui pourraient affecter la présentation et le contenu général du journal et mèneront à bien leur travail en tenant compte du besoin constant de répondre aux développements de la métrologie pratique et légale.

Je suis certain que, lecteurs de notre Bulletin, vous serez intéressés par cette évolution future et je voudrais vous encourager à participer à ces développements en faisant connaître vos vues aux nouveaux rédacteurs et, si approprié, en leur envoyant des articles.

To our readers

For 14 years now, the OIML Bulletin has been the responsibility of Mr Stig Ake Thulin. It is my pleasure to emphasize that the work performed by Mr Thulin has been extraordinary, thus producing a technical journal that covers the numerous aspects of practical and legal metrology and an efficient source of information for our members.

Mr Thulin retired in September 1992 and the Bulletin will now be produced by Ms Kristine French and Mr Philippe Degavre. Ms French and Mr Degavre have been reflecting as to potential changes that would affect the general lay-out and contents of the journal and they will proceed with their work in a manner that takes into account the constant need to respond to the developments in practical and legal metrology.

I am certain that as readers of our Bulletin, you will be interested in this future evolution and I would like to encourage you to participate in these developments by informing the new editors of your views and, if appropriate, by contributing articles.

B.A.

Ninth International Conference of Legal Metrology

Vouliagmeni, Greece, was the location of the ***Ninth International Conference of Legal Metrology*** *wich was held November 2 - 6, 1992.*

The hospitality of the Greek Government and the natural beauty of the environment created an atmosphere that was conducive to a successful Conference and Twenty-Seventh Meeting of the International Committee of Legal Metrology.

The Conference was officially commenced by Mr V. MANTZORIS, Greek Minister of Commerce and Industry, who welcomed more than 115 delegates from 41 Member States as well as representatives of 5 Corresponding Members and 8 International Institutions in liaison with OIML. The opening ceremony also included speeches by Mrs K. TSOUNI, President of the Hellenic Organization of Standardization (ELOT) and Mr A. KOMMATAS, Director of Metrology Department in Greece.

After having thanked the Minister, Mr K. BIRKELAND, President of CIML, outlined the fundamental developments within OIML during the past four years and defined the necessary directions that our Organization must take to maintain a strong leadership in the legal metrology community.

After the election of Mr L. ISSAEV (Russia) as President of the Conference, and Mr M. BENKIRANE (Morocco) and Mr J. BIRCH (Australia) as Vice-Presidents the delegation proceeded with the various items of the agenda.

A significant result of the Conference was the formal sanction of 12 Recommendations that had already been approved and published, as well as six Draft Recommendations directly presented for approval. In addition, several resolutions were drawn up concerning subjects such as OIML's role in assisting developing countries, liaisons with international institutions, and matters involv-ing the Organization's administration and finance.

Representatives of ISO, CEN, CENELEC, CECIP, WELMEC and COOMET delivered reports addressing the current relations between OIML and their institutions (a report from IUPAC was read by an agent from BIML). The Conference drafted a resolution emphasizing the importance of maintaining a satisfactory state of cooperation and increasing liaisons with international institutions and European bodies concerned with legal metrology and standardization.

Pictured from left to right: B. ATHANÉ, Director of the International Bureau of Legal Metrology; K. BIRKELAND, President of the International Committee of Legal Metrology; V. MANTZORIS, Greek Minister of Commerce and Industry; A. KOMMATAS, Director of the Greek Metrology Department; K. TSOUNI, President of the Hellenic Organization of Standardization (ELOT); A. VLACHOS, Head of Metrology Department.

Financially, the OIML budget for the years 1993-1996 indicates a growth factor of practically zero. This was necessary as the Organization attemps to cope with the present difficult international economic situation.

Moreover, the Conference reenforced the need for continued advancements in the fundamental work of OIML, including the *OIML Certificate System for Measuring Instruments* and the creation of new technical committees and work projects.

The date and place of the Tenth International Conference of Legal Metrology have not yet been established and relevant information will be published in the Bulletin when these decisions have been made.

In addition to the Conference sessions, the International Committee of Legal Metrology (CIML) held its twenty-seventh meeting. An exceptional decision was made to extend the presi-dential mandate of Mr BIRKELAND until 1994, at which time the election of a new CIML president will be held. Mr BIRKELAND has already successfully completed two six-year mandates in this position.

CIML will meet again in October 1993 in Berlin following an invitation from CIML Vice-President, Prof Manfred KOCHSIEK (Germany).

Pleasant weather conditions in Vouliagmeni allowed for the enjoyment of the nearby beaches, swimming, tennis and promenades. Participants and their conjoints were also invited to enhance their appreciation of Greek culture by partaking in several events organized by the Greek hosts, including a visit to the Acropolis, a city tour of Athens, lunch in the port of Piraeus and a splendid dinner cruise around the Saronikos Bay. Congratulations to the tourist agency, AFEA, for its contribution to the success of the Conference.

BIML would like to extend its sincere appreciation and thanks to the Greek hosts for the efficient organization of the Conference and the opportunity to explore the country's natural geographical beauty and rich culture.

K.F.

Neuvième Conférence Internationale de Métrologie Légale

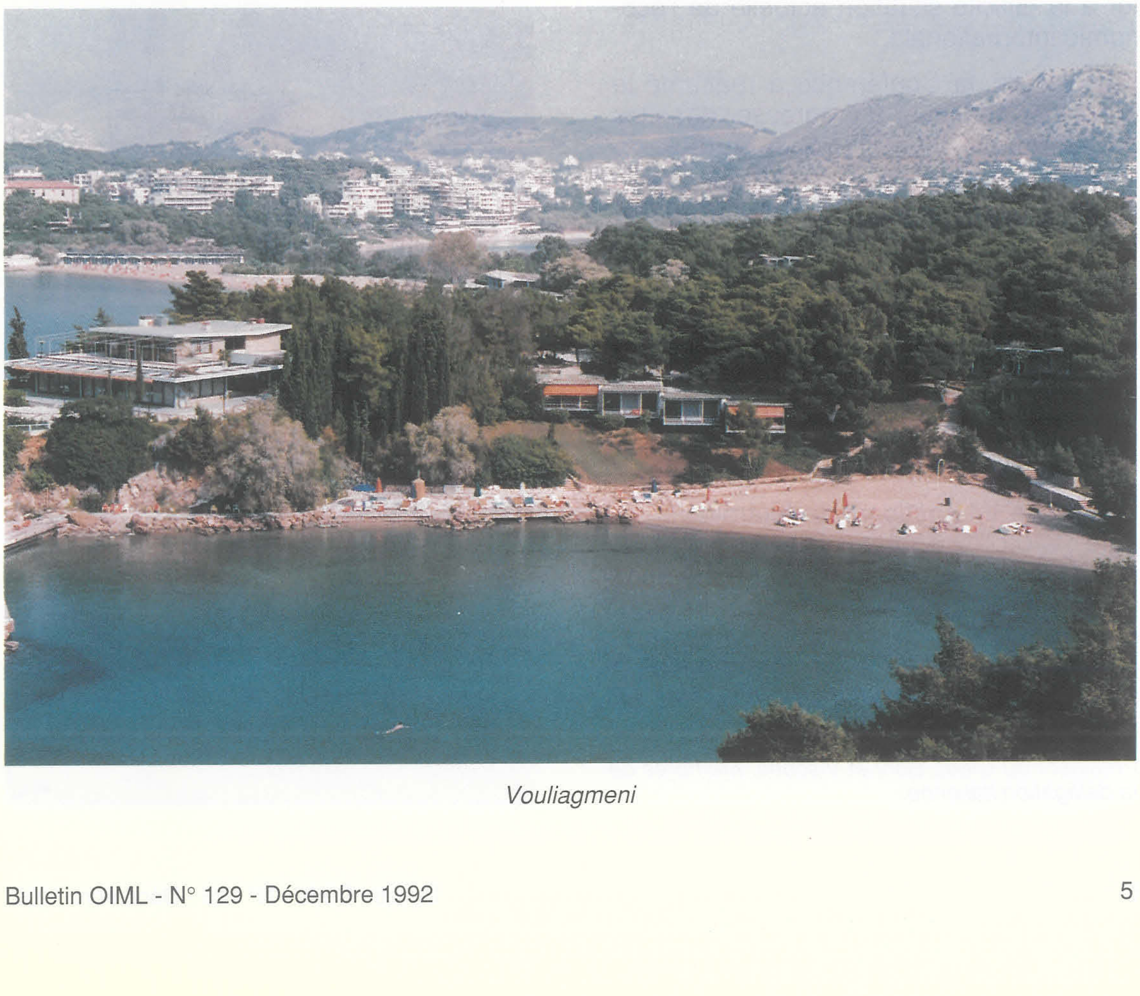
*C'est à Vouliagmeni, Grèce, que s'est tenue la **Neuvième Conférence Internationale de Métrologie Légale** du 2 au 6 novembre 1992.*

L'hospitalité du gouvernement grec ainsi que la beauté naturelle de l'environnement ont créé une ambiance qui a contribué au succès de la Conférence et de la vingt-septième réunion du Comité International de Métrologie Légale.

La Conférence a été officiellement ouverte avec une allocution de M. V. MANTZORIS, Ministre grec du commerce et de l'industrie, qui a accueilli environ 115 délégués provenant de 41 Etats Membres ainsi que les représentants de 5 Membres Correspondants et 8 Institutions Internationales en liaison avec l'OIML. La cérémonie d'ouverture a compris également des discours de Madame K. TSOUNI, Présidente de l'Organisation Hellénique de Normalisation (ELOT) et de Monsieur A. KOMMATAS, Directeur du Service de Métrologie en Grèce.

Après avoir remercié le Ministre, M. K. BIRKELAND, Président du CIML, s'est exprimé sur les développements principaux de notre Organisation pendant les quatre dernières années et a défini les directions à suivre pour que l'OIML puisse maintenir son leadership auprès de la communauté de métrologie légale.

Suivant l'élection de M. L. ISSAEV (Russie) comme Président de la Conférence, et MM. M. BENKIRANE (Maroc) et J. BIRCH (Australie) comme Vice-Présidents, les délégations ont entamé l'examen des divers points de l'ordre du jour.



Vouliagmeni

Un résultat important de la Conférence a été la sanction formelle de 12 Recommandations déjà approuvées et publiées, ainsi que de six Projets de Recommandations directement présentés pour approbation. De plus, plusieurs résolutions ont été élaborées sur des sujets tels que le rôle de l'OIML concernant l'aide aux pays en développement, les liaisons avec d'autres institutions internationales, et les questions administratives et financières de l'Organisation.

Des rapports ont été présentés par les représentants d'ISO, CEN, CENELEC, CECIP, WELMEC et COOMET à propos des relations entre l'OIML et ces institutions (un rapport d'IUPAC a été lu par un agent du BIML). La Conférence a adopté une résolution soulignant l'importance de maintenir un état de coopération satisfaisant et d'accroître les liaisons avec les institutions internationales et les organes européens de métrologie légale et normalisation.

En ce qui concerne les questions financières, le budget de l'OIML couvrant les années 1993 à 1996 montre une croissance de pratiquement zéro. Cela résulte de la nécessité pour l'Organisation de s'adapter à la difficile situation actuelle de l'économie internationale.

Par ailleurs, la Conférence a réaffirmé le besoin de continuer à progresser dans les domaines de travail fondamentaux de l'OIML, y compris le *Système de Certificats OIML pour les Instruments de Mesure* et la création de nouveaux comités techniques et thèmes de travail.

La date et le lieu de la Dixième Conférence Internationale de Métrologie Légale n'ont pas encore été fixés et les informations relatives à ce sujet seront publiées dans le Bulletin dès que les décisions auront été prises.

Le Comité International de Métrologie Légale (CIML) a également tenu sa vingt-septième réunion et la décision a été prise de prolonger exceptionnellement le mandat présidentiel de M. BIRKELAND jusqu'en 1994, moment où l'élection d'un nouveau président du CIML aura lieu. M. BIRKELAND a déjà accompli avec succès deux mandats de six ans à ce poste.

Le CIML se réunira en octobre 1993 à Berlin à la suite d'une invitation du Vice-Président du CIML, Prof Manfred KOCHSIEK (Allemagne).

Grâce aux conditions de temps agréables à Vouliagmeni, les participants et leurs conjoints ont eu l'occasion de profiter des plages, de la natation, du tennis, et des promenades. Ils ont été également invités à enrichir leur connaissance de la culture grecque en participant aux activités organisées par les hôtes grecs, comprenant une visite de l'Acropole, un tour d'Athènes, un déjeuner au port du Pirée et un splendide dîner-croisière dans la baie de Saronikos. Félicitations à l'agence de tourisme, AFEA, pour sa contribution au succès de la Conférence.

Le BIML se permet d'exprimer sa reconnaissance profonde et ses remerciements aux hôtes grecs pour l'organisation efficace de la Conférence et aussi pour l'occasion donnée aux participants de découvrir la beauté géographique naturelle et la riche culture du pays.

La fin d'une visite à l'Acropole - MM. Birkeland, Président du CIML, Boni et Visconti, Membres de la délégation italienne.

CLEAN AIR MEASUREMENT

Interlaken, 28 September - 1 October 1992

The topic chosen for this seventh OIML technical seminar was air pollution measurements including measuring instruments for vehicle exhaust gas, continuous monitoring of ambient air and control of stack gas emissions.

This subject had been suggested by O. PILLER, our Swiss CIML member; the practical arrangements for the seminar were taken care of by the staff of his Institute, the Swiss Federal Office of Metrology.

The site of Interlaken in the touristic region near the Jungfrau mountain is certainly not a polluted area and could rather be used for clean air sampling, hence the name adopted for the seminar. The venue was Park Mattenhof, a first class hotel with reasonable prices and specially equipped meeting rooms.

Fifty specialists from seventeen countries participated in the seminar. Many of them were from institutions other than the national legal metrology services. We are particularly grateful for the important participation from ISO TC 146 "Air Quality" and CEN TC 264. The chairman of ISO TC 146, Mr A. ARONDS, assisted us in finding many of the lecturers.

The seminar was opened by Mr O. PILLER whose speech is reproduced in this isssue of the Bulletin. Twenty-four papers were presented during the four days of the seminar. Two of the lectures on vehicle exhaust measurements were illustrated by demonstrations outside in the garden. In addition to the use and practical testing of instruments, the speakers covered subjects such as standardization, development of instruments and measuring methods, reference gases, training of staff, and tax regulations on polluting gas emissions.

Summaries of the papers are given at the end of this report and a selection of them will be published in the OIML Bulletin, starting with this issue. The paper by Dr W. RICHTER was already published in Bulletin n° 128 of September 1992.

Conclusions

As expected, the seminar revealed the great importance of work on pollution measuring instrumentation. In addition to the methods of measurement described in the standards of ISO and CEN, there is an urgent need for OIML Recommendations on diesel engine particulate measuring instruments and on stack emission continuous monitoring equipment.

Ambient air monitors for various components are being installed in an increasing number of dwelling areas. Requirements for the accuracy and testing of these commercial instruments should therefore also be included in the work priorities of the appropriate OIML secretariat on air pollution.

It is to be noted that much greater attention must be paid to emissions of nitrogen oxides. Many countries are introducing very strict requirements and heavy taxes relative to emissions of these gases, thereby bringing about the necessity for reliable and verifiable measurements of these components (1).

The organizers found that the seminar entirely fulfilled its goal, thanks to the variety of reports presented, the high level of the speakers, and the interesting discussions.

Acknowledgements

BIML would like to thank once again Mr PILLER for his initiative and staff, particularly Mr SCHLATTER, for the perfect organizational arrangements.

All the participants were most grateful for the excursion offered by the Swiss Federal Office of Metrology which allowed us to admire the collection of the Abbeg foundation, followed by a very pleasant dinner with typical Swiss music.

A.T.

(1) It was frightening to learn from Mr R. SVEDBERG's speech that the emission of nitrogen oxides in Sweden in 1990 totalized more than 400 000 t of which more than half this sum originated from road and non-road vehicles.

Opening address

by **O. PILLER**
Director of the Swiss Federal Office of Metrology

Mister Chairman, Ladies and Gentlemen,

It is a great pleasure and honour for me to welcome you here to Interlaken. You came to Switzerland from all parts of the world to discuss measurement equipment and measurement methods used in the control of air pollution.

We live in a time that is marked like never before by scientific research linked to an immense technical development. We are all aware of the results of this enormous development. It has brought an unprecedented prosperity particularly to the industrialized nations. It led to an astonishing mobility and enabled an almost instant world wide exchange of information through the advance of telecommunication networks. Modern medical technology led to a reduction of infant mortality and to a welcome increase in life expectancy. In highly developed states, new methods of food production have eliminated hunger to a great extent.

At the beginning of the 1960's, when space technology provided the first satellite pictures of our planet, we have been overwhelmed by the beauty of our space-ship "earth". We were also very proud that technical development had brought us that far. What an exalted feeling we had when in 1969 the first man, Neil Armstrong, was setting foot on the ground of the Moon. At the beginning of the 1970's, the first report of the Club of Rome titled "Borders of Growth" brought a big disillusionment. According to this report, we must expect a collapse of our economic and environmental system during the middle of the 21st century if we continue to follow the ideology of unlimited growth. Our limited living space cannot cope for much longer with the present uncontrolled growth rate of population, industrial production, energy consumption and consumption of raw materials.

In 1987, the Brundtland-report was published. As you may know, this is a report from the world commission responsible for the environment and development. In this report the following sentence appeared: "Most of the political decision makers will be dead, when the consequences of sour rain, hothouse effect, destruction of ozone and the loss of species are obvious. But, most of the young people will still be living".

At the world summit in Rio, it was made obvious that the responsible politicians are timidly and hesitatingly becoming aware of the seriousness of environmental destruction. We can only hope that the measures which have already been taken, or which must still be taken, will be effective in time.

One of the central and acute problems today is air pollution which is mainly caused by traffic and heating. For this reason, many states have passed laws on this subject or are on the point of doing so. A serious legislation should be based upon two levels.

The first level should be dedicated to prevention. Air pollution must be limited by measures taken at the source of the problem. Sources refer to stationary facilities like heating plants, waste incinerators, ventilation systems of factories or streets, as well as mobile machines and vehicles. As a precautionary measure, the emission of air pollutants should be fundamentally limited, even when no direct danger is expected. The maximum emission levels are set in such a way that they can be observed under the current technical and operating conditions provided that this is economically acceptable. This principle enforces the idea, that only state of the art methods should be used in the production and use of goods which could pollute our environment. This pressure to innovate most likely has positive economical impact on the highly industrialized countries and their high-tech export industries.

The second level becomes important, as soon as it is found or expected that the emissions of pollutants are harmful or annoying. The limits for harmful effects or nuisances form the basis for impact thresholds. These impact thresholds are fixed in such a way that, in the light of current knowledge and experience, immissions below these levels do not endanger persons, animals and plants.

If the limiting values of immissions are exceeded, the responsible sources have to be found. These sources must be modernized at the cost of their owners.

People responsible for the execution of environmental laws should first fix the impact thresholds for air pollutants. To do this, extensive scientific investigations are needed, as well as precise measurement equipment and reasonable, meaningful measurement methods.

Measurement methods and measurement equipment build the basis of an effective pollution control, to which this seminar is decicated. I thank you very much for your willingness to be in charge of this important task and I wish you plenty of success in managing this pretentious activity.

I hope very much that you will still find enough time to get to know the region of Interlaken which is internationally known because of its famous mountains Eiger, Mönch, and Jungfrau of which we Swiss people are so proud.

CLEAN AIR MEASUREMENT | Interlaken 28 Sept - 1 Oct 1992

Summaries of the presentations

International development of standards for air quality

by Cornelis A. Aronds, Chairman, and Klaus Grefen, Secretary ISO/TC 146

In the field of international standardization of air pollution monitoring methods, an important aim is to achieve a more efficient use of manpower and funds in order to accelerate standardization procedures. Unfortunately, the efforts required to carry out the formidable task of expanding the field and harmonizing the compounds and methods are too weak. In part, the solution may be found in a closer cooperation between all organizations involved together with an efficient division of work within the programs. This paper covers the problems of this approach.

Measurement traceability versus legal traceability in air quality measurement

by Dr. Harry L. Rook
Materials Science and Engineering Laboratory
National Institute of Standards and Technology
Gaithersburg, Maryland, U.S.A.

The adjective "traceable", derived from the verb "to trace", has four distinct definitions with more than 12 nuances, according to Webster's English dictionary. A few notable articles have appeared 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 of 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 attempt to describe a system for traceability of analytical measurements and illustrate who is responsible for what and how it is quantitatively assured.

Automotive emission analysis using FTIR spectrophotometer

by M. Adachi
Automotive Instrument Development Project Department
Horiba Ltd, Japan

Two new techniques have been applied to FTIR emission analysis which add significant potential to automotive emission measurement. One of these is the use of the mathematical multivariate analysis which is called the partial least squares method. This spectrum discrimination technique, in combination with high resolution spectrum data, enables superior analysis for heavy-overlapping species in the emission. The other technique is a flow conditioned gas sampling cell which is designed especially for real time emission measurement. The flow in the gas cell has been analyzed with computer simulation and the gas cell has a flow conditioner inside with a 10 meter optical path. Seven seconds of 90 percent gas replacement time can be achieved with this cell. As a result, highly accurate realtime data can be obtained with relatively fast response.

In this paper, spectrum factors extracted from overlapping species and quantification simulations are shown using standard gases. The realtime measurement of methanol fueled vehicles with and without catalyzer will be compared. In addition, we compare data from the FTIR with data collected by conventional analyzers. The results show the detailed emission pattern of several species which have not been analyzed before.

Gas analyser with excellent long-term stability for measurement of exhaust gases from Otto engines and turbidity measuring equipment for diesel engines

by Dr. K. Wendt
Siemens AG
Karlsruhe, Germany

The principles of operation are explained; excellent long-term stability for an analysing system is achieved by using a NDIR-bench with opto-pneumatic infrared detectors that realize a gas correlation technique. Field tests have shown that the accuracy for measuring the components CO, CO_2, and HC are remaining within the requirements of OIML Class I for at least six months without recalibration.

For the measurement of exhaust from Diesel engines, an equipment is presented that directly fits on to the exhaust pipe and is capable of giving a time resolved plot of the particle emission. Different evaluation methods calculate peak or integral values in agreement with international regulations or as stated by the customer.

Method of determination of NO_x in exhaust gas and in reference calibration gas by NEDA-photometry

by Saburo Yanagisawa
Prof. emeritus Keio University, Japan
Convenor or ISO/TC146/SCI/WG3

This is a new method of determination of NO_x. Sample gas is shaken with NaOH-alkaline H_2O_2-solution and NO_x is converted into NO_2 form. This NO_2 is colour-developed with NEDA reagent and is photometrically determined.

The condition of perfect formation of NO_2 from NO_x is explained by Pourbaix's oxidation-reduction theory.

NO_x in exhaust gas is determined in one hour; NO and NO_2 in reference calibration gas is determined within 20 minutes by adding catalase enzyme, an instantaneaous H_2O_2-decomposing reagent.

Pattern approval and verification system based on OIML R 99 in Hungary

by Mária Rohály
National Office of Measures (OMH), Budapest, Hungary

The introduction of a more strict environmental supervision of vehicle exhaust emission has given new tasks for OMH due to the great number of new sophisticated instruments that been imported.

According to the Hungarian Law on Metrology N° XLV (1991) the pattern approval and the initial and yearly subsequent verification are obligatory.

The new OIML Recommendation R 99 was very useful in our work.

The lecture summarizes the most important experiences obtained from the course of more than 15 pattern approvals and gives a survey of the applied system of verification.

Monitoring and controlling unwanted emissions of pollutants from motor vehicles in the United States

by William B. Clemmens (US EPA) and Samuel E. Chappell (NIST)

Currently, emissions from motor vehicles are regulated within the United States of America (U.S.A.) by the U.S. Environmental Protection Agency (EPA). The procedures include monitoring and control of inspection and maintenance (I/M) testing programs implemented by state and local governments and federal surveillance of vehicle production. The metrological and technical performance of the instruments used in the field I/M testing are consistent with the requirements provided in OIML Recommendation 99 "Instruments for Measuring Vehicle Exhaust Emissions". This paper provides a brief identification of these programs.

The U.S. EPA has found that the traditional idle I/M tests, conducted on a periodic basis for measuring emissions from in-use vehicles, is losing its ability to effectively identify vehicles with high emissions. The primary cause is the greater flexibility available in the design of sophisticated digital engine controls which are in widespread use in the U.S.A. New techniques for identifying vehicles with high emissions are being considered for U.S. regulations. These include on-vehicle monitoring requirements (on-board diagnostics-OBD), on road measurements (the likely technique: remote sensing), and an I/M version of the new vehicle certification procedure.

The I/M version of the new vehicle certification procedure, called the "High Tech I/M Test" involves a chassis dynamometer with inertia weights, a constant volume sampler to collect and dilute the vehicle exhaust, and emission instruments significantly more sensitive than those specified in OIML R 99. During testing, an in-use vehicle would be operated over a transient driving cycle, and HC, CO, and NO_x are measured as mass emissions in grams per mile. In addition, evaporative emission has been found to be a significant contributor to volatile organic compounds (VOC) in the ambient air. The High Tech I/M Test would measure the purge function and the pressure integrity of the evaporative system in the vehicle.

A resarch program for this High Tech I/M Test has been in operation for approximately two years. This paper summarizes the results of the research and the feasibility and possible schedule for implementation of the High Tech Test.

In addition, the anticipated implementation and public costs of this new program are compared with existing I/M test programs within the U.S.A. Data indicate that the emission reductions anticipated from using the High Tech Test will be six times better than the average I/M Program, and three times better than the best I/M programs. These data also indicate that the High Tech Test is twice as cost effective than stationary source emission controls. The cost to the public for the High Tech Test is expected to be comparable or lower than existing I/M programs.

Swiss reference gases in emission measuring instruments: principles and practices

by J.-F. Perrochet
Swiss Federal Office of Metrology, Wabern

The Swiss Federal Office of Metrology presently has standards of gas mixtures essentially based on comparative measurements. This principle is applied to horizontal (same concentration) and vertical comparisons of gas mixtures coming from different factories, including some primary reference materials from other national laboratories. Apparatus, calculation methods, and results are presented. The diffusion of reference gas mixtures is accomplished through the Swiss Accreditation Service. Some particularities are shown in the paper. Finally, the widening of the Swiss Basis to references for immission measurements announces new problems. Some of the perspectives are described.

Gas standards and monitoring techniques for application to air quality and vehicle and industrial emission measurements

by P.T. Woods and R.H. Partridge
Division of Quantum Metrology, National Physical Laboratory, Teddington, UK

The National Physical Laboratory (NPL) is the focus of the United Kingdom National Measurement System and as such provides nationally-traceable standards to which UK measurements of air quality and pollutant emissions can be referenced. Work is also underway on the development of new open-path and remote monitoring techniques to supplement conventional atmospheric monitoring methods.

NPL has established a national facility where primary gas standards are prepared. These in turn are used to certify secondary standards which are disseminated for calibrations in industry and government laboratories. NPL has participated in intercomparisons with other national standards laboratories, for example, the National Institute for Standards and Technology, USA, in order to demonstrate the international uniformity of nationally-prepared gas standards. Collaboration with the National Measurement Institute, Holland, is also underway as part of a EUROMET programme to rationalise gas standards work throughout Europe.

The UK has now established a nationally-traceable framework for the measurement of vehicle emissions which are carried out as part of an annual test. This entails commercial laboratories accredited under the National Measurements Accreditation Scheme using nationally-traceable reference gases for instrument type-testing. It also entails regular checks on accuracy of vehicle emission monitors in all UK garages using nationally-traceable reference mixtures.

Over the past ten years, a range of new flexible atmospheric monitoring instruments have been developed to carry out measurements difficult to make with traditional "point" sensing methods.

NPL has developed a range of these, which are capable of integrated-path or range-resolved measurements of a wide range of air pollutants directly in the atmosphere up to distances of several kilometres. The advantages of these techniques are outlined and results of field measurements which demonstrate their applications are presented. Examples of commercial exploitation are given. Progress with the preparations of a British Standard, which is intended to serve as the basis for a European standard, are also outlined.

Reliable measurement of gaseous and particulate pollutants in vehicle exhaust emission surveillance in Germany

by W. Richter
Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Requirements and tests are described for measuring instruments used for in-use vehicle exhaust emission surveillance in Germany. According to new regulations, petrol-engine vehicles equipped with catalytic converters and diesel-engine vehicles are also included in this programme. Measuring instruments for the exhaust components CO, CO_2, "HC" and O_2 designed to determine the air fraction λ, and diesel smoke meters (opacimeters and filter-type instruments) are covered in detail (This paper was published in OIML Bulletin n° 128).

Experience gained with verification of instruments for measuring vehicle exhaust emissions and preparation for future tasks

by Dipl.-Ing. Wolfhard Gögge
Director of Legal Metrology, Eichdirektion Rheinland-Pfalz
Bad Kreuznach, Germany

Since 1980, instruments for measuring vehicle exhaust emissions have been verified in Germany which means that the CO contents in the exhaust gases of vehicles with gasoline driven engines at idling speed are measured according to present regulations.

The tests are being performed with test gases of different mixtures.

Instruments for measuring vehicle exhaust emissions are only correct if they are properly maintained in addition to the verification. Information as to the condition of the measuring instruments as encountered by the verification officiers as well as the influence of the maintenance on the correctness of measurement results is given.

In the future, the involvement of verification authorities in this field will increase. It is planned to measure additional components of hydrocarbon in the exhaust gases as well as the content of soot in the exhaust fumes of diesel engines. The requirements that will be accorded to the measuring instruments and procedures are explained.

A demonstration of the test equipment mounted on a vehicle of the Eichdirektion Rheinland-Pfalz followed, showing the verification of instruments for measuring vehicle exhaust emissions.

Evaluation of performance characteristics of in stack or ambient air analysers

by Rémi Perret
Institut National de l'Environnement Industriel et des Risques, France

Continuous monitoring is increasingly used, either in ambient air networks or in industrial plants for emission measurements. It is therefore necessary to determine performance characteristics and industrial use suitability of commercially available devices.

Main metrological characteristics, such as detection limit, zero and span instability, response curve, and interferences may be determined in a laboratory by standardized procedures (ISO 8158, ISO DIS 9169). Laboratory tests also have to study other points of major interest for the user, such as the influence of the external temperature, electrical supply variations, and radio interferences.

Field tests provide useful data on long time drift, failures, and clogging. Although the results of these tests are only indicative and (particularly for emission measurement devices) depend on the choice of the industrial plant, they are a powerful tool to determine the real suitability of the instruments.

The influence of ambient conditions on the emissions of NO_x from domestic boilers

by Dr. ir. C.J.A. Pulles
VEG-Gasinstituut, Apeldoorn, Nederland

The emission of NO_x from boilers is influenced by a number of factors. In particular, the influence of combustion air temperature and humidity is important. Therefore NO_x emission measurements of boilers have to be performed under standardized conditions or the measurements must be corrected for deviations from these standard conditions. VEG-Gasinstituut has conducted a series of tests, in collaboration with CETIAT (France), to determine the necessary corrections. This project is sponsored by the Bureau Communautaire de Référence (B.C.R.).

The tests have been done for a variety of appliances. NO_x emission and several other parameters have been measured as a function of air temperature and humidity. Some appliances were also tested with different gas fuels. Care has been taken to ensure that other operating conditions (i.e. rating) remained constant.

Some results of the tests were presented. The conclusions of this project presented to B.C.R. were also discussed.

The use of automatic instruments and calibration gases in the Swiss National Air Pollution Monitoring Network (NABEL)

by Dr. B. Buchmann
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The Swiss National Air Pollution Monitoring Network (NABEL) has been in operation since 1978. A modernization and extension of the network to 16 automatic monitoring stations has been completed in 1991. NO_2, SO_2, O_3, and CO are measured continuously. The aim of this network is to record long-term pollution levels at different sites and to assess the effectiveness of air pollution control measures. This requires a well defined and adequate data quality.

To achieve this primary goal the correct use of suitable measurement methods is necessary, e.g.:

- the use of measuring instruments with well-known analytical performance;
- the use of calibration gases of defined concentration.

To accomplish these demands, the following steps are essential:

- the operation of a well-equipped gas analytical laboratory;
- the operation of a calibration laboratory;

– experiments to determine precision, comparability, accuracy and possible interferences;
– the participation in international round robin tests.

The present paper gives practical examples of the activities within NABEL concerning the important topic of quality assurance.

Training in quality assurance for air pollution measurement, calibration and test procedures

by Di Benedetto
Ecole Nationale Supérieure des Mines de Saint-Etienne, France

A five day training course is organized in France twice a year for technical supervisors in charge of the metrology of particulates and gaseous pollutants. These courses include a detailed study of analyzer calibration and intercalibration methods.

The philosophy of this course is presented. It can be summarized as follows:

– the task of calibrating air pollution analyzers is very difficult owing to the reactivity of the pollutants gases and their low concentration;
– large errors in concentration values can occur for the standards if improper materials and procedures are used;
– the technician in charge of the calibration of an air pollutant analyzer must:
  - check all the parameters that are controlled;
  - use correct procedures;
  - use clean and adapted materials;
  - use traceable standards;
  - use cross-checking validation to calibrate the analyzers, (e.g. standards can be prepared by different methods: dilution from cylinders, permeation, gas phase titration).

The essential contents of the practical training sessions are also described including the equipment used and the experiments.

NO_x emission measuring instruments

by Ing. R.A.M. Ogink
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In the Netherlands, the only two NO_x emission measuring methods recognized at the moment by the national government are the wet-chemical method and the chemiluminescence method. Measuring equipment featuring electrochemical cells and equipment operating according to the infrated/ultraviolet absorption principle is drawing much attention because of the low purchase price and high usability.

VEG-GASINSTITUUT has been commissioned by the Ministry of Housing, Physical Planning and Environment to carry out a project in which equipment operating according to the latter two principles is tested.

The objectives of the study are as follows:

– gaining insight into the characteristics of NO_x analyzers with electrochemical cells and NO_x analyzers based on infrared or ultraviolet absorption;
– getting to know the operational properties and possibilities of measuring equipment based on the above principles;
– utilizing the experience thus gained in drawing up standards and measuring instructions.

Four routes are to be distinguished in experimentation with the analyzers:

- determining the characteristics, mainly with the use of calibration gases;
- applying the instruments to emission measurements of various firing installations to get a feel for the operational behavior;
- intermediate check-up of characteristic values to spot any changes with time;
- continuous measurements on a cogeneration installation.

The paper focuses on the results of this study.

Continuous monitoring systems for SO_2 and NO_x emission control

by Dr. Gunnar Nyquist
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Atmospheric Research Division, Sweden

In Sweden, continuous measurements of the emission of SO_2 must be performed on all furnaces > 50 MW and of NO_x on all furnaces > 10 MW in order to determine the mass flow of nitrogen oxides (as NO_2) and sulfur dioxide (as S). The emission measuring systems must meet some minimum performance specifications for to be used, and once a year the equipment shall be calibrated by an independent laboratory. The requirements pertaining to measuring devices, calibration procedures and measuring principles are described.

Environmental charge on nitrogen oxide emissions - the Swedish experience

by R. SVEDBERG
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Swedish Environmental Protection Agency

As of January 1992, a fee of SEK 40 000 per tonne is levied on nitrogen oxide emissions from large and medium-sized energy generation plants. It is the first fee in Sweden based on measured emissions. Since the installlation of monitoring equipment cannot be required for smaller energy plants, the fee 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.

This paper attemps to provide:

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

The influence of calibration and sampling on the continuous measurement of sulphur dioxide and nitrogen oxides in flue gases

by Tuula Vahlman and Kari Larjava
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A dynamic gas dilution system combined with water vapor generation was developed and built in the laboratory to investigate the effect of calibration and sampling during continuous flue gas analysis.

Different gas concentrations were procuced by mixing the primary gas with the diluting gas using thermal flow meters. The linearity of continuous NO and SO_2 analyzers was investigated with the dilution system. It was observed that because of the non-linear behaviour of the analyzers errors of 10 to 20 % can occur when using two-point calibration.

The effect of H_2O and CO_2 on the measurement of SO_2, NO and NO_2 was studied using various gas conditioning systems. It was found that water vapor had no significant effect on the measured concentrations when the analysis was carried out at flue gas temperature or when using a dilution probe. However, the conventional cooling system caused losses in SO_2 concentrations and particularly in NO_2 concentrations. The influence of CO_2 was also studied but no effects could be observed. The effects of permeation drying were also studied.

The coarse dust recorder - A sampling device for long-term coarse dust monitoring

by Ernest L.M. Vrins
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During the development of dust sampling devices, much attention has been paid to fine dust samplers, the so-called "PM10" samplers, due to the potential health effects of fine dust. Coarse dust was assumed to be of minor importance, as it is not being inhaled. There are, however, other effects of coarse dust than can be of considerable importance, including its environmental impact which can be nuisance, economical damage or soil pollution.

The sources, the dispersion, and the effects of coarse dust are different from the sources of fine dust. Therefore, coarse dust sampling devices have different requirements. Coarse dust is mainly emitted by mechanical processes such as wind erosion, handling activities and resuspension by vehicle movements. The emission is irregular, sometimes unpredictable and depends on weather conditions. For research on dust emission, coarse dust measurements have to be performed with a high time resolution during long periods.

The dispersion of dust is strongly influenced by the high deposition rate which depends on the particle size. Information about the particle size distribution is indispensable in coarse dust studies. The aerodynamic behavior of coarse particles, different from the surrounding air, also demands special sampling requirements. For coarse dust, representative sampling under all kinds of weather conditions is a much larger effort than for fine dust.

The design of the Coarse Dust Recorder takes all these requirements into account. Coarse dust particles are representatively sampled on a small part of a long strip by inertial impaction. After 20 minutes, the strip is moved and a new part of the strip is exposed. In this way the dust is being collected during one week. Afterwards, the strip is analyzed by an automatic image analysis system. This results in a detailed description of the variations in the coarse dust concentration and in the particle size distribution during that week. As it only needs to be serviced once a week, it is an appropriate device for long-term dust monitoring. The Coarse Dust Recorder has been used in a one-year dust monitoring program near a coal storage site. It was also implemented in a study of the relationship between dust exposure and dust nuisance. The results of these studies have underlined the usefulness of the device.

Gas sensors for the measurement of emission gases

by Heikki Torvela
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Lappeenranta University of Technology, Finland

There is an urgent need at the moment for the development of sensors capable of measuring concentrations of emission gases. This is due to the requirements for the control of emissions as well as the control of processes for reduced emissions. Solid state gas sensors are being developed for use for in-situ measurement. These sensors are quick in their response and resistant to aggressive environments as well as to high temperatures. They are also simple and inexpensive in production and use.

Different types of gas sensors are being studied in many research laboratories and institutes. In this paper, main properties of some types of solid state sensors under development for emission measurements are summarized. Results of tests of gas sensors, carried out in the laboratory and in actual environments such as power plants, are also presented. Sensors tested include those for carbon monoxide and hydrogen sulphide.

Solid state sensors are promising for use in emission measurements. Development work is directed towards the improvement of their performance. This includes the improvement of their selectivity and stability properties. Results of the tests of using catalytic additives in the sensor materials, so as to improve the sensor performance, are also presented. For instance, the interference caused by other gas components in the detection of CO by tin dioxide based gas sensors could be reduced by properly controlling the concentration of a catalytic additive and the operation temperature of the sensors.

(This paper was only distributed as the authors were not able to attend the seminar).

Swiss contribution to the quality of stack gas measuring instruments

by Oskar Wyrsch
Swiss Federal Office of Metrology

The paper concerns the Swiss type approval of measuring instruments for the determination of air pollution caused by the flue gases of heatings, operating on fuel oil or natural gas. Supporting precautions to keep a high level of quality of the measuring devices are explained.

The instruments measure gas temperatures (combustion air and exhaust gas) and the concentration of oxygen or CO_2 (for the calculation of the efficiency), as well as of CO, NO and SO_2, and the smoke number. (Gas concentrations are determined by electrochemical sensors or by applying the Orsat principle).

The performance of the Swiss type approval of these instruments is discussed. The accredited laboratories are responsible for the control of each new or reconditioned measuring instrument. The Swiss Federal Office of Metrology also checks reference gases for the accredited laboratories.

The research of calibration gas mixtures used in environmental monitoring and industrial analysis

by Li Changkai
National Research Center for Certified Reference Materials, China

Air pollution monitoring is the foundation of investigating the tendency and regularity of pollution and of deciding the measures of prevention and control. It is a very important part of environmental protection. The research of standard gas mixtures is a significant portion of air pollution monitoring.

China National Research Center for Certified Reference Materials has undertaken the task of studying and developing standard gas mixtures used in environmental monitoring. Up to the present, different kinds of standard gas mixtures in cylinder and standard gas generators, a standard ozone generator and a dynamic diluting device have been completed and have been used in various regions of China. They have occupied an important role in calibration, evaluation of analytical methods, instruments and guarantee of accurate and identical measurements.

INTERNATIONAL DEVELOPMENT OF STANDARDS FOR AIR QUALITY*

by **A. ARONDS**, Chairman
K. GREFEN, Secretary
ISO/TC 146 "Air Quality"

SUMMARY – In the field of international standardization of air pollution monitoring methods, an important aim is to achieve a more efficient use of manpower and funds in order to accelerate standardization procedures. Unfortunately, the efforts required to carry out the formidable task of expanding the field and harmonizing the compounds and methods are too weak. In part, the solution may be found in a closer cooperation between all organizations involved together with an efficient division of work the programs. This paper covers the problems of this approach.

Introduction

Several institutes, scientists and engineers throughout the world are occupied with the difficult task of harmonizing measuring methods in the field of environment. A part of this task concerns the methods for investigating the effects of chemical pollutants on air quality.

International coordination of this work took place during several decades through the channels of the International Organization for Standardization, ISO. For specific subjects, other organizations also harmonized methods; for example, the United Nations Environment Programme operates the Global Environmental Measurement Systems (GEMS) and the World Meteorological Organization integrates many monitoring and research activities in their Global Atmosphere Watch. There is a close relation between ISO/TC 146 and the Commission on Atmospheric Chemistry of the International Union of Pure and Applied Chemistry (IUPAC) and recently, the liaisons with the International Organization of Legal Metrology (OIML) have been renewed with the purpose of investigating common interests and possible plans of action. This subject will be dealt with later in this paper.

On a European scale, there has been a development parallel to the unification actions of the Commission of the European Community. A continental air pollution measuring program was started in the framework of a cooperative program for monitoring and evaluating the long-range transmission of air pollutants in Europe (EMEP). Afterwards, the CEC increasingly issued directives containing air quality and emission standards, which led to the need for additional internationally standardized methods.

The purpose of this paper is to elucidate the development of International Organization for Standardization (ISO) and European Committee for Standardization (CEN) programs for the near future. The difficulties presently encountered in attemps at harmonization as well as future developments will be discussed including possible cooperation with OIML.

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

ISO in brief

ISO acts as the national standards body of some 90 countries, and its scope covers standardization in all fields except electrical and electronic engineering which are the responsibility of the International Electrotechnical Commission (IEC).

An extensive exposé about the organization and activities of ISO can be found in an article of K.G. Lingner [1].

ISO/TC 146

Twenty-one countries are registered as Participating members and 30 countries as Observing members of the Technical Committee 146, which deals with air quality measuring methods. The ISO/TC 146 maintains official liaisons with 14 organizations such as CEC, ILO, IUPAC, OIML, UNECE, UNEP, WHO and WMO. TC 146 has to report to the Chief Executive Officer of ISO, residing at the Central Secretariat in Geneva, Switzerland. The Technical Board supervises the programs and proceedings of all Technical Committee of ISO.

ISO/TC 146 "Air Quality" has an extensive program, which is covered in detail in the paper of C.A. Aronds [2]. Practically every standardization project has been allocated to a subcommittee under the responsibility of a national secretariat. The categories are:

- Subcommittee 1: Stationary source emissions
- Subcommittee 2: Workplace atmospheres
- Subcommittee 3: Ambient atmospheres
- Subcommittee 4: General aspects

At present, SC 1 is dealing with the preparation of draft standards for the measurement of dust (low concentrations), sulfur dioxide (ionchromatographic), nitrogen oxides, carbon monoxide, carbon dioxide, oxygen and polycyclic aromatic hydrocarbons.

SC 2 covers the field of dust in several forms; specific components in dust such as arsenic and cadmium; anorganic gases comprising carbon monoxide and sulfur dioxide; and a number of organic compounds.

SC 3 the first committee to be established continues to work with anorganic gases and dusts; for example, conventional compounds such as sulfur dioxide, nitrogen oxides and ozone and less conventional compounds such as hydrogensulfide, ammonia and fluorine. Organic compounds belong to the more recent work items of this committee, in particular, the non-methane hydrocarbons and polycyclic aromatic hydrocarbons.

SC 4 works on general aspects including terminology, performance characteristics, sampling strategies, handling of temperature pressure and humidity data. The main question concerns the future program of these committees in relation to the programs of other organizations. Therefore, it is necessary to cover their respective interests.

National and international interests

The main motive for standardization of methods in any field is economical. Standardization should lead to simplification, keeps efficiency, and quality of method that costs to a minimum.

This is also true for methods used in the field of environmental monitoring, and as automatic instruments play an increasingly important role in this task, their standardization becomes a special issue.

Recognition of the economic value of standardization does not automatically lead to a significant financial investment in these activities. Although many scientists and engineers devote part of their time to international standardization, their efforts are not sufficient to comply with the increasing demands.

There are other complications: Group interests may be protected within a country, but they may lead to large conflicts on a supranational scale. This is one of the reasons that contributes to the slow and time consuming nature of standardization. Presently, an average of seven years is necessary to create an international standard yet the recent trend to incorporate standards for measuring methods into governmental regulations has catalyzed the standardization process to some extent.

The aim of ISO is to achieve a "production" time of a standard that does not exceed four years. However projects funded by the Commission of the European Community and carried out under the supervision of CEN, must be finished within 2 1/2 to 3 years. Such a strict target can only be reached provided that there is sufficient interest among the users, the will to support the project and the technical possibilities necessary to carry out the work with appropriate speed.

These aspects have a bearing on the programs of the international standardization organizations.

Cooperation between ISO and CEN

As mentoned earlier in this paper, the Commission of the European Community has assigned a specific task to CEN (see also the paper of K. Grefen [3]). Since ISO's appearance in the field of standardization of environmental monitoring methods, it became clear that the duplication of work on this program would be a waste of effort and funds. The problem lies in the fact that there are not many specialists in this particular branch. Therefore, a close coordination between the programs of ISO and CEN is mandatory. An agreement was obtained in Vienna to deal with this matter. Cooperation should be established by:

– correspondence between the relevant secretariats with an extensive exchange of information;
– mutual representations at meetings;
– joint coordination meetings;
– parallel voting and approval procedures;
– adoption of standards from the other organizations (and vice versa) by a special procedure.

A Joint Group of the Technical Boards from ISO and CEN supervises the cooperation activities.

Future work of ISO and CEN

The ISO/TC 146 does not have a definite long term program for future work. Subjects of interest are discussed in the meetings of the working groups and the subcommittees in which the specialists of the respective fields take part. However, long term policy is lacking, due to the fact that there is no uniform "employer".

New motivation to plan for the future resulted from the creation of the CEN committees. A list of proposals was drawn up by CEN/TC 264, which includes the following topics:

Emissions	Ambient Air	Indoor Air/Others
Dioxines	Minimum requirements	Planning measurements
Hydrogen chloride	Planning measurements	Dioxines
Odors	Metals	Formaldehyde
Hydrogen fluoride	Formaldehyde	Testing filter materials
Ammonia	Dioxines	Soil gas
Metals	BTX	
Formaldehyde	C/F-Hydrocarbons	
Lead		
Calibration autom. syst.		

There is some difficulty concerning the division of these topics between the programs of CEN and ISO. A number of criteria were proposed:

- Is there a specific interest of the Commission of the European Community?
- Does there exist a set deadline for completing the standard? A period of 3 years is considered to be very short for a complete ISO-procedure.
- Are national standards already available and supported by experimental data?
- Is high reliability of the method required for its use in an international legal regulation?
- Are sufficient funds available to carry out the standardization work within due time?

At present, there is very little experience to ascertain the validity and feasibility of these criteria. Further discussions between the relevant secretariats are needed to develop practical programs for ISO/TC 146 and CEN/TC 264 for the near future.

Cooperation between ISO, CEN and OIML

On a seminar organized by the OIML it is also appropriate to consider the possibility of a more close cooperation between ISO, CEN, and OIML, or more specifically, between ISO/TC 146, CEN/TC 264 and OIML/SP 17/SR 1. The latter deals with measurement instruments in the field of air pollution. OIML is very interested in the performance of these instruments and develops methods and equipment for checking their compliance with metrological requirements. No formal overlapping exists between OIML's program and that of ISO. At this moment, it is unclear as to how these organizations will harmonize their programs. For the time being, solutions for cooperation must be found depending on each individual case.

Closing remarks

The purpose of this paper is mainly to inform the reader of the organization of international standardization of air pollution measuring methods, the participants in this work, and why the coordination of programs is necessary. It should aslo be considered as a recommendation to all specialists and other interested parties to partake in this work in order to achieve the goals within an appropriate period of time.

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[1] K.G. Lingner, "International standards and the world standards movement", ISO/TC 146 Newsletter, Vol. n° 1 (1991)

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[3] K. Grefen, "Standard setting procedures for clean air in the FRG in view of the European single market", Kommission Reinhaltung der Luft (KRdL) im VDI und DIN, Düsseldorf 1990

Biography

Cornelis A. Aronds, was born in Indonesia and came to The Netherlands in 1935. He studied chemistry and engineering in Amsterdam and in 1954, he accepted the post of research engineer at Hoogovens IJmuiden, where he carried out investigations in the field of air pollution monitoring and control for more than 35 years. Mr Aronds became involved in standardization work in 1970 and was first appointed chairman of the Subcommittee 1 of ISO/TC 146 in 1980. Nine years later, Aronds became chairman of this technical committee. Mr Aronds is presently the senior adviser of the head of the Environmental Control and Physical Planning Department of Hoogovens IJmuiden.

Klaus Grefen undertook practical engineering instruction from 1960 to 1961 in steelworks and powerplants. From 1961 to 1966, he studied ferrous metallurgy at the technical university of Clausthal and graduated as a certified engineer. He was appointed as a scientific researcher of the Max Planck Institute for Iron Research in Düsseldorf and in 1972, he obtained his doctorate degree. The following year, Dr Grefen became scientific researcher at the VDI Kommission Reinhaltung der Luft, in 1976, deputy head and in October 1992, head of the office of this committee. Dr Grefen has been secretary of the ISO Technical Committee 146 "Air Quality" since March 1990 and secretary of the CEN/TC 264 since March 1991.

EUROPEAN STANDARDS FOR AIR QUALITY MEASUREMENT: ACTUAL DEVELOPMENT*

by **J-F. VICARD**

Chairman CEN/TC 264 "Air Quality"

1 Introduction

Cornelis ARONDS and Klaus GREFEN have discussed in a previous presentation the "international development of standards for air quality measurement". I concur fully with their approach pointing towards international cooperation. In this respect, we are benefitting from a favorable situation: for both ISO/TC 146 "Air Quality" and CEN/TC 264 "Air Quality", the secretary is Klaus GREFEN (VDI in DIN) and each chairman has taken part in the last corresponding TC meeting in Tokio and in Lyon.

As chairman of CEN/TC 264, I would therefore focus my presentation on two topics of particular interest for this OIML seminar: the legal background and the methodology for validating the actual test results.

2 Legal background

In the fall of 1990 the CEN (European body for standardization) accepted a German proposal and decided to establish a technical committee (TC 264) to develop standards in the field of "Air Quality".

During its first meeting in March 1991 with the participation of 18 countries, TC 264 adopted the following scope [1].

"Standardization of methods for air quality characterization of emissions, ambient air, indoor air, gases in and from the ground and deposition,

- in particular, measurement methods for air pollutants (for example particles, gases, odours, microorganisms) and methods for the determination of the efficiency of gas cleaning systems.

Excluded are:

- the determination of limit values for air pollutants;
- workplaces and clean rooms; and
- radioactive substances".

The legal European authorities are in charge of setting limit values as well as establishing the criteria for evaluation of the compliance with these limit values so that the legal field and standardization field are distinct.

However, these two fields are very close, resulting in specific features for the standards to be established and validated. One actual example is the proposed Directive on incineration of hazardous waste. [2]

In annex III of this proposed directive, it is specified that the sampling and analysis of all pollutants including dioxins and furanes as well as reference measurement methods to calibrate automated measurement systems shall be carried out as given by CEN standards. While awaiting the elaboration of the CEN standards, national standards shall apply.

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

It also specifies acceptable uncertainty for the measurement:

"The values of the 95 % confidence intervals determined at the emission limit values shall not exceed the following percentages of the emission limit values":

Carbon monoxide	:	10 %
Sulphure dioxide	:	10 %
Total dust	:	20 %
Total organic carbon	:	30 %
Hydrogen chloride	:	30 %

This means that the regulated pollutants are defined by means of a standardized method of measurement and that such method should be validated to evaluate the "gray zone" which is vital for checking compliance with the limit value.

The legal and financial consequences of a non-compliance situation are very important. Non-compliance requires that the test results be audited in order to determine whether the test has been performed in situ according to the standard, and consequently to validate such test result.

It is also to be noted that, in view of the fair-trade regulations, european standardized methods are required and should be applied in the same way by all the involved parties within EEC.

3 Methodology

The two working groups established in 1991 for Dioxins (emission) and for gaseous HCl/Inorganic chloride (emission) are working out standards incorporating performance criteria for the considered method. Through such an approach, the existing methods are efficiently combined in a first draft. A first phase of testing is conducted to validate the performance criteria and the method, and the draft is amended accordingly. Then a second phase of testing takes place with parallel measurement in the field, each sampling train being operated while fullfilling the above performance criteria.

A statistical analysis results in an estimation of the gray zone for the considered ranges of concentration.

When the standard will be applied, the gray zone for each individual test could be determined on the basis of such initial testing provided that fulfillment of the performance criteria of the method has been verified.

This work focuses on very low concentrations corresponding to intended regulated values of 0,1 ng TEQ/Nm^3 for dioxins and 5 mg/Nm^3 for HCl. For such low concentrations, significant testing is needed and both tasks have been mandated by the EEC/EFTA.

The above methodology may look simple but in fact, there are several difficulties. In particular the well-known interlaboratory round-robin test method as standardized in ISO 5725, does not apply.

For air quality measurement, it is not possible to prepare identical samples of air to be analyzed by a selection of laboratories. On the contrary it is necessary that each institute performs in the field the sampling and the treatment of collected material in view of further analysis/quantification in its laboratory (all steps fulfilling the performance criteria).

When a serie of two such "parallel measurements" are performed, the difference between the two test results of each couple is a new function that allows the statistical estimation of the "repeatability/reproducibility" for each range of concentration encountered during the parallel measurements. It is to be noted that in such test, the concentration in the flue gas of the considered pollutant cannot be fixed but fluctuates according to the plant operation, and that if repeated single tests were performed they will only estimate a combination of the variability of the method and of the variability of the concentration of the pollutant in the flue gases during the test.

The above "repeatabililty/reproducibility" corresponds with the legal implication when enforcing the regulation. It is assumed that, for each couple, the gases being sampled in the two sampling trains are the same. Consequently, the estimated "gray zone" corresponds - for a given risk - to the possible difference that could be found if a measurement is repeated, assuming that the plant operates identically.

It is also to be noted that a similar situation exists for all measurements of environmental parameters in connection with regulation enforcement since such measurements require in situ sampling and subsequent analysis/quantification in the laboratory, for air as well as for water and residue/soil.

4 Closing remarks

Regulations aiming at a high degree of protection of the environment and of the human health require a standardized method of measurement that can be used with confidence for low concentrations.

This represents a very demanding challenge for all experts engaged in the field of clean air measurement, especially in the methodological field.

References

[1] CEN/TC 264 Scope (March 1991)

[2] Commission of the European Communities, 23 March 1992
Proposal for a council directive on the incineration of hazardous waste, JOCE

Biography

Jean-François VICARD graduated as a certified engineer in France in 1965. He has been engaged mainly in the field of Air Pollution Control, including research and development, plant engineering, measurement for air, liquid and residue. He is presently Directeur General of LAB S.A. in Lyon. He has been involved with the standardization of measurement method for "Air Quality" and was nominated Chairman of CEN/TC 264 in 1991 when this technical committee was established. He is a member of the scientific advisory board of the French agency for Environment and Energy (ADEME).

ETATS-UNIS D'AMERIQUE

NEW METHODS FOR IDENTIFYING GROSS POLLUTING VEHICLES IN THE UNITED STATES OF AMERICA*

by **W.B. Clemmens**
U.S. Environmental Protection Agency
and **S.E. Chappell**
U.S. National Institute of Standards and Technology

Abstract

Currently, the emissions from motor vehicles are regulated within the United States of America by the U.S. Environmental Protection Agency (EPA). This responsibility includes monitoring and regulation of periodic emission Inspection and Maintenance (I/M) programs implemented by state and local governments.

The U.S. EPA has found that the traditional idle I/M tests, conducted on a periodic basis for measuring emissions from in-use vehicles, are losing their ability to effectively identify vehicles with high emissions. The primary cause is the greater flexibility available in the design of sophisticated digital engine controls which are in widespread use in the U.S.A. New techniques for identifying vehicles with high emissions are being considered for U.S. regulations. These methods include on-vehicle monitoring requirements (On-Board Diagnostics - OBD), on-road measurements (the likely technique - Remote Sensing), and a field version of the new car certification procedure.

The I/M version of the new certification procedure, called the "high-tech" I/M test involves a chassis dynamometer with inertia weights, a constant volume sampler to collect and dilute the vehicle exhaust, and emission instruments significantly more sensitive than those specified in OIML R 99. During testing, an in-use vehicle would be operated over a transient driving cycle, and hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) will be measured as mass emissions in grams per mile. In addition, evaporative emission have been found to be a significant contributor to Volatile Organic Compounds (VOC) in the ambient air. The high-tech I/M test measures the purge function and the pressure integrity of the evaporative system in the vehicle.

A research program using this high-tech I/M test has been in operation for approximately three years. Data from this research program indicate that the emission reductions from the high-tech test will be almost six times better than the average I/M Program in the United States, and nearly three times better than the best programs. The data also indicate that the high-tech test is more cost effective than other I/M programs, and significantly more cost effective than the remaining choices for stationary source emission controls. The cost to the public for the high-tech test is expected to be comparable to (if not lower than) existing I/M programs.

1 Introduction

The Environmental Protection Agency has had the responsibility in the United States for the development of inspection and maintenance (I/M) program policy since the passage of the

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

Clean Air Act (CAA) in 1970. This policy allowed state governments within the United States to implement I/M programs as a means to improve local air quality. No requirements for analyzer performance were included in the EPA policy. However, in 1974 the state of California Bureau of Automotive Repair (BAR) developed specifications for analyzers sold in California. Known as the "BAR 74" specifications, they were generally adopted by industry and other states implementing I/M programs. The OIML R 99 specifications for class 2 instruments are similar to the BAR 74 specifications.

It was not until the passage of additional amendments to the Clean Air Act in 1977, that EPA had the legal authority to mandate I/M programs, but only for areas with long term air quality problems. For these areas, EPA established a policy in 1978 requiring State Implementation Plans (1) (SIPs) to include a schedule for implementing the I/M program, a description of the state administrative requirements for the I/M program, and the minimum emission reductions from the local in-use vehicle fleet with the I/M program designed by the state or local government.

In May of 1980, EPA published regulations [1] with approved vehicle test procedures, limited analyzer performance requirements, and limited quality assurance requirements for vehicle testing. The regulations also set vehicle pass/fail levels at 200 ppm HC (hexane), and 1.2 % CO for 1981 and later model year vehicles. Because the vehicle standards were linked to the required vehicle emission warranty for these model year vehicles, the EPA analyzer requirements only addressed instrument performance near the the pass/fail levels for the vehicle. In essence, the EPA requirements served more as standard for a "comparison" instrument, than as a true analyzer.

After the passage of the 1977 CAA amendments and during the development of EPA regulations, several events occured that influenced the development of future inspection analyzers and inspection programs. First the California BAR updated and revised the BAR 74 specification in late 1979. Called the BAR 80, this specification for the first time introduced the requirement for adjusting the analyzer in the field with calibration gas as a routine operating procedure. The BAR 80 also included improved analyzer performance specifications. However, reading and interpreting the results was largely the responsibility of the instrument operator.

Based on experience with existing programs, EPA was becoming concerned in the late 1970s with the observed inability of operators to maintain the inspection analyzer in a proper manner, and to interpret the readings correctly for the vehicle owner. This concern was particularly acute in programs were a local garage owner was allowed to inspect a vehicle for official results. Further, such concerns were not addressed in the BAR 80 specifications. To address these concerns, EPA published a series of technical reports [2], [3], [4] in the fall of 1980 and the spring of 1981. These reports proposed using microprocessor control within the analyzer to monitor many maintenance functions (i.e., automatic checking facilities), and to automatically determine the pass/fail status of a vehicle during the official inspection.

The California BAR adopted many of the automatic quality assurance (QA) suggestions proposed by EPA in a revised analyzer specification called the BAR 84 specification. These included automatic gas calibration checks, leak checks, and hydrocarbon residue checks (of the sample line) on a specified schedule. Also included was the automatic collection of official test data (vehicle descriptive information, inspector number, emission values, etc) and maintenance data (data and time of gas calibration, leak check, etc.) on cassette tape for analysis by the I/M

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(1) States are required to periodically submit SIPs to EPA. The SIP commits the state to carry out the commitments promised in the SIP to reduce the ambient air pollution.

program office. EPA guidance in the latter part of the 1980s required states implementing new programs, or upgrading existing ones, to incorporate BAR 84 analyzer features.

The 1980s saw the implementation of I/M programs in around 70 metropolitan areas throughout the United States. About half were operated in a decentralized format where local garages were allowed to conduct the official inspection. The remainder were conducted in a centralized format where the official inspection was conducted at high volume facilities dispersed throughout the local area. Most of the centralized programs were operated by a contractor selected by the state or local government throught a public bidding process. Only a few centralized programs were actually operated by a state or local government agency.

2 Evaluation of existing I/M programs

Beginning in 1984, EPA began auditing I/M programs across the United States as part of the National Air Audit System. These audits included both announced (or overt) and unannounced (or covert) checks of the inspection centers. Overt audits checked analyzers for calibration accuracy, leaks, and reviewed analyzer log books for proper maintenance. In addition, overt audits observed the performance of an official test, and checked for compliance with administrative record keeping and testing requirements. Covert audits were generally conducted with vehicles set to fail the I/M test. The covert auditor would observe the testing as a normal customer, and would not announce that they were an official with the program office.

Initial audits were directed at I/M programs where the official test was allowed to be conducted by local garages (i.e, decentralized programs). Overt audits found that many decentralized programs with BAR 84 analyzers could not accurately account for all official "certificates of compliance". However, analysis of the audit records on calibration and leak checking showed an improvement with the BAR 84 analyzer over the manually adjusted and maintened BAR 80 analyzer. Even so, self evaluations conducted by I/M program offices found that decentralized inspectors (with BAR 84 analyzers) were passing from 34 to 82 percent of the covert vehicles that were set to fail the test [7]. Data from EPA covert audits confirms these results [6], [7].

In the late 1980s, the California BAR sought to upgrade the BAR 84 analyzers. This effort was undertaken partly because the sizeable number of BAR 84 analyzers purchased during 1984 were reaching the end of their useful life, and were becoming increasingly costly to maintain to BAR's ridged quality assurance requirements. Also, problems with the cassette tape data collection system made it difficult to effectively use the data to audit individual inspection stations. These problems included lost records and unreadable data. Furthermore, the time between when a test was performed and when the test data could be analyzed made it difficult to carry out swift enforcement actions. This was because a tape would hold up to 200 tests, and because individual garages conducted inspections at different rates (i.e., inspections per week).

The efforts resulted in the BAR 90 specifications which included improved metrological performance over the BAR 84 analyzer. The metrological performance of the BAR 90 is similar to the specifications for Class 1 analyzers in OIML R99. The largest difference between the BAR 90 analyzer and the BAR 84 analyzer was the addition of a fully configured personal computer (PC) and video monitor to the analyzer for process control, as well as administrative record keeping and quality control. Additional features included the ability to use an optical bar-code reader to read bar-coded vehicle identification numbers (VINs), expansion slots to allow the addition of a NOx analyzer, a dynamometer, and a system to read On-Board Diagnostic (OBD) codes. Also included were provisions for collecting repair data, and a telephone modem to collect the data on a daily basis if needed. However, even with the BAR 90, preliminary data suggests that 30 percent of the vehicles that should be failed are being passed under decentralized inspections [7].

3 Clean Air Act Amendments of 1990

The Clean Air Act was amended again in November of 1990. The 1990 amendments increased the number of metropolitan areas in the United States to 177 that would be required to implement an I/M program. They also introduced the concept of a "basic" program and an "enhanced" program. Areas which marginally exceeded the National Ambient Air Quality Standards would only be required to implement a "basic" program. Approximately 80 areas with worse air pollution will be required to implement an "enhanced" program.

The 1990 amendments require enhanced programs to control hydrocarbons (HC) and oxides of nitrogen (NOx), and they also require the EPA to determine a performance standard to define an enhanced program. Such a performance standard is generally based on the percentage reduction in the average emission levels from the vehicles subject to the I/M program. EPA was instructed to include in the performance standard, a combination of emission testing, including "on-road" emission testing, and inspections to detect tampering with the emission control devices.

The following I/M program elements are required by the 1990 amendments to form the basis of the EPA performance standard. The states are also required to include these elements in their enhanced I/M programs.

- Computerized emission analyzers
- On-road testing
- No waivers (2) unless emission warranty repairs have been completed
- A $450 expenditure (3) for emission repairs before a waiver can be granted
- Requirement for vehicles to pass the test (or receive a waiver) before they can be registered (or re-registered)
- Test vehicle emissions annually, unless the state can demonstrate that testing every two years, in combination with additional program features, will exceed the performance requirements
- Operate the inspection program on a centralized basis, unless the state can demonstrate that a decentralized program will be equally effective
- Inspect On-Board Diagnostic (OBD) systems

4 Development of improved I/M tests

Concurrent with the earlier I/M audits and prior to adoption of the Clean Air Act Amendments of 1990, EPA began to have concerns that the traditional I/M tests which typically included a test at idle and at 2500 RPM (no load) were not finding all of the cars needing repair.

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(2) Many I/M programs allow vehicles to receive a waiver from the emission test, if an effort has been made to properly repair the vehicle,and it still fails. The benefits of the I/M program are reduced by the emission contribution from the waived vehicles when determining the performance of an I/M program.

(3) The limit for cost waivers currently varies between about $50 and $300 in the United States. Some states have a sliding scale for waiver limits versus model year of the vehicle. A few states require only an estimate of the cost, not the actual expenditure.

This concern was particularly true for the late model cars with feedback computer control. EPA was also beginning to be aware that the emission from fuel vapors while the car is being driven (called running losses) could be significant.

To evaluate these concerns, EPA began a multifaceted test program to recruit in-use vehicles, and evaluate methods to improve the ability of I/M programs to reduce emission from in-use vehicles. The program began with an objective to determine the true performance of in-use vehicles relative to the new car certification test (called the Federal Test Procedure or FTP, also known as the CVS-75). The FTP involves operating a vehicle over a prescribed cycle of speed versus time on a chassis dynamometer. The driving cycle is 1 372 seconds long, followed by a repeat of the first 505 seconds. The cycle for a vehicle begins with a cold-start (emissions are collected during engine cranking). After 1 372 seconds the engine is turned-off for ten minutes. Following the 10 minute hot-soak, a final 505 seconds of driving begins with a hot-start of the engine. The emissions are collected in sample bags for prescribed periods during the cycle with a constant volume sampler (CVS). The sample bags effectively integrate the emissions during each portion of the cycle. Hydrocarbons (HC) are measured by Flame Ionization Detector (FID), carbon monoxide (CO) and carbon dioxide (CO2) are measured by Non Dispersive Infrared (NDIR), and oxides of nitrogen (NOx) are measured by chemiluminescense.

The traditional means to recruit vehicles for additional laboratory testing was to identify the model year and technology desired, and to then randomly select vehicles from automobile ownership registration lists. The owner would then be contacted, and invited to participate. Incentives to participate included such items as free repairs, saving bonds, and a substitute vehicle for the vehicle owner.

EPA was, however, concerned that owners that had tampered vehicles, of those with extremely poorly maintained vehicles were not participating. To overcome this concern, EPA through its contractors, installed a modified FTP emission measurement system in a centralized test lane in August 1989. The pilot installation was in the state of Maryland. The equipment was subsequently moved to Hammond, Indiana, and testing began in February 1990. Approximately 600 cars were tested at the Maryland site. As of July, 1992, slightly over 10 000 vehicles have been tested at the Indiana site. In June of 1992, EPA began testing with modified FTP equipment in Phoenix, Arizona, thus providing two research locations.

The centralized I/M facilities in which the modified FTP equipment was installed typically had several inspection lanes. The FTP equipment occupied only one of the lanes. Vehicles reporting for their scheduled official inspection test were randomly recruited as they entered the facility. Recruited vehicles were not failed on the modified FTP test, however, the recruited vehicles were still subject to the official I/M test. The recruitment was based on the owner's willingness to participate, and the availability of the FTP equipment for testing. The owners were monetarily compensated for their participation. A portion of the vehicles tested on the modified FTP equipment were subsequently recruited for additional laboratory testing.

The main difference between the test conducted in the inspection lane and the FTP for new car certification was the length of the transient driving cycle, and the lack of any hot or cold-starts in the inspection lane test. The basic driving cycle for the Federal Test Procedure is almost 23 minutes long. A twenty three minute cycle was inconsistent with the desire to test large numbers of vehicles at I/M facilities. Therefore, a shorter test cycle of only 240 seconds was developed. This cycle has since been known as the IM240 cycle. The IM240 does not include any engine starts, and will be more fully described relative to current I/M tests in Section 5 on the proposed high-tech I/M test.

In addition to measuring exhaust emissions, the vehicles that were recruited for the IM240 exhaust test were also tested for malfunctions in the system that controls emissions of fuel vapor. The two tests of the evaporative control system that were conducted are known as the "purge" and "pressure" test. The details of these tests are described in the section on the proposed high-tech I/M test. A separate sample of vehicles passing and failing the purge or pressure tests were recruited to the laboratory for running loss tests. In a running loss test the vehicle is operated in a sealed room over several replicate hot-start driving cycles (note: the first start is a cold-start). The room temperature is elevated to simulate hot summertime conditions. Most running loss tests are run at 35° C or 40° C, and the fuel vapors escaping from the car into the sealed room are continually measured for the duration of the test. Exhaust emissions are ducted out of the sealed room for separate analysis.

From these test programs, EPA found that IM240 exhaust test was much better at identifying 1983 and later model year vehicles needing repair than any of the idle tests currently used. However, for earlier model year vehicles, the current I/M tests are adequate. This is because most of the 1983 and later model year vehicles employ some form of electronic fuel injection.

EPA also found that a significant number of vehicles had malfunctions in their evaporative emission control systems. Data from the Indiana site indicates that nearly one-half of the vehicles by age 13 will have a catastrophic failure in the evaporative system that will make the system virtually useless. Furthermore, on hot days, when converting the fuel vapor emissions (HC) from the inoperative systems to an equivalent g/mi emission level, the evaporative HC can be several times greater than the exhaust HC.

Another important benefit identified from these programs was the ability to truly test the effectiveness of repairs to the vehicle with the IM240 exhaust test. This was especially true with respect to the 1983 and later model year vehicles. Previous audit data and anecdotal evidence had suggested that some mechanics were making adjustments that would cheat the idle test (e.g., removing a vacuum hose, raising the idle speed, etc.) to obtain a passing reading. In other cases, the repairs to pass the idle test would have no effect on the mass emissions from the IM240. Even worse, because idle tests can not properly measure NOx emissions, repairs to fix idle HC or CO emissions would make NOx emissions worse. SAE (Society of Automotive Engineers) paper number 920822 [8], and follow-on studies that are not yet complete, show that vehicles can be repaired to low HC, CO, and NOx emissions simultaneously.

5 Proposed "high-tech" I/M test

In response to the Clean Air Act Amendment of 1990, and as a result of the success of the Maryland and Hammond research programs, EPA published proposed regulations on July 13, 1992 for a more stringent I/M test in areas required to implement enhanced I/M programs. The new I/M test combines the three types of tests conducted on vehicles in Maryland and Indiana programs. Called the "high-tech" I/M test, it includes the following:

- Transient, mass emission tailpipe test (IM240)
- Purge flow test of the evaporative canister
- Pressure test of the evaporative system

As implied in Section 4, the IM240 exhaust emission test is substantially different from traditional I/M tests, which only measure emissions at idle and/or at 2500 RPM (in neutral). A few states in the U.S.A., however, conduct the I/M test vehicles on a dynamometer, but only operate the vehicle at one speed. As previously described, during the IM240, the vehicle is operated over a driving cycle that has many different speeds, and includes vehicle acceleration and deceleration in a manner similar to city driving. Vehicle acceleration and deceleration can be significant sources of emissions from malfunctioning vehicles. The IM240, like the FTP measures emissions in terms of mass of hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx), while only HC and CO emission concentration levels are measured in traditional I/M tests. Emissions in mass units are a more accurate way of measuring the emission performance of large and small engines, and are more directly related to the contribution that each car makes to air pollution. In addition, the IM240 can measure fuel economy.

The purge and pressure tests check for proper functioning of the evaporative emission system on the vehicle. The evaporative emission system uses engine vacuum to draw fuel vapors in the fuel tank, and those temporarily stored in the evaporative canister, into the engine for combustion. The purge test determines whether this system is functioning properly by measuring the flow of vapors into the engine during the IM240. The pressure test checks the evoporative emission system for leaks that would allow fuel vapors to escape into the atmosphere.

In general, the IM240 test and the purge test would apply to 1984 and later model year vehicles certified in the U.S.A., when tested on a biennial basis (4). A two speed test (i.e., idle and 2500 RPM) would apply to older model year vehicles with the same basis, and the pressure test would apply to 1971 and later model year vehicles.

A check of the On-Board Diagnostic (OBD) sytem will be added to both basic and high-tech I/M tests when vehicles with OBD systems are certified to Federal new car requirements [7]. Proposed regulations requiring OBD for Federal vehicles beginning in the 1984 model year were published on September 24, 1991 in the *Federal Register.* The state of California currently has regulations requiring second generation of OBD systems (known as OBD II) for 1984 model year and later model year vehicles.

5.1 IM240 Test Procedure

For official inspection tests, the IM240 begins by driving the vehicle onto the dynamometer, activating vehicle restraints, positioning the exhaust collection device, and positioning the auxiliary engine cooling fan. An inspector then conducts the test by driving the vehicle while on the dynamometer according to the prescribed cycle (Figure 1) displayed on a video screen. The inspector follows the driving cycle by using the accelerator pedal and the brake to speed-up and slow-down the vehicle in the same manner as if the vehicle were being driven on a city street. The vehicle speed is indicated by a cursor on the video screen, and the inspector adjusts the vehicle speed to keep the cursor on the driving cycle trace.

The process of following the IM240 driving trace is essentially the same as that used to conduct the FTP. However, QA requirement for following the IM240 trace are relaxed slightly to account for in-use conditions, such as wet tires, etc.

The length of the IM240 cycle is fixed, however, the actual duration of the official test will vary depending upon the observed emission levels of a vehicle. In contrast to the FTP, the instantaneous emission levels are monitored in real time, and continually integrated for the duration of the IM240. This allows a computer to continually assess a vehicle's emission level during each phase of the test. Exceptionally clean or dirty vehicles can be quickly identified by using computer algorithms. Therefore, as soon as the emission rates indicates that a vehicle is exceptionally clean or dirty, the inspector can be notified to stop the emission test.

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(4) States have the flexibility to adjust the applicable model years depending on other I/M program features that together produce the required emission reductions.

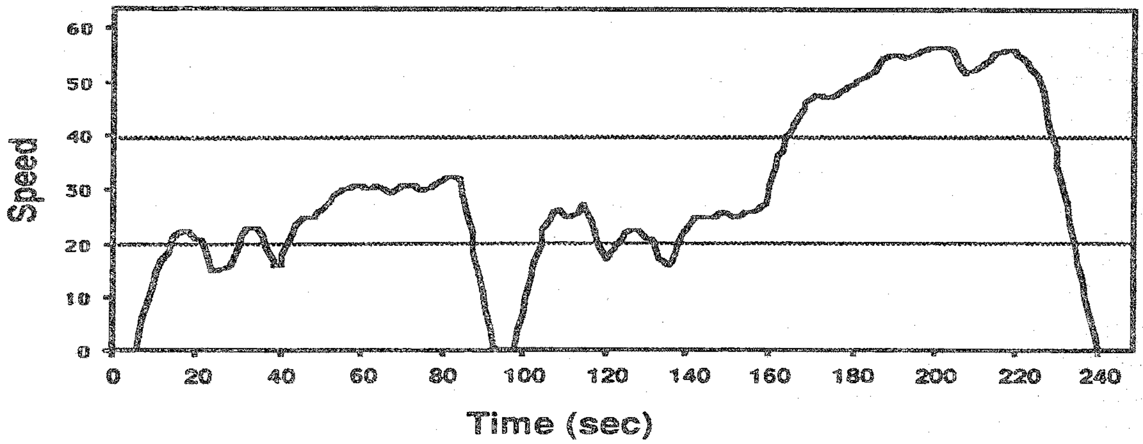

Fig. 1 – IM240 Driving Trace

For vehicles that are close to maximum allowable emission levels, the test may continue for a full 240 seconds. Thus, while the complete driving cycle is 240 seconds (four minutes) long, the average test time will be only two to three minutes for the fleet of cars subject to I/M tests. The importance of reducing the average test time is that it increases the number of vehicles per unit time that can be tested per dynamometer, and consequently reduces the number of dynamometers needed for a given I/M vehicle population.

The maximum permissible emission levels used for the IM240 are about two to three times higher than the levels used to certify new vehicles. The specific levels used by EPA in developing the enhanced I/M requirements were 0.8 grams per mile (g/mi) HC, 15 g/mi CO, and 2.0 g/mi NOx.

5.2 IM240 Test Equipment

The equipment needed to perform the IM240 (see Figure 2) is, of course, different from the equipment used to perform either the idle test, or the single-speed dynamometer tests used by some I/M programs (e.g., Arizona and Florida). These differences include dynamometer capabilities, video driver trace monitors, special sampling systems, and emission analyzers.

As in the research programs described in Section 4, much of this equipment is expected to be similar to the FTP equipment. However, there are expected to be some differences between the FTP equipment, and equipment that is optimized for the high test rates that would be seen in a high-tech I/M program. One is that the high-tech test system will be completely automated, and will make extensive use of integrated quality assurance functions and control charts.

The primary difference between the dynamometer used for the IM240 and those used for single speed I/M tests is the addition of inertia flywheels. The FTP dynamometers also use inertia flywheels. The inertia flywheels used are based on the weight of the car being tested, and allows the inspection test to simulate vehicle acceleration and deceleration by putting a load on the engine. In the FTP, inertia weights are selected to the nearest 56.8 kilograms (125 pounds), whereas the IM240 will select weights to the nearest 227 kilograms (500 pounds). The coarser inertia weight selection in the IM240 dynamometer requires fewer inertia flywheels, with a corresponding reduction in complexity and cost.

For the official test, the selection of the inertia weight and test horsepower for an individual vehicle will be automatically determined by computer so that the I/M inspector is only required to drive the vehicle onto the dynamometer. Even the system used to hold the vehicle on the dynamometer will be automatic in order to minimize test set-up and improve testing efficiency.

The mass of emissions emitted by a vehicle are determined by collecting the entire exhaust flow from the vehicle with a device known as a Constant Volume Sampler (CVS). Within the CVS, the exhaust is diluted by fresh air, and the total volume of the exhaust mixture is measured. In the FTP, the total volume measured by the CVS for each test phase is combined with the concentration levels of pollutants in the mixture collected by the sample bag (i.e., % or ppm) to calculate the mass of emissions for each test phase. The IM240 procedure will calculate the instantaneous CVS flow on a second-by-second basis, and combine the flow values with the instantaneous emission concentrations to determine the mass of emissions.

One of the main reasons for using the CVS concept is that it has proven over time to be the only reliable and non intrusive method for measuring exhaust flow, which is vital in computing the mass of emissions from a vehicle. In addition, the fresh air dilution preserves the integrity ot the sample, and also protects the emission analyzers from high concentrations of water vapor produced by the vehicle. The dilution process also allows the measurement system to accommodate the differences in exhaust flow between small engines and large engines while measuring the true amount of emission from each type of engine.

Typically a FTP CVS has a flow rate of around 1.65 m^3/sec (350 SCFM - Standard Cubic Feet per Minute). However, the FTP is conducted under closely controlled temperature and humidity conditions. To prevent the sample integrity from being affected by the varied environmental conditions encountered in the field, the typical IM240 CVS flow rate is increased to around 3.3 m^3/sec (700 SCFM).

The diluted sample, however, lowers the concentration of the pollutants to be measured, and hence, requires more sensitive emission analyzers than those used by traditional I/M programs. At the maximum permissible levels of mass emissions used in the EPA proposal, the average emission concentrations over the IM240 cycle were around 50 ppm C_3HC, 350 ppm CO, and 30 ppm NOx wxith a 3.3 m^3/sec CVS. HC emissions are measured with a Flame Ionization Detector (FID) for both the FTP and IM240. This differs from the hexane equivalent NDIR technique for HC measurements used by BAR and OIML type analyzers. CO and CO_2 emissions are measured using Non Dispersive Infrared (NDIR) analyzers. NOx emissions are measured with a chemiluminescence analyzer.

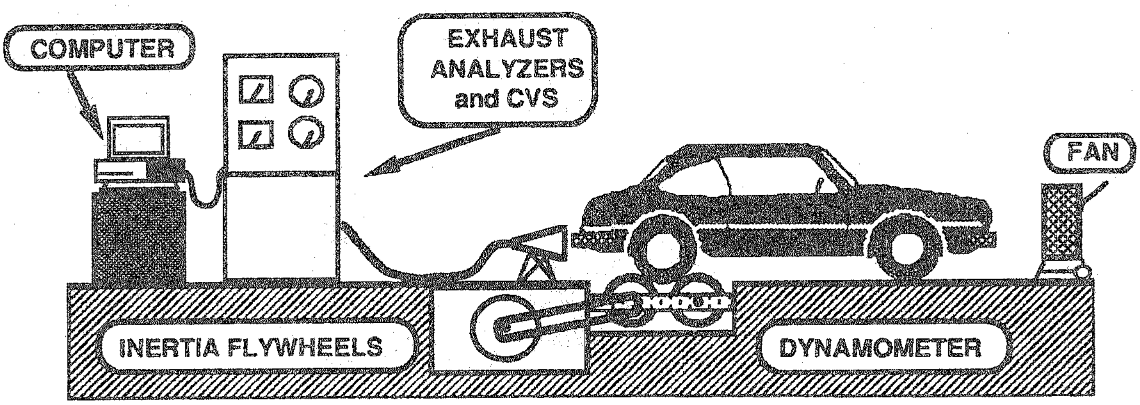

Fig. 2 – IM240 Test equipment

5.3 Evaporation System Purge Test

Since 1971, fuel tanks on cars have been designed to be a closed system in which vapors that evaporate from the gasoline in the tank are not released into the atmosphere. The system is sealed and under pressure so that excess vapors are shunted to a charcoal canister known as the evaporative canister.

The evaporative system purge test is used to determine whether fuel vapor stored in the evaporative canister and present in the fuel tank are being properly drawn into the engine for combustion while the car is being driven. If the purge system is not working properly, then the evaporative canister can become saturated with fuel vapor and start to leak hydrocarbons into the atmosphere. In addition to causing HC emissions, failure of the purge system can also reduce fuel economy.

The purge test is conducted while the vehicle is on the dynamometer, and at the same time as the IM240. Purge flow is measured (see Figure 3) by simply inserting a flow meter at one end of the hose that runs between the evaporative canister and the engine.

Purge failures are determined by the total volume of flow observed during the IM240, not by instantaneous flow rates. The vehicle must purge a minimum volume of 1 liter in order to pass. Most cars in proper working order will accumulate as much as 25 liters during the IM240 cycle. As soon as a vehicle purges 1 liter of volume, the purge test is complete, and the entire IM240 driving cycle ends as soon as final results are determined for the emission test. Thus, the purge test time is very short for most vehicles.

The purge test requires a flow meter that can measure the equivalent volume observed over the transient cycle. Additionally, hoses and universal fittings are required to hook up the flow meter as indicated below. Finally, a computer is needed to control the test process, collect, and record the data, and determine the pass/fail status.

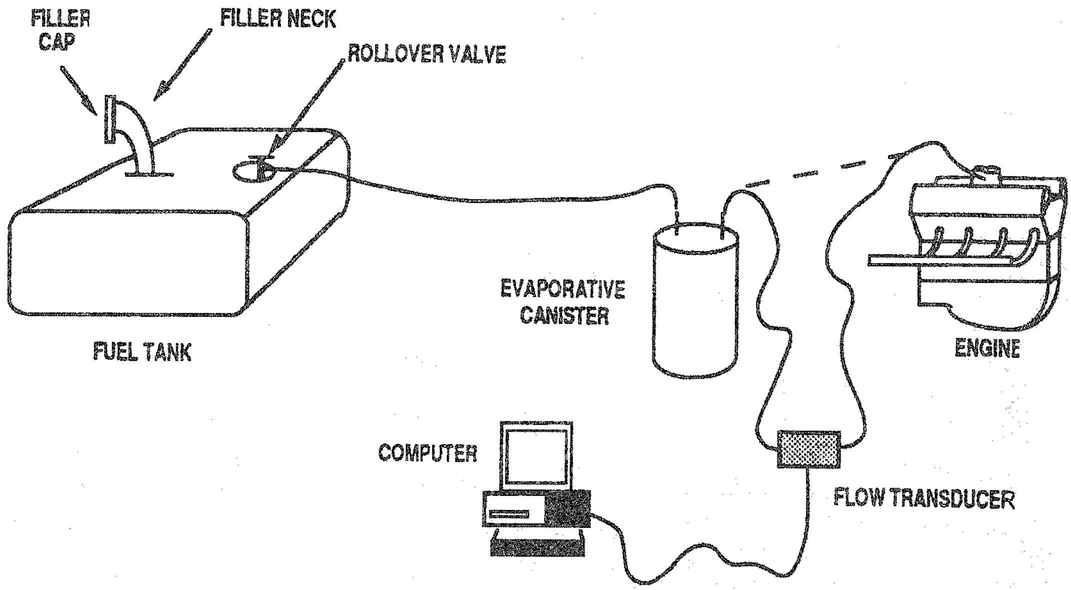

Fig. 3 – Purge Test Schematic

5.4 Evaporative System Pressure Test

The pressure test checks the system for leaks that would allow fuel vapors to escape into the atmosphere. A "pressure decay" method (Figure 4) is used to monitor for pressure losses in the system. In this method, the vapor lines to the fuel tank, and the fuel tank itself are filled with nitrogen to a pressure of 3.5 kPa (14 inches-of-water, or about 0.5 psi). To pressurize these components, the inspector must locate the evaporative canister, remove the vapor line from the fuel tank, and hook up the pressure test equipment to the vapor line. After the system is filled, the pressure supply system is closed off, and the loss in pressure is observed. If the system remains above 2 kPa (8 inches-of-water) after two minutes, the vehicle passes the test.

A source of nitrogen, a pressure gauge, a valve, and associated hoses and fittings are needed to perform the pressure test. In addition, a computer is used to automatically meter the nitrogen, monitor the pressure, and collect and process the results. In addition, algorithms are being developed to optimize the test so that a pass/fail decision can be made in less than two minutes on most vehicles.

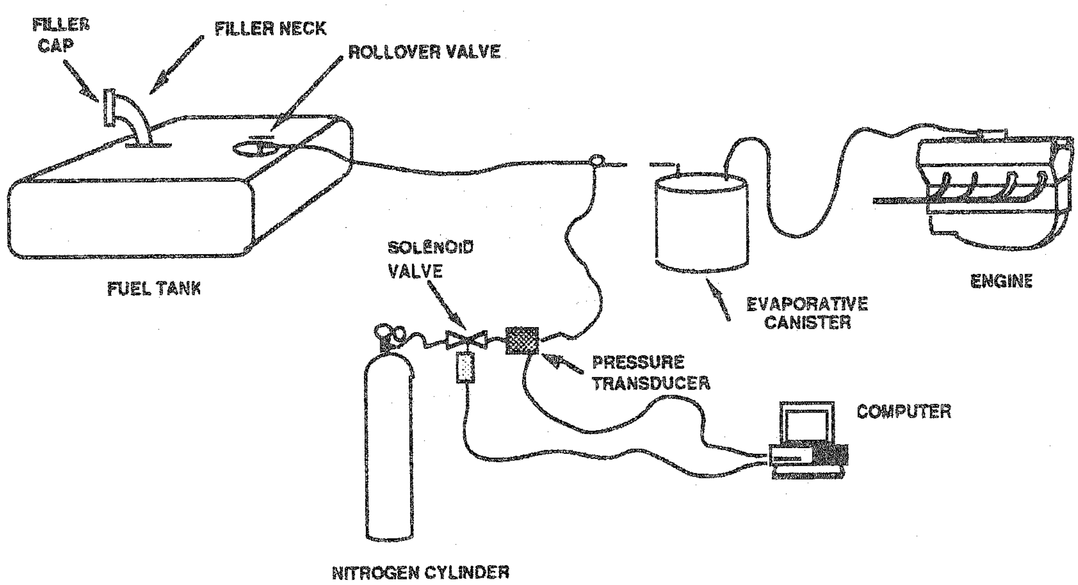

Fig. 4 – Pressure Test Schematic

6 On-road testing

The Clean Air Act of 1990 also calls for I/M programs to include on-road testing of vehicles. EPA proposed to require I/M programs to test 0.5 percent of the vehicles subject to I/M by on-road means in the regulations proposed on July 13, 1990. Traditionally, on-road testing has involved pulling vehicles over, and administering a traditional idle test. However, new technology with remote sensing devices (RSDs) has provided a strong cost effective alternative to the road side pull-over test. Test EPA proposed regulations are neutral on the technology to be used, however, vehicles failing an RSD test would be required to undergo a non-scheduled I/M test. In enhanced I/M program areas, that would mean a high-tech I/M test. Vehicles failing the road side pull-over would be required to be repaired sufficiently to pass the non-scheduled I/M test.

RSDs work by focusing a beam, or in some cases multiple beams, of infrared light across the roadway into an infrared detector. The instrument determines the concentration of the pollutant in the path of the beam based on the amount of infrared light absorbed by the detector at specified wavelengths, and the theoretical ratio of carbon monoxide to carbon dioxide in auto exhaust. The first models had only carbon monoxide (CO) capability. More recent models generally include an HC channel. In addition, efforts are under way to develop NO measurement capability using a Non Dispersive Ultraviolet (NDUV) method, and a Tunable Diode Laser technique. No efforts are underway to develop a method for measuring evaporative emissions by the RSD method.

Figure 5 shows a schematic of an early RSD system in a roadside setting used in an EPA study that compared RSD identification rates to IM240 results [9]. The principal parts of the system include the IR detector and source; a video camera to record the license plates of passing vehicles; a modified police radar detector (5) for vehicle acceleration ; a personal computer equipped with an A/D board; and special software developed by the University of Denver. Also included in the system are the special calibration equipment and reference gas containers.

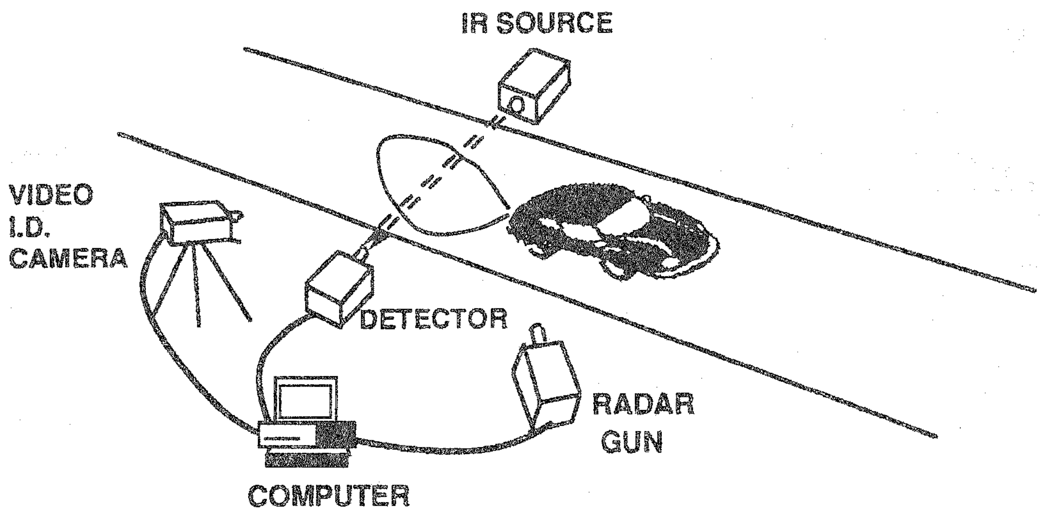

Fig. 5 – Remote sensing device schematic

In the study described in reference [9], 239 vehicles of 1983 and later model year vintage that had undergone an IM240 test at the Hammond, Indiana test site were recruited to drive by an RSD unit set-up on a nearby freeway on-ramp. Cars with greater than 10 g/mi on the IM240 were considered gross emitters. Fifty three cars fit that category. When a 4.5 percent CO level (a customary maximum permissible level) was established, the RSD found only six of the fifty three cars (11.3 percent). In other words, the RSD missed 88.7 percent of the gross emitters. The RSD at this established level also failed one vehicle (14.3 percent of the RSD failed vehicles) that was below 10 g/mi on the IM240. Furthermore, the RSD found only 3 of the 10 worst emitters (all were over 50 g/mi). Lowering the RSD permissible level (e.g., to 3 percent), increased the identification of gross emitters by the RSD, however, the fraction of false failures

(5) As a general note, the radar detector has proven to be ineffective for measuring vehicle acceleration, and other methods for measuring vehicle acceleration are being investigated.

increased significantly. The RSD performed marginally better on older vintage cars (1976 to 1980 model year cars with predominantly non-feedback carburetor and oxidation catalyst technology). Preliminary data from other sources suggest that it may be possible to reduce false RSD failures by requiring multiple RSD readings (on different days, or locations) before a decision is made on each vehicle.

The cause for the inability of the RSD to identify a large fraction of the gross emitters is probably because an instantaneous RSD emission measurement is not likely to be representative of an overall driving cycle, even though the instantaneous RSD measurement may be very accurate.

The EPA considers RSD technology as a potential I/M tool, however, as reflected in the proposed regulations. This new technology is expected, in time, to be developed such that false failures will be reduced. Data from other studies also indicate that RSD identified vehicle samples include more tampered vehicles than would be expected from random road side checks. This makes the RSD more efficient in finding such vehicles. Finally, RSD can be used as an effective enforcement tool between officially scheduled I/M tests to create a deterrence to tampering, and an incentive for timely and proper maintenance.

7 Conclusions

Clearly over the past 20 years, the response to the mandates of the Clean Air Act has had a positive effect on the development of emission measurement equipment and procedures for vehicle testing in the U.S.A. The 1990 amendments are having probably the most dramatic effect to date on improving the capability of equipment and procedures with the advent of high-tech I/M, remote sensing (RSD), and OBD.

The research programs with the new high-tech I/M test have proven to be very successful both in operation and in finding cars needing repair. The data from these programs have shown the high-tech I/M test to be the most effective air pollution control strategy available, when considering other air pollution control programs and strategies in the United States today (including emissions from stationary sources). The data have also shown the high-tech I/M test to be more cost effective than implementing additonal stationary source controls as well as existing I/M programs.

An additional benefit of the high-tech I/M program is its ability to evaluate more accurately the effectiveness of repairs to failed vehicles, as well as providing substantial diagnostic information to the repair industry. It also is the only program that has proven that it can accurately test for NOx emissions.

8 References

[1] Motor Vehicles; Emission Control System Performance Warranty Short Tests and Warranty Regulations; Final Rule; *Federal Register*, Thursday, May 22, 1980.

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[3] EPA-AA-IMS-80-5-B; Recommended Specifications for Emission Inspection Analyzers; EPA Technical Report; September, 1980, (Available through the US National Technical Information Service as report No. PB - 81153504).

[4] EPA-AA-IMS-80-5-C; Recommended Specifications for Emission Inspection Analyzers; Change Notice Number 1; EPA Technical Report; March, 1981, (Available through the US National Technical Information Service as report No. PB - 81195760).

[5] EPA-450/2-88-002; National Air Audit System Guidance Manual for FY 1988 and Fy 1989; EPA, Office of Air Quality and Standards Report; February 1988.

[6] EPA-AA-TSS-I/M-89-2; I/M Network Choice: Effects on Inspection Quality, Cost, and Convenience; EPA, Office of Mobile Sources Technical Report; December, 1989.

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[8] N.D. Brown, E.L. Glover, and W.B. Clemmens; Effect of Engine Condition in FTP Emissions and In-Use Repairability; SAE Paper No. 920822; February, 1992.

[9] E.L. Glover and W.B. Clemmens; Identifying Excess Emitters with a Remote Sensing Device: A Preliminary Analysis; SAE Paper No. 911672; August, 1991.

MULTICOMPONENT CONTINUOUS MEASUREMENT OF AUTOMOTIVE EMISSIONS USING FTIR SPECTROPHOTOMETER*

by **M. ADACHI**
HORIBA Limited, Kyoto, Japan

Abstract

An automotive emission analyzer using Fourier transform infrared spectrophotometer (FTIR) has been developed. The technique, although recognized to have a potential to measure the unregulated pollutants, has been suffering from unacceptable features such as slow response, noise for some species, sample handling, and complex operations. In this study, several new concepts have been employed to the system in order to mature the utilization of the FTIR for practical emission measurement.

The system is demonstrated using three different fuel/engine systems. To complement these results, measurement of major pollutants such as CO_2, CO, NO_x can be achieved using a nondispersed infrared analyzer and a chemiluminescent analyzer. The results show that (1) the FTIR system is well correlated with the conventional methods, (2) improved response time enables detailed discussion of transient nature, and (3) the species which have not been observed by the conventional analyzers can be analyzed with these improved features.

1 Introduction

Due to the worldwide movement of protecting the environment and the problem of fossil energy being one of the biggest source air pollution, the regulations for automotive emission are becoming more and more stringent. Hydrocarbon emission, in particular, is to be reduced in order to minimize the ozone formation in the atmosphere [1]. One of the solutions for the vehicle manufacturer is to use alternative fuel such as reformulated gasoline, methanol, or compressed natural gas.

However, vehicles utilizing the alternative fuel emit peculiar pollutant species.

This situation has generated the need for the emission measurements to sense more components, deal lower concentrations, and to take into account the transient nature. According to the recent proposal in California [1], non-oxygenated hydrocarbons containing 12 or fewer carbon atoms and oxygenated hydrocarbons containing five or fewer carbon atoms must be measured for the new regulation. These unregulated species have only been analyzed by chemical techniques which require highly-trained operators and which has no hope for real-time measurement. Vehicle fueled with methanol, for example, is thought to be one of the best candidates for the low emission vehicles. However, it emits unburned methanol and formaldehyde which are highly reactive in the air. Generally, these species are analyzed by high performance liquid chromatography (HPLC) or gas chromatography (GC) using a reaction with 2,4-dinitrophenylhydrazine (DNPH) and with water. However, due to the reasons mentioned above, it is extremely challenging to look at the transient nature of these species.

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

Since the FTIR method is based on infrared absorption, theoretically any gas component which absorbs infrared light can be analyzed. In addition, the method has the potential of being used for continuous measurements using only a few seconds for each scan. Moreover, the high resolution spectrum, quarter of a wavenumber in this study, has the possibility of analyzing large numbers of components simultaneously. Many investigators have been reporting the feasibility of FTIR utilization in measurement of automotive emission and have proved the capabilities of multicomponent analysis and continuous measurement [2, 3, 4, 5, 6, 7, 8]. Recently, improved sensitivity and real-time capability have been demonstrated using mlultivariate analysis and a gas sampling cell equipped with a flow conditioner [9].

The objectives of the present paper are to provide a description of the system's architecture, and correlations with conventional measurement techniques. As an example, the FTIR system is applied to three different fuel/engine systems: a gasoline engine, a Diesel engine, and a methanol engine. Continuous emission patterns for the three systems are shown and discussed.

2 Apparatus

The FTIR system consists of three major units: an optical unit, a sampling unit, and a computer. The optical unit is shown in Figure 1. Infrared light emitted from the broad band light source passes through the aperture and is collimated before reaching the interferometer. In this study, the interferometer is generating approximately a four centimeter optical retardation using three seconds per scan in order to obtain one quarter of a wavenumber spectra resolution. Also, the interferometer is equipped with an automatic aligner to find the optimum interference efficiency. The He-Ne laser (6328Å) is used to control the interferometer. The interfered light subsequently goes to the gas sampling cell. Normal operating conditions of the cell are twenty liter per minute flow rate, 80 °C wall temperature, and 85kPa inside pressure.

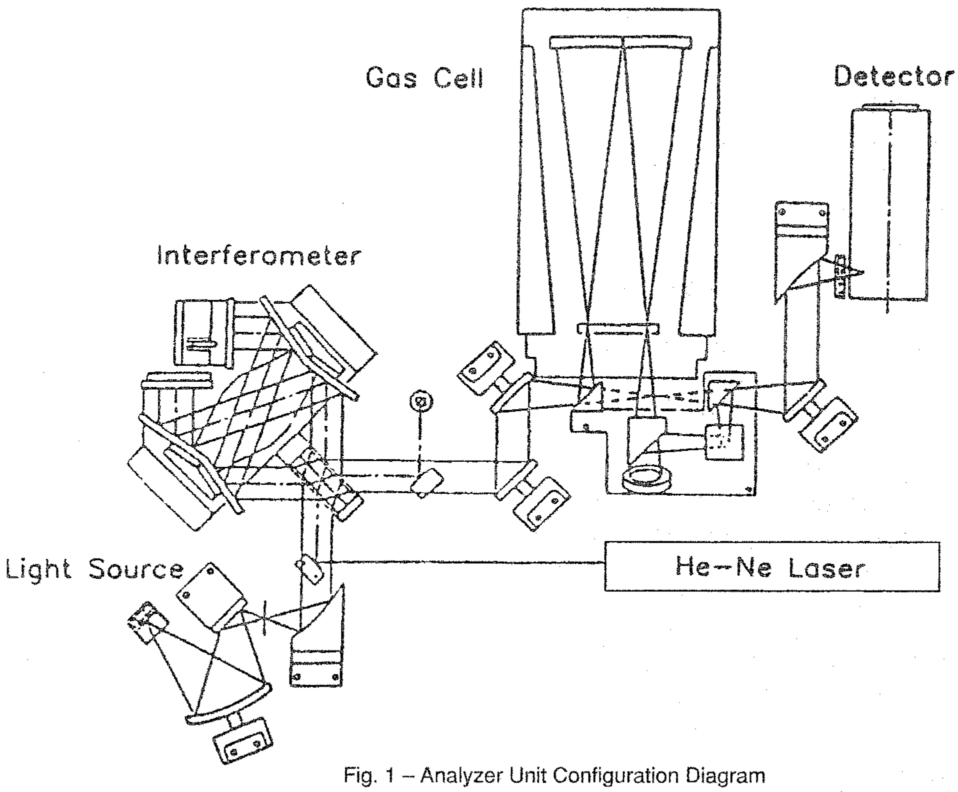

Fig. 1 – Analyzer Unit Configuration Diagram

The total optical path in the gas cell is ten meters having reflected 43 times, and the volume is 1.8 liter. Sample gas inlet and outlet ports are specially designed for quick gas replacement. Both ports gradually expand in diameter. Also, before flowing into the optical path, gas flow passes through the flow conditioner which decreases recirculations in the gas cell. As a result, ninety percent of the gas replacement time of the cell is seven seconds [9]. After the gas cell, the light passes through the aberrration compensator and finally reaches the mercury cadmium telluride (MCT) detector.

An interferogram collected at the detector is fed into an array processor. Then it is converted to a power and an absorption spectrum. The concentration calculation is also processed in the array processor using multivariate analysis [9]. Subsequently, the concentration data is transported to the computing system. Simple and easy operations are provided using window environment and additional operation console. The entire system's configuration permits concentration outputs to be updated every three seconds. Table 1 shows the components and those concentration ranges to be measured in this study. The noise RMS values have been measured using nitrogen gas as a sample, and are less than 0.5 percent of each full scale range for most of the components.

TABLE 1 – COMPONENTS AND RANGES

Component	Range (ppm)
Carbon monoxide	0-200
Carbon monoxide	0-2000
Carbon monoxide	0-30000
Carbon dioxide	0-2 %
Carbon dioxide	0-10 %
Nitric oxide	0-400
Nitric oxide	0-2000
Nitrogen dioxide	0-100
Nitrous oxide	0-100
Water	0-15 %
Ammonia	0-200
Sulfur dioxide	0-500
Formaldehyde	0-100
Formaldehyde	0-1000
Acetaldehyde	0-100
Methanol	0-200
Methanol	0-2000
Ethanol	0-100
Acetone	0-100
MTBE	0-100
Formic acid	0-50
Methane	0-500
Ethylene	0-100
Ethane	0-100
Propylene	0-100
1,3-Butadiene	0-100
Isobuthylene	0-100
Benzene	0-500
Toluene	0-500

3 Experiment

3.1 Set up

The experiment was carried out using the set up shown in Figure 2. The emission from the tail pipe is supplied to a constant volume sampler (CVS). Dilution is done at the CVS using a flow rate of 9 000 liter per minute. Diluted emission is then flowing into several analyzing systems including FTIR, nondispersive infrared analyzer (NDIR), chemiluminescent analyzer (CLA), sampling bag, and impinger system. The impinger system consists of two bubbling pots and can impinge the emission at the two bubblers simultaneously. The sampling line from the tail pipe to CVS and the CVS to the FTIR system are heated to 113 °C.

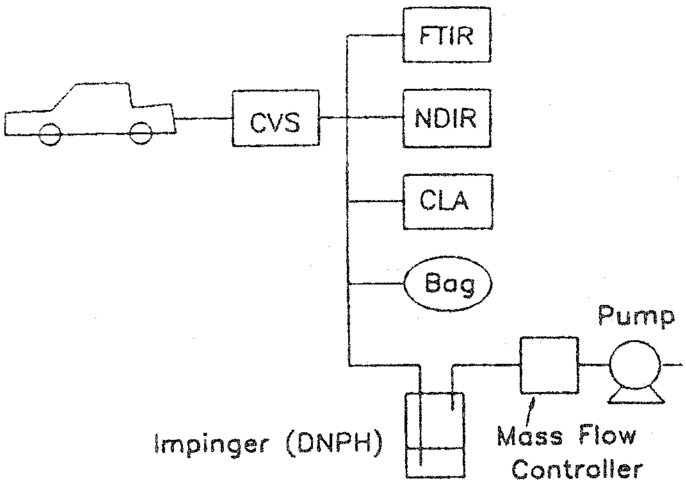

Fig. 2 – Exhaust Gas Analyzing System Schematic

3.2 Samples

A gasoline fueled vehicle, a methanol fueled vehicle, and a Diesel vehicle have been tested to collect multicomponent continuous data. The gasoline fueled spark ignited engine employed in the present study has a 1.5 liter displacement volume and a three way catalyst. The engine is operated using (1) commercially available gasoline and (2) a blend of gasoline, 85 % and methyl tertiary buthyl ether (MTBE), 15 %, which is a well-known octane booster containing oxygen. The methanol fueled system has a 2.0 liter displacement volume and a removable three-way catalyst. The fuel used in this case is a blend of methanol, 85 % and gasoline, 15 % (M85).

The real-time measurement has been carried out using the FTP75 test mode. The FTP75 consists of a cold transient (CT) phase, a stabilized (CS) phase, and a hot transient (HT) phase. Figure 3 shows the velocity pattern for the CT phase (505 sec) of FTP75.

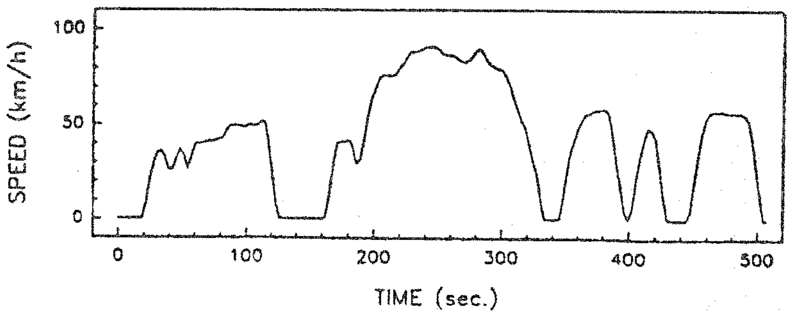

Fig. 3 – Driving Cycle (LA-4, CT)

4 Results

4.1 Comparisons with other methods

The methanol fueled engine is used to observe the correlation with other methods. The comparisons with NDIR and CLA are shown in Figure 4 measuring carbon monoxide, carbon dioxide, and nitric oxide. The outputs for the FTIR system look smoother than that for the conventional analyzers. This is due to the time response difference between the FTIR and the conventionals, i.e. 7 seconds for FTIR and 1.5 to 3 seconds for the conventionals. However, the patterns are similar in appearance.

Absolute concentration values also appear to have good correlation for each component, if the slower relative response time of this FTIR system is considered.

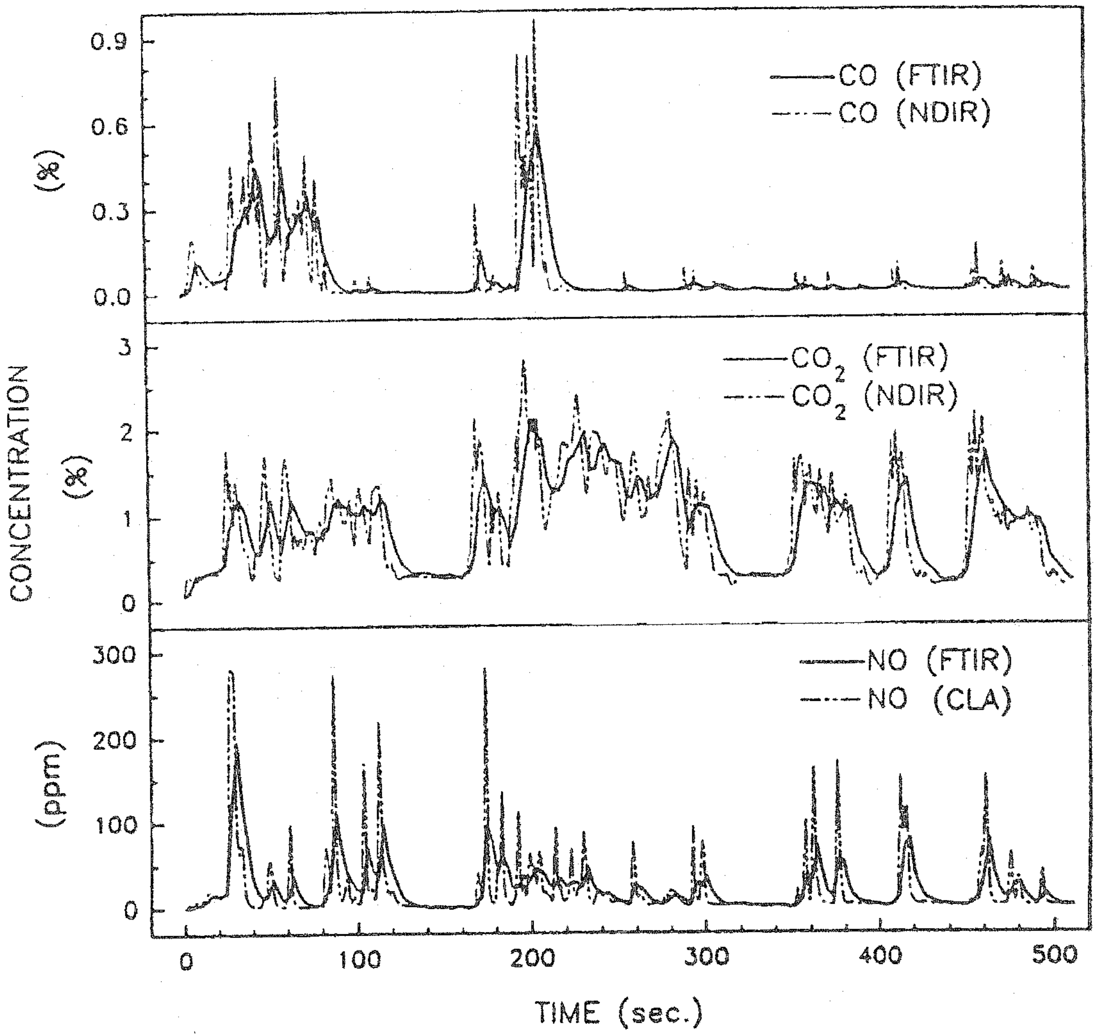

Fig. 4 – Comparison of FTIR and Conventional Method

Figure 5 shows the comparisons of absolute concentrations of the components using the exhaust sample in the sampling bags (for each running phase of the FTP75). Satisfactory correlations with the methods can be seen here.

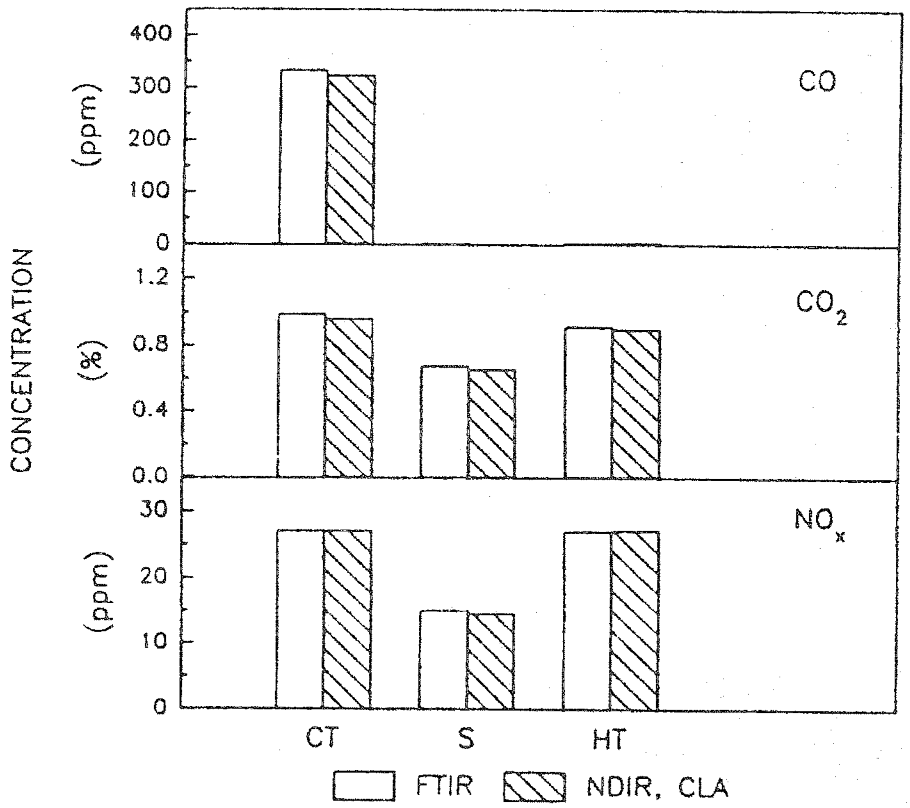

Fig. 5 – Comparison of FTIR and Conventional Method

Table 2 indicates the comparisons with the DNPH method which measures formaldehyde in the emission. Two concentration data for DNPH-GC method correspond to the value obtained from the two bubblers in the impinger system. The values for the FTIR system are calculated by taking averages of realtime data.

TABLE 2 – COMPARISON WITH DNPH METHOD

	LA-4 CT	**LA-4 HT**
DNPH-GC (1)	3.2	0.1
DNPH-GC (2)	3.1	0.1
FTIR	3.8	0.2

ppm

4.2 Gasoline Fueled Vehicle

Comparisons of emissions using normal gasoline and MTBE doped gasoline are shown in Figure 6. It is observed that the amount of carbon monoxide is decreased by the use of MTBE.

This can be seen clearly at the first cycle and the beginning of the second cycle in the CT phase (see Figure 3). After approximately 200 seconds, the carbon monoxide concentration is suppressed because the catalyst is heated to its working temperature. On the other hand, the increase in nitric oxide emission can be seen at about 50 and 200 seconds. The unburned MTBE appears at the beginning of the first cycle with a maximum concentration of approximately 9 ppm. The plot for the ammonia concentration shows a gradual increase from 0 to 200 seconds and almost constant concentration from 300 seconds for both fuels. The plot also shows that ammonia emission is decreased by the doping of MTBE although the patterns behave similar to one another.

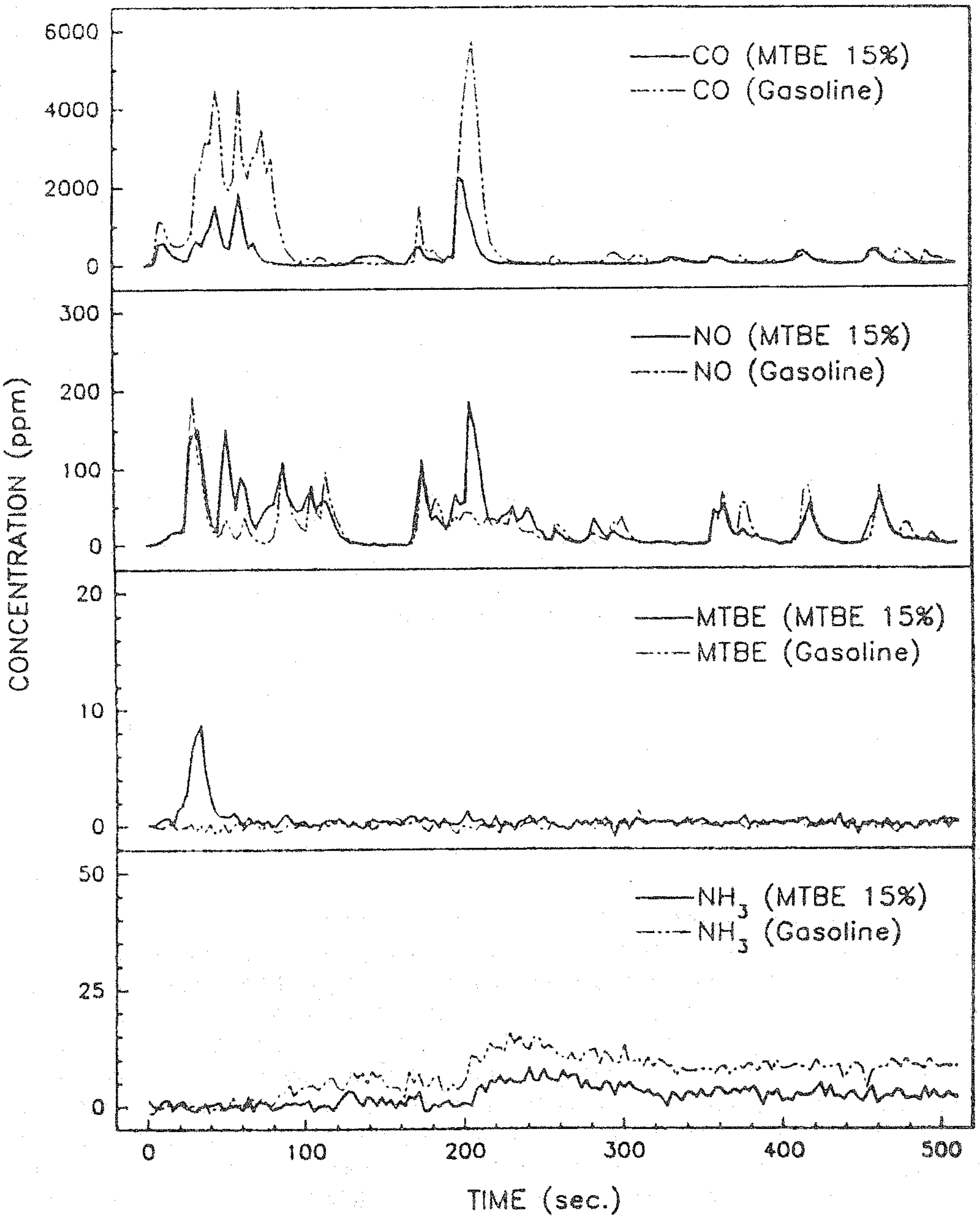

Fig. 6 – Real time Emission from Gasoline Fueled Vehicle

4.3 Diesel Vehicle

Figure 7 presents the emission pattern for sulfur dioxide and nitrogen dioxide. Both of these components are characteristic emissions from the Diesel engine. The emission of sulfur dioxide shows its pattern clearly while nitrogen dioxide is barely observable.

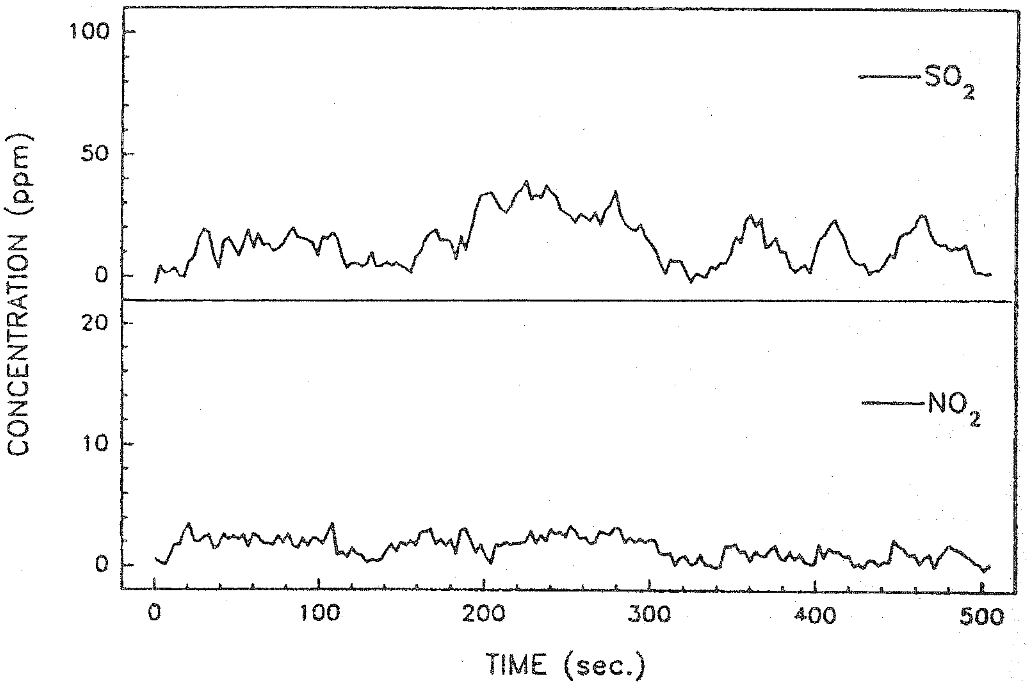

Fig. 7 – Real time Emission from Diesel Engine Vehicle

4.4 Methanol Fueled Vehicle

Figure 8 shows the emission pattern for methanol, formaldehyde, ammonia, and nitrous oxide from a methanol fueled vehicle. Data with and without the catalyst are plotted for each component. For the first 80 seconds, a high concentration of methanol emission is observed regardless of the existence of the catalyst. Then the concentration is decreased evidently at the second cycle since the engine is heated up. For the case without a catalyst, small peaks of methanol emission appear at the points corresponding to the accelerations of the last three cycles. Emission of formaldehyde has a similar behavior. Almost no emission appears after 200 seconds for the case with a catalyst. In contrast these components, ammonia and nitrous oxide emission appears only when the catalyst is installed. Ammonia is emitted after 200 seconds. This implies that somehow, ammonia is generated by the catalyst. In addition, the concentration remains constant after 300 seconds. Nitrous oxide also appears at about 100 seconds and 200 seconds but does not remain constant as in the case of ammonia.

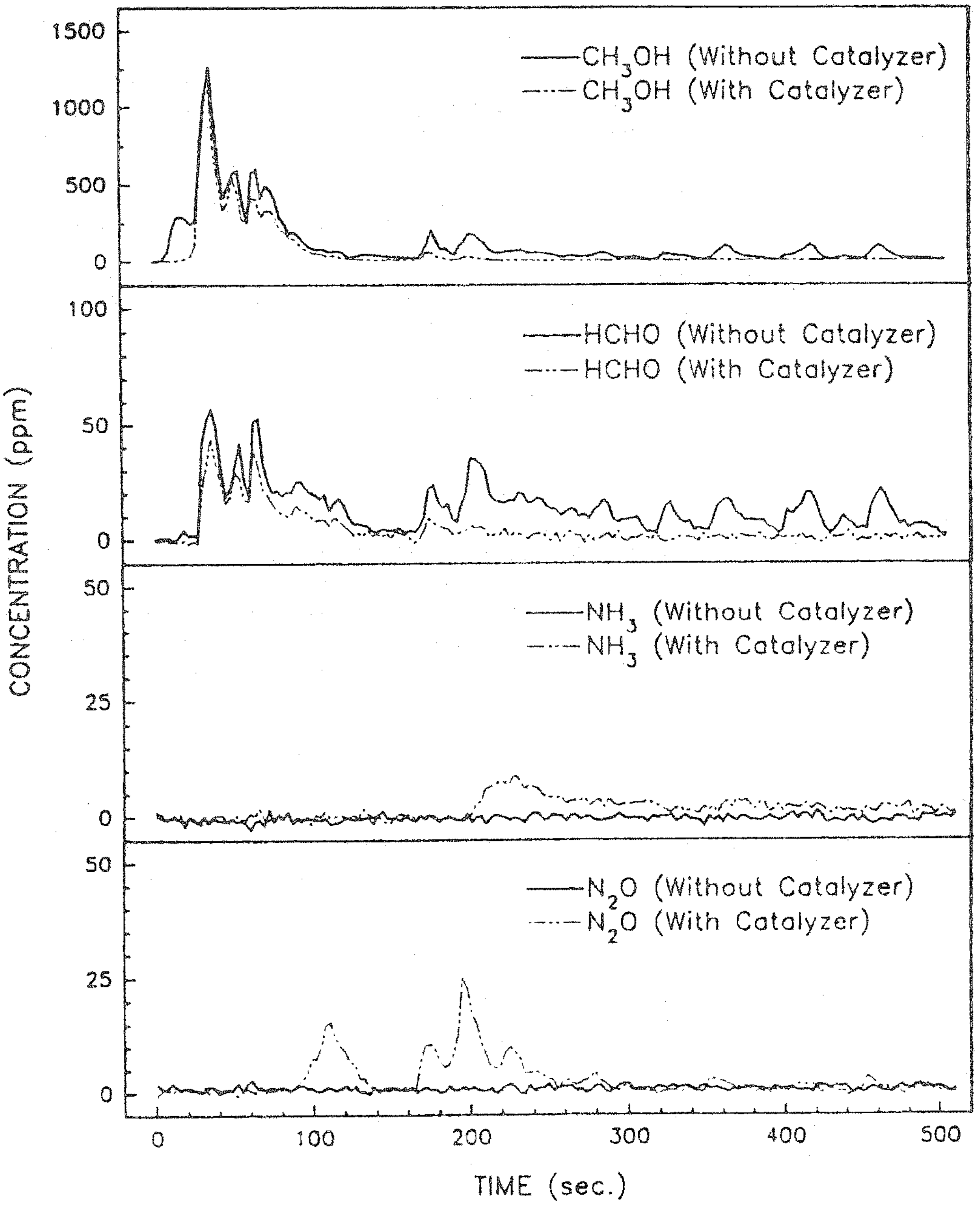

Fig. 8 – Real time Emission from Methanol Fueled Vehicle

A comparison of measured water vapor concentration and expected water vapor concentration is shown in Figure 9. The expected water vapor concentration is calculated as carbon dioxide concentration multiplied by two for this methanol fueled case. Diluted air for the CVS is heated to avoid sample condensation in the CVS. The plot shows that until 100 seconds, the measured concentration is evidently lower than the expected concentration. On the contrary, after about 180 seconds, measured concentration exceeds the expected concentration. This is because the water vapor is first condensed between the exhaust manifold and tail pipe. Then, when those parts are heated the condensed water evaporates again. After 400 seconds, both measured and expected concentrations show good accordance.

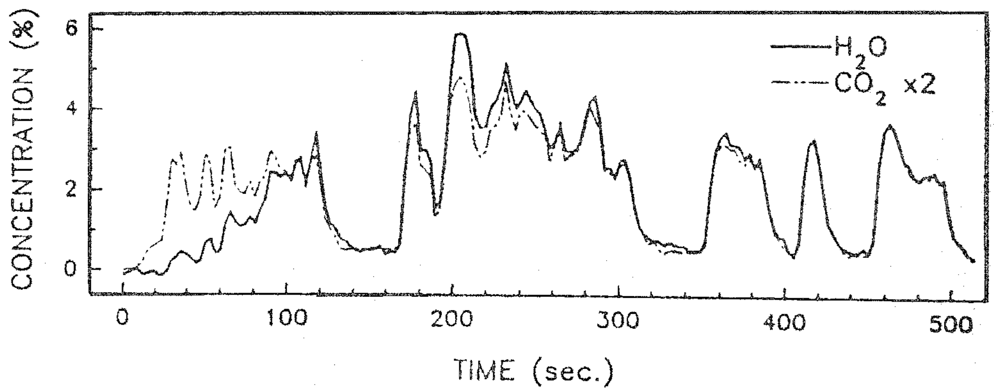

Fig. 9 – Real time Emission from Methanol Fueled Vehicle

5 Summary

An emission analyzer using FTIR has been developed for providing multicomponent continuous measurement of automotive emission. The system has been demonstrated using gasoline, Diesel, and methanol vehicle. Correlations with other techniques have satisfactory results and improved response time, and introduces the discussion of the transient nature of the emissions. Overall, the result implies the system's capability for the practical use in the automotive industry.

References

[1] California Air Resources Board, Proposed Regulations for Low Emission Vehicles and Clean Fuels, Aug 13, 1990

[2] Heller, B., et al., SAE Paper 900275

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INFORMATIONS

NOUVEAUX MEMBRES du COMITÉ – *NEW CIML MEMBERS*

DANEMARK/*DENMARK* - Mr P. Claudi JOHANSEN, Assistant Head, Secretariat for Metrology, National Agency of Industry and Trade.

INDE/*INDIA* - Mr N.S. PANGTNEY, Deputy Director, Weights and Measures.

JAPON/*JAPAN* - Mr Y. KURITA, Director General, National Research Laboratory of Metrology.

ROUMANIE/*ROMANIA* - Mr P.G. IORDACHESCU, General Director, Romanian Bureau of Legal Metrology.

PUBLICATIONS DE L'OIML

La Neuvième Conférence Internationale de Métrologie Légale (voir rapport au début de ce Bulletin) a définitivement sanctionné les Recommandations R 60, 76 et 95 à 104, déjà publiées après leur approbation par le CIML.

La Conférence a également sanctionné cinq nouvelles Recommandations et une Recommandation révisée, qui seront publiées successivement au cours des mois à venir; il s'agit de textes sur les manomètres étalons, les réfractomètres, les ponts-bascules ferroviaires, les peseuses totalisatrices discontinues, les instruments de pesage électroniques (révision de R 74) et les ensembles de mesurage massiques directs de quantités de liquides. Les cinq nouvelles Recommandations, dont les numéros n'ont pas encore été attribués, figureront dans la liste des publications du prochain Bulletin.

OIML PUBLICATIONS

The Ninth International Conference of Legal Metrology (see report in the first pages of this Bulletin) has sanctioned Recommendations R 60, 76 and 95-104 which had already been published after their approval by CIML.

The Conference also sanctioned five new Recommendations and a revised Recommendation, which will be successively published during the upcoming months; these include texts on standard manometers, refractometers, rail-weighbridges, discontinuous totalizing wheighing instruments, electronic weighing instruments (revision of R 74) and direct mass flow measuring systems for quantities of liquids. The new five Recommendations, whose numbering has not yet been allocated, will be incorporated in the list of publications in the next Bulletin.

TRAINING COURSE IN THE VERIFICATION OF WEIGHING INSTRUMENTS

Munich, 3-13 August 1993

In view of the success of the 1991 and 1992 training courses organized by PTB at the German Academy for Metrology (DAM) in Munich and co-sponsored by OIML, a similar course will be given in 1993 on the dates indicated above.

The course is intended to train employees of legal metrology services that are building up or improving verification activities in the field of electronic nonautomatic weighing instruments and in the testing of vehicle weighbridges (mechanical and electronic).

The training program will include lectures on theoretical principles as well as practical verification exercises. Particular attention will be given to explanations of the conformance tests to the requirements contained in OIML Recommendations.

As was the case for previous courses, a certain number of fellowships will be granted by German authorities in order to cover travel and hotel costs for participants from certain countries.

Due to the fact that the total number of trainees must be limited to 20, participation will be subject to a careful selection by the organizers; as a general rule, only one candidate from a country will be accepted.

The candidates must prove that they have an adequate knowledge of the English language and submit a report concerning the operation of legal metrology and verification in their country.

The detailed program, as well as application and questionnaire forms, will be sent to potential applicants. Please send all requests to

Mr H. Apel
Physikalisch-Technische Bundesanstalt
Bundesallee 100
Postfach 33 45
BRAUNSCHWEIG
Germany

The completed applications must reach PTB before 15 February 1993.

PUBLICATIONS

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

RECOMMANDATIONS INTERNATIONALES
INTERNATIONAL RECOMMENDATIONS

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

R 18	—	Pyromètres optiques à filament disparaissant *Visual disappearing filament pyrometers*	1989
R 20	—	Poids des classes de précision E_1 E_2 F_1 F_2 M_1 de 50 kg à 1 mg *Weights of accuracy classes E_1 E_2 F_1 F_2 M_1 from 50 kg to 1 mg*	1973
R 21	—	Taximètres *Taximeters*	1973
R 22	—	Tables alcoométriques internationales *International alcoholometric tables*	1975
R 23	—	Manomètres pour pneumatiques de véhicules automobiles *Tyre pressure gauges for motor vehicles*	1973
R 24	—	Mètre étalon rigide pour agents de vérification *Standard one metre bar for verification officers*	1973
R 25	—	Poids étalons pour agents de vérification *Standard weights for verification officers*	1977
R 26	—	Seringues médicales *Medical syringes*	1973
R 27	—	Compteurs de volume de liquides (autres que l'eau). Dispositifs complémentaires. *Volume meters for liquids (other than water). Ancillary equipment*	1973
R 29	—	Mesures de capacité de service *Capacity serving measures*	1973
R 30	—	Mesures de longueur à bouts plans (calibres à bouts plans ou cales-étalons) *End standards of length (gauge blocks)*	1981
R 31	—	Compteurs de volume de gaz à parois déformables *Diaphragm gas meters*	1989
R 32	—	Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine *Rotary piston gas meters and turbine gas meters*	1989
R 33	—	Valeur conventionnelle du résultat des pesées dans l'air *Conventional value of the result of weighing in air*	1973
R 34	—	Classes de précision des instruments de mesurage *Accuracy classes of measuring instruments*	1974
R 35	—	Mesures matérialisées de longueur pour usages généraux *Material measures of length for general use*	1985
R 36	—	Vérification des pénétrateurs des machines d'essai de dureté *Verification of indenters for hardness testing machines*	1977
R 37	—	Vérification des machines d'essai de dureté (système Brinell) *Verification of hardness testing machines (Brinell system)*	1977
R 38	—	Vérification des machines d'essai de dureté (système Vickers) *Verification of hardness testing machines (Vickers system)*	1977

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

R 58	—	Sonomètres *Sound level meters*	1984
R 59	—	Humidimètres pour grains de céréales et graines oléagineuses *Moisture meters for cereal grains and oilseeds*	1984
R 60	—	Réglementation métrologique des cellules de pesée *Metrological regulations for load cells*	1991
R 61	—	Doseuses pondérales à fonctionnement automatique *Automatic gravimetric filling machines*	1985
R 62	—	Caractéristiques de performance des extensomètres métalliques à résistance *Performance characteristics of metallic resistance strain gauges*	1985
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