

## Traceable Calibrations for Infrared Remote Sensing

Infrared Remote Sensing is an increasingly important tool for studies of earth resources or environmental monitoring. However, measurements have to be traceable to SI units to be comparable world-wide and reliable in the long term. A new infrared calibration facility established by PTB provides highly accurate standard sources of infrared radiation for this purpose.

Applications of Infrared Remote Sensing (IRS) are rapidly spreading in a variety of fields such as meteorology, environmental monitoring, agriculture, mining, or oil exploration. As an example, in a recent cooperation with the Max Planck Institute for Meteorology, PTB has calibrated detectors for the investigation of the «cold skin» of the ocean. Temperature changes of only 0,1 K in the cold skin have a crucial impact on the CO<sub>2</sub> content of the earth's atmosphere. The successful monitoring of local or global changes requires the accurate traceability of measurements to SI units, in particular in case small changes of key quantities are to be detected which may be indicative of medium- or long-term trends.

Within a European research project, PTB has therefore developed heat-pipe blackbody radiators as primary infrared radiation source standards for calibrations of low-temperature IRS instruments with large target areas. The new facility comprises four blackbody radiators. Their spectral radiation emission can be calculated from their temperatures on the basis of Planck's radiation law. The heat-pipes are operational in the temperature range from -60 °C to 960 °C. Their tuneable temperatures are directly related to the SI base unit of tempera-

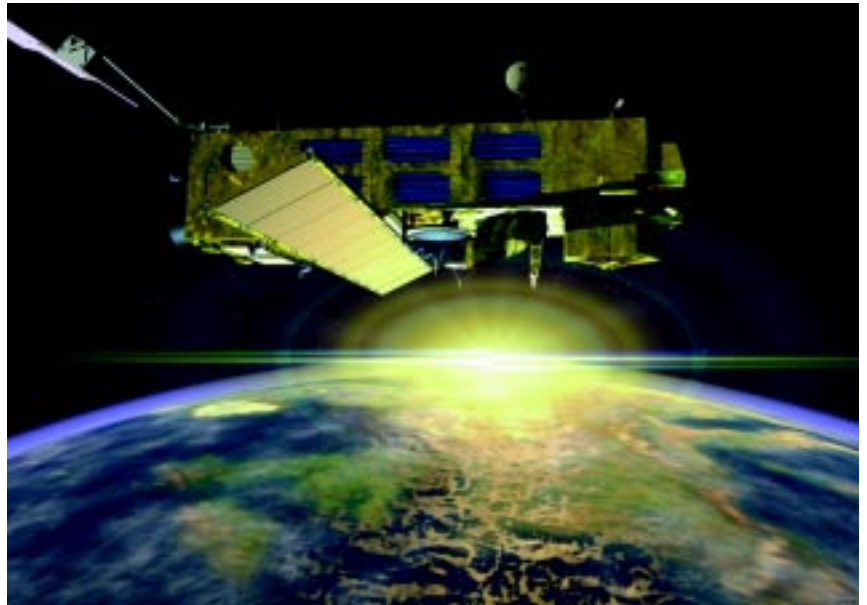
ture with standard uncertainties between 30 mK and 190 mK by means of standard platinum resistance thermometers.

The new calibration service makes way for a very short calibration chain from the national standard to the user's measuring instrument which results in small calibration uncertainties. This will enable PTB to comply with the growing demands in the fields of radiometric and radiation thermometric calibrations for wavelengths from about 1 µm to 50 µm.

For further information please contact J. Fischer,  
fax: (+49 30) 34 81-510, email: joachim.fischer@ptb.de

*Even sophisticated measurement methods such as satellite-based remote sensing have to be accurately traceable to the international system of SI units if they are to provide reliable results. Suitable radiation standards for this purpose are available at PTB.*

*Photo: ESA - Denman productions*



## Measured Once, Accepted Everywhere

A major step on the way towards the elimination of technical barriers to free trade was taken in Paris on 14 October 1999 during the 21<sup>st</sup> CPM, the General Meeting of the Metre Convention. The directors and presidents of the national metrology institutes (NMIs) of 38 of the 48 Member States of the Metre Convention and two international organisations signed the Mutual Recognition Arrangement (MRA). The president of the PTB, Prof. E. O. Göbel, signed the document in behalf of both the PTB and the BAM, the German Federal Institute for Materials Research and Testing.

The MRA, the full title of which is «Mutual recognition of national measurement standards and

of calibration and measurement certificates issued by national metrology institutes», was drawn up by the International Committee of Weights and Measures (CIPM). It is not a diplomatic treaty, but a technical arrangement. Accordingly, essential points of the MRA are regulations concerning world-wide «key comparisons». The key comparisons are to show the degree of equivalence of national standards and measurement capabilities (PTBnews 97.2). The MRA stipulates that the results of the key comparisons are to be published by the BIPM, the Bureau International des Poids et Mesures. The BIPM will also maintain a key comparison database accessible via the internet. Besides the

*continued on page 3*

# A Novel Ionisation Chamber for Radiation Therapy

PTB has developed a novel ionisation chamber with increased accuracy at reduced expense for therapy dosimetry. The chamber is commercially produced for clinical dosimetry and is also used as an international transfer standard.

In Germany, more than 300 000 persons develop cancer every year. Approximately half of the patients treated for cancer undergo radiation treatment. The most of these are treated with photons and electrons from accelerators. Since successful treatment depends essentially upon the accuracy of the dose applied, the requirements on dosimetry are growing as improved techniques of radiation delivery and tumour localisation are developed.

Clinical dosimetry at accelerators is performed with ionisation chamber dosimeters. In devices of this type, the ionising radiation generates charged particles in a chamber. These particles are detected after separation by an applied high voltage. The design of the chamber is crucial for the accuracy that can be achieved. For example, air-filled cavities and the walls of the chambers may seriously perturb the radiation field to be measured. Moreover, the response of the ionisation chamber depends on the polarity of the supply voltage. Even after the corresponding detailed corrections, these effects substantially reduce the achievable accuracy.

PTB has investigated these effects and has established requirements and preferable constructional features for clinical electron chambers in collaboration with the International Atomic Energy Agency (IAEA) and the World Health Organisation (WHO). In the frame of a research project supported by in-

*Radiation therapy asks for accurate and reliable radiation dosimetry.*

*Photo: Scanditronix Medical*



dustry, the latest scientific findings have been incorporated in the development of a novel robust reference ionisation chamber for clinical dosimetry. As a result, the polarity effect is significantly smaller in the new chamber than in all comparable chambers. In addition, the perturbation of the radiation field by this chamber is so small that it is classified as negligible by new national and international recommendations.

The new chamber is now manufactured by two German companies and distributed world-wide. The chamber has been developed for clinical routine but it serves also as a transfer standard at IAEA and BIPM.

*For further information please contact  
M. Roos, fax: (+49 531) 592-64 05,  
email: martin.roos@ptb.de*

## Measuring Low Gas-Flow Rates

A new PTB facility allows to calibrate gas flow rates as low as 0,2 l/h by means of an interferometric length measurement system.

The accurate measurement of very low flow rates of gases is becoming increasingly important, e. g., in the fields of gas analytic, combustion research or the production of process gases with well defined composition.

PTB has set up a new measurement facility for flow rates between 0,2 l/h and 200 l/h. The facility comprises of a group of three precision glass cylinders and mercury-sealed pistons. The flow rate is determined as the product of the cross section area of the cylinder and the velocity of the piston. The movement of the piston is measured by means of an interferometric



*Calibrated nozzles are well suited as transfer standards of flow rates. With a new facility, which allows to measure very small gas flow rates, PTB can now calibrate micro nozzles, too.*

length measuring system. This ensures the traceability of low gas flow rates to the units of length and time. The position of the piston is recorded continuously, without fixed start and stop positions. The analysis of the velocity data allows not only to monitor the instantaneous flow rate during the measuring time but also to correlate fluctuations with the performance of the flow meter under test.

The three systems with piston diameters of 19 mm, 44 mm and 144 mm are designed to investigate and calibrate all types of flow meters and controllers as well as critical nozzles. The relative calibration uncertainty is as low as  $U = 0,3 \%$  (coverage factor  $k = 2$ ) for flow rates less than 1 l/h. The uncertainty has been confirmed by cross comparisons of the three cylinders and by inter-comparisons with wet gas meters.

Current investigations test the suitability of micro nozzles as simple and cost-effective standards for flow rates below 10 l/h.

*For further information please contact R. Kramer,  
fax: (+49 531) 592-13 05, email: rainer.kramer@ptb.de*

# New Test Procedure for Cash Gaming Machines

The results of plays show stochastic characteristics which may be tested precisely by means of stochastic methods. Lately, PTB applies a new automated test procedure based on such objective methods within the framework of pattern approvals.

In Germany and for PTB, the testing of cash gaming machines for commerce and the corresponding legal references have a 65 years tradition. The legal task during pattern evaluation is to check whether the prescribed requirements are met. So far, test procedures have been applied which were based on an individual detail analysis of the gaming rules and the rules of chance.

With the use of microprocessors, plays have become more and more complicated and test procedures ever more time-consuming. Hence, a new testing concept was developed during the last years. The new concept employs an automated procedure on the basis of mathematical methods, which replaces the time-consuming detail analyses. This allows to quantitatively specify the qualitative requirements and thereby assess the latter objectively.

The procedure is based on the registration and automatic evaluation of a large number of data sets of a long sequence of plays. The single play is regarded as a «black box». The data set for each play are the input and output quantities, such as charge and payout. These quantities are registered via a standardised interface. The data are then analysed with stochastic test methods. De-

pending on the requirements to be tested, appropriate tests of significance are applied to suitable test quantities (for example, the minimum value of the payout proportion). A test criterion is regarded as being fulfilled if the relevant test quantity does not fall below a critical value. The critical values are chosen to

result in an overall significance level of about 1 % for the test procedure. This means that a cash gaming machine meeting the statistical requirements will pass the test with a probability of 99 %.

The new test procedure presents an effective assessment, objectively oriented to the protection of the player as intended by the legislator. The use of the software version of the procedure has made pattern testing considerably more efficient.

For further information please contact Th. Bronder, fax: (+49 30) 34 81-551, email: [thomas.bronder@ptb.de](mailto:thomas.bronder@ptb.de)



Measurement software controls the cash gaming machine and captures in a «fast-play-mode» approximately three million sets of data

## Events

(Further information can be found in the WWW via <http://www.ptb.de/choosing> "English", then "News")

15<sup>th</sup> International Conference on Spectral Line Shapes (ICSLS XV)

PTB Berlin-Charlottenburg, 10 to 14 July 2000

Information and registration: M. Korte,

fax: (+49 30) 34 81-490, email: [icsls@ptb.de](mailto:icsls@ptb.de)

Measured Once,  
Accepted Everywhere  
*continued from page 1*

results of key comparisons, the database will contain information on the calibration and measurement capabilities submitted by the NMIs through their regional metrology organisations (RMOs) and reviewed by a Joint Committee of the RMOs and the BIPM. The key comparisons are a fundamental means of quality assurance for the NMIs. In fact, the MRA requires not only that NMIs participate in key comparisons to demonstrate equivalence, but also that each NMI adopts a quality system. This can be done with or without assessment by an accreditation body. PTB has chosen to set up a quality system according to ISO 17 025 without third-party assessment.

The MRA fits in a series of other agreements which aim at the facilitation of global commerce by making redundant, frequently expensive testing in different countries unnecessary. A recent example that opens the way for the mutual recognition of measurements performed on both sides of the Atlantic Ocean is the «Arrangement on Cooperation in the Fields of Metrology and Measurement Standards» signed by the U. S. and the European Community a few days before the MRA.

The text of the MRA and pertinent annotations as well as more detailed information on the key comparisons (presently, more than one hundred) are available via <http://www.bipm.fr> at the WWW site of the BIPM.

PTBnews 99.3  
English edition  
December 1999

Published by  
Physikalisch-Technische  
Bundesanstalt (PTB)  
Braunschweig and Berlin  
Germany

Chief Editor *Burkhard Wende*  
PTB, Abbestr. 2-12  
D - 10587 Berlin  
phone: (+49 30) 34 81-480  
fax: (+49 30) 34 81-503  
email: [ptbnews@ptb.de](mailto:ptbnews@ptb.de)

# Field Bus for Hazardous Environments

In cooperation with manufacturers PTB has recently developed an explosion protection concept for a digital field bus. A field bus which complies with the concept can be used for process automation in industrial plants with flammable substances.

In automated chemical or petrochemical plants the data supplied by a great number of sensors must be read out and electric signals must be delivered for actuating a variety of devices over large distances in an environment of flammable substances. The data bus systems connecting the various subsystems must be intrinsically safe against explosions besides having more common properties such as high transmission reliability, dependable availability, easy maintenance and cost effectiveness. In addition, the systems should be based on open standards.

In cooperation with major instrument manufacturers, PTB has developed the Field Bus Intrinsically Safe Concept (FISCO) as an explosion protection concept. 10 to 32 devices can be connected to a single field bus segment with cable lengths up to about 1 km. The two-wire bus does not only provide the signal transmission line. It can also deliver the electrical power required by field sensors and transducer devices with low power consumption. Meanwhile, the FISCO model has been adopted by the Process Field Bus (PROFIBUS) organisation as the basis for intrinsically safe field bus systems. These systems have been successfully introduced to the

*Explosion protection is one of PTB's legal tasks. Work in this field started in 1949. In commemoration of this, a symposium «50 Years of Explosion Protection with PTB» was held at Braunschweig on 29 September 1999. Recently, PTB has developed an explosion protection concept for a digital field bus. This allows the field bus to be used safely for process automation in industrial plants with flammable substances, e. g., in petrochemical plants.*

*Photo: Bayer AG*



European market and first installations have also been completed in the USA.

Additional investigations performed by PTB have shown that the use of frequencies between 50 kHz and 200 kHz may allow to increase the available electric power significantly in future field bus systems while maintaining the intrinsic safety. *For further information please contact U. Johannsmeyer, fax: (+49 531) 592-34 05, email: ulrich.johannsmeyer@ptb.de*

## Ultra-Precise Measurement of Optical Surfaces

Today's best optical flats, spheres and aspheres require ultra-precise manufacturing and measurements of their surface forms with deviations from their calculated form as small as 1 nm. In order to meet these requirements PTB has developed a novel system which allows to measure the macroscopic form of large surfaces with sub-nanometre resolution.

In high-technology fields such as satellite communication or production of integrated electronic circuits, progress often depends crucially on optical components with smooth surfaces of well defined shape. For example, the best presently used photolithography objectives have a diameter of more than 200 mm and consist of more than 30 lenses including aspheric ones. The quality management for the manufacture of such lenses requires absolute measurements of the real surface shapes with uncertainties as small as 1 nm.

To meet these demands on ultra-precise optical topography measurements of large surfaces, PTB has developed a novel deflectometric scanning facility based on a set of PTB patents. A prototype of the device is now available for measuring optical flats. Some of the main innovations, in particular the high-precision angular stabilisation of the scanning stages with respect to all three angular coordinates and the error free reconstruction algorithm for general difference measurements, can also be applied to fields other than optics. The new concept does not require reference surfaces and allows to perform absolute topography measurements of optical surfaces of almost any diameter. For a high-quality optical flat the reproducibility of topography measurements was found to be better than 0,2 nm under typical experimental conditions. Extension of the technique to measurements of aspheres is under development. *For further information please contact M. Schulz, fax: (+49 531) 592-42 72, email: michael.schulz@ptb.de*



*The precise measurement of optical surfaces is prerequisite to the development of lithographic lenses which are to realise the smallest possible structures on semiconductors.*

*Photo: Carl Zeiss*