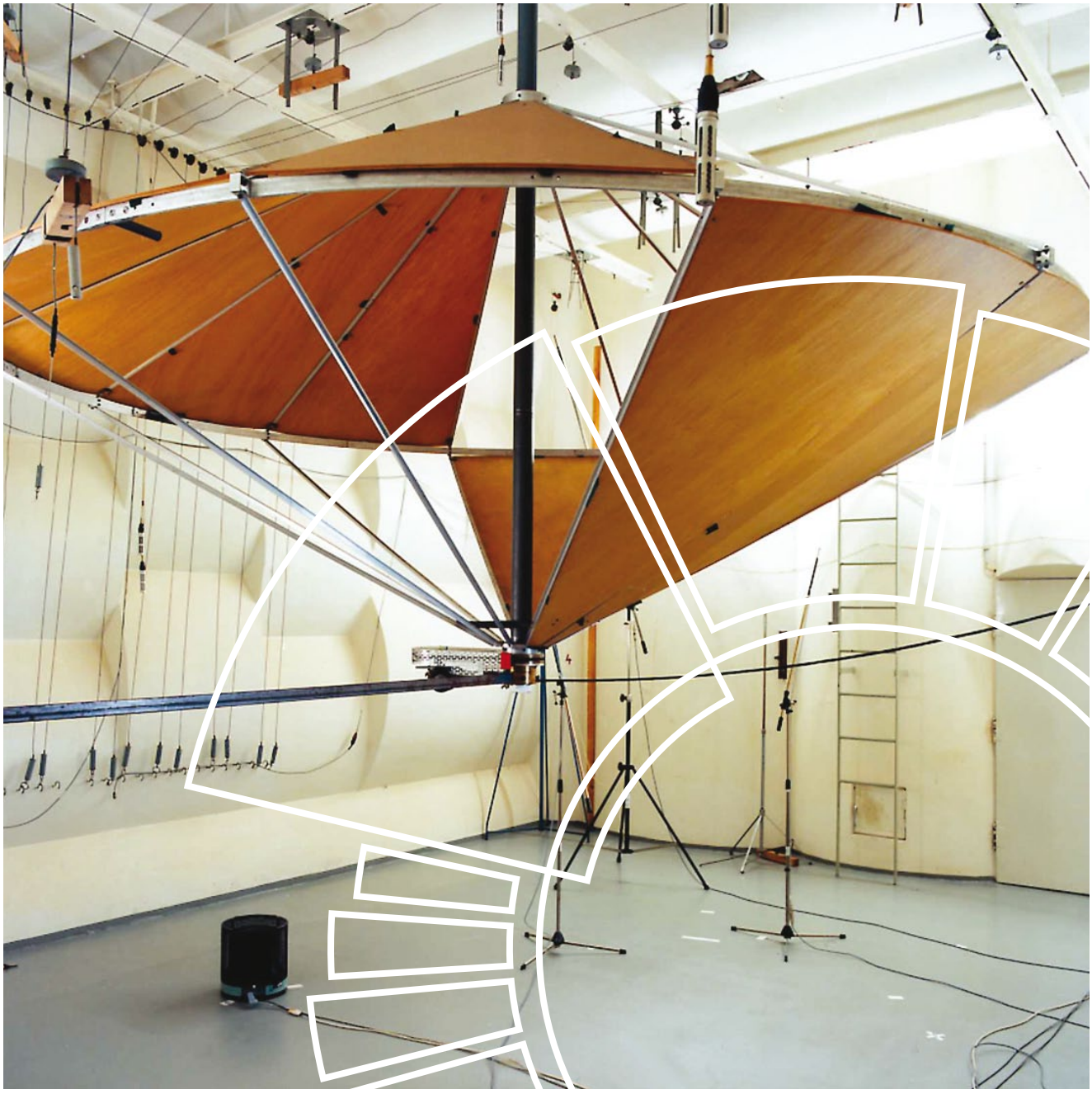
PTB INFO SHEET

PHYSIKALISCH-TECHNISCHE BUNDESANSTALT

DIVISION 1

Mechanics and Acoustics



Mechanics and Acoustics

How heavy, how strong, how fast, how loud? Division 1 is your reference for the precision measurement of mechanic and acoustic quantities. In addition to basic research, the main task of this Division is to supply services, i. e. calibrations in the field of industrial metrology and type tests in the field of legal metrology.

The "measure of all masses" in Germany: the national prototype of the kilogram at PTB.

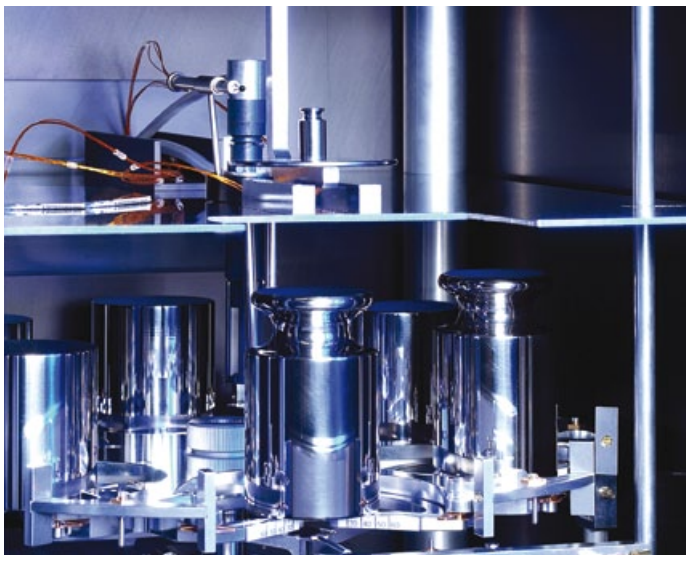
Kilogram

When it comes to stating what a kilogram is, the whole responsibility rests on a small metallic cylinder of just 39 millimetres in height and 39 millimetres in diameter: the international prototype of the kilogram. A copy of this master kilogram – which lies under three glass bells in a safe at the International Bureau of Weights and Measures (BIPM) in Sèvres near Paris – bearing the number 52 – is kept at PTB and has the task of being the "national prototype of the kilogram of Germany". But whoever wants to determine an unknown mass needs more than just one single comparison weight with a mass of one kilogram. This is why PTB is establishing a complete mass scale on the basis of this prototype: Authorities and users from legal metrology and industry "link themselves up" to this mass scale and have their weights and mass standards between one milligram and 5000 kilograms verified or calibrated at PTB. At the same time, the kilogram is currently a subject of research because the metrologists would rather rely on natural constants than on a physical object – above all, since this object is suspected to change in the course of time. A redefinition is being aimed at by the International Avogadro Cooperation (IAC) which uses silicon spheres as test objects: The aim of this project – in which PTB is participating as well – is to redetermine the Avogadro constant by "counting" the number of atoms of the 1 kg silicon sphere so exactly that one day, it will be possible to redefine the kilogram in terms of a natural constant. ■

Weighing Instruments

Weighing instruments are devices for measurement artists – at least when highest accuracy of the last decimal place is demanded – as, for example, in the case of PTB's 1 kg prototype balance. At the same time, weighing instruments are, however, quite common devices – for example, when the price of a commodity is to be determined with high reliability. The value of the goods which are invoiced every year in Germany on the basis of weighing processes exceeds, for example, 500 billion euros. As soon as a weighing instrument is used in official or commercial transactions, it needs a recognized approval. For this purpose, PTB performs type examinations mainly on the basis of European and international regulations and standards, and grants, on average, more than 100 type approval certificates for non-automatic weighing instruments and more than 50 certificates for automatic weighing instruments every year. In order to receive a type approval certificate a weighing instrument must successfully pass a number of metrological and functional tests in which its later conditions of use are simulated.

No matter how different the weighing instruments are – from



View into the proto-type balance with the aid of which 1 kg mass standards can be linked up with the national kilogram prototype.

the precision scale to the rugged lift truck scale – PTB can test them all. In addition to tests of complete instruments, all components of modular weighing systems can be checked and certified: from the load cell, being the "heart" of each weighing instrument, to the point-of-sale (POS) system that is connected to a non-automatic weighing instrument, and the PC placed behind it – including the software. ■

Dynamics

A book lying on a table exerts a weight force on that table – the force acts statically, i. e. not time-dependent. In many practical applications, however, dynamic forces can also appear, e.g. forces which act only for a short time – as in the case of an impact – or forces which constantly change their direction or intensity, as in the case of every vibration. The testing engineers must be prepared for these dynamic conditions. This is why PTB has developed and set up various – partly worldwide unique – standard measuring machines of which mechanic quantities, such as acceleration, pressure or force, are generated with sinusoidal and shock-shaped time dependencies and are measured with high precision with the aid of laser interferometers. In contrast to the usual static measurements, this metrological infrastructure allows sensors to be properly calibrated for dynamic applications. It is only in this way that the measurement uncertainties of the "dynamic real case" become reliable. ■

© Albrich / fotolia.com

Velocity

Have you driven faster than the speed limit? If you have been caught as a "traffic offender" and you read this on a fine, you will be annoyed but you will hardly be able to change the power of that fact. Because one thing is quite sure: The measurement result of your velocity is reliable, because each measuring instrument (radar unit, light barrier or induction loop) has successfully passed a type test at PTB and has been verified by a verification authority. This is prescribed by the German Verification Act and is intended to protect people from the consequences of incorrect measurement values. The most important requirement for a type approval is that the measurement error of a device must really never exceed the maximum permissible errors (3 km/h for velocity values of up to 100 km/h, 3 % for velocity values above 100 km/h). The core pieces of type examinations are comparison measurements in road traffic, which are performed by means of a high-precision PTB reference facility and always consist of several thousands of single measurements. ■

Force

The highest national standard devices for force measurements are available at PTB. These serve to realize the so-called force scale that extends over more than seven decimal powers: from small forces (less than one newton) to 16.5 million newtons. For each range on this scale, a special force standard machine is required which is specially tailored to its needs.

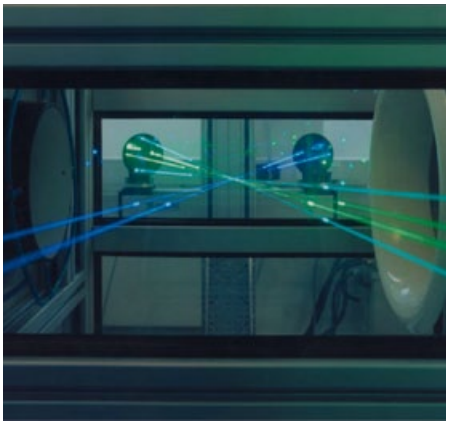
Force standard machines work according to different principles. For most accurate measurements up to 2 MN so-called deadweights are used which generate well-defined forces in the gravitational field of the Earth. Hydaulic amplification is used to generate forces larger than 2 MN – for example for the calibration of force transducers which are incorporated in bucket wheels in surface mining or in offshore oil platforms. Similar standard machines are available for torque measurements. Here, the forces – also generated by deadweights – are transmitted to a torque transducer via a lever arm with defined length. The largest machine can measure torques of up to 1.1 million newton metres. The fact that force measurements have something to do with safety becomes particularly evident when carrying out crash tests with dummies. The force which acts on the dummy in the case of an artificial accident is determined by force transducers everywhere on the dummy's body. These devices are checked at regular intervals by the automobile companies in their calibration laboratories. The force calibration machines used for this purpose can be traced back directly to the standards of PTB. PTB renders its calibration services, i.e. the dissemination of the force scale and of the torque scale, at both the national and the international level. And for the worldwide harmonization of the force scale and of the torque scale, PTB plays an active role as pilot laboratory in different international intercomparisons. ■

The 2 MN force standard machine is the largest deadweight machine of PTB.

Liquids

Every year, a considerable amount of liquid flows through pipes, hoses, filling facilities and taps in Germany: 62 million tons of fuels, 38 million tons of light fuel oil, 5500 billion litres of drinking water, 32 billion litres of milk and 12 billion litres of beer are only some of the liquid quantities to be measured. Correspondingly comprehensive are the approvals and certifications of the measuring instruments used for this purpose which are all subject to the Verification Act. Apart from the routine tests, novel measuring techniques based on modern procedures are to be developed, as industry and science as well as medicine, environmental and consumer protection demand ever higher accuracies in quantity and flow-rate measurements of liquids in motion. With the Hydrodynamic Test Field, PTB has the most exact measuring equipment worldwide in this field at its disposal and is, in addition, able to realize smallest measurement uncertainties of 0.02 % in a very large measuring range from 0.3 m^3/h to 2100 m^3/h. ■

Measurement sections and weighing systems of the Hydrodynamic Test Field.



Calibration of a wind measuring device (anemometer) with the aid of Laser Doppler Anemometry.

Flow Velocity

How fast does a gas or a liquid flow through a pipe? What wind velocity is prevailing in the wind tunnel? Such questions can and will be answered by a special laser technique – the Laser Doppler Anemometry. This technique makes use of the effect that the frequency of electromagnetic waves changes in a moving, transparent medium when the light strikes small scattered particles in the flowing medium. This Doppler effect allows a non-invasive velocity measurement of flowing gases and liquids to be carried out. Laser Doppler anemometer (LDA) systems are used to investigate flows, calibrate wind measuring devices and measure volume flowrates. If, for example, the velocity profile of a pipe cross section is measured, this can be used to determine the quantity of the medium flown through. All in all, the LDA technique can be used to precisely realize and disseminate the unit "flow velocity". ■

Gases

A gigantic pipeline system for natural gas runs through Europe. Every year, more than 150 billion cubic metres (m^3) of natural gas flow to Germany, ¾ of them are combusted in Germany for the generation of energy, with a comparably small emission of CO_2. Due to the great value of this "merchandise", a generally accepted charging measure is important.

In addition to the calorific value, invoicing is based on the unit "cubic metre in the standard state" which can – with modern measuring instruments – be determined with an uncertainty of approx. 0.15 %. In the past, the measurement methods and, thus, also the measurement values used in transnational trade were, however, slightly different. Meanwhile, France, the Netherlands and Germany have agreed on a weighted mean value and thus on a uniform, harmonized reference level.

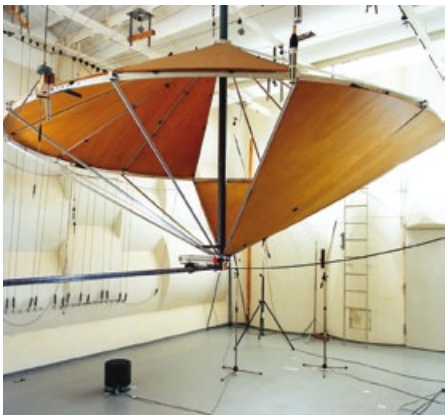
In this way, a kind of "European standard" for the volume unit has thus been created for high-pressure natural gas.

However, not only industry, but also private customers must be able to rely ultimately on correct gas measurements. Correct measuring of the more than 10 million domestic gas meters (mainly diaphragm gas meters) is, on the one hand, ensured by type approvals and conformity assessments of these gas meters and, on the other hand, by the regular monitoring and checking at one of the several hundred test facilities in Germany which have, in turn, been calibrated by comparison with the national standard. In this way, PTB ensures high metrological quality of all measuring instruments used for the purchase and sale of natural gas. ■

Ultrasound

One of the first contacts a human being has with the outside world is inaudible – the first photo of a baby is taken with ultrasound. In many doctor's surgeries, such ultrasonic images are standard for the examination of embryos and foetuses in the womb as well as for the general routine check of the internal organs of adult patients. To allow correct and safe operation of the ultrasonic equipment, its sound field must be measured and characterized comprehensively. For this purpose, several measuring set-ups are available at PTB – not only for diagnostic, but also for therapeutic or surgical ultrasonic equipment. All these measurements are, of course, based on the units of ultrasound: the pascal for the sound pressure and the watt for the sound power. Both of them are realized, maintained, and disseminated to users in industry and society. ■

Is the baby really healthy? With the aid of modern 4D ultrasound, many things can be detected already long before a baby's birth.



PTB's reverberation room: The rotating screen makes sure that the sound of a noise source is distributed in the room as uniformly as possible.

Audible Sound

In one of the most extraordinary rooms of PTB, the "anechoic room", there is silence. All six (!) walls here are designed in such a way that each incident sound is not reflected as usual, but is almost completely swallowed. In this way, sound level meters and microphones can be acoustically tested free from room influences. Sound level meters are the most important measuring instruments for the measurement of noise.

Noise impairs the quality of life, can cause health problems for people and leads to considerable costs. In a type examination, PTB determines admissibility for the verification of sound level meters and sound calibrators. With the aid of special microphones, the unit of sound pressure is disseminated within the scope of a free field or a pressure calibration (depending on whether the microphone is intended to be used in the free sound field or in a pressure chamber). In addition, PTB contributes significantly to the standardization of sound measuring instruments. These instruments also encompass sound intensity measuring instruments, personal sound exposimeters, and devices for the measurement of aircraft noise.

But even if there is nothing to be heard, PTB's services are required: The regular checking of audiometers is made possible through the provision and testing of "artificial ears" through PTB. In addition, reference hearing thresholds – which are, so to speak, the "golden" ear for all new audiological procedures – are determined and made available, which is, however, often not straight forward. In particular, modern objective audiometry devices require sophisticated calibration and adaptation techniques also developed at PTB. ■

Applied Acoustics

Noise does not stop at the front door of our homes! 80 % of the population have direct neighbours and 90 % of them cannot help hearing them. Moreover, an increasing number of technical facilities expose our home to sound waves. PTB's acousticians have committed themselves to "acoustic environmental protection" in this field. They do not only operate various test facilities for tracking the transmission of sound in buildings, but they also develop completely new measuring procedures to make the sound sources' "noise emission capability" measurable and, thus, also predictable. Examples of this are waste water noise and the so-called impact sound. The PTB acousticians also work on the improvement of the existing acoustic measurement procedures which, due to the extremely complex physical background, are subjected to many uncertainty factors. All this experience is highly appreciated by industry, by the supreme construction control board and by the standardization and regulation bodies. ■

Departments and Contacts

Head of Division:

Dr. Roman Schwartz
Phone: +49 531 592-1010
E-mail: roman.schwartz@ptb.de

Department 1.1 Mass

- Realization of Mass
- Weighing Instruments
- Dynamic Weighing
- IT Weighing Technology

Dr. Dirk Ratschko
Phone: +49 531 592-1100
E-mail: dirk.ratschko@ptb.de

Department 1.2 Solid Mechanics

- Realization of Force
- Realization of Torque
- Periodic Forces

Dr. Rolf Kumme
Phone: +49 531 592-1200
E-mail: rolf.kumme@ptb.de

Department 1.3 Velocity

- Speed Measuring Instruments
- IT Measuring Instruments for Traffic Enforcement
- Dynamic Pressure Measurement

Dr. Frank Michael Jäger
Phone: +49 531 592-1300
E-mail: frank.jaeger@ptb.de

Department 1.4 Gas Flow

- Fluid Flow Measuring Techniques
- Gas Meters
- High Pressure Gas

Dr. Helmut Többen
Phone: +49 531 592-1400
E-mail: helmut.toebben@ptb.de

Department 1.5 Liquid Flow

- Liquid Meters
- Liquid Test Facilities
- Traceability in Liquid Flow Measurement

Dr. Gudrun Wendt
Phone: +49 531 592-1500
E-mail: gudrun.wendt@ptb.de

Department 1.6 Sound

- Sound in Air
- Ultrasound
- Noise Measuring Technology

Dr. Christian Koch
Phone: +49 531 592-1600
E-mail: christian.koch@ptb.de

Department 1.7 Acoustics and Dynamics

- Realization of Acceleration
- Applied Acoustics
- Impact Dynamics

Prof. Dr. Werner Scholl
Phone: +49 531 592-1700
E-mail: werner.scholl@ptb.de

Division 1 conducts basic research in the fields of mechanic and acoustic measurands. Standard machines and devices are developed to realize and disseminate the measurement scales for all important mechanic and acoustic quantities with highest accuracy. This includes the setting up of special measurement facilities to carry out calibrations for DAkkS (the German Accreditation Body) and type tests according to national regulations, European Directives and International Recommendations of the OIML. PTB employees render advice in all matters of the respective measuring devices and techniques. ■

Secretariat
Cindy Rogasch
Phone: +49 531 592-1011
Telefax: +49 531 592-1015
E-mail: cindy.rogasch@ptb.de

Physikalisch-Technische Bundesanstalt
Division 1: Mechanics and Acoustics
Bundesallee 100
38116 Braunschweig
www.ptb.de

As of: March 2012