PTB INFO SHEET

PHYSIKALISCH-TECHNISCHE BUNDESANSTALT

PTB – the National Metrology Institute of Germany

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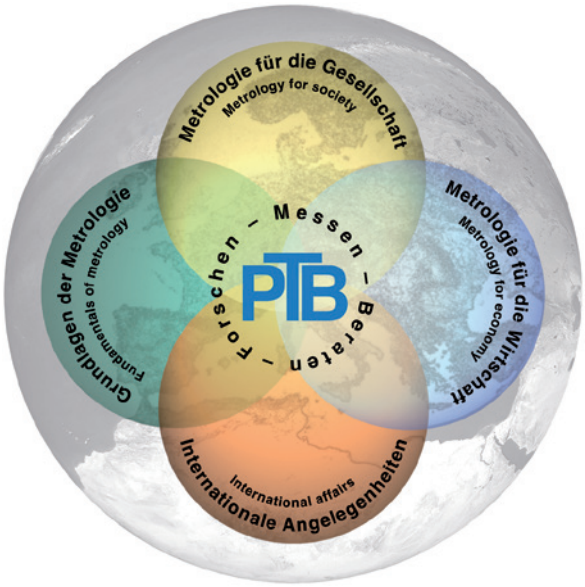
Accurately? Yes, accurately! But higher accuracy is always possible. The Physikalisch-Technische Bundesanstalt (PTB) tries to achieve this. PTB is the National Metrology Institute of Germany with scientific and technical service tasks. It measures with the highest accuracy and reliability – metrology as the core competence.



The research and services of PTB serve clear purposes of science, society and the economy. This is reflected in the four business areas.

What is PTB?

The Physikalisch-Technische Bundesanstalt is the supreme authority for accurate and precise measurement in Germany: it is responsible for the realization and dissemination of the physical units; it is a metrological research institute and the service provider for science, society and the economy; and it is – far beyond national borders – one of the first addresses, at all, of metrology. Metrology – the scientific basis of measurement and of applications derived from it – is essential for our modern world.

No scientific experiment, no industrial process and no trade of goods and merchandise can do without quantification, i. e. without measurement technology. Measurement technology and metrology – its scientific backbone – have today virtually become a matter of course. However, this matter of course of precise and reliable measurements must be acquired; and this not only once, but continually – synchronously with the continually increasing accuracy requirements of the "metrology customers". The mandate for a National Metrology Institute (NMI) – such as the Physikalisch-Technische Bundesanstalt – is to ensure a continuously functioning and, consequently, a reliable and progressive metrological infrastructure which meets both the highest requirements of science and high-technology industry and the marginal conditions of legal metrology in everyday life. All these facets are combined under the umbrella of PTB. ■

Uniform worldwide

Comparison measurements between the National Metrology Institutes (NMIs) are an essential precondition for establishing a measuring system which is uniform worldwide.

If two people want to communicate with each other, they should speak the same language. In the scientific-technical world, in which objects are produced, quantified, and evaluated based on a division of labour, measurement results represent such a language. Thus, a measuring system which is uniform worldwide is indispensable, especially for globalization in our times. In practical applications, worldwide uniformity is achieved only by concrete cooperations, a great number of confidence-building measures and transparent measurement results. For this reason, PTB cooperates with the other National Metrology Institutes (NMIs) in a large number of joint research and development projects and is, at the international level, firmly integrated into the metrological structures: from the Metre Convention and the "Organisation Internationale de Métrologie Légale (OIML)" to the "European Association of National Metrology Institutes (EURAMET)" and the "Western European Legal Metrology Cooperation (WELMEC)". The central element to achieving a worldwide uniform and harmonized metrology and to removing, at the same time, technical barriers to trade between the states, is international comparison measurements between the national metrology institutes. This allows the degree of harmonization of the national standards and of the calibration and measurement capabilities of the individual states to be determined quantitatively. The results of these comparison measurements, which are carried out at the highest level, are stored in a data base. They are accessible to the public, and they are part of the quality assessment and quality assurance of the institutions involved. As PTB has special laboratories for almost all relevant physical quantities, the number of comparison measurements in which PTB participates is very high (between 50 and 100 per year). ■

The International System of Units

Seven units determine the basis of all measurement. But this basis is shaky here and there. A conversion of the International System of Units is imminent – via the tracing back of the units to fundamental constants of nature.

The International System of Units (Système international d'unités, SI) is based on the intention of universally describing the fundamental phenomena of the physical world – time, length, mass, temperature, electric current, …– and to define the physical units uniformly worldwide. These roots go back to the era of the French Revolution. The muddle of units still ruling at that time was supposed to be stopped – and just as importantly: The units were not supposed to be arbitrary, but rather universal. The metre and the kilogram were the "first children" of this revolutionary idea – an idea which still now sways science, because the base units must even today live somewhat with definitory insufficiencies: Just bear in mind the unit of mass and its embodiment by a certain metal cylinder in a safe of the International Bureau for Weights and Measures (BIPM). The scientific challenge is to place the base units on a solid and permanent basis, as has already been successfully accomplished for the second and the metre with reference to atomic excitations and the speed of light. PTB is decisively involved in this current restructuring of the system of units: for example with the Avogadro project for the redefinition of the kilogram and the mole, with the "Boltzmann constant" project for the redefinition of the kelvin, and with the experiment to trace the ampere back to the elementary charge of the electron. If metrologists are able to master this challenge, then in future a set of fundamental constants will determine the base units.

As soon as the required experiments will have achieved sufficiently small uncertainties and be consistent with one another, the General Conference of the Metre Convention (CGPM) will adopt the new definitions, determine exact numerical values for the fundamental constants involved and establish the "new SI". ■

Prominent showpieces: the atomic clocks (here the two fountain clocks) of PTB. No other physical quantity can be measured as precisely as time.

Technical Cooperation

For the Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (Federal Ministry of Economic Cooperation and Development) PTB implements about 40 projects in more than 70 countries – for the promotion of quality infrastructure (QI).

PTB's responsibility relates not only to the last measurable digits behind the comma and the international comparison of these results. PTB also promotes projects for the establishment of a quality infrastructure (QI) in many developing countries and in countries in transition within the scope of the German Development Cooperation, in order to help the local industry to establish the required metrological infrastructure. In the 1960s, technology transfer and the establishment of metrological partner organizations was started. Today, the cooperation mainly relates to the establishment and development of the quality infrastructure in the partner countries as well as to offers addressed to the users for making use of the QI services. The Technical Cooperation Department of PTB is integrated into the development policy of the Federal Government and makes its contributions to the fight against poverty within the scope of the focal point "sustainable economic development". PTB advises partner governments and ministries, promotes the institutions of quality infrastructure and also supports small and medium-sized enterprises. This work is very appreciated worldwide, which is meanwhile reflected by a great number of current cooperations with former partner countries at the highest metrological level and for the benefit of both sides. Partner countries of the initial years such as China, India, South Korea, Brazil, Argentina, Mexico, and later also Kenya and South Africa, today represent their interests independently in the respective international technical organizations. ■

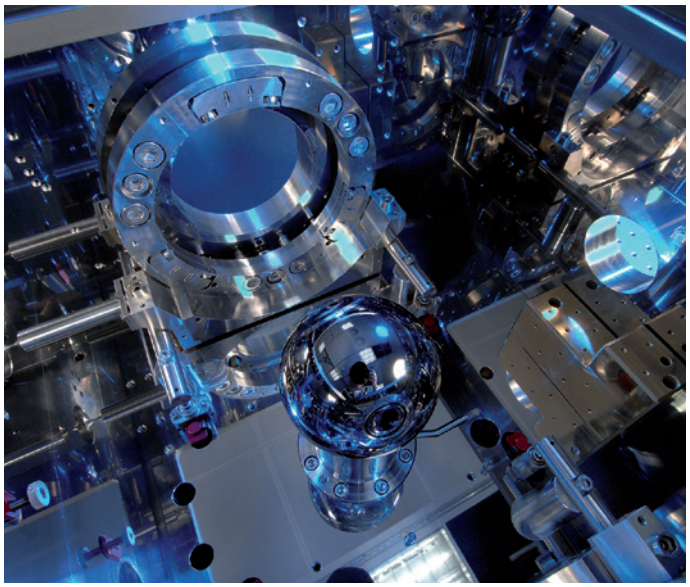
Calibration of a force transducer in Chile.

Research in Europe

More than 20 European metrology institutes take part in the European Metrology Research Programme.

"Classical metrology", which has so far been geared to physical measurement technology, permanently faces the task of extending the measurement ranges and of reducing the measurement uncertainties. For some time, however, also metrological contributions to the solution of the great challenges of our time, which are defined by terms such as health, energy, environment, safety and mobility, have become important to the degree to which exact quantification is required. Therefore, other disciplines – such as chemistry, biotechnology and medicine – are, in this context, knocking on the doors of metrology. One single national metrology institute alone cannot shoulder the burden of theses abundant tasks. For this reason, most of the European metrology institutes have committed themselves to cooperate in their research and development work. For that purpose, a European Metrology Research Programme (EMRP), half of which is funded by the European Commission, was elaborated to serve as a basis for the next few years. As the largest metrology institute in Europe, PTB shoulders – in accordance with its research budget – almost 40 % of the funds to be raised. Here, too, the tendency is clear. Metrology research, which was formerly mainly national, becomes European. ■

PTB is the largest metrology institute in Europe. The executive office of EURAMET, the association of the European metrology institutes, is domiciled on the campus of PTB in Braunschweig.

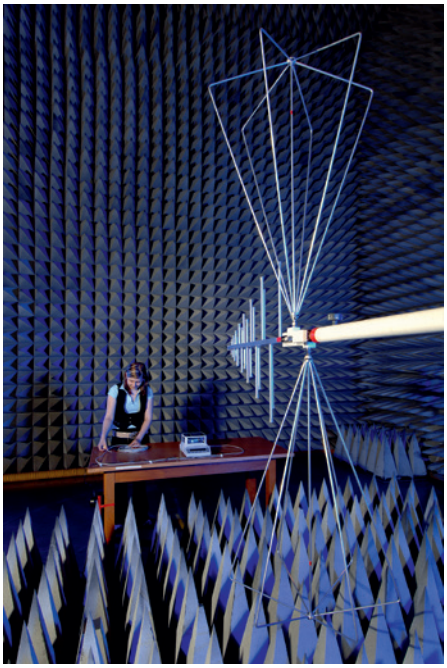


Metrological research (in most cases) requires perseverance. The Avogadro project for the redefinition of the kilogram and the mole has spanned more than two decades.

PTB in the German Research Landscape

The portion of research and development tasks within the entire spectrum of tasks of PTB amounts to about two thirds.

Depending on the concrete situation, it can be either an advantage or a disadvantage within a group to have too many traits that deviate from the other group members and consequently have a special status within the group. For PTB with its clear focus on metrological research and development (R&D), this applies within the group of the so-called "departmental research institutes" (i. e. institutes which are assigned to individual federal departments). Whereas many of the institutions of the so-called "departmental research" have the character of a regulatory authority, PTB understands itself, in the first instance, as a research institute with a corresponding degree of autonomy and scientific freedom. PTB belongs to the group of departmental research institutes because it is formally managed as a subordinate authority in the business domain of the Bundesministerium für Wirtschaft und Technologie (Federal Ministry for Economy and Energy – BMWi). From the very beginning, PTB has not been a "classical authority" but a research institution with a sovereign service task, which has today been established in a total of 23 laws and ordinances. The research work at PTB is thereby always moulded by metrology, application-oriented as a matter of principle, and therefore it is clearly distinguishable from purely fundamental research. Its special approach, which is aimed at metrological precision, makes PTB a much desired partner for the most different cooperation projects with universities and non-university research institutions, and it takes part in special research fields and excellence clusters. Due to its metrological competence, PTB occupies a central position in the German research landscape. It can, however, only meet the high expectations if policy grants it the same framework conditions. ■



As a provider of metrological services, PTB annually performs several thousand calibrations and tests. Photo: Measurements for electromagnetic compatibility.

Partner of Industry

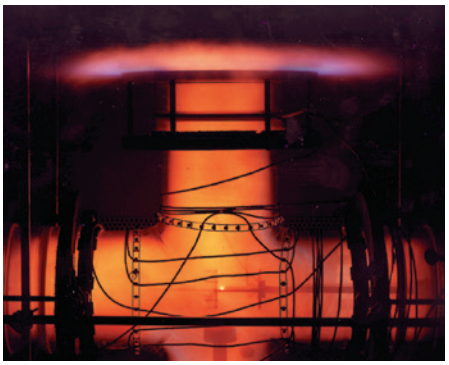
The service character of PTB is also reflected in several thousand calibrations per year.

The German Units and Time Act explicitly assigns two tasks to PTB: the realization and the dissemination of the physical units. To realize such a unit means to operate, to maintain and to develop a national standard for the unit in question (or, if required, national standards for the whole scale of this unit) according to the state of science. This task as a "guardian of the units" is necessarily complemented by the dissemination of the units to the customers in industry and society by suitable "bridges from this island of highest accuracy to the worlds of application". This is achieved by calibration, i. e. by metrologically comparing the devices of the customers with the PTB standards. PTB works in accordance with a principle of subsidiarity and cedes the calibration to an external laboratory, provided that this laboratory can meet the requirements in the same way as PTB. For that reason, industrial enterprises from high-technology branches, on the one hand, contact PTB with special calibration requests and, on the other hand, accredited calibration laboratories, in particular, which must – in accordance with the quality management provisions – submit their own reference standards for calibration at regular intervals. The several thousand calibrations which PTB carries out every year thus provide the basis for several millions of calibrations in Germany as a highly industrialized country, which contributes considerably to the economic value creation in Germany. The German economy benefits from the internationally renowned image of PTB, as a certificate of PTB represents a significant competitive advantage on the market. PTB certificates enjoy worldwide confidence and are recognized in almost all countries. ■

Protection Function – for Man and the Environment

Each highly technical society is also this: a risk society. Reliable metrology is needed to recognize these risks and to minimize them.

Modern metrology is required to extend the knowledge at the front of science, as a highly specialized production aid in the high-technology industry and as a reliable accounting mechanism in economy and trade. But also a society – especially a highly technical one – must be made aware of the risks in which it lives, and these risks must be illustrated by concrete measurement values. If the facts are known, harmful consequences can possibly be avoided. How high is the current radiation burden of the environment by natural and artificial radioactivity? Which substances do we blow – and in what concentration – into the air from exhausts and factory chimneys? Which measures can we take to confine the noise in our working environment and in our world of mobility? How can explosions in chemical production plants, gas pipelines or in other ignition-capable atmospheres be avoided or confined? Our society needs reliable answers to questions of this kind. Correct measurements are the prerequisite for the quantification of these risks. In Germany, PTB provides the metrological basis also for the surveillance of the environment and the protection of the citizens, for example, with its trace survey station for radioactive substances in the air, with the type examinations of exhaust meters and their chemical analysis, with its standards for sound and ultrasound measurements, or with its know-how in physical safety technology and explosion protection. Here, reliable metrology is a means of objectification and helps to take decisions in our risk society. ■



Safety engineering is a top priority – not only in explosion protection.
Photo: Ignition of a gas mixture via laser radiation.

Locations: Braunschweig and Berlin

In addition to the traditional site in Berlin, where two scientific divisions constitute the "Berlin Institute", PTB is, with the bulk of its tasks and staff members, domiciled in Braunschweig.

Two sites, two histories, two faces, one institution. First of all there is Berlin, the traditional site of PTB. In today's Charlottenburg-Wilmersdorf district, the Physikalisch-Technische Reichsanstalt (PTR) was founded on grounds which Werner Siemens donated to the German Empire, in the immediate vicinity of the Technical University. For more than 50 years, the PTR was concentrated at this location. Then came the Third Reich, the war, the destructions and, after the end of the war, the liquidation of the PTR in the two German states. In 1946, the parts of the PTR which had been removed to Weida in Thuringia were converted into an "Amt für Maß und Gewicht" (Agency of Weights and Measures). In 1953, the PTR on the traditional grounds in Charlottenburg was affiliated as "Berlin Institute" to the PTB, which was meanwhile domiciled in Braunschweig. Today, the Berlin site of PTB is closely interlinked with the scientific landscape in Berlin. A great number of scientific cooperations exist with the Technical University – not only due to the spatial contiguity – and also with the Humboldt University. In medical physics, in particular the cooperations with the medical centres and the university hospitals should be mentioned and, for physics with synchrotron radiation, cooperation at the scientific and economic site Adlershof with an own storage ring, the Metrology Light Source, and the laboratory at the storage ring Bessy II of the Helmholtz Centre in Berlin. Whereas in Berlin, PTB is a small institution in a large scientific landscape which is well-established in circles of experts, the situation of PTB is quite different at its headquarters in Braunschweig. In the research region Braunschweig, PTB is – in addition to the Technical University, with which a great number of cooperations are maintained – the largest research institution and, due to its magnitude, much more present in the public awareness, in particular due to one physical quantity: time. The reputation of PTB in Braunschweig is, to a great extent, based on its atomic clocks which – unjustifiably – eclipse its other top performances, because "time is made in Braunschweig". PTB thus ranks among the most prominent landmarks of the city. In this situation, two things are unimaginable: PTB without Berlin, and Braunschweig without PTB. ■

The Charlottenburg campus – the founding site of PTB – accommodates the Berlin Institute with approximately 450 staff members.

The main site of today's PTB is located in the western section of Braunschweig. Approximately 1500 staff members work here.

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