Measurement standards

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The Central Office of Measures (GUM) performs tasks in the scope of scientific, industrial and legal metrology. It makes possible to ensure the uniformity of measures and required accuracy of measurement in Poland by realization and maintenance of measurement standards and dissemination of units of measurement. This concerns SI units and other legal units of measurement. In the year 2016 the Central Office of Measures celebrates 50th anniversary of introduction of the International System of Units (1966 - Introduction of the SI as legal in Poland).

The Central Office of Measures performs calibrations, expert assessments of measuring instruments, conformity assessments of measuring instruments and type approval and verification of measuring instruments as well. When carrying out its activities GUM uses the SI base units:

- the metre
- the kilogram
- the second
- the ampere
- the kelvin
- the mole
- the candela

The BIPM SI units definitions

Developing and maintenance of the national measurement standards and other measurement standards of the highest measurement units reproduction accuracy class on the national level are two of the basic tasks of every National Metrology Institute which in Poland is the Central Office of Measures. The national measurement standards ensure a reference basis for many areas of the national economy including most of the industry, trade, health, life and environment protection branchesand the area of the security and public order protection, consumer rights, pre-packaged goods control etc. as well. Together with other measurement standards the national measurement standards build up a chain of connections which are linked to dissemination of measurement units. This chain ensures the measurement uniformity necessary for the whole country. Please, see below the national measurement standards maintained by GUM.

The national mass standard

- prototype No.51 of the kilogram

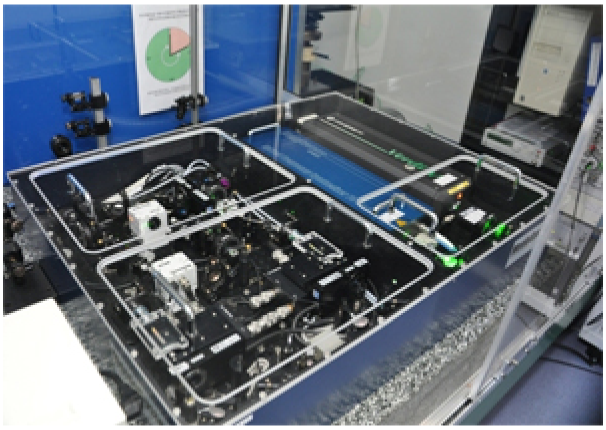
The basis for dissemination of a mass unit is the national standard prototype No. 51 of the kilogram, made of an alloy of platinum and iridium (90% Pt, 10 %Ir) in the shape of a cylinder with the diameter of the base equal to its height (approx. 39 mm), compared periodically to the international standard of kilogram (IPK). The standard has been utilized in GUM since 1952. International comparisons of the national standards of the mass unit 1 kg were performed in the International Bureau of Weights and Measures (BIPM) in 1988-1992. The mass of the Polish prototype, determined 1990, amounted to 1 kg+ 227 · 10^{-9} kg with the combined standard uncertainty of 2,3 · 10^{-9} kg.

Dissemination of a unit of measurement takes place through the calibration. It is required that the chain of traceability remain unbroken. Calibrations are of the hierarchic nature, starting from the prototype of the kilogram, through the copies of the kilogram and the mass standards of E_1, E_2, F_1, F_2 andM_1 classes of accuracy, down to utility instruments (non-automatic weighing instruments). Dependent upon the use and technical parameters, weighing instruments are divided into accuracy classes: ordinary (IIII), medium (III), high (II) and special (I). Weighing instruments of high and special classes are used in research laboratories for precise mass measurements of tested samples. Weighing measurements of the medium class are most frequently met in everyday life as commonly used in sales. However, weighing instruments of the ordinary class are of industrial use, e.g. in technological production lines. In each of the above uses, the result of measuring a unit in any field is related to the national standard - the prototype No. 51 of the kilogram.

The national length standard

The national length standard was established for the first time on 15 March 1980. Currently the standard is recognised by the decision of the President of the Central Office of Measures No.1/2003 of 24 April 2003. The national length standard is a measurement facility reproducing standard laser radiation wave lengths, consisting of:

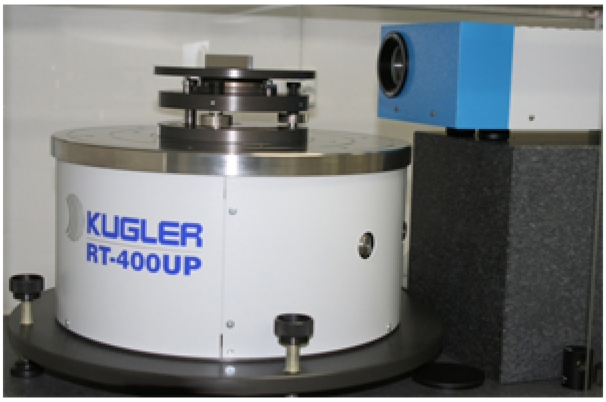
- He-Ne laser stabilized with iodine



- optical frequency synthesizer

The facility is used to provide traceability in the field of length measurements through calibrations of stabilized metrological lasers heads of laser interferometers and He-Ne iodine stabilized lasers in (532 ÷ 1064) nm radiation wave length range, using the optical frequency beat method with relative expanded uncertainty equal to$U_w = 10^{-13}$.

The national plane angle standard



The national plane angle standard was established for the first time on 12 July 1979. The recent certificate of recognizing the standard as the national standard was issued on 28 July 2003.

Currently, after few modernizations, the national plane angle standard consists of two facilities: the facility for reproducing the unit by division of the full circle and the small angle generator, reproducing the unit by determining the ratio of two lengths, in the range of 40 arcminutes.

Optical polygons (U = 0,07"), writing angle blocks (U = 0,07"), autocollimators, angle encoders and precision electronic levels *(value of expanded uncertaintyis dependent on the resolution of the instrument)* arecalibrated on these stations.

Measurement facility of the refractive index standard was recognized as the national standardon 28 July 2003. It consists of a goniometer-spectrometer and standard prisms

Values of the refractive index of solid refractive index standards in the range of $n = (1,2 \div 2,2)$ with expanded uncertainty $U = 3 \times E^{-06}$ are determined on the measurement facility. Refractive index standards are used for calibration of refractometers.

The national standard of optical rotation

The national standard of optical rotation is the set of 5 quartz plates of the measurement range of: (-10 ÷ 40)° in angular scale and (-25 ÷ 100)°Z in sugar scale, in 20° C temperature and 546,3 nm wave length. The measurement facility of the standard was recognized as the national standard on 28 July 2003.

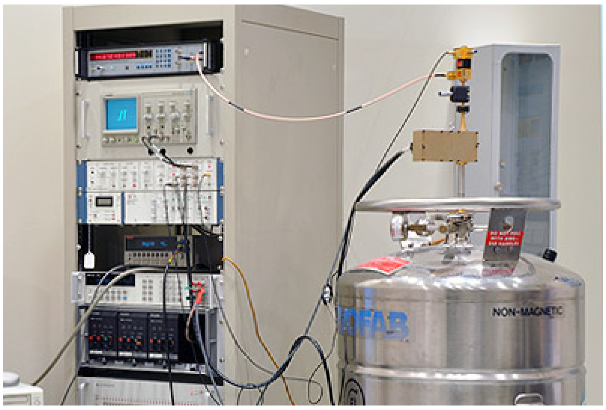
Quartz plates are used for calibration of photoelectric and visual polarimeters.

The national resistance standard

The national resistance standard is a measuring system which consists of the group of six standard resistors of 1 Ω nominal value of resistance, placed in a thermostat and a current comparator. Currently, the standard based on the quantum Hall effect is the best realisation of the unit of measure of resistance.

This measurement standard has been working since 28 July 2003. Earlier it had been working as the national etalon since 30 December 1980.

The national DC voltage standard



The national DC voltage standard is a measuring system which consists of the original intrinsic standard based on the Josephson effect with 10 V rated junction and the measurement system for verification of the characteristics and calibrations.

This measurement standard has been working since 20 January 2004. Earlier it had been working (since 28 August 1979) as the national etalon containing eleven measurement elements - Weston 4305 saturated cells.

The national inductance standard

The national inductance standard is a maesurement system consisting of the group of four standard induction coils, of 10 mH nominal value of inductance and precision comparators and bridges.

This measurement standard has been working since 29 August 2003.

The national capacitance standard

The national capacitance standard is the measurement system consisting of the group of thermostated capacitors with a quartz dialectric of 10 pF nominal values and precision transformer bridges.

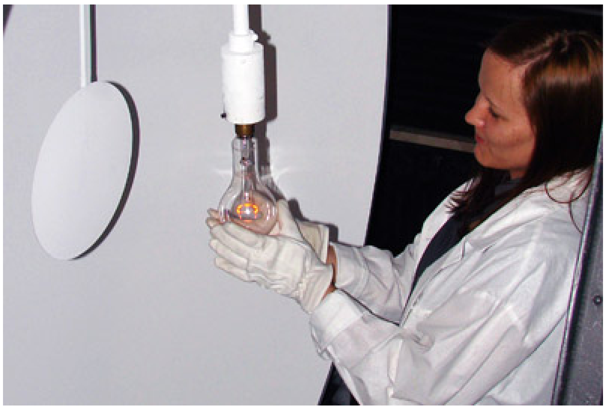
This measurement standard has been working since 24 April 2003. Earlier it had been working as the national etalon since 29 June 1989.

The national time and frequency

The national time and frequency standard is the measurement system consisting of the group of cesium frequency standards, UTC (PL) generation and control system and of their internal and remote comparisons.

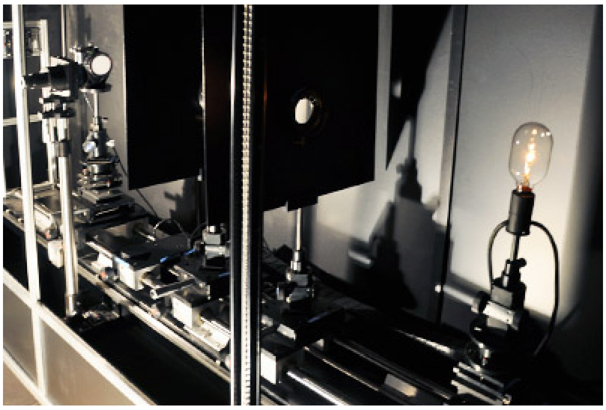
This measurement standard has been working since 29 August 2003. Earlier it had been working for more than twenty years (since 21 December 1981) as the national etalon.

National luminous flux standard



It was recognized by the President of GUM in 2001. The standard consists of the group of five photometric Toshiba lamps (PS type, of 100 V nominal value of DC voltage and 200 W). The national luminous flux standard provides traceability for the light sources industry, research institutes of electro-technical industry and automotive industry.

National luminous intensity standard



It was established by the President of GUM in 2001. The standard consists of the group of five photometric Toshiba lamps (T 64 type, of 100V nominal value of DC voltage and of 200W). The national luminous intensity standard provides traceability for the majority of measurements in the scope of photometry performed for light sources industry, automotive industry, aviation industry, ironworks, sanitary-epidemiological stations, research institutes of electrotechnical and automotive industry, and also calibration and research laboratories performing photometric measurements. The reference luminous intensity standards are used for calibtaring luxmeters, luminance meters, luminance standards, tristimulus colorimeters, white light NDT meters, photometric calibrations and utility standards of luminous intesity, utilized in research institutes of electrotechnical and automotive industry.

National pH standard

The measurement standard, operational since the beginning of 1970's, used for reproduction of a unit of pH and ensuring traceability for pH measurements, was established as the national standard for pH unit in 1980. In 1999, and subsequently in 2003, the original decision was confirmed by succesive decisions resulting from legal changes.

The measurement standard of the pH, which is recognized as a national standard, is a system consisting of the thermostated hydrogen – silver chloride cells without transference (so-called Harned cells), a set of instruments for measuring electromotive force, temperature and preassure, and a data acquisition and processing device for calculation of the measurement result.

The primary method of pH measurement is based on measurement of the electromotive force ofhydrogen - silver / silver chloride cells without liquid junction, containing the pH standard with addition of a small amount of chloride ions.

The pH measurements are probably the most frequently performed determinations in chemical andphysico-chemical laboratories. Results of these measurements are widely used in many fields, most of all in health protection (e.g. pH measurements of physiological liquids) and environment protection (e.g. monitoring purity of rivers, lakes, drinking water, quality of wastewater). In industry, pH measurements are used to control technological processes and quality of products (e.g. in chemical, food, pharmaceutical, cosmetic, fermentation and paper industry). In agriculture, pH measurements are used to i.a. determine properties of soil and fertilisers. pH of environment is the important parameter having an impact on materials' susceptibility to corrosion.

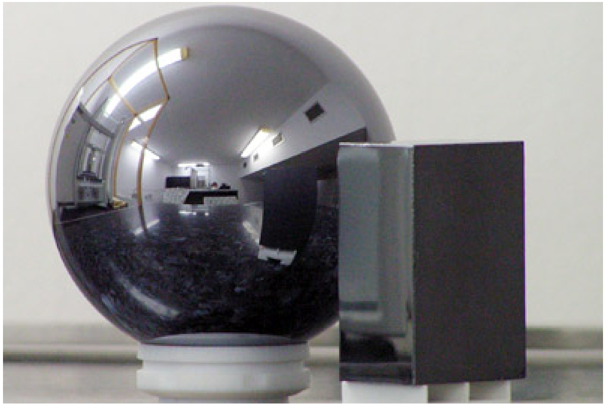
National temperature standard

The standard has been operational since 1960's. It was established for the first time by the decision of the President of the Polish Committee for Standardisation, Measures and Quality Control (PKNMiJ) in 1980. After the Law on Measures had entered into force in 2001, the new certificate of the standard was drawn up and re-issued in 2003. The standard is intended for reproducing and transferring the unit of temperature in Poland in the range from -189,3442º C to 961,78º C.

The temperature standard is the measurement system which consists of several components. The most important components are: fixed point cells, Ar, Hg,H_2O, Ga, In, Sn, Zn, Al, Ag, which realize the definitional fixed points (corresponding to the physical transformations of pure substances), in accordance with the International Temperature Scale of 1990 (MST-90); standard platinum resistance thermometers (SPRT); resistance bridges; thermostating devices and standard resistors.

The standard constitutes the source of traceability for national calibration and testing laboratories and also for direct users of instruments. It means that any user of the temperature measuring instrument, either for the needs of aprocess (most frequently in food, chemical, engineering, iron and steel industry) or during the implementation of services (i.a.medical, transport, technical, catering services), has the possibility to review the credibility of such instrument's indications, by calibrating it in a competent laboratory, maintaining relation (traceability) to the temperature standard in GUM.

National density standard



- Density standards, made from single-crystal silicon: SILO2 sphere and WASO

9.2 rectangular prism

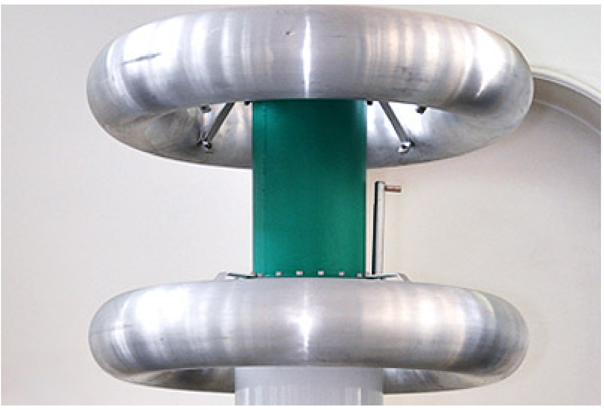
- SILO 2 standard while hydrostatic weighing, on their supports in the vessels immersed in the thermostats.

It has been established officially more than 30 years ago. In 1983, by the decision of the President of the Polish Committee for Standardisation, Measures and Quality, two facilities - for unit of liquid density and for unit of solid density - obtained the certificate of the national etalon. In 1990's, these standards were replaced with WASO 9.2 single cristal silicon in the shape of a rectangular prism of approx. 159 g. Its density was determined twice in comparison with PTB (the German National Metrology Institute) standards: by hydrostatic weighing against C1 and C2 Zerodur cubes (1985) and by pressure flotation against Si-1 silicon sphere (primary standard) (1998). WASO 9.2 was recognized as the national standard by the President of GUM in 1999.

In 2003, GUM purchased the 1 kg SILO2 sphere made of the single-crystal silicon of approx. 93.6 mmdiameter. It was calibrated two times against PTB primary standards, by means of the pressure of flotation method: in 2003 and in 2013.

The density unit is transferred to standards and measuring instruments used in many fields of science and industry, in order to determine properties of materials, technological processes' parameters, amount and quality of products (chemical, petrochemical, spirit, pharmaceutical, food industry etc.), such as hydrometers, oscillation-type density meters, pycnometers, reference materials.

National standard of alternating voltage ratio at frequency of 50 Hz



The national standard of AC voltages ratio at 50Hz consists of gas capacitors of type 3330/10000 and air capacitor of type 3330/2000. The nominal voltage is (1÷400) kV and the nominal value of the voltage ratio is: 40:1or 400:1.

The AC voltages ratio at 50Hz is an electrical quantity with wide scope of applications in the electricity production. This basic area of application of the measurement standards which reproduce AC voltages ratio - the so called inductive voltage instrument transformer - is the measurement of the electric power (with the parallel usage of the electricity meters) at electric power producer facilities (powerplants) and in electric power transmission from the energy producers to the customers (high, medium and low voltage power supply networks). The electricity meters, because of their parameters, are not able to measure this power directly. For this reason there is a need to apply a special kind of measuring system including an interface element - the inductive voltage instrument transformer which is connected with power grid and electricity meter working at low voltage level of the secondary transformer. The exact measurement of the electricity power in the power gridsis essentially important to identify the energy losses in transmission. The financial settlements between energy industry, energy producers and big energy customers take place on the basis of the measurement system indications.

The exact measurement of the above mentioned quantities is also applied in the process of inductive voltage instrument transformer production. These devices have to meet specific requirements, particularly regarding accuracy. The accuracy is also essential for research and calibrating laboratories for which the standards maintained by GUM are the best source of traceability.

The national AC voltage standard is a measuring system used for very exact transfer of the AC voltage by comparing its effective values with the exact known values ofthe DC voltages. It consists of two sets of the thermal voltage converters of AC/DC voltage: electronic converter which serves to transfer the voltage in the range from 22 mV to 700 mV, one set of three thermal voltage converters of AC/DC voltage and five range resistors which serves to transfer voltages in the range from 1 V to 1000 V. Thanks to these converters it's possible to transfer the AC voltage at frequencies from 10 Hz to 1 MHz.

The AC voltage is one of the main electrical quantities which is inseparably linked to the quantities in the field of electronics, electrical engineering and electricity. This quantity is very important for different areas of the national economy. The AC voltage is used in measurements of the physical quantities (in particular RLC measurements) and non-electrical quantities to the electrical ones including converting to the AC voltage - the inductive proximity sensors.

Both above mentioned standards have been working in GUM since 19 December 2014. Previously they used to have a status of the reference standards.

The national standard of AC currents ratio at 50 Hz consists of comparator type 4764, auxiliary comparator type 4781, and power transformer type NCD 200. The AC currents ratio at 50 Hz is an electrical quantity widely applied in the electricity branch.

The basic area of usage of the measurement standards reproducing AC currents ratio, the power transformer, is the measurement of the electric power (with the parallel usage of the electricity meters) at the electric power producers facilities (power plants) and in electric energy transmission from the energy producers to the cosumers (high, medium and low voltage power supply networks).

There is a demand for receiving of accurate measurement results for high voltage and currents electrice energy. The electricity meters, because of their parameters, are not able to measure this power directly. For this reason there is a need to apply special kind of measuring system including an interface element - the power transformer connected with power grid and electricity meter working at low current value level of the secondary power transformer. The exact measurement of the electricity power in the power grids is essentially important to identify the energy losses in transmission.

The financial settlements between energy industry, energy producers and big energy consumers take place on the basis of measurement system indications.

The exact measurement of the above mentioned quantities is applied in power transformers production. These devices have to meet specific requirements, particularly regarding accuracy. The accuracy is also essential for research and calibrating laboratories for which the source of measurements uniformity are the standards maintained by GUM.

The above mentioned standard has been working in GUM since 30th January 2015. Previously it used to have a status of reference standard.