

**VNIIM report to CCM 2021**  
**VNIIM report «Mass and related quantities».**

**State Primary Measurement Standard of unit of mass – kilogram (GET 3)**

1. Development of the State Primary Measurement Standard of unit of mass – kilogram GET 3-2020

In accordance with the Strategy for ensuring the uniformity of measurements in the Russian Federation until 2025, work was carried out in 2020 to restructure GET-3 composition. The following additional equipment was introduced:

- Sartorius CCL 1007 vacuum mass comparator with vacuum transportation system (BTC) No. 33300001 for transferring the unit of mass to secondary measurement standards in vacuum and atmospheric air at controlled constant pressure;
- a set of buoyancy and sorption artifacts: stainless steel weights of special shape with a nominal mass of 1 kg used to determine density of air and inert gases and specific sorption by direct method on the surface of compared weights;
- YCM16C multichannel automatic climate station for continuous monitoring of ambient air both inside the comparator working chamber and outside of it;
- a set of mass comparators for maximum loads from  $5 \cdot 10^{-3}$  to 40 kg for transferring the unit of mass to the area of multiples and submultiples of kilogram values.

Improved GET 3 ensures dissemination of the unit of mass using 1 kg CCL 1007 vacuum mass comparator with readability of  $1 \cdot 10^{-11}$  kg. In this case, direct method is used for measuring air density inside the comparator's sealed chamber. For this, mass differences of artifacts were measured first. Relative uncertainty of air density measurements decreased threefold from  $1.5 \cdot 10^{-4}$  to  $0.5 \cdot 10^{-4}$ . Dissemination error of the State Primary Measurement Standard has been reduced 10 times from  $6 \cdot 10^{-9}$  kg to  $6 \cdot 10^{-10}$  kg. Research of a set of submilligram weights was carried out required for calibration of microbalances with an error of less than 1 mg, widely used in medical, chemical industry and ecology analysis. Obtained values of weights with nominal values of 50  $\mu$ g, 100  $\mu$ g, 200  $\mu$ g (2 pieces), and 500  $\mu$ g and their standard uncertainties are comparable, for example, with Planck mass in Plank system of units.

2. Mass Laboratory of the D.I. Mendeleev Institute for Metrology is participating in international bilateral comparisons of artifacts in vacuum. The comparison started in 2019. Pilot Laboratory: (CMI) Czech Metrologies Institute Okružni – Czech Institute of Metrology, 2 participants.

The purpose of this comparison is to conduct bilateral pilot comparisons of artifacts in vacuum using modern vacuum mass comparators. The comparison are carried out within the framework of cooperation program between VNIIM and CMI. It is registered with EURAMET.

Work is at the stage of results discussion and preparation of Draft A report.

3. On October 6, 2020, the 25<sup>th</sup> Online Meeting of COOMET TC 1.6 “Mass and Related Quantities” was conducted. More than 50 representatives from the following 18 NMIs of 17 COOMET and EURAMET Member States took part in the Meeting: BelGIM (Belarus), IMBIH (Bosnia and Herzegovina), National Institute for Metrological Research (Cuba), PTB (Germany), GeoSTM (Georgia), RSE "KazInMetr" (Kazakhstan), Center for Standardization and Metrology under the Ministry of Energy of the Kyrgyz Republic (Kyrgyz Republic), Lithuanian Power Engineering

Institute (Lithuania), NSC of Moldova (Republic of Moldova), D.I. Mendeleev Institute for Metrology, VNIIFTRI (Russian Federation), TUBITAK UME (Turkey), NSC “Institute of Metrology” (Ukraine), UzNIM (Republic of Uzbekistan), Tajikstandart (Tajikistan), RISE (Sweden), CEM (Spain), and BIPM (France).

### **State Primary Measurement Standard of Unit of Density (GET 18)**

In 2020, research was carried out on methods and means of transferring a unit of density to standard measures of density from the Secondary Measurement Standards of Regional Centers in order to find ways to reduce uncertainty when transferring a unit of density.

As part of the research, the following works were conducted:

1. Investigation of technical characteristics of the standard measures of density from the Secondary Measurement Standards of Regional Centers in order to determine the impact on metrological characteristics,
2. Development of recommendations establishing requirements for technical characteristics of the standard measures of density,
3. Investigation of thermal expansion coefficients of the standard measures of density,
4. Comparative analysis of the study results of the standard measures of density from different manufacturers.

Investigation of the contribution of the uncertainty of the coefficient of thermal expansion of the standard measures of density to the combined standard measurement uncertainty of density of a liquid-comparator by secondary standards.

### **State Primary Measurement Standard of Unit of Pressure and Vacuum**

In 2020 regular works on international comparisons were postponed to 2021 due to the current epidemiological situation.

During 2020, the work on review and examination of regulatory and technical documentation and reports of international comparisons in the field of pressure and vacuum in the framework of the Working Group on Pressure and Vacuum of the Consultative Committee "Mass and Related Quantities" (CCM Working Group on Pressure and Vacuum (WGPV)) was constantly carried out.

### **State Primary Measurement Standard of units of dynamic and kinematic viscosity**

#### **(GET 17)**

In 2020, the following studies were carried out:

1. Research of metrological characteristics of the standard complexes EK GET 17/1-KVI and EK GET 17/2-KVN;
2. Research of metrological characteristics of the reference complex GET 17/3-DVP;
3. Research of the metrological characteristics of the reference complex GET 17/4-DVD/

In 2020, the following Key Comparison on viscosity to be continued: CCM Key Comparison of the Viscosity (CCM.V–K4).

Pilot laboratory: CENAM, 12 participants.

The Comparison used two Newtonian fluid samples with nominal values of 170 mm<sup>2</sup>/s and 4600 mm<sup>2</sup>/s at a temperature of 20 °C (Standard liquid A, Standard liquid B).

In accordance with the technical requirements, the following works are carried out:

1. Measurements of kinematic viscosity of reference liquids (Standard liquid A, Standard liquid B) at temperatures of 10 °C, 20 °C, 40 °C, and 100 °C,
2. Processing the measured values of kinematic viscosity of reference liquids (Standard liquid A, Standard liquid B) at temperatures of 10 °C, 20 °C, 40 °C, and 100 °C,
3. Drawing up protocols for measuring the kinematic viscosity of reference liquids (Standard liquid A, Standard liquid B) using GET 17-2018.

The Protocols for measuring the kinematic viscosity of comparator liquids (Standard liquid A, Standard liquid B) using GET 17-2018 were sent to the Pilot Laboratory.

Received Draft A from the Pilot Laboratory.

Draft B is under review.

### **Laboratory of gravimetry**

In 2019-2020 the State primary standard of acceleration unit in gravimetry was modified and officially recognized in Russian Federation with the modified home-made absolute laser interferometric gravimeter ABG-VNIIM-2 (uncertainty of type A: 2.0 μGal; uncertainty of type B: 2.0 μGal). (State primary special standard GET 190-2019 for acceleration in gravimetry, Measurement techniques, vol. 63, pp 513-519, 2020)

The superconducting gravimeter *iGrav-038* (produced by GWR Instruments, Inc, USA) is put into operation and is under investigations to enter it as part of Primary standard GET 190-2019 as well as a new gravimetric site “Lomonosov-2”.