NATIONAL SCIENTIFIC CENTRE
“INSTITUTE OF METROLOGY”
(NSC “Institute of Metrology”)

Mironositskaya Str. 42, Kharkov, 61002.
Tel. (+38-057) 700-34-09 – reception,
Fax: (+38-057) 700-34-47,
E-mail: info@metrology.kharkov.ua

Report of NSC “Institute of Metrology”
for the CCM

April, 2021
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Introduction

The National Scientific Centre "Institute of Metrology" (NSC IM) is a Head center for ensuring the unity of measurements in Ukraine. NSC "Institute of Metrology" passed more than a century of development from the first verification chamber of measures and weighs to the National Scientific Centre "Institute of Metrology".

NSC “Institute of Metrology”:
- creates, improves, stores and applies national measurement standards of units of values in 7 types of measurements;
- performs fundamental scientific research in the field of metrology, and also performs work related to the development and implementation of state programs on metrology and the concept of the development of the metrological system of Ukraine;
- provides scientific and applied research, performs scientific and research works related to the creation, improvement, storage, comparison, application of national measurement standards, creating systems for transferring the size of units of measurements;
- takes part in the development of projects for technical regulations, other regulatory acts, as well as regulatory documents in the field of metrology and metrological activities;
- carries out coordination and scientific and methodological support of work to ensure the unity of measurements for the relevant fields of activity;
- performs conformity assessment of measuring equipment;
- carries out calibration of measuring instruments;
- performs verification, on a voluntary basis, measuring instruments that are not applied in the field of legally regulated metrology and are in operation;
- performs verification of legally regulated measuring instruments that are in operation;
- performs measurements in the field of legally regulated metrology;
- maintains an information fund for the directions of its activities;
- performs international cooperation on issues that belong to its competence;
- stores 54 national primary measurement standards and 15 secondary measurement standards, which reproduce, maintain and transfer the units to state enterprises of the Department of Technical Regulation of the Ministry of Economy of Ukraine, enterprises and organizations of Ukraine and other CIS countries;
- performs international comparisons of National primary standards with national standards of other countries;
- prepares human resources of higher qualifications in the field of metrology and metrological activity;
- performs training at courses on raising proficiency of specialists-metrologists;
- organizes and performs workshops, international and national scientific and technical conferences on metrology and metrological assurance;
1 Structure of the institute

General structure of the institute is given in Annex 1.

Basic data on the staff of the institute

<table>
<thead>
<tr>
<th>Number of human resources in 2021</th>
<th>pers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>among which:</td>
<td></td>
</tr>
<tr>
<td>basic staff</td>
<td>224</td>
</tr>
<tr>
<td>where on contract basis</td>
<td>17</td>
</tr>
<tr>
<td>Doctors of Science</td>
<td>6</td>
</tr>
<tr>
<td>Candidates of Science</td>
<td>11</td>
</tr>
<tr>
<td>laureates of State Prize</td>
<td>1</td>
</tr>
<tr>
<td>part-time basis</td>
<td>16</td>
</tr>
</tbody>
</table>

Quality System

NSC IM has the confirmed quality system: QSF-R44 certificate of recognition of quality management system according to ISO/IEC 17025 issued 10.05.2016.

2 Technical capabilities in the field of mass and related quantities

The reference measurement standards of Ukraine in the field of mass and related quantities were created in the late 90s of the 20th century after Ukraine became independent. NSC IM maintains the national primary standards in the field of mass, pressure, hardness, flowmetry and gravimetry. NSC IM provides transfer and uniformity of measurements in these fields.

Mass

NSC IM maintained the national primary mass standard.
The national primary mass standard includes the 1 kg reference mass standard made of stainless steel, two 1 kg copies, sets of weights and set of mass comparators.
Dissemination of the unit of mass is carried out in the range from 1 mg to 50 kg with accuracy \( E_1 \).
In 2019, after Ukraine became a full member of the Metre Convention, the first calibration of the original kilogram standard in the BIPM was performed.
NSC IM has a hydrostatic installation for determining the volumes of weights.
NSC IM participates in international comparisons and acts as a pilot laboratory (COOMET.M.M-S8).

Pressure

The reference measurement standards of the NSC “Institute of Metrology” for pressure include four national primary standards – DETU 04-03-01, NDETU M-01-2018, NDETU M-03-2019, DETU 04-01-96, covering the range of absolute pressures from 0.001 Pa up to 7 MPa and gauge pressures from minus 0.1 MPa to 400 MPa.
In the design of the standards DETU 04-03-01, NDETU M-01-2018, NDETU M-03-2019, the principle of an unsealed piston is used to measure medium and high pressures. The standards include deadweight testers with piston-cylinder-unit (PSU) with appropriate measuring ranges and sets of special weights for them.
The standard DETU 04-01-96 for measuring low absolute pressures is implemented on the basis of special compression vacuum gauges, the principle of which is based on the change in the height of the liquid column depending on the pressure during its preliminary compression.

At present NSC “Institute of Metrology” participates in international comparisons of COOMET “Supplementary comparison of national standards of gauge pressure in the range from 1 MPa to 10 MPa” (COOMET.M.P-S1), where it is a pilot laboratory. In future – participation in international comparisons for other pressure and vacuum ranges. The national standards created by the NSC “Institute of Metrology” contribute to metrological traceability and the development of technologies in different fields, such as the fuel and energy complex, mechanical engineering, metallurgy, food and chemical industries, aircraft construction. In plans – increasing the amount of the existing reference measurement standards for the expanding the measurement range, as well as creating a national standard for differential pressures.

Gravity
The National primary measurement standard of the gravity acceleration unit, which includes a ballistic stationary gravimeter and a ballistic transportable gravimeter, a fundamental gravimetric point was created by NSC IM in 1996. The measurement standard maintains and transfers the unit of gravity to working measurement standards, as well as to working measuring instruments. Ballistic stationary and transportable, components of the measurement standard, are the measuring instruments of gravity acceleration.

The range of values of gravity acceleration is from 9.77 m/s² to 9.85 m/s². The expanded uncertainty of measurements $U = 11\cdot10^{-8}$ m/s² with a coverage factor $k = 2$ and confidential probability $P=0.95$. The measurement standard participated in the comparisons of absolute gravimeters COOMET.M.G-S1 (COOMET Project 634/UA/14).

Prospective areas planned in the field of gravimetry:

Since 2012 scientific and research works are being performed: “Development and research of a ballistic laser gravimeter based on precision mobile devices using linear pulsed electromechanical transducers to measure the absolute value of gravity acceleration”. (Patent № 96904, Ukraine; Patent № 111307, Ukraine; Patent № 2011128560, Russia). In 2018 there was started an initiative scientific and research work: “Development and research of an absolute gravimeter based on precision atomic interferometry of ultracold atoms with laser cooled atoms and their spatial localization”.

Fields of application
- Metrology: ensuring reproduction of physical quantities: mass, force, pressure;
- Geodesy: creation of planned high-altitude geodetic and gravimetric networks;
- Geophysics: mineral exploration, geodynamic processes research;
- Space engineering: for calibrating satellite measurement systems.

Hardness
Scientific Centre of the Mechanical Measurements provides the standard measurements in the fields of hardness. NSC IM has two National measurement standards: National Primary Standard of Hardness Units on Rockwell and Superficial-Rockwell scales and National Primary Standard of Hardness Units on Brinell and Vickers scales.

National Primary Standard of Hardness Units on Rockwell and Superficial-Rockwell scales has five hardness levels 80-86 HRA, 80-100 HRBW, 20-30 HRC, 40-50 HRC, 60-70 HRC and six hardness levels 90-94 HR15N, 40-50 HR30N, 76-84 HR30N, 43-54 HR45N, 47–53 HR30TW, 70-82 HR30TW.

National Primary Standard of Hardness Units on Brinell and Vickers scales has six blocks of the Brinell scales with hardness levels 100 HBW 5/250/15, 200 HBW 5/750/15, 400 HBW 5/750/15,
100 HBW 10/1000/15, 200 HBW 10/3000/15, 400 HBW 10/3000/15 and six hardness levels 450 HV1, 750 HV1, 450 HV5, 750 HV5, 450 HV30, 750 HV30.

NSC IM participates in international comparisons in the field of hardness measurements and acts as a pilot laboratory (COOMET.M.H-S8).

**Liquid flow**

Liquid flowmeters are used in almost all sectors of the Ukrainian economy. For metrological assurance of reference and working flowmeters, the national primary standard of the unit of volume liquid flow in the range from 2.8·10⁻⁴ m³/s to 2.8·10⁻² m³/s, mass liquid flow in the range from 2.8·10⁻¹ to 28 kg/s, liquid volume in the range from 0.1 m³ to 3.0 m³, and liquid mass in the range from 100.0 kg to 3000 kg running through the pipeline, DETU 03-04-04 (hereinafter – the measurement standard), is used. The measurement standard realises the weight principle of operation, for which a tank with water is weighed on the scales that has passed through the flow meter.

Metrological characteristics of the measurement standard:
- measuring range from 0.1 m³/h to 100 m³/h
- maximum permissible error ± 0.04%.

The measurement standard takes part in the international comparisons using the Coriolis flowmeters as the transfer standards.

NSC IM maintains the primary measurement standard of the unit of liquid volume. Measuring instruments for measuring the volume of liquid is used in almost all sectors of the economy of Ukraine. One of the main methods of measuring the volume of liquid is the static method using capacity measures. For metrological assurance of liquid volume measurements, working standards of the 1st and 2nd classes are used, which receive the size of the unit of liquid volume from the national primary standard of the unit of liquid volume, DETU 03-03-13 (hereinafter – the measurement standard). Calibration of working standards of the 1st class (measuring tanks) on the measuring standard is performed by the weight method using distilled water.

Metrological characteristics of the standard:

<table>
<thead>
<tr>
<th>Range</th>
<th>Expanded uncertainty $U$</th>
</tr>
</thead>
<tbody>
<tr>
<td>from 1·10⁻³ m³ to 1·10⁻¹ m³ and from 5·10⁻¹ m³ to 1 m³</td>
<td>8·10⁻⁵</td>
</tr>
<tr>
<td>from 1·10⁻¹ m³ (included) from 5·10⁻¹ m³ (included)</td>
<td>5·10⁻⁵</td>
</tr>
</tbody>
</table>

The measurement standard takes part in international comparisons, in which NSC “Institute of Metrology” is a pilot. The reference measuring tanks of the 1st class are used as the transfer standards.

### 3 International Comparisons

NSC IM participates in international comparisons and acts as a pilot laboratory. List of the comparisons is showed below.

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Description</th>
<th>Status</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>COOMET.M.M-K1</td>
<td>Comparison of mass standards Stainless steel kilogram standards</td>
<td>Approved for equivalence</td>
<td>Participant</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Status/Phase</td>
<td>Participant Type</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>COOMET.M.M-K5</td>
<td>Comparison of mass standards Mass: 200 mg, 1 g, 50 g, 200 g and 2 kg</td>
<td>Approved for equivalence</td>
<td>Participant</td>
</tr>
<tr>
<td>COOMET.M.M-S2</td>
<td>Supplementary bilateral comparison in the field of mass measurements Mass of 200 mg, 1 g, 50 g, 200 g and 1 kg</td>
<td>Report in progress, draft A</td>
<td>Pilot</td>
</tr>
<tr>
<td>COOMET.M.M-S5</td>
<td>Comparison of mass standards Mass: 50 mg, 50 g, 1 kg and 2 kg</td>
<td>Measurements completed</td>
<td>Pilot</td>
</tr>
<tr>
<td>EURAMET.M.M-S9</td>
<td>Sub-milligram mass comparison Mass: 0.5 mg, 0.2 mg, 0.2D mg, 0.1 mg and 0.05 mg</td>
<td>Approved</td>
<td>Participant</td>
</tr>
<tr>
<td>COOMET.M.P-S1</td>
<td>Comparison of standards of gauge pressure Gauge pressure: 1 MPa to 10 MPa</td>
<td>Report in progress, draft A</td>
<td>Pilot</td>
</tr>
<tr>
<td>COOMET.M.H-K1</td>
<td>Hardness (Vickers HV1, HV5, HV30) Hardness levels: 450 HV, 750 HV</td>
<td>Approved for equivalence</td>
<td>Participant</td>
</tr>
<tr>
<td>COOMET.M.H-S3</td>
<td>Comparison of national hardness standards of Superficial-Rockwell scales Hardness: Superficial-Rockwell 90-94 HR15N, 40-50 HR30N, 76-84 HR30N, 43-54 HR45N, 45-55 HR30TW, 70-82 HR30TW</td>
<td>Measurements completed</td>
<td>Pilot</td>
</tr>
<tr>
<td>COOMET.M.H-S4</td>
<td>Brinell Hardness Hardness levels: 100 HBW, 200 HBW, 400 HBW</td>
<td>Approved</td>
<td>Participant</td>
</tr>
<tr>
<td>COOMET.M.H-S5</td>
<td>Key comparison of national hardness standards of Rockwell scales Hardness: Rockwell A: 80 - 86 HRA; Rockwell B: 80 - 100HRBW; Rockwell C: 20 - 30 HRC, 40 - 50 HRC, 60 - 70 HRC, 25 HRC, 45 HRC, 65 HRC</td>
<td>Approved</td>
<td>Participant</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Status</td>
<td>Category</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>COOMET.M.G-S1</td>
<td>Gravitational acceleration Free-fall acceleration at a nominal value of 9.81 m/s²</td>
<td>Approved</td>
<td>Pilot</td>
</tr>
<tr>
<td>COOMET.M.FF-S6</td>
<td>Comparison of the determination of static volume of reference metallic tanks Volume of liquid: 5 L, 10 L and 20 L</td>
<td>Measurements in progress</td>
<td>Pilot</td>
</tr>
<tr>
<td>COOMET.M.FF-S7</td>
<td>Liquid volume Volume at 10 µL and 1000 µL</td>
<td>Measurements in progress</td>
<td>Participant</td>
</tr>
<tr>
<td>COOMET.M.FF-S10</td>
<td>Water flow and mass rate Flow rate From 0.1 t/h to 45 t/h</td>
<td>Measurements in progress</td>
<td>Participant</td>
</tr>
</tbody>
</table>

Degrees of equivalence of NSC IM national standards are showed below.

COOMET.M.M-K1
4. Published calibration and measurement capabilities of the institute
NSC IM has published CMCs in the field of mass and related quantities (mass – 5, gravity – 1, hardness – 1).

5. Research projects
NSC IM participates in EMPIR Project 19RPT02, “Improvement of the realisation of the mass scale”.
The aim of the project is developing of EURAMET calibration guidance for mass scale realization and creation of software tools.

Research of additional factors in the measurement equation and the uncertainty budget of the results of hardness measurements.

Development and research of a ballistic laser gravimeter based on precision mobile devices using linear pulse electromechanical transducers to measure the absolute value of gravitational acceleration.

NSC IM planed researched that concerned
Development and advancement of an absolute gravimeter based on precision atomic interferometry of ultracold atoms with laser cooling of atoms and space localization


Patents of NSC “Institute of Metrology” in the field of Mass and related quantities


SC-1 Scientific Centre of Temperature and Optical Measurements
SC-2 Scientific Centre of Space-Time Measurements
SC-3 Scientific Centre of Mechanical Measurements
SC-4 Scientific Centre of Legal Metrology, International Cooperation and Information Technologies
SC-5 Scientific Centre of Electromagnetic Measurements
SC-6 Scientific and Technical Centre of General Metrology, Conformity Assessment and Testing
SC-7 Scientific Centre of Quantum Measurements