



The features of the CIPM MRA implementation by the Azerbaijan Republic

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Abstract

Participation in the Mutual Recognition Arrangement (MRA) of the International Committee on Weights and Measures (CIPM) offers great opportunities for recognition in other countries of the results of calibration and measurements performed by National Metrology Institutes. The Azerbaijan Republic signed the Memorandum of Understanding of Euro-Asian Cooperation of National Metrological Institutions (COOMET) in 2007 and the Metre Convention in 2015. The Azerbaijan Institute of Metrology (AzMI) also signed the CIPM MRA in 2015.

Within the framework of the CIPM MRA, AzMI has been participating in nine international comparisons of the national measurement standards from 2012 to 2019 in four measurement areas (EM, M, RI, T). Key and supplementary comparisons of the measurement standards in different areas of measurements are carried out by Regional Metrology Organizations (RMOs), in particular COOMET. The results of five COOMET comparisons are published in the Key Comparison Database (KCDB) of the International Bureau on Weights and Measures (BIPM) already for EM, M, and T.

AzMI has total 25 published entries of calibration and measurement capabilities (CMCs) in KCDB of BIPM: 24 entries for temperature (T) and one entry for viscosity (M.V). The Institute has the ability to prepare for the publication of CMCs for EM and M. The Institute also can prepare for the publication of CMCs for RI, EM (using future results of comparison for electric resistance standards), and M (using future results of comparison for density of liquids and comparison for liquid volume).

Keywords: measurement; comparison; measurement standard; calibration and measurement capability; national metrology institute.

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Introduction

Participation in the Mutual Recognition Arrangement (MRA) of the International Committee on Weights and Measures (CIPM) [1] offers great opportunities for recognition in other countries of the results of calibration and measurements performed by National Metrology Institutes (NMIs). The Azerbaijan Republic signed the Memorandum of Understanding of Euro-Asian Cooperation of National Metrological Institutions (COOMET) in 2007 and the Metre Convention in 2015. The Azerbaijan Institute of Metrology (AzMI) as Azerbaijan NMI also signed the CIPM MRA in 2015.

The CIPM MRA plays an important role in ensuring the international equivalence of the national measurement standards of different countries through their comparisons [2] and publishing the calibration and measurement capabilities (CMCs) of NMIs [3]

that have signed this agreement. Results of all comparisons of the measurement standards are published in a special key comparison database (KCDB) of the International Bureau on Weights and Measures (BIPM) [4].

Key and supplementary comparisons of the measurement standards in different areas of measurements are carried out by Regional Metrology Organizations (RMOs), in particular COOMET. For RMO comparisons the reference value (RV) and degree of equivalence (DoE) of the national measurement standards with corresponding uncertainty are established. The obtained results of comparisons serve as the basis for the preparation and publication in KCDB of BIPM of the NMI CMCs after the corresponding inter-regional reviewing [5].

Metrological traceability is important for national accredited laboratories and industrial metrology [6, 7]. First of all, it is based on the results of comparison

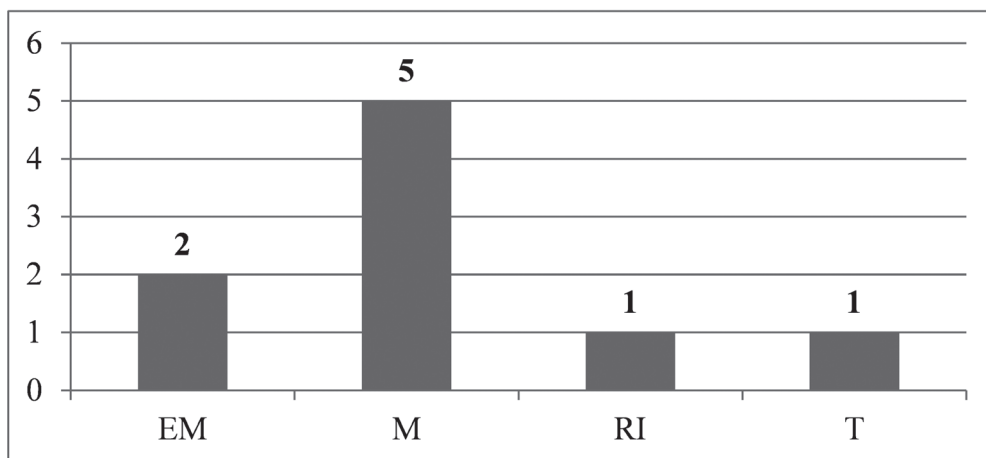


Fig. 1. The distribution of all comparisons by measurement areas

of the national measurement standards and calibration of measuring instruments and working standards for accredited calibration and testing laboratories. In this case, it is obligatory to assess the measurement uncertainty [8] at all stages of the implementation of metrological activities.

1. The problem statement, aim and objectives of the study

The research was aimed at developing recommendations for NMI with the aim of more effectively implement the provisions of the CIPM MRA and improving of metrological traceability at the national level.

To achieve this aim, the following objectives must be accomplished:

- to analyze the results obtained by AzMI in comparisons of the measurement standards in different measurement areas and published CMCs of AzMI;
- to establish and investigate the possibility of preparing new CMCs of AzMI based on the results of the performed comparisons in order to expand the base for calibration of measuring instruments and working standards for national accredited laboratories.

2. Comparisons of the national measurement standards

Within the framework of the CIPM MRA, AzMI has been participating in nine international comparisons of the national measurement standards (one is key comparison and eight are supplementary comparisons) from 2012 to 2019 in four measurement areas (EM – electricity and magnetism, M – mass and related quantities, RI – ionizing radiation, T – thermometry). As it can be seen, all comparisons are very

important for measurements that are massively carried out in the industry of the Azerbaijan Republic.

The distribution of all comparisons by measurement areas is shown in Fig. 1 (M includes measurement sub-areas: M.D – density of liquids, M.FF – liquids volume, M.M – mass, M.P – gauge pressure, M.V – liquids kinematic viscosity).

The results of 5 COOMET comparisons are published in the KCDB of BIPM already for EM (COOMET.EM-K6.a [9]), M (COOMET.M.V-S1 [10], COOMET.M.M-S4 [11], and COOMET.M.P-S5 [12]), and T (COOMET.T-S2 [13]).

COOMET.RI(I)-S3 comparison of the national measurement standards of air kerma for X-radiation quantities used for radiation protection and diagnostic radiology for RI, COOMET.EM-S19 comparison of electric resistance standards for EM, and COOMET.M.D-S1 comparison for density of liquids, and COOMET.M.FF-S7 comparison for liquid volume for M are in progress now.

3. Comparisons of the national measurement standards for electromagnetic quantities

The COOMET key comparison of AC/DC voltage transfer references (COOMET.EM-K6a) was performed in the framework of COOMET 566/UA/12 project from 2013 to 2014. In this comparison five NMIs took part: SE “Ukrmetteststandard” – UMTS (Ukraine), pilot laboratory; VNIIM (Russia); SMS – AzMI now (Azerbaijan); BelGIM (Belarus); INM (Romania).

RVs (x_{ref}) and expanded uncertainties (U_{ref}) for COOMET.EM-K6a comparison at frequencies of 20 Hz, 1 kHz, 20 kHz, 100 kHz, and 1 MHz are given in Table 1. DoE of NMI-participants are given on Fig. 2 at frequency of 1 kHz only (for example).

Table 1

RVs and expanded uncertainties at all frequencies

20 Hz		1 kHz		20 kHz		100 kHz		1 MHz	
x_{ref}	U_{ref}	x_{ref}	U_{ref}	x_{ref}	U_{ref}	x_{ref}	U_{ref}	x_{ref}	U_{ref}
3.22	5.38	0.30	3.48	-1.98	3.69	-6.81	6.14	-40.38	31.83

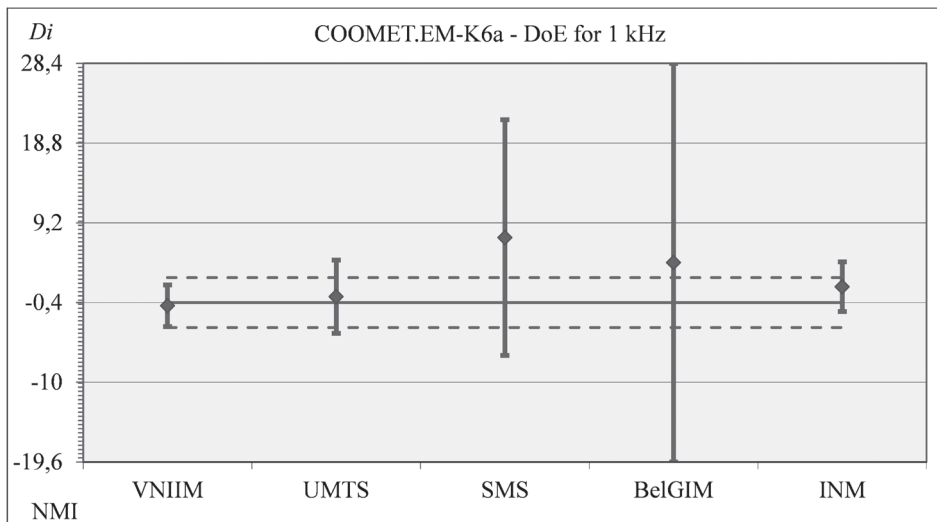


Fig. 2. DoE of NMI-participants at frequency of 1 kHz

Link of results from COOMET.EM-K6a to the CCEM-K6a [14] carried out between 1993 and 1999 was proposed (Fig. 3). VNIIM (Russia) is linking NMIs as far as they also participated in CCEM-K6a. The Azerbaijan Republic was not a signatory of the CIPM MRA at the time of the comparison therefore the results of the SMS were not linked. The linking of the SMS results was carried out in [15].

4. Comparisons of the national measurement standards for mass and related quantities

The COOMET supplementary comparison for measurement of liquids kinematic viscosity of 20 mm²/s, 100 mm²/s, 1000 mm²/s and temperature of 20 °C (COOMET.M.V-S1) was performed in the framework of COOMET 588/RU-a/12 project from February to May 2013. In this comparison two NMIs took part: VNIIM (Russia), pilot laboratory; AZSTAND – AzMI now (Azerbaijan).

Results of NMI-participants for COOMET.M.V-S1 comparison are given in Table 2 [10].

The COOMET bilateral supplementary comparison for mass standards (COOMET.M.M-S4) was performed in the framework of COOMET 722/AZ/17 project from December 2016 to February 2017. In this comparison two NMIs took part: CMI (Czech), pilot laboratory, and AzMI (Azerbaijan). The transfer standards were OIML class E₂ standard weights with nominal mass values of 5 kg, 500 g, 20 g, 2 g and 100 mg.

Deviations from mass (Δm) and expanded uncertainties ($U\Delta m$) for COOMET.M.M-S4 comparison are given in Table 3 [11].

The COOMET bilateral supplementary comparison of hydraulic gauge pressure standards from 5 to 34 MPa (COOMET.M.P-S5) was performed in the framework of COOMET 723/AZ/17 project from April to June 2017. In this comparison two NMIs took part:

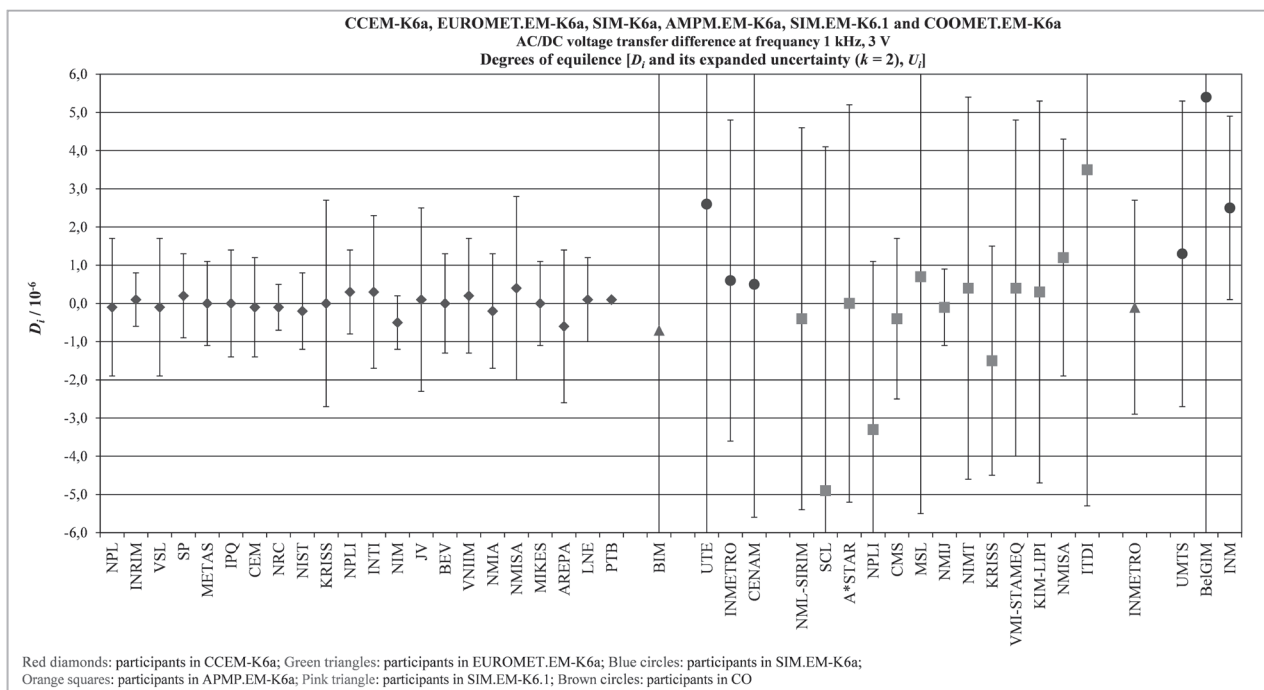


Fig. 3. Linked DoE of NMI-participants at frequency of 1 kHz

Results of NMI-participants for COOMET.M.V-S1 comparison, mm²/s

Table 2

Liquid	VNIIM		AzMI		Δ	$U(\Delta)$
	x_{VNIIM}	u_{VNIIM}	x_{AzMI}	u_{AzMI}		
20	19.446	0.096%	19.461	0.204%	0.015	0.451%
100	112.49	0.100%	112.64	0.230%	0.150	0.502%
1000	1007.3	0.100%	1007.2	0.300%	-0.100	0.620%

Note: $\Delta = x_{AzMI} - x_{VNIIM}$; $U^2(\Delta) = 2\sqrt{(u_{AzMI}^2 + u_{VNIIM}^2)}$

Deviations from mass and expanded uncertainties

Table 3

Nominal value	CMI		AzMI	
	Δm	$U_{\Delta m}$	Δm	$U_{\Delta m}$
5 kg	1.1 mg	0.8 mg	1.6 mg	0.8 mg
500 g	0.39 mg	0.09 mg	0.40 mg	0.08 mg
20 g	0.021 mg	0.009 mg	0.025 mg	0.008 mg
5 g	0.0131 mg	0.0053 mg	0.0189 mg	0.0041 mg
100 mg	0.0007 mg	0.0030 mg	0.0002 mg	0.0016 mg

CMI (Czech), pilot laboratory, and AzMI (Azerbaijan). The transfer standard was a digital manometer, Crystal XP 2i with the gauge pressure range from 0 to 34000 kPa.

Results of NMI-participants for COOMET.M.P-S5 comparison are given in Table 4 ($\Delta = x_{AzMI} - x_{CMI}$) [12].

5. Comparisons of the national measurement standards for temperature

The COOMET supplementary comparison for calibration of 100 Ω industrial platinum resistance thermometers in thermostats at temperature range from -40 to 420 °C (COOMET.T-S2) was performed in the framework of COOMET 642/MD/14 project

from August 2015 to February 2018. In this comparison seven NMIs took part: INM (Moldova), pilot laboratory, CSM (Kyrgyzstan), KazInMetr (Kazakhstan), GEOSTM (Georgia), IMBiH (Bosnia and Herzegovina), UME (Turkey), and AZSTAND (Azerbaijan). The transfer standards were two platinum resistance thermometers (PRTs).

Results of NMI-participants for COOMET.T-S2 comparison are given in Table 5 and in Fig. 4 at 30 °C only (for example) [13], where t is measured temperature reported by the NMI-participants; $R(t)$ is measured resistance reported by the NMI-participants; $U(t)$ is expanded uncertainties for $R(t)$; W_t is values defined as the quotient between the resistance value

Results of NMI-participants for COOMET.M.P-S5 comparison, kPa

Table 4

Conventional value of pressure	CMI		AzMI		Δ
	x_{CMI}	U_{CMI}	x_{AzMI}	U_{AzMI}	
0	0	1	0.0	0.6	0.0
5000	-1	1	-2.4	0.6	1.4
10000	-5	1	-5.7	1.7	0.7
15000	-8	1	-8.7	1.7	0.7
20000	-10	1	-10.5	1.6	0.5
25000	-11	2	-11.4	1.6	0.4
30000	-13	2	-12.8	1.8	-0.2
34000	-15	2	-14.7	1.5	-0.3
34000	-15	2	-14.7	1.5	-0.3
30000	-14	1	-13.1	1.7	-0.9
25000	-12	2	-12.1	0.8	0.1
20000	-10	1	-11.0	1.6	1.0
15000	-9	3	-9.5	1.6	0.5
10000	-5	1	-6.2	1.7	1.2
5000	-2	1	-2.9	1.6	0.9
0	-1	1	-0.2	1.5	-0.9

Results of NMI-participants for COOMET.T-S2 comparison

Laboratory	$t, ^\circ\text{C}$	$U(t), ^\circ\text{C}$	$R(t), \Omega$	$W(t_{cp}), \Omega/\Omega$
INM	29.985	0.012	111.9408	1.118571
CSM	29.961	0.020	111.9245	1.118606
AzMI	30.065	0.009	111.8511	1.118548
GEOSTM	30.003	0.012	111.9430	1.118614
IMBiH	29.976	0.007	111.9337	1.118554
UME	30.072	0.010	111.9725	1.118572
KazInMetr	30.030	0.046	112.0997	1.118659
INM	30.015	0.012	111.9523	1.118588

of the thermometer at the calibration point and the resistance value at the triple point of water; $W(t_{cp})$ is calculated W at the nominal value of the calibration point t_{cp} . RV of comparison at 30 °C is $W_{ref} = 1.118579 \Omega/\Omega$ and expanded uncertainties of RV at 30 °C is $U_{ref} = 0.014 ^\circ\text{C}$.

6. Calibration and measurement capabilities of the Azerbaijan Republic

AzMI has COOMET Certificate QSF-R53 on recognition of a quality management system according to ISO/IEC 17025 issued 01/31/2018 until 01/31/2023 for EM, M, RI, T. AzMI has a total of 25 published CMCs in KCDB of BIPM: 24 entries for temperature (T) in 2020 based on COOMET.T-S2 comparison and one entry for viscosity (M.V) in 2018 based on COOMET.M.V-S1 comparison.

AzMI has the ability to prepare for the publication of CMCs for EM (using published in 2016 results of COOMET.EM-K6.a comparison of AD/DC voltage transfer standards) and M (using published in 2019 results of COOMET.M.M-S4 comparison of mass stan-

dards and published in 2018 results of COOMET.M.P-S5 comparison of gauge pressure).

AzMI also can prepare for the publication of CMCs for RI (using future results of COOMET.RI(I)-S3 comparison of the national measurement standards of air kerma for X-radiation quantities used for radiation protection and diagnostic radiology from 2016 to 2017), EM (using future results of COOMET.EM-S19 comparison for electric resistance standards from 2015 to 2017), and M (using future results of COOMET.M.D-S1 comparison for density of liquids from 2012 to 2015, and COOMET.M.FF-S7 comparison for liquid volume from 2018 to 2019).

Summary

AzMI has been participating in COOMET comparisons of the national measurement standards in different measurement areas. It holds a valid COOMET Certificate on recognition of a quality management system according to ISO/IEC 17025. The Azerbaijan Republic has published CMCs in two measurement areas in KCDB of BIPM.

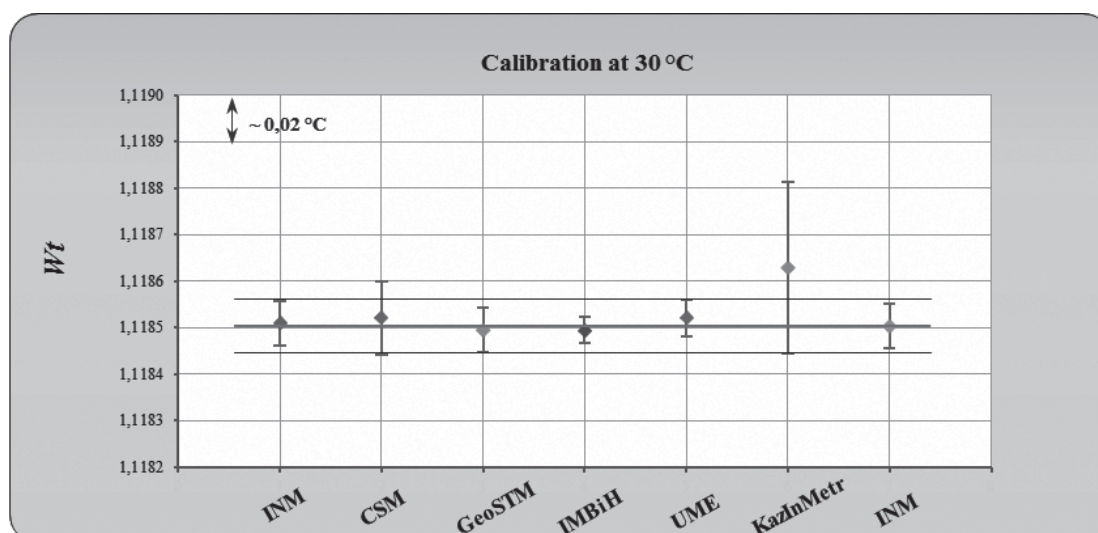


Fig. 4. Results of NMI-participants at 30 °C

AzMI has the ability to prepare for the publication of CMCs for EM and M (M.M, M.P) and also can prepare for the publication of CMCs for RI, EM and M using future results of COOMET com-

parisons. This will allow expanding the base for calibration of measuring instruments and working standards for national accredited calibration and testing laboratories.

Особливості реалізації Угоди CIPM MRA Азербайджанською Республікою

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Анотація

Участь в Угоді про взаємне визнання (MRA) Міжнародного комітету з мір та ваг (CIPM) пропонує великі можливості для визнання в інших країнах результатів калібрування та вимірювань, проведених національними метрологічними інститутами. Азербайджанська Республіка підписала Метричну конвенцію в 2015 році. Азербайджанський інститут метрології (AzMI) також підписав CIPM MRA у 2015 році.

Ключові та додаткові звірення еталонів у різних галузях вимірювань проводяться регіональними метрологічними організаціями (РМО), зокрема Європейсько-азіатського співробітництва національних метрологічних установ (COOMET). У рамках CIPM MRA AzMI брав і продовжує брати участь у дев'яти міжнародних звірваннях національних еталонів COOMET із 2012 по 2019 рр. у чотирьох галузях вимірювання (ЕМ, М, RI, Т), зокрема в одному ключовому звірванні та восьми додаткових.

Результати п'яти звірень COOMET вже опубліковані в Базі даних ключових звірень (KCDB) Міжнародного бюро з мір та ваг (BIPM) для ЕМ, М і Т. AzMI має діючий сертифікат COOMET про визнання системи управління якістю відповідно до стандарту ISO/IEC 17025. Азербайджанська Республіка опублікувала в KCDB BIPM рядки калібрувальних і вимірювальних можливостей (СМС) у двох видах вимірювань. AzMI має загалом двадцять п'ять опублікованих рядків (СМС) у KCDB BIPM: двадцять чотири рядки для температури (Т) і один рядок для в'язкості (М.V).

Інститут має можливість підготуватися до публікації СМС-рядків для ЕМ і М (М.М, М.Р), а для RI, ЕМ (використовуючи майбутні результати звірень для еталонів електричного опору) і М (використовуючи майбутні результати звірень щодо щільності рідин і звірень щодо об'єму рідини). Це дозволить розширити базу для калібрування вимірювальних приладів і робочих стандартів для національних акредитованих лабораторій калібрування та випробувань.

Ключові слова: вимірювання; звірення; еталон; калібрувальні та вимірювальні можливості; національний метрологічний інститут.

Особенности реализации Соглашения CIPM MRA Азербайджанской Республикой

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Аннотация

Участие в Соглашении о взаимном признании (MRA) Международного комитета мер и весов (CIPM) открывает большие возможности для признания в других странах результатов калибровки и измерений, выполненных

национальными метрологическими институтами. Азербайджанская Республика подписала Метрическую конвенцию в 2015 г. Азербайджанский институт метрологии (AzMI) также подписал CIPM MRA в 2015 г.

В рамках CIPM MRA AzMI участвовал и продолжает участвовать в девяти международных сличениях национальных эталонов с 2012 по 2019 гг. в четырех областях измерений (EM, M, RI, T). Результаты пяти сличений COOMET уже опубликованы в Базе данных ключевых сличений (KCDB) Международного бюро мер и весов (BIPM) для EM, M и T.

Всего AzMI опубликовал 25 строк калибровочных и измерительных возможностей (СМС) в KCDB BIPM: 24 строки для температуры (T) и одна строка для вязкости (M.V). Институт имеет возможность подготовиться к публикации СМС-строк для EM и M, а также для RI, EM (с использованием будущих результатов сличений эталонов электрического сопротивления) и M (с использованием будущих результатов сличений по плотности жидкостей и сличений по объему жидкости).

Ключевые слова: измерение; сличение; эталон; калибровочные и измерительные возможности; национальный метрологический институт.

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