Evaluation of current status in field of electrical voltage measurements

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Abstract. In this paper, evaluation of the current status in the field of electrical voltage measurement at a certain moment is given. The reference base and measuring instruments of approved types are analyzed.

1. Introduction
Measurements are essential in any area of human activity [1-5]. In order to be able to effectively apply measurements in practice, it is necessary to change their results (within the required accuracy) when using other means and measurement methods, changing the operator, time and place of measurement and other components of the measuring process [6-8]. This property is called the uniformity of measurements in Russia and other CIS countries.

The legal basis for ensuring the uniformity of measurements is regulatory metrology, which is a set of the state acts and normative and technical documents of various levels that regulate metrological regulations, requirements and standards.

The system for ensuring the uniformity of measurements in accordance with GOST R 8.000-2015 “The state system for ensuring the uniformity of measurements. Main principles” is a set of legislative acts, a reference database, a database of measuring instruments, a base of standard samples, organizations, metrological standards, methodological documents that represent the metrological infrastructure of the Russian Federation. This infrastructure provides a reliable and efficient functioning of transport and healthcare systems, energy and communication complexes, state industries and defense sectors, trade and housing and public utilities, science and education. Recognition of the measurement and testing results, carried out in any country, is possible only if there is a metrological infrastructure, operating according to approved international rules and regulations.

2. Evaluation of the reference database
In the sphere of state regulation of ensuring the uniformity of measurements, all measurement results should be traced to the State Primary Standards (SPS) [9]. Information on the SPS of measurement units is taken from the Federal Fund for ensuring the uniformity of measurements. Information on the State Primary Standards of measurement units is presented in Table 1.
**Table 1. Information on the State Primary Standards of measurement units**

| Registration number | Description of a standard (SPS-State Primary Standard; SPSS-State Primary Special Standard) | Custodian Institute of a standard | Approval date | Date of information update |
|---------------------|-------------------------------------------------------------------------------------------------|---------------------------------|--------------|---------------------------|
| GAT (SS) 191-2011   | SPSS units of AC voltage of industrial frequency in the range from 1 to 500 kV               | FGUP "VNIIMS"                   | 2012         | 18.04.2016                |
| GAT (SS) 204-2012   | SPSS units of electrical voltage of standardized lightning and switching pulses in the range from 1 to 1000 kV | FGUP "VNIIMS"                   | 2012         | 15.04.2013                |
| GAT (SS) 182-2010   | SPSS units of pulsed electrical voltage with a pulse duration from 4·10^{-11} to 1·10^{-5} s | FGUP "VNIIMFTRI"                | 2011         | 29.04.2016                |
| GAT (SS) 176-2009   | SPSS AC voltage of the industrial frequency                                               | FGUP "VNIIMS"                   | 2010         | 15.06.2012                |
| GAT (SS) 181-2010   | SPSS units of DC voltage-volt in the range ±(1…500) kV                                      | FGUP "VNIIMS"                   | 2010         | 06.06.2012                |
| GAT (SS) 27-2009    | SPSS units of electrical voltage-volt in the frequency range of 3·10^7 - 2·10^9 Hz          | FGUP "VNIIM named after Mendeleev" | 2009         | 08.08.2012                |
| GAT (SS) 89-2008    | SPSS units of electrical voltage (volt) in the frequency range of 10 - 3·10^7 Hz            | FGUP "VNIIM named after Mendeleev" | 2008         | 10.08.2012                |
| GAT (SS) 13-01      | SPS electrical voltage units                                                                 | FGUP "VNIIM named after Mendeleev" | 2001         | 14.08.2012                |

The Federal Fund for ensuring uniformity of measurements contains information on about 10000 measurement standards for electric voltage. The number of approved standards is shown in Table 2 and in the distribution diagram of approved standards by year (Figure 1).

**Table 2 Number of approved standards**

| Year of approval of standards of measurement units | Number of approved standards of measurement units |
|---------------------------------------------------|-----------------------------------------------|
| 2012                                              | 175                                           |
| 2013                                              | 1030                                          |
| 2014                                              | 1796                                          |
| 2015                                              | 3312                                          |
| 2016                                              | 2015                                          |
| 2017                                              | 1207                                          |
Some information on secondary standards is shown in Table 3.

**Table 3. Information on secondary standards**

| No | Registration number | Description                                                                 | Custodian | CI, in months | Rosstandart Order |
|----|---------------------|------------------------------------------------------------------------------|-----------|---------------|-------------------|
| 1  | 2.1.ZBT.0914.2017   | State secondary standard (SSS) units of alternating electrical voltage in the range of values (0.1 – 10) V in the frequency range (30 – 2000) MHz | FBU       | 24            | 30.01.2018       |
| 2  | 2.1.ZZT.0225.2017   | State secondary standard units of alternating electrical voltage in the range from 2 mV to 1000 V in the frequency range from 10 Hz to 1 MHz | FGUP      | 12            | 30.10.2017       |
| 3  | 2.1.ZZM.0350.2017   | State secondary standard units of DC electrical voltage in the range from -1 to -100 KV and from 1 to 100 KV. | FGUP      | 12            | 14.03.2017       |
| 4  | 2.2.GZZ.0016.2017   | Secondary standard units of the scaling conversion factor and the phase shift of AC electrical voltage of the industry frequency in the range from 1 to 330/√3KV | LLC "NPP (RPE) Mars-Energo “ | 24            | 13.10.2015       |
| 5  | 2.1.ZZT.0011.2017   | State secondary standard units of harmonic currents in coaxial paths in the range from 0.1 to 3.0 V in the frequency range from 30 to 1000 MHz VET(SS) 27-01-05 | FGUP      | 24            | 20.08.2015       |
| 6  | 2.1.ZZB.0076.2017   | State secondary standard (reference standard) units of electrical voltage and electromotive force with nominal units 1 V and 10 V (GVET (SSS) 13-10-89) | FGUP "VNIIM named after Mendeleev " | 12            | 19.08.2015       |
| 7  | 2.1.ZSP.0617.2017   | State secondary standard units of AC voltage in the value range 0.0001 - 1000 V, in the frequency range 10 - 3·10^7 Hz | FBU "Test-St. Petersburg “ | 12            | 04.06.2015       |
| 8  | 2.1.ZBN.1882.2017   | State secondary standard units of AC voltage in the value range (0.1 - 10) V and in the frequency range (30 - 2·10^5) MHz | FBU "Nizhegorodsky SMCC“ | 24            | 01.06.2015       |
| 9  | 2.1.ZZT.0007.2017   | State secondary standard units of DC electrical voltage of nominal value of 1 V (VET (SSS) 13-13-01) | FGUP "VNIIMFTRI" | 36            | 26.03.2014       |
| 10 | 2.1.ZZV.0023.2017   | State secondary standard units of electrical voltage-transfer secondary standard with a nominal value of 1 V (GVET 13-3-2010) | FGUP "VNIIM named after Mendeleev “ | 12            | 31.12.2013       |
| 11 | 2.1. ZAY.0061.2013  | State secondary standard units of AC voltage in the value range of (0.1 - 300) V, (10 - 30·10^6) Hz | FBU "Krasnodarsky SMCC “ | 12            | 15.05.2013       |
| 12 | 2.1. ZAY.0050.2013  | State secondary standard units of AC voltage in the value range of (2·10^3 - 1·10^3) V, in the frequency range of (10 - 1·10^6) Hz | FBU "Krasnodarsky SMCC “ | 12            | 15.05.2013       |
| 13 | 2.1.ZZM.0026.2017   | State secondary standard units of electrical voltage GVET 13-12-04 | FGUP "VNIIMS“ | 36            | 13.03.2013       |

*Calibration interval
Figure 1. Diagram of number of approved standards by year

Analysis by the criterion “Calibration interval” is shown in Table 4.

| Year   | 2015 |
|--------|------|
| Month  | 6    |
| Number of | 13   |
| Year   | 2016 |
| Month  | 6    |
| Number of | 20   |
| Year   | 2017 |
| Month  | 6    |
| Number of | 25   |

Having conducted a standard analysis by the criterion “Calibration Interval”, it can be concluded that a general trend is maintained and the largest number of the measuring means has CI of 12 months. Having conducted a standard analysis by a year of the last periodic calibration, it can be concluded that a large number of standards are currently not calibrated with expired date of the last calibration. Having conducted a standard analysis by the grades, it can be concluded that the standards of the third grade were approved: for 2015 – 265 pcs, 2016 – 467 pcs, 2017 – 487 pcs; the next place in the number is occupied by the standards of the second grade.

3. Conclusion
Using the information of the Federal Fund for ensuring the uniformity of measurements and other scientific and technical sources, analysis of the reference database was conducted in this article. The analysis shows that in the reference database, most of the standards are of the third grade, the number of approved standards increased from 2012 up to 2015 with a decline in 2016. Having conducted a
standard analysis by the criterion “Calibration Interval”, it can be concluded that the general trend is maintained and the largest number of the measuring means has CI of 12 months.

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