FINAL REPORT

Supplementary comparisons of reference measuring systems of electric capacitance and loss dissipation factor on AC high voltage of power frequency COOMET 604/RU-a/13 (COOMET.EM-S18)

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Abstract – The supplementary comparisons of reference measuring systems of electric capacitance and loss dissipation factor (tan δ) on AC high voltage of power frequency in the voltage range from 1 to 150 kV have been performed among the following national metrological institutes (NMIs): VNIIMS, CMI, GEOSTM and SE "Ukrmetrteststandard". Its description and measurement results are presented below.

Index Terms – Comparisons, standard uncertainty, measurement, electric capacitance, loss dissipation factor (tan δ), transfer standard, AC voltage.

I. INTRODUCTION

Comparisons of reference measuring systems of electric capacitance and loss dissipation factor on AC high voltage of power frequency in the voltage range from 1 to 150 kV were carried out in 2013 – 2016 under COOMET project 604/RU-a/13 (COOMET.EM-S18).

The Pilot laboratory of the comparisons was VNIIMS. The comparisons were performed with the VNIIMS transfer standard or VNIIMS reference capacitor as an object of comparison by each participating laboratory in turn using their measuring equipment and reference systems for electric capacitance and loss dissipation factor (tan δ) measurements.

As each laboratory made measurements at different voltages and capacities, the comparison results are treated as a sequence of bilateral comparisons with a pilot laboratory (VNIIMS).

II COMPARISON TRAVELLING STANDARD

Brief description of VNIIMS reference measurement system

The VNIIMS mobile reference system for electric capacitance *C* and loss dissipation factor (tan δ) of electric AC voltage of power frequency in the range of nominal values from 1 to 150 kV measurements is represented on Pictures 1 - 2.

The reference system providing reproduction of electric capacitance *C* of electric AC voltage of power frequency in the range of nominal values from 1 to 150 kV consists of the following components (see Picture 1 below):

a) High voltage standard capacitor KVE-150;

b) Module for measuring the capacitance and loss dissipation factor (tan δ) MV-capacitor – MVE bridge

Picture 1 - VNIIMS reference equipment for electric capacitance *C* measurements

The VNIIMS mobile reference system for loss dissipation factor (tan δ) measurements is represented on Picture 2.

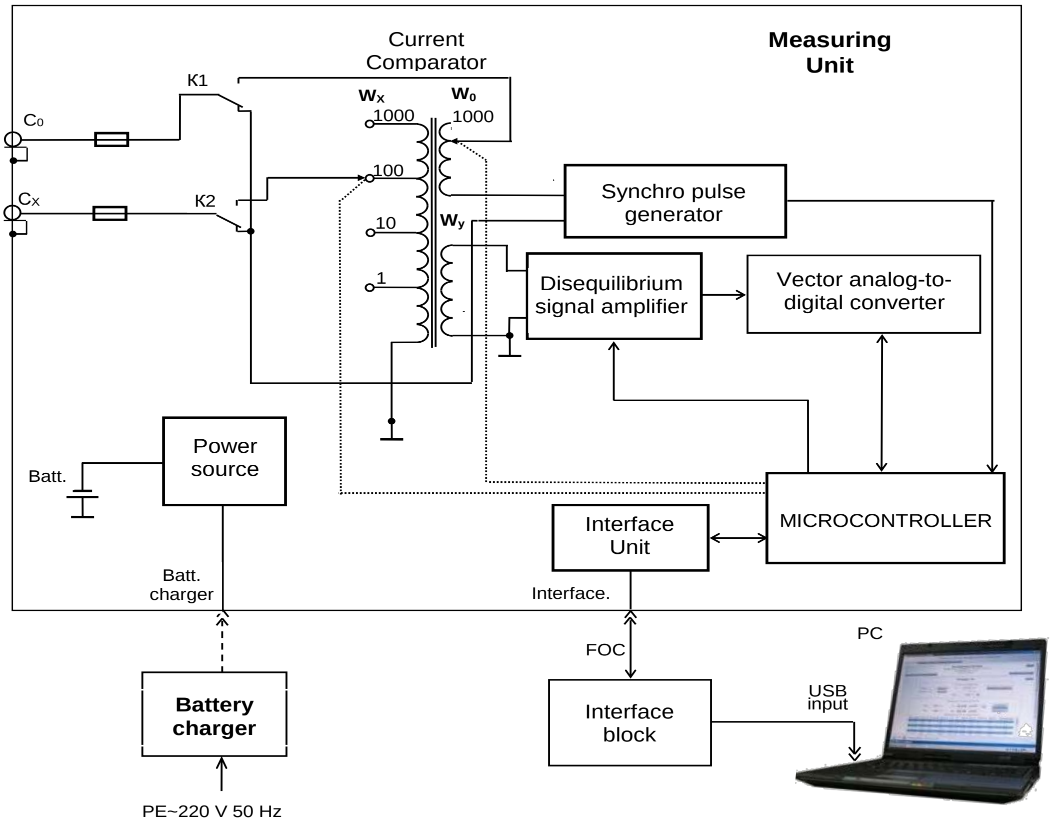
The reference system provides reproduction of loss dissipation factor (tan δ) of electric AC voltage of power frequency in the range of nominal values from 1 to 10 kV. The reference system consists of a module for measuring the capacitance and loss factor (tan δ) of the MV-capacitor – MVE bridge represented on Picture 1 b), and a reference for electrical capacitance and tan δ measurements of SA6221D-30-10, represented on Picture 2:

Picture 2 - VNIIMS reference SA6221D-30-10

The method of measurement of electric capacitance *C* and loss dissipation factor (tan δ) by means of the VNIIMS reference system is performed according to the scheme represented on Picture 3.

The first two steps are self-calibration of the reference standard. The third step is the measurement of the calibrated (investigated) transformer characteristics. If it is not necessary to check the product of the ratios of the reference capacitor to the measured capacitor and vice versa, then the second and third steps may be combined. The block diagram of self-calibration of the VNIIMS reference system and measurement of the characteristics of the voltage transformer is represented on Picture 3.

The ratio of currents and the ratio of phase displacements are set by reference low-voltage and high-voltage capacitors and compared by the reference high-voltage bridge (AC comparator) on the inputs: low-voltage (reference) and high-voltage (measured).



Picture 3 – Scheme of measurements with VNIIMS reference system

The Personal Computer (PC) is designed to control the measurement process, visualize the measurement results, and view the archive of measurement results.

The Measuring Unit (MU) combines the main components of the Module. Communication between PC and the MU is carried out using the Interface block (IB) via a fully dielectric fiber-optic cable (FOC), which ensures the safety of personnel. IB is connected to PC via a USB input. The built-in battery is used as a MU power source.

The Interface Unit (IU) performs the function of converting optical signals into electrical signals in MU.

The Current Comparator (CC), the reference capacitor (C_0), which is connected to the input, and the measured capacitor (C_X), which is connected to the C_X input, form a bridge measurement circuit.

The disequilibrium signal amplifier (DSA) amplifies the disequilibrium signal of the bridge circuit to the level necessary for the efficient operation of a vector analog-to-digital converter (VADC). VADC is a combination of two synchronous detectors with mutually quadrature reference oscillations and two analog-to-digital converters (ADC) connected to their outputs. The values of the codes read by the microcontroller from these ADCs are proportional to the corresponding quadrature components of the disequilibrium signal.

The microcontroller converts the commands coming from the PC into control signals of the measuring unit nodes, and also transmits to the PC through FOC the values of the codes generated by the ADCs, information about the overload of the input circuits by current and battery discharge.

The CC contains windings W_X and W_0, through which the compared currents flow (the current of the reference capacitor and the current of the measuring object) and the winding W_y, which serves to isolate the disequilibrium signal.

The synchro pulse generator (SPG) generates pulses synchronous with the measuring signal. The period of these pulses is measured using a microcontroller. Due to this, the reference oscillations formed by it for synchronous detectors in VADC are coherent with the currents compared by the CC.

The measurement process is based on the variational measurement method which provides for a change (variation) in the ratio of currents to a value known with the necessary accuracy. The difference between the values of the measured value before and after the variation is used as a calibration signal. The calculations necessary to obtain the result are performed by the PC.

When measuring tan δ, a differential method is used as long as tan δ of the sample capacitor is of the same order as the measured one.

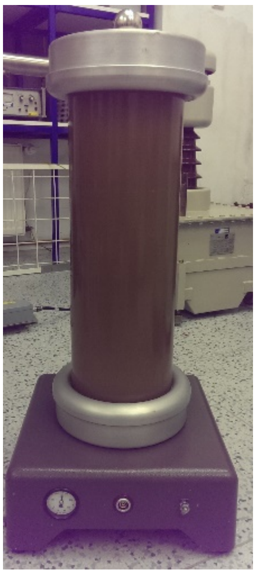
The VNIIMS reference system was self-calibrated before the measurements were made by each participant. The results of the self-calibration were stored in the reference comparator memory.

Brief description of participating NMIs' standards

CMI:

The CMI primary standard for electric capacitance *C* and loss dissipation factor (tan δ) of electric AC voltage of power frequency in the range of nominal values from 1 to 150 kV measurements is represented on Pictures 4 - 5.

The primary standard providing reproduction of electric capacitance *C* of electric AC voltage of power frequency in the range of nominal values from 1 to 150 kV consists of the following components (see Picture 4 below):



a) Gas-filled capacitor 3380/100/100;

b) High voltage comparator-bridge Tettex 2809 QJ for capacitance and tan δ measurements

Picture 4 - CMI primary standard for electric capacitance *C* measurements

The CMI primary standard for loss dissipation factor (tan δ) measurements is represented on Pictures 4b), 5.

The primary standard provides reproduction of loss dissipation factor (tan δ) of electric AC voltage of power frequency in the range of nominal values from 1 to 2 kV. The primary standard consists of a high voltage comparator-bridge Tettex 2809 QJ for capacitance and tan δ measurements represented on Picture 4 b), and an air capacitor 3320/1000, represented on Picture 5.

Picture 5 - CMI air capacitor 3320/1000

GEOSTM:

The GEOSTM primary standard for electric capacitance *C* and loss dissipation factor (tan δ) of electric AC voltage of power frequency in the range of nominal values from 1 to 75 kV measurements is represented on Pictures 6 - 7.

The primary standard providing reproduction of electric capacitance *C* of electric AC voltage of power frequency in the range of nominal values from 1 to 75 kV consists of the following components as shown in Picture 6 below:

a) Mica capacitor R.JAHRE; b) Gas-filled capacitor MCF 75/350 c) High voltage comparator-bridge MEP-03 for capacitance and tan δ measurements

Picture 6 - GEOSTM primary standard for electric capacitance *C* measurements

The GEOSTM primary standard for loss dissipation factor (tan δ) measurements is represented on Pictures 6c), 7.

The primary standard provides reproduction of loss dissipation factor (tan δ) of electric AC voltage of power frequency for operating voltage 1 kV. The primary standard consists of a high voltage comparator-bridge MEP-03 for capacitance and tan δ measurements represented on Picture 6 c), and a capacitor VGK-2, represented on Picture 7.

Picture 7 - GEOSTM capacitor VGK-2

A two-stage electromagnetic current comparator consisting of a system of two magnetic conductors made of an alloy with high magnetic permeability and a multilayer screen system: an electrostatic screen made of copper foil and an electromagnetic screen consisting of three layers with alternating screens of permalloy, copper and permalloy. This was used as the main node of the high voltage bridge MEP-03. The construction provides minimal noise of the circuit elements and negligible values of the parameters of the electromagnetic comparator windings: ohmic resistance, scattering inductance and internal capacitance. The shielding system provides attenuation of external electromagnetic fields. The high sensitivity of the two-stage electromagnetic current comparator ensures the comparison of currents of the order of units and tens of microamps with an error of 10^{-6}.

When measuring tan δ a direct method was used. With the direct method, the tangent of the dielectric loss dissipation factor of the reference and measured capacitors are of different orders.

<u>SE "Ukrmetrteststandard":</u>

The SE "Ukrmetrteststandard" primary standard for electric capacitance *C* and loss dissipation factor (tan δ) of electric AC high voltage of power frequency measurements is represented on Picture 8.

The primary standard consists of the following components as shown in Picture 8:

a) Vacuum capacitor SA 60002 and standard high voltage comparator-bridge MVE-01 for capacitance and tan δ measurements;   b) Gas-filled capacitor MSR-600

Picture 8 - SE "Ukrmetrteststandard" primary standard for electric capacitance *C* and tan δ measurements

Performance of SE "Ukrmetrteststandard" standard high voltage comparator-bridge MVE-01 is quite similar to the VNIIMS MVE bridge though some differences in the software may be possible.

III. MEASURED VALUES

Two values were measured during comparisons: electric capacitance and loss dissipation factor (tan δ). The dDifference between the measurement values of electric capacitance *C* is defined as:

$$\delta_{\mathrm{C}} = \frac{C_{NMI} - C_{\mathrm{VNIIMS}}}{C_{\mathrm{VNIIMS}}} \cdot 100\,\% \qquad (1)$$

where:

δc – difference between the measurement values of electric capacitance *C* of VNIIMS and participating NMI reference systems, %;

C_{VNIIMS} – value of electric capacitance *C* measured by VNIIMS reference system, pF;

C_{NMI} – value of electric capacitance *C* measured by participating NMI standard, pF.

Difference between the measurement values of loss dissipation factors (tan δ) is defined as:

$$\Delta tg\delta = tg\delta_{NMI} - tg\delta_{VNIIMS} \qquad (2)$$

where:

$\Delta tg\delta$ – difference between the measurement values of tan δ of VNIIMS and participating NMI reference systems;

$tg\delta_{VNIIMS}$ – value of tan δ measured by VNIIMS reference system;

$tg\delta_{NMI}$ – value of tan δ measured by participating NMI standard.

IV. SCHEDULE OF THE COMPARISONS

Table 4.1 – Schedule of the comparisons

№	NMI		Country	Dates of comparisons
pilot	VNIIMS	Russian research institute for metrological service (VNIIMS)	Russian Federation	2013 - 2016
1	CMI	Czech Metrology Institute (CMI)	Czech Republic	2013 - 2014
2	GEOSTM	Georgian National Agency for Standards and Metrology (GEOSTM)	Georgia	2013 - 2015
3	SE “Ukrmetrtes tstandard”	State enterprise “All-Ukrainian state research and production center for standardization, metrology, certification and consumers’ rights protection” (SE “Ukrmetrteststandard”)	Ukraine	2015 - 2016

V. PARTICIPANT’S CAPABILITIES

For the comparisons, NMIs made available national standards with the following metrological characteristics:

VNIIMS used national standard with rated value of primary voltage: U_1 = (1 – 150) kV;
expanded uncertainty of electric capacitance *C* (C_{VNIIMS}) = 0,015 %;
expanded uncertainty of dielectric dissipation factor (tan δ_{VNIIMS}) = 0,00005 in the range of nominal values from 1 kV to 10 kV.

CMI used national standard with rated value of primary voltage: U_1 = (1 – 100) kV;
expanded uncertainty of electric capacitance *C* (C_{CMI}) = 0,05 %;
expanded uncertainty of dielectric dissipation factor (tan δ_{CMI}) for operating voltage 1 kV is represented in Table 5.1.

Table 5.1

Measured value tan δ_x	**Expanded uncertainty**
5,0e-5	0,000025

Measured value tan δ_x	Expanded uncertainty
1,0E-04	0,000023
1,0E-03	0,000032
1,0E-02	0,000081
1,0E-01	0,000078

GEOSTM used national standard with rated value of primary voltage: U_1 = (1 – 75) kV;
expanded uncertainty of electric capacitance *C* (C_{GEOSTM}) = from 0,006 % to 0,019 %;
expanded uncertainty of dielectric dissipation factor (tan δ_{GEOSTM}) for operating voltage 1 kV is represented in Table 5.2.

Table 5.2

Measured value tan δ_x	Expanded uncertainty
0	0,000068
10^{-4}	
10^{-3}	0,000072
10^{-2}	0,00015

SE “Ukrmetrteststandard” used national standard with rated value of primary voltage:
U_1 = (1 – 100) kV for operating voltage from 1 kV to 2 kV;
expanded uncertainty of electric capacitance *C* ($C_{Ukrmetrteststandard}$) = 0,05 %;
expanded uncertainty of dielectric loss dissipation factor (tan $\delta_{Ukrmetrteststandard}$) = 3E-05. See summary in Table 5.3.

Table 5.3

Nominal value of electrical capacity, pF	5…100000
Nominal value of tan δ	0…1
Expanded uncertainty of electric capacitance *C*, %	0,05
Expanded uncertainty of dielectric lossdissipation factor	$3 \cdot 10^{-5}$

VI. OBJECTS OF COMPARISONS

During the comparisons, transportation of the reference capacitors and a reference for tan δ measurements used as the objects of comparisons, was organized by VNIIMS. Also some reference capacitors of the participating NMIs were used during the measurements in the high voltage laboratories of the participating NMIs with the use of reference systems of VNIIMS and NMIs standards.

Brief metrological characteristics of the capacitors used as objects of comparisons of VNIIMS and laboratories of participating NMIs stable in time are presented below.

6.1 *VNIIMS objects of comparisons*

The following VNIIMS capacitors were used as the objects of comparisons for capacity *C* measurements in CMI and GEOSTM high voltage laboratories:

6.1.1 Capacitor SA-6021-27-10

Picture 9

Table 6.1 Specification

High voltage range, kV	1…10
Nominal value of electrical capacity, pF	28
Nominal value of tan δ	$\pm 5\cdot 10^{-5}$

6.1.2 Capacitor KGI-30-1-1000

Picture 10

Table 6.2 Specification.

High voltage range, kV	1…30
Nominal value of electrical capacity, pF	995
Nominal value of tan δ	$\pm 5\cdot 10^{-5}$

6.1.3 Capacitor KGI -30-1-50

Picture 11

Table 6.3 Specification.

High voltage range, kV	1…30
Nominal value of electrical capacity, pF	60
Nominal value of tan δ	$\pm 5\cdot 10^{-5}$

6.1.4 Capacitor KGI-42-1-300

Picture 12

Table 6.4 Specification.

High voltage range, kV	1…40
Nominal value of electrical capacity, pF	314
Nominal value of tan δ	$\pm 5\cdot 10^{-5}$

6.1.5 Capacitor KGI-100-1-50.

Picture 13

Table 6.5 Specification.

High voltage range, kV	1…100
Nominal value of electrical capacity, pF	49
Nominal value of tan δ	$\pm 5 \cdot 10^{-5}$

6.1.6 VNIIMS reference SA6221D-30-10 was used as the object of comparisons for tan δ measurements in the CMI and GEOSTM high voltage laboratories.

Capacitor SA6210D-1-1000, represented on Picture 14, is equipped with a set of measures of the tangent of the dielectric dissipation angle.

Picture 14

Table 6.6 Specification.

Nominal high voltage value, kV	1
Nominal value of electrical capacity, pF	1000
Nominal values of tan δ	$5 \cdot 10^{-5}$ $1 \cdot 10^{-4}$ $1 \cdot 10^{-3}$ $1 \cdot 10^{-2}$ $1 \cdot 10^{-1}$

6.1.7 VNIIMS capacitor. The following VNIIMS capacitor was used as the object of comparisons for capacity *C* measurements in the UKRMETRTESTSTANDARD [1] high voltage laboratory:

Picture 15

Table 6.7 Specification.

High voltage range, kV	1…2
Nominal value of electrical capacity, pF	100
Nominal value of tan δ	$5{,}5 \cdot 10^{-5}$

[1] It was impossible for VNIIMS specialists to visit UKRMETRTESTSTANDARD high voltage laboratory with VNIIMS reference mobile equipment that is why it was decided to use VNIIMS capacitor as the object of comparisons. The voltage level was limited not by NMIs capabilities but by the nominal voltage of the object of comparisons.

6.2 *CMI objects of comparisons*

The following CMI capacitors were used as the objects of comparisons for capacity *C* measurements in the CMI high voltage laboratory additionally to VNIIMS objects of comparisons:

6.2.1 Air capacitor Tettex Instruments 3320/10.

Picture 16

6.2.2 Air capacitor Tettex Instruments 3320/100.

Picture 17

6.2.3 Air capacitor Tettex Instruments 3320/1000.

Picture 18

6.2.4 Air capacitor Tettex Instruments 3320/10000.

Picture 19

VII. METHODS AND MEASUREMENT PROCEDURE

All measurements within the framework of the comparison program were performed at AC voltage with a nominal frequency of 50 Hz.

<u>CMI</u>:

The HV transformer Trafo-Union PEO 8/100A/K-1, rated voltage 100 kV, rated power 8 kVA was used as a HV source and the stabilized voltage source SIEMENS MS 4-4, 50 Hz, was used as a power supply during comparisons in the CMI high voltage laboratory.

<u>GEOSTM</u>:

The HV transformer IOM 100/25, rated voltage 100 kV, rated power 25 kVA was used as a HV source and a stabilized voltage source, 50 Hz, was used as a power supply during comparisons in the GEOSTM high voltage laboratory.

Measurements of electric capacitance in the framework of comparisons in the CMI and GEOSTM HV laboratories were carried out according to the measuring capabilities of the participating NMIs. This also included alternate determination of the electrical capacitance of the investigated capacitors with the use of VNIIMS TRMS and NMI standard of the participating laboratory at the following voltage levels:

<u>CMI</u>:

– for HV gas-filled capacitor KGI-42-1-300 - 1; 5; 10; 15; 20 kV;

– for HV gas-filled capacitor KGI-30-1-1000 - 1; 5; 10; 20; 30 kV;

– for HV gas-filled capacitor KGI-30-1-50 - 1; 5; 10; 20; 30 kV;

– for capacitor SA6221D-30-10 - 1; 5; 10 kV;

– for capacitors 3320/10, 3320/100, 3320/1000 и 3320/10000 – 1 kV, 1,5 kV и 2 kV.

GEOSTM:

– for HV gas-filled capacitor KGI-42-1-300 - 1; 5; 10; 15; 20 kV;
– for HV gas-filled capacitor KGI-30-1-1000 - 1; 5; 10; 15; 20; 30 kV;
– for HV gas-filled capacitor KGI-30-1-50 - 1; 5; 10; 15; 20; 30 kV;
– for capacitor SA6021-27-10 - 1; 5; 10 kV.

SE "Ukrmetrteststandard":

– for VNIIMS capacitor - 1; 1,5; 2 kV.

Measurements of tan δ during the comparisons in CMI and GEOSTM were performed according to the measuring capabilities of the participating NMIs and included alternate determination of tan δ of the investigated capacitors with the use of VNIIMS TRMS and NMI standard of the participating laboratory at AC voltage of 1 kV of power frequency.

During the measurements, the values of the electrical capacitance of the objects of comparisons were determined alternately with the use of VNIIMS TRMS and NMI standard of the participating laboratory:

CMI:
from 10 pF to 1000 pF

GEOSTM:
from 30 pF to 1000 pF

SE "Ukrmetrteststandard":
100 pF

During the measurements, the values of tan δ were determined alternately from $5*10^{-5}$ to $1\cdot10^{-2}$ of the object of comparisons with a set of measures using the VNIIMS comparison reference and the CMI and GEOSTM standards. Testing VNIIMS capacitor – object of comparison sent to SE "Ukrmetrteststandard" - was performed in VNIIMS laboratory and in SE "Ukrmetrteststandard" laboratory not simultaneously as transportation of VNIIMS reference system there was not possible at the time being.

At least ten (10) readings were made for each measurement.

VIII. ANALYSIS OF COMPARISON DATA

For each combination of voltage steps the resulting comparison reference value (CRV) of the electric capacitance and dielectric loss dissipation factor for each bilateral supplementary comparison is calculated as the weighted mean of results of measurements presented by the participant NMI and VNIIMS:

$$C_0 = \frac{\sum_{L=1}^{n} C_L \cdot u^{-2}(C_L)}{\sum_{L=1}^{n} u^{-2}(C_L)}$$

$$\mathrm{tg}\delta_o = \frac{\sum_{L=1}^{n} tg\delta_L \cdot u^{-2}(tg\delta_L)}{\sum_{L=1}^{n} u^{-2}(tg\delta_L)} \qquad (3)$$

with standard uncertainty:

$$u(C_O) = \frac{1}{\sqrt{\sum_{L=1}^{n} u^{-2}(C_L)}}$$

$$u(\mathrm{tg}\delta_o) = \frac{1}{\sqrt{\sum_{L=1}^{n} u^{-2}(tg\delta_L)}} \qquad (4)$$

The difference in the participant's result to the CRV is given by:

$$\Delta C_L = C_L - C_O$$

$$\Delta tg\delta_L = tg\delta_L - tg\delta_o$$

with uncertainty

$$u(\Delta C_L) = \sqrt{u^2(C_L) - u^2(C_O)}$$

$$u(\Delta tg\delta_L) = \sqrt{u^2(tg\delta_L) - u^2(tg\delta_o)} \qquad (5)$$

The credibility of the reference values and their uncertainties is characterized by the χ^2 test, given by the formulae (5) and (6). Values of this function are determined for the results of electric capacitance χ_C^2 and dielectric loss dissipation factor $\chi_{tg\delta}^2$ measurement at all operation voltages and burdens are determined by formulae:

$$\chi_C^2 = \sum_{L=1}^{n} \frac{(C_L - C_O)^2}{u^2(C_L)}, \qquad (6)$$

$$\chi_{tg\delta}^2 = \sum_{L=1}^{n} \frac{(tg\delta_L - tg\delta_o)^2}{u^2(tg\delta_L)}, \qquad (7)$$

where C_o, $tg\delta_0$ - reference values of electric capacitance and dielectric loss dissipation factor measurements;

C_L, $tg\delta_L$ - are the results of electric capacitance and dielectric loss dissipation factor for each NMI participating in the particular bilateral comparison (VNIIMS and one other participant);

$u(C_L)$, $u(tg\delta_L)$ - combined standard uncertainties of electric capacitance and dielectric loss dissipation factor represented by each NMI participating in the particular bilateral comparison;

n – a number of NMIs participating in comparisons (equals 2 for bilateral comparisons).

IX. RESULTS OF COMPARISONS

The distribution function χ^2 is tabulated in Annex A. The received values χ_C^2 and $\chi_{tg\delta}^2$ do not exceed the critical value $\chi_{0,95}^2(n-1)$ for the confidence level P = 0,95 and number of degrees of freedom (*n*-1), that is an objective evidence of uncertainties declared by NMI during the comparisons:

$$\chi_C^2 < \chi_{0,95}^2(n-1) = 3.841, \qquad (8)$$

$$\chi_{tg\delta}^2 < \chi_{0,95}^2(n-1) = 3.841. \qquad (9)$$

Standard uncertainties had been used in the calculation of equivalence graphs represented below.

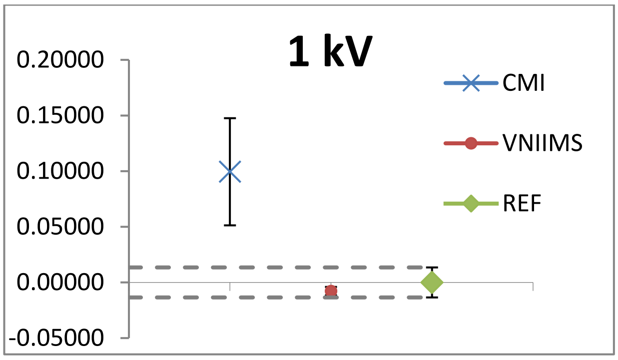
More detailed presentation of results of comparisons of electric capacitance in the form of the Tables A.1.1 – A 1.6, including the results of measurements of all NMI participating the comparisons, may be found in Annex A.

Results of comparisons

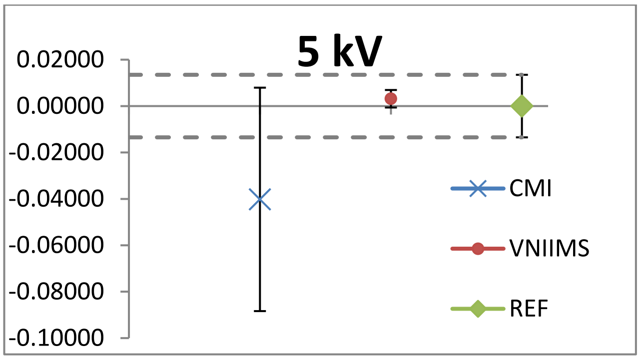
CMI:

A-1 Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor SA6221D-30-10, 2 pF [1].

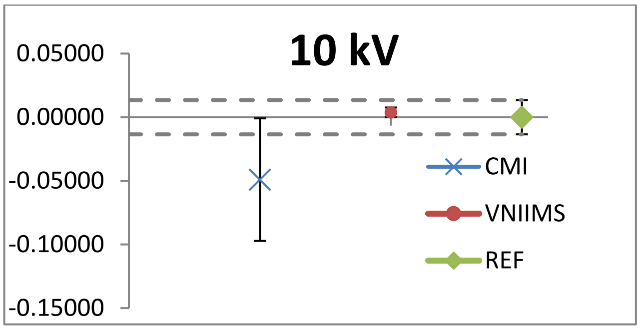
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	CMI	1	0,09944	0,04815
	VNIIMS	2	-0,00780	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	CMI	1	-0,04022	0,04815
	VNIIMS	2	0,00315	0,00377
	REF	3	0,00000	0,01348



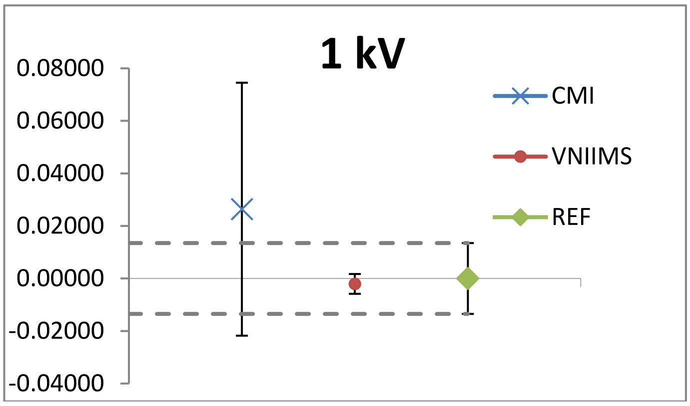
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	CMI	1	-0,04905	0,04815
	VNIIMS	2	0,00385	0,00377
	REF	3	0,00000	0,01348



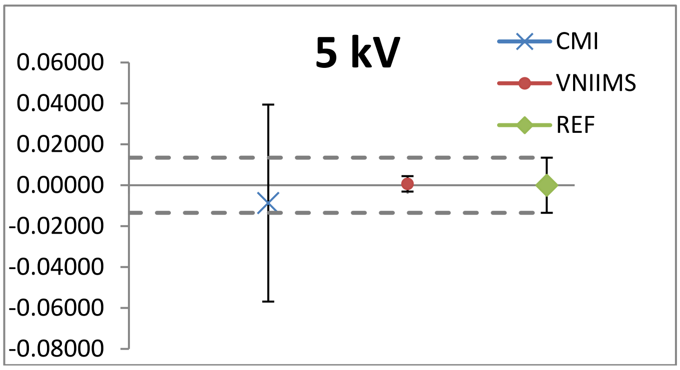
1 These uncertainties are not approved so far, so this point may be considered experimental and not obligatory for the comparisons measurements. CMC entries of the participants for values of electrical capacity below 10 pF do not exist so far. Presumably there is not enough sensitivity to measure such a low voltage with such a small capacity.

A-2 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor SA6221D-30-10, 8 pF.

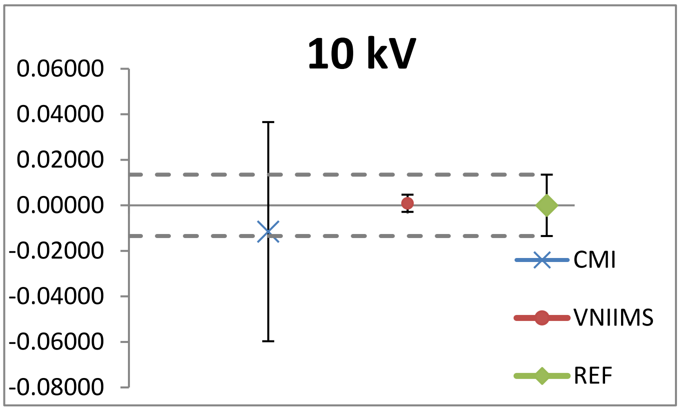
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	CMI	1	0,02637	0,04815
	VNIIMS	2	-0,00207	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	CMI	1	-0,00872	0,04815
	VNIIMS	2	0,00068	0,00377
	REF	3	0,00000	0,01348

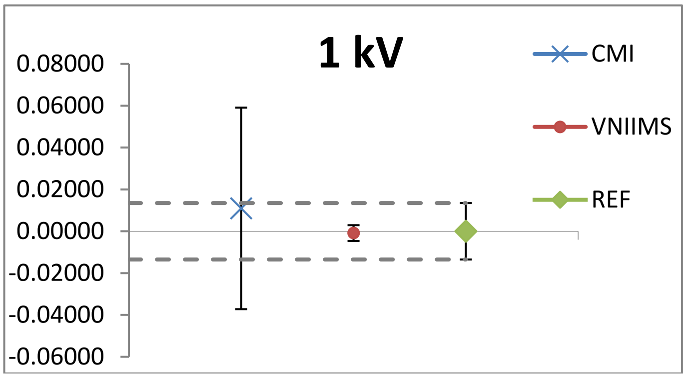


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	CMI	1	-0,01156	0,04815
	VNIIMS	2	0,00091	0,00377
	REF	3	0,00000	0,01348

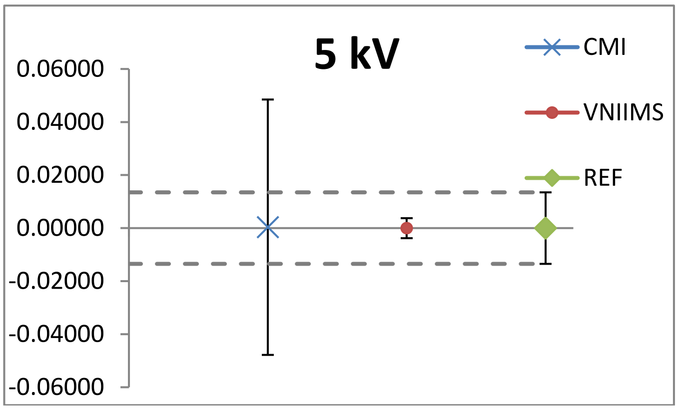


A-3 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor SA6221D-30-10, 30 pF.

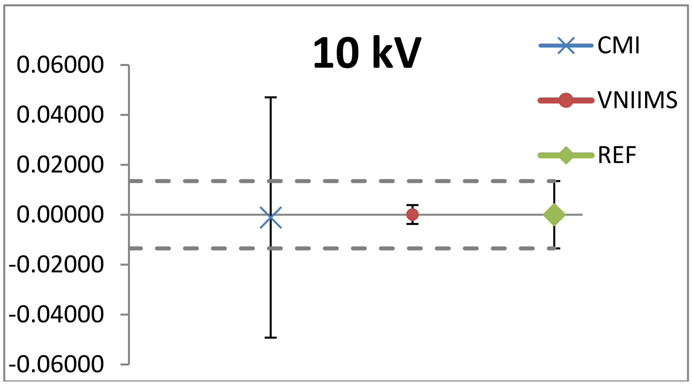
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
1	CMI	1	0,01092	0,04815
	VNIIMS	2	-0,00086	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
5	CMI	1	0,00034	0,04815
	VNIIMS	2	-0,00003	0,00377
	REF	3	0,00000	0,01348

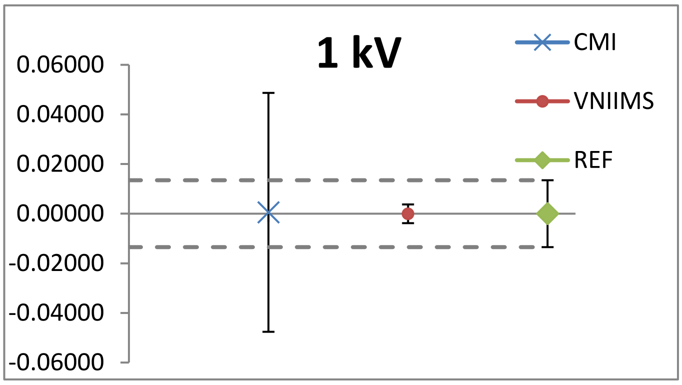


U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
10	CMI	1	-0,00110	0,04815
	VNIIMS	2	0,00009	0,00377
	REF	3	0,00000	0,01348

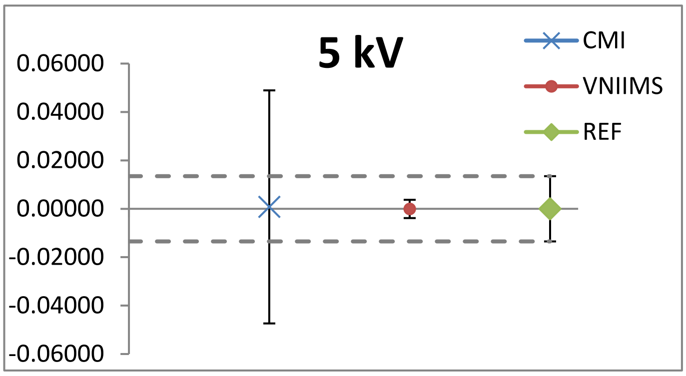


A-4 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor KGI-42-1-300, 314 pF.

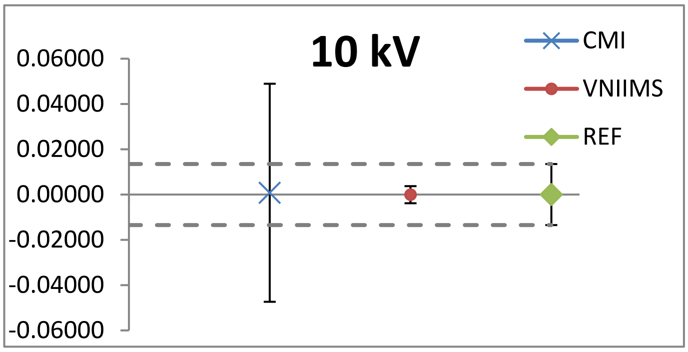
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
1	CMI	1	0,00054	0,04815
	VNIIMS	2	-0,00004	0,00377
	REF	3	0,00000	0,01348



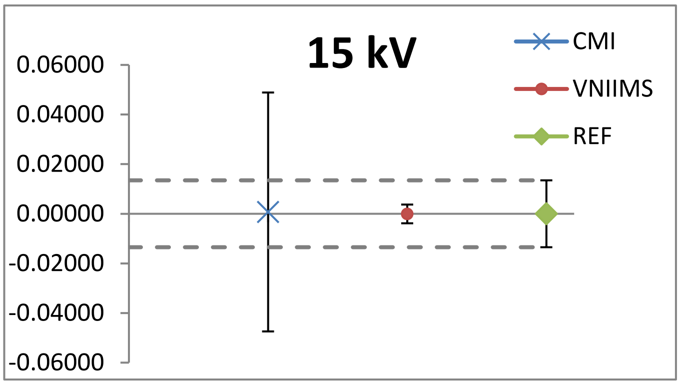
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
5	CMI	1	0,00078	0,04815
	VNIIMS	2	-0,00006	0,00377
	REF	3	0,00000	0,01348



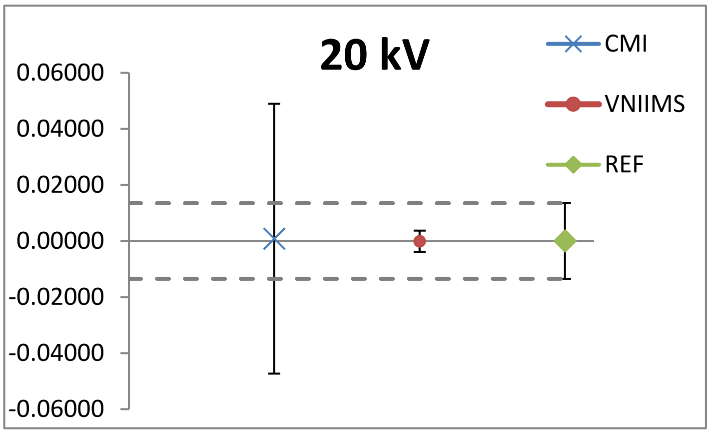
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
10	CMI	1	0,00078	0,04815
	VNIIMS	2	-0,00006	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
15	CMI	1	0,00073	0,04815
	VNIIMS	2	-0,00006	0,00377
	REF	3	0,00000	0,01348

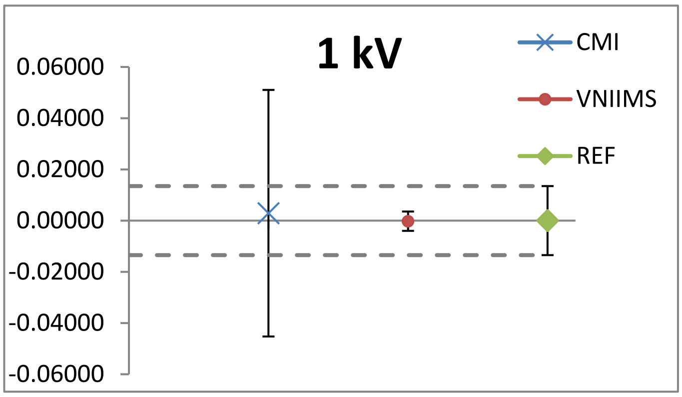


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	CMI	1	0,00083	0,04815
	VNIIMS	2	-0,00006	0,00377
	REF	3	0,00000	0,01348

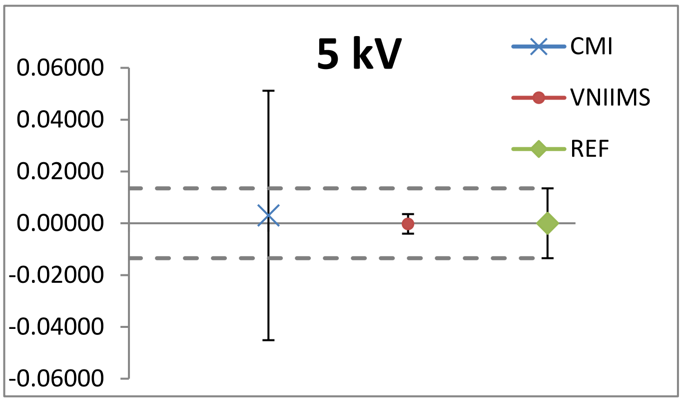


A-5 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor KGI-30-1-1000, 995 pF.

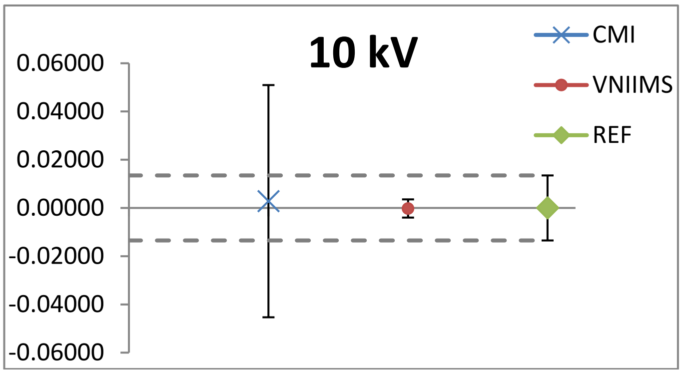
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	CMI	1	0,00289	0,04815
	VNIIMS	2	-0,00023	0,00377
	REF	3	0,00000	0,01348



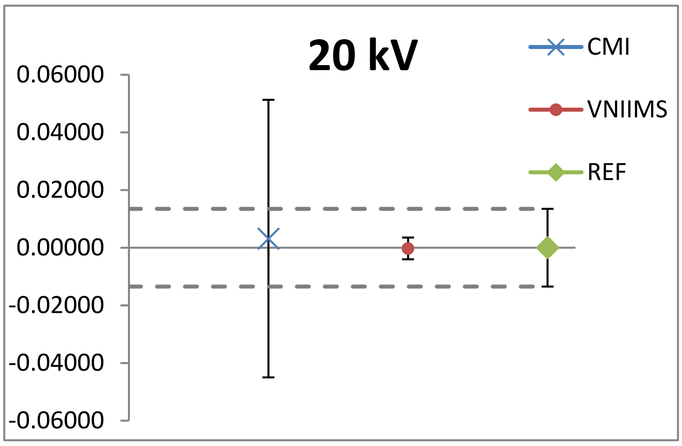
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
5	CMI	1	0,00301	0,04815
	VNIIMS	2	-0,00024	0,00377
	REF	3	0,00000	0,01348



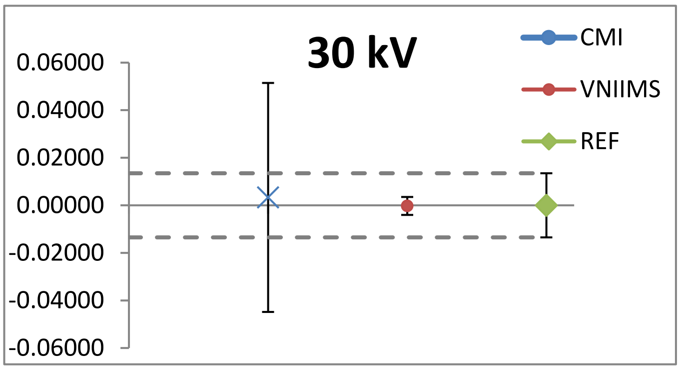
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
10	CMI	1	0,00281	0,04815
	VNIIMS	2	-0,00022	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
20	CMI	1	0,00316	0,04815
	VNIIMS	2	-0,00025	0,00377
	REF	3	0,00000	0,01348

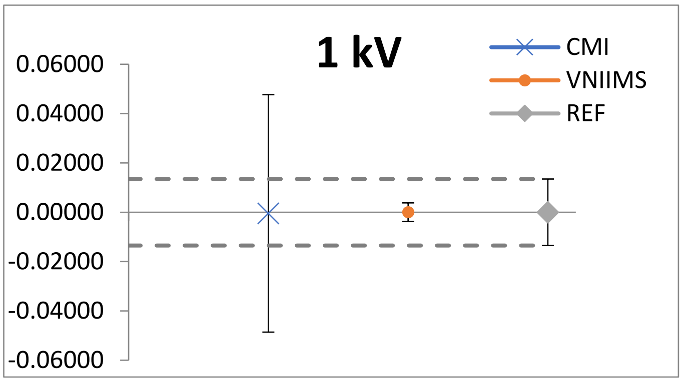


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
30	CMI	1	0,00332	0,04815
	VNIIMS	2	-0,00026	0,00377
	REF	3	0,00000	0,01348

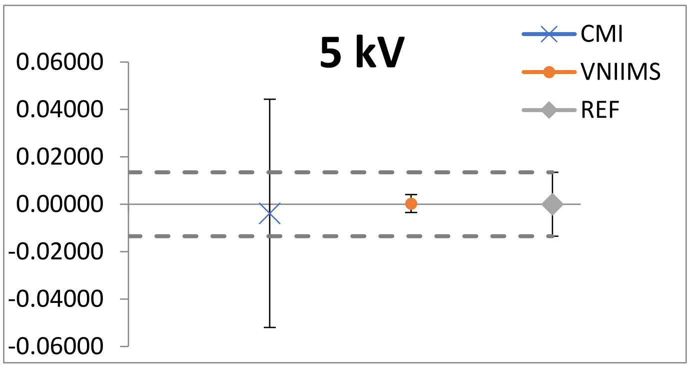


A-6 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor KGI-30-1-50, 60 pF.

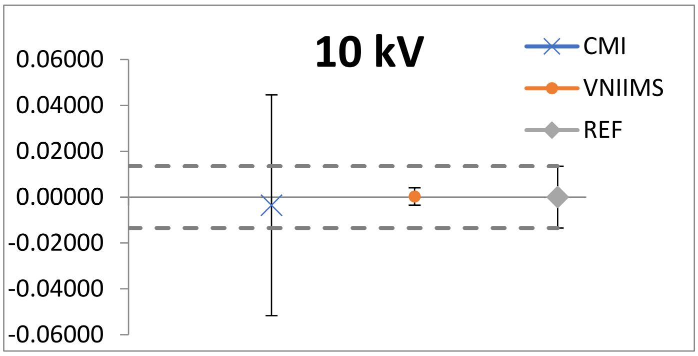
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	CMI	1	-0,00046	0,04815
	VNIIMS	2	0,00004	0,00377
	REF	3	0,00000	0,01348



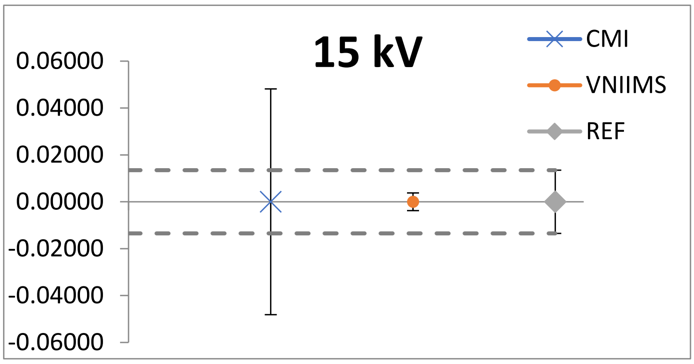
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	CMI	1	-0,00383	0,04815
	VNIIMS	2	0,00030	0,00377
	REF	3	0,00000	0,01348



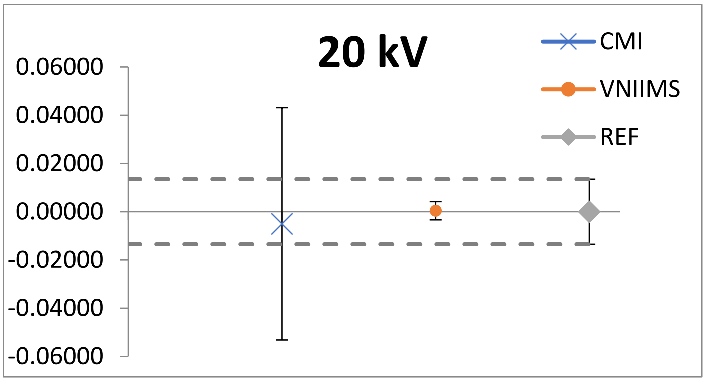
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	CMI	1	-0,00354	0,04815
	VNIIMS	2	0,00028	0,00377
	REF	3	0,00000	0,01348



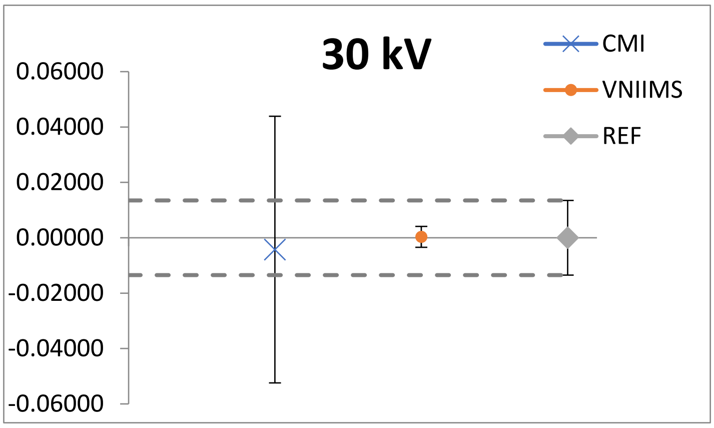
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	CMI	1	-0,00503	0,04815
	VNIIMS	2	0,00039	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	CMI	1	-0,00503	0,04815
	VNIIMS	2	0,00039	0,00377
	REF	3	0,00000	0,01348

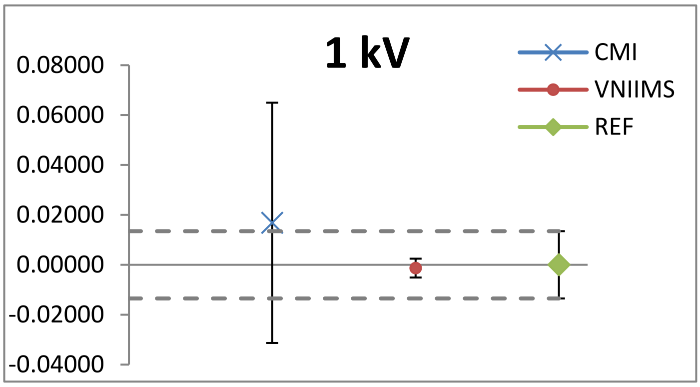


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
30	CMI	1	-0,00426	0,04815
	VNIIMS	2	0,00033	0,00377
	REF	3	0,00000	0,01348

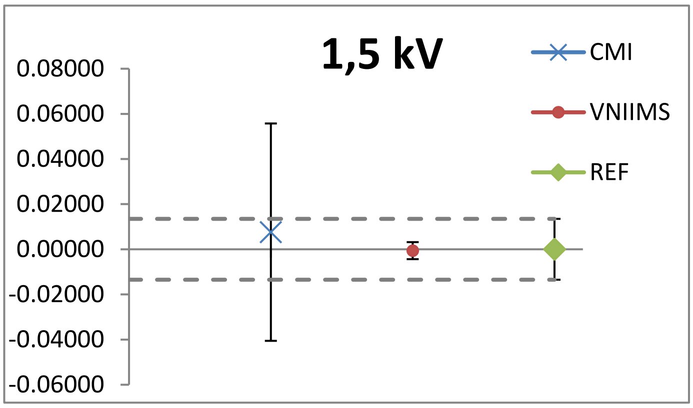


A-7 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor 3320/10, 10 pF.

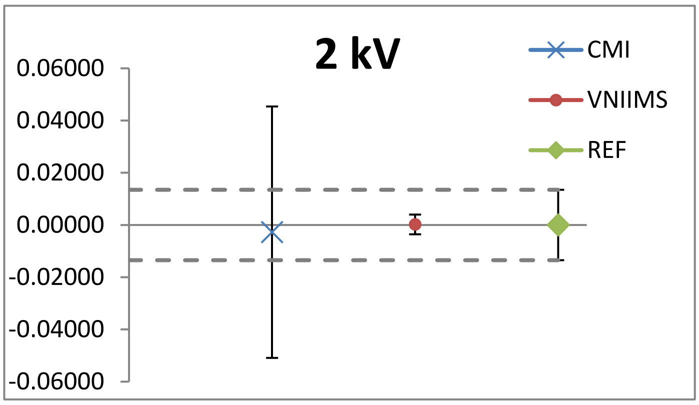
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	CMI	1	0,01682	0,04815
	VNIIMS	2	-0,00132	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1,5	CMI	1	0,00759	0,04815
	VNIIMS	2	-0,00060	0,00377
	REF	3	0,00000	0,01348

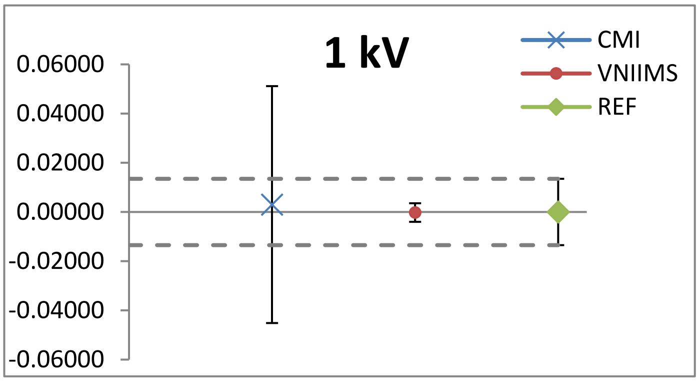


U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
2	CMI	1	-0,00275	0,04815
	VNIIMS	2	0,00022	0,00377
	REF	3	0,00000	0,01348

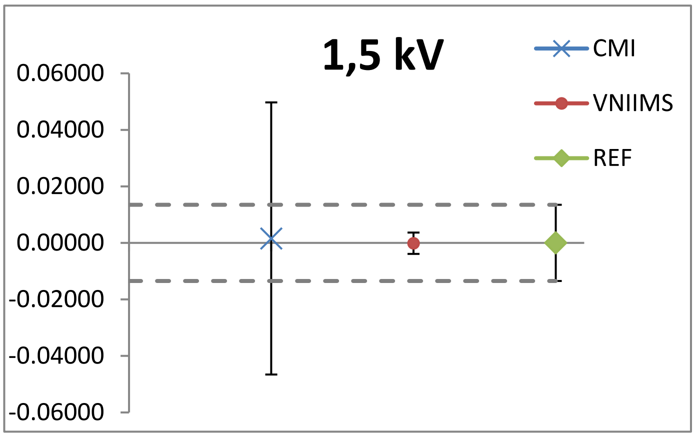


A-8 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor 3320/100, 100 pF.

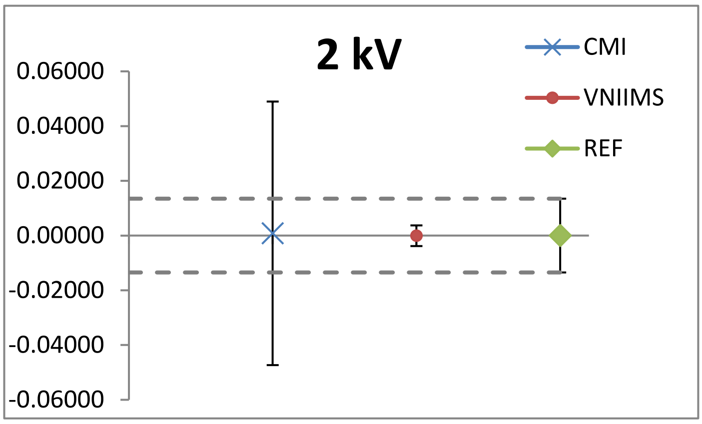
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
1	CMI	1	0,00300	0,04815
	VNIIMS	2	-0,00024	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
1,5	CMI	1	0,00157	0,04815
	VNIIMS	2	-0,00012	0,00377
	REF	3	0,00000	0,01348

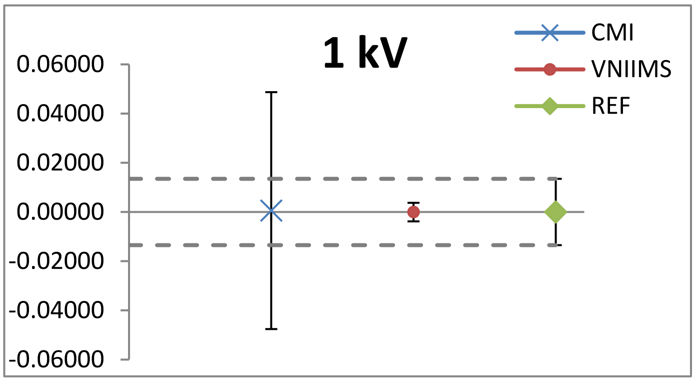


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
2	CMI	1	0,00081	0,04815
	VNIIMS	2	-0,00006	0,00377
	REF	3	0,00000	0,01348

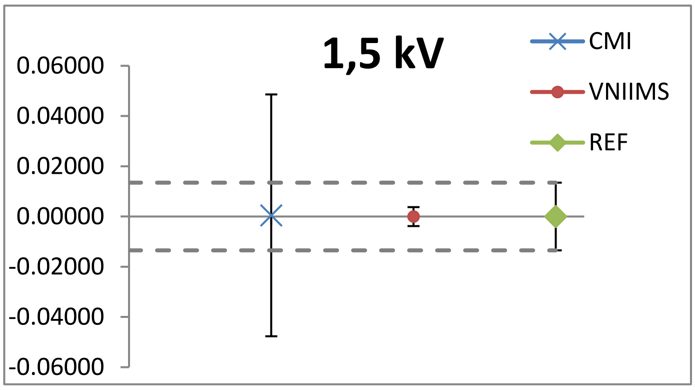


A-9 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor 3320/1000, 1000 pF.

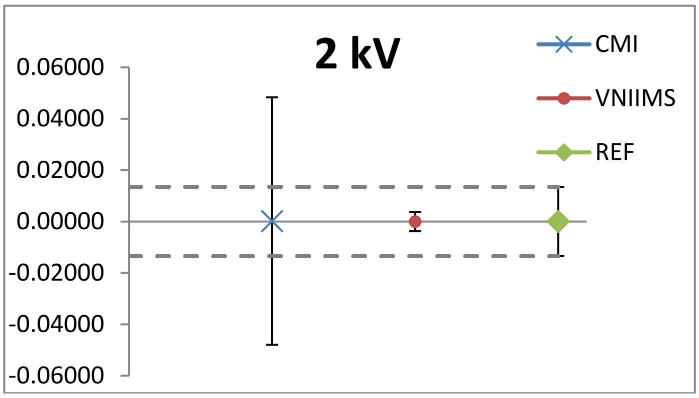
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	CMI	1	0,00056	0,04815
	VNIIMS	2	-0,00004	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1,5	CMI	1	0,00046	0,04815
	VNIIMS	2	-0,00004	0,00377
	REF	3	0,00000	0,01348

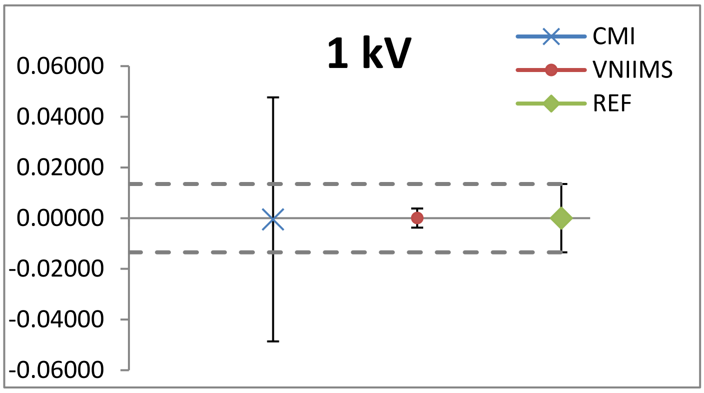


U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
2	CMI	1	0,00017	0,04815
	VNIIMS	2	-0,00001	0,00377
	REF	3	0,00000	0,01348

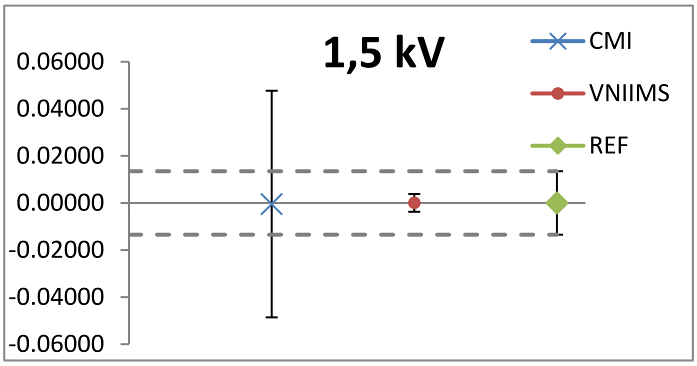


A-10 – Results of comparisons of electric capacitance between VNIIMS and CMI for capacitor 3320/10000, 10000 pF.

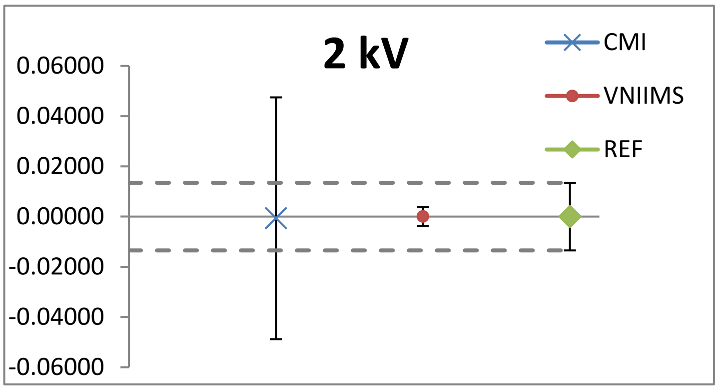
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
1	CMI	1	-0,00048	0,04815
	VNIIMS	2	0,00004	0,00377
	REF	3	0,00000	0,01348



U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
1,5	CMI	1	-0,00046	0,04815
	VNIIMS	2	0,00004	0,00377
	REF	3	0,00000	0,01348

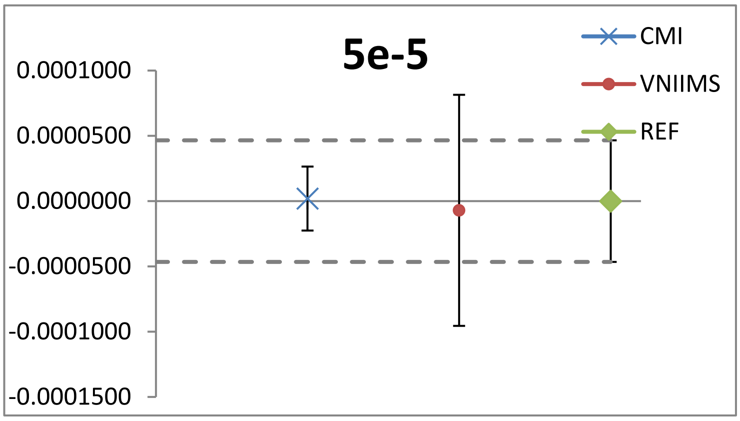


U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
2	CMI	1	-0,00067	0,04815
	VNIIMS	2	0,00005	0,00377
	REF	3	0,00000	0,01348

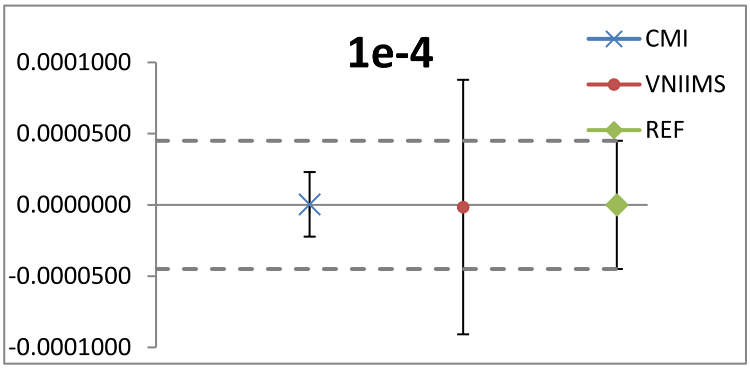


B-1 – Results of comparisons of loss dissipation factor (tan δ) between VNIIMS and CMI.

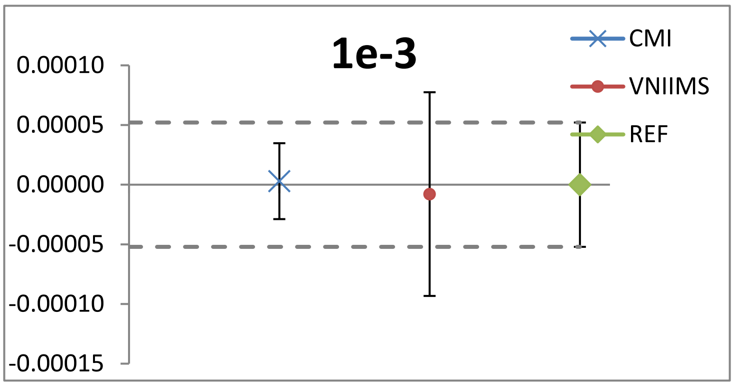
tan $\delta_{\text{ном}}$	LAB.	№	*Δ(tan δ)*	*U(Δtan δ)*
5e-5	CMI	1	0,0000020	0,000025
	VNIIMS	2	-0,0000071	0,000088
	REF	3	0,0000000	0,000047



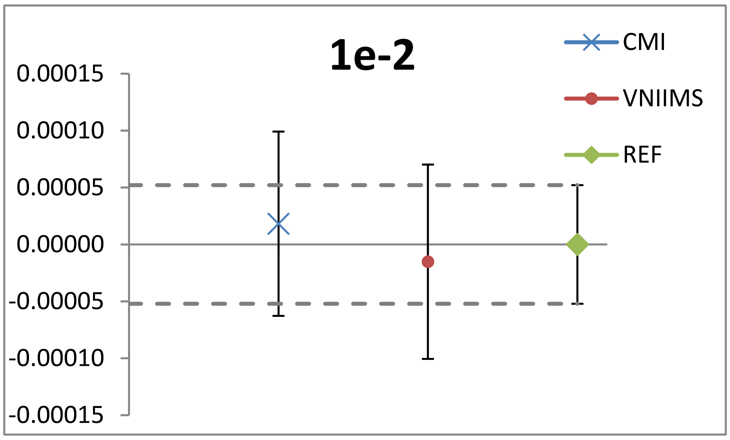
tan $\delta_{\text{ном}}$	LAB.	№	*Δ(tan δ)*	*U(Δtan δ)*
1e-4	CMI	1	0,0000004	0,000023
	VNIIMS	2	-0,0000015	0,000089
	REF	3	0,0000000	0,000045



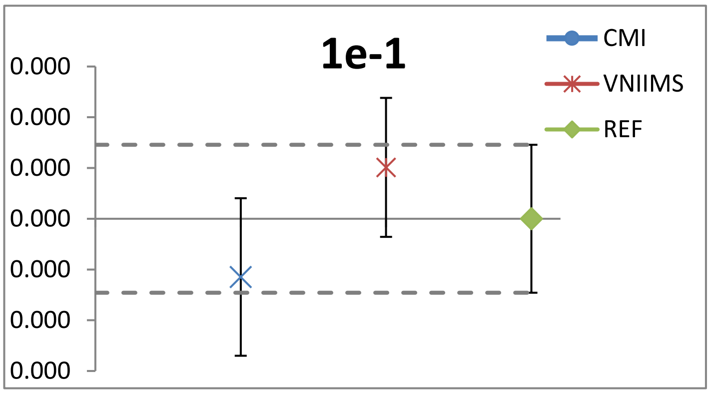
tan $\delta_{\text{хном}}$	LAB.	№	Δ(tan δ)	$U(\Delta$tan δ)
1e-3	CMI	1	0,00000	0,00003
	VNIIMS	2	-0,00001	0,00009
	REF	3	0,00000	0,00005



tan $\delta_{\text{хном}}$	LAB.	№	Δ(tan δ)	$U(\Delta$tan δ)
1e-2	CMI	1	0,00002	0,00008
	VNIIMS	2	-0,00002	0,00007
	REF	3	0,00000	0,00007



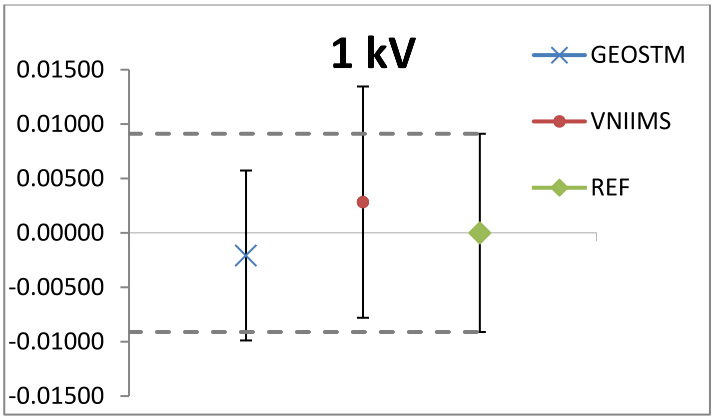
tan $\delta_{\text{хном}}$	LAB.	№	Δ(tan δ)	$U(\Delta$tan δ)
1e-2	CMI	1	-0,00006	0,000078
	VNIIMS	2	0,00005	0,000068
	REF	3	0,00000	0,000073



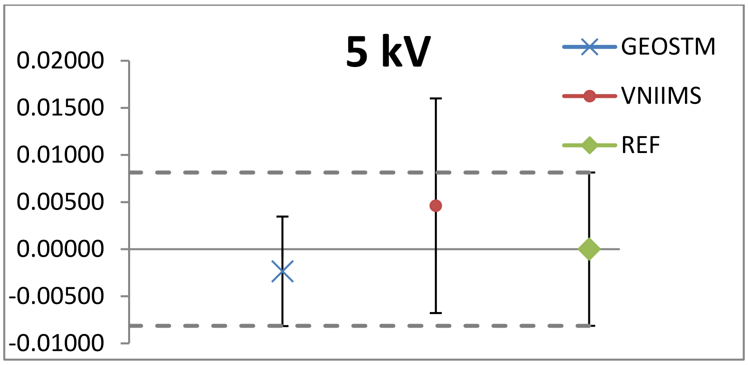
GEOSTM:

C-1 – Results of comparisons of electric capacitance between VNIIMS and GEOSTM for capacitor SA6021-27-100 and GEOSTM reference system: capacitor R.JAHRE and comparator-bridge MEP-03.

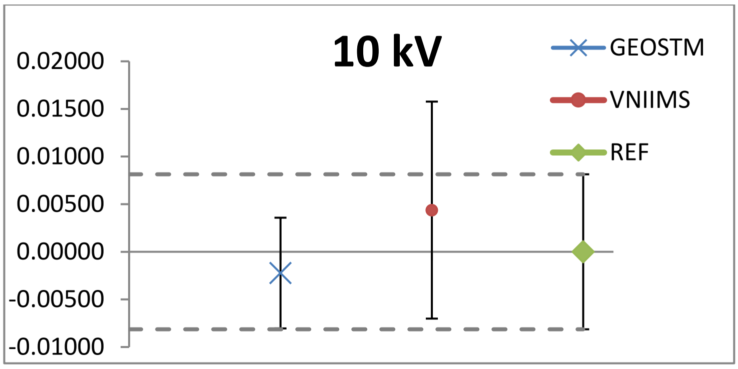
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
2	GEOSTM	1	-0,00208	0,00781
	VNIIMS	2	0,00283	0,01063
	REF	3	0,00000	0,00911



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	GEOSTM	1	-0,00235	0,00581
	VNIIMS	2	0,00461	0,01139
	REF	3	0,00000	0,00814

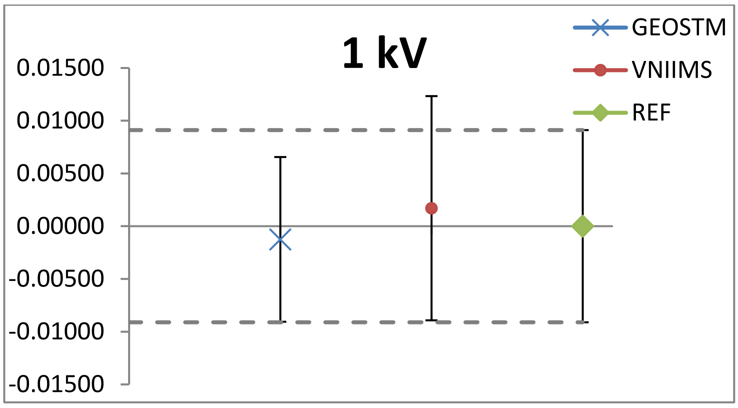


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	GEOSTM	1	-0,00223	0,00581
	VNIIMS	2	0,00438	0,01139
	REF	3	0,00000	0,00814

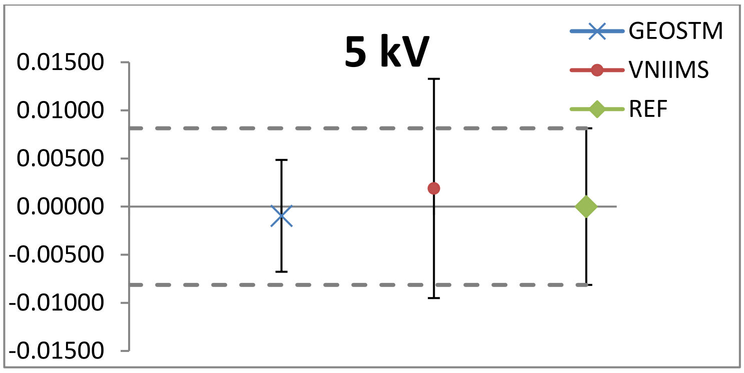


C-2 – Results of comparisons of electric capacitance between VNIIMS and GEOSTM for capacitor KGI-42-1-314 and GEOSTM reference system: capacitor R.JAHRE and comparator-bridge MEP-03.

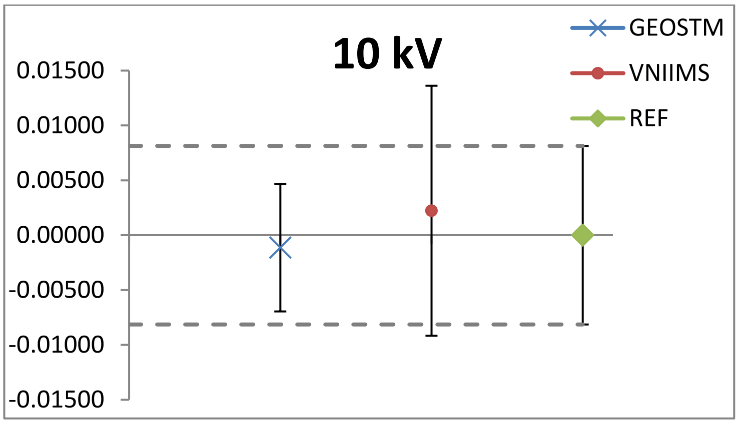
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	GEOSTM	1	-0,00125	0,00781
	VNIIMS	2	0,00170	0,01063
	REF	3	0,00000	0,00911



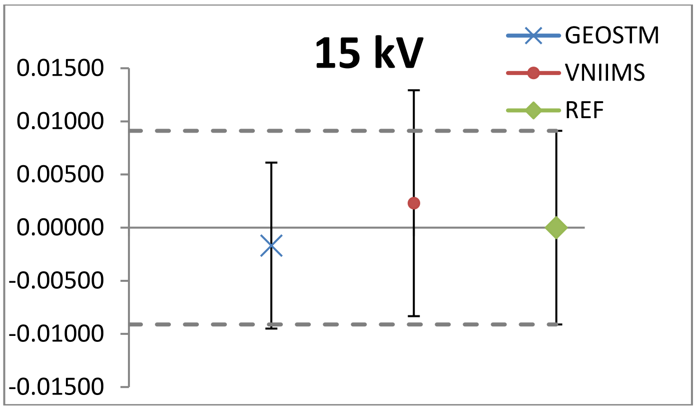
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	GEOSTM	1	-0,00096	0,00581
	VNIIMS	2	0,00188	0,01139
	REF	3	0,00000	0,00814



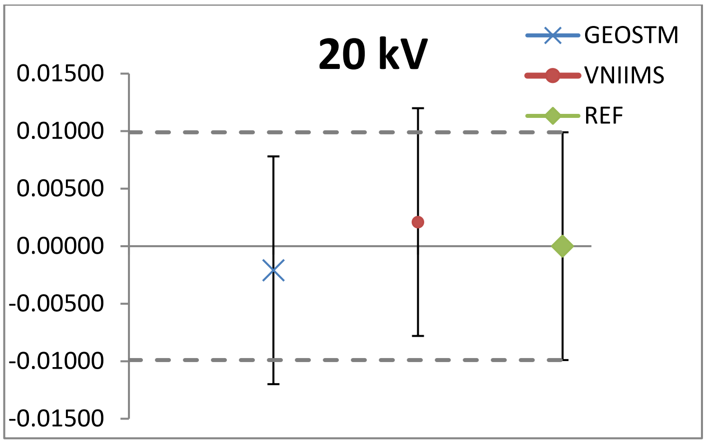
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	GEOSTM	1	-0,00114	0,00581
	VNIIMS	2	0,00223	0,01139
	REF	3	0,00000	0,00814



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
15	GEOSTM	1	-0,00169	0,00781
	VNIIMS	2	0,00230	0,01063
	REF	3	0,00000	0,00911

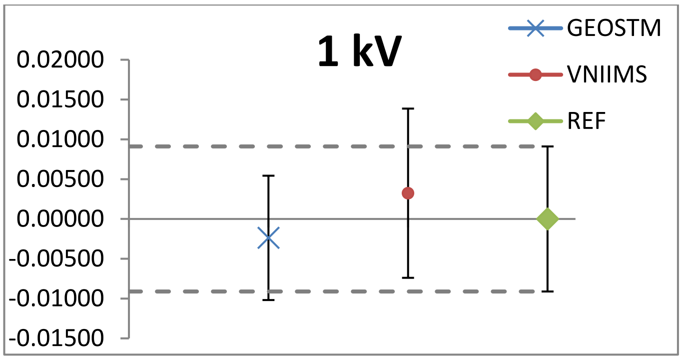


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	GEOSTM	1	-0,00210	0,00990
	VNIIMS	2	0,00210	0,00990
	REF	3	0,00000	0,00990

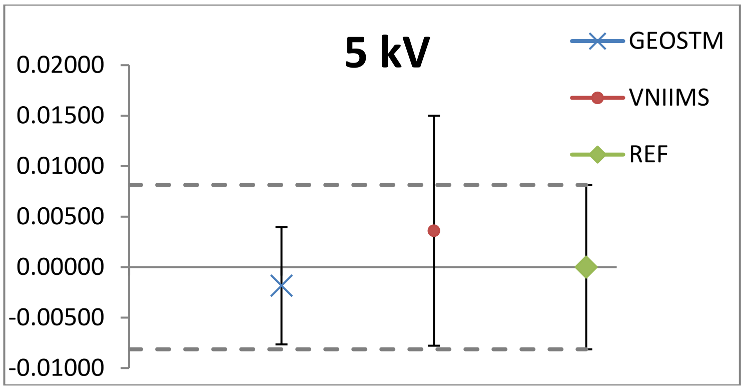


C-3 – Results of comparisons of electric capacitance between VNIIMS and GEOSTM for capacitor KGI-30-1000 and GEOSTM reference system: capacitor R.JAHRE and comparator-bridge MEP-03.

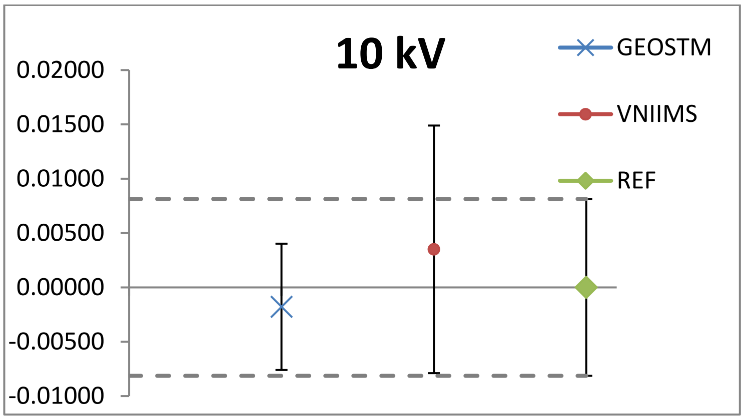
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	GEOSTM	1	-0,00238	0,00781
	VNIIMS	2	0,00323	0,01063
	REF	3	0,00000	0,00911



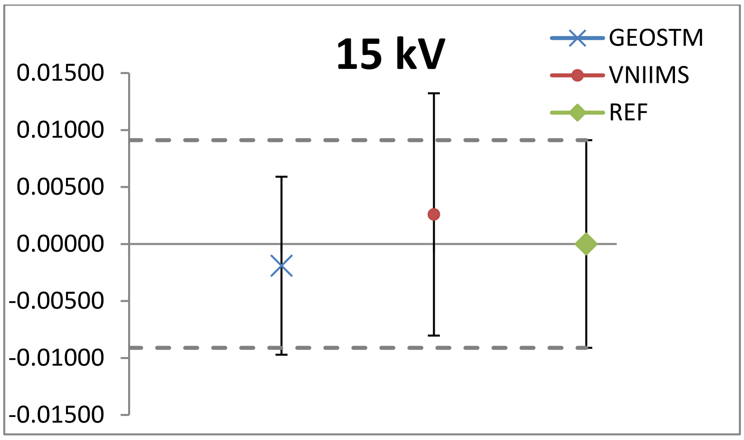
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
5	GEOSTM	1	-0,00184	0,00581
	VNIIMS	2	0,00361	0,01139
	REF	3	0,00000	0,00814



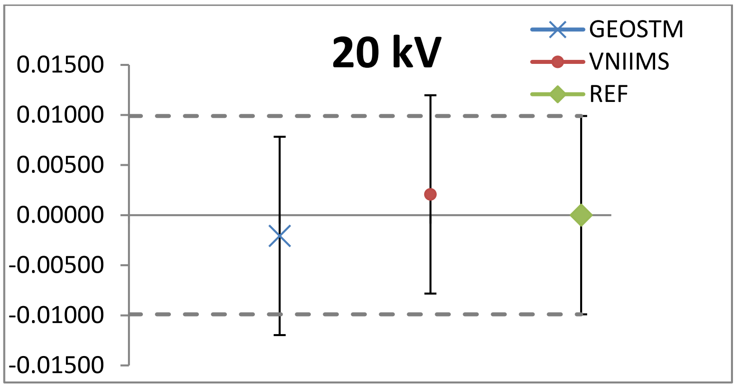
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
10	GEOSTM	1	-0,00179	0,00581
	VNIIMS	2	0,00350	0,01139
	REF	3	0,00000	0,00814



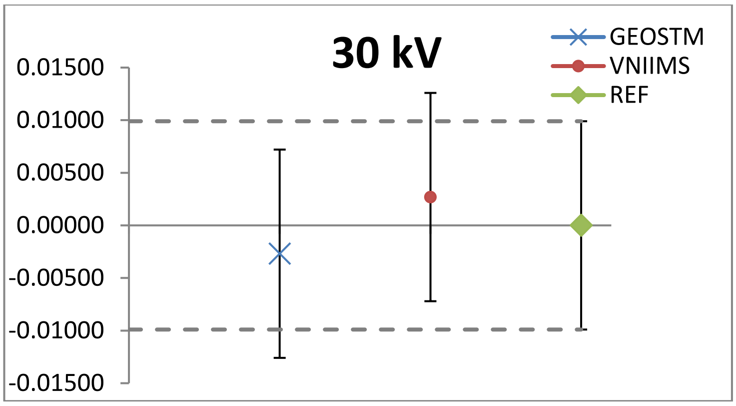
U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
15	GEOSTM	1	-0,00191	0,00781
	VNIIMS	2	0,00259	0,01063
	REF	3	0,00000	0,00911



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	GEOSTM	1	-0,00207	0,00990
	VNIIMS	2	0,00207	0,00990
	REF	3	0,00000	0,00990

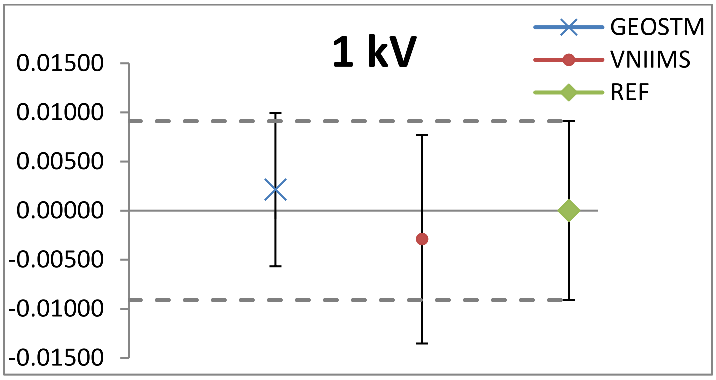


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
30	GEOSTM	1	-0,00269	0,00990
	VNIIMS	2	0,00269	0,00990
	REF	3	0,00000	0,00990

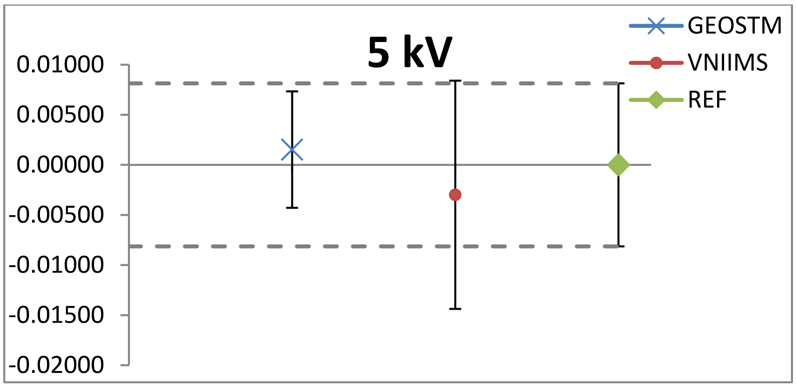


C-4 – Results of comparisons of electric capacitance between VNIIMS and GEOSTM for capacitor KGI-30-1-50 and GEOSTM reference system: capacitor R.JAHRE and comparator-bridge MEP-03.

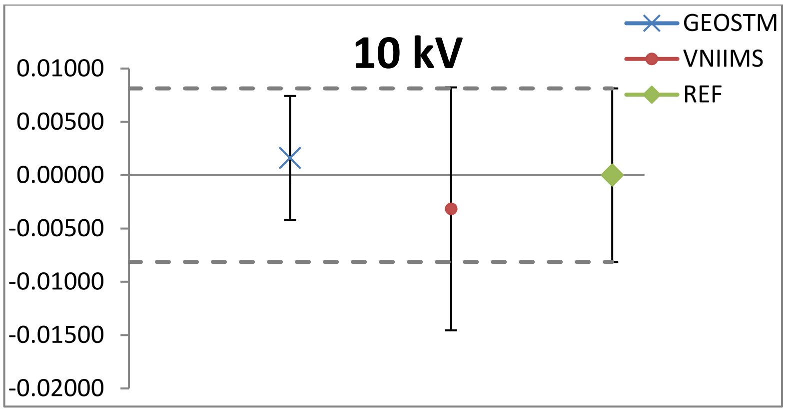
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	GEOSTM	1	0,00213	0,00781
	VNIIMS	2	-0,00290	0,01063
	REF	3	0,00000	0,00911



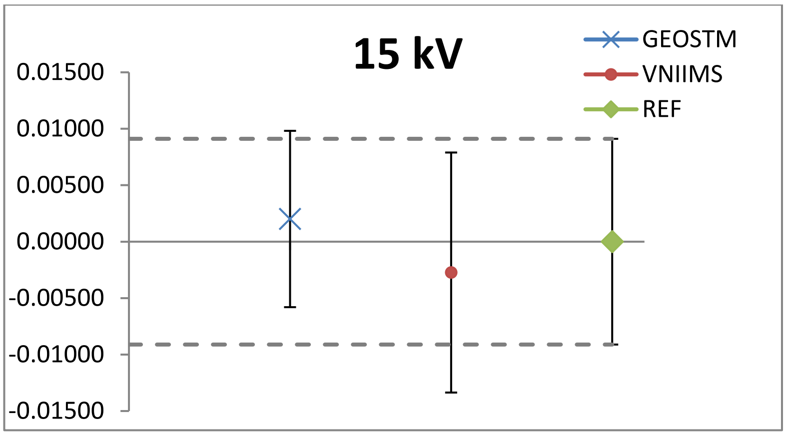
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	GEOSTM	1	0,00152	0,00581
	VNIIMS	2	-0,00299	0,01139
	REF	3	0,00000	0,00814



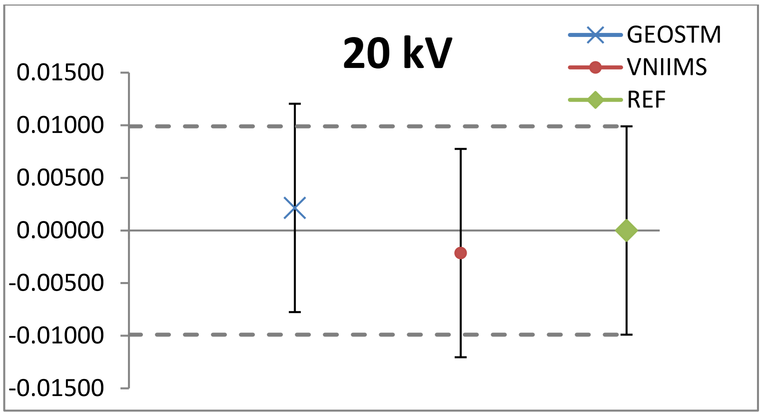
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	GEOSTM	1	0,00161	0,00581
	VNIIMS	2	-0,00316	0,01139
	REF	3	0,00000	0,00814



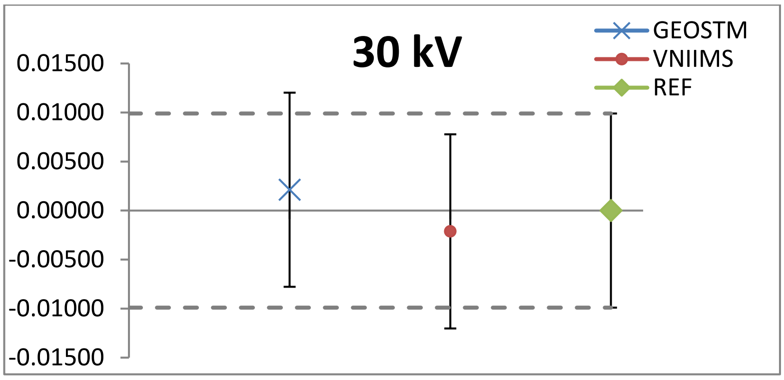
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
15	GEOSTM	1	0,00201	0,00781
	VNIIMS	2	-0,00273	0,01063
	REF	3	0,00000	0,00911



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	GEOSTM	1	0,00215	0,00990
	VNIIMS	2	-0,00215	0,00990
	REF	3	0,00000	0,00990

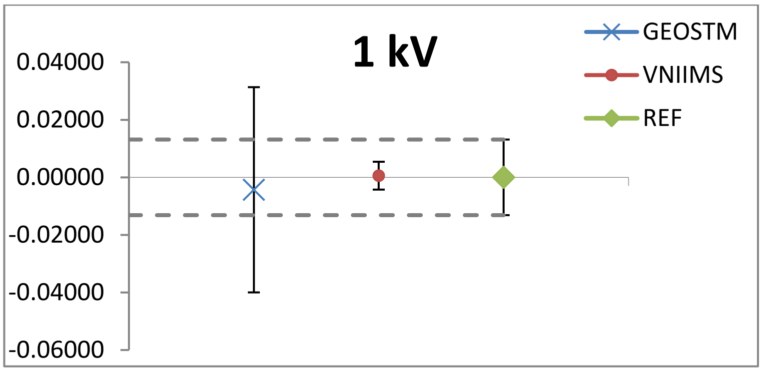


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
30	GEOSTM	1	0,00212	0,00990
	VNIIMS	2	-0,00212	0,00990
	REF	3	0,00000	0,00990

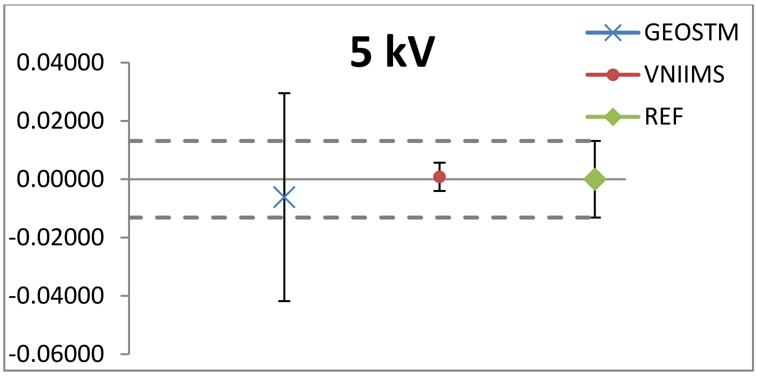


C-5 – Results of comparisons of electric capacitance between VNIIMS and GEOSTM for capacitor SA6021-27-100 and GEOSTM reference system: capacitor MCF 75/350 and comparator-bridge MEP-03.

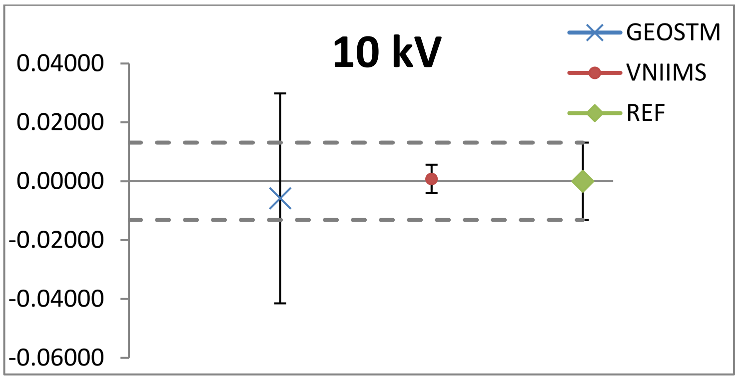
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	GEOSTM	1	-0,00432	0,03566
	VNIIMS	2	0,00059	0,00484
	REF	3	0,00000	0,01314



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	GEOSTM	1	-0,00613	0,03566
	VNIIMS	2	0,00083	0,00484
	REF	3	0,00000	0,01314

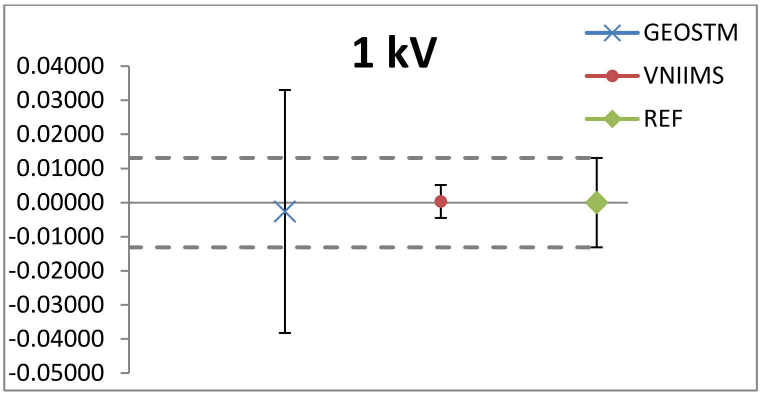


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	GEOSTM	1	-0,00582	0,03566
	VNIIMS	2	0,00079	0,00484
	REF	3	0,00000	0,01314

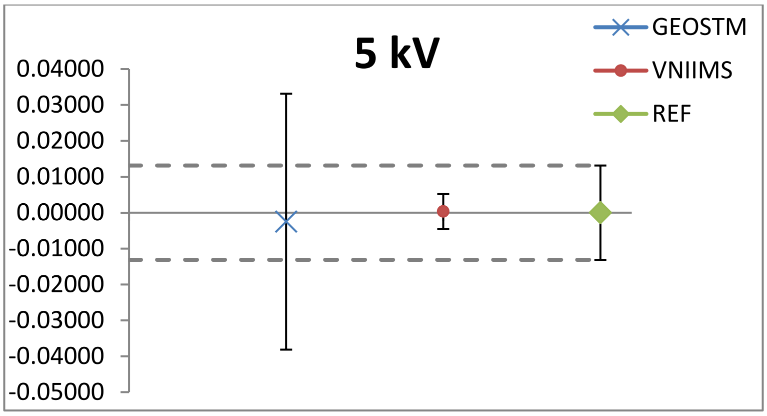


C-6 – Results of comparisons of electric capacitance between VNIIMS and GEOSTM for capacitor KGI-42-1-314 and GEOSTM reference system: capacitor MCF 75/350 and comparator-bridge MEP-03.

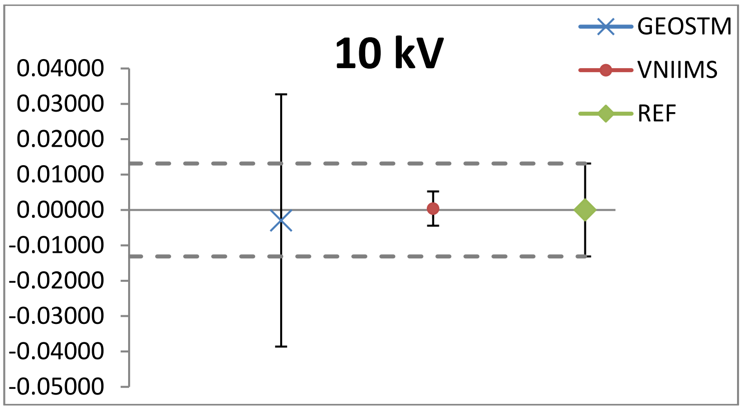
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	GEOSTM	1	-0,00260	0,03566
	VNIIMS	2	0,00035	0,00484
	REF	3	0,00000	0,01314



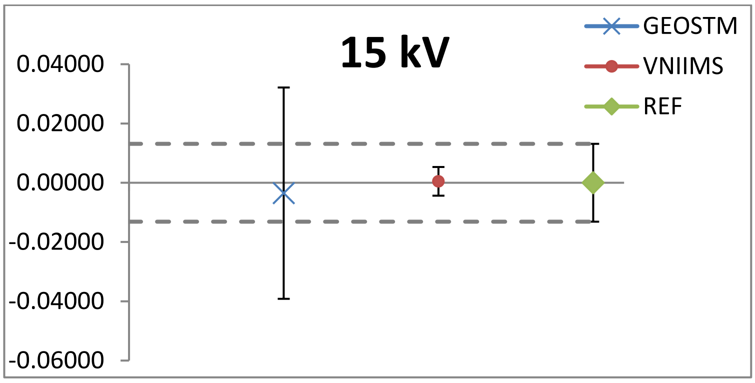
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	GEOSTM	1	-0,00251	0,03566
	VNIIMS	2	0,00034	0,00484
	REF	3	0,00000	0,01314



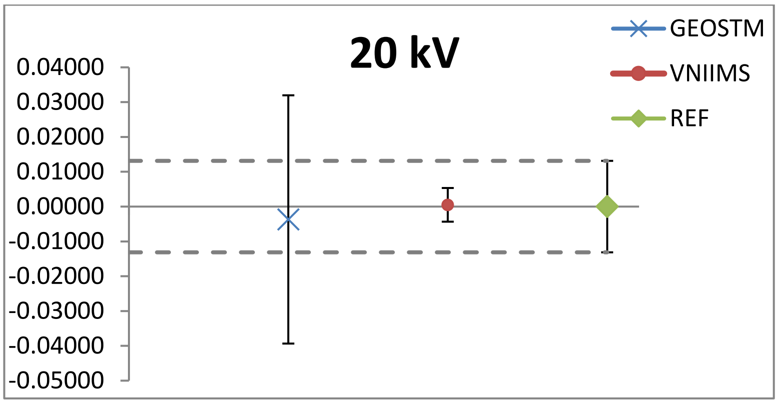
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	GEOSTM	1	-0,00296	0,03566
	VNIIMS	2	0,00040	0,00484
	REF	3	0,00000	0,01314



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
15	GEOSTM	1	-0,00351	0,03566
	VNIIMS	2	0,00048	0,00484
	REF	3	0,00000	0,01314

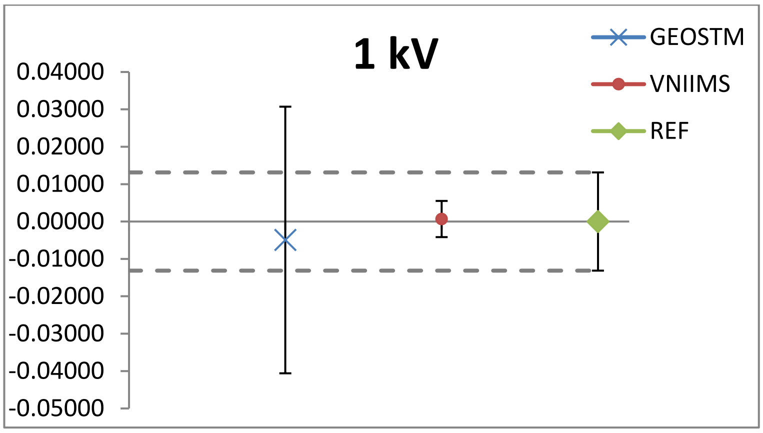


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	GEOSTM	1	-0,00369	0,03566
	VNIIMS	2	0,00050	0,00484
	REF	3	0,00000	0,01314

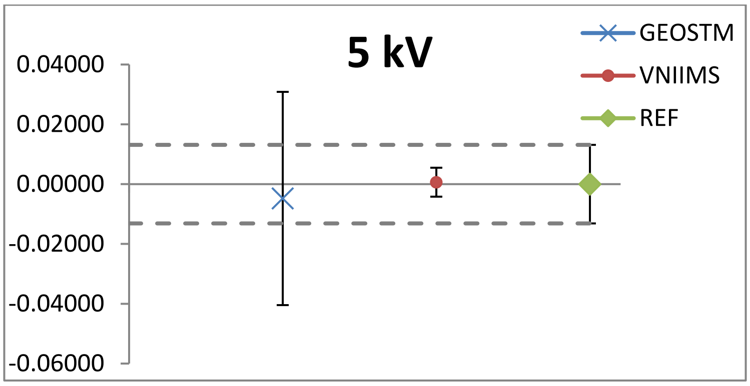


C-7 – Results of comparisons of electric capacitance between VNIIMS and GEOSTM for capacitor KGI-30-1-1000 and GEOSTM reference system: capacitor MCF 75/350 and comparator-bridge MEP-03.

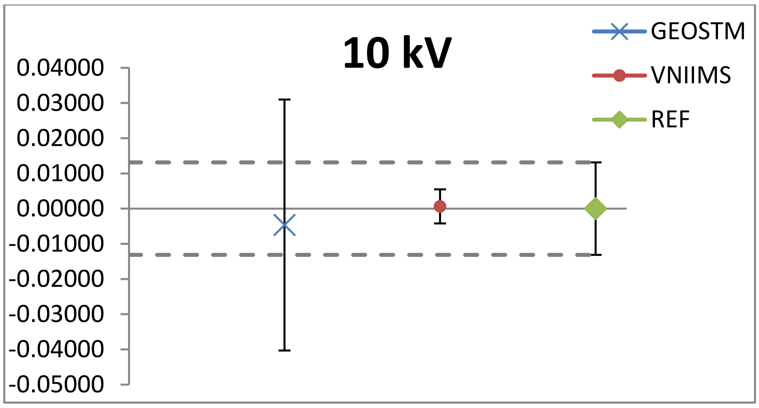
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	GEOSTM	1	-0,00494	0,03566
	VNIIMS	2	0,00067	0,00484
	REF	3	0,00000	0,01314



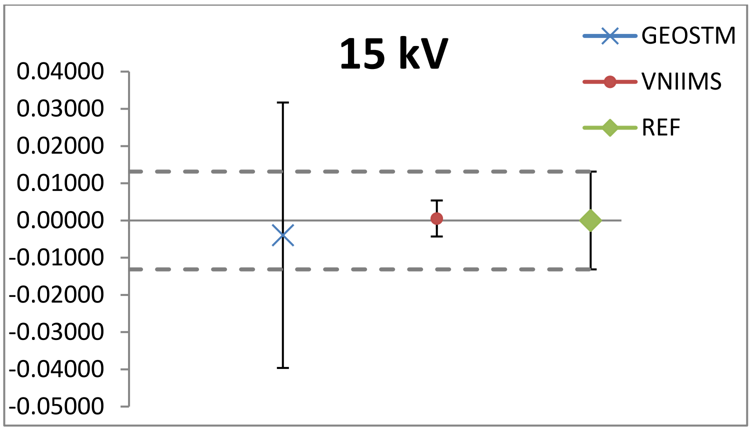
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	GEOSTM	1	-0,00480	0,03566
	VNIIMS	2	0,00065	0,00484
	REF	3	0,00000	0,01314



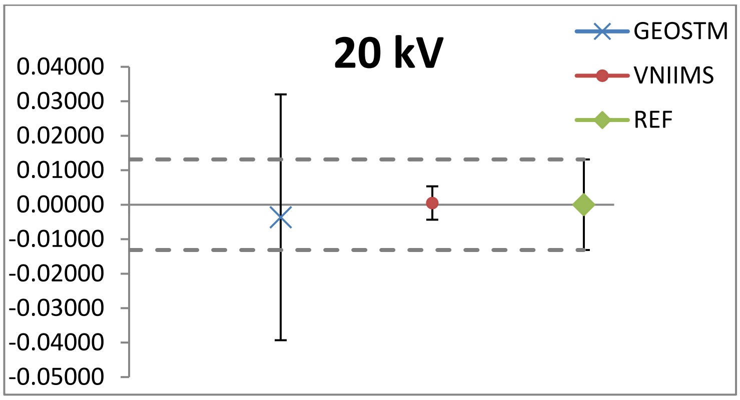
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	GEOSTM	1	-0,00466	0,03566
	VNIIMS	2	0,00063	0,00484
	REF	3	0,00000	0,01314



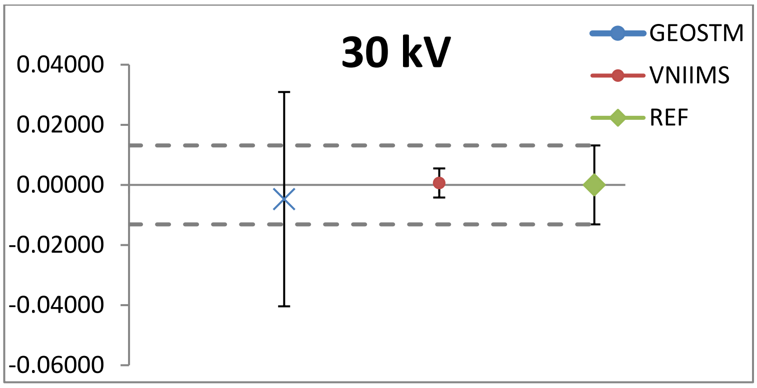
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
15	GEOSTM	1	-0,00396	0,03566
	VNIIMS	2	0,00054	0,00484
	REF	3	0,00000	0,01314



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	GEOSTM	1	-0,00365	0,03566
	VNIIMS	2	0,00050	0,00484
	REF	3	0,00000	0,01314

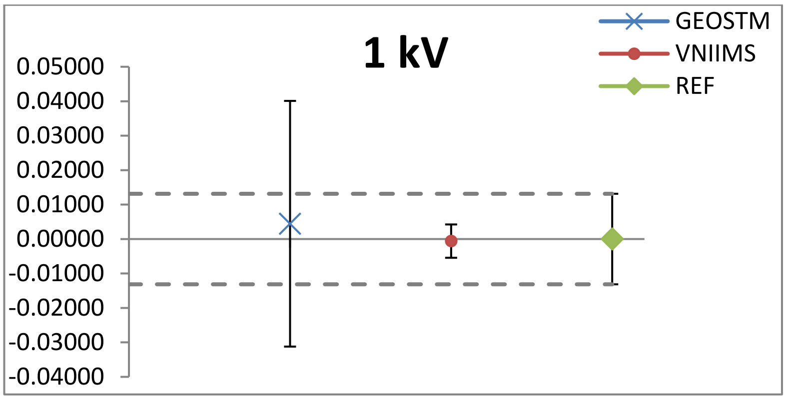


U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
30	GEOSTM	1	-0,00474	0,03566
	VNIIMS	2	0,00064	0,00484
	EF	3	0,00000	0,01314

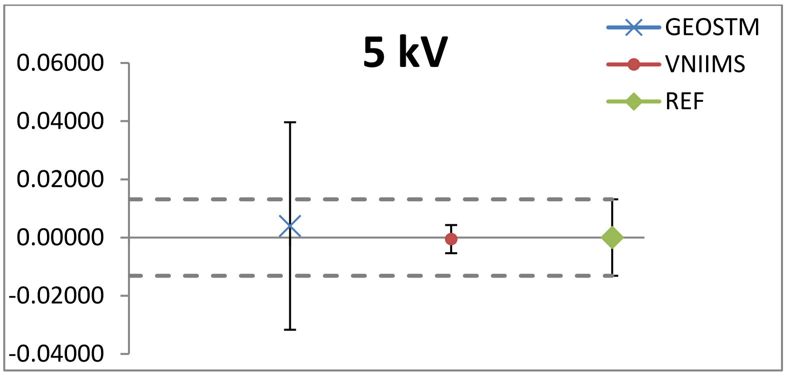


C-8 – Results of comparisons of electric capacitance between VNIIMS and GEOSTM for capacitor KGI-30-1-50 and GEOSTM reference system: capacitor MCF 75/350 and comparator-bridge MEP-03.

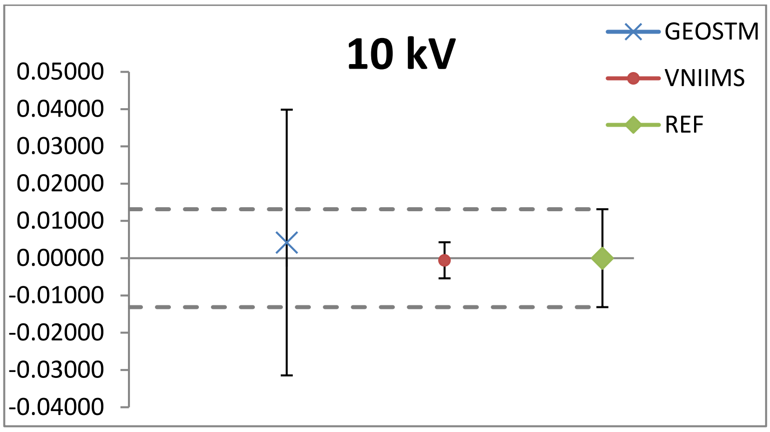
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
1	GEOSTM	1	0,00444	0,03566
	VNIIMS	2	-0,00060	0,00484
	REF	3	0,00000	0,01314



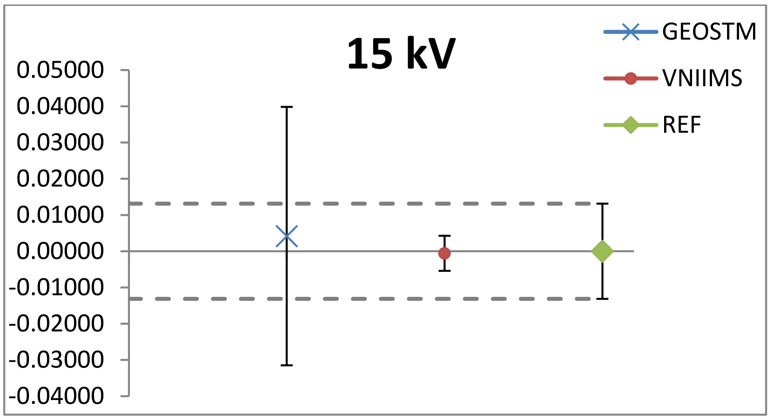
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
5	GEOSTM	1	0,00397	0,03566
	VNIIMS	2	-0,00054	0,00484
	REF	3	0,00000	0,01314



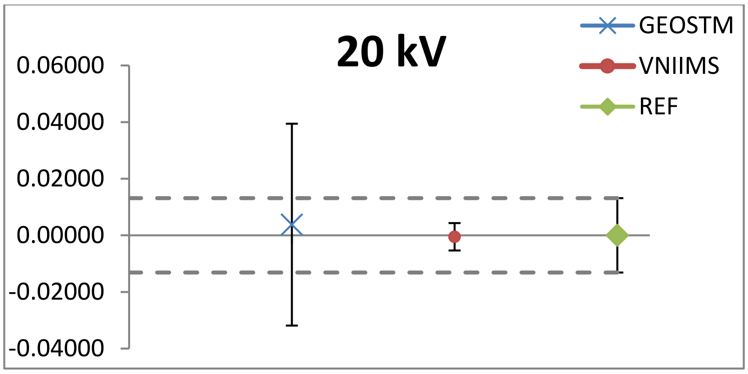
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
10	GEOSTM	1	0,00420	0,03566
	VNIIMS	2	-0,00057	0,00484
	REF	3	0,00000	0,01314



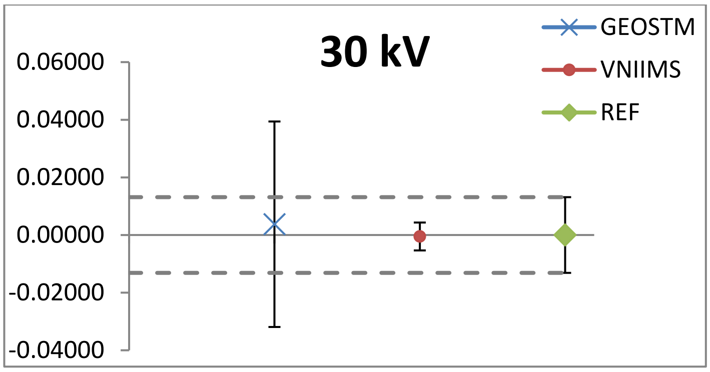
U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
15	GEOSTM	1	0,00417	0,03566
	VNIIMS	2	-0,00057	0,00484
	REF	3	0,00000	0,01314



U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
20	GEOSTM	1	0,00378	0,03566
	VNIIMS	2	-0,00051	0,00484
	REF	3	0,00000	0,01314

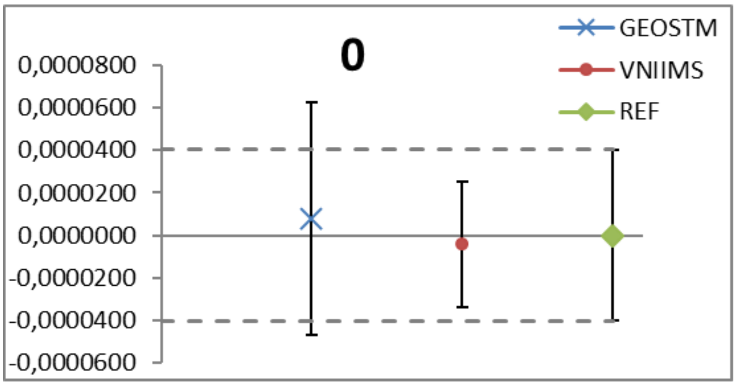


U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
30	GEOSTM	1	0,00374	0,03566
	VNIIMS	2	-0,00051	0,00484
	REF	3	0,00000	0,01314



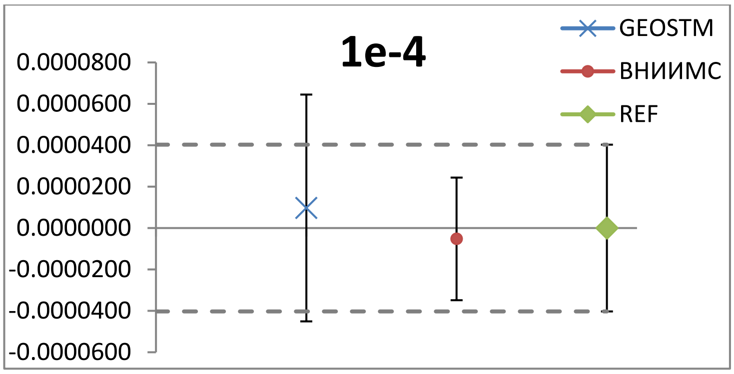
D-1 – Results of comparisons of loss dissipation factor (tan δ) between VNIIMS and GEOSTM, 1 kV, tan δ_{nom} = 0.

tan $\delta_{хном}$	LAB.	№	*Δ(tan δ)*	*U(Δtan δ)*
0	GEOSTM	1	0,0000076	0,00005
	VNIIMS	2	-0,0000041	0,00003
	REF	3	0,0000000	0,00004



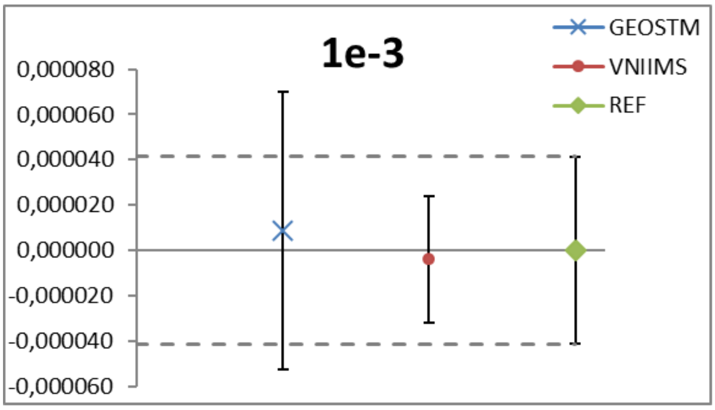
D-2 – Results of comparisons of loss dissipation factor (tan δ) between VNIIMS and GEOSTM, 1 kV, tan δ_{nom} = $1 \cdot 10^{-4}$.

tan $\delta_{хном}$	LAB.	№	*Δ(tan δ)*	*U(Δtan δ)*
$1 \cdot 10^{-4}$	GEOSTM	1	0,0000097	0,000055
	VNIIMS	2	-0,0000052	0,000030
	REF	3	0,0000000	0,000040



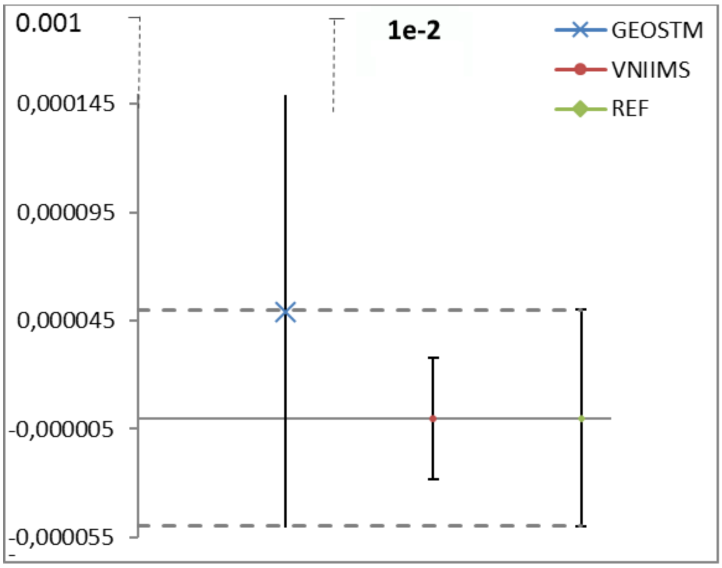
D-3 – Results of comparisons of loss dissipation factor (tan δ) between VNIIMS and GEOSTM, 1 kV, tan $\delta_{nom} = 1\cdot10^{-3}$.

tan δxном	LAB.	№	*Δ(tan δ)*	*U(Δtan δ)*
$1\cdot10^{-3}$	GEOSTM	1	0,000009	0,000061
	VNIIMS	2	-0,000004	0,000028
	REF	3	0,000000	0,000041



D-4 – Results of comparisons of loss dissipation factor (tan δ) between VNIIMS and GEOSTM, 1 kV, tan δnom = $1\cdot10^{-2}$.

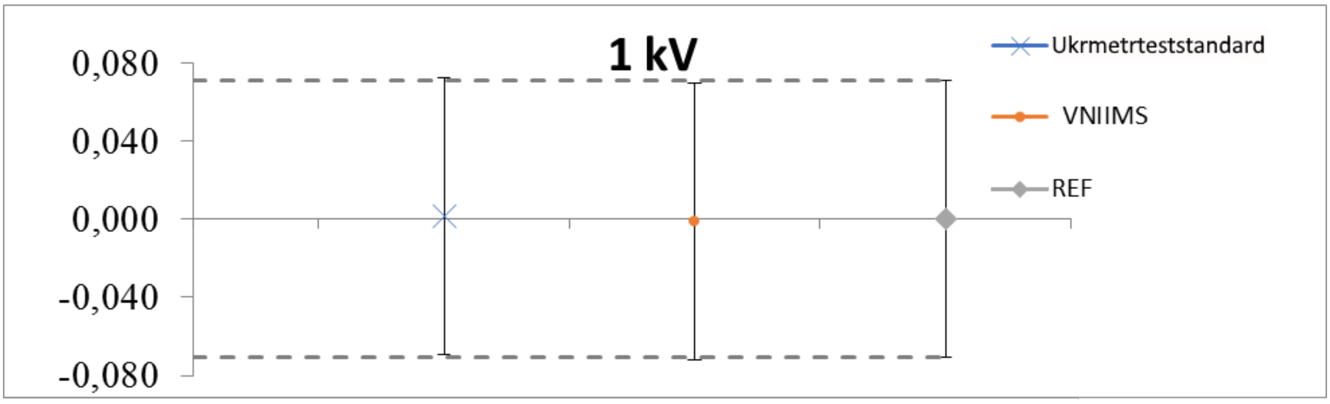
tan δxном	LAB.	№	*Δ(tan δ)*	*U(Δtan δ)*
$1\cdot10^{-2}$	GEOSTM	1	0,000049	0,00150
	VNIIMS	2	0,000000	0,000002
	REF	3	0,000000	0,000050



SE “Ukrmetrteststandard”

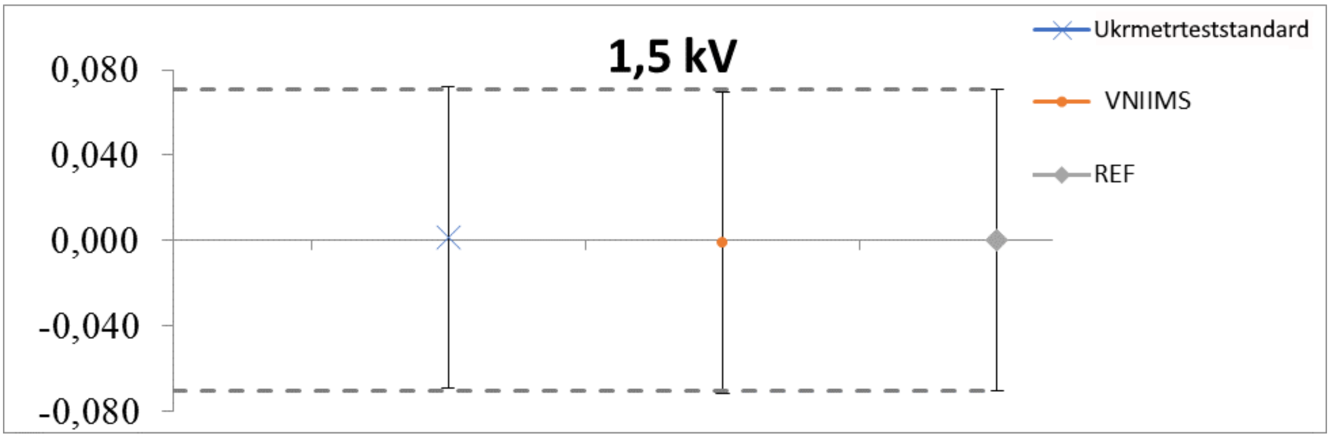
E-1 – Results of comparisons of electric capacitance between VNIIMS and SE “Ukrmetrteststandard”, 1 kV.

U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
1	SE “Ukrmetrteststandard”	1	0,00137	0,07071
	VNIIMS	2	-0,00137	0,07071
	REF	3	0,00000	0,07071



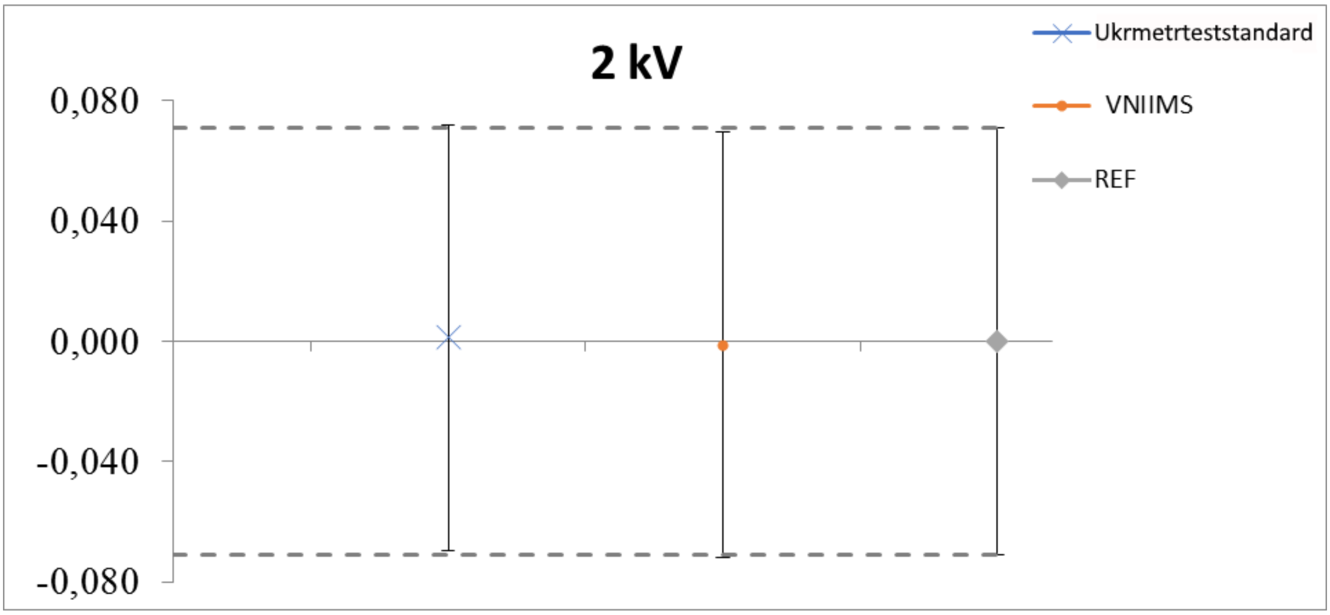
E-2 – Results of comparisons of electric capacitance between VNIIMS and SE “Ukrmetrteststandard”, 1,5 kV.

U, (kV)	LAB.	№	*Δ(C), %*	*U(ΔC), %*
1,5	SE “Ukrmetrteststandard”	1	0,00128	0,07071
	VNIIMS	2	-0,00128	0,07071
	REF	3	0,00000	0,07071



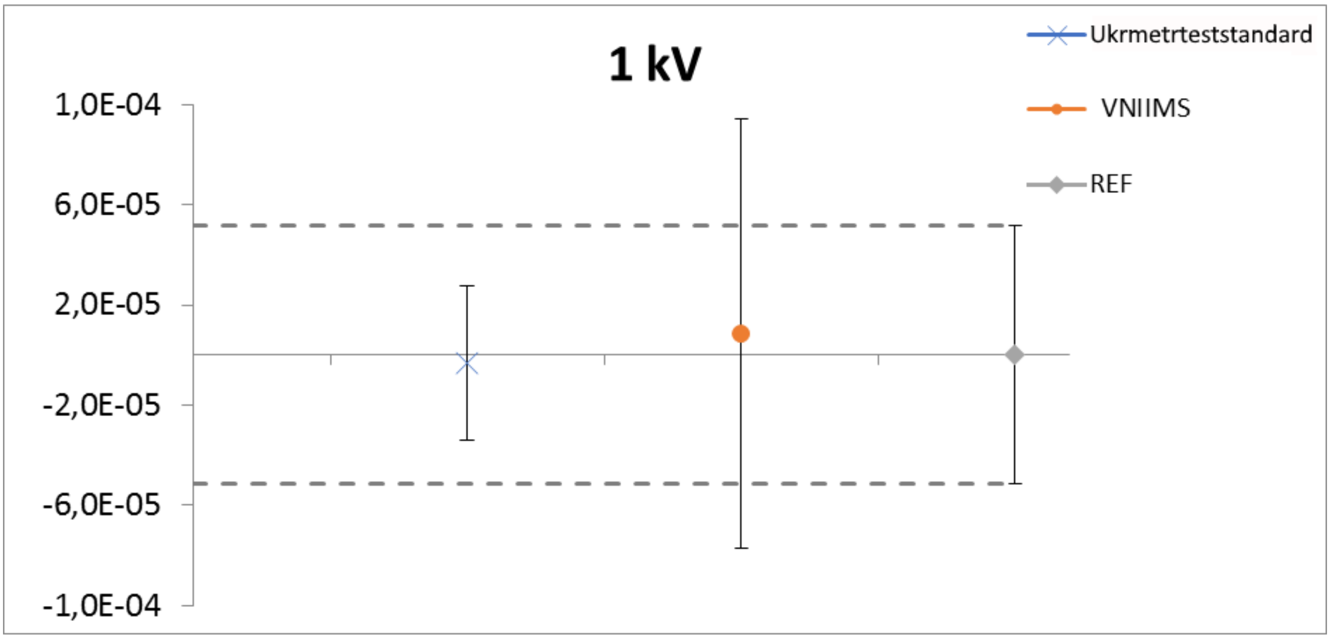
E-3 – Results of comparisons of electric capacitance between VNIIMS and SE “Ukrmetrteststandard”, 2 kV.

U, (kV)	LAB.	№	Δ(C), %	U(ΔC), %
2	SE “Ukrmetrteststandard”	1	0,00120	0,07071
	VNIIMS	2	-0,00120	0,07071
	REF	3	0,00000	0,07071



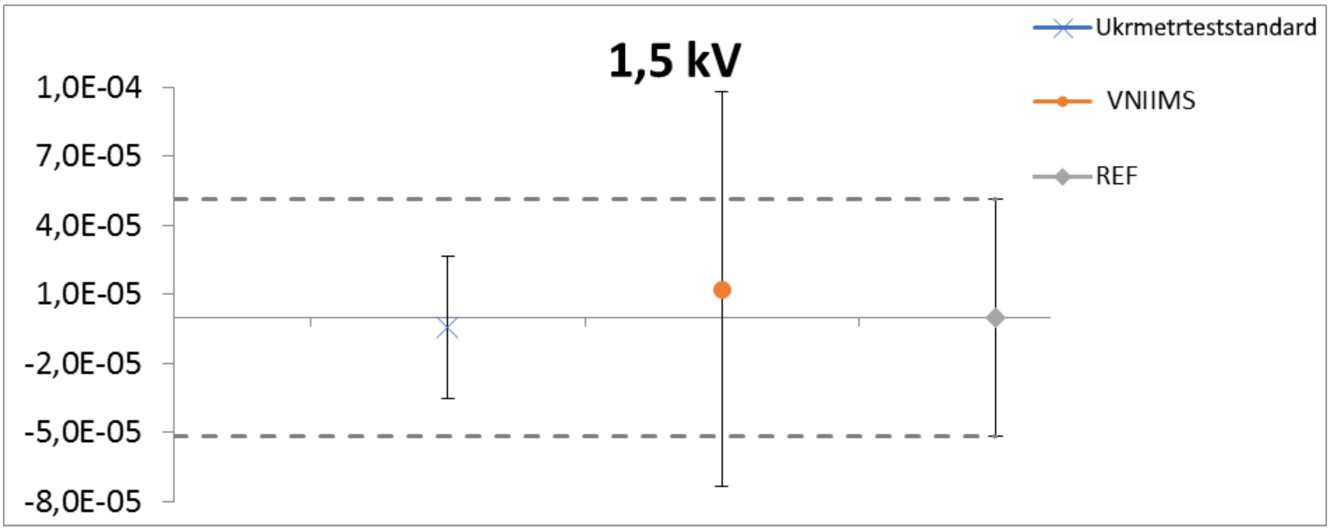
F-1 – Results of comparisons of loss dissipation factor (tan δ) between VNIIMS and SE “Ukrmetrteststandard”, 1 kV.

U, (kV)	LAB.	№	Δ(tan δ)	U(Δtan δ)
1	SE “Ukrmetrteststandard”	1	0,0000076	0,00005
	VNIIMS	2	-0,0000041	0,00003
	REF	3	0,0000000	0,00004



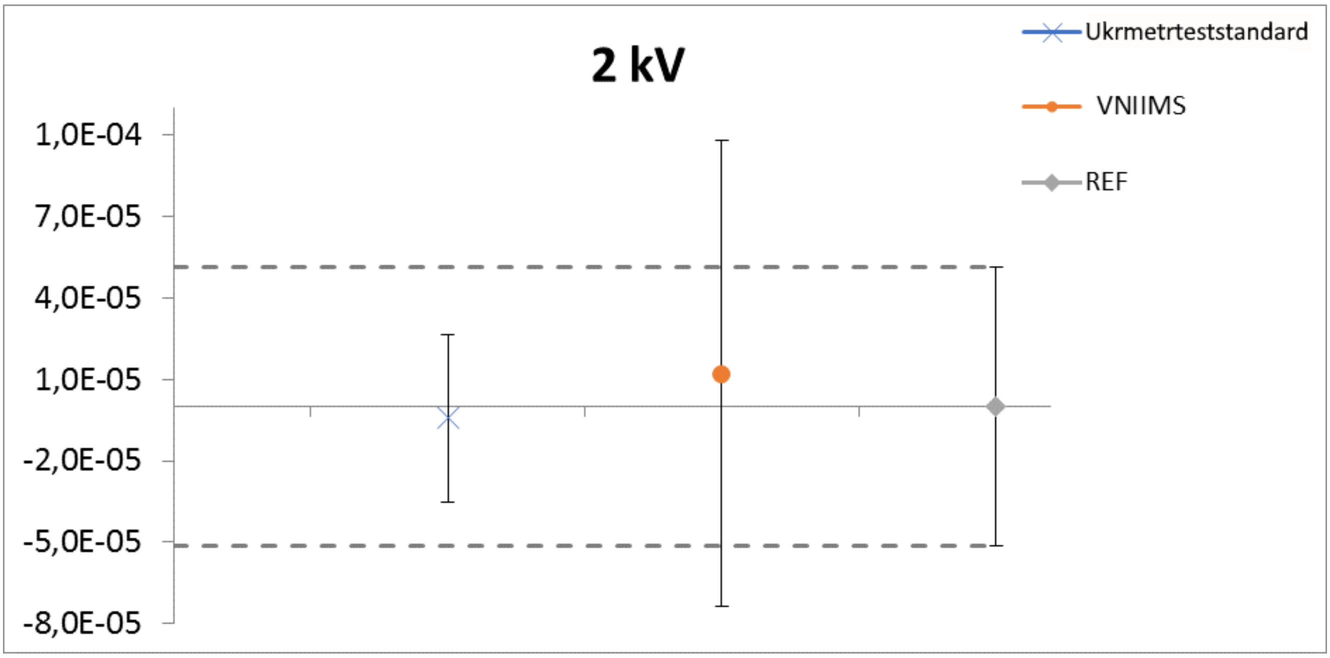
F-2 – Results of comparisons of loss dissipation factor (tan δ) between VNIIMS and SE “Ukrmetrteststandard”, 1,5 kV.

U, (kV)	LAB.	№	*Δ(tan δ)*	*U(Δtan δ)*
1,5	SE “Ukrmetrteststandard”	1	0,0000076	0,00005
	VNIIMS	2	-0,0000041	0,00003
	REF	3	0,0000000	0,00004



F-3 – Results of comparisons of loss dissipation factor (tan δ) between VNIIMS and SE “Ukrmetrteststandard”, 2 kV.

U, (kV)	LAB.	№	*Δ(tan δ)*	*U(Δtan δ)*
2	SE “Ukrmetrteststandard”	1	0,0000076	0,00005
	VNIIMS	2	-0,0000041	0,00003
	REF	3	0,0000000	0,00004



X. CONCLUSION

All data presented by NMIs during the measurements, calculation and processing of the results of comparisons is recognized as consistent, being an objective evidence of uncertainties declared during the present comparisons under the COOMET project.

This is also the evidence of corresponding measurement and calibration capabilities for those values of electric capacitance and loss dissipation factor (tan δ) of AC high voltage of power frequency and may be approved and are the objective confirmation of the uncertainties, for the BIPM database.

Besides, for NMIs having a higher accuracy of measurements results may be accepted as the grounds for corresponding changes to the BIPM database based on the agreed protocols of comparisons with the improved uncertainties of the state standards.

Annex A

Tables A.1.1 – A.1.10 – Results of comparisons of electric capacitance VNIIMS – CMI

Table A.1.1 – Capacitor SA 6221D-30-10, 2 pF.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	1,95135	0,00674	0,01348	0,09944	-0,00780	0,02407	0,00189	0,04815	0,00377	0,00650	0,08060	2,06524	2,06524
5	1,95114	0,00674	0,01348	-0,04022	0,00315	0,02407	0,00189	0,04815	0,00377	0,00106	0,03259	0,83526	0,83526
10	1,95114	0,00674	0,01348	-0,04905	0,00385	0,02407	0,00189	0,04815	0,00377	0,00158	0,03976	1,01877	1,01877

Tables A.1.2 – Capacitor SA 6221D-30-10, 8 pF.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	7,83432	0,00674	0,01348	0,02637	-0,00207	0,02407	0,00189	0,04815	0,00377	0,00736	0,08580	0,54762	0,54762
5	7,83411	0,00674	0,01348	-0,00872	0,00068	0,02407	0,00189	0,04815	0,00377	0,00081	0,02838	0,18116	0,18116
10	7,83408	0,00674	0,01348	-0,01156	0,00091	0,02407	0,00189	0,04815	0,00377	0,00142	0,03762	0,24011	0,24011

Table A.1.3 – Capacitor SA 6221D-30-10, 30 pF.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	29,28828	0,00674	0,01348	0,01092	-0,00086	0,02407	0,00189	0,04815	0,00377	0,01766	0,13289	0,22686	0,22686
5	29,28804	0,00674	0,01348	0,00034	-0,00003	0,02407	0,00189	0,04815	0,00377	0,00002	0,00412	0,00704	0,00704
10	29,28801	0,00674	0,01348	-0,00110	0,00009	0,02407	0,00189	0,04815	0,00377	0,00018	0,01337	0,02282	0,02282

Table A.1.4 – Capacitor KGI - 42-1-300.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	314,29010	0,00674	0,01348	0,00054	-0,00004	0,02407	0,00189	0,04815	0,00377	0,00497	0,07049	0,01121	0,01121
5	314,28974	0,00674	0,01348	0,00078	-0,00006	0,02407	0,00189	0,04815	0,00377	0,01042	0,10207	0,01624	0,01624
10	314,28963	0,00674	0,01348	0,00078	-0,00006	0,02407	0,00189	0,04815	0,00377	0,01050	0,10246	0,01630	0,01630
15	314,28980	0,00674	0,01348	0,00073	-0,00006	0,02407	0,00189	0,04815	0,00377	0,00913	0,09553	0,01520	0,01520
20	314,29030	0,00674	0,01348	0,00083	-0,00006	0,02407	0,00189	0,04815	0,00377	0,01163	0,10785	0,01716	0,01716

Table A.1.5 – Capacitor KGI - 30-1-1000.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	995,19940	0,00674	0,01348	0,00289	-0,00023	0,02407	0,00189	0,04815	0,00377	0,01445	0,12022	0,06011	0,06011
5	995,20140	0,00674	0,01348	0,00301	-0,00024	0,02407	0,00189	0,04815	0,00377	0,01568	0,12521	0,06260	0,06260
10	995,20678	0,00674	0,01348	0,00281	-0,00022	0,02407	0,00189	0,04815	0,00377	0,01359	0,11658	0,05829	0,05829
20	995,23526	0,00674	0,01348	0,00316	-0,00025	0,02407	0,00189	0,04815	0,00377	0,01722	0,13124	0,06562	0,06562
30	995,28990	0,00674	0,01348	0,00332	-0,00026	0,02407	0,00189	0,04815	0,00377	0,01897	0,13774	0,06887	0,06887

Table A.1.6 – Capacitor KGI - 30-1-50.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	60,35092	0,00674	0,01348	-0,00046	0,00004	0,02407	0,00189	0,04815	0,00377	0,00013	0,01141	0,00945	0,00945
5	60,35136	0,00674	0,01348	-0,00383	0,00030	0,02407	0,00189	0,04815	0,00377	0,00924	0,09612	0,07963	0,07963
10	60,35138	0,00674	0,01348	-0,00354	0,00028	0,02407	0,00189	0,04815	0,00377	0,00790	0,08886	0,07362	0,07362
20	60,35230	0,00674	0,01348	-0,00503	0,00039	0,02407	0,00189	0,04815	0,00377	0,01589	0,12605	0,10443	0,10443
30	60,35186	0,00674	0,01348	-0,00426	0,00033	0,02407	0,00189	0,04815	0,00377	0,01142	0,10684	0,08852	0,08852

Table A.1.7 – Capacitor 3320/10.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	10,00284	0,00674	0,01348	0,01682	-0,00132	0,02407	0,00189	0,04815	0,00377	0,00488	0,06987	0,34926	0,34926
1,5	10,00285	0,00674	0,01348	0,00759	-0,00060	0,02407	0,00189	0,04815	0,00377	0,00100	0,03155	0,15769	0,15769
2	10,00282	0,00674	0,01348	-0,00275	0,00022	0,02407	0,00189	0,04815	0,00377	0,00013	0,01144	0,05718	0,05718

Table A.1.8 – Capacitor 3320/100.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	99,99323	0,00674	0,01348	0,00300	-0,00024	0,02407	0,00189	0,04815	0,00377	0,01554	0,12465	0,06233	0,06233
1,5	99,99319	0,00674	0,01348	0,00157	-0,00012	0,02407	0,00189	0,04815	0,00377	0,00424	0,06513	0,03257	0,03257
2	99,99296	0,00674	0,01348	0,00081	-0,00006	0,02407	0,00189	0,04815	0,00377	0,00114	0,03382	0,01691	0,01691

Table A.1.9 – Capacitor 3320/1000.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	1000,0048	0,00674	0,01348	0,00056	-0,00004	0,02407	0,00189	0,04815	0,00377	0,05341	0,23111	0,01156	0,01156
1,5	1000,0057	0,00674	0,01348	0,00046	-0,00004	0,02407	0,00189	0,04815	0,00377	0,03709	0,19259	0,00963	0,00963
2	1000,0085	0,00674	0,01348	0,00017	-0,00001	0,02407	0,00189	0,04815	0,00377	0,00481	0,06933	0,00347	0,00347

Table A.1.10 – Capacitor 3320/10000.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
1	10000,528	0,00674	0,01348	-0,00048	0,00004	0,02407	0,00189	0,04815	0,00377	4,01187	2,00297	0,01001	0,01001
1,5	10000,626	0,00674	0,01348	-0,00046	0,00004	0,02407	0,00189	0,04815	0,00377	3,70920	1,92593	0,00963	0,00963
2	10000,757	0,00674	0,01348	-0,00067	0,00005	0,02407	0,00189	0,04815	0,00377	7,69139	2,77334	0,01387	0,01387

Tables A.2.1 – A.2.8 – Results of comparisons of electric capacitance VNIIMS – GEOSTM

Table A.2.1 – Capacitor SA 6021-27-10, GEOSTM used as a standard R.JAHRE and MEP-03.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) GEOSTM***	***Δ(εL) VNIIMS***	***u(ΔεL) GEOSTM***	***u(ΔεL) VNIIMS***	***U(ΔεL) GEOSTM***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(GEOSTM)***	***En(VNIIMS)***
1	28,21444	0,00456	0,00911	-0,00208	0,00283	0,00390	0,00531	0,00781	0,01063	0,02252	0,15007	0,26595	0,26595
5	28,21404	0,00407	0,00814	-0,00235	0,00461	0,00291	0,00570	0,00581	0,01139	0,05216	0,22839	0,40475	0,40475
10	28,21400	0,00407	0,00814	-0,00223	0,00438	0,00291	0,00570	0,00581	0,01139	0,04701	0,21681	0,38422	0,38422

Table A.2.2 – Capacitor KGI 42-1-314, GEOSTM used as a standard R.JAHRE and MEP-03.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) GEOSTM***	***Δ(εL) VNIIMS***	***u(ΔεL) GEOSTM***	***u(ΔεL) VNIIMS***	***U(ΔεL) GEOSTM***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(GEOSTM)***	***En(VNIIMS)***
1	314,2949	0,00456	0,00911	-0,00125	0,00170	0,00390	0,00531	0,00781	0,01063	1,01592	1,00793	0,16035	0,16035
5	314,2940	0,00407	0,00814	-0,00096	0,00188	0,00291	0,00570	0,00581	0,01139	1,08097	1,03970	0,16540	0,16540
10	314,2929	0,00407	0,00814	-0,00114	0,00223	0,00291	0,00570	0,00581	0,01139	1,51073	1,22912	0,19554	0,19554
15	314,2917	0,00456	0,00911	-0,00169	0,00230	0,00390	0,00531	0,00781	0,01063	1,84851	1,35960	0,21630	0,21630
20	314,2885	0,00495	0,00990	-0,00210	0,00210	0,00495	0,00495	0,00990	0,00990	1,77045	1,33058	0,21168	0,21168

Table A.2.3 – Capacitor KGI 30-1-1000, GEOSTM used as a standard R.JAHRE and MEP-03.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) GEOSTM***	***Δ(εL) VNIIMS***	***u(ΔεL) GEOSTM***	***u(ΔεL) VNIIMS***	***U(ΔεL) GEOSTM***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(GEOSTM)***	***En(VNIIMS)***
1	995,13729	0,00456	0,00911	-0,00238	0,00323	0,00390	0,00531	0,00781	0,01063	0,37035	0,60857	0,30428	0,30428
5	995,15139	0,00407	0,00814	-0,00184	0,00361	0,00291	0,00570	0,00581	0,01139	0,40100	0,63325	0,31662	0,31662
10	995,15485	0,00407	0,00814	-0,00179	0,00350	0,00291	0,00570	0,00581	0,01139	0,37824	0,61501	0,30751	0,30751
15	995,16899	0,00456	0,00911	-0,00191	0,00259	0,00390	0,00531	0,00781	0,01063	0,23828	0,48814	0,24407	0,24407
20	995,18610	0,00495	0,00990	-0,00207	0,00207	0,00495	0,00495	0,00990	0,00990	0,17530	0,41869	0,20935	0,20935
30	995,22915	0,00495	0,00990	-0,00269	0,00269	0,00495	0,00495	0,00990	0,00990	0,29599	0,54405	0,27202	0,27202

Table A.2.4 – Capacitor KGI 30-1-50, GEOSTM used as a standard R.JAHRE and MEP-03.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) GEOSTM***	***Δ(εL) VNIIMS***	***u(ΔεL) GEOSTM***	***u(ΔεL) VNIIMS***	***U(ΔεL) GEOSTM***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(GEOSTM)***	***En(VNIIMS)***
1	60,34950	0,00456	0,00911	0,00213	-0,00290	0,00390	0,00531	0,00781	0,01063	0,10878	0,32981	0,27325	0,27325
5	60,35086	0,00407	0,00814	0,00152	-0,00299	0,00291	0,00570	0,00581	0,01139	0,10015	0,31647	0,26219	0,26219
10	60,35096	0,00407	0,00814	0,00161	-0,00316	0,00291	0,00570	0,00581	0,01139	0,11208	0,33478	0,27736	0,27736
15	60,35142	0,00456	0,00911	0,00201	-0,00273	0,00390	0,00531	0,00781	0,01063	0,09633	0,31037	0,25714	0,25714
20	60,35104	0,00495	0,00990	0,00215	-0,00215	0,00495	0,00495	0,00990	0,00990	0,06844	0,26161	0,21674	0,21674
30	60,35125	0,00495	0,00990	0,00212	-0,00212	0,00495	0,00495	0,00990	0,00990	0,06707	0,25899	0,21457	0,21457

Table A.2.5 – Capacitor SA 6021-27-10, GEOSTM used as a standard MCF 75/350 and MEP-03.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) GEOSTM***	***Δ(εL) VNIIMS***	***u(ΔεL) GEOSTM***	***u(ΔεL) VNIIMS***	***U(ΔεL) GEOSTM***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(GEOSTM)***	***En(VNIIMS)***
1	28,21507	0,00657	0,01314	-0,00432	0,00059	0,01783	0,00242	0,03566	0,00484	0,00467	0,06833	0,12109	0,12109
5	28,21510	0,00657	0,01314	-0,00613	0,00083	0,01783	0,00242	0,03566	0,00484	0,00941	0,09703	0,17195	0,17195
10	28,21501	0,00657	0,01314	-0,00582	0,00079	0,01783	0,00242	0,03566	0,00484	0,00848	0,09211	0,16323	0,16323

Table A.2.6 – Capacitor KGI 42-1-314, GEOSTM used as a standard MCF 75/350 and MEP-03.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) GEOSTM***	***Δ(εL) VNIIMS***	***u(ΔεL) GEOSTM***	***u(ΔεL) VNIIMS***	***U(ΔεL) GEOSTM***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(GEOSTM)***	***En(VNIIMS)***
1	314,29913	0,00657	0,01314	-0,00260	0,00035	0,01783	0,00242	0,03566	0,00484	0,21062	0,45893	0,07301	0,07301
5	314,29882	0,00657	0,01314	-0,00251	0,00034	0,01783	0,00242	0,03566	0,00484	0,19510	0,44170	0,07027	0,07027
10	314,29863	0,00657	0,01314	-0,00296	0,00040	0,01783	0,00242	0,03566	0,00484	0,27267	0,52218	0,08307	0,08307
15	314,29739	0,00657	0,01314	-0,00351	0,00048	0,01783	0,00242	0,03566	0,00484	0,38323	0,61905	0,09848	0,09848
20	314,29351	0,00657	0,01314	-0,00369	0,00050	0,01783	0,00242	0,03566	0,00484	0,42318	0,65052	0,10349	0,10349

Table A.2.7 – Capacitor KGI 30-1-1000, GEOSTM used as a standard MCF 75/350 and MEP-03.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) GEOSTM***	***Δ(εL) VNIIMS***	***u(ΔεL) GEOSTM***	***u(ΔεL) VNIIMS***	***U(ΔεL) GEOSTM***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(GEOSTM)***	***En(VNIIMS)***
1	995,16281	0,00657	0,01314	-0,00494	0,00067	0,01783	0,00242	0,03566	0,00484	0,07678	0,27709	0,13854	0,13854
5	995,18081	0,00657	0,01314	-0,00480	0,00065	0,01783	0,00242	0,03566	0,00484	0,07237	0,26902	0,13451	0,13451
10	995,18342	0,00657	0,01314	-0,00466	0,00063	0,01783	0,00242	0,03566	0,00484	0,06826	0,26127	0,13064	0,13064
15	995,18946	0,00657	0,01314	-0,00396	0,00054	0,01783	0,00242	0,03566	0,00484	0,04940	0,22226	0,11113	0,11113
20	995,20179	0,00657	0,01314	-0,00365	0,00050	0,01783	0,00242	0,03566	0,00484	0,04190	0,20470	0,10235	0,10235
30	995,24954	0,00657	0,01314	-0,00474	0,00064	0,01783	0,00242	0,03566	0,00484	0,07075	0,26598	0,13299	0,13299

Table A.2.8 – Capacitor KGI 30-1-50, GEOSTM used as a standard MCF 75/350 and MEP-03.

Voltage range $U_{ном}[kV]$	***εr, (%)***	***u(εr)***	***U(εr)***	***Δ(εL) GEOSTM***	***Δ(εL) VNIIMS***	***u(ΔεL) GEOSTM***	***u(ΔεL) VNIIMS***	***U(ΔεL) GEOSTM***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(GEOSTM)***	***En(VNIIMS)***
1	60,34811	0,00657	0,01314	0,00444	-0,00060	0,01783	0,00242	0,03566	0,00484	0,02255	0,15017	0,12442	0,12442
5	60,34939	0,00657	0,01314	0,00397	-0,00054	0,01783	0,00242	0,03566	0,00484	0,01808	0,13445	0,11139	0,11139
10	60,34940	0,00657	0,01314	0,00420	-0,00057	0,01783	0,00242	0,03566	0,00484	0,02023	0,14223	0,11784	0,11784
15	60,35011	0,00657	0,01314	0,00417	-0,00057	0,01783	0,00242	0,03566	0,00484	0,01997	0,14132	0,11708	0,11708
20	60,35005	0,00657	0,01314	0,00378	-0,00051	0,01783	0,00242	0,03566	0,00484	0,01636	0,12790	0,10597	0,10597
30	60,35027	0,00657	0,01314	0,00374	-0,00051	0,01783	0,00242	0,03566	0,00484	0,01603	0,12662	0,10490	0,10490

Table A.3.1 – Results of comparisons of electric capacitance VNIIMS – SE “Ukrmetrteststandard”

Voltage range $U_{ном}[kV]$	***C_o, %***	***u(C_o), %***	***U(C_o), %***	***Δ(C_L) UKR***	***Δ(C_L), % VNIIMS***	***u(ΔCL), % UKR***	***u(ΔCL), % VNIIMS***	***U(ΔC_L), % UKR***	***U(ΔC_L), % VNIIMS***	χ^2	***En(UKR)***	***En(VNIIMS)***
1	97,48336	0,03536	0,07071	0,00137	-0,00137	0,03536	0,03536	0,07071	0,07071	0,00143	0,01939	0,01939
1,5	97,48352	0,03536	0,07071	0,00128	-0,00128	0,03536	0,03536	0,07071	0,07071	0,00124	0,01804	0,01804
2	97,48343	0,03536	0,07071	0,00120	-0,00120	0,03536	0,03536	0,07071	0,07071	0,00109	0,01696	0,01696

Table A.4.1 – Results of comparisons of loss dissipation factor (tan δ) VNIIMS – CMI

tan $\delta_{ном}$	***εr***	***u(εr)***	***U(εr)***	***Δ(εL) CMI***	***Δ(εL) VNIIMS***	***u(ΔεL) CMI***	***u(ΔεL) VNIIMS***	***U(ΔεL) CMI***	***U(ΔεL) VNIIMS***	χ^2	R_b	***En(CMI)***	***En(VNIIMS)***
5,0e-5	0,00010	0,00002	0,00005	0,0000020	-0,0000071	0,00001	0,0000442	0,000025	0,000088	0,02547	0,15960	0,07980	0,07980
1,0E-04	0,00010	0,00002	0,00004	0,0000004	-0,0000015	0,00001	0,0000447	0,000023	0,000089	0,00116	0,03405	0,01702	0,01702
1,0E-03	0,00099	0,00003	0,00005	0,0000029	-0,0000079	0,00002	0,0000427	0,000032	0,000085	0,03414	0,18476	0,09238	0,09238
1,0E-02	0,00992	0,00004	0,00007	0,0000182	-0,0000152	0,00004	0,0000337	0,000081	0,000067	0,20261	0,45012	0,22506	0,22506
1,0E-01	0,09964	0,00004	0,00007	-0,0000574	0,0000506	0,00004	0,0000342	0,000078	0,000068	2,18687	1,47881	0,73940	0,73940

Table A.5.1 – Results of comparisons of loss dissipation factor (tan δ) VNIIMS – GEOSTM

tan $\delta_{ном}$	***tan δ_o***	***u(tan δ_o)***	***U(tan δ_o)***	***Δtan δ_L GEOSTM***	***Δtan δ_L VNIIMS***	***u(Δtan δ_L) GEOSTM***	***u(Δtan δ_L) VNIIMS***	***U(Δtan δ_L) GEOSTM***	***U(Δtan δ_L) VNIIMS***	$\chi_{tg\delta}^2$	***E(tan δ_L) GEOSTM***	***E(tan δ_L) VNIIMS***
0	0,0000944	0,000020	0,000040	0,0000076	-0,0000041	0,000027	0,000015	0,000055	0,000030	0,077	0,14	0,14
$1\cdot10^{-4}$	0,0000973	0,000020	0,000040	0,0000097	-0,0000052	0,000027	0,000015	0,000055	0,000030	0,125	0,18	0,17
$1\cdot10^{-3}$	0,0010001	0,000021	0,000041	0,0000089	-0,0000041	0,000031	0,000014	0,000061	0,000028	0,084	0,15	0,15
$1\cdot10^{-2}$	0,0099608	0,000025	0,000050	0,0000492	-0,0000001	0,000750	0,0000008	0,0015	0,000002	0,0043	0,03	0,05

Table A.6.1 – Results of comparisons of loss dissipation factor (tan δ) VNIIMS – SE “Ukrmetrteststandard”

Voltage range $U_{ном}[kV]$	**tan δ_o**	**u(tan δ_o)**	**U(tan δ_o)**	**Δtan δ_L UKR**	**Δtan δ_L VNIIMS**	**u(Δtan δ_L) UKR**	**u(Δtan δ_L) VNIIMS**	**U(Δtan δ_L) UKR**	**U(Δtan δ_L) VNIIMS**	$\chi_{tg\delta}^2$	**E_n (UKR)**	**E_n (VNIIMS)**
1	2,59E-06	2,57E-05	5,14E-05	-3,09E-06	8,57E-06	1,54E-05	4,29E-05	3,09E-05	8,57E-05	0,08	0,09999	0,09999
1,5	2,67E-06	2,57E-05	5,14E-05	-4,37E-06	1,21E-05	1,54E-05	4,29E-05	3,09E-05	8,57E-05	0,16	0,14149	0,14149
2	2,40E-06	2,57E-05	5,14E-05	-4,30E-06	1,19E-05	1,54E-05	4,29E-05	3,09E-05	8,57E-05	0,16	0,13926	0,13926