Supplementary comparisons of DC high voltage measuring reference instruments
COOMET 449/RU-a/08
(COOMET.EM-S7)

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Abstract – The supplementary comparisons of DC high voltage measuring reference instruments up to 100 kV have been performed among the following national metrological institutes (NMIs): VNIIMS, LCOE, BIM and SE “Ukrmetrteststandard”.
Its description and measurement results are presented below.
Index Terms – Comparisons, expanded uncertainty, measurement, reference instrument, transfer standard, DC voltage.

I. INTRODUCTION

Comparisons were carried out in 2008 – 2010 under COOMET project 449/RU-a/08 (COOMET.EM-S7).

The Pilot laboratory of comparisons was FGUP “VNIIMS”. The comparisons were performed with the FGUP “VNIIMS” transfer standard which was measured by each participating laboratory in turn using its measuring equipment and objects for DC voltage.

Because each laboratory made measurements at different voltages and different principles of measurements were used in each NMI, the comparison results are treated as a sequence of bilateral comparisons with the pilot (VNIIMS).

II. COMPARISON TRAVELLING STANDARD

Brief description of VNIIMS reference measurement system

The reference measurement system (RMS) is a differential instrument of DC high voltage DWINA-100 on the basis of series circuit of stabilitrons. It consists of the high voltage block, low voltage block, measuring cable, digital DC voltmeter, and accessories (ground cable, jumper cable, protective resistance).

The principle of the RMS operation is based on the use of non-linear characteristic of series circuit of stabilitrons, having high stability, small differential resistance, and consequently, small dependence on the corona currents, leakage currents on the surface of dielectric, and also, on the typical problem of high voltage dividers - depending on the ratios.

The RMS consists of the high voltage block (stabilitrons connected in series circuit, making a group with the stabilization voltage of 1000V each one), low voltage block, that is stable in time, current stabilizer, that sets the operation current to 5,000 mA, DC voltmeter, aimed at measuring differential voltage of the high voltage block.

A more detailed description and a picture of the VNIIMS reference measurement system is represented in Annex A.

III. MEASURED VALUES

The DC high voltage rated value (U) was measured during the comparisons with the LCOE and BIM.

Voltage error (δU) is defined as:

$$\delta U = \frac{U_{ref} - U_{VNIIMS/LCOE/BIM}}{U_{ref}} \bullet 100 \qquad (1).$$

The measurand during the comparisons between VNIIMS – SE “Ukrmetrteststandard” was the scale factor K of VNIIMS transfer reference measuring system (hereinafter referred as – TRMS VNIIMS).

The scale factor measurement error is defined according to the formula:

$$\Delta K = \overline{K}_{VNIIMS/\text{Ukrmetrteststandard}} - K_{ref}\,, \qquad (2).$$

IV. SCHEDULE OF THE COMPARISONS

Table 1 – Schedule of the comparisons

№	NMI		Country	Terms
pilot	VNIIMS	Russian research institute for metrological service (VNIIMS)	Russian Federation	2008 - 2011
1	LCOE	Laboratorio Central Oficial de Electrotecnia (LCOE)	Spain	2009
2	SE “Ukrmetrteststandard”	State enterprise “All-Ukrainian state research and production center for standardization, metrology, certification and consumers’ rights protection” (SE “Ukrmetrteststandard”)	Ukraine	2010
3	BIM	Bulgarian Institute of Metrology (BIM)	Bulgaria	2011

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 – 100) kV; rated value of secondary voltage: U_2 = (1 – 1000) V; for confidence level P = 0,95 and with coverage factor k = 2, expanded uncertainty $U_{0,95}(_{\mathrm{VNIIMS}})$ = 5E-05. A more detailed description of VNIIMS reference system, its construction and principle of operation is briefly represented in Annex A.

LCOE used national standard with: rated value of primary voltage: U_1 = (1 – 200) kV; nominal ratio (scale factor) of resistive divider: 10 000; for confidence level P = 0,95 and with coverage factor k = 2, expanded uncertainty $U_{0,95}(_{\mathrm{LCOE}})$ = 1E-04.

BIM used national standard with: rated value of primary voltage: U_1 = (1 –100) kV; nominal ratio of divider: 10 000; for confidence level P = 0,95 and with coverage factor k = 2, expanded uncertainty $U_{0,95}(_{\mathrm{BIM}})$ = 4E-02.

SE "Ukrmetrteststandard" used national standard with: rated value of primary voltage: U_1 = (1 –180) kV; rated value of secondary voltage: U_2 = (1 – 100) V; for confidence level P = 0,95 and with coverage factor k = 2, expanded uncertainty $U_{0,95}(_{\mathrm{Ukrmetrteststandard}})$ = 1,2E-03.

VI. PARTICIPANT'S REFERENCE EQUIPMENT

Reference instruments of laboratories of participating NMIs stable in time with metrological characteristics presented below were used as objects of comparisons:

Measuring system based on differential instrument measuring DC high voltage and a voltmeter of SE "Ukrmetrteststandard":

– SE "Ukrmetrteststandard": differential measuring instrument - DC voltage range from 1 to 180 kV; current stabilizer – DC voltage range from 1 to 100 V, voltmeter.

Measuring systems based on DC high voltage dividers and voltmeters of laboratories of LCOE and BIM:

– LCOE: resistive voltage divider ROSS ENGINEERING VD240-6Y-CBD-KC-BBC – DC voltage range from 1 to 240 kV; nominal ratio of divider: 10 000; voltmeter Hewlett-Packard 3458A;

– BIM: resistive-capacitive divider PHENIX Technologies KMV200 - DC voltage range from 1 to 200 kV; nominal ratio of divider: 10 000; voltmeter Wavetek 1281.

VII. METHODS AND MEASUREMENT PROCEDURE

Each of the participating laboratories used its usual method of measurements to get the best possible measurement results within the time for the comparison.

During the comparisons direct method of comparisons was used between VNIIMS – LCOE – BIM. Synchronization of voltmeters was made according to the time by means of manual regulation. The pulsation level of the high DC voltage was controlled by means of an oscilloscope. Time was measured by means of a stopwatch.

During the comparisons between VNIIMS – LCOE – BIM the following voltage levels were used: 1 kV, 10 kV, 50 kV, 75 kV, 100 kV.

During the comparisons of objects of VNIIMS – SE "Ukrmetrteststandard" the following voltage levels were used: 1 kV, 5 kV, 10 kV, 50 kV, 80 kV, 100 kV, 150kV, 200 kV.

VIII. ANALYSIS OF COMPARISON DATA

For each DC high voltage step the resulting comparison reference value (CRV) of the voltage for each bilateral supplementary comparison is calculated as the weighted mean of results of measurements presented by the participant NMI and VNIIMS:

$$f_r = \frac{\sum_{L=1}^{2} f_L u^{-2}(f_L)}{\sum_{L=1}^{2} u^{-2}(f_L)} \qquad (3)$$

with standard uncertainty:

$$u(f_r) = \frac{1}{\sqrt{\sum_{L=1}^{2} u^{-2}(f_L)}} \qquad (4)$$

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

$$\Delta(f_L) = f_L - f_r \qquad (5)$$

with uncertainty

$$u(\Delta f_L) = \sqrt{u^2(f_L) - u^2(f_r)} \qquad (6)$$

The credibility of the reference values and their uncertainties is characterized by the χ^2 test, given by the formulae (7). Values of this function are determined for the results of DC high voltage / scale factor measurement for each DC high voltage level by formula:

$$\chi_f^2 = \sum_{L=1}^{n} \frac{(f_L - f_r)^2}{u^2(f_L)}, \qquad (7)$$

f_r - average values for the differences of the measurement results from the DC high voltage / scale factor (equation 3);

f_L- are the differences of the measurement results from the DC high voltage / scale factor for each NMI participating the comparisons;

$u(f_L)$ - are combined standard deviations (standard uncertainties) of the differences of measurements results from DC high voltage / scale factor, represented by each NMI participating in the particular bilateral comparison;

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

IX. RESULTS OF COMPARISONS

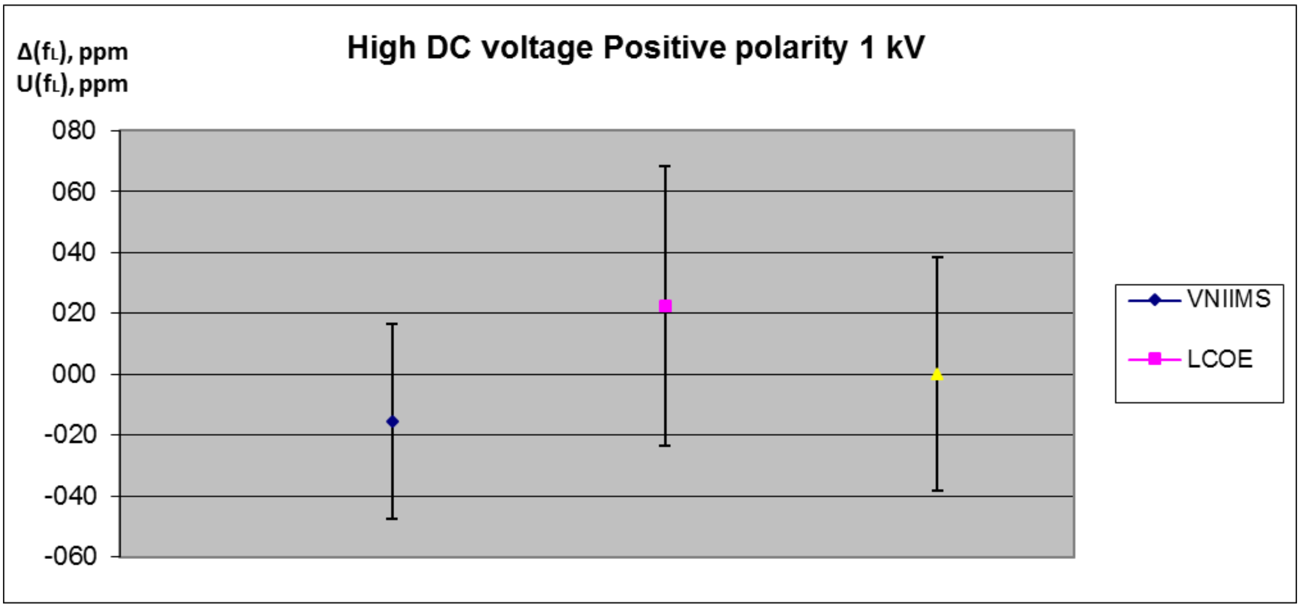
Distribution function χ^2 is tabulated in Annex A. The received values χ_f^2 do not exceed the critical value $\chi^2_{0,95}(n-1)$ for the confidence level P = 0,95 and number of degrees of freedom (n-1), which constitutes an objective evidence of the uncertainties declared by NMI during the comparisons:

$$\chi_f^2 < \chi^2_{0,95}(n-1) \qquad (8)$$

Graphic results of the comparisons of DC high voltage are demonstrated on examples below (Figures 1 - 15). On axis Y results are represented as relative value in ppm.

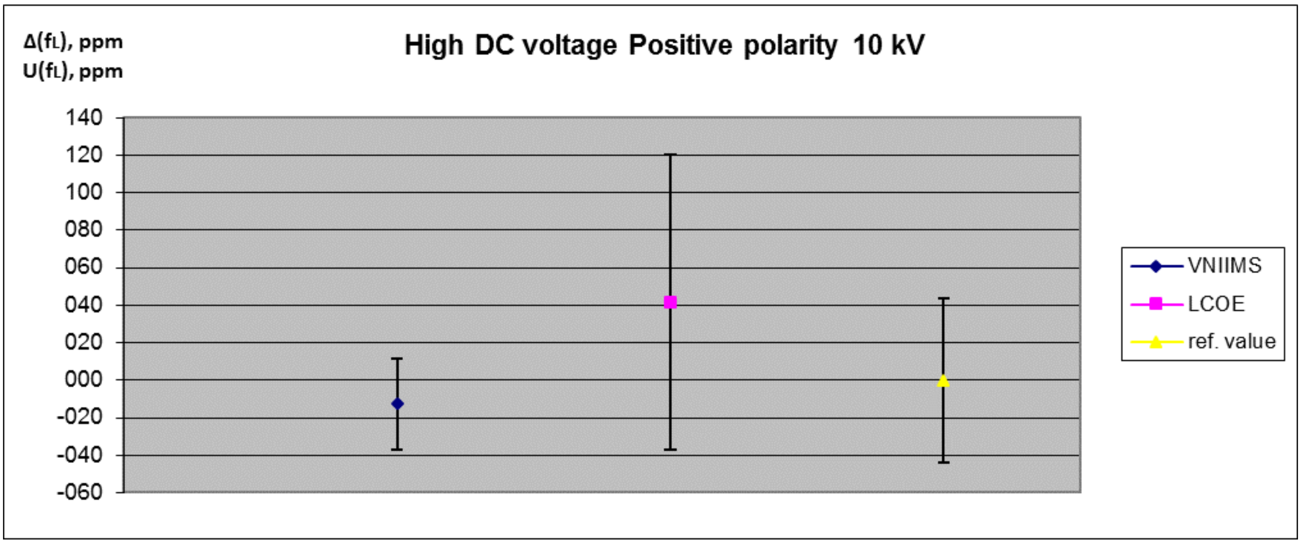
Standard uncertainties had been used in the calculation of equivalence graphs represented below.

More detailed presentation of the results of the comparisons of DC high voltage in the form of the Tables A.1 – A.3, including the results of measurements of all NMI participating the comparisons, may be found in Annex B.



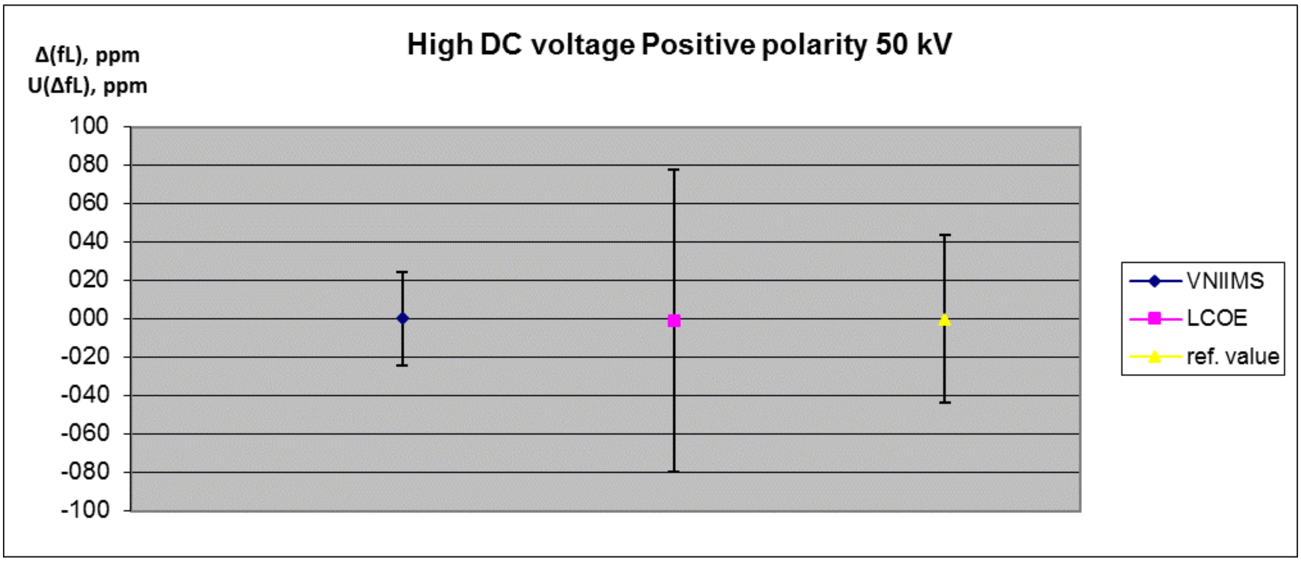
+ 1 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	-15,52	32,01
LCOE	22,35	46,09
ref. value	0,00	38,41

Figure 1. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 1 kV, positive polarity)



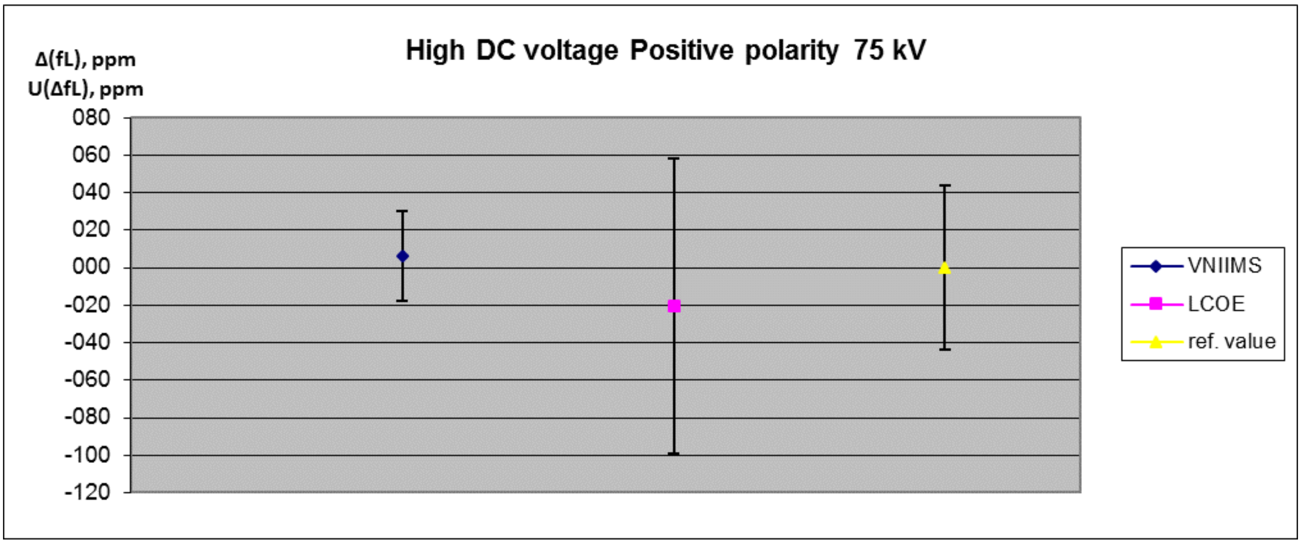
+ 10 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	-12,78	24,28
LCOE	41,39	78,67
ref. value	0,00	43,71

Figure 2. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 10 kV, positive polarity)



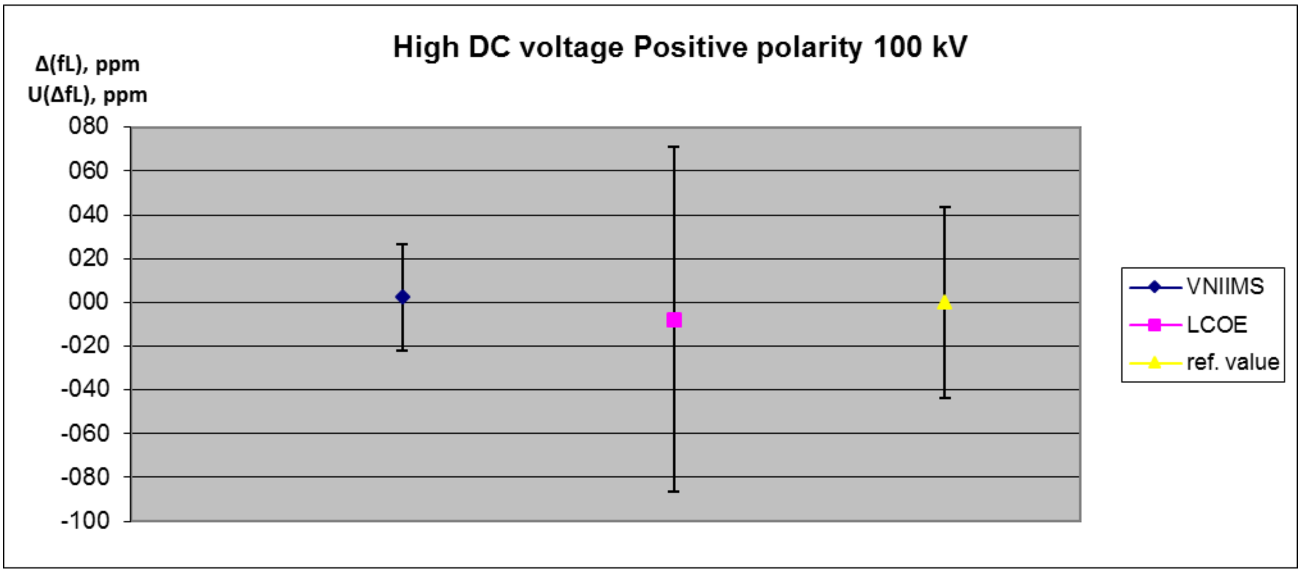
+ 50 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	0,32	24,28
LCOE	-1,04	78,67
ref. value	0,00	43,71

Figure 3. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 50 kV, positive polarity)



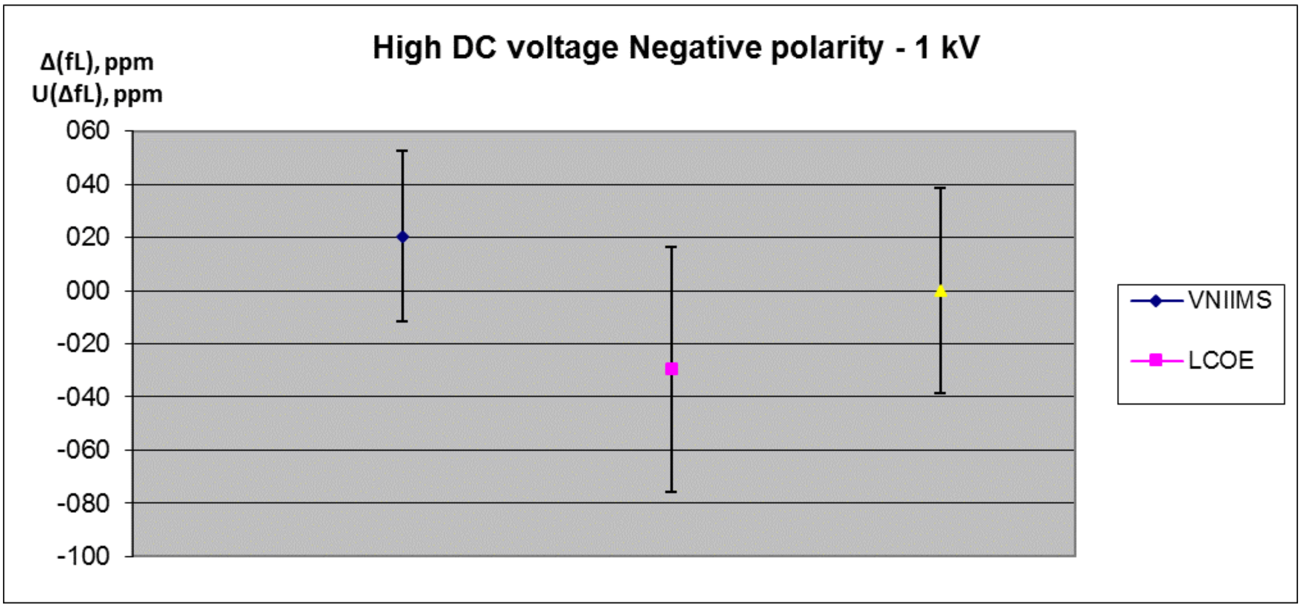
+ 75 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	6,27	24,28
LCOE	-20,32	78,67
ref. value	0,00	43,71

Figure 4. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 75 kV, positive polarity)



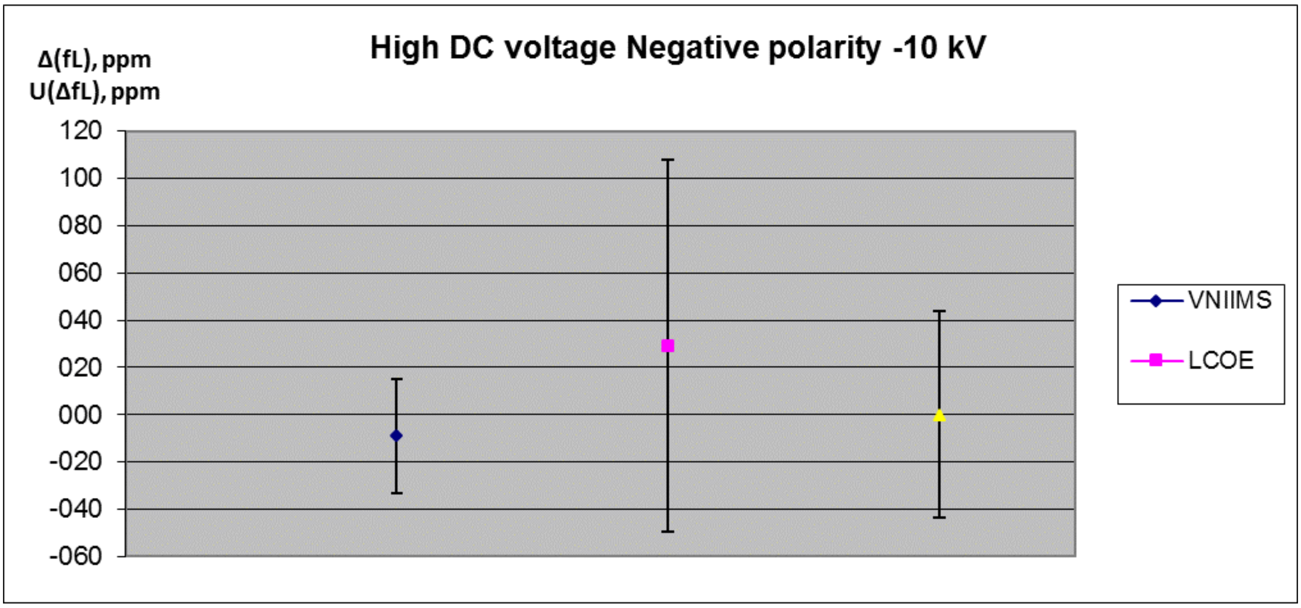
+ 100 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	2,40	24,28
LCOE	-7,77	78,67
ref. value	0,00	43,71

Figure 5. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 100 kV, positive polarity)



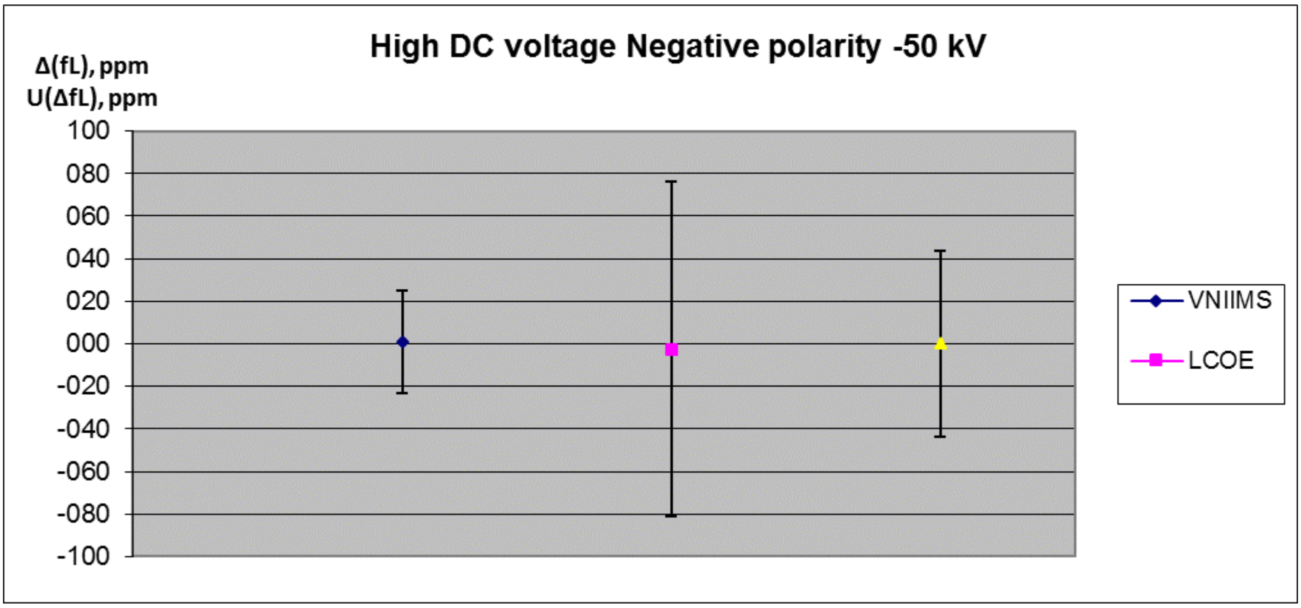
- 1 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	20,48	32,01
LCOE	-29,50	46,09
ref. value	0,00	38,41

Figure 6. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 1 kV, negative polarity)



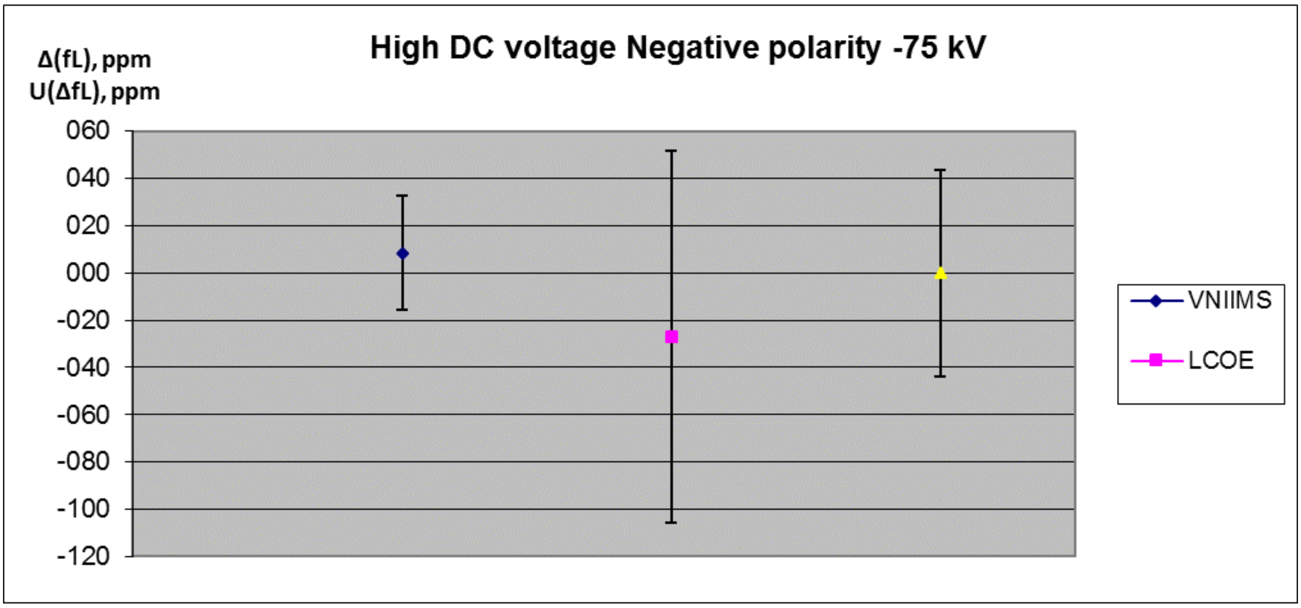
- 10 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	-9,02	24,28
LCOE	29,22	78,67
ref. value	0,00	43,71

Figure 7. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 10 kV, negative polarity)



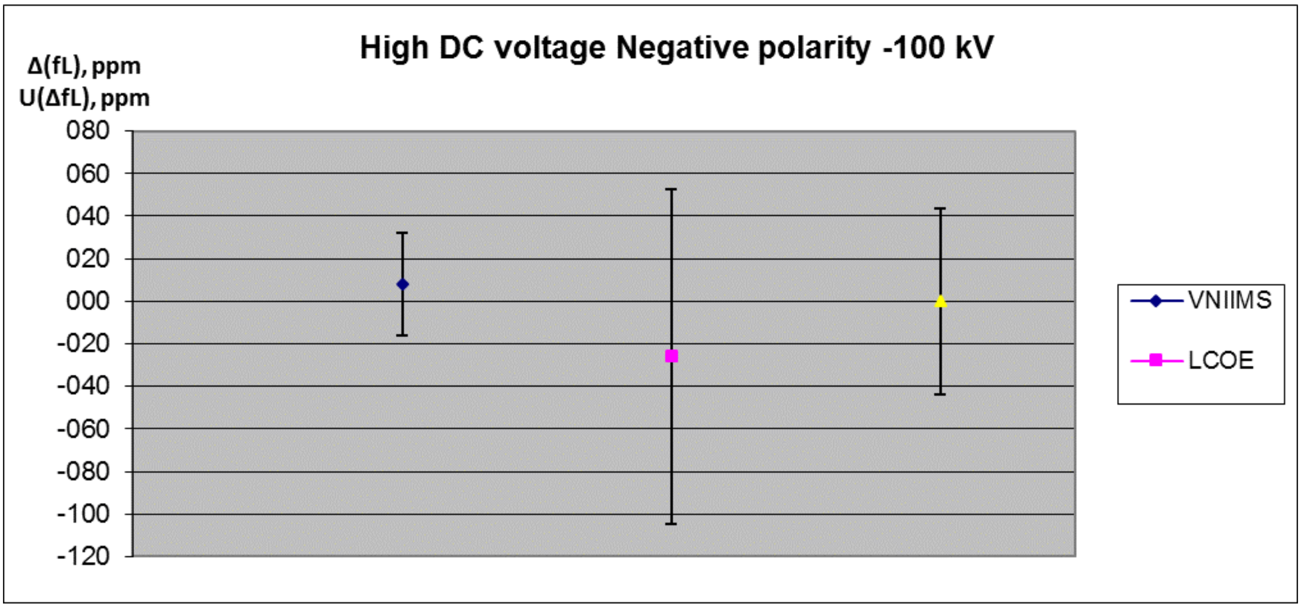
- 50 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	0,83	24,28
LCOE	-2,68	78,67
ref. value	0,00	43,71

Figure 8. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 50 kV, negative polarity)



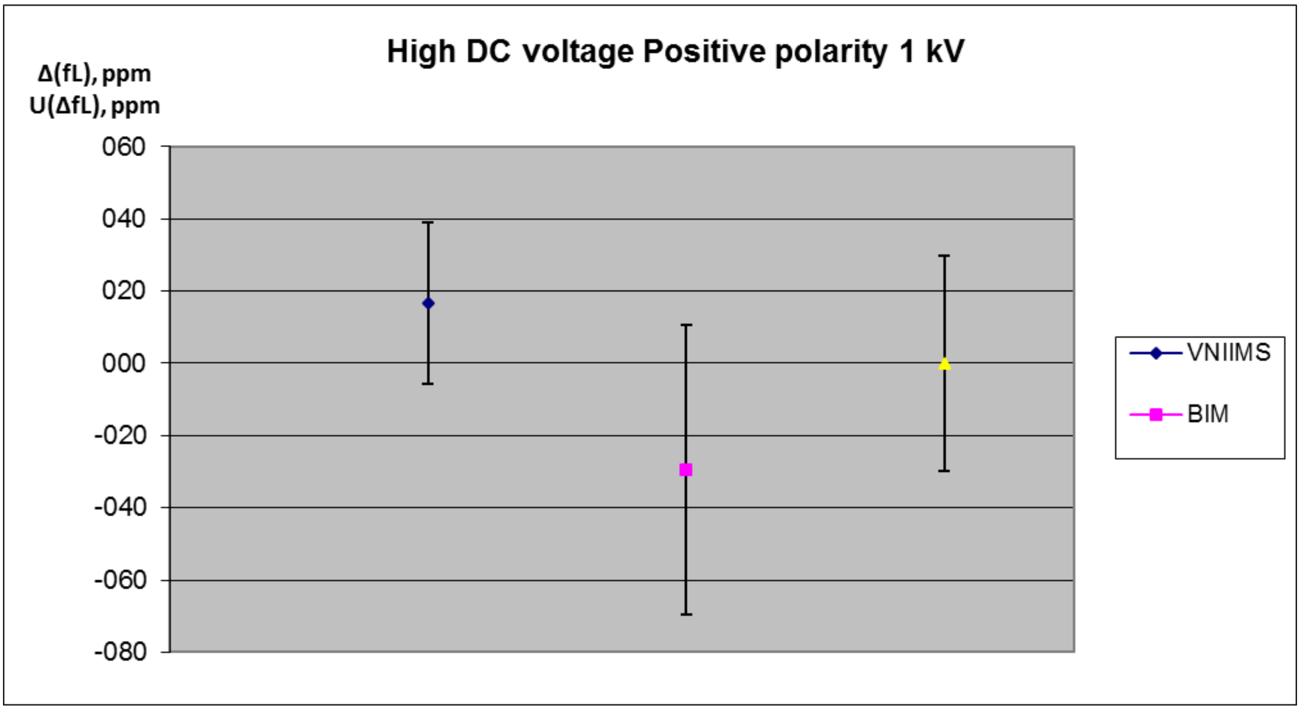
- 75 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	8,39	24,28
LCOE	-27,19	78,67
ref. value	0,00	43,71

Figure 9. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 75 kV, negative polarity)



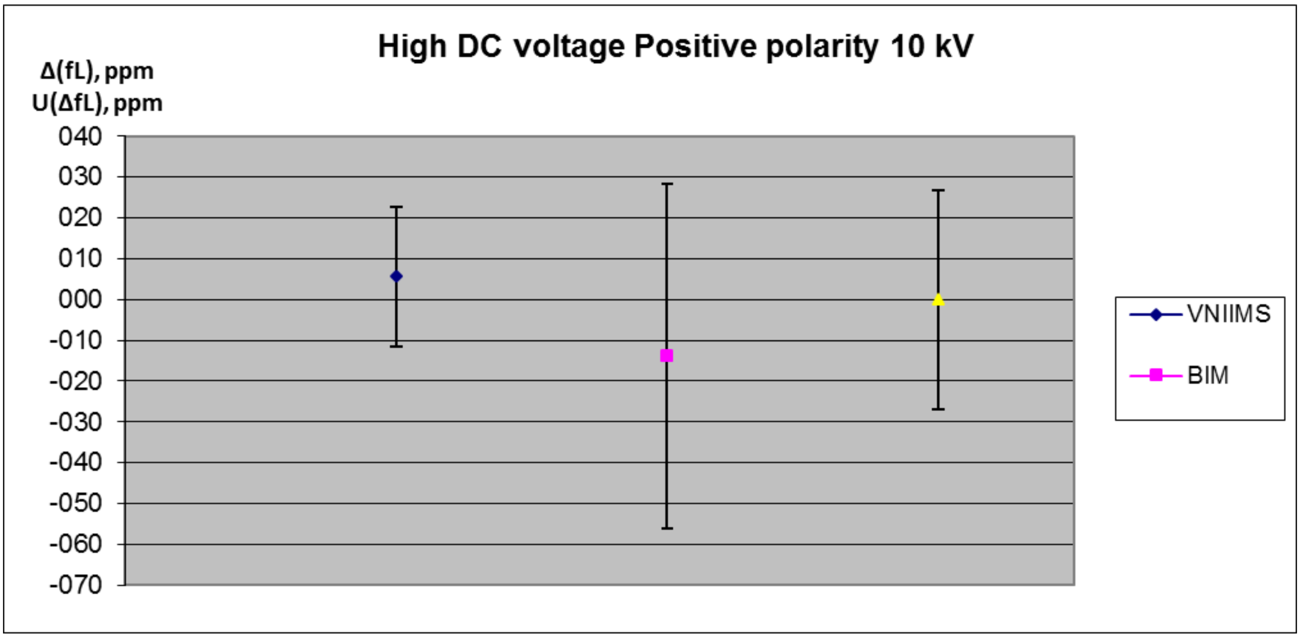
- 100 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	7,98	24,28
LCOE	-25,85	78,67
ref. value	0,00	43,71

Figure 10. Results of comparisons of DC high voltage between VNIIMS and LCOE (voltage level 100 kV, negative polarity)



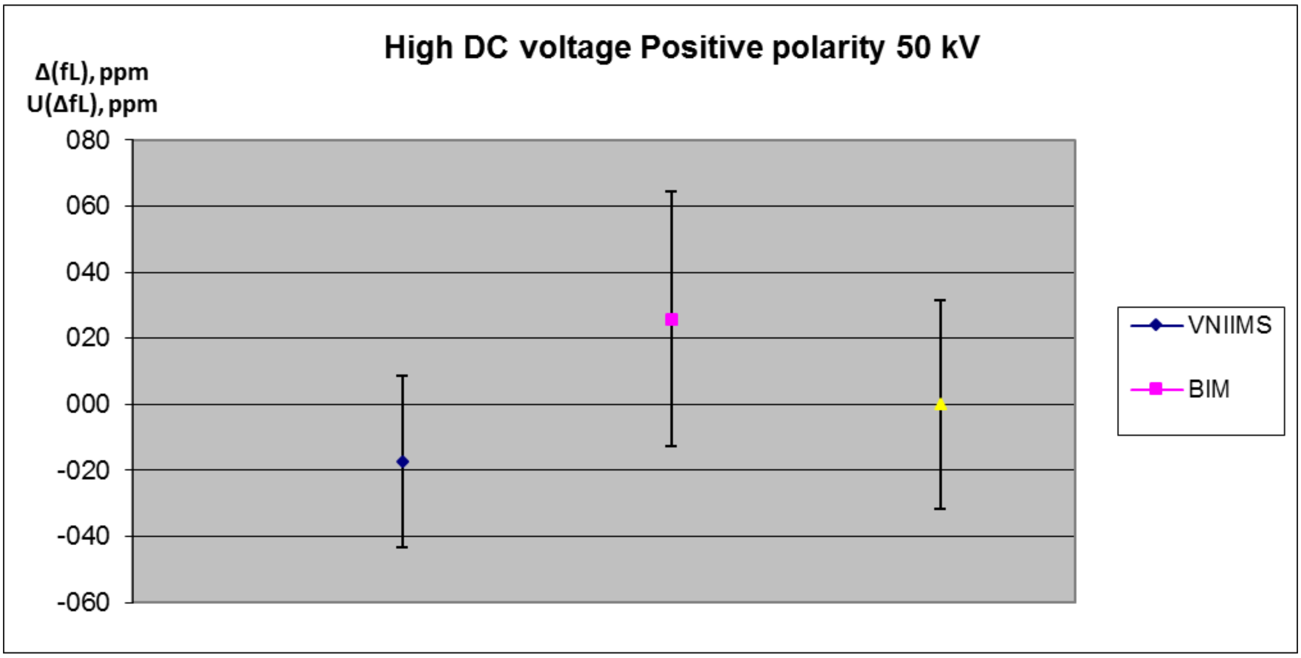
1 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	16,52	22,39
BIM	-29,53	40,04
ref. value	0	29,94

Figure 11. Results of comparisons of DC high voltage between VNIIMS and BIM (voltage level 1 kV, positive polarity)



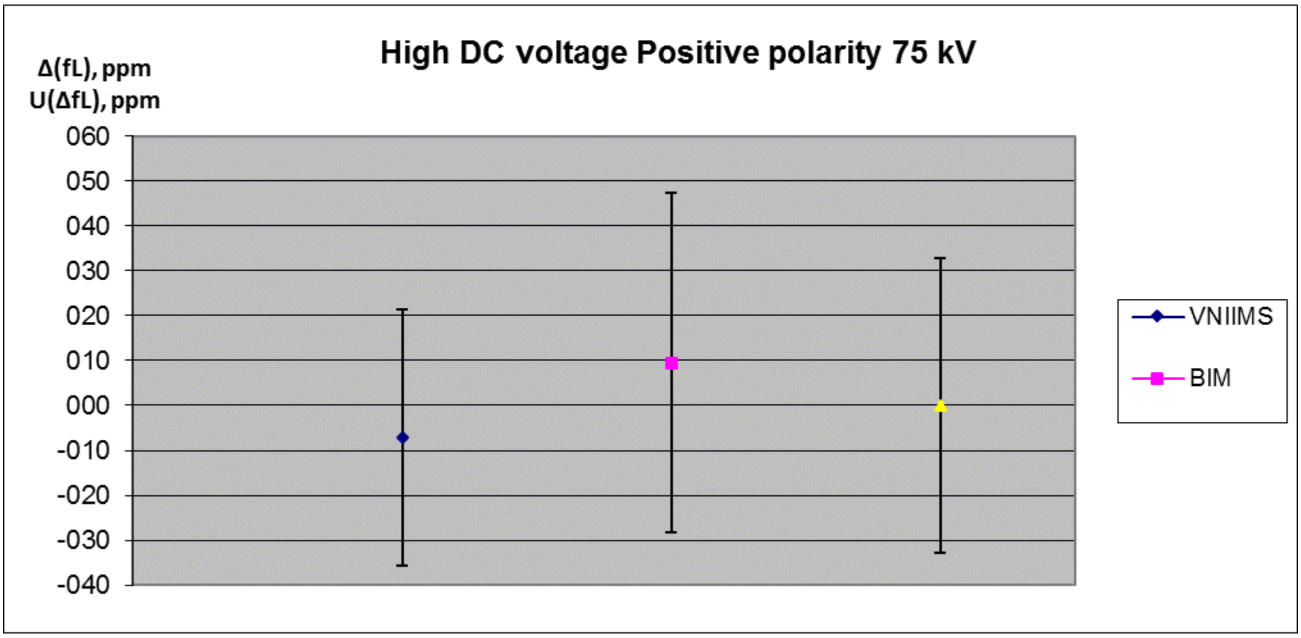
10 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	5,62	17,13
BIM	-13,83	42,16
ref. value	0	26,87

Figure 12. Results of comparisons of DC high voltage between VNIIMS and BIM (voltage level 10 kV, positive polarity)



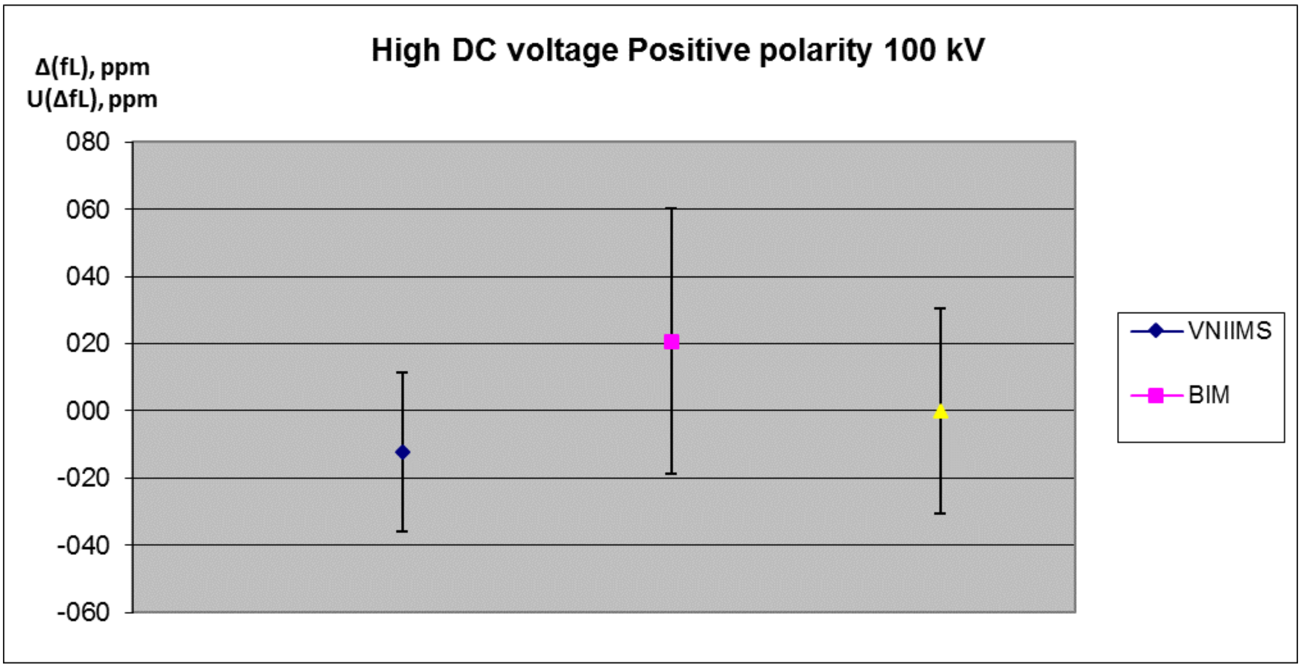
50 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	-17,31	25,91
BIM	25,85	38,70
ref. value	0	31,66

Figure 13. Results of comparisons of DC high voltage between VNIIMS and BIM (voltage level 50 kV, positive polarity)



75 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	-7,22	28,51
BIM	9,55	37,74
ref. value	0	32,80

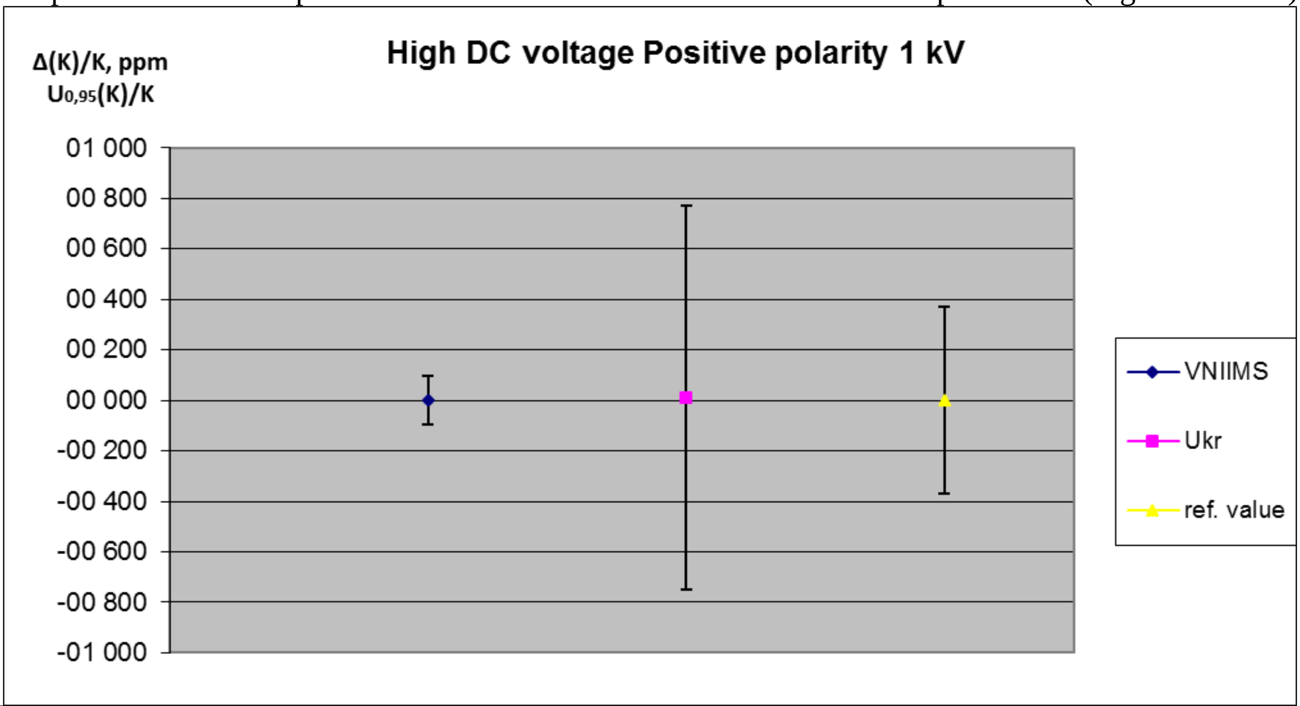
Figure 14. Results of comparisons of DC high voltage between VNIIMS and BIM (voltage level 75 kV, positive polarity)



100 kV	$\Delta(f_L)$, ppm	$U(\Delta f_L)$, ppm
VNIIMS	-12,37	23,65
BIM	20,70	39,55
ref. value	0	30,58

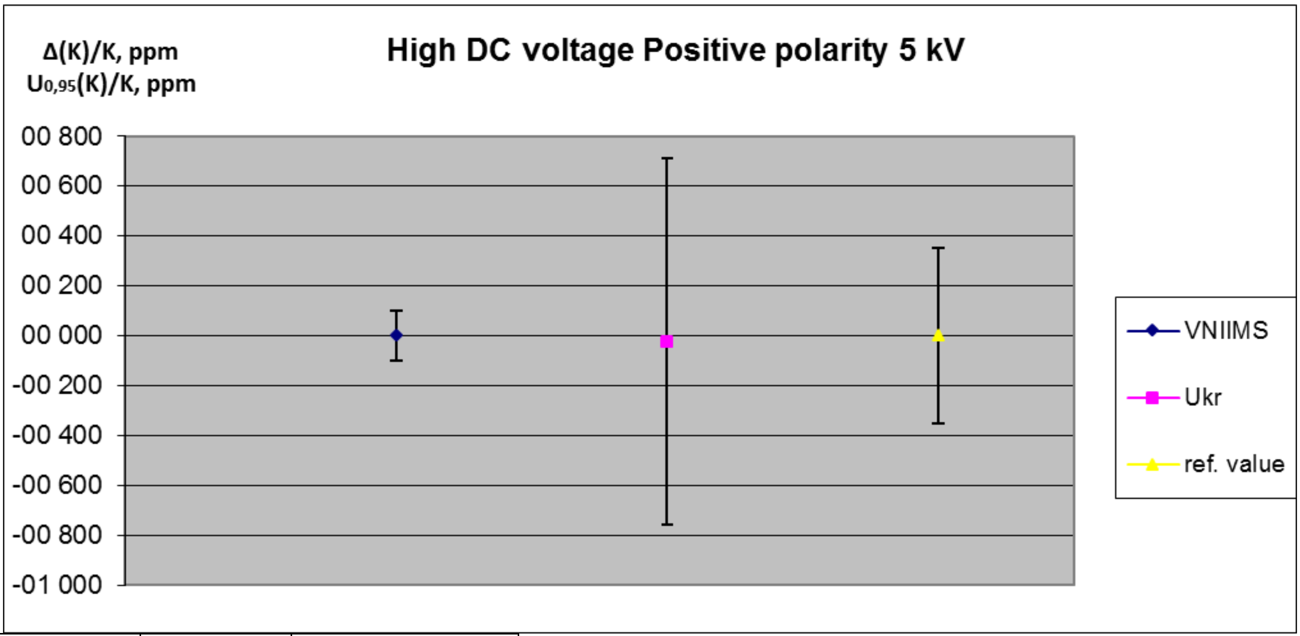
Figure 15. Results of comparisons of DC high voltage between VNIIMS and BIM (voltage level 100 kV, positive polarity).

Graphic results of comparisons of scale factor are demonstrated on examples below (Figures 16 - 23):



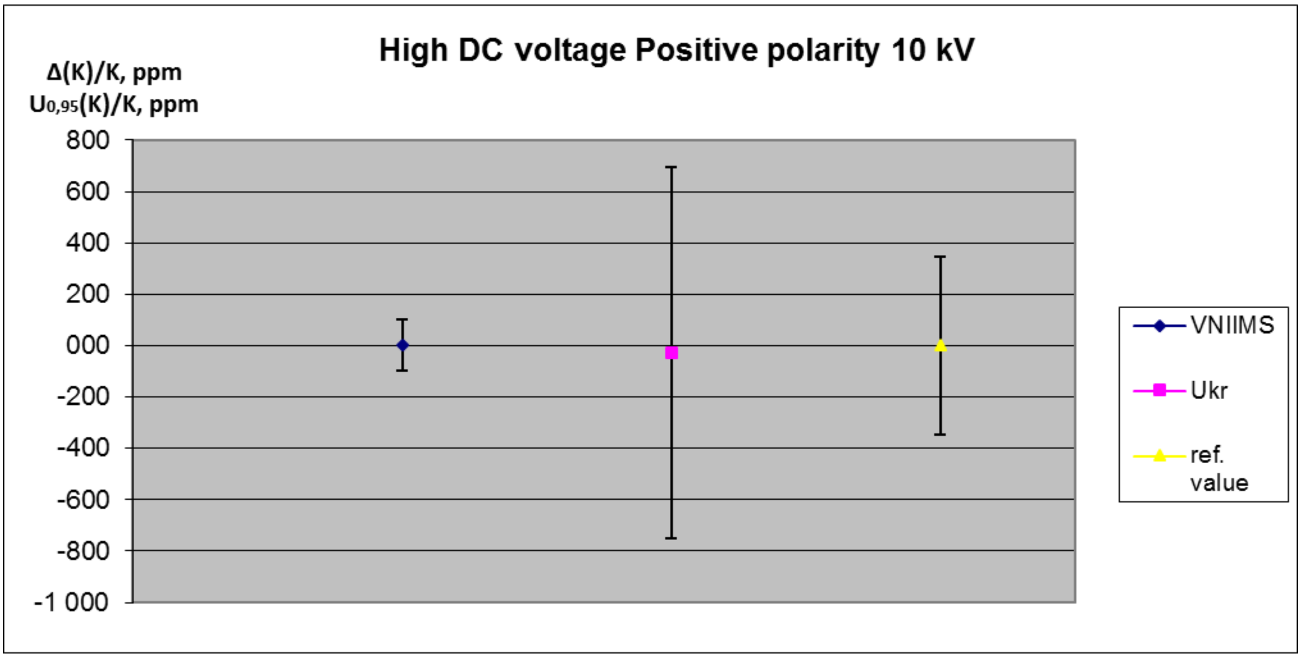
1 kV	Δ(K)/K ppm	$U_{0,95}$(K)/K ppm
VNIIMS	-0,1535	97,91
UKR	9,25	760,31
ref. value	0,0000	369,08

Figure 16. Results of comparisons of DC high voltage between VNIIMS and SE “Ukrmetrteststandard” (voltage level 1 kV, positive polarity)



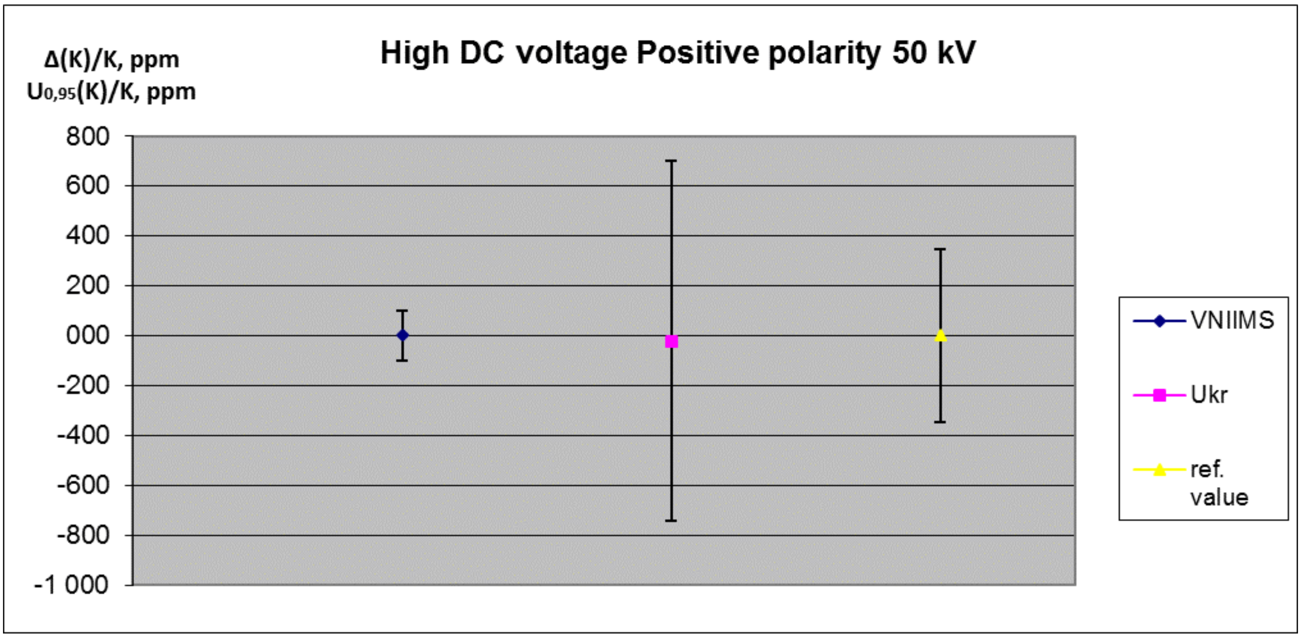
5 kV	Δ(K)/K ppm	$U_{0,95}$(K) ppm
VNIIMS	0,4546	102,12
UKR	-23,49	734,08
ref. value	0,0000	353,12

Figure 17. Results of comparisons of DC high voltage between VNIIMS and SE “Ukrmetrteststandard” (voltage level 5 kV, positive polarity)



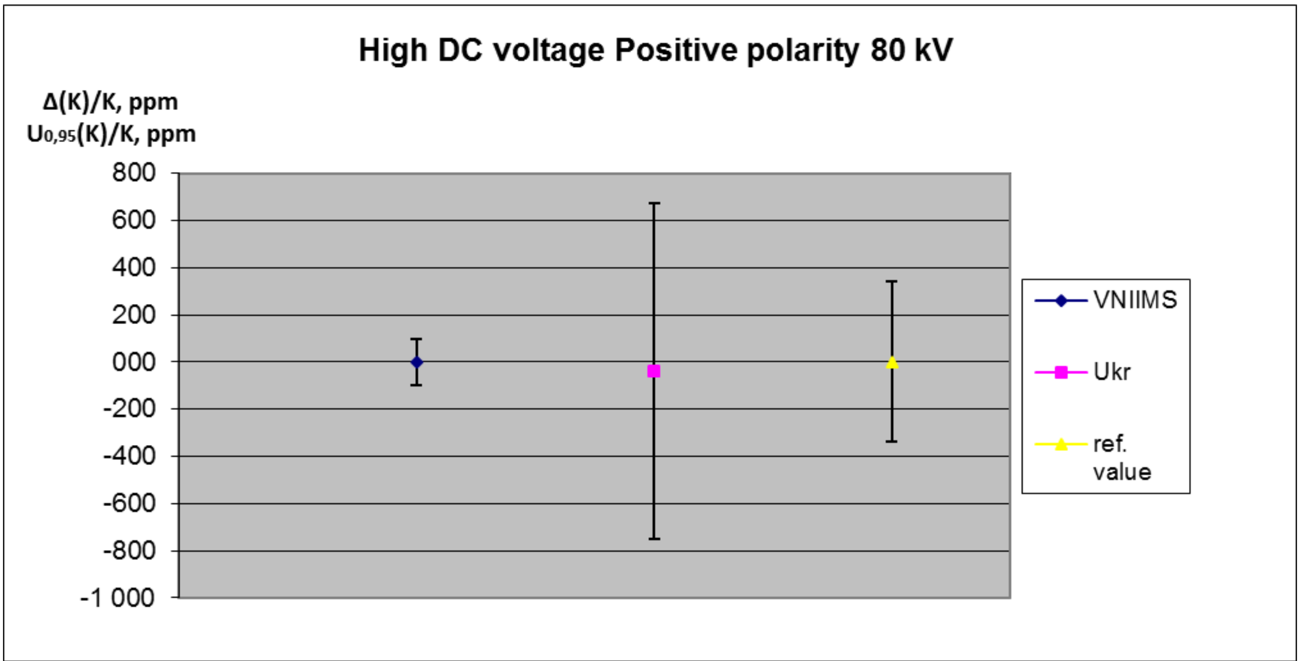
10 kV	Δ(K)/K ppm	$U_{0,95}$(K) ppm
VNIIMS	0,5524	100,32
UKR	-28,62	722,10
ref. value	0,0000	345,78

Figure 18. Results of comparisons of DC high voltage between VNIIMS and SE “Ukrmetrteststandard” (voltage level 10 kV, positive polarity)



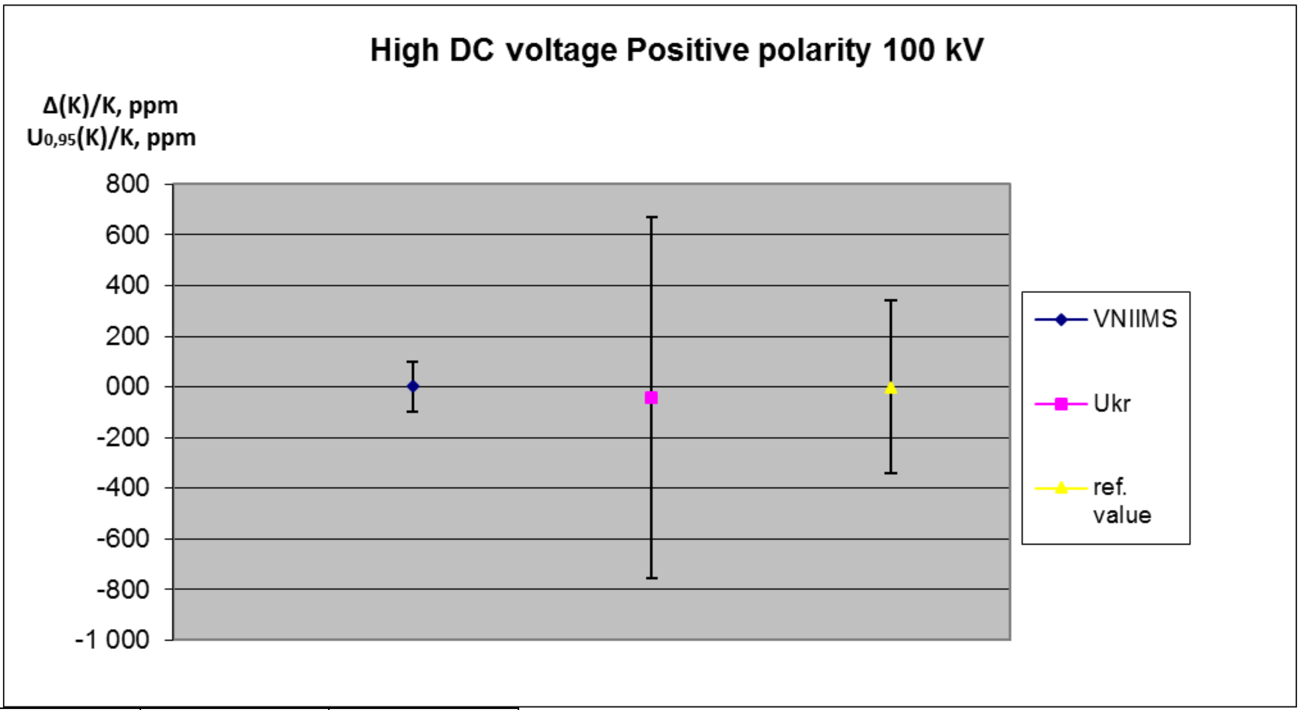
50 kV	Δ(К)/K ppm	$U_{0,95}$(К) ppm
VNIIMS	0,4171	100,36
UKR	-21,61	722,27
ref. value	0,0000	345,85

Figure 19. Results of comparisons of DC high voltage between VNIIMS and SE “Ukrmetrteststandard” (voltage level 50 kV, positive polarity)



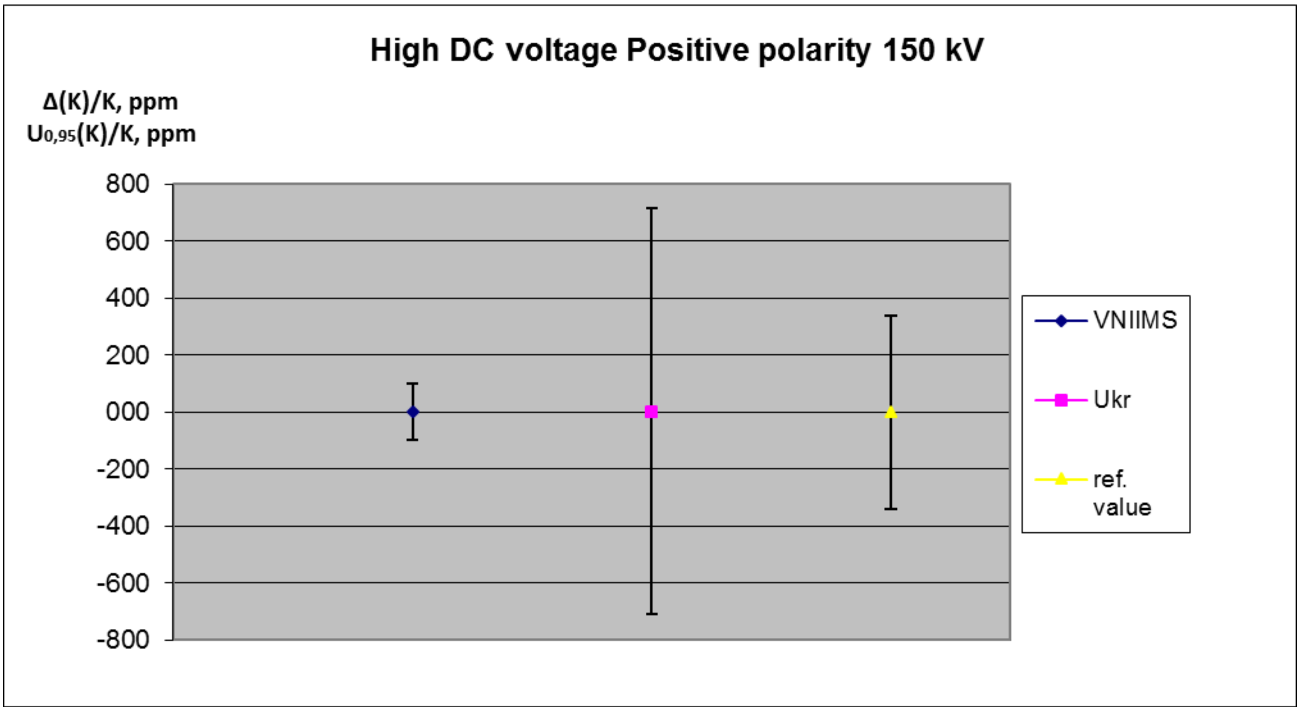
80 kV	Δ(К)/K ppm	$U_{0,95}$(К) ppm
VNIIMS	0,7109	98,96
UKR	-36,87	712,61
ref. value	0,0000	339,87

Figure 20. Results of comparisons of DC high voltage between VNIIMS and SE “Ukrmetrteststandard” (voltage level 80 kV, positive polarity)



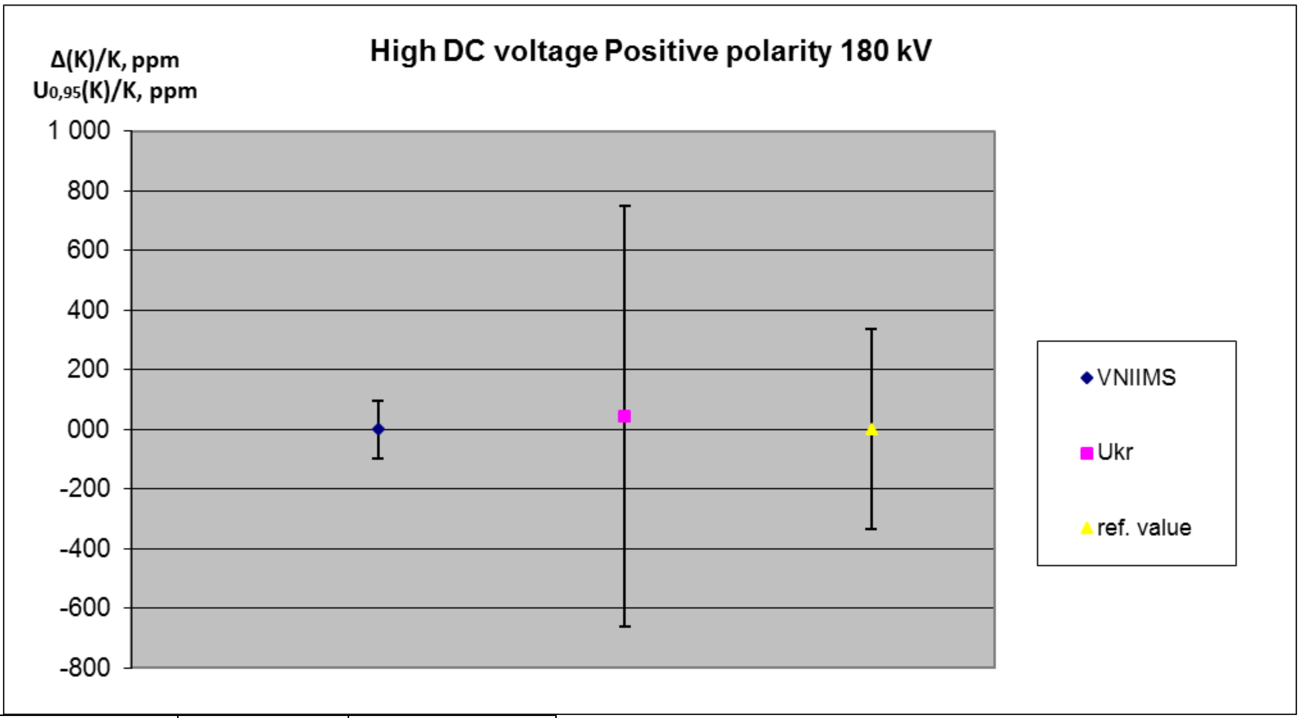
100 kV	Δ(K)/K ppm	$U_{0,95}$(K) ppm
VNIIMS	0,8072	98,96
UKR	-41,86	712,62
ref. value	0,0000	339,87

Figure 21. Results of comparisons of DC high voltage between VNIIMS and SE “Ukrmetrteststandard” (voltage level 100 kV, positive polarity)



150 kV	Δ(K)/K ppm	$U_{0,95}$(K) ppm
VNIIMS	-0,0393	98,96
UKR	2,04	712,50
ref. value	0,0000	339,81

Figure 22. Results of comparisons of DC high voltage between VNIIMS and SE “Ukrmetrteststandard” (voltage level 150 kV, positive polarity)



180 kV	Δ(K)/K ppm	$U_{0,95}$(K) ppm
VNIIMS	-0,8288	97,94
UKR	42,93	704,85
ref. value	0,0000	335,08

Figure 23. Results of comparisons of DC high voltage between VNIIMS and SE “Ukrmetrteststandard” (voltage level 180 kV, positive polarity)

VIII. CONCLUSION

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

This comparison also serves as objective evidence for the corresponding calibration and measurement capabilities (CMCs), stated in the BIPM database, for the measured values of DC high voltage. For those NMIs which declared smaller uncertainties in this comparison as for their CMCs, the results could be accepted for corresponding changes of the CMCs in the BIPM database.

Annex A

VNIIMS reference system

Construction of VNIIMS reference system is based on two basic components:

– the high voltage block (hereinafter referred as - HVB-100);

– the low voltage block (hereinafter referred as - LVB-U2/1000).

The HVB-100 is the main component of the instrument. It consists of the base frame, one module of 100 kV voltage, and the high voltage shield, and is used to perform high voltage measurements. HVB-100 is used for measuring high DC voltage in the range from 1 kV to 100 kV with the resolution of 1000 V. HVB-100 consists of a dielectric cylinder, metallic flanges, 100 measuring boards, 1000 V each one, connected in series, on which 118 Zener – diodes (D818) are placed in series connection. The Zener – diodes, used for the boards mounting were subjected to the procedure of artificial ageing under high temperature, ensuring stability in time of the whole device. The number of the boards connected in series may be chosen depending on the level of measurements and may be changed by means of commutation of the boards that are not used. In the frame of the dielectric shield of HVB-100 opposite to the 1 kV boards holes for blowing air over the boards with the purpose of cooling the Zener – diodes are provided.

Between the output of the HVB-100 and the ground a Zener-diode is supplemented to protect the device against the break of the connecting cable. Protection of the low voltage block (hereinafter referred as - LVB-U2/1000) is also provided by the spark gap of safety gap.

For protection of the Zener – diodes from possible mechanical damages a dielectric shield is provided. It is also used during the forced air cooling in the process of operation of the entire system.

LVB-U2/1000 is connected in series with HVB-100. It is used to provide the stability of the current values (current stabilizer (regulator)), detection of the differential voltage, protection of the measuring circuit from overload. Structurally it is assembled in a portable case.

The VNIIMS reference system (differential voltage meter DWINA-100) is represented on Picture 1.

Picture 1– VNIIMS reference system

Annex B

Table A.1 – Results of comparisons of DC high voltage VNIIMS – LCOE

U_N **[kV]**	f_{VNIIMS} **ppm**	f_{LCOE} **ppm**	$u(f_{VNIIMS})$ **ppm**	$u(f_{LCOE})$ **ppm**	f_r **ppm**	$u(f_r)$ **ppm**	$U(f_r)$ **ppm**	$\Delta(f_{VNIIMS})$ **ppm**	$\Delta(f_{LCOE})$ **ppm**	$u(\Delta f_{VNIIMS})$ **ppm**	$u(\Delta f_{LCOE})$ **ppm**	$U(\Delta f_{VNIIMS})$ **ppm**	$U(\Delta f_{LCOE})$ **ppm**	χ_f^2	R_B
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Positive polarity															
1	-67,10	-29,23	25,00	30,00	-51,58	19,21	38,41	-15,52	22,35	16,00	23,05	32,01	46,09	0,940	0,970
10	-84,90	-30,73	25,00	45,00	-72,12	21,85	43,71	-12,78	41,39	12,14	39,34	24,28	78,67	1,107	1,052
50	-43,00	-44,36	25,00	45,00	-43,32	21,85	43,71	0,32	-1,04	12,14	39,34	24,28	78,67	0,001	0,026
75	-31,00	-57,59	25,00	45,00	-37,27	21,85	43,71	6,27	-20,32	12,14	39,34	24,28	78,67	0,267	0,517
100	-63,50	-73,67	25,00	45,00	-65,90	21,85	43,71	2,40	-7,77	12,14	39,34	24,28	78,67	0,039	0,198
Negative polarity															
-1	30,96	-19,02	25,00	30,00	10,48	19,21	38,41	20,48	-29,50	16,00	23,05	32,01	46,09	1,638	1,280
-10	-69,51	-31,27	25,00	45,00	-60,49	21,85	43,71	-9,02	29,22	12,14	39,34	24,28	78,67	0,552	0,743
-50	-40,47	-43,97	25,00	45,00	-41,30	21,85	43,71	0,83	-2,68	12,14	39,34	24,28	78,67	0,005	0,068
-75	-31,29	-66,87	25,00	45,00	-39,68	21,85	43,71	8,39	-27,19	12,14	39,34	24,28	78,67	0,478	0,691
-100	-39,52	-73,35	25,00	45,00	-47,50	21,85	43,71	7,98	-25,85	12,14	39,34	24,28	78,67	0,432	0,657

Table A.2 – Results of comparisons of DC high voltage VNIIMS – BIM

U_N **[кВ]**	f_{VNIIMS} **ppm**	f_{BIM} **ppm**	$u(f_{VNIIMS})$ **ppm**	$u(f_{BIM}$ **ppm**	f_r **ppm**	$u(f_r)$ **ppm**	$U(f_r)$ **ppm**	$\Delta(f_{VNIIMS})$ **ppm**	$\Delta(f_{BIM})$ **ppm**	$u(\Delta f_{VNIIMS})$ **ppm**	$u(\Delta f_{BIM})$ **ppm**	$U(\Delta f_{VNIIMS})$ **ppm**	$U(\Delta f_{BIM})$ **ppm**	χ^2_f	R_B
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Positive polarity															
1	4,00	-42,05	18,69	25,00	-12,52	14,97	29,94	16,52	-29,53	11,20	20,02	22,39	40,04	2,2	1,48
10	4,00	-15,44	15,93	25,00	-1,62	13,44	26,87	5,62	-13,83	8,56	21,08	17,13	42,16	0,4	0,66
50	4,00	47,16	20,45	25,00	21,31	15,83	31,66	-17,31	25,85	12,95	19,35	25,91	38,70	1,8	1,34
75	4,00	20,77	21,73	25,00	11,22	16,40	32,80	-7,22	9,55	14,25	18,87	28,51	37,74	0,3	0,51
100	4,00	37,07	19,33	25,00	16,37	15,29	30,58	-12,37	20,70	11,82	19,78	23,65	39,55	1,1	1,05

Table A.3 – Results of comparisons of DC high voltage VNIIMS – UKRMETRTESTSTANDART, while measuring the scale factor at positive polarity

U_N **[кВ]**	**К ref**	**Uc (K_{ref})**	**$U_{0,95}$ (K_{ref})**	**u_B VNIIMS**	**u_c(К) VNIIMS**	**$U_{0,95}$ (K_{VNIIMS})**	**u_B UKR**	**u_c(К) UKR**	**$U_{0,95}$ K_{UKR})**	$U(f_o)$ **ppm**	$\Delta(f_{VNIIMS})$ **ppm**	$\Delta(f_{UKR})$ **ppm**	**χ2(К)**
Positive polarity													
1	2059,967	0,38014	0,76028	-0,00032	0,10085	0,20169	0,01906	0,78312	1,56623	369,08	-0,1535	9,25	0,00060
5	2059,781	0,36368	0,72736	0,000936	0,10517	0,21034	-0,04839	0,75600	1,51200	353,12	0,4546	-23,49	0,00418
10	2060,172	0,35618	0,71237	0,001138	0,10334	0,20668	-0,05896	0,74380	1,48760	345,78	0,5524	-28,62	0,00640
50	2059,39	0,35612	0,71224	0,000859	0,10334	0,20667	-0,04449	0,74370	1,48740	345,85	0,4171	-21,61	0,00365
80	2059,276	0,34994	0,69988	0,001464	0,10189	0,20378	-0,07591	0,73370	1,46740	339,87	0,7109	-36,87	0,01091
100	2059,262	0,34994	0,69988	0,001662	0,10189	0,20378	-0,08619	0,73370	1,46740	339,87	0,8072	-41,86	0,01407
150	2059,223	0,34988	0,69975	-8,1E-05	0,10189	0,20378	0,00419	0,73360	1,46720	339,81	-0,0393	2,04	0,00003
180	2059,356	0,34503	0,69006	-0,00171	0,10085	0,20169	0,08842	0,72580	1,45160	335,08	-0,8288	42,93	0,01513