DRAFT B REPORT OF EUROMET.EM-S25

MAY 2007

Content

1. Introduction

1.1 Aim

Supplementary comparison EUROMET.EM-S25 is organized within the framework of Phare 2002 Project BG0201.12 "Strengthening of the National Conformity Assessment System – Technical Assistance for Standardization and Metrology", EUROPE Aid/116486/D/SV/BG.

The main tasks of the comparison is aimed at acquiring the following objectives:

- Demonstration of equivalence of metrological practice in measurements of AC-DC Voltage Transfer Difference;
- Proof of the correctness of calibration results;
- Proof of the correct traceability of the standards.

The comparison is accomplished in accordance with the EUROMET "Guidelines on Conducting Comparisons" and CCEM "Guidelines for Planning, Organizing, Conducting and Reporting Key, Supplementary and Pilot Comparisons".

1.2 **Definition of the ac-dc voltage transfer difference**

The ac-dc voltage transfer difference δ of a transfer standard is defined as:

$$\delta = (V_{ac} - V_{dc}) / V_{dc}$$

where

V_{ac} is the rms value of the ac input voltage

V_{dc} is the dc input voltage which when reversed produces the same mean output voltage of the transfer standard as V_{ac}.

2. Participants and organization

2.1 **Participants:** PTB (DE), NCM (BG)

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2.3 Time schedule

Start Date:	February 2006.
First measurements at PTB:	From 2006-02-16 to 2006-02-20.
Measurements at NCM:	From 23 March 2006 to 19 June 2006.
Final measurements at PTB:	From 2006-08-18 to 2006-08-21.

2.4 Transportation

The NCM car was used for transportation of the traveling standard from PTB to NCM. The standard was accompanied by ATA – carnet in order to solve custom formalities. A hand transportation of the standard back to Germany was organized by NCM.

2.5 Unpacking, handling, packing

Unpacking, handling, packing were performed following the Instruction Manual 792A.

3. Travelling standard

As a travelling standard thermal transfer standard Fluke 792A which was provided by PTB was used.
At the rated input voltage the output voltage is approximately 2 V. The input connector of the standard is a stainless steel 50 Ω type "N female". The output connectors are 4 mm binding posts, female. For providing operating power a self-made AC-adaptor is included. The adaptor is

designed for extremely low coupling to (and from) mains supply and has the same voltage output as the battery power pack of Fluke 792 A. The recommendation was to leave 792A powered continuously.

3.1Description of the standard

Table 1. Description of the standard

Type	792A AC/DC Transfer Standard	
Manufacturer	Fluke	
Serial Number	0000407	
Size	Transfer Unit	Power Supply for 792A
Height	17,8 cm	9,7 cm
Width	21,6 cm	10,5 cm
Depth	30,5 cm	22 cm
Weight	8,4 kg	< 1 kg

3.2 Quantities to be measured

The ac-dc voltage transfer difference of the travelling standard was measured at voltages 10 V and 100 V and frequencies 55 Hz, 1 kHz, 20 kHz and 100 kHz.

3.3 Measuring instructions

Visual inspection and conditioning of the standards have to be performed. Before doing any measurements the standard was thermally stabilized in the environment in use for at least 12 hours.

3.4 Measurement performance

The measurements were performed in respect to the following:

- The **ac-dc voltage transfer difference** of the travelling standard at **23°C** is to be reported.
- The **reference plane** of the measured ac-dc voltage transfer difference was at the centre of Tee connector. NCM used GR-874 type Tee connector.
- The recommended **ambient conditions** are temperature (23±1)°C and relative humidity (45±10)% that was met by both laboratories.
- The low of the input connector and guard and ground terminals of the transfer standard were connected to common ground in order to maintain a defined calibration condition. The guard and ground terminal were connected directly. The output low and the input low are internally connected in the Fluke 792A.
- Provided self – made AC adaptor powered the travelling standard.
- Minimum 15 minutes was allowed for **stabilisation** after power on and after changing the range.

- The **measuring frequency** is within 1 % of the nominal frequency. The frequency and its uncertainty is reported by both laboratory.
- Shielded twisted – pair leads with the shield connected to the transfer standard GUARD and the DMM GUARD were used.

4. Description of the measuring method

4.1 NCM method

The measurement set-up, which is used for measurement of AC-DC difference, is multifunction calibrator Wavetek 4808 which is used as AC and DC source and two multimeters Wavetek 1281.
The system is operated manually and the switching is performed internally. The output voltages of two AC-DC transfers are measured directly. The measuring sequence is DC+, AC, DC-, AC. The time between switching is 60 s for measurements with Fluke A55 and 90 s for Thin-Film Miltijunction Thermal Converter.
Between 40 and 50 measurements (in series of 10 observations each) of AC-DC difference are used for calculation of the mean value and standard deviation of the mean.

4.2 Statement of traceability at NCM

The reference standards thermal voltage converters, Fluke A55 and 90 Ω Thin-Film Multijunction Thermal Converter in combination with range resistor R-100 V, are traceable to PTB.

4.3 PTB method

The PTB measurement setup utilizes a Fluke 5440A Calibrator to supply the dc voltage and a Fluke 5720A Calibrator to supply the ac voltage. A transfer switch made by METAS connects the parallel connection of the DUT and a PTB standard alternatively to the ac source or the dc source. The output voltage of the DUT is measured using a Agilent 3458A multimeter, while the output voltage of the planar multijunction thermal converter used as PTB standard is measured using a Keithley 2182 nanovoltmeter. Setting the sources, switching from ac to dc and vice versa as well as reading the voltmeters for the output voltages is done by a PC programmed in LabView. It also calculates and stores the results. One measurement consists of measuring the sequence “ac, +dc, ac, -dc, ac” and 12 measurements were taken for each frequency and averaged.

5. Measurement results

5.1 Results of the participants and degree of equivalence with respect to CRV

Tables 2 and 3 report the AC-DC difference and uncertainty given by NCM and PTB, degree of equivalence D_{NCM} with expanded uncertainty $U_{\mathrm{D,NCM}}$ for the participant NCM. The degree of equivalence D_{NCM} is given with respect to the measurement result of PTB, which was taken as comparison reference value (CRV):

$$D_{\mathrm{NCM}} = \delta_{\mathrm{NCM}} - \delta_{\mathrm{PTB}}, \qquad (1)$$

with the expanded uncertainty :

$$U_{D_{\mathrm{NCM}}} = \sqrt{U_{\mathrm{NCM}}^2 + U_{\mathrm{PTB}}^2}\ . \qquad (2)$$

Table 2. Results of the participants at measuring voltage10 V

Frequency	Measured ac-dc voltage difference in 10^{-6}				Degree of equivalence, D_{NCM} in 10^{-6}	Expanded uncertainty, $U_{D_{\mathrm{NCM}}}$ in 10^{-6}
	Results PTB		Results NCM			
	δ_{PTB}	U_{PTB}	δ_{NCM}	U_{NCM}	D_{NCM}	$U_{D_{\mathrm{NCM}}}$
55 Hz	+0,9	4	+1,2	16	+0,3	17
1 kHz	+0,5	3	+1,6	15	+1,1	15
20 kHz	+0,8	3	-1,5	17	-2,3	17
100 kHz	-0,1	7	-3,2	14	-3,1	16

Table 3. Results of the participants at measuring voltage100 V

Frequency	Measured ac-dc voltage difference in 10^{-6}				Degree of equivalence, D_{NCM} in 10^{-6}	Expanded uncertainty, $U_{D_{\mathrm{NCM}}}$ in 10^{-6}
	Results PTB		Results NCM			
	δ_{PTB}	U_{PTB}	δ_{NCM}	U_{NCM}	D_{NCM}	$U_{D_{\mathrm{NCM}}}$
55 Hz	+2	10	+2,7	21	+0,7	23
1 kHz	+0,4	10	+1,6	12	+1,2	16
20 kHz	+1,9	10	+4,1	12	+2,2	16
100 kHz	+2,9	25	+2,4	32	-0,5	41

The reference standard of NCM was calibrated at PTB, therefore the results are correlated. As can be seen from the uncertainty budget for NCM, the uncertainty of the reference standard of NCM calibrated at PTB is small with respect to the other uncertainty components. Therefore, correlation was not taken into account.

6. Measurement uncertainty

A detailed uncertainty analysis and an uncertainty budget in accordance with the ISO Guide to the Expression of Uncertainty in Measurement are reported. The uncertainty contributions are summarised in the uncertainty budgets in Appendix 1.

The main uncertainty contributions evaluated by both laboratories are:

- reference standard;
- measuring set-up;
- reproducibility.

The uncertainty due to the long term stability of the PTB-standard since the key comparison CCEM-K6.a is included in the uncertainty of the reference standard.

7. Conclusion

The comparison EUROMET.EM-S25 was organized with main objective to show the international equivalence of NCM AC-DC Voltage Transfer Standard. In order to evaluate the degree of equivalence the results of NCM were given in respect to CRV. The obtained results show very good agreement with the reference value within the expanded uncertainties.

8. References

[1] M. Klonz, "Final Report of CCEM-K6.a: Key Comparison of AC/DC Voltage Transfer Standards at the Lowest Attainable Level of Uncertainty", published online in the *Key Comparison Data Base:* http://kcdb.bipm.fr

Appendix 1 Summary of uncertainty budgets

Key comparison *EUROMET.EM-S25* "ac-dc transfer difference at medium voltages"

Acronym of institute:
PTB

Date: 2006-09-25

Remarks:

Measuring voltage: 10 V

Contribution of:	Std. unc. *f*=55 Hz	Std. unc. *f*=1 kHz	Std. unc. *f*=20 kHz	Std. unc. *f*=100 kHz	T ype	Distribution
Standard and Comparison	1,0	1,0	1,0	3,0	B	normal
Scatter of measurements	1,1	0,4	0,7	0,7	A	normal
Reproducibility	0,9	0,4	0,5	0,7	A	rectangular

Standard uncertainty (*k*=1):	1,7	1,1	1,3	3,2
Expanded unc:	4	3	3	7
Eff. deg. of freedom:	>50	>50	>50	>50

Measuring voltage: 100 V

Contribution of:	Std. unc. *f*=55 Hz	Std. unc. *f*=1 kHz	Std. unc. *f*=20 kHz	Std. unc. *f*=100 kHz	Type	Distribution
Standard and Comparison	5,0	5,0	5,0	12,5	B	normal
Scatter of measurements	0,6	0,2	0,5	0,8	A	normal
Reproducibility	0,3	0,2	0,3	0,4	A	rectangular

Standard uncertainty (*k*=1):	5,0	5,0	5,0	12,5
Expanded unc:	10	10	10	25
Eff. deg. of freedom:	>50	>50	>50	>50

Measuring frequency:

	Nominal frequency			
	55 Hz	1 kHz	20 kHz	100 kHz
Measuring frequency	55 Hz	1000 Hz	20.000 Hz	100.000 Hz
Expanded uncertainty	$1 \cdot 10^{-4}$	$1 \cdot 10^{-4}$	$1 \cdot 10^{-4}$	$1 \cdot 10^{-4}$

Influence parameters:

	Min	Max	Remarks
Ambient temperature / ºC	22,5	23,5	

Key comparison *EUROMET.EM-K6.a* "ac-dc transfer difference at medium voltages"

Acronym of institute:

NCM

Date of measurments:
23 March – 19 June 2006
Remarks:
Measuring voltage: 10 V

N	Contribution of:	Std. unc. f=55 Hz	Std. unc. f=1 kHz	Std. unc. f=20 kHz	Std. unc. f=100 kHz	Type	Distribution
1	Reference Standard	2,5	2,5	2,5	2,5	B	Normal
2	Difference measurement	7,8	7,0	7,9	6,2	A	Normal
	Standard Deviation of the Measurement	3,3	3,0	2,8	2,4	A	Normal
	Measurement Set-up	7,1	6,3	7,4	5,8	B	Normal

Standard unc (k=1):	8,2	7,4	8,3	6,7
Expanded unc:	16	15	17	14
Eff. deg. of freedom:	1075	1184	2133	1201

Measuring voltage: 100 V

N	Contribution of:	Std. unc. f=55 Hz	Std. unc. f=1 kHz	Std. unc. f=20 kHz	Std. unc. f=100 kHz	Type	Distribution
1	Reference Standard	5	5	5	12,5	B	Normal
2	Difference measurement	9,5	3,0	3,5	9,4	A	Normal
	Standard Deviation of the Measurement	3,0	1,0	0,7	0,6	A	Normal
	Measurement Set-up	9,0	2,8	3,4	9,4	B	Normal

Standard unc (k=1):	10,7	5,8	6,1	15,6
Expanded unc:	21	12	12	32
Eff. deg. of freedom:	933	91	111	123

Measuring frequency:

	Nominal frequency			
	55 Hz	1 kHz	20 kHz	100 kHz
Measuring frequency	55 Hz	1 kHz	20 kHz	100 kHz
Expanded uncertainty	$<1 \cdot 10^{-4}$	$<1 \cdot 10^{-4}$	$<1 \cdot 10^{-4}$	$<1 \cdot 10^{-4}$

Influence parameters:

	Min	Max	Remarks
Ambient temperature / ºC	22,5	23,9	