Management of the AC-DC Voltage Transfer Difference Comparison in the SIM Region

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Abstract

In 2002, the Centro Nacional de Metrología of Mexico proposed and organized some comparisons on ac-dc voltage transfer difference. These comparisons were carried out following the guidelines for key comparisons, issued by the International Committee of Weights and Measures. In December 2004 measurements were completed and in 2006 the first draft of the report was circulated for review. The way the comparisons were conducted as well as the experience acquired during their execution is the subject of this document.

1. Introduction

In the Sistema Interamericano de Metrología (SIM) region there are national metrology institutes (NMIs) with capabilities to measure ac-dc voltage transfer difference, such as, the National Research Council (NRC) from Canada, the National Institute of Standards and Technology (NIST) from United States of America, the Instituto Nacional de Tecnología Industrial (INTI) from Argentina, the Instituto Nacional de Metrologia, Normalizaçao e Qualidade Industrial (INMETRO) from Brazil, the Administración Nacional de Usinas y Transmisiones Eléctricas (UTE) from Uruguay and the Centro Nacional de Metrología (CENAM) from Mexico. Up to now only NRC, NIST and INTI have participated in key or regional comparisons. With the goal to strength the interaction among the NMI´s with capabilities to measure ac-dc voltage transfer difference, in the SIM region, and to establish the degree of equivalence of national measurement standards maintained by NMI´s [1], some comparisons were proposed.

2. Planning the comparison

During a SIM meeting in 2002, CENAM proposed a regional comparison on ac-dc transfer voltage difference, in such meeting were discussed the possible participants, the travelling standard and the measured points. CENAM was proposed as pilot laboratory and as provider of the travelling standard. The comparisons were agreed by the representatives of the NMI´s and CENAM was responsible to prepare the technical protocol. In 2003 the technical protocol was issued and sent for review to the participants.

3. Technical protocol

The technical protocol was developed following the International Committee of Weights and Measures (CIPM) guidelines for key comparisons [2], including on it, the definition of the measurand, the travelling standard description, the list of participants, a proposal timetable, the procedure in case of unexpected delay, information for customs clearance and financial aspects, how to handling the travelling standard, the proposed measured points, measurement conditions, a proposed procedure of evaluating the reference values, the linking with the corresponding key comparison, report of the results, deadlines to deliver reports and responsibilities for the preparation of the first draft of the report (draft A).

After review of the protocol, the measurement points were modified with the agreement of the participant laboratories. The points to be measured were selected to evaluate ac-dc voltage transfer difference measurements at 3 V as well as step-up and step-down techniques, which were 100 mV and 1kV. See table I. Voltages and frequencies were in agreement with the next Committee Consultative of Electricity and Magnetism (CCEM) key comparisons: CCEM-K6a, CCEM-K9 and CCEM-K11, with the aim of linking the results of such comparisons with the results of the SIM comparison. The 120V/53 Hz point was included for having a link to support the calibration of the power measurements.

Table I. Selected points to be measured.

SIM.EM-K6a	SIM.EM-K9	SIM.EM-K11	SIM.EM-Supplementary
3 V / 1 kHz 3 V / 20 kHz 3 V / 100 kHz 3 V / 1 MHz	1 kV / 1 kHz 1 kV / 10 kHz 1 kV / 20 kHz 1 kV / 50 kHz 1 kV / 100 kHz	100 mV / 1 kHz 100 mV / 20 kHz 100 mV / 100 kHz 100 mV / 1 MHz	120 V / 53 Hz

The measurement period was also modified because the proposed one was too optimistic. Six weeks were established for measuring fourteen points, clearing customs, preparation of the travelling standard, making measurements and shipping to the next laboratory. The comparison was planned to start in January 2004 and to conclude the measurements in September of that year. Six national laboratories took part on the comparisons: NRC, NIST, INTI, UTE, INMETRO and CENAM. The travelling standard was a commercial thermal transfer standard with voltage ranges from 2 mV up to 1 kV and frequency ranges from 10 Hz up to 1 MHz, whose good stability behavior is well known.

It was agreed to evaluate the reference value as the weighted mean of the reported values from laboratories in SIM who took part in the CCEM-K6a, CCEM-K9 and CCEM-K11 key comparisons. It was also agreed that the pilot laboratory took the responsibility to prepare the draft A.

Comments and discussion, such as modification of the schedules and technical information were carried out by means of electronic mail but also using a forum created for SIM by NIST, called “Forum for the Americas”, which has the benefit that not only the participating laboratories can read and upload comments, but also the SIM community who ask for a registration can access to such forum.

The technical protocol was sent for review to the working group of low frequency (WGLF) and to the CCEM; suggestions from those committees were added, such as: give a strict format to the participants for reporting the results, compress uncertainty tables in order to put more than one frequency in the same table, editing and references corrections. The protocol was approved by the WGLF and the CCEM. Three key comparisons were registered, SIM.EM-K6a, SIM.EM-K9, SIM.EM-K11, and a supplementary comparison at 120 V/53 Hz, all of them using one technical protocol and one travelling standard.

4. Circulation of the travelling standard

The travelling standard was measured once by each laboratory, except CENAM. The travelling standard returned to CENAM each time its shipment was changed. It was agreed to hand carry the travelling standard when sent to South America, to avoid any possible damage

of it and any possible delay during the customs clearance. Thanks to the OAS (Organization of the American States) financing, flight tickets from Mexico-Argentina-Mexico, Uruguay-Brazil-Uruguay and Brazil-Mexico-Argentina were afforded.

The pilot laboratory sent the travelling standard to the first participant laboratory in January 2004. The comparison was carried out with a reasonable delay during the 2004. After the measurement of the five laboratories the travelling standard was sent back to the pilot laboratory in November 2004. The pilot laboratory performed the last measurements to verify the state of the travelling standard and the measurements were concluded in December 2004. See the schedule followed by the travelling standard on table II.

Table II. Schedule followed by the travelling standard.

Participant Laboratory	Reception of the travelling standard	Transport of the travelling standard
CENAM (Mexico)	Owner	
NIST (United States)	January 8th 2004	Courier Service
CENAM (Mexico)	February 27th 2004	Courier Service
INTI (Argentina)	March 4th 2004	Hand Carried
UTE (Uruguay)	May 14th 2004	Hand Carried
INMETRO (Brazil)	June 25th 2004	Hand Carried
CENAM (Mexico)	August 2nd 2004	Hand Carried
NRC (Canada)	September 9th 2004	Courier Service
CENAM (México)	November 2nd 2004	Courier Service

It was useful to manage on time the comparison that the participant laboratories knew their country customs procedures to get the temporal importation permission before the arrival of the travelling standard, each country having different procedures and different periods of answer.

During the circulation of the travelling standard there was a constant communication between the sending laboratory, the receiving laboratory and the pilot laboratory, to know the departures and arrival dates of the travelling standard.

5. Elaboration of the Draft A

Reports of the participants were received during 2004 and during 2005. Due to unforeseen situations at CENAM, the draft A was not issued for revision until January 2006. Even with a state format and with reports well organized, it was a hard task for the pilot laboratory to place together the information and to carry out the evaluation of the uncertainties, because most of the reference values of the participants' standards were correlated, this due to their common traceability to a third national standard. In general the results of the comparison were in agreement, but up to now the results are confidential to the participant laboratories until the draft B will be issued.

The pilot laboratory has received the first comments of the draft A, asking for including information of the stability of the travelling standard, degrees of freedom and also proposing guidelines to evaluate in a rigorous way the correlation. The pilot laboratory works on the corrections of the draft A and is waiting for comments of the other participants.

6. Conclusions

Organize and pilot a comparison is a hard work. Nevertheless, good organization, as the guidelines for key comparison issued by the CIPM helps to focus the attention on the technical work. Now, at the point where the comparison is another big challenge comes: deep statistical analysis. However, thanks to the experiences of others Regional Metrology Organizations (RMO) performing key comparisons, many technical references, giving guidelines for the statistical analysis, could be consulted. Many experiences were acquired: conducting a comparison, little improvements on the measurement systems and knowledge of statistical methods for the evaluation of the results.

7. Acknowledges

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8. References

1. Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes. Paris, 14 October 1999.

2. Guidelines for CIPM key comparison (Appendix F to the “Mutual recognition of national measurements standards and of measurements certificates issued by national metrology institutes (MRA)). March 1999.

3. Technical protocol of SIM.EM-K6a, SIM.EM-K9 and SIM.EM-K11comparisons. December 2003.