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SIM Key Comparison in Pneumatic Gauge Pressure for High Accuracy Pressure Balances up to 7 MPa

[1]J. C. Torres-Guzman, [1]J. Aranzolo, [2]D. A. Olson, [3]J. Forastieri, [4]A. Solano, [5]C. Neira, [6]P. R. G. Couto, [7]L. De La Cruz, [8]J. Palma, [9]S. Garcia, [10]A. Foreman†

[1]CENAM, Mexico. [2]NIST, USA. [3]INTI, Argentina. [4]LACOMET, Costa Rica. [5]INM, Colombia. [6]INMETRO, Brazil. [7]INACAL, Peru. [8]ENAER, Chile. [9]CENAMEP, Panama. [10]BSJ, Jamaica
Email of corresponding author: jorge.torres@cenam.mx[1]

Abstract – This report describes the results of a pneumatic pressure standards key comparison among eleven SIM National Metrology Institutes in order to determine their degree of equivalence in the pressure range from 0.6 MPa to 7 MPa in gauge mode. The pilot laboratory was the Centro Nacional de Metrología (CENAM, Mexico). All participating institutes used pneumatic pressure balances as their pressure standard. The transfer standard was a complete system including a pressure balance with a free-deformational piston-cylinder assembly and a set of masses. Eleven participants completed their measurements, although, only ten laboratories reported the pressure-dependent effective areas of the transfer standard at specified pressures with the associated uncertainties; NRC/Canada withdrew the comparison by not sending their measurements. NIST, USA, provided the reference values to link the results to the CCM.P-K1.c comparison of the ten laboratories that sent their results. To evaluate the compatibility of results of the participants their relative deviations from those obtained by NIST results were analysed. The results of 7 participating NMIs agree with NIST reference values within their expanded uncertainties (k=2).

Keywords: Comparison, pressure balances.

1. INTRODUCTION.

This comparison aimed to obtain the equivalence statements into SIM region derived from CCM key Comparison CCM.P-K1.c, in the range from 0.6 MPa to 7 MPa, in pneumatic gauge pressure. This comparison will provide the means to the laboratories to support their uncertainty statements given in their CMC Tables. The number of participants was eleven, three NMI from NORAMET, two from CAMET, one from CARIMET, two from ANDIMET and three from SURAMET. NRC/Canada withdrew the comparison by not sending their measurements. The Centro Nacional de Metrología (CENAM), Mexico, was the pilot laboratory. The Technical Protocol used was prepared in accordance with the Guidelines for CIPM Key Comparisons.

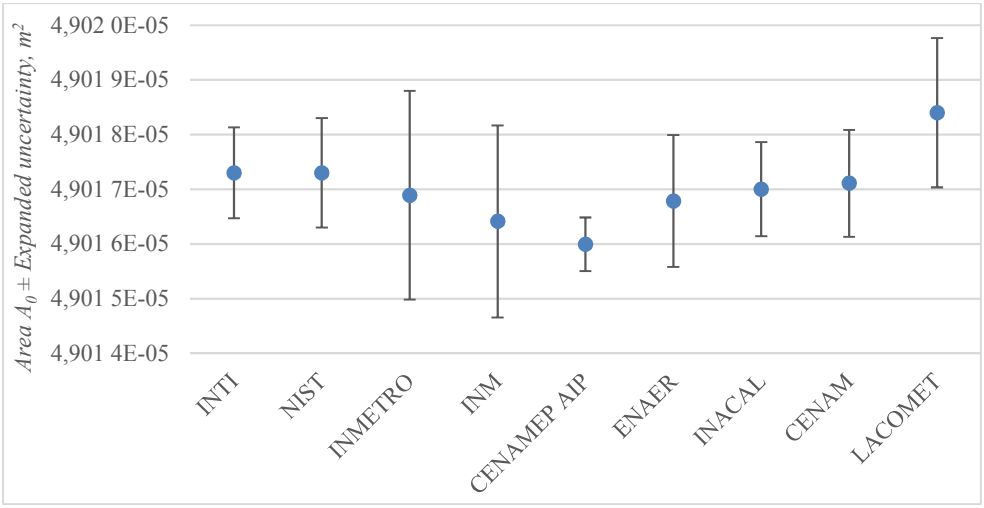
The transfer standard was a piston-cylinder assembly of 0.5 cm^2 nominal effective area with serial number 1150. It is part of a pressure balance equipped with a set of masses manufactured by Fluke (DH Instruments), USA. The TS drift was checked by comparing the results obtained on the calibrations performed by CENAM at the beginning and at the end of the comparison, were it can be shown that the TS had no drift. The worst repeatability calculated for the TS (at 5 300 kPa) was $7.0 \cdot 10^{-11}$ m^2. The repeatability uncertainty combined with the area uncertainty was the one used. All laboratories used high accuracy pressure balances as their standards.

2. MEASUREMENTS RESULTS

Table 1 and graph 1 present the results for A_0 and its corresponding expanded uncertainty for each participating NMI, m^2. In table 1, laboratories in italics did not calculated A_0 (INMETRO, INM and CENAMEP). In order to compare results CENAM made the calculations by means of the lineal regression method. INMETRO used 23 °C as reference temperature. In order to compare the results a temperature correction was used to transfer their results to 20 °C reference temperature.

Table 1. TS A_0 and its corresponding expanded uncertainty as obtained by each NMI, m^2.

NMI	A_0 / m^2	UA_0 / m^2	b / 1/Pa	Ub / 1/Pa
INTI	4.90173E-05	8.3E-10	-3.9E-12	2.0E-13
NIST	4.90173E-05	1.0E-09	-2.7E-12	6.1E-13
INMETRO	4.90169E-05	1.9E-09	-3.8E-12	6.5E-13
INM	4.90164E-05	1.8E-09	-2.8E-12	1.8E-13
CENAMEP AIP	4.90160E-05	4.9E-10	1.8E-10	1.8E-12
ENAER	4.90168E-05	1.2E-09	-2.7E-12	3.5E-13
INACAL	4.90170E-05	8.6E-10	-7.6E-10	3.4E-13
CENAM	4.90171E-05	9.8E-10	-3.1E-13	8.9E-14
BSJ	4.65027E-05	7.4E-07	8.3E-09	4.1E-09
LACOMET	4.90184E-05	1.4E-09	-1.8E-12	3.3E-13



Graph 1. TS A_0 and its corresponding expanded uncertainty as obtained by each NMI, m^2. For clarity, BSJ is not included.

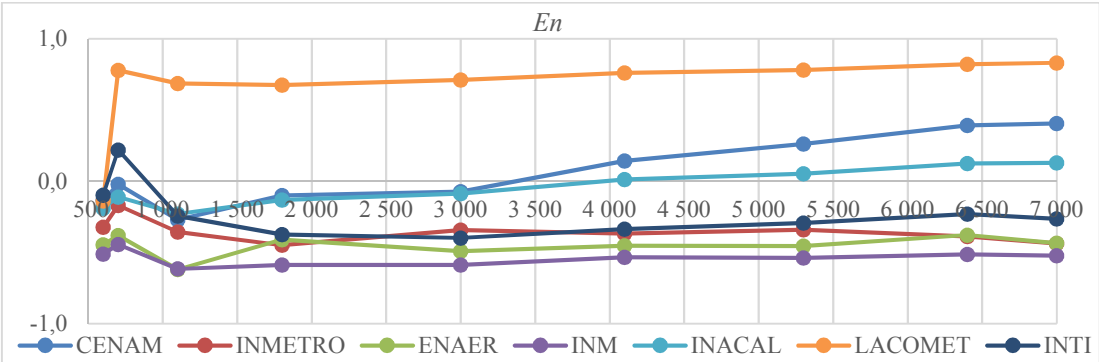
3. EVALUATION OF RESULTS AND CONCLUSIONS

For evaluation of the NMIs performance the normalized error equation (*En*) criteria was applied to their TS effective area results.

In this SIM comparison, 11 laboratories participated. From those, one did not sent their measurement results (NRC/Canada). As it can be seen for the normalized error results shown in table 2 and graph 2, from the 10 laboratories which sent their results, seven laboratories have compatibility of their results with those of the references values provided by NIST. Two laboratories (CENAMEP and BSJ) have no compatibility with the reference values or with those results of the other participating laboratories.

Table 2. Participating NMIs normalized error equation values with respect to the reference (NIST) for effective area.

NMI	600 kPa	700 kPa	1 100 kPa	1 800 kPa	3 000 kPa	4 100 kPa	5 300 kPa	6 400 kPa	7 000 kPa
INTI	-0.10	0.22	-0.24	-0.37	-0.40	-0.34	-0.29	-0.23	-0.26
CENAM	-0.13	-0.02	-0.27	-0.10	-0.07	0.14	0.26	0.39	0.41
INMETRO	-0.32	-0.17	-0.36	-0.45	-0.34	-0.37	-0.34	-0.39	-0.44
ENAER	-0.45	-0.38	-0.62	-0.41	-0.49	-0.45	-0.45	-0.38	-0.43
INM	-0.51	-0.44	-0.62	-0.59	-0.59	-0.53	-0.54	-0.51	-0.52
INACAL	-0.19	-0.11	-0.23	-0.13	-0.09	0.01	0.05	0.13	0.13
LACOMET	-0.14	0.78	0.69	0.68	0.71	0.76	0.78	0.82	0.83
CENAMEP	5	7	13	22	37	49	57	63	66
BSJ	-2140	-1861	-1184	-722	-419	-309	-234	-189	-170



Graph 2. Effective area normalized error equation values of compatible participating laboratories.

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