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DIFFERENTIAL PRESSURE COMPARISON FROM 20 Pa TO 3 500 Pa BETWEEN CEM-SPAIN AND CENAM-MEXICO

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Abstract − The results of a comparison in differential pressure between CEM-Spain and CENAM-Mexico are presented here. The comparison was performed in 2008. A high accuracy digital manometer was used for the comparison. The manometer had good behaviour during the period of the comparison, having a small drift which had no effect in the comparison. The results of the measurements showed very good agreement between the measurements performed by CEM and CENAM. For the range of the comparison it can be said that CEM and CENAM have equivalence of measurements.

Keywords: Differential pressure, comparison.

1. INTRODUCTION

In 2008 a comparison in differential pressure, in the range from 20 Pa up to 3 500 Pa, was carried out between the Centro Español de Metrología (CEM) Spain and the Centro Nacional de Metrología (CENAM) Mexico. The comparison started in April and finished in November (including draft and final report).

CENAM carried out 2 calibrations of the transfer standard (TS): the first one at the beginning of the comparison round and the second one at the end.

1.1 Transfer Standard (TS)

A Paroscientific digital manometer was used as TS with accuracy class 0,01% of the reading interval. Its measurement range goes from 0 kPa up to 20 kPa; with a resolution of 0,03 Pa.

1.2 Procedure

The procedure of the comparison included the measurement of 10 target differential pressures distributed in the measurement range. The procedure included 6 measurement series and each series covered the 10 target pressures in ascending order.

A detailed protocol for the comparison was developed by CENAM and followed by the two laboratories to make the measurements.

The procedure, in general, followed similar rules to those of international comparisons [1, 2].

1.3 Standard Systems used by the Laboratories

CENAM used a reference system formed by two high accuracy pressure balances (50 mm diameter cylinder); one is used to maintain the static pressure and the other one is used to set the differential pressure. The details of the pressure system are presented in Table 1.

Table 1. Reference pressure system used by CENAM to calibrate the TS.

	Piston cylinder assembly.	Base	Piston cylinder assembly. Reference pressure.	Base
Manufacturer	DH Instruments	DH Instruments	DH Instruments	DH Instruments
Type	PC 7607-5	PG 7607	PC 7607-5	PG 7607
Serial Number	231	122	216A	123

CEM used a forced piston gauge working in differential mode as reference system. The details of the pressure system used are presented in Table 2.

Table 2. Reference pressure system used by CEM to calibrate the TS.

	Forced piston gauge	Piston cylinder assembly
Manufacturer	DH Instruments	DH Instruments
Type	FPG 8601	10 kPa/kg
Serial Number	128	126

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2. TRANSFER STANDARD CHARACTERIZATION

In Table 3, the information of the two calibrations carried out at CENAM is included.

The table shows the error and uncertainty assigned to the TS in each of the two calibrations for each target differential pressure, according to the comparison range.

Table 3. Error and uncertainty for the two calibrations carried out at CENAM to the TS.

Differential pressure	TS Error 1st Cal.	TS Error 2nd Cal.	TS U (*k*=2) 1st Cal.	TS U (*k*=2) 2nd Cal.
Pa	Pa	Pa	Pa	Pa
20	-0,12	-0,02	± 0,19	± 0,18
50	-0,13	-0,04	± 0,18	± 0,18
100	-0,17	-0,07	± 0,19	± 0,18
498	-0,31	-0,22	± 0,20	± 0,19
997	-0,36	-0,32	± 0,20	± 0,19
1 496	-0,35	-0,40	± 0,21	± 0,20
1 994	-0,34	-0,42	± 0,22	± 0,20
2 493	-0,33	-0,41	± 0,23	± 0,20
2 992	-0,34	-0,40	± 0,24	± 0,21
3 490	-0,35	-0,38	± 0,25	± 0,21

Figure 1 shows the two calibrations performed to the TS at CENAM in a graphical form.

The figure includes the error and the uncertainty for each target differential pressure measured.

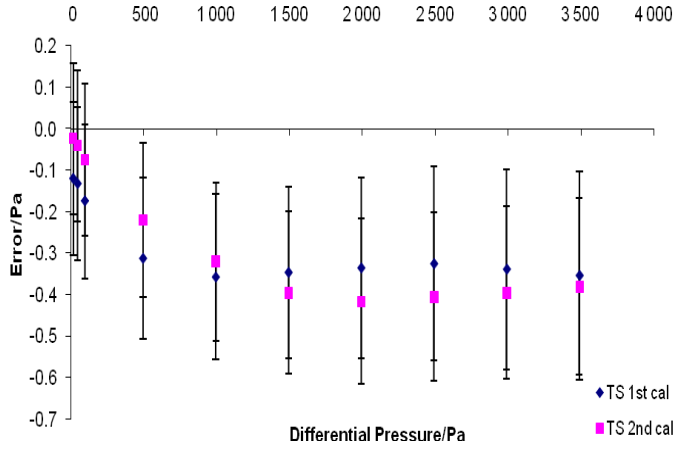

Figure 1. Error and uncertainty of the TS according to the two calibrations performed by CENAM.

According to the data showed in Table 1 and graphed in Figure 1, it is considered adequate to discard the drift of the TS as a significant source of influence for the comparison results.

On the other hand, the stability of the TS was good as it can be seen by comparing the results on Table 1 of the uncertainty values for the two calibrations performed to the TS by CENAM. The characterization of the TS was as described in reference [3].

3. MEASUREMENTS RESULTS

From this section on, the average of the two calibrations performed by CENAM are considered as the results from CENAM and are included to be compared with the results obtained of the measurements made by CEM in their calibration of the TS.

Table 4 shows the results of the measurements made by CEM.

Table 4. CEM results, error and uncertainty of the TS for each target pressure.

TS Pressure	TS Error	U (*k=2)*
Pa	Pa	Pa
19,97	-0,036	0,068
49,95	-0,054	0,067
99,94	-0,077	0,082
499,85	-0,16	0,12
999,84	-0,18	0,13
1 499,79	-0,25	0,15
1 999,78	-0,25	0,23
2 499,79	-0,24	0,28
2 999,83	-0,32	0,37
3 499,68	-0,37	0,45

Figure 2 shows the results of the measurements made by CEM in graphical form. The graph includes the errors and uncertainties for each target differential pressure, according to the range proposed in the protocol of this comparison.

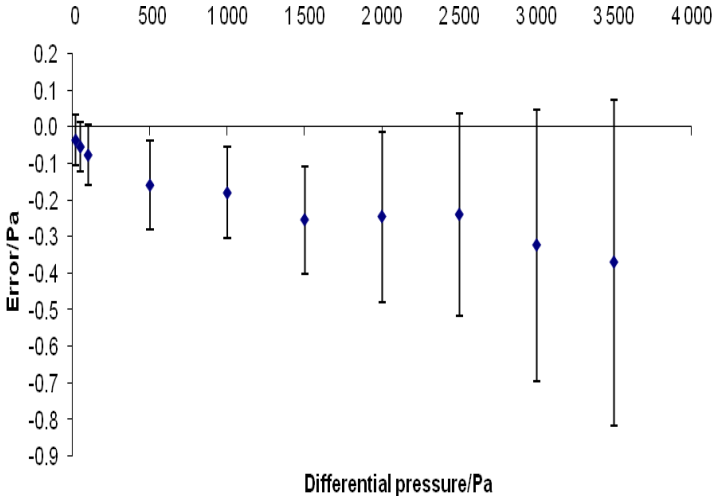

Figure 2. CEM results, error and uncertainty of the TS for each target pressure.

Table 5 shows the results of the measurements carried out by CENAM to the TS.

The average of the two calibrations performed by CENAM to the TS is considered as CENAM´s final results.

Table 5. CENAM results, error and uncertainty of the TS for each target pressure, which is the average of the 2 calibrations performed.

TS Pressure	TS Error	U (*k=2)*
Pa	Pa	Pa
20	-0,07	0,19
50	-0,09	0,18
100	-0,12	0,19
498	-0,27	0,19
997	-0,34	0,19
1 496	-0,37	0,20
1 994	-0,38	0,21
2 493	-0,37	0,21
2 992	-0,37	0,22
3 490	-0,37	0,23

Figure 3 shows the final results assigned to CENAM, as the average of the two calibrations performed.

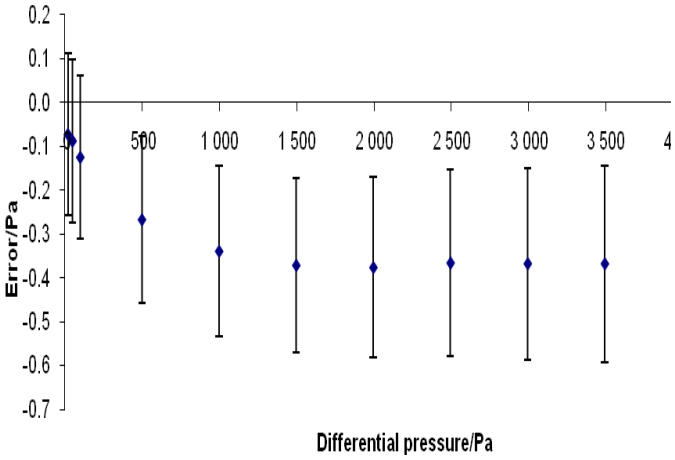

Figure 3. Results obtained by CENAM.

4. COMPARISON RESULTS

Figure 4 shows the results obtained from the measurements made on the TS by the two laboratories, CEM and CENAM.

This graph allows the comparison of the measurements results obtained. It is also possible to observe the concordance of the measurements made to the TS by the two laboratories.

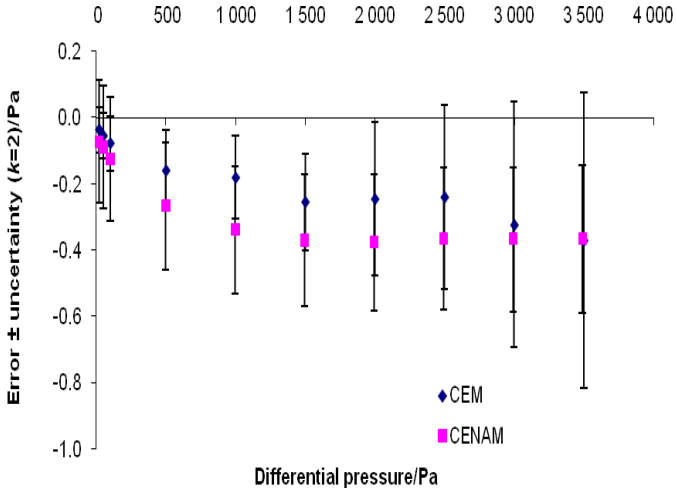

Figure 4. Error and uncertainty (k=2) assigned by CEM and CENAM.

To assess the results of the comparison, the results of the two laboratories are entered in the method of the normalized error equation [4, 5]. The relationship used for the normalized error equation is described in equation 1.

$$E_N = \frac{E_{CEM} - E_{CENAM}}{\sqrt{U_{CEM}^2 + U_{CENAM}^2}} \quad (1)$$

Where:

E_N Normalized error equation value for the corresponding target differential pressure, (k = 2),

E_{CEM} Error of the TS found by CEM,

E_{CENAM} Error of the TS found by CENAM,

U_{CEM} Estimated expanded uncertainty assigned to the target differential pressure measured in the TS by CEM, (k = 2),

U_{CENAM} Estimated expanded uncertainty assigned to the target differential pressure measured in the TS by CENAM, (k = 2).

The data included in Table 2 and Table 3 are considered for the calculations of the normalized error equation application, made by means of equation (1). The following Table 6, shows the normalized error equation values obtained for each target differential pressure.

Table 6. Normalized error equation results.

Differential pressure, Pa	Normalized error equation values
20	0,18
50	0,17
100	0,23
500	0,47
1 000	0,69
1 500	0,47
2 000	0,42
2 500	0,36
3 000	0,10
3 500	-0,01

As it can be seen in table 4, all results of the normalized error equation are below 1. This indicates an excellent agreement between the measurements made by CEM with those performed by CENAM.

Figure 5 shows, in a graphical format, the results calculated with equation (1) and showed in Table 4.

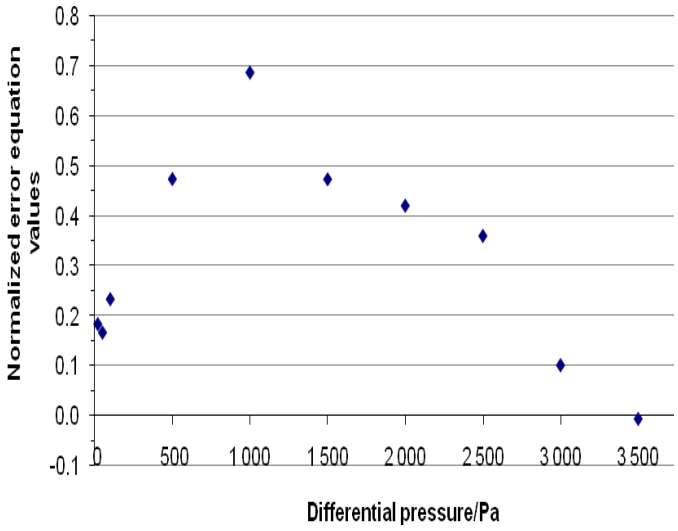

Figure 5. Normalized error equation values obtained for each target differential pressure.

5. CONCLUSIONS

In accordance with the results obtained from the measurements performed on the TS (for differential pressure from 20 Pa to 3 500 Pa) by CEM (Spain) and by CENAM (Mexico) and taken into account the values obtained by the use of the normalized error equation, it is possible to conclude that there is equivalence in measurements in differential pressure from 20 Pa to 3 500 Pa between CEM (Spain) and CENAM (Mexico).

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