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CALIBRATION OF THE FULL SPAN OF A NEGATIVE PRESSURE DIGITAL GAUGE IN CITIES ABOVE THE MEAN SEA LEVEL

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Abstract – In Colombia, there are many industries and technological centers located in cities several meters above the sea level (> 1 000 m), this condition restrict the scope for the negative pressure gauge calibrations to the local atmospheric pressure, as no all accredited laboratories have the negative pressure calibration branch, the costumer may need to send the device to a city where could not be possible to reach the device full span, typically (~-101 kPa to 0 kPa). But for a a digital negative pressure gauge there is an alternative way, by using absolute pressure gauges to reach a pressure higher than the local pressure and zeroing the device under calibration and then covering the desired calibration span. In this work we show the results of calibrate a digital negative pressure gauge by the classical and the proposed method.

Keywords: digital pressure gauge, negative gauge, indirect calibration

1. INTRODUCTION

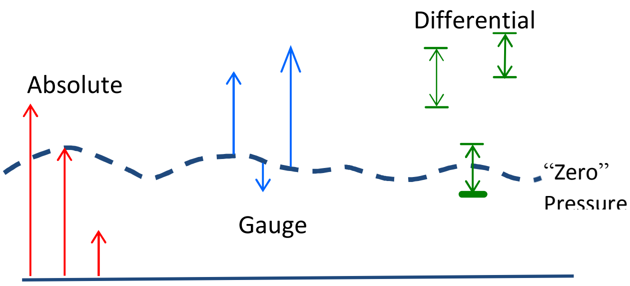

Fig. 1. Types of Pressure.

There are different ways to identify the pressure measurements according to the pressure value used as reference. (see Fig. 1).

The local atmospheric pressure mean value change with the local elevation above the sea level. This mean that the maximum value of the negative gauge pressure its restricted by the local atmospheric pressure mean value, then the calibration capabilities for negative pressure is restricted too.[1]

Then a device used in a city near to the sea level could not be calibrated in its full negative gauge span if its calibrated in high altitude cities, this will constrain the offer in market to only local accredited laboratories. (see Fig. 2.)

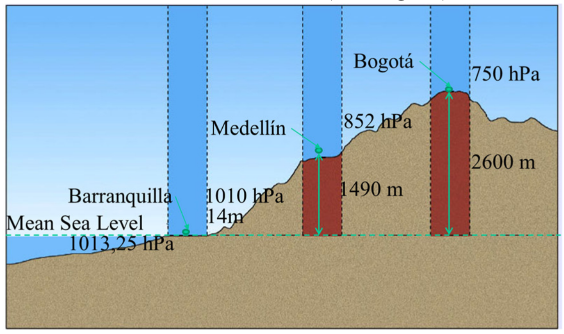

Fig. 2. Examples of local atmospheric pressure in Colombia.

But for digital manometers with zero adjustment it could be a useful alternative. By setting the device to an absolute pressure system and Appling pressure until the absolute pressure in the equipment reach the appropriate pressure, then the zeroing the device under test and then procced to calibrate the instrument by decreasing and increasing the absolute pressure. (see Fig. 3.)

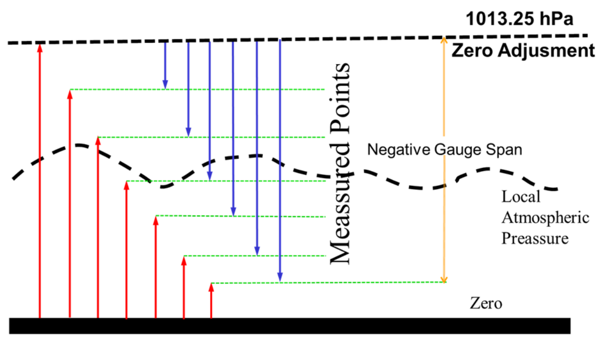

Fig. 3. Indirect method to calibrate negative gauge manometers

2. METHOD

In order to test the indirect method we calibrated two different devices with the traditional method and with the indirect method using an inverted piston-cylinder gauge and a pressure balanced operated in absolute mode.

2.1. Reference Standards

For the negative pressure we use the piston/cylinder assembly Budenberg type 07/14-01 pressure balance s/n 12278 with piston/cylinder assembly s/n F82, which can be used for negative pressures by inverting the system (see Fig. 4 a)). This assembly was calibrated by PTB in negative gauge mode in 2013 (certificate PTB 3333034/13). The effective area, nominally 323 mm^2, and the weight set are traceable to INM, Colombia. The nominal pressures measured were – 75 hPa, -150 hPa, 219 hPa,-289 hPa, -389 hPa, -488 hPa, -588 hPa, -688 hPa, -738 hPa, no higher negative pressure can be reached due to local pressure restriction (see Fig. 2).

The reference standard for absolute pressure was a DH Instruments PG7601 pressure balance s/n 589 equipped with a piston/cylinder assembly s/n 806. The effective area of the piston/cylinder unit is nominally 35 mm^2, was determined by crossfloating measurements at PTB the weight set DHI s/n

a) b)

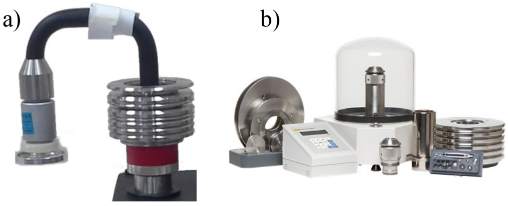

Fig. 4 Reference Standards

2430 used on the pressure balance was calibrated at the INM – Colombia mass laboratory. (see Fig. 4 b)). The nominal values of absolute pressure and their equivalent negative gauge pressure measured were:

Absolute Pressure (hPa)	Indirect Negative Pressure (hPa)
1126	-0
1052	-75
977	-150
907	-219
837	-289
738	-389
638	-488
588	-538
538	-588
439	-688
389	-738
239	-887
189	-937
100	-1027

Table 1Absolute pressure and their equivalent negative pressure nominal values

In both cases the fluid used for transmitting pressure was nitrogen.

2.2 Calibration Procedure

We calibrate the device following the guideline for Calibration of Pressure Gauges DKD-R 6-1 [2]. (see Fig. 5.)

For the direct negative gauge comparisons the measurement process was

1. Pre-pressurisation 3 times to -738 hPa
2. 2 minutes at atmospheric pressure
3. Zeroing
4. Measurements at the specified nominal pressures 0 hPa to -738 hPa
5. Approximately 2 minutes at -738 hPa
6. Measurements at specified nominal pressures from --738 hPa to 0 hPa
7. 2 minutes at atmospheric pressure
8. Repetition of steps from 2 to 7 one more time.

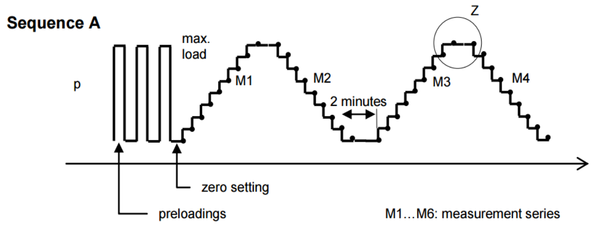

Fig. 5. Calibration Sequence

For the *indirect* negative gauge comparisons the measurement process was

1. Pressurisation the system up to 1126 hPa.
2. Pre-pressurisation 3 times to -1027 hPa (100 hPa absolute pressure)
3. 2 minutes at 0 hPa (1126 hPa absolute pressure)
4. Zeroing (at 1126 hPa absolute pressure)
5. Measurements at the specified indirect negative nominal pressures 0 hPa to -1027 hPa
6. Approximately 2 minutes at -1027 hPa (100 hPa absolute pressure)
7. Measurements at specified nominal pressures from -1027 hPa to 0 hPa. (from 100 hPa to 1126 hPa absolute pressure).
8. 2 minutes at 0 hPa pressure (1126 hPa absolute pressure)
9. Repetition of steps from 3 to 8 one more time.

2.3. Device Under Test

We tested this method with two equipment

Manofacturer	Ametek	Fluke
Model	IPIMKII 100C	2700 G BG2M
Accuracy	0.25%FS	0.05% FS
Resolution	0.01 hPa	1 hPa
Span	-820 hPa	-800 hPa

Table 2 Devices under test

3. RESULTS

3.1. Calibration Results

For the indirect method, we need to subtract the value of the pressure when the zeroing was made to each measured pressure value to the absolute pressure reference value,

$$P_{\mathrm{ref}} = P_{\mathrm{std}} - P_{\mathrm{zero\_set}}$$

Then an additional uncertainty must be added to the uncertainty budget.[3]

$$u_{P_{\mathrm{reference}}} = \sqrt{u^2_{P_{\mathrm{standard}}} + u^2_{\mathrm{zero\_set}}}$$

First we calibrated the results of the IPIMKII 100C in direct negative mode, the results of this Calibration are in

Table 3. After that we calibrated with the indirect method, but unfortunately we did not measure exactly the same points.

P_0 (hPa)	E_{ref} (hPa)	$U(E_{ref})$ (hPa).
0	0	-0.03
-75	75	-0.25
-150	150	-0.22
-219	-0.26	0.16
-289	-0.22	0.16
-389	-0.22	0.21
-488	-0.26	0.17
-538	-0.29	0.22
-588	-0.27	0.14
-688	-0.19	0.22
-738	-0.26	0.16

Table 3 Calibration of the IPIMKII 100C (Direct)

Even so, we want to compare the behavior of the results (E_{t1}) and we noted a big drift of the zero value that can be seen as a systematic error in the results, so we corrected each measurement series by their own zero value, this values are labelled as E_{t2} in Table *4*.

P_0 (hPa)	E_{t1} (hPa)	$U(E_{t1})$ (hPa).	E_{t2} (hPa)	$U(E_{t2})$ (hPa).
0	0.9	1.2	0.90	1.2
80	-1.0	1.2	-0.07	0.09
110	-1.0	1.1	-0.10	0.18
249	-1.2	1.2	-0.30	0.20
329	-1.0	1.1	-0.04	0.31
399	-1.2	1.2	-0.24	0.3
449	-1.08	0.93	-0.13	0.41
598	-1.17	0.98	-0.22	0.44
668	-1.15	0.91	-0.20	0.63
738	-1.12	0.90	-0.17	0.66
827	-1.11	0.90	-0.16	0.75

Table 4Results for the IPIMKII 100C (Indirect)

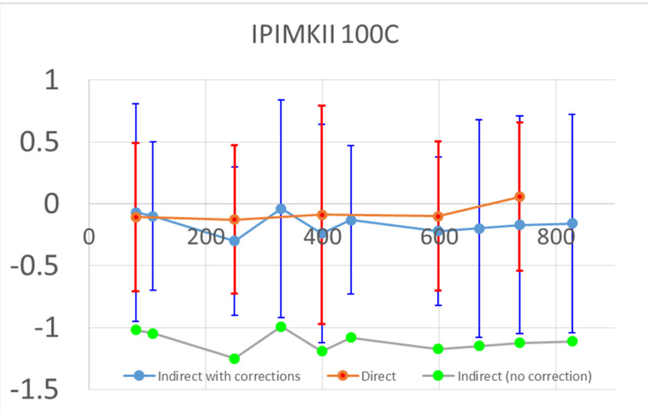

Fig. 6 IPIMKII 100C Calibration results

In the Fig. 6 we can see how the corrected values match better with the reference value of the direct calibration.

For the calibration of the 2700 G BG2M manometer, we measured the same points with both methods and once more we got a big zero drift, so we made the same correction of the zero. The results can be seen in Table *5*, the values marked with N/A are values intended to check interpolation and extrapolation of the calibration results.

P_0 (hPa)	E_{ref} (hPa)	$U(E_{ref})$ (hPa).	E_{t1} (hPa)	$U(E_{t1})$ (hPa).	E_{t2} (hPa)	$U(E_{t2})$ (hPa).
0	0.00	0.6	1.5	2.2	0.75	0.88
-75	0.25	0.6	-1.8	1.8	-0.51	0.88
-150	-0.24	0.88	-1.8	1.6	-0.52	0.60
-219	-0.25	0.6	-1.5	1.6	-0.29	0.60
-289	-0.02	0.6	-1.8	1.4	-0.32	0.88
-389	0.31	0.6	-1.7	2	0.01	0.88
-488	-0.12	0.88	-1.9	1.5	-0.42	0.6
-538	-0.05	0.6	-1.8	1.5	-0.26	0.6
-588	N/A	N/A	-1.8	1.4	-0.35	0.88
-688	-0.73	0.88	-2.0	1.9	-0.02	0.88
-738	-0.28	0	-1.9	1.9	0.14	0.88
-887	N/A	N/A	-2.1	1.4	-0.38	0.88
-937	N/A	N/A	-2.0	1.4	-0.22	0.88
-1027	N/A	N/A	-1.7	1.4	0.07	0.88

Table 5Results for the 2700 G BG2M (Direct and Indirect)

In Fig. 7 we can see the better match of the corrected results for the 2700 G BG2M calibration; the lower uncertainty also came from the correction of the zero drift.

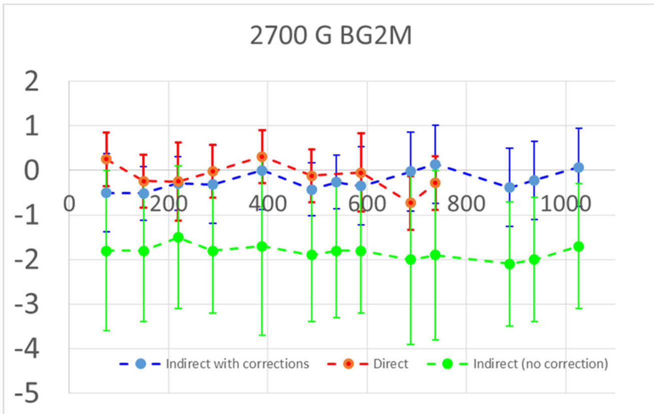

Fig. 7. 2700 G BG2M Calibration results

However, the correction used for the indirect results is not documented in DKD-R 6-1, but has been used in other negative pressure calibration [4]. As a new technical guide related to the measurements of negative gauge pressure is been prepared [4] this method could be improved to solve the problem for the calibration of negative gauge pressure measuring devices at high altitudes.

4. CONCLUSIONS

- It is possible to calibrate the full span of a digital negative pressure gauge in cities high above the sea level.
- A comparison between laboratories at different altitudes will show the usefulness of the method.
- The devices show high drift at zero point.

ACKNOWLEDGMENTS

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REFERENCES

[1] Torres Jorge, Romero Luis, Benjamín Soriano, Comparación Nacional en la magnitud de presión negativa (-100 kpa a 0 kpa), CENAM, MÉXICO 1999

[2] Guideline DKD-R 6-1 Calibration of Pressure Gauges

[3] JCGM 100:2008 Guide to the expression of uncertainty in measurement (GUM), BIPM, IEC, IFCC, ILAC, ISO, IUPAC, IUPAP and OIML

[4] S Saxholm et al EURAMET.M.P-S9 / EURAMET 1170, LOOP1 Comparison in the negative gauge pressure range -950 to 0 hPa 2016 Metrologia 53 07010.