INSTRUMENT TEST REPORT NUMBER 639

Test of a Crouzet 2100 Digital Barometer against the WMO Region V Standard Barometer

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Introduction

The French National Metrology Agency (Bureau National Metrologie) has a travelling barometer (Crouzet 2100 digital barometer, serial number 96) which is used for inter-laboratory comparisons.

The Australian counterpart of the BNM, NATA (National Association of Testing Authorities), arranged for the Physics Laboratory to perform a comparison of the Crouzet barometer against the WMO Region V Standard Barometer (Hass barometer) while the Crouzet was in Australia.

The Hass Primary Standard was calibrated by the National Measurement Laboratory in February 1994; the results of this calibration are reported in NML report RS23956, dated 27 May 1994. The overall uncertainty assigned to a Hass measurement is ±0.03 hPa (at a confidence level of 95%).

Equipment Set-up

The Hass and Crouzet were connected together via stainless steel tubing system in the Primary standard room. The pressure, in the system, was controlled by a Ruska 7010 digital pressure controller. The calibration medium was dry air supplied from a gas cylinder. See Figure 1 for equipment set-up.

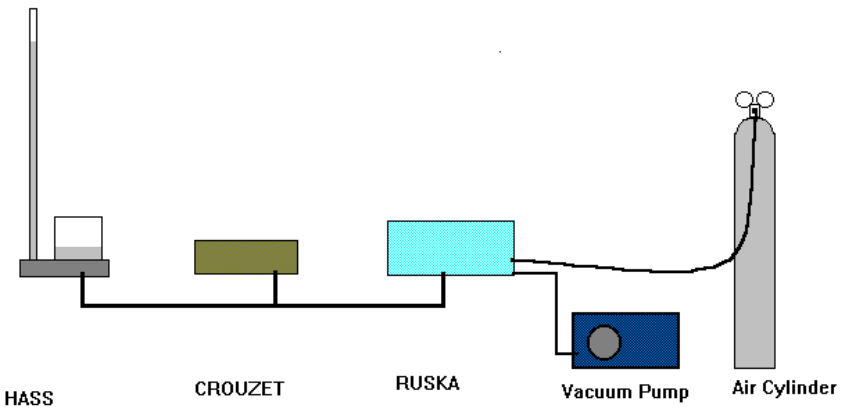

Figure 1.

Procedure

The Crouzet barometer was first conditioned by reducing the pressure in the system down to 20 hPa for 1 min, restoring the pressure back to ambient for 1 min then reducing the pressure to 20 hPa for 5 minutes (Figure 2). The measurement cycle was then initiated.

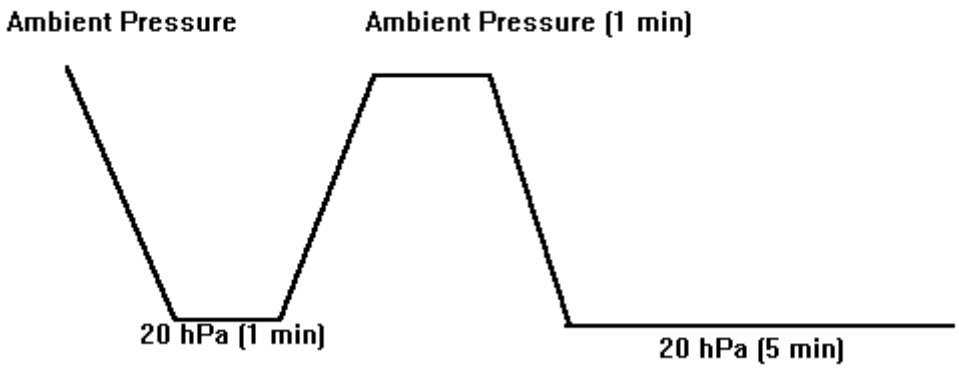

Figure 2 - Conditioning Cycle

Following the conditioning, the Crouzet was tested for 3 cycles of increasing and decreasing pressure at the following nominal pressures (hPa) 100, 200, 400, 600, 800, 900 and 1000. (Figure 3)

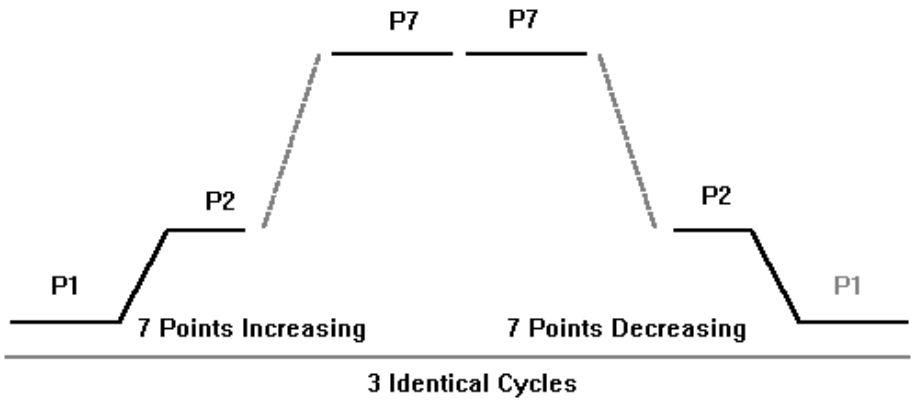

Figure 3 - Measurement Cycle.

<u>Measurement Procedure:</u>

1. The pressure was set on the Ruska and the system left to stabilise for 5 minutes.
2. The base of the Hass was lightly struck with a soft rubber mallet, this assisted the formation of a meniscus on the mercury column and improved the accuracy of the pressure reading, particularly during the decreasing pressure section of the cycle.
3. The Hass main scale vernier and cistern micrometer were then set.
4. The Ruska pressure was read and recorded.
5. The Crouzet pressure was read and recorded.
6. The Hass thermometer was then read and recorded.
7. The Hass vernier and micrometer were then read and recorded.

Results

The differences between the Hass and the Crouzet, and the Hass and the Ruska 7010 were calculated for each pressure level and cycle. These are shown in Figure 4 and Figure 5.

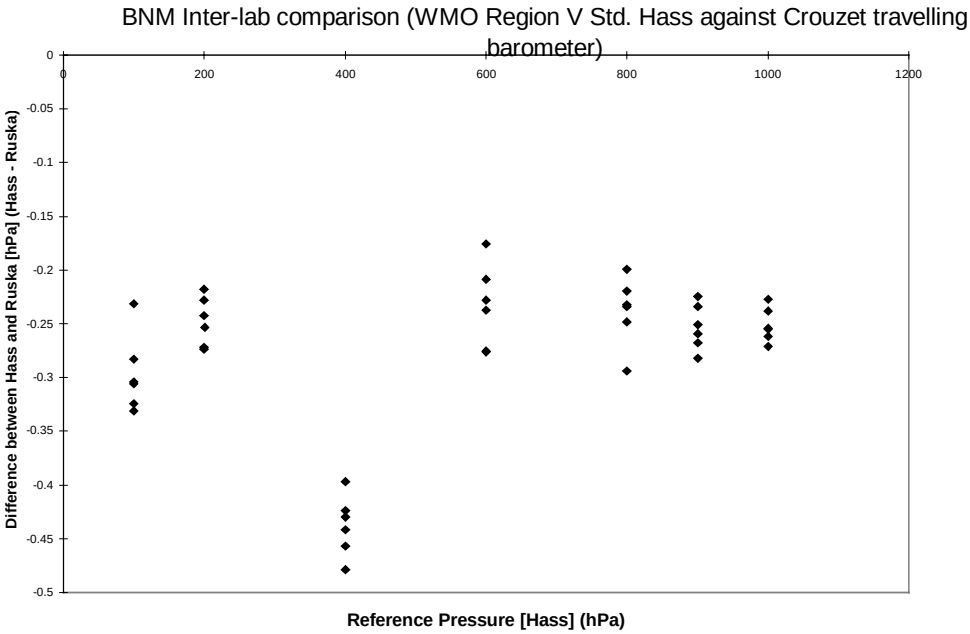

Figure 4. Difference between Hass and Crouzet barometer

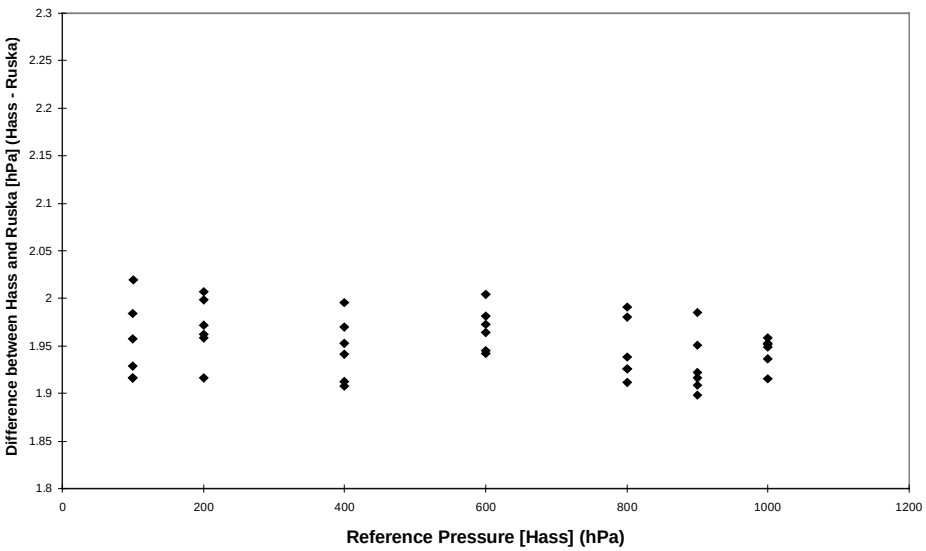

Figure 5. Difference between Hass and Ruska 7010

Analysis of results:

Generally, the Hass and the Crouzet are within -0.28 hPa, in the range 200 to 1000 hPa. However there is a significant difference of -0.44 hPa at 400 hPa. This was determined to be an artefact of the Crouzet alone and not due to the response of the Hass. The graph of the difference between the Hass and Ruska does not show this deviation.

The average difference, sample standard deviation and the uncertainty in the difference (95% confidence, excluding the uncertainty in the Hass) were calculated for ascending, descending and all measurements at each nominal pressure level for all cycles and are given in Tables 1 to 3. The average differences are graphed in Figure 6.

Ascending Pressures			
Reference Pressure (hPa)	Difference Reference - Crouzet (hPa)	U_{95}[1] ± (hPa)	number of points
100	-0.27	0.13	3
200	-0.26	0.09	3
400	-0.42	0.11	3
600	-0.21	0.09	3
800	-0.23	0.11	3
900	-0.25	0.14	3
1000	-0.26	0.08	3

Table 1. Average Difference, Ascending Pressure

Descending			
Reference Pressure (hPa)	Difference Reference - Crouzet (hPa)	U_{95} ± (hPa)	number of points
100	-0.32	0.11	3
200	-0.24	0.09	3
400	-0.45	0.13	3
600	-0.25	0.08	3
800	-0.24	0.11	3
900	-0.26	0.08	3
1000	-0.24	0.05	3

Table 2. Average Difference, Descending Pressure

[1] $U_{95(\text{mean difference})}$, the Uncertainty in the mean, is defined as $\sqrt{U_{95}^{2}(Crouzet) + U_{95}^{2}(Hass)}$

where: $U_{95(\text{barometer})} = \dfrac{t \times \sigma_{(barometer)}}{\sqrt{n}}$

where: t = Student's t value for a two-tailed test for n-1 degrees of freedom.
σ = Sample standard deviation.

All Measurements			
Reference Pressure (hPa)	Difference Reference - Crouzet (hPa)	U_{95} ± (hPa)	number of points
100	-0.30	0.04	6
200	-0.25	0.02	6
400	-0.44	0.03	6
600	-0.23	0.04	6
800	-0.24	0.03	6
900	-0.25	0.02	6
1000	-0.25	0.02	6

Table 3. Average Difference, All measurements

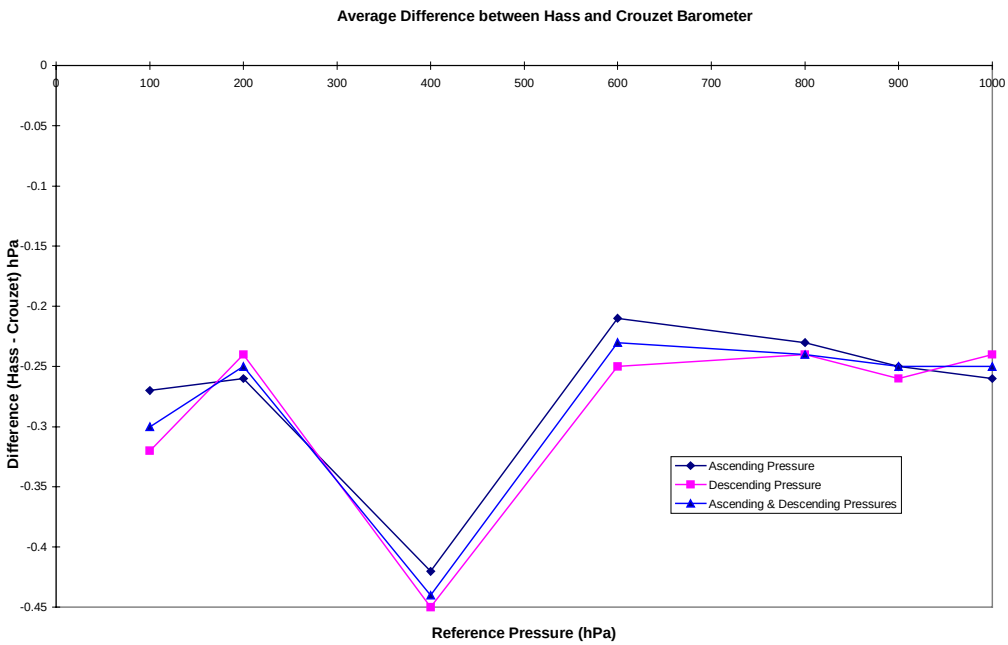

Figure 6. - Crouzet average difference from Hass.

The average difference between the Hass and the Crouzet for the entire data set, uncertainty in this difference, the Standard Error in the Crouzet and the overall uncertainty of the barometer including the uncertainty in the Hass are given in Table 4.

All measurements in hPa.				
Average Difference	U_{95} in Average Difference	Standard Error[2]	Overall Uncertainty[3]	Number of Points
-0.28	±0.02	±0.14	±0.04	42

Table 4. - Crouzet Summary

[2] Standard Error is defined as $t \times \sigma$

[3] Overall uncertainty is defined as $\sqrt{U_{95}^{2}(Crouzet) + U_{95}^{2}(Hass)}$

Conclusion:

The Crouzet Barometer (serial number 96) was found to have had an average difference of -0.28 hPa compared to the Hass, the overall uncertainty (U_{95}) in this difference is ±0.04 hPa. The Standard Error for the difference between the Crouzet and the Hass was calculated to be ±0.14 hPa.