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Calibration of a Thies First Class Advanced X at ambient conditions

- implications for the pressure corrected output signal -

Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Str. 65
26316 Varel
Germany

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Company: Deutsche WindGuard Wind Tunnel Services GmbH
Oldenburger Straße 65
26316 Varel
Germany
Telephone: +49 4451 95 15 239
Fax: +49 4451 95 15 29
E-Mail: D.Westermann@windguard.de

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Author: A. Roß, M. Sc.
H. Westermann, B. Sc.

Approved by: Dipl.-Phy. D. Westermann

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Deutsche WindGuard Wind Tunnel Services GmbH is an associated Member of MEASNET and is accepted by MEASNET for the Calibration of Anemometers.

Deutsche WindGuard Wind Tunnel Services GmbH is an approved testing laboratory for the anemometer calibration competence area within the IECRE scheme.

Revision History

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Note: The last revision replaces all previous versions of the report.

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Disclaimer:

We hereby state, that the results in this report are based upon generally acknowledged and state-of-the-art methods and have been neutrally conducted to the best of our knowledge and belief. No guarantee, however, is given and no responsibility is accepted by Deutsche WindGuard Wind Tunnel Services GmbH for the correctness of the derived results. The work presented in this report complies with the present day valid standards and guidelines and the corresponding quality management system of Deutsche WindGuard. Any partial duplication of this report is allowed only with written permission of Deutsche WindGuard Wind Tunnel Services GmbH. The results of the following report refer to the investigated test objects only.

This report covers 10 pages.

1 Introduction

The Thies First Class Advanced X (FCAX) has multiple outputs. Amongst others the sensor is able to apply an air pressure correction to the output signal. The manufacturer published a calibration note for the sensor explaining the pressure corrected sensor output, which is calculated with the following formula:

$$v_{Pcorrected} = \frac{v_{sensor}}{correction\ value}$$

The correction values are saved as a look-up table in the sensor and are then applied by means of a linear interpolation between the correction values.

Furthermore, it is possible to upload a correction table to adjust the sensor output. If available, the sensor will first apply this correction table and afterwards the pressure correction value to calculate the pressure corrected output signal.

The sensor treats the correction table as if the corresponding measurement was performed at an ambient pressure of 1000 hPa, there is no option to additionally pass the ambient pressure value. If the measurement is not performed at 1000 hPa and the correction table is not adapted to 1000 hPa, the pressure corrected output signal will be affected by this adjustment. In this report this influence shall be analyzed.

First the ambient condition present at Deutsche WindGuard facilities are analyzed. Furthermore, the correction values applied by the FCAX are presented, followed by the correction coefficient used for the ambient conditions present in the wind tunnel during calibration. With the obtained data the deviation of the pressure corrected sensor output is evaluated.

2 Ambient pressure at the wind tunnel

The ambient pressure at wind tunnel WT II and WT IV for the years 2015 – 2019 are shown in Figure 1. More than 20000 data points covering different daytimes are evaluated for wind tunnel WT II and more than 15000 for wind tunnel WT IV. Wind tunnel WT I and WT III are in the immediate vicinity of those wind tunnels and therefore are not further analyzed.

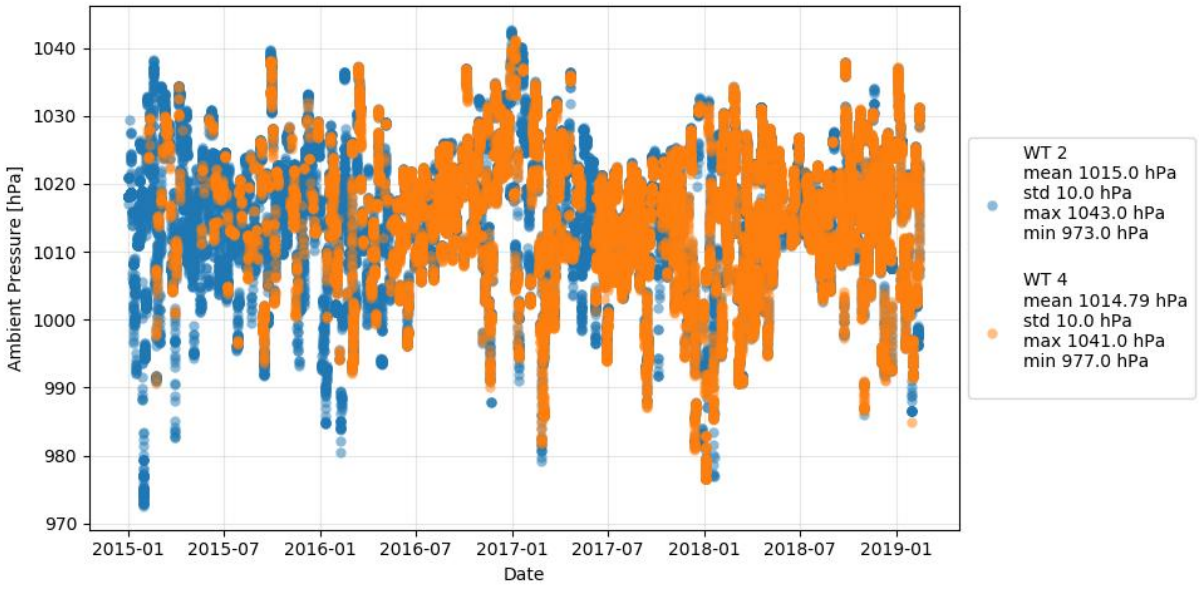

Figure 1: Ambient pressure at wind tunnel WTII and WTIV from 2015 – 2019.

The ambient pressure in WT II and WT IV has a similar characteristic. This can also be seen in the histogram presented in Figure 2.

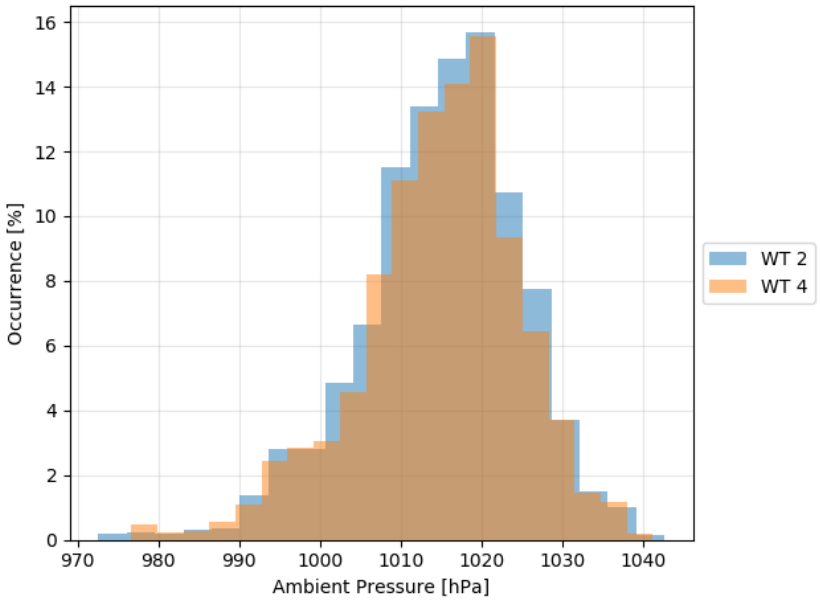

Figure 2: Percent distribution of the occurrence of different ambient pressure values at wind tunnel WT II and WT IV from 2015 – 2019.

For the further evaluation just the ambient conditions at wind tunnel WT II are considered, as the minimal and maximal values are slightly greater. The statistical values used are listed in Table 1.

Table 1: Statistical values for the ambient pressure at wind tunnel WTII covering a period of more than 4 years.

Ambient Pressure	WT II
Mean value	1015 hPa
Standard deviation	10 hPa
Maximum value	1043 hPa
Minimum value	973 hPa

3 Sensor correction value

As already mentioned, the calibration note provided by the manufacturer of the sensor lists correction values for different pressure values and air velocity combinations. The correction values provided covering the range between minimum and maximum ambient pressure in wind tunnel WT II are listed in Table 2.

Table 2: Correction factor and slope given in the calibration note from Thies for the First Class Advanced X sensor.

Air velocity [m/s]	Ambient Pressure (uPressure) [hPa]	Correction factor (uCorrFac) [-]	Slope (uGain) [1/hPa]
4	895.7092	0.9933	6.62E-05
4	996.8352	1.0000	4.16E-05
4	1085.9956	1.0037	
6	907.1328	0.9949	5.48E-05
6	1000.0084	1.0000	2.64E-05
6	1073.5848	1.0019	
8	897.0576	0.9957	4.29E-05
8	996.7672	1.0000	2.00E-05
8	1082.896	1.0017	
10	906.0516	0.9971	3.07E-05
10	1000.3272	1.0000	2.52E-05
10	1076.2480	1.0019	
12	899.1588	0.9975	2.51E-05

Air velocity [m/s]	Ambient Pressure (uPressure) [hPa]	Correction factor (uCorrFac) [-]	Slope (uGain) [1/hPa]
12	997.5296	1.0000	2.31E-05
12	1081.0056	1.0019	
14	904.6048	0.9974	2.70E-05
14	1000.2812	1.0000	2.11E-05
14	1078.6772	1.0016	
16	902.2448	0.9976	2.45E-05
16	999.2772	1.0000	1.90E-05
16	1080.0916	1.0015	

The calibration note instructs to evaluate the wind speed table above and below the measured wind speed. The correction value for both wind speeds should be calculated using the nearest lower pressure value and the corresponding gain value. Afterwards a linear regression between the two wind speeds should be used to calculate the correction value for the evaluated wind speed.

To keep it simple only the given wind speeds are evaluated, which cover a wind speed range of 4 m/s up to 16 m/s.

4 Correction coefficient for ambient condition of WTII

The mean, minimum and maximum corrections which will be applied by the sensor during a calibration in wind tunnel WT II (according to Table 1) to calculate the pressure corrected sensor output are listed in Table 3.

Table 3: Correction factor at the maximum and minimum ambient pressure present in WT II for different wind speeds.

Air velocity [m/s]	Correction factor at		
	973 hPa	1015 hPa	1043 hPa
4	0.99841630	1.00075528	1.00191951
6	0.99851978	1.00039522	1.00113339
8	0.99898097	1.00036546	1.00092670
10	0.99916078	1.00036930	1.00107404
12	0.99938487	1.00040434	1.00105239
14	0.99926315	1.00031019	1.00090026
16	0.99933304	1.00029818	1.00082920

Assuming the anemometer is calibrated in wind tunnel WT II at the maximum, minimum and mean air pressure present and afterwards the digital output without the pressure correction is adjusted. The sensor will theoretically indicate the same wind speed (without pressure correction) as given by the reference system, as long as the ambient condition has not changed. The pressure corrected output signal on the other hand will be calculated with the corresponding correction factor listed in Table 3 and the equation given in Section 1 Introduction, leading to a deviation between pressure corrected output signal and the reference air velocity.

The pressure corrected output signal and the absolute deviation are listed in Table 4.

Table 4: Pressure corrected output at the maximum and minimum air pressure present in WT II for different air velocities.

Air velocity [m/s]	Pressure corrected output [m/s]			Absolut deviation [m/s]		
	973 hPa	1015 hPa	1043 hPa	973 hPa	1015 hPa	1043 hPa
4	4.006	3.997	3.992	0.006	-0.003	-0.008
6	6.009	5.998	5.993	0.009	-0.002	-0.007
8	8.008	7.997	7.993	0.008	-0.003	-0.007
10	10.008	9.996	9.989	0.008	-0.004	-0.011
12	12.007	11.995	11.987	0.007	-0.005	-0.013
14	14.010	13.996	13.987	0.010	-0.004	-0.013
16	16.011	15.995	15.987	0.011	-0.005	-0.013

The maximum deviation between pressure corrected output signal and the reference air velocity is 0.013 m/s. This value is calculated for air velocities above 12 m/s and an ambient pressure of 1043 hPa. This pressure value only occurred once in four years.

Usually the ambient pressure value will lie between 1000 hPa and 1030 hPa. For this pressure range the deviation will be below 0.01 m/s.

5 Conclusion

The ambient condition in all wind tunnels are almost the same. The calculation was performed with the statistical data gained from wind tunnel WT II. Nevertheless, the results are valid for all wind tunnels present in the facilities of Deutsche WindGuard Wind Tunnel Services GmbH.

After a calibration and adjustment of a FCAX sensor at ambient condition in a wind tunnel of Deutsche WindGuard, the pressure corrected output of the sensor will have a maximum theoretical deviation of 0.013 m/s, compared to the reference air velocity.

The sensor output is only given with two decimal places, leading to a deviation in the pressure corrected output signal which is in the same magnitude as the resolution itself. Furthermore, for the majority of the measurements no deviation will be seen at all.

It is therefore concluded that an air pressure dependent correction of the reference wind speed is not necessary for the adjustment and would lead to confusion for the end-user if the reported calibration table differs from the correction table.