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Akkreditierungsstelle
D-K-15140-01-00Calibration certificate
*Kalibrierschein*Calibration mark
Kalibrierzeichen

| |
|-------------|
| 1715161 |
| D-K- |
| 15140-01-00 |
| 12/2017 |

| | |
|---|--|
| Object <i>Gegenstand</i> | Cup Anemometer |
| Manufacturer <i>Hersteller</i> | Thies Clima D-37083 Göttingen |
| Type <i>Typ</i> | 4.3351.10.000 |
| Serial number <i>Fabrikat/Serien-Nr.</i> | 12179340 |
| Customer <i>Auftraggeber</i> | HydroWind BVBA B-1850 Grimbergen (Brussels) |
| Order No. <i>Auftragsnummer</i> | Email 2017-11-20, Wery |
| Project No. <i>Projektnummer</i> | VT171188 |
| Number of pages <i>Anzahl der Seiten</i> | 4 |
| Date of Calibration <i>Datum der Kalibrierung</i> | 18.12.2017 |

This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).

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Date
Datum

18.12.2017

Head of the calibration laboratory
Leiter des Kalibrierlaboratoriums

Dipl. Phys. Dieter Westermann

Person in charge
Bearbeiter

Kai Schuster, B. Eng.

Calibration object
Kalibriergegenstand

Cup Anemometer

Calibration procedure
Kalibrierverfahren

- Deutsche WindGuard Wind Tunnel Services: VA Anemometerkalibrierung
- Based on following standards:
- MEASNET ANEMOMETER CALIBRATION PROCEDURE Version 2 / 2009
- IEC 61400-12-1:2017 Power performance measurements of electricity producing wind turbines
- IEC 61400-12-2:2013 Power performance of electricity producing wind turbines based on nacelle anemometry
- ISO 3966:2008 Measurement of fluid in closed conduits
- ISO 16622:2002 Meteorology - Sonic anemometers/thermometers

Place of calibration
Ort der Kalibrierung

Wind tunnel of Deutsche WindGuard WindTunnel Services GmbH, Varel

Test conditions
Messbedingungen

| | |
|------------------------------|-----------------------|
| wind tunnel area | 10000 cm ² |
| anemometer frontal area | 230 cm ² |
| diameter of mounting pipe | 34 mm EN 10217 |
| blockage ratio ¹⁾ | 0.023 [-] |
| software version | 7.7 |

¹⁾ Due to the special construction of the test section no blockage correction is necessary.

Ambient conditions
Umgebungsbedingungen

| | |
|-----------------------|----------------------|
| air temperature | 18.8 °C ± 0.1 °C |
| air pressure | 1019.6 hPa ± 0.3 hPa |
| relative air humidity | 35.9 % ± 2.0 % |

Measurement uncertainty
Messunsicherheit

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor $k=2$. It has been determined in accordance with DAkkS-DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.
The reference flow speed measurement is traceable to the German NMI (Physikalisch-Technische Bundesanstalt) standard for flow speed. It is realized by using a PTB owned and calibrated Laser Doppler Anemometer (Standard Uncertainty 0.2 %, $k=2$)

Additional remarks
Zusätzliche Anmerkungen

-

Calibration result

Kalibrierergebnis

| Sensor out | Tunnel Speed | Uncertainty |
|------------|--------------|-------------|
| Hz | m/s | m/s |
| 82.223 | 4.000 | 0.050 |
| 123.083 | 5.884 | 0.051 |
| 166.212 | 7.880 | 0.051 |
| 210.260 | 9.904 | 0.051 |
| 253.909 | 11.911 | 0.052 |
| 296.233 | 13.839 | 0.052 |
| 338.372 | 15.804 | 0.053 |
| 316.894 | 14.804 | 0.052 |
| 276.100 | 12.905 | 0.052 |
| 231.040 | 10.895 | 0.051 |
| 187.846 | 8.887 | 0.051 |
| 145.325 | 6.932 | 0.050 |
| 102.209 | 4.961 | 0.050 |

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Statistical analysis

| | |
|-------------------------|---|
| Slope | $0.04595 \text{ (m/s)/(Hz)} \pm 0.00006 \text{ (m/s)/(Hz)}$ |
| Offset | $0.2440 \text{ m/s} \pm 0.014 \text{ m/s}$ |
| Standard error (Y) | 0.014 m/s |
| Correlation coefficient | 0.99999 |

Remarks

The calibrated sensor complies with the demanded linearity of MEASNET



Graphical representation of the result

Grafische Darstellung des Ergebnisses

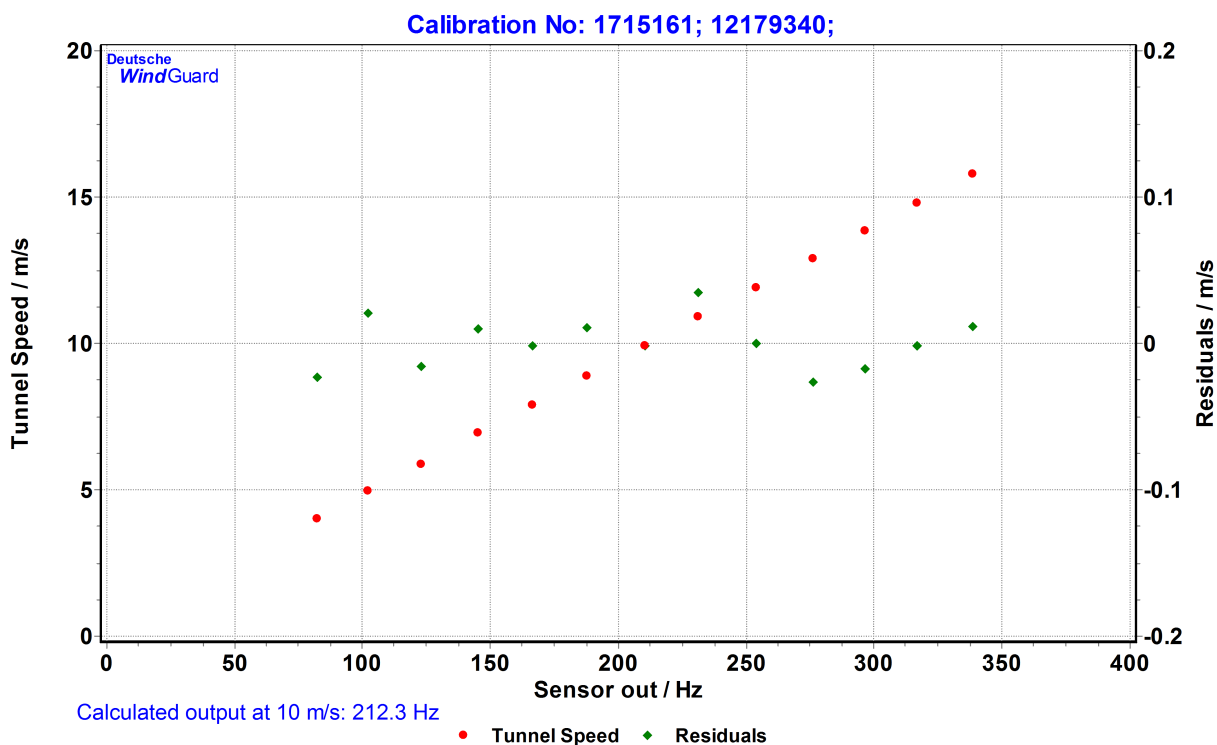
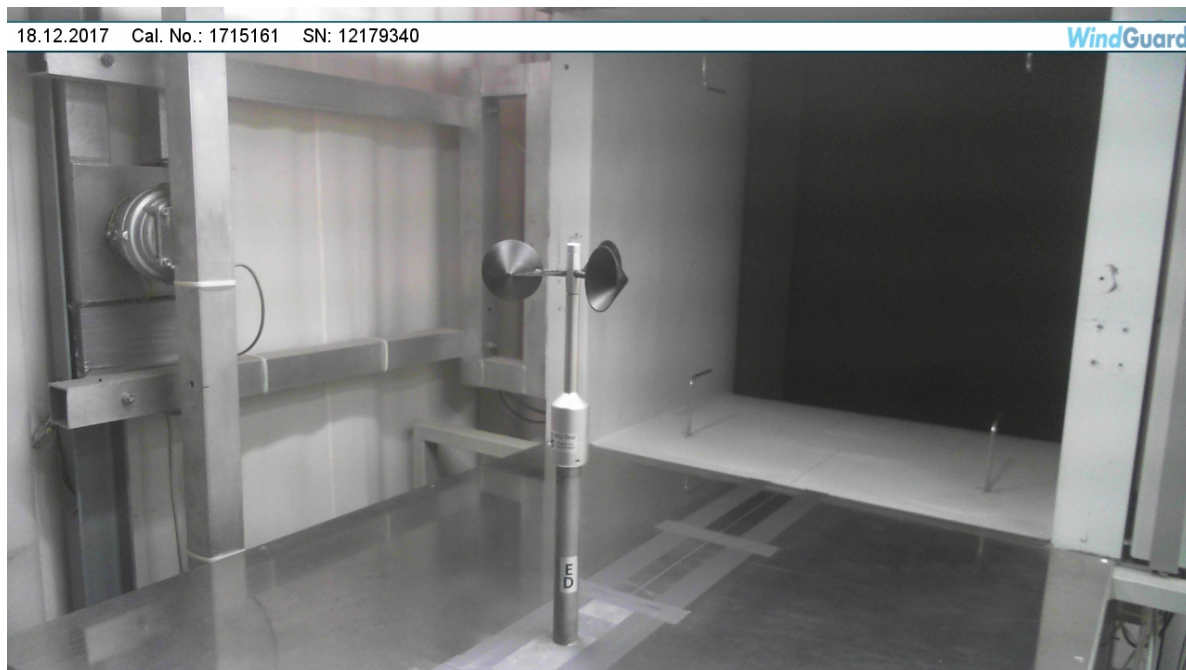


Photo of the measurement setup

Foto des Messaufbaus



Remark: The proportions of the set-up may not be true to scale due to imaging geometry.