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

1715152

D-K-

15140-01-00

12/2017

|   |  |
|---|--|
| <b>Object</b><br><i>Gegenstand</i>                          | Cup Anemometer                                 |
| <b>Manufacturer</b><br><i>Hersteller</i>                    | Thies Clima<br>D-37083 Göttingen               |
| <b>Type</b><br><i>Typ</i>                                   | 4.3351.10.000                                  |
| <b>Serial number</b><br><i>Fabrikat/Serien-Nr.</i>          | 12179348                                       |
| <b>Customer</b><br><i>Auftraggeber</i>                      | HydroWind BVBA<br>B-1850 Grimbergen (Brussels) |
| <b>Order No.</b><br><i>Auftragsnummer</i>                   | Email 2017-11-20, Wery                         |
| <b>Project No.</b><br><i>Projektnummer</i>                  | VT171188                                       |
| <b>Number of pages</b><br><i>Anzahl der Seiten</i>          | 4  |
| <b>Date of Calibration</b><br><i>Datum der Kalibrierung</i> | 15.12.2017                                     |

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*

15.12.2017

Head of the calibration laboratory  
*Leiter des Kalibrierlaboratoriums*

Dipl. Phys. Dieter Westermann

Person in charge  
*Bearbeiter*

Techniker Dirk Henniges

**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 <sup>2</sup> |
| anemometer frontal area      | 230 cm <sup>2</sup>   |
| diameter of mounting pipe    | 34 mm                 |
| blockage ratio <sup>1)</sup> | 0.023 [-]             |
| software version             | 7.7                   |

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

**Ambient conditions**  
*Umgebungsbedingungen*

|                       |                     |
|-----------------------|---------------------|
| air temperature       | 20.6 °C ± 0.1 °C    |
| air pressure          | 994.6 hPa ± 0.3 hPa |
| relative air humidity | 34.6 % ± 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*

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## Calibration result

Kalibrierergebnis

| Sensor  | Tunnel Speed | Uncertainty |
|---------|--------------|-------------|
| Hz      | m/s          | m/s         |
| 81.155  | 3.965        | 0.050       |
| 122.504 | 5.873        | 0.051       |
| 165.679 | 7.867        | 0.051       |
| 210.010 | 9.892        | 0.051       |
| 253.594 | 11.890       | 0.051       |
| 295.374 | 13.818       | 0.052       |
| 338.591 | 15.781       | 0.052       |
| 316.279 | 14.797       | 0.052       |
| 274.538 | 12.882       | 0.052       |
| 230.412 | 10.854       | 0.051       |
| 187.050 | 8.870        | 0.051       |
| 144.869 | 6.914        | 0.051       |
| 101.215 | 4.926        | 0.050       |

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## Statistical analysis

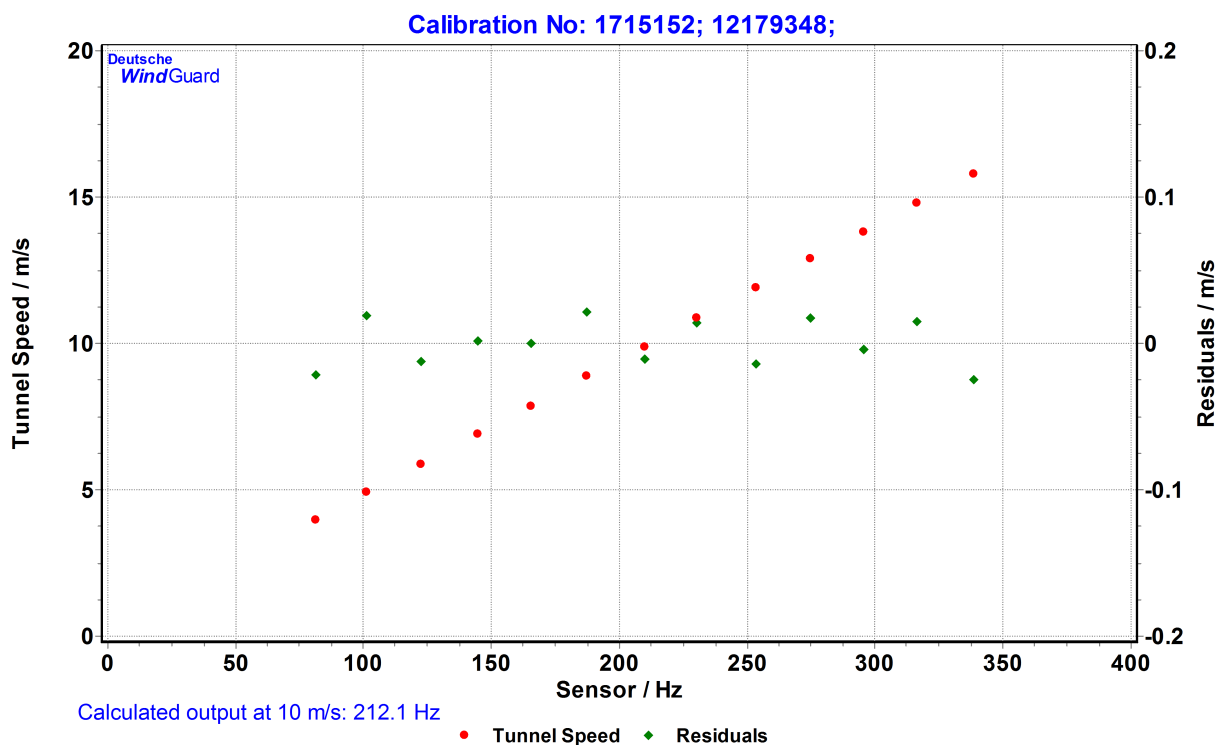
|                         |   |
|-------------------------|---|
| Slope                   | $0.04591 \text{ (m/s)/(Hz)} \pm 0.00006 \text{ (m/s)/(Hz)}$ |
| Offset                  | $0.2603 \text{ m/s} \pm 0.013 \text{ m/s}$                  |
| Standard error (Y)      | $0.013 \text{ m/s}$   |
| Correlation coefficient | $0.99999$   |

## Remarks

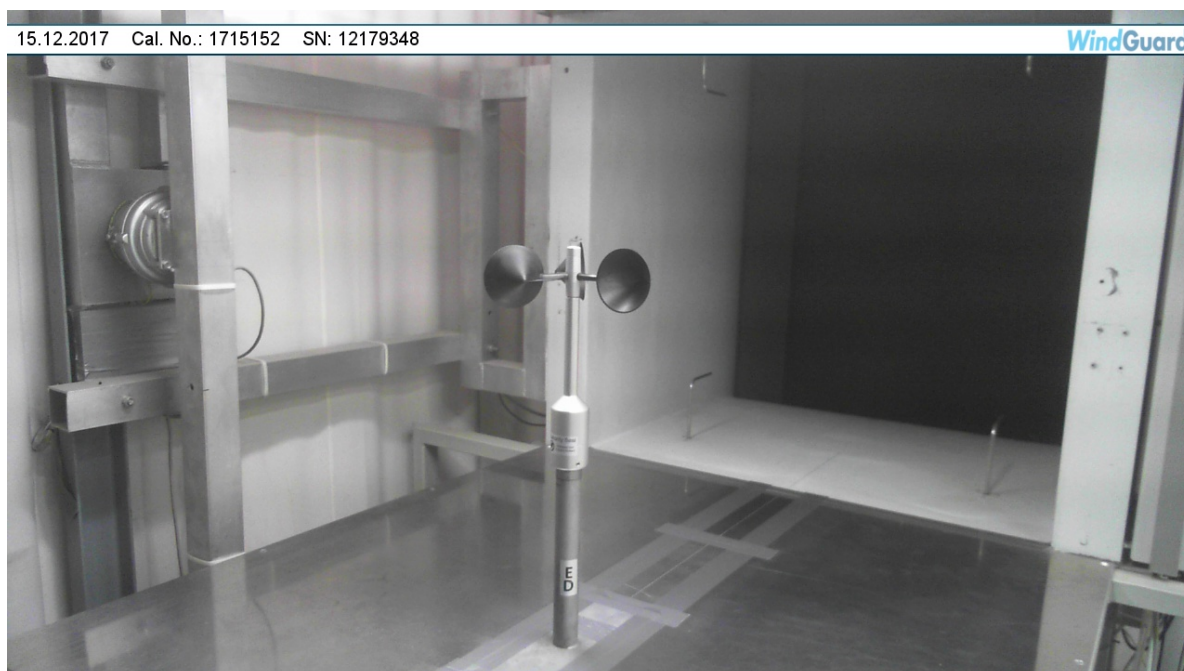
The calibrated sensor complies with the demanded linearity of MEASNET



### 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.