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

1715162
D-K-
15140-01-00
12/2017

<b>Object</b> <i>Gegenstand</i>	Cup Anemometer
<b>Manufacturer</b> <i>Hersteller</i>	Thies Clima D-37083 Göttingen
<b>Type</b> <i>Typ</i>	4.3351.10.000
<b>Serial number</b> <i>Fabrikat/Serien-Nr.</i>	12179339
<b>Customer</b> <i>Auftraggeber</i>	HydroWind BVBA B-1850 Grimbergen (Brussels)
<b>Order No.</b> <i>Auftragsnummer</i>	Email 2017-11-20, Wery
<b>Project No.</b> <i>Projektnummer</i>	VT171188
<b>Number of pages</b> <i>Anzahl der Seiten</i>	4
<b>Date of Calibration</b> <i>Datum der Kalibrierung</i>	18.12.2017

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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 <sup>2</sup>
anemometer frontal area	230 cm <sup>2</sup>
diameter of mounting pipe	34 mm EN 10217
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	19.0 °C ± 0.1 °C
air pressure	1020.6 hPa ± 0.3 hPa
relative air humidity	35.7 % ± 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 out	Tunnel Speed	Uncertainty
Hz	m/s	m/s
82.273	4.004	0.050
123.306	5.891	0.050
166.647	7.886	0.051
210.254	9.886	0.051
254.192	11.910	0.052
295.402	13.827	0.052
338.945	15.796	0.054
315.982	14.806	0.052
275.390	12.901	0.052
230.943	10.880	0.052
187.586	8.870	0.051
145.436	6.935	0.051
102.740	4.963	0.050

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## Statistical analysis

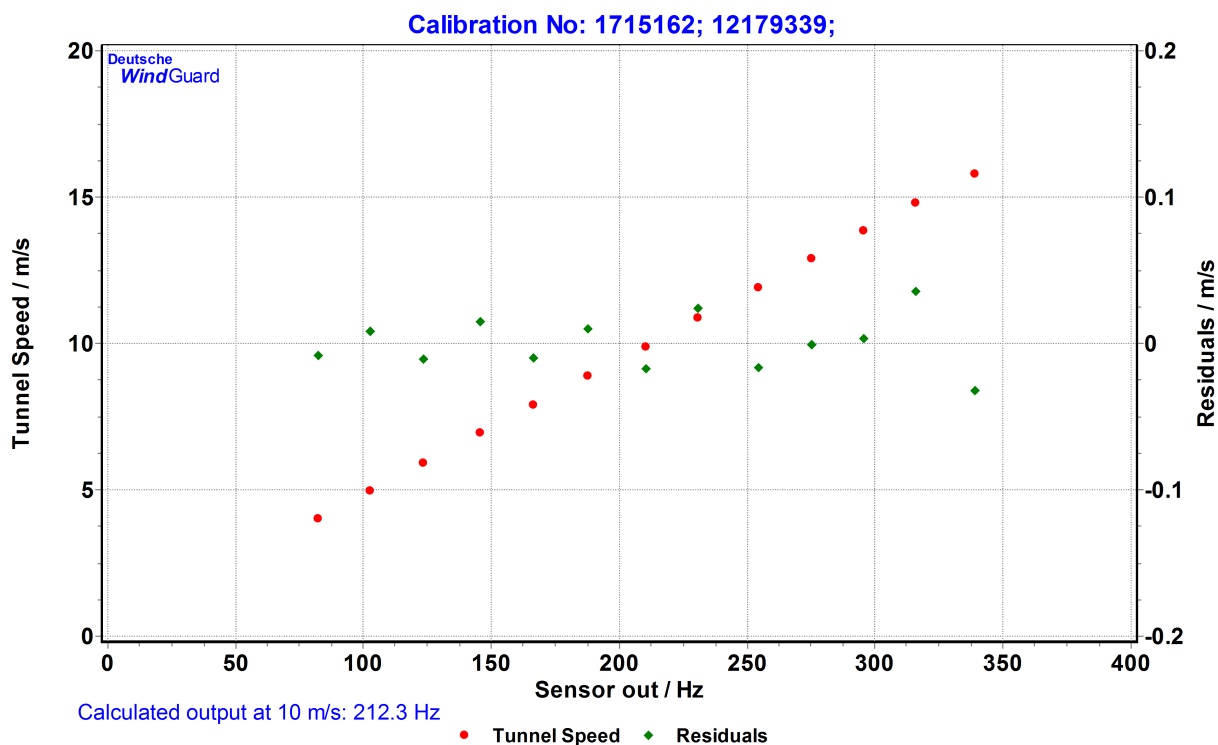
Slope	0.04603 (m/s)/(Hz) $\pm$ 0.00007 (m/s)/(Hz)
Offset	0.2247 m/s $\pm$ 0.015 m/s
Standard error (Y)	0.015 m/s
Correlation coefficient	0.99999

## Remarks

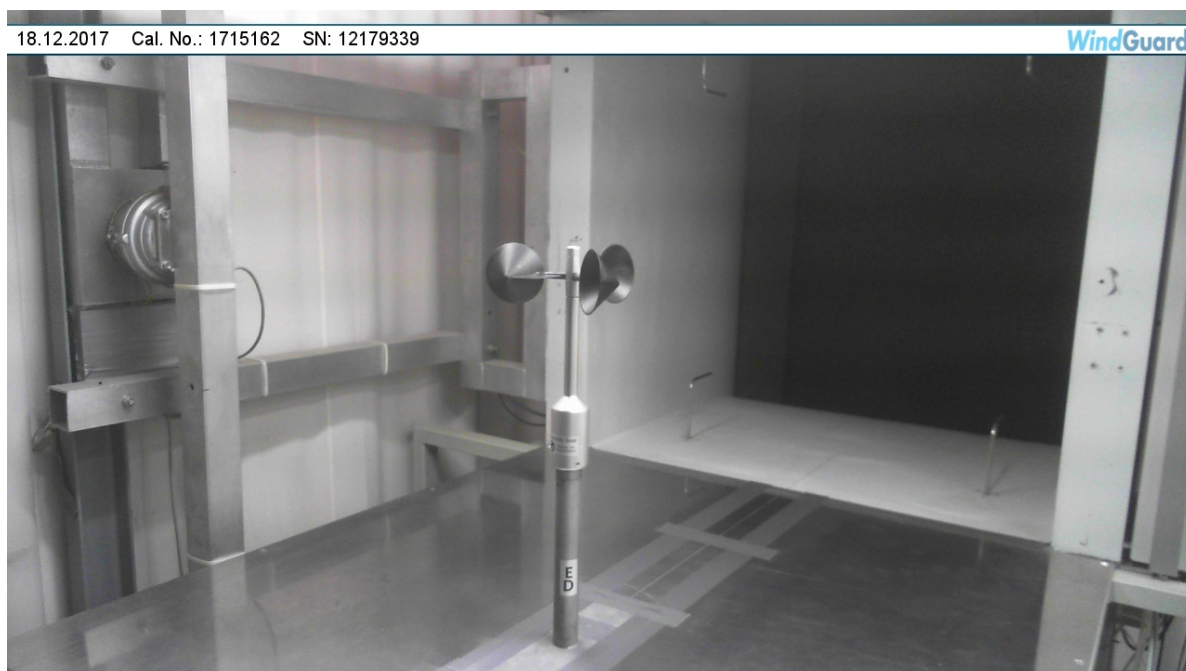
The calibrated sensor complies with the demanded linearity of MEASNET



### 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.