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

1715122

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>	12179372
<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>	14.12.2017

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Date  
*Datum*

14.12.2017

Head of the calibration laboratory  
*Leiter des Kalibrierlaboratoriums*

Dipl. Phys. Dieter Westermann

Person in charge  
*Bearbeiter*

Hendrik Jansen, 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
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	20.4 °C ± 0.1 °C
air pressure	987.5 hPa ± 0.3 hPa
relative air humidity	35.2 % ± 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
80.870	3.961	0.050
122.279	5.875	0.050
165.934	7.879	0.051
209.350	9.896	0.051
253.381	11.901	0.052
295.257	13.824	0.052
337.586	15.786	0.053
316.176	14.794	0.053
274.708	12.888	0.052
230.359	10.855	0.051
186.512	8.861	0.051
144.786	6.921	0.051
101.396	4.927	0.050

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## Statistical analysis

Slope	$0.04599 \text{ (m/s)/(Hz)} \pm 0.00004 \text{ (m/s)/(Hz)}$
Offset	$0.2576 \text{ m/s} \pm 0.009 \text{ m/s}$
Standard error (Y)	$0.009 \text{ m/s}$
Correlation coefficient	$1.00000$

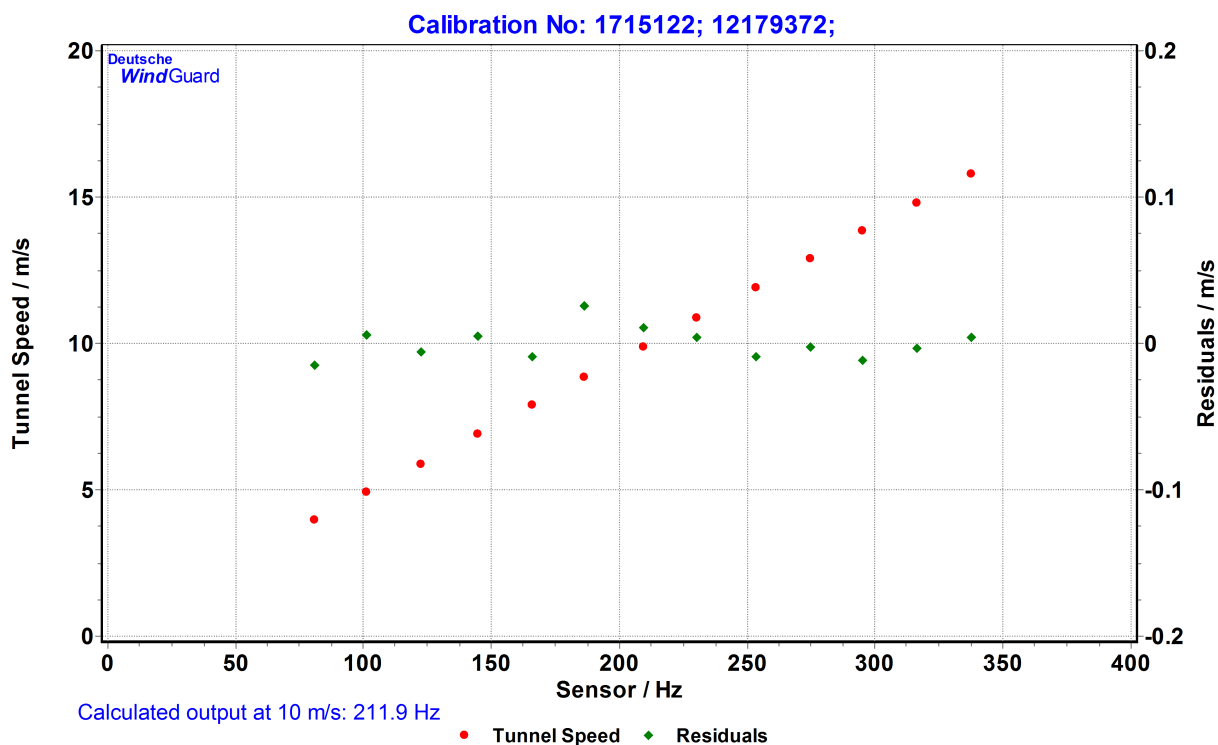
## Remarks

The calibrated sensor complies with the demanded linearity of MEASNET



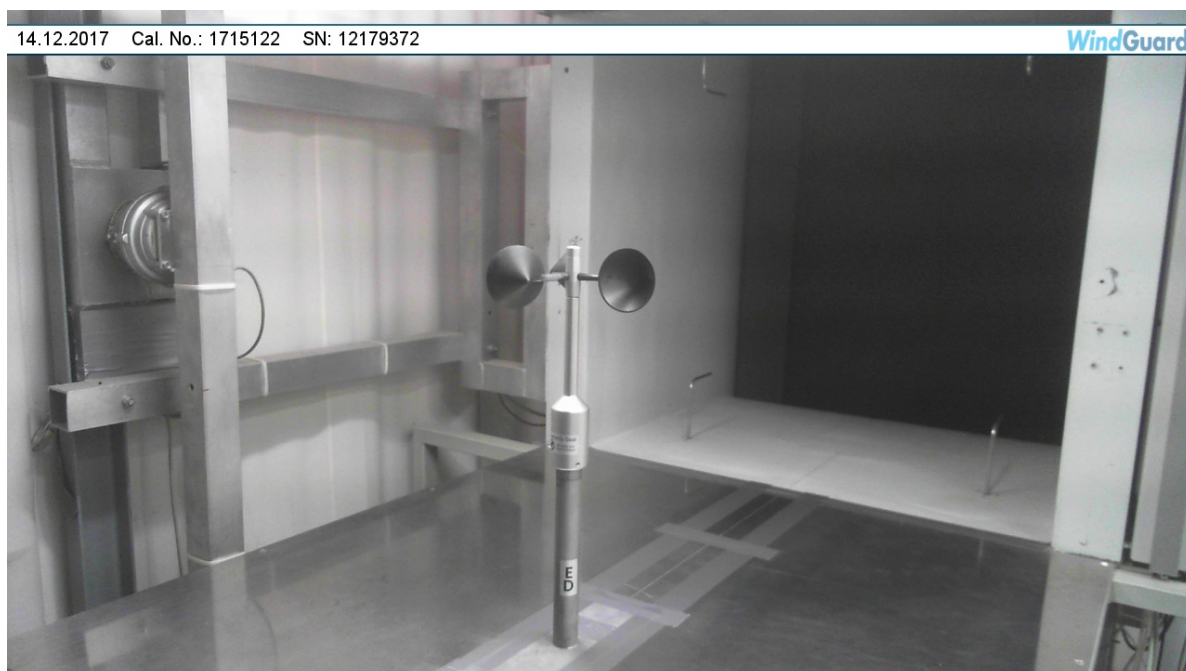
### Graphical representation of the result

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.