



ANEXO 5

CERTIFICADOS DE CALIBRACIÓN DE LOS INSTRUMENTOS

akkreditiert durch die / accredited by the

Deutsche Akkreditierungsstelle GmbH



als Kalibrierlaboratorium im / as calibration laboratory

Deutschen Kalibrierdienst



Kalibrierschein
Calibration certificate

Kalibrierschein
Calibration certificate

180307
D-K- 20511-01-00
2018-01

Gegenstand Object	Cup Anemometer
Hersteller Manufacturer	Thies GmbH Göttingen
Typ Type	Thies fc advanced II / 4.3352.10.000
Fabrikat/Serien-Nr. Serial number	01180065
Auftraggeber Customer	Ammonit Measurement GmbH, Berlin
Auftragsnummer Order No.	005AK118, 2018/01/04
Anzahl der Seiten des Kalibrierscheines Number of Pages of the certificate	3
Datum der Kalibrierung Date of calibration	24.01.18

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

*This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI). The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.*

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This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum
Date

Leiter des Kalibrierlaboratoriums
Head of the calibration laboratory

Bearbeiter
Person in charge

24.01.2018

Dipl.-Ing. D. Wüstenberg

Dipl.-Geoök. S. Müller



Kalibriergegenstand <i>Object</i>	Cup Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400-12-1:2005 (DIN EN 61400-12-1:2006) Wind turbines - Power performance measurements of electricity producing wind turbines IEC 61400-12-1 Ed. 2 CDV (DIN EN 61400-12-1 Ed. 2 CDV : 2015) Wind turbines - Power performance measurements of electricity producing wind turbines MEASNET - Anemometer Calibration Procedure - Version 2 - 10/2009	
Ort der Kalibrierung <i>Place of calibration</i>	AWT Bargeshagen	
Messbedingung <i>Test conditions</i>	wind tunnel area ¹⁾	14400 cm ²
	anemometer frontal area ²⁾	300 cm ²
	diameter of mounting pipe ³⁾	34,0 mm
	blockage ratio ⁴⁾	0.021 [-]
Umgebungsbedingungen <i>Air conditions</i>	air temperature	17.4 °C (+- 1.0 K)
	air pressure	1009 hPa (+- 1.0 hPa)
	relative humidity	49 % (+- 2.0 %)
Dateiinformation <i>File conditions</i>	thi-01180065_z20_30	
Anmerkungen <i>Remarks</i>	Correlation Coefficient >= 0.99995 The anemometer under test fulfills the MEASNET requirement for linearity.	
Auswertesoftware <i>Software version</i>	anemo_aus_awt_04_02_rev3.VBS	

Der Kalibrierschein wurde elektronisch unterschrieben.

The calibration certificate was signed electronically.

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals / Cross-sectional area of the orifice of the wind tunnel

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Anemometers inkl. Montagerohr / Simplified cross-sectional area of the anemometer including mounting pipe

³⁾ Durchmesser des Montagerohrs / Diameter of the mounting pipe

⁴⁾ Verhältnis von 2) zu 1) / Ratio 2) to 1)

Kalibrierergebnis:

Results

Anzeige Anemometer / Indication anemometer Hz	Strömungsgeschwindigkeit / Air flow velocity [m/s]	Erweiterte Messunsicherheit / Expanded Uncertainty [m/s]
80.80	3.94	0.10
123.38	5.90	0.10
166.59	7.88	0.10
209.52	9.86	0.10
251.96	11.84	0.10
296.16	13.83	0.10
340.01	15.82	0.10
318.06	14.83	0.10
273.69	12.83	0.10
231.26	10.85	0.10
188.38	8.87	0.10
144.58	6.89	0.10
102.02	4.93	0.10

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor $k=2$ ergibt. Sie wurde gemäß DAkkS-DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95% im zugeordneten Wertintervall.

Reported is the expanded uncertainty which results from the standard uncertainty by multiplication with the coverage factor $k = 2$. It has been calculated according to DAkkS-DKD-3. The value of the measurand is found within the attributed interval with a probability of approximately 95 %.

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Calibration Report - MEASNET-annex

page 1/3



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www.ammonit-windtunnel.com

24.01.2018

Dipl.-Geök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object: Cup Anemometer
Manufacturer: Thies GmbH Göttingen
Customer: Ammonit Measurement GmbH, Berlin
Order number/date: 005AK118, 2018/01/04

Type: Thies fc advanced II / 4.3352.10.000
Serial-/Cup number: 01180065 / -
Inventory number: -
Report number: 180307_D-K-20511-01-00_2018-01

Calibration

- Date and Time: 24.01.2018 13:18
- Wind tunnel: AWT Bargeshagen
- Software version: anemo_aus_awt_04_02_rev3.VBS
- Campaign report: 001AK118
- Date of campaign report: 31.03.2018

Ambient conditions

- Air temperature: 17.4 °C
- Rel. Humidity of air: 49 %
- Air pressure: 1009 hPa

Regression curve:

- Range of regression: 4 m/s to 16 m/s
- Slope: 0.045889 m/(s*Hz)
- Offset: 0.243739 m/s
- Correlation coefficient: 0.999991
- Standard error in y: 0.017286 m/s

calculated values at given flow speed

m/s	Hz
10.00	212.61
16.00	343.36

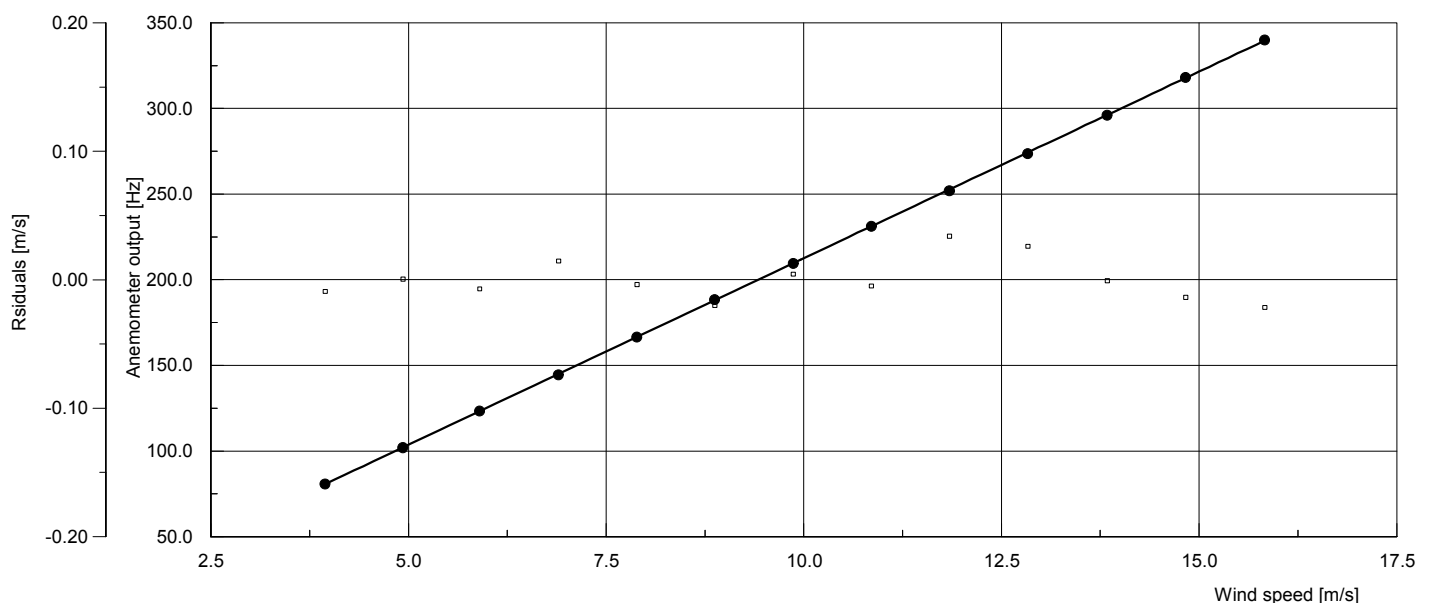
MEASNET is an association of companies which are engaged in the field of wind energy and want to ensure high quality measurements, the uniform interpretation of standards and recommendations as well as the interchangeability of results.

All MEASNET members must be accredited according to ISO/IEC 17025 for the MEASNET approved measurements and have to demonstrate their ability in an individual assessment. In addition the participation in regular round robin tests is mandatory (compliance factor < 1 %). For further details see www.measnet.com.

Only test reports for anemometer calibration with a correlation coefficient ≥ 0.99995 fulfill the MEASNET criteria for linearity and obtain the MEASNET stamp.



The anemometer under test fulfills the MEASNET requirement for linearity.



Calibration Report - MEASNET-annex

page 2/3



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24.01.2018

Dipl. Geök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180065 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180307_D-K-20511-01-00_2018-01

Measurements

Measurements were made according to the guidelines set by the MEASNET network at the Wind Tunnel of Ammonit WindTunnel GmbH in Bargeschagen. The reference velocity was measured using a Prandtl Tube. The anemometer was placed on the standard mounting tube of the test section (a steel tube with the diameter 34,0 mm). The anemometer has run in for minimum 5 min at about 10 m/s before the calibration procedure begins.

The calibration was performed under both, rising and falling wind speed in the range mentioned in page 1. The sampling frequency was 1 Hz and the sampling interval 30 sec. Before collecting data at each wind speed, one minute delay was allowed for stable conditions to become established.

Remarks

- Correlation Coefficient ≥ 0.99995
- The anemometer under test fulfills the MEASNET requirement for linearity.

Uncertainties

- Standard uncertainty of slope (A): 0.000059 m/(s*Hz) - Standard uncertainty of slope (B): 0.013343 m/s

Reference	Standard deviation	Anemometer	Residuals	Uncertainties	Uncertainties	Uncertainties
Wind Speed [m/s]	Ref. wind speed [m/s]	output [Hz]	[m/s]	Type A [m/s]	Type B [m/s]	total [m/s]
3.94	0.01	80.80	-0.01	0.00	0.04	0.10
5.90	0.01	123.38	-0.01	0.00	0.04	0.10
7.88	0.01	166.59	-0.00	0.01	0.05	0.10
9.86	0.01	209.52	0.00	0.01	0.06	0.10
11.84	0.01	251.96	0.03	0.01	0.07	0.10
13.83	0.02	296.16	-0.00	0.01	0.09	0.10
15.82	0.02	340.01	-0.02	0.01	0.10	0.10
14.83	0.01	318.06	-0.01	0.01	0.09	0.10
12.83	0.02	273.69	0.03	0.01	0.08	0.10
10.85	0.01	231.26	-0.00	0.01	0.07	0.10
8.87	0.01	188.38	-0.02	0.01	0.06	0.10
6.89	0.01	144.58	0.01	0.01	0.05	0.10
4.93	0.00	102.02	0.00	0.00	0.04	0.10

Calibration Report - MEASNET-annex

page 3/3



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24.01.2018

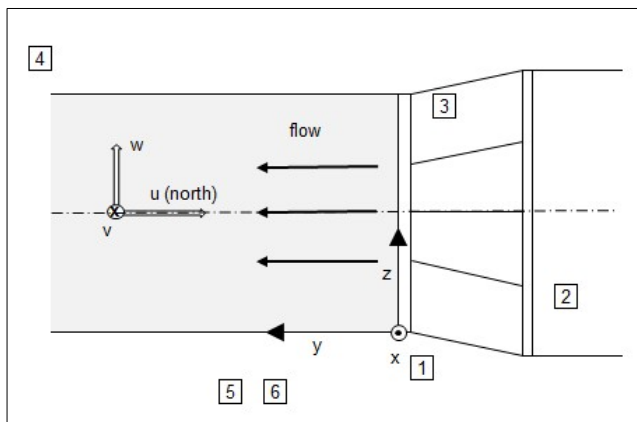
Dipl. Geoök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180065 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180307_D-K-20511-01-00_2018-01

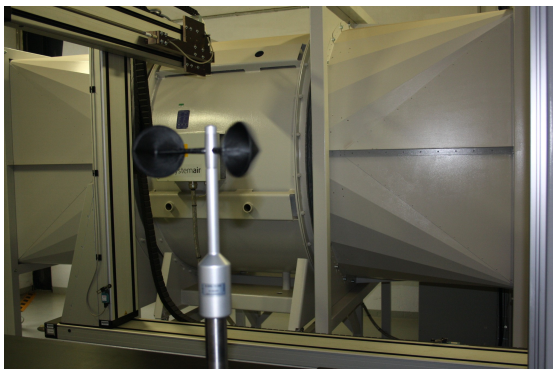
Equipment used	Type	Manufacturer	Inv.-No	Calibration
Prandtl tube	06565	Airflow	0008WT16	14141 PTB 17
Diff. press. sensor	Setra 239	Setra Systems, Inc.	0041WT15	S6889-D-K-15055-01-00-2017-03
Temp. sensor	KRC2/5	Galltec GmbH	0013WT16	14-0974-D-K-15186-01-00-2017--10
Humidity sensor	KRC2/5	Galltec GmbH	0013WT16	14-0974-D-K-15186-01-00-2017-10
Barometer	PTB110	Vaisala GmbH	0015WT16	723-D-K-15157-01-00-2017-08
A to D card	PCI-6033E	Nat. Instr. GmbH	0011WT15	0001 AWT 2017-09
Counter card	PCI-6033E	Nat. Instr. GmbH	0011WT15	0023 AWT 2017-09
Calibrator	METRACAL MC	GMC-I GmbH	0037WT15	QC109-D-K-15080-01-01-2017-10

Sketch of the wind tunnel:



Origin of Coordinates (1): Lower left Edge of the Nozzle
Centre of Cups (Anemometer): $x=600, y=600, z=600$ [mm]
Prandtl Tube Position (3): 4 Tubes at the Corners of the Nozzle
Pre-Chamber Pressure (2)
Temperature- and Humidity Sensor (4): At the edge of the
Wind-Tunnel Cross-Section Leaving Jet
Barometric Pressure (5): next to the Leaving Jet
Data Acquisition (6)
Different Calibration Position: See Remarks Page 2

Photo of the anemometer:



Summary:

- Report number:	180307_D-K-20511-01-00_2018-01
- Type:	Thies fc advanced II / 4.3352.10.000
- Serial-/Cup number:	01180065 / -
- Slope:	0.045889 m/(s*Hz)
- Offset:	0.243739 m/s
- Correlation coefficient:	0.999991

The anemometer under test fulfills the MEASNET requirement for linearity.

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Deutsche Akkreditierungsstelle GmbH



Deutsche
Akkreditierungsstelle
D-K-20511-01-00

als Kalibrierlaboratorium im / as calibration laboratory

Deutschen Kalibrierdienst



Kalibrierschein
Calibration certificate

Kalibrierschein
Calibration certificate

180308
D-K- 20511-01-00
2018-01

Gegenstand Object	Cup Anemometer
Hersteller Manufacturer	Thies GmbH Göttingen
Typ Type	Thies fc advanced II / 4.3352.10.000
Fabrikat/Serien-Nr. Serial number	01180066
Auftraggeber Customer	Ammonit Measurement GmbH, Berlin
Auftragsnummer Order No.	005AK118, 2018/01/04
Anzahl der Seiten des Kalibrierscheines Number of Pages of the certificate	3
Datum der Kalibrierung Date of calibration	24.01.18

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Datum
Date

Leiter des Kalibrierlaboratoriums
Head of the calibration laboratory

Bearbeiter
Person in charge

24.01.2018

Dipl.-Ing. D. Wüstenberg

Dipl.-Geoök. S. Müller



Kalibriergegenstand <i>Object</i>	Cup Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400-12-1:2005 (DIN EN 61400-12-1:2006) Wind turbines - Power performance measurements of electricity producing wind turbines IEC 61400-12-1 Ed. 2 CDV (DIN EN 61400-12-1 Ed. 2 CDV : 2015) Wind turbines - Power performance measurements of electricity producing wind turbines MEASNET - Anemometer Calibration Procedure - Version 2 - 10/2009	
Ort der Kalibrierung <i>Place of calibration</i>	AWT Bargeshagen	
Messbedingung <i>Test conditions</i>	wind tunnel area ¹⁾	14400 cm ²
	anemometer frontal area ²⁾	300 cm ²
	diameter of mounting pipe ³⁾	34,0 mm
	blockage ratio ⁴⁾	0.021 [-]
Umgebungsbedingungen <i>Air conditions</i>	air temperature	17.5 °C (+- 1.0 K)
	air pressure	1008 hPa (+- 1.0 hPa)
	relative humidity	50 % (+- 2.0 %)
Dateiinformation <i>File conditions</i>	thi-01180066_z20_30	
Anmerkungen <i>Remarks</i>	Correlation Coefficient >= 0.99995 The anemometer under test fulfills the MEASNET requirement for linearity.	
Auswertesoftware <i>Software version</i>	anemo_aus_awt_04_02_rev3.VBS	

Der Kalibrierschein wurde elektronisch unterschrieben.

The calibration certificate was signed electronically.

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals / Cross-sectional area of the orifice of the wind tunnel

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Anemometers inkl. Montagerohr / Simplified cross-sectional area of the anemometer including mounting pipe

³⁾ Durchmesser des Montagerohrs / Diameter of the mounting pipe

⁴⁾ Verhältnis von 2) zu 1) / Ratio 2) to 1)

Kalibrierergebnis:

Results

Anzeige Anemometer / Indication anemometer Hz	Strömungsgeschwindigkeit / Air flow velocity [m/s]	Erweiterte Messunsicherheit / Expanded Uncertainty [m/s]
80.44	3.94	0.10
122.52	5.90	0.10
166.15	7.87	0.10
209.16	9.86	0.10
252.20	11.84	0.10
295.98	13.83	0.10
340.25	15.83	0.10
317.47	14.83	0.10
273.55	12.83	0.10
230.72	10.85	0.10
187.42	8.87	0.10
144.37	6.89	0.10
101.44	4.92	0.10

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor $k=2$ ergibt. Sie wurde gemäß DAkkS-DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95% im zugeordneten Wertintervall.

Reported is the expanded uncertainty which results from the standard uncertainty by multiplication with the coverage factor $k = 2$. It has been calculated according to DAkkS-DKD-3. The value of the measurand is found within the attributed interval with a probability of approximately 95 %.

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Calibration Report - MEASNET-annex

page 1/3



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24.01.2018

Dipl.-Geök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180066 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180308_D-K-20511-01-00_2018-01

Calibration

- Date and Time: 24.01.2018 13:38
- Wind tunnel: AWT Bargeshagen
- Software version: anemo_aus_awt_04_02_rev3.VBS
- Campaign report: 001AK118
- Date of campaign report: 31.03.2018

Ambient conditions

- Air temperature: 17.5 °C
- Rel. Humidity of air: 50 %
- Air pressure: 1008 hPa

Regression curve:

- Range of regression: 4 m/s to 16 m/s
- Slope: 0.045835 m/(s*Hz)
- Offset: 0.270968 m/s
- Correlation coefficient: 0.999993
- Standard error in y: 0.014894 m/s

calculated values at given flow speed

m/s	Hz
10.00	212.26
16.00	343.16

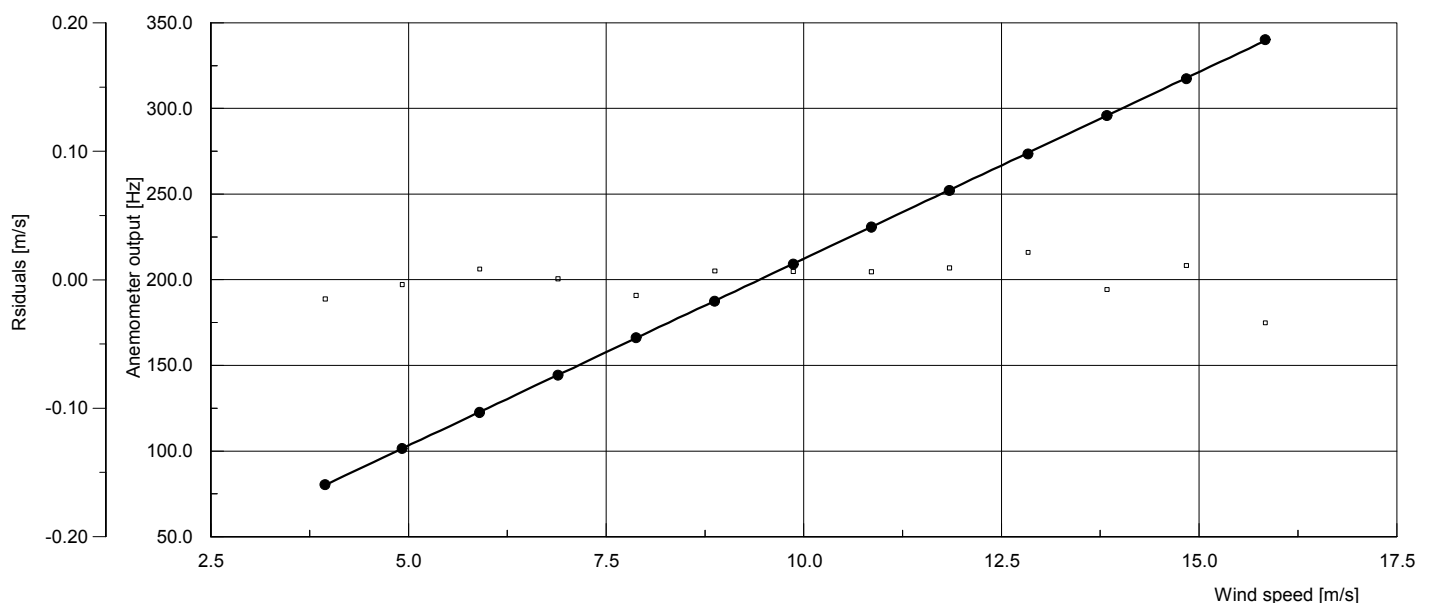
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Only test reports for anemometer calibration with a correlation coefficient ≥ 0.99995 fulfill the MEASNET criteria for linearity and obtain the MEASNET stamp.



The anemometer under test fulfills the MEASNET requirement for linearity.



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Dipl. Geök. S. Müller

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(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180066 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180308_D-K-20511-01-00_2018-01

Measurements

Measurements were made according to the guidelines set by the MEASNET network at the Wind Tunnel of Ammonit WindTunnel GmbH in Bargeschagen. The reference velocity was measured using a Prandtl Tube. The anemometer was placed on the standard mounting tube of the test section (a steel tube with the diameter 34,0 mm). The anemometer has run in for minimum 5 min at about 10 m/s before the calibration procedure begins.

The calibration was performed under both, rising and falling wind speed in the range mentioned in page 1. The sampling frequency was 1 Hz and the sampling interval 30 sec. Before collecting data at each wind speed, one minute delay was allowed for stable conditions to become established.

Remarks

- Correlation Coefficient ≥ 0.99995
- The anemometer under test fulfills the MEASNET requirement for linearity.

Uncertainties

- Standard uncertainty of slope (A): 0.000051 m/(s*Hz) - Standard uncertainty of slope (B): 0.011459 m/s

Reference	Standard deviation	Anemometer	Residuals	Uncertainties	Uncertainties	Uncertainties
Wind Speed [m/s]	Ref. wind speed [m/s]	output [Hz]	[m/s]	Type A [m/s]	Type B [m/s]	total [m/s]
3.94	0.00	80.44	-0.01	0.00	0.04	0.10
5.90	0.00	122.52	0.01	0.00	0.04	0.10
7.87	0.01	166.15	-0.01	0.01	0.05	0.10
9.86	0.01	209.16	0.01	0.01	0.06	0.10
11.84	0.01	252.20	0.01	0.01	0.07	0.10
13.83	0.02	295.98	-0.01	0.01	0.09	0.10
15.83	0.02	340.25	-0.03	0.01	0.10	0.10
14.83	0.01	317.47	0.01	0.01	0.09	0.10
12.83	0.01	273.55	0.02	0.01	0.08	0.10
10.85	0.01	230.72	0.01	0.01	0.07	0.10
8.87	0.01	187.42	0.01	0.01	0.06	0.10
6.89	0.01	144.37	0.00	0.01	0.05	0.10
4.92	0.01	101.44	-0.00	0.00	0.04	0.10

Calibration Report - MEASNET-annex

page 3/3



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www.ammonit-windtunnel.com

24.01.2018

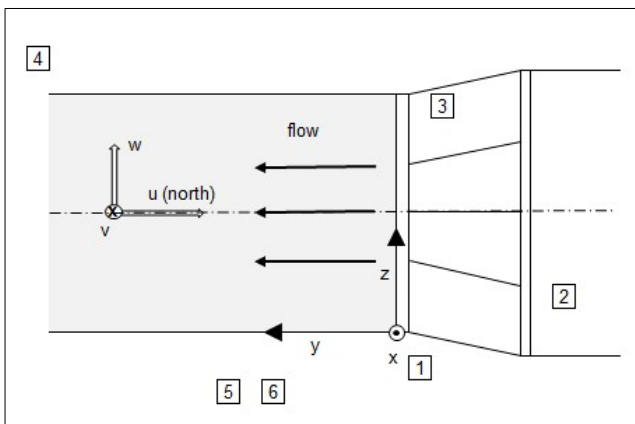
Dipl. Geöök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180066 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180308_D-K-20511-01-00_2018-01

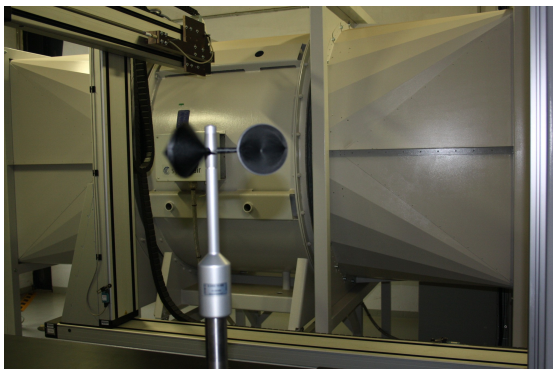
Equipment used	Type	Manufacturer	Inv.-No	Calibration
Prandtl tube	06565	Airflow	0008WT16	14141 PTB 17
Diff. press. sensor	Setra 239	Setra Systems, Inc.	0041WT15	S6889-D-K-15055-01-00-2017-03
Temp. sensor	KRC2/5	Galltec GmbH	0013WT16	14-0974-D-K-15186-01-00-2017--10
Humidity sensor	KRC2/5	Galltec GmbH	0013WT16	14-0974-D-K-15186-01-00-2017-10
Barometer	PTB110	Vaisala GmbH	0015WT16	723-D-K-15157-01-00-2017-08
A to D card	PCI-6033E	Nat. Instr. GmbH	0011WT15	0001 AWT 2017-09
Counter card	PCI-6033E	Nat. Instr. GmbH	0011WT15	0023 AWT 2017-09
Calibrator	METRACAL MC	GMC-I GmbH	0037WT15	QC109-D-K-15080-01-01-2017-10

Sketch of the wind tunnel:



Origin of Coordinates (1): Lower left Edge of the Nozzle
Centre of Cups (Anemometer): $x=600, y=600, z=600$ [mm]
Prandtl Tube Position (3): 4 Tubes at the Corners of the Nozzle
Pre-Chamber Pressure (2)
Temperature- and Humidity Sensor (4): At the edge of the
Wind-Tunnel Cross-Section Leaving Jet
Barometric Pressure (5): next to the Leaving Jet
Data Acquisition (6)
Different Calibration Position: See Remarks Page 2

Photo of the anemometer:



Summary:

- Report number:	180308_D-K-20511-01-00_2018-01
- Type:	Thies fc advanced II / 4.3352.10.000
- Serial-/Cup number:	01180066 / -
- Slope:	0.045835 m/(s*Hz)
- Offset:	0.270968 m/s
- Correlation coefficient:	0.999993

The anemometer under test fulfills the MEASNET requirement for linearity.

akkreditiert durch die / accredited by the

Deutsche Akkreditierungsstelle GmbH



als Kalibrierlaboratorium im / as calibration laboratory

Deutschen Kalibrierdienst



Kalibrierschein
Calibration certificate

Kalibrierschein
Calibration certificate

180309
D-K- 20511-01-00
2018-01

Gegenstand Object	Cup Anemometer
Hersteller Manufacturer	Thies GmbH Göttingen
Typ Type	Thies fc advanced II / 4.3352.10.000
Fabrikat/Serien-Nr. Serial number	01180067
Auftraggeber Customer	Ammonit Measurement GmbH, Berlin
Auftragsnummer Order No.	005AK118, 2018/01/04
Anzahl der Seiten des Kalibrierscheines Number of Pages of the certificate	3
Datum der Kalibrierung Date of calibration	24.01.18

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

*This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI). The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.*

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.

This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum
Date

Leiter des Kalibrierlaboratoriums
Head of the calibration laboratory

Bearbeiter
Person in charge

24.01.2018

Dipl.-Ing. D. Wüstenberg

Dipl.-Geoök. S. Müller



Kalibriergegenstand <i>Object</i>	Cup Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400-12-1:2005 (DIN EN 61400-12-1:2006) Wind turbines - Power performance measurements of electricity producing wind turbines IEC 61400-12-1 Ed. 2 CDV (DIN EN 61400-12-1 Ed. 2 CDV : 2015) Wind turbines - Power performance measurements of electricity producing wind turbines MEASNET - Anemometer Calibration Procedure - Version 2 - 10/2009	
Ort der Kalibrierung <i>Place of calibration</i>	AWT Bargeshagen	
Messbedingung <i>Test conditions</i>	wind tunnel area ¹⁾	14400 cm ²
	anemometer frontal area ²⁾	300 cm ²
	diameter of mounting pipe ³⁾	34,0 mm
	blockage ratio ⁴⁾	0.021 [-]
Umgebungsbedingungen <i>Air conditions</i>	air temperature	17.5 °C (+- 1.0 K)
	air pressure	1008 hPa (+- 1.0 hPa)
	relative humidity	50 % (+- 2.0 %)
Dateiinformation <i>File conditions</i>	thi-01180067_z20_30	
Anmerkungen <i>Remarks</i>	Correlation Coefficient >= 0.99995 The anemometer under test fulfills the MEASNET requirement for linearity.	
Auswertesoftware <i>Software version</i>	anemo_aus_awt_04_02_rev3.VBS	

Der Kalibrierschein wurde elektronisch unterschrieben.

The calibration certificate was signed electronically.

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals / Cross-sectional area of the orifice of the wind tunnel

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Anemometers inkl. Montagerohr / Simplified cross-sectional area of the anemometer including mounting pipe

³⁾ Durchmesser des Montagerohrs / Diameter of the mounting pipe

⁴⁾ Verhältnis von 2) zu 1) / Ratio 2) to 1)

Kalibrierergebnis:

Results

Anzeige Anemometer / Indication anemometer Hz	Strömungsgeschwindigkeit / Air flow velocity [m/s]	Erweiterte Messunsicherheit / Expanded Uncertainty [m/s]
80.52	3.95	0.10
123.49	5.90	0.10
166.38	7.88	0.10
209.23	9.86	0.10
252.28	11.84	0.10
295.93	13.83	0.10
339.93	15.82	0.10
318.02	14.83	0.10
274.00	12.84	0.10
230.96	10.85	0.10
187.00	8.87	0.10
144.65	6.89	0.10
102.01	4.92	0.10

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor $k=2$ ergibt. Sie wurde gemäß DAkkS-DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95% im zugeordneten Wertintervall.

Reported is the expanded uncertainty which results from the standard uncertainty by multiplication with the coverage factor $k = 2$. It has been calculated according to DAkkS-DKD-3. The value of the measurand is found within the attributed interval with a probability of approximately 95 %.

Die Deutsche Akkreditierungsstelle GmbH ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The Deutsche Akkreditierungsstelle GmbH (DAkkS) is signatory to the multilateral agreements of the European cooperation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates. The other signatories inside and beyond Europe can be taken from the web-pages of EA (www.european-accreditation.org) and ILAC (www.ilac.org).

Calibration Report - MEASNET-annex

page 1/3



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www.ammonit-windtunnel.com

24.01.2018

Dipl.-Geök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object: Cup Anemometer
Manufacturer: Thies GmbH Göttingen
Customer: Ammonit Measurement GmbH, Berlin
Order number/date: 005AK118, 2018/01/04

Type: Thies fc advanced II / 4.3352.10.000
Serial-/Cup number: 01180067 / -
Inventory number: -
Report number: 180309_D-K-20511-01-00_2018-01

Calibration

- Date and Time: 24.01.2018 13:58
- Wind tunnel: AWT Bargeshagen
- Software version: anemo_aus_awt_04_02_rev3.VBS
- Campaign report: 001AK118
- Date of campaign report: 31.03.2018

Ambient conditions

- Air temperature: 17.5 °C
- Rel. Humidity of air: 50 %
- Air pressure: 1008 hPa

Regression curve:

- Range of regression: 4 m/s to 16 m/s
- Slope: 0.045875 m/(s*Hz)
- Offset: 0.255503 m/s
- Correlation coefficient: 0.999991
- Standard error in y: 0.016745 m/s

calculated values at given flow speed

m/s	Hz
10.00	212.42
16.00	343.21

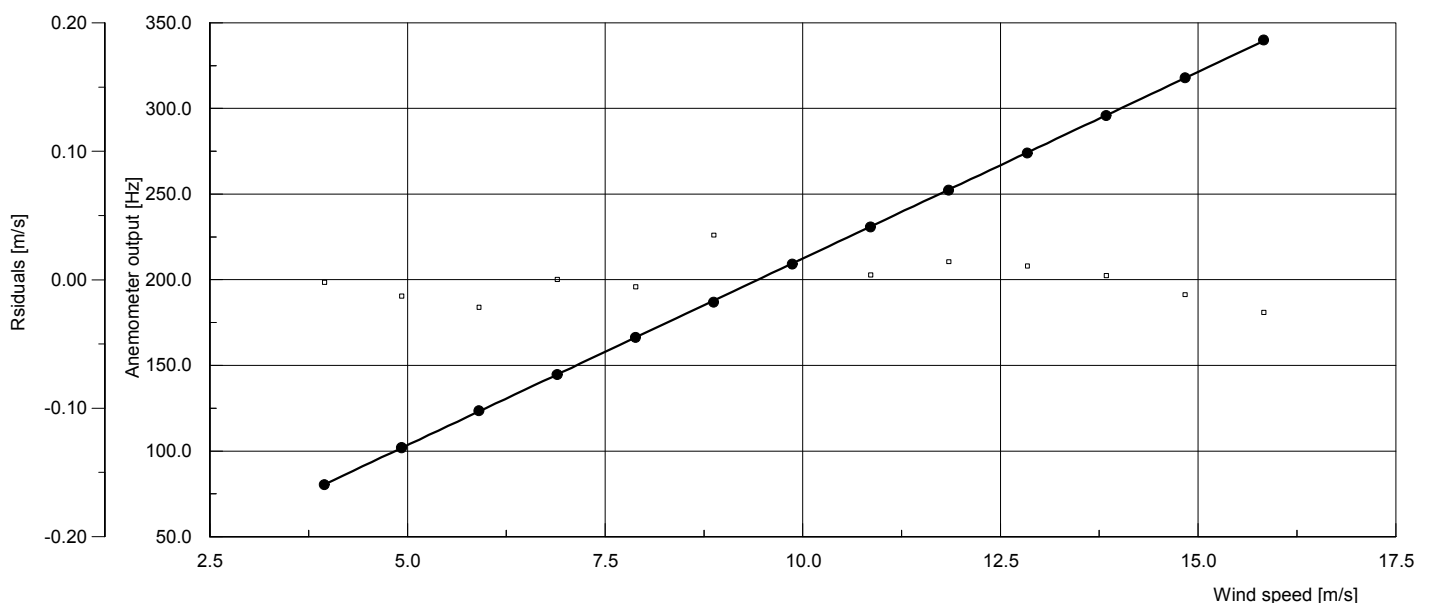
MEASNET is an association of companies which are engaged in the field of wind energy and want to ensure high quality measurements, the uniform interpretation of standards and recommendations as well as the interchangeability of results.

All MEASNET members must be accredited according to ISO/IEC 17025 for the MEASNET approved measurements and have to demonstrate their ability in an individual assessment. In addition the participation in regular round robin tests is mandatory (compliance factor < 1 %). For further details see www.measnet.com.

Only test reports for anemometer calibration with a correlation coefficient ≥ 0.99995 fulfill the MEASNET criteria for linearity and obtain the MEASNET stamp.



The anemometer under test fulfills the MEASNET requirement for linearity.



Calibration Report - MEASNET-annex

page 2/3



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24.01.2018

S. Müller
Dipl. Geök. S. Müller

D. Wüstenberg
Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180067 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180309_D-K-20511-01-00_2018-01

Measurements

Measurements were made according to the guidelines set by the MEASNET network at the Wind Tunnel of Ammonit WindTunnel GmbH in Bargeschagen. The reference velocity was measured using a Prandtl Tube. The anemometer was placed on the standard mounting tube of the test section (a steel tube with the diameter 34,0 mm). The anemometer has run in for minimum 5 min at about 10 m/s before the calibration procedure begins.

The calibration was performed under both, rising and falling wind speed in the range mentioned in page 1. The sampling frequency was 1 Hz and the sampling interval 30 sec. Before collecting data at each wind speed, one minute delay was allowed for stable conditions to become established.

Remarks

- Correlation Coefficient ≥ 0.99995
- The anemometer under test fulfills the MEASNET requirement for linearity.

Uncertainties

- Standard uncertainty of slope (A): 0.000057 m/(s*Hz) - Standard uncertainty of slope (B): 0.012911 m/s

Reference	Standard deviation	Anemometer	Residuals	Uncertainties	Uncertainties	Uncertainties
Wind Speed [m/s]	Ref. wind speed [m/s]	output [Hz]	[m/s]	Type A [m/s]	Type B [m/s]	total [m/s]
3.95	0.00	80.52	-0.00	0.00	0.04	0.10
5.90	0.01	123.49	-0.02	0.00	0.04	0.10
7.88	0.01	166.38	-0.01	0.01	0.05	0.10
9.86	0.01	209.23	0.01	0.01	0.06	0.10
11.84	0.01	252.28	0.01	0.01	0.07	0.10
13.83	0.01	295.93	0.00	0.01	0.09	0.10
15.82	0.02	339.93	-0.03	0.01	0.10	0.10
14.83	0.02	318.02	-0.01	0.01	0.09	0.10
12.84	0.01	274.00	0.01	0.01	0.08	0.10
10.85	0.01	230.96	0.00	0.01	0.07	0.10
8.87	0.01	187.00	0.03	0.01	0.06	0.10
6.89	0.01	144.65	0.00	0.01	0.05	0.10
4.92	0.00	102.01	-0.01	0.00	0.04	0.10

Calibration Report - MEASNET-annex

page 3/3



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24.01.2018

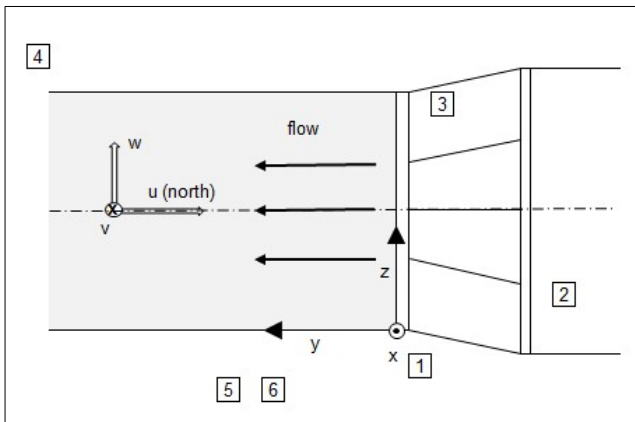
Dipl. Geöök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180067 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180309_D-K-20511-01-00_2018-01

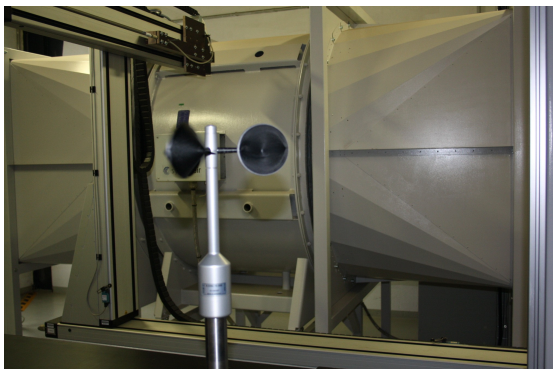
Equipment used	Type	Manufacturer	Inv.-No	Calibration
Prandtl tube	06565	Airflow	0008WT16	14141 PTB 17
Diff. press. sensor	Setra 239	Setra Systems, Inc.	0041WT15	S6889-D-K-15055-01-00-2017-03
Temp. sensor	KRC2/5	Galltec GmbH	0013WT16	14-0974-D-K-15186-01-00-2017--10
Humidity sensor	KRC2/5	Galltec GmbH	0013WT16	14-0974-D-K-15186-01-00-2017-10
Barometer	PTB110	Vaisala GmbH	0015WT16	723-D-K-15157-01-00-2017-08
A to D card	PCI-6033E	Nat. Instr. GmbH	0011WT15	0001 AWT 2017-09
Counter card	PCI-6033E	Nat. Instr. GmbH	0011WT15	0023 AWT 2017-09
Calibrator	METRACAL MC	GMC-I GmbH	0037WT15	QC109-D-K-15080-01-01-2017-10

Sketch of the wind tunnel:



Origin of Coordinates (1): Lower left Edge of the Nozzle
Centre of Cups (Anemometer): $x=600, y=600, z=600$ [mm]
Prandtl Tube Position (3): 4 Tubes at the Corners of the Nozzle
Pre-Chamber Pressure (2)
Temperature- and Humidity Sensor (4): At the edge of the
Wind-Tunnel Cross-Section Leaving Jet
Barometric Pressure (5): next to the Leaving Jet
Data Acquisition (6)
Different Calibration Position: See Remarks Page 2

Photo of the anemometer:



Summary:

- Report number:	180309_D-K-20511-01-00_2018-01
- Type:	Thies fc advanced II / 4.3352.10.000
- Serial-/Cup number:	01180067 / -
- Slope:	0.045875 m/(s*Hz)
- Offset:	0.255503 m/s
- Correlation coefficient:	0.999991

The anemometer under test fulfills the MEASNET requirement for linearity.

akkreditiert durch die / accredited by the

Deutsche Akkreditierungsstelle GmbH



als Kalibrierlaboratorium im / as calibration laboratory

Deutschen Kalibrierdienst



Kalibrierschein
Calibration certificate

Kalibrierschein
Calibration certificate

180310
D-K- 20511-01-00
2018-01

Gegenstand Object	Cup Anemometer
Hersteller Manufacturer	Thies GmbH Göttingen
Typ Type	Thies fc advanced II / 4.3352.10.000
Fabrikat/Serien-Nr. Serial number	01180068
Auftraggeber Customer	Ammonit Measurement GmbH, Berlin
Auftragsnummer Order No.	005AK118, 2018/01/04
Anzahl der Seiten des Kalibrierscheines Number of Pages of the certificate	3
Datum der Kalibrierung Date of calibration	24.01.18

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

*This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI). The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.*

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Datum
Date

Leiter des Kalibrierlaboratoriums
Head of the calibration laboratory

Bearbeiter
Person in charge

24.01.2018

Dipl.-Ing. D. Wüstenberg

Dipl.-Geoök. S. Müller



Kalibriergegenstand <i>Object</i>	Cup Anemometer	
Kalibrierverfahren <i>Calibration procedure</i>	IEC 61400-12-1:2005 (DIN EN 61400-12-1:2006) Wind turbines - Power performance measurements of electricity producing wind turbines IEC 61400-12-1 Ed. 2 CDV (DIN EN 61400-12-1 Ed. 2 CDV : 2015) Wind turbines - Power performance measurements of electricity producing wind turbines MEASNET - Anemometer Calibration Procedure - Version 2 - 10/2009	
Ort der Kalibrierung <i>Place of calibration</i>	AWT Bargeshagen	
Messbedingung <i>Test conditions</i>	wind tunnel area ¹⁾	14400 cm ²
	anemometer frontal area ²⁾	300 cm ²
	diameter of mounting pipe ³⁾	34,0 mm
	blockage ratio ⁴⁾	0.021 [-]
Umgebungsbedingungen <i>Air conditions</i>	air temperature	17.5 °C (+- 1.0 K)
	air pressure	1008 hPa (+- 1.0 hPa)
	relative humidity	50 % (+- 2.0 %)
Dateiinformation <i>File conditions</i>	thi-01180068_z20_30	
Anmerkungen <i>Remarks</i>	Correlation Coefficient >= 0.99995 The anemometer under test fulfills the MEASNET requirement for linearity.	
Auswertesoftware <i>Software version</i>	anemo_aus_awt_04_02_rev3.VBS	

Der Kalibrierschein wurde elektronisch unterschrieben.

The calibration certificate was signed electronically.

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals / Cross-sectional area of the orifice of the wind tunnel

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Anemometers inkl. Montagerohr / Simplified cross-sectional area of the anemometer including mounting pipe

³⁾ Durchmesser des Montagerohrs / Diameter of the mounting pipe

⁴⁾ Verhältnis von 2) zu 1) / Ratio 2) to 1)

Kalibrierergebnis:

Results

Anzeige Anemometer / Indication anemometer Hz	Strömungsgeschwindigkeit / Air flow velocity [m/s]	Erweiterte Messunsicherheit / Expanded Uncertainty [m/s]
80.57	3.94	0.10
123.33	5.90	0.10
166.43	7.88	0.10
209.21	9.86	0.10
252.25	11.84	0.10
296.48	13.83	0.10
340.87	15.83	0.10
318.12	14.83	0.10
274.41	12.83	0.10
231.26	10.85	0.10
188.49	8.87	0.10
144.80	6.89	0.10
102.19	4.92	0.10

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor $k=2$ ergibt. Sie wurde gemäß DAkkS-DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95% im zugeordneten Wertintervall.

Reported is the expanded uncertainty which results from the standard uncertainty by multiplication with the coverage factor $k = 2$. It has been calculated according to DAkkS-DKD-3. The value of the measurand is found within the attributed interval with a probability of approximately 95 %.

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Calibration Report - MEASNET-annex

page 1/3



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24.01.2018

Dipl.-Geök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180068 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180310_D-K-20511-01-00_2018-01

Calibration

- Date and Time: 24.01.2018 14:18
- Wind tunnel: AWT Bargeshagen
- Software version: anemo_aus_awt_04_02_rev3.VBS
- Campaign report: 001AK118
- Date of campaign report: 31.03.2018

Ambient conditions

- Air temperature: 17.5 °C
- Rel. Humidity of air: 50 %
- Air pressure: 1008 hPa

Regression curve:

- Range of regression: 4 m/s to 16 m/s
- Slope: 0.045794 m/(s*Hz)
- Offset: 0.255561 m/s
- Correlation coefficient: 0.999990
- Standard error in y: 0.017976 m/s

calculated values at given flow speed

m/s	Hz
10.00	212.79
16.00	343.81

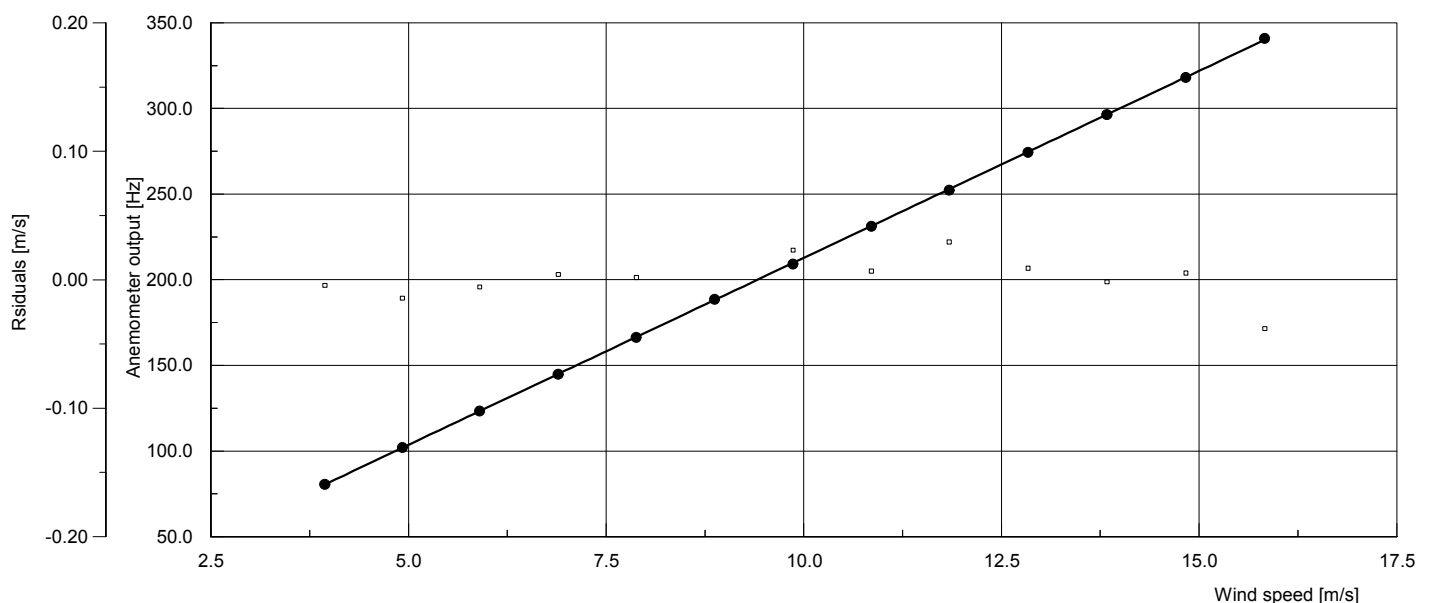
MEASNET is an association of companies which are engaged in the field of wind energy and want to ensure high quality measurements, the uniform interpretation of standards and recommendations as well as the interchangeability of results.

All MEASNET members must be accredited according to ISO/IEC 17025 for the MEASNET approved measurements and have to demonstrate their ability in an individual assessment. In addition the participation in regular round robin tests is mandatory (compliance factor < 1 %). For further details see www.measnet.com.

Only test reports for anemometer calibration with a correlation coefficient ≥ 0.99995 fulfill the MEASNET criteria for linearity and obtain the MEASNET stamp.



The anemometer under test fulfills the MEASNET requirement for linearity.



Calibration Report - MEASNET-annex

page 2/3



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24.01.2018

Dipl. Geök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180068 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180310_D-K-20511-01-00_2018-01

Measurements

Measurements were made according to the guidelines set by the MEASNET network at the Wind Tunnel of Ammonit WindTunnel GmbH in Bargeschagen. The reference velocity was measured using a Prandtl Tube. The anemometer was placed on the standard mounting tube of the test section (a steel tube with the diameter 34,0 mm). The anemometer has run in for minimum 5 min at about 10 m/s before the calibration procedure begins.

The calibration was performed under both, rising and falling wind speed in the range mentioned in page 1. The sampling frequency was 1 Hz and the sampling interval 30 sec. Before collecting data at each wind speed, one minute delay was allowed for stable conditions to become established.

Remarks

- Correlation Coefficient ≥ 0.99995
- The anemometer under test fulfills the MEASNET requirement for linearity.

Uncertainties

- Standard uncertainty of slope (A): 0.000062 m/(s*Hz) - Standard uncertainty of slope (B): 0.013855 m/s

Reference	Standard deviation	Anemometer	Residuals	Uncertainties	Uncertainties	Uncertainties
Wind Speed [m/s]	Ref. wind speed [m/s]	output [Hz]	[m/s]	Type A [m/s]	Type B [m/s]	total [m/s]
3.94	0.00	80.57	-0.00	0.00	0.04	0.10
5.90	0.01	123.33	-0.01	0.00	0.04	0.10
7.88	0.01	166.43	0.00	0.01	0.05	0.10
9.86	0.01	209.21	0.02	0.01	0.06	0.10
11.84	0.01	252.25	0.03	0.01	0.07	0.10
13.83	0.01	296.48	-0.00	0.01	0.09	0.10
15.83	0.01	340.87	-0.04	0.01	0.10	0.10
14.83	0.02	318.12	0.01	0.01	0.09	0.10
12.83	0.01	274.41	0.01	0.01	0.08	0.10
10.85	0.01	231.26	0.01	0.01	0.07	0.10
8.87	0.01	188.49	-0.02	0.01	0.06	0.10
6.89	0.01	144.80	0.00	0.01	0.05	0.10
4.92	0.00	102.19	-0.01	0.00	0.04	0.10

Calibration Report - MEASNET-annex

page 3/3



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24.01.2018

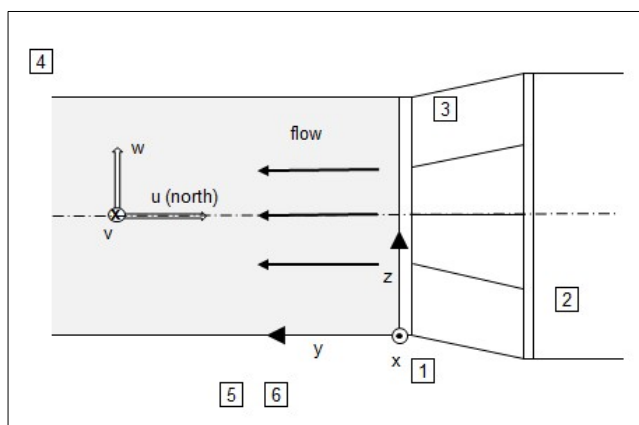
Dipl. Geöök. S. Müller

Dipl.-Ing. D. Wüstenberg
(signed electronically)

Object:	Cup Anemometer	Type:	Thies fc advanced II / 4.3352.10.000
Manufacturer:	Thies GmbH Göttingen	Serial-/Cup number:	01180068 / -
Customer:	Ammonit Measurement GmbH, Berlin	Inventory number:	-
Order number/date:	005AK118, 2018/01/04	Report number:	180310_D-K-20511-01-00_2018-01

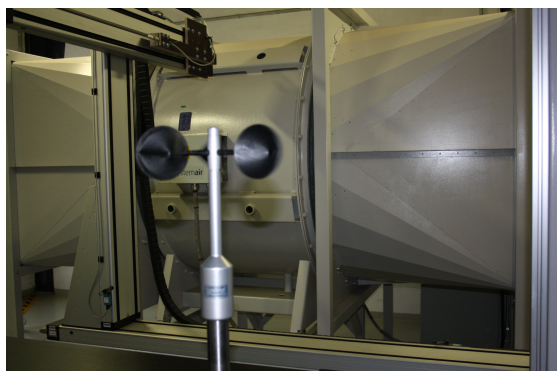
Equipment used	Type	Manufacturer	Inv.-No	Calibration
Prandtl tube	06565	Airflow	0008WT16	14141 PTB 17
Diff. press. sensor	Setra 239	Setra Systems, Inc.	0041WT15	S6889-D-K-15055-01-00-2017-03
Temp. sensor	KRC2/5	Galltec GmbH	0013WT16	14-0974-D-K-15186-01-00-2017--10
Humidity sensor	KRC2/5	Galltec GmbH	0013WT16	14-0974-D-K-15186-01-00-2017-10
Barometer	PTB110	Vaisala GmbH	0015WT16	723-D-K-15157-01-00-2017-08
A to D card	PCI-6033E	Nat. Instr. GmbH	0011WT15	0001 AWT 2017-09
Counter card	PCI-6033E	Nat. Instr. GmbH	0011WT15	0023 AWT 2017-09
Calibrator	METRACAL MC	GMC-I GmbH	0037WT15	QC109-D-K-15080-01-01-2017-10

Sketch of the wind tunnel:



Origin of Coordinates (1): Lower left Edge of the Nozzle
Centre of Cups (Anemometer): $x=600, y=600, z=600$ [mm]
Prandtl Tube Position (3): 4 Tubes at the Corners of the Nozzle
Pre-Chamber Pressure (2)
Temperature- and Humidity Sensor (4): At the edge of the
Wind-Tunnel Cross-Section Leaving Jet
Barometric Pressure (5): next to the Leaving Jet
Data Acquisition (6)
Different Calibration Position: See Remarks Page 2

Photo of the anemometer:



Summary:

- Report number:	180310_D-K-20511-01-00_2018-01
- Type:	Thies fc advanced II / 4.3352.10.000
- Serial-/Cup number:	01180068 / -
- Slope:	0.045794 m/(s*Hz)
- Offset:	0.255561 m/s
- Correlation coefficient:	0.999990

The anemometer under test fulfills the MEASNET requirement for linearity.