


Summary report VT121244 – Version 1.1

3 D Sonic Anemometer Classification

According to IEC 61400-12-1 Edition 2.0 (2017- 03) Classification Scheme

<p>Description of Anemometer</p> <p>Manufacturer: Adolf Thies GmbH&Co.KG Hauptstrasse 76 37083 Göttingen</p> <p>Identification: Ultrasonic Anemometer 3D</p> <p>Type: 4.3830.xx.xxx¹</p> <p>SN: 03130046</p> <p>SN: 03130048</p> <p>SN: 03130049</p> <p>SN: 03130050</p> <p>SN: 03170258</p> <p>Dimension: 600 x 300 mm</p>	
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Reference:

Deutsche WindGuard Wind Tunnel Services GmbH

Measuring period: 2016 - 2017

Wind Tunnel: Deutsche WindGuard Wind Tunnel Services GmbH, Varel

Procedure:

The classification is based on a numerical calculation of the response of a sonic anemometer to fluctuating wind speeds. The chosen spectrum of the wind speed time series was a *Kaimal* spectrum for non-isotropic condition (turbulence length scale 350 m. The wind speed time series have been generated with a software tool provided by Risø - National Laboratory, Denmark. Other parameters which may influence the response of an anemometer in fluctuating wind conditions are:

- Off axis response for different tilt angles
- Different ambient temperatures and air pressure

All relevant parameters have been measured in various wind tunnels of Deutsche WindGuard Wind Tunnels Services GmbH which fulfils the requirements described in IEC 61400-12-1 Edition 2.0, Annex F. The influence of air temperature was measured using a specially designed variable air density wind tunnel.

The determination of the anemometer's response to quasi statically inclined/and or yawed air flow was performed with the help of an automatic tilt and yaw angle device installed in the wind tunnel. During the yaw measurements the tilt angle of the sonic was fixed for the following tilt angles: 0°, ±2°, ±5°, ±10°, ±15°, ±20°, ±30°. The yaw direction was continuously yawed with a sweep rate of about 0.2°/s. The measurements were performed for the wind speeds: 4 m/s, 8 m/s, 12 m/s, and 16 m/s. For each direction, the deviation of the indicated wind speed of the sonic anemometer from the ordinary calibration at the reference direction was derived.

¹ The type number of the tested serial numbers is 4.3830.20.340. This classification report is valid for all sensors with type number 4.3830.xx.xxx as the last 5 digits specify the configuration and have no influence on the test results itself.

Directional characteristic

Reference:

WindGuard quality system procedure for calibration of wind direction sensors: D 5836

Accredited according to IEC 17025

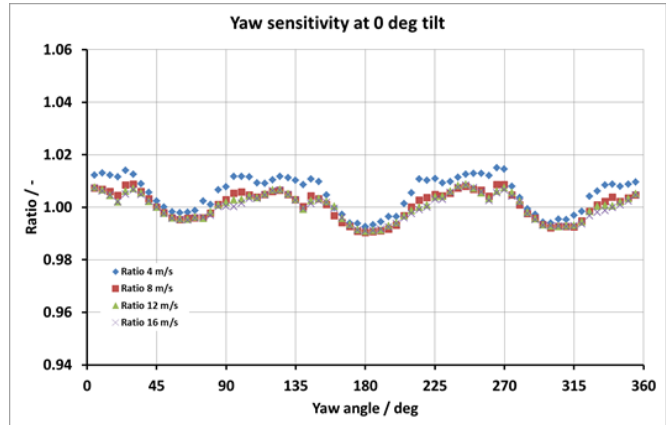
Result:

Figures showing the of axis response of Thies 3D Ultrasonic Anemometer 4.3830.xx.xxx (exemplary serial number 03130046).

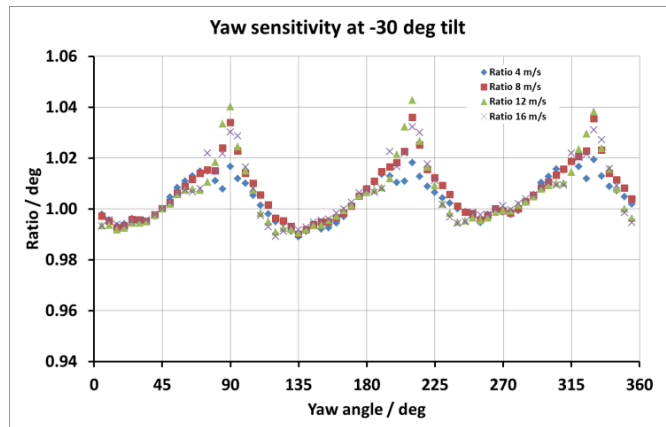
The sensor was yawed from 0 to 400 deg and back to 0 deg at different tilt angles according to IEC.

The information presented show the bin averaged data for 5 deg bin's.

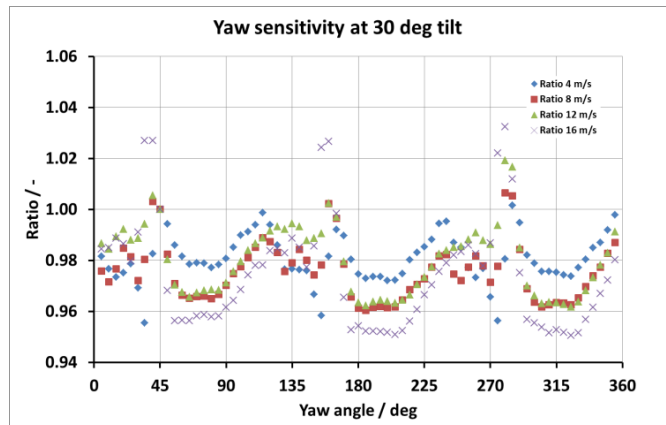
Five anemometers were tested. Each individual yaw sensitivity was used for classification.



Yaw sensitivity of SN 03130046 at 0 deg tilt;



Yaw sensitivity of SN 03130046 at -30 deg tilt;



Yaw sensitivity of SN 03130046 at 30 deg tilt;

Air temperature induced effects

Reference:

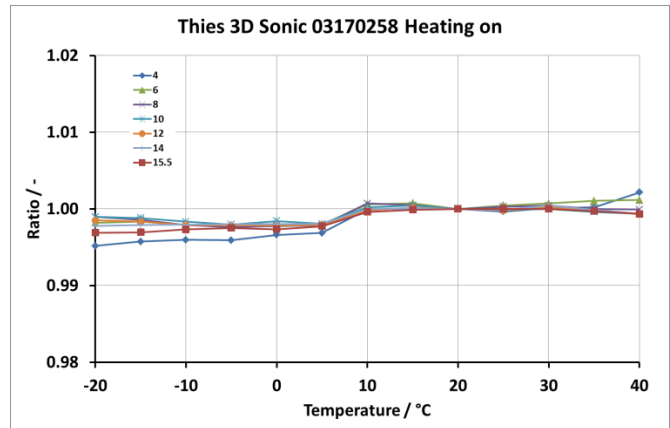
WindGuard quality system procedure for calibration of wind speed sensors at variable air temperature (*in preparation*).

Result:

Figure showing the influence of air temperature on the anemometer behaviour at tunnel speeds of 4, 6, 8, 10, 12, 14 and 15.5 m/s (exemplary serial number 03170258).

Internal heating: **ON**

Uncertainty in temperature: <1 K
Uncertainty in flow speed: < 0.1 m/s



Air temperature induced effects

Reference:

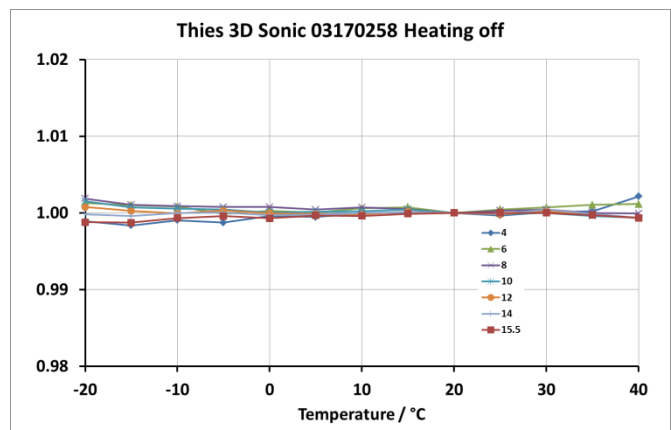
WindGuard quality system procedure for calibration of wind speed sensors at variable air temperature (*in preparation*).

Result:

Figure showing the influence of air temperature on the anemometer behaviour at tunnel speeds of 4, 6, 8, 10, 12, 14 and 15.5 m/s (exemplary serial number 03170258).

Internal heating: **OFF**

Uncertainty in temperature: <1 K
Uncertainty in flow speed: < 0.1 m/s



Tilt angular response

Reference:

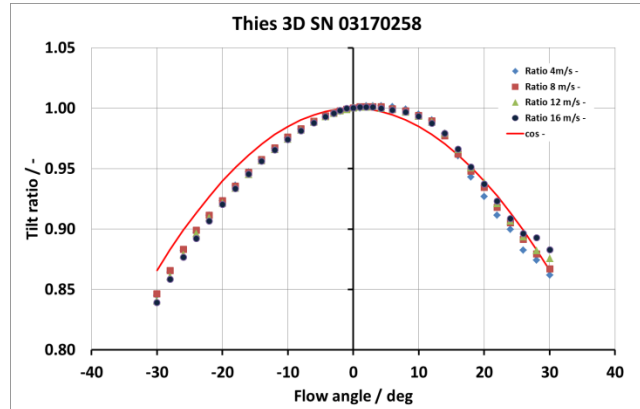
IEC 61400-12-1 Edition 2.0
Wind Turbine Power Performance Testing
2017-03

WindGuard quality system procedure for calibration of wind speed sensors at non-horizontal inflow conditions: *D 5832*

Accredited according to IEC 17025

Result:

Figure showing the of axis response of Thies 3D Ultrasonic Anemometer 4.3830.xx.xxx (exemplary for serial number 03170258), for tunnel speeds of 4 m/s, 8 m/s, 12 m/s and 16 m/s.



Five anemometers have been tested. Each individual tilt data was used for classification check.

Classification parameters

	Class A Terrain meets requirements in Annex B	Class B Terrain does not meet requirements in Annex B	Class C Terrain meets requirements in Annex B	Class D Terrain does not meet requirements in Annex B
	Range	Range	Range	Range
Wind speed V (m/s)	4 to 16	4 to 16	4 to 16	4 to 16
Turbulence intensity	0.03 to 0.12 + 0.48/V	0.03 to 0.12 + 0.96/V	0.03 to 0.12 + 0.48/V	0.03 to 0.12 + 0.96/V
Turbulence structure $\sigma_u/\sigma_v/\sigma_w$	1/0.8/0.5*	1/0.8/0.5*	1/0.8/0.5*	1/0.8/0.5*
Air Temperature (°C)	0 to 40	-10 to 40	-20 to 40	-20 to 40
Air density (kg/m³)	0.9 to 1.35	0.9 to 1.35	0.9 to 1.35	0.9 to 1.35
Average upflow angle (°)	-3 to 3	-15 to 15	-3 to 3	-15 to 15
Wind direction (°)	0 to 360	0 to 360	0 to 360	0 to 360

Table 1 Classification parameters according to IEC 61400-12-1 Edition 2.0 2017-03 used for classification

Class A/C Classification

Reference:

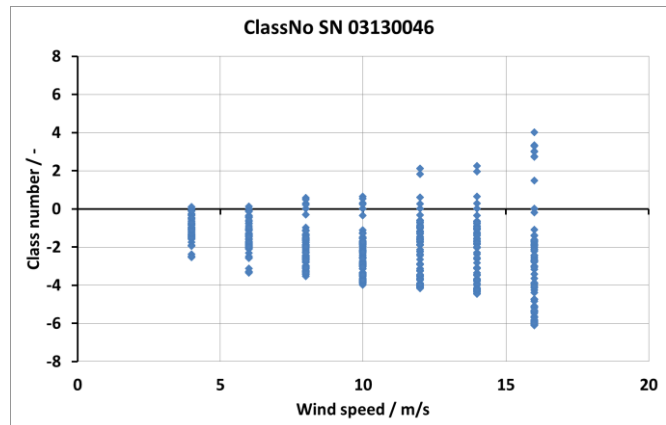
IEC 61400-12-1 Edition 2.0
Wind Turbine Power Performance Testing
2017-03

Result:

Figure showing the calculated total deviation of the Thies 3 D Sonic anemometer type 4.3830.xx.xxx, taking into account all influencing parameters according to **Class A** definition.

Internal shaft heating: ON / OFF

Classification index: A/C 5.3
(average of five sensors)



As there is only a very small variation due to temperature in sonic's visible the influence of temperature was not taken into account for classification. Therefore **Class C** is assumed to be identical to **Class A**

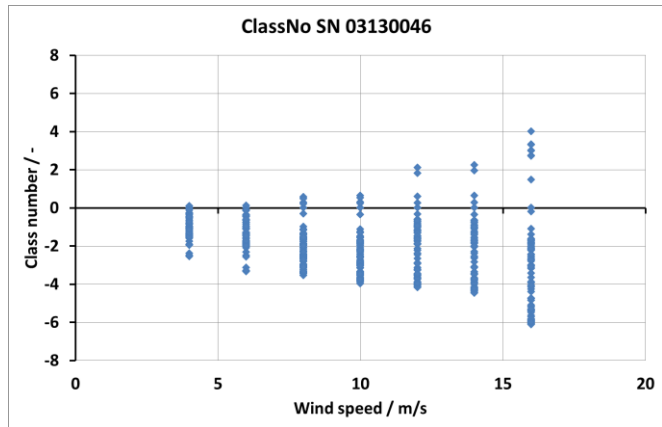
Class B/D Classification

Reference:

IEC 61400-12-1 Edition 2.0
Wind Turbine Power Performance Testing
2017-03

Result:

Figure showing the calculated total deviation of the Thies 3 D Sonic anemometer type 4.3830.xx.xxx taking into account all influencing parameters according to **Class B** definition.



Internal shaft heating ON / OFF

Classification index: B/D 5.4
(average of five sensors)

As there is only a very small variation due to temperature in sonic's visible the influence of temperature was not taken into account for classification. Therefore **Class D** is assumed to be identical to **Class B**

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Results presented in this report are valid for the item tested only.

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