



# Wind Turbine Generator System Acoustic Noise Test Report for the Gaia Wind 11-kW Wind Turbine

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**Wind Turbine Generator System  
Acoustic Noise Test Report**

**for the**

**Gaia Wind 11-kW Wind Turbine  
in**

**Boulder, CO**

**Conducted for**

**National Renewable Energy Laboratory  
1617 Cole Blvd.  
Golden, CO 80401**

**Conducted by**

**Wind Energy Program  
DOE / NREL**

**Arlinda Huskey**

**March 31, 2011**

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## **1.0 Background**

This test is being conducted as part of the U.S. Department of Energy's (DOE) Independent Testing project. This project was established to help reduce the barriers of wind energy expansion by providing independent testing results for small turbines. In total, four turbines are being tested at the National Wind Technology Center (NWTC) as a part of this project. Acoustic noise testing is one of up to five tests that may be performed on the turbines; other tests may include duration, safety and function, power performance, and power quality tests.

## **2.0 Test Summary**

The Gaia-Wind 11-kW wind turbine was installed at the National Wind Technology Center located south of Boulder, Colorado. The test turbine is a two-bladed, downwind wind turbine with a rated power of 11 kW. The test turbine was tested in accordance with the International Electrotechnical Commission standard, IEC 61400-11 Ed 2.1 2006-11 Wind Turbine Generator Systems – Part 11 Acoustic Noise Measurement Techniques, hereafter referred to as the Standard. Noise and meteorological data were collected on two days, 28 February 2009 and 11 March 2010. Standardized wind speed (at 10 meters) was determined from wind speed measured at hub height (at 18.2 meters).

## **3.0 Test Turbine**

Figure 1 shows a picture of the test turbine and Table 1 lists the turbine configuration.



**Figure 1. Gaia-Wind 11-kW test turbine at the NWTC. PIX #15705.**

**Table 1. Test turbine Configuration and Operational Data**

	<b>Test Turbine</b>
<b>Wind turbine details:</b>	
Manufacturer	Gaia-Wind
Model number	Gaia-Wind 11-k/w
Serial number	10711114
<b>Configuration:</b>	
Vertical or horizontal axis	Horizontal
Upwind or downwind rotor	Downwind
Hub height	18.2 m
Horizontal distance from rotor center to tower axis	2.1 m
Diameter of rotor	13 m
<b>Operating details:</b>	
Passive/active stall or pitch-controlled turbine	Passive stall
Constant or variable speed	Constant
Rotational speed at standardized integer wind speed from 6 to 10 m/s	60-61 rpm
Pitch angle at standardized integer wind speeds from 6 to 10 m/s	0 degrees
Rated power output	11 kW
Control software version	Gaia-Wind IC-1000, Rev. 1:P00515\031020
<b>Geometric Configuration:</b>	
Tower type (lattice or tube)	Tubular
<b>Rotor details:</b>	
Rotor control devices	Tip brakes
Blade type	Gaia-Wind T202, glass fiber, centrifugally activated tip brake
Number of blades	2
Presence of vortex generators, stall strips, serrated trailing edges, etc.	None

## 4.0 Test Site

The test turbine is located at site 3.1 at the National Wind Technology Center, south of Boulder, Colorado. The topography surrounding the test site is flat with some small bushes. Figure 2 shows the turbine and meteorological tower locations. This figure also shows nearby turbines and topographical features of the site.

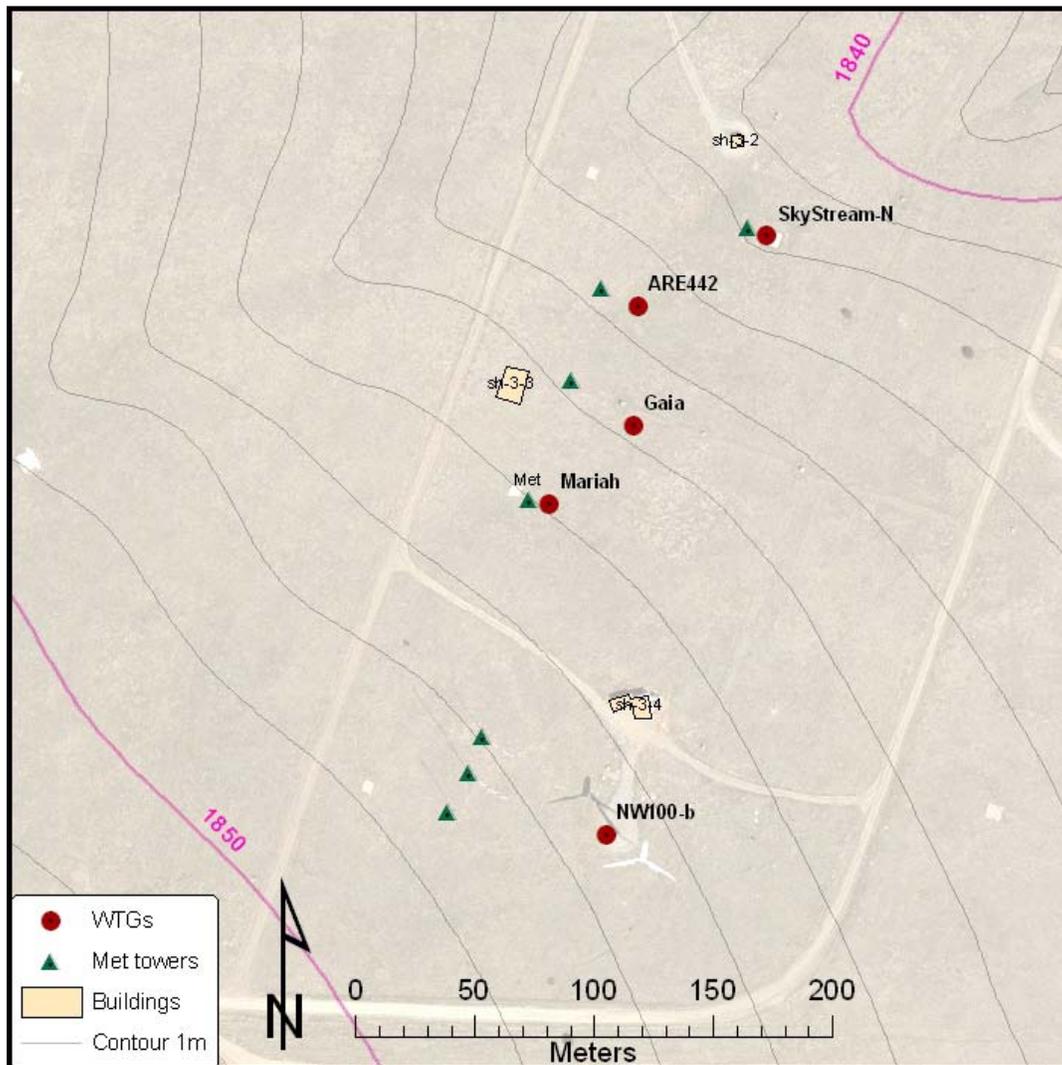


Figure 2. Test turbine location

**Table 2. Structures close to test turbine**

Source	Location	Shutdown for noise test
NW100b	3.4	Yes
ARE 442	3.3a	Yes
Southwest Windpower Skystream (2*)	3.2	Yes
Endurance	3.1	Yes
CART	4.2	No
EW50	1E1	Yes
Bergey Excel	1.4	No

## **5.0 Test Equipment**

### **5.1 Equipment Descriptions**

Table 3 shows the list of equipment used for the test. All instruments meet the requirements defined by the Standard.

**Table 3. Equipment list for acoustic test**

<b>Instrument</b>	<b>Manufacturer</b>	<b>Model Number</b>	<b>Serial Number</b>	<b>Calibration Due Date</b>
Digital Recorder and Signal Analyzer	Delta Acoustics	NoiseLab	1258E43	November 24, 2010
Microphone	Bruel & Kjaer	4189-A-021	2395206	November 21, 2010
Preamplifier	Bruel & Kjaer	4012	2373719	November 21, 2010
Calibrator	Bruel & Kjaer	4231	2326144	November 11, 2009 January 14, 2011
Anemometer (replaced during test)	Thies	First Class	0707890  0707892	April 7, 2009 February 4, 2010 Anemometer post-Test calibrated and was in compliance
Wind Vane	Met One	020C	X4357	April 7, 2009 March 18, 2010
Pressure Sensor (replacing during test)	Vaisala	PTB101B	T5030003	August 26, 2009 Pressure sensor Post-test calibrated and was in compliance
Temperature Sensor (replaced during test)	Met One	T-200 RTD	0789021	October 10, 2009 Temperature sensor post-test calibrated and was in compliance
Data acquisition (replaced during test)	National Instruments	Compact DAQ w/LabView  cDAQ backplane NI 9229 NI 9217 NI 9205  NI 9229 NI 9217 NI 9205	  12E4DA3 12CBC7A 12BFEE2 12E9C99  140A596 140DCB9 140E2BD	  August 14, 2008 July 20, 2008 October 8, 2008 Modules post-test Calibrated and were In compliance February 10, 2010 February 12, 2010 February 10, 2010 Modules post-test calibrated and were in compliance

## 5.2 Instrumentation Locations

The anemometer and wind vane were on a meteorological tower located 32.7 meters from the test turbine at a bearing of 290° true. The anemometer was at hub height 18.3 m. The meteorological tower distance is 2.5 rotor diameters from the test turbine and within the range of between 2 and 4 rotor diameters specified in the IEC standard.

Table 4 gives the location of the microphone for the measurement sessions.

**Table 4. Microphone positions for turbine and background measurements**

Microphone	Distance to Turbine [m]	Slant Distance [m]	Position relative to turbine [degrees]
Reference	24.7	30.7	295

## 6.0 Results

### 6.1 Test Conditions

The analysis was done using the measured wind speed and 10-second averages of the data. NREL has found that noise from small wind turbines correlates better with measured wind speed than it does with derived wind speed. For the 24 February 2009 data, the range of standardized wind speeds and wind directions used for the analysis were 1.4 to 16.3 m/s and 118 to 355 degrees, respectively. The range of temperature and pressure were 14.6 to 16.3 C and 80.4 to 80.7 kPa, respectively. For the 11 March 2010 data, the range of standardized wind speeds and wind directions used for the analysis were 3.1 to 12.2 m/s and 256 to 309 degrees, respectively. The range of temperature and pressure were 3.9 to 6.2 C and 80.3 to 80.4 kPa, respectively.

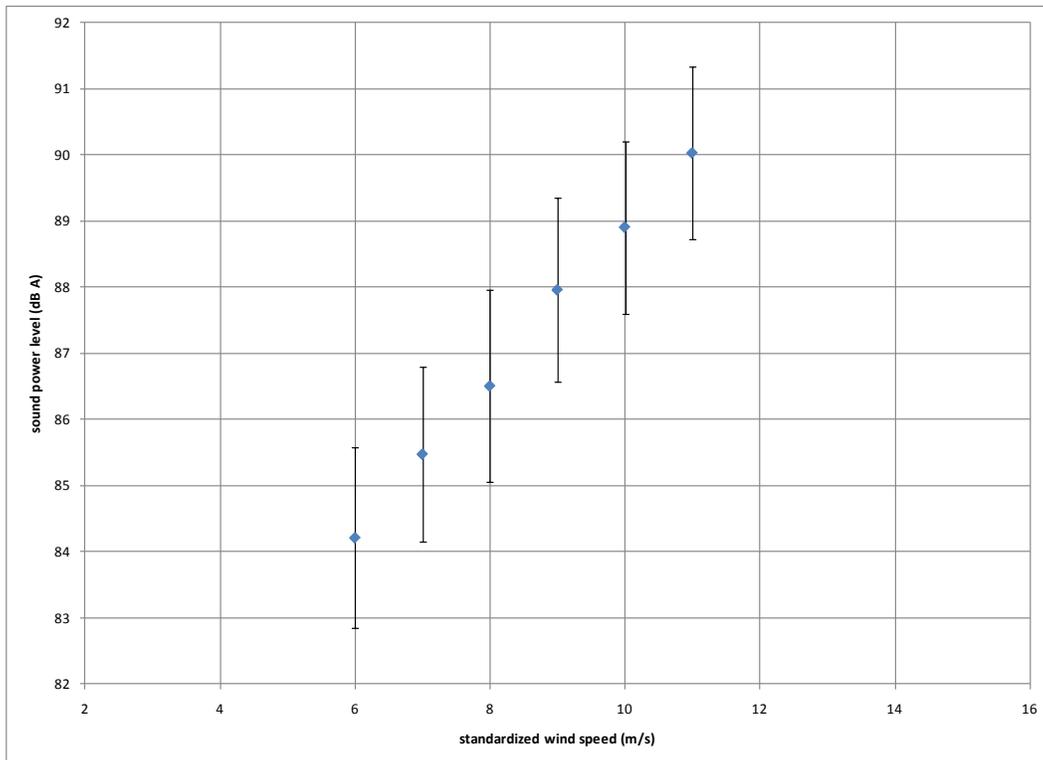
### 6.2 Apparent Sound Power Level

The apparent sound power level at standardized wind speeds of 6, 7, 8, 9, 10, 11, and 12 m/s are shown in Table 5 and Figure 3. In this test, wind speed was measured at a hub height of 18.2 m and then standardized to a 10 m height, assuming an idealized wind profile based on a terrain roughness of 0.05 m.

**Table 5. Sound power levels for integer wind speeds 6 m/s through 12 m/s**

<b>Wind Speed Bin [m/s]</b>	<b>Sound Power Level [dB (A)]</b>	<b>Combined Uncertainty [dB (A)]</b>
6	84.2	1.4
7	85.5	1.3
8	86.5	1.4
9	88.0	1.4
10	88.9	1.3
11	90.0	1.3

Figure 3 shows sound power levels at the standard integer wind speeds. The sound pressure levels were binned by wind speed. The integer wind speed values were calculated by interpolation between bins.



**Figure 3. Sound power levels as a function of the standardized wind speed**

Figure 4 shows the scatter plot of the sound pressure levels of the turbine and background noise.

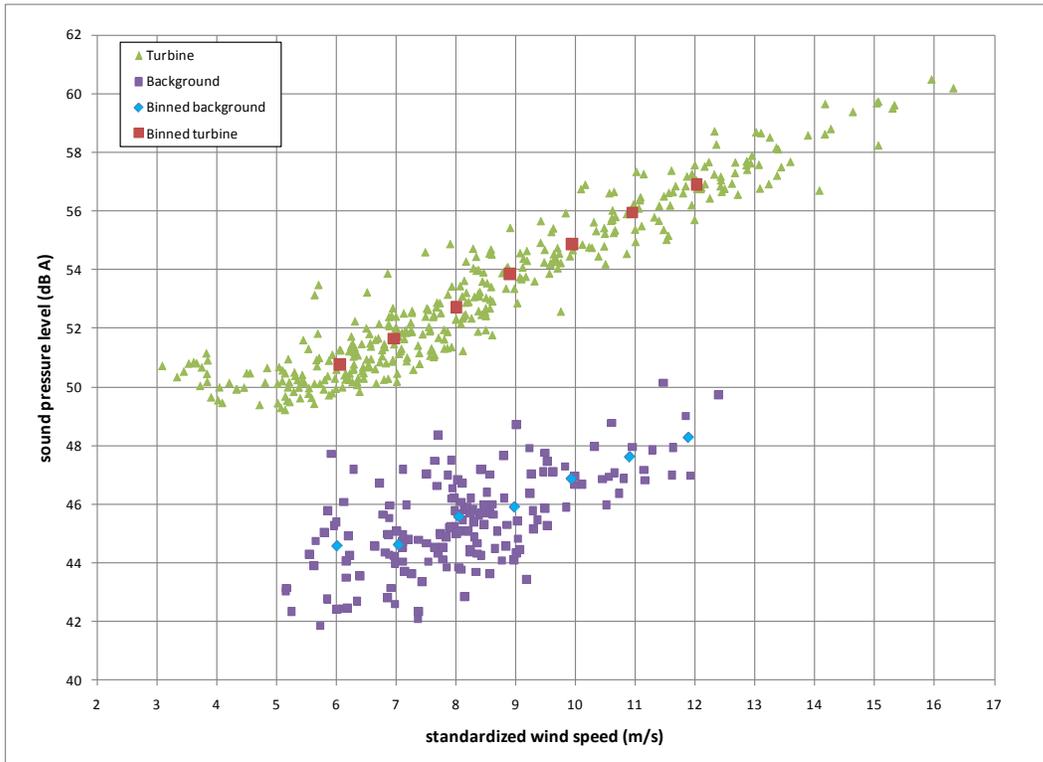


Figure 4. Measured sound pressure levels as a function of the standardized wind speed.

### 6.3 One-Third Octave Analysis

One-third octave levels were analyzed at standardized wind speed of 6, 7, 8, 9, 10, and 11 m/s. The results are given in Table 6 and Figure 5.

**Table 6. One-third octave analysis for wind speed bins 6 through 9 m/s**

Center Frequency	6 m/s one-third octave levels	7 m/s one-third octave levels	8 m/s one-third octave levels	9 m/s one-third octave levels
[Hz]	[dB A]	[dB A]	[dB A]	[dB A]
20	NR	NR	NR	NR
25	NR	NR	NR	NR
31.5	NR	NR	NR	NR
40	NR	NR	NR	NR
50	NR	NR	NR	NR
63	NR	NR	NR	NR
80	NR	NR	NR	NR
100	NR	32.2* ± 2.4	32.8* ± 2.2	NR
125	NR	NR	NR	NR
160	33.8* ± 2.3	35.0* ± 2.3	36.6* ± 2.3	NR
200	NR	NR	NR	NR
250	39.2* ± 2.3	40.1* ± 2.3	41.0* ± 2.2	NR
315	38.6* ± 2.3	39.2* ± 2.3	40.6* ± 2.3	41.4* ± 2.3
400	37.9* ± 2.3	38.6* ± 2.2	40.0* ± 2.3	40.9* ± 2.3
500	38.7* ± 2.2	39.7 ± 2.0	40.6* ± 2.3	41.4* ± 2.3
630	40.2 ± 2.1	41.4 ± 2.0	42.4 ± 2.2	43.4* ± 2.3
800	39.5 ± 2.0	40.4 ± 1.9	41.4 ± 2.2	42.3* ± 2.3
1000	39.3 ± 1.9	39.4 ± 1.9	40.2* ± 2.3	41.5* ± 2.4
1250	37.8 ± 1.9	38.6 ± 1.9	39.7 ± 2.3	40.9* ± 2.4
1600	39.4 ± 1.9	40.6 ± 1.9	42.0 ± 2.0	42.5 ± 2.2
2000	37.0 ± 2.0	38.6 ± 2.0	40.3 ± 2.1	41.5 ± 2.3
2500	36.1 ± 2.1	38.1 ± 2.1	40.3 ± 2.1	41.9 ± 2.2
3150	34.6 ± 2.1	36.7 ± 2.1	39.1 ± 2.2	40.8 ± 2.3
4000	32.1 ± 2.0	33.9 ± 2.0	36.1 ± 2.2	37.6 ± 2.4
5000	31.3 ± 2.1	33.0 ± 2.0	34.4 ± 2.0	35.2 ± 2.2
6300	30.8 ± 2.0	32.1 ± 2.0	32.9 ± 2.0	33.0 ± 2.1
8000	25.2* ± 2.2	25.9* ± 2.2	26.8* ± 2.3	NR
10000	NR	NR	NR	NR

\* The difference between total and background noise was less than 6 dB but greater than 3 dB. A standard background correction of 1.3 dB was applied.

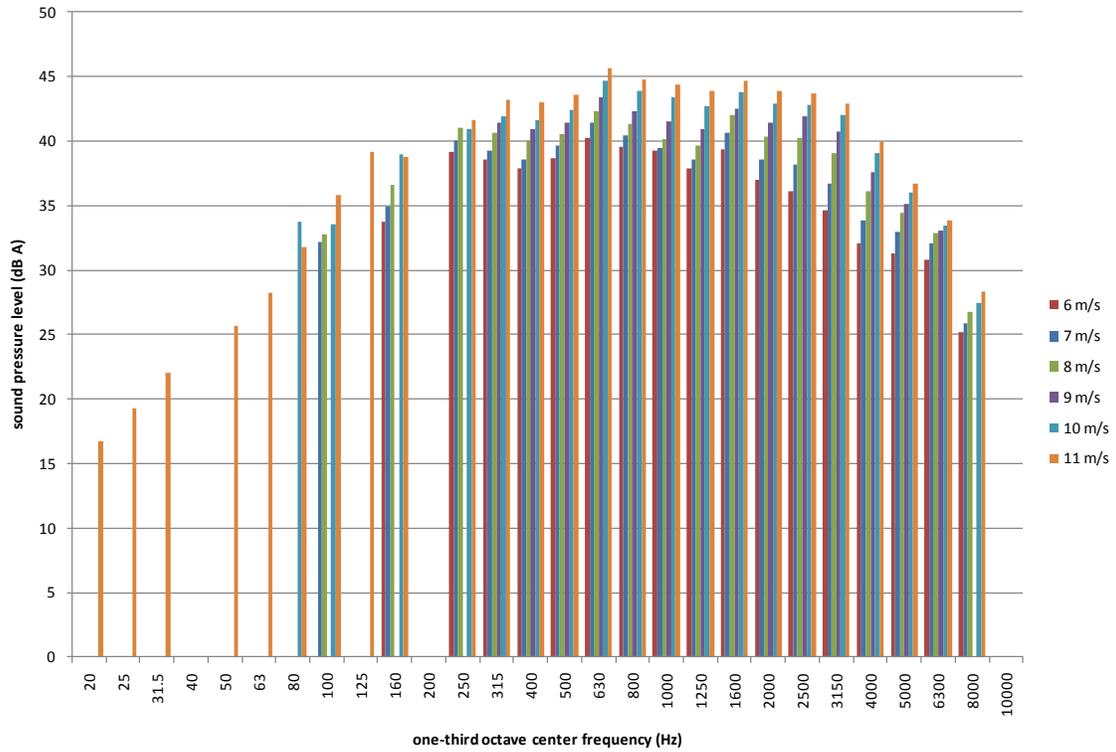
NR The difference between total and background noise was less than 3 dB so no results are reported.

**Table 6 (continued). One-third octave analysis for wind speed bins 10 and 11 m/s**

<b>Center Frequency</b>	<b>10 m/s one-third octave levels</b>	<b>11 m/s one-third octave levels</b>
<b>[Hz]</b>	<b>[dB A]</b>	<b>[dB A]</b>
20	NR	16.8* ± 2.6
25	NR	19.2* ± 2.5
31.5	NR	22.0* ± 2.6
40	NR	NR
50	NR	25.6 ± 2.3
63	NR	28.3* ± 2.4
80	33.8 ± 2.5	31.8 ± 2.4
100	33.5* ± 2.4	35.8 ± 2.2
125	NR	39.1* ± 2.2
160	38.9* ± 2.3	38.8* ± 2.3
200	NR	NR
250	40.9* ± 2.3	41.7* ± 2.3
315	41.9* ± 2.3	43.2 ± 2.2
400	41.6* ± 2.3	43.0 ± 2.1
500	42.4 ± 2.1	43.6 ± 1.9
630	44.7 ± 1.9	45.7 ± 1.9
800	43.9 ± 1.9	44.8 ± 1.9
1000	43.4 ± 1.9	44.4 ± 1.9
1250	42.8 ± 2.0	43.9 ± 1.9
1600	43.8 ± 1.9	44.7 ± 1.9
2000	42.9 ± 1.9	43.8 ± 1.9
2500	42.8 ± 1.9	43.7 ± 1.9
3150	42.0 ± 1.9	42.9 ± 1.9
4000	39.1 ± 1.9	39.9 ± 1.9
5000	36.1 ± 1.9	36.7 ± 1.9
6300	33.5 ± 1.9	33.9 ± 1.9
8000	27.4* ± 2.3	28.3* ± 2.3
10000	NR	NR

\* The difference between total and background noise was less than 6 dB but greater than 3 dB. A standard background correction of 1.3 dB was applied.

NR The difference between total and background noise was less than 3 dB so no results are reported.



**Figure 5. One-third octave levels**

### 6.4 Tonality

The tonality analysis resulted in reportable tones for 6, 7, 8, and 9 m/s. The tonality analysis was not conducted for the 10 m/s wind speed bin because the data available was not suitable for assessing tonality. Table 7 shows the results for the tonality analysis.

**Table 7. Tonality results**

k (m/s)	6			7			8				9			
Freq (Hz)	807	1569	1614	810	1569	1620	648	810	1575	1623	651	813	1578	1623
$\Delta L_{tn1,k}$	-6.1	-8.8	-17.3	-0.7	-17.2	-4.3	-14.5	-1.9	-17.2	-17.3	-4.6	1.2	-17.2	-17.3
$\Delta L_{tn2,k}$	-5.2	-8.3	-17.3	-0.7	-17.2	-4.7	-3.3	1.8	-17.2	-5.8	-2.8	1.5	-17.2	-17.3
$\Delta L_{tn3,k}$	-6.7	-0.1	-17.3	-3.9	-8.8	-17.3	0.0	0.6	-17.2	-3.4	-7.8	-2.0	-17.2	-17.3
$\Delta L_{tn4,k}$	-5.8	-1.1	-17.3	-3.7	-8.5	-17.3	-4.4	-4.7	1.7	-17.3	-2.8	2.8	-17.2	-10.4
$\Delta L_{tn5,k}$	-2.8	1.8	2.2	-3.7	0.3	-17.3	-5.9	-3.1	-0.5	-17.3	-3.6	3.3	-17.2	-8.5
$\Delta L_{tn6,k}$	-4.2	-0.4	0.2	-5.7	-0.4	0.0	-5.3	-3.9	0.2	0.5	-3.2	3.1	-17.2	-8.6
$\Delta L_{tn7,k}$	-6.1	1.3	1.7	-2.2	-0.2	-17.3	-5.8	-5.0	-0.4	-17.3	-14.5	-6.0	-2.3	-1.6
$\Delta L_{tn8,k}$	-7.9	-2.3	-1.8	-5.9	-3.7	-3.3	-5.7	-5.6	-1.0	-17.3	-14.5	-7.1	-4.0	-2.7
$\Delta L_{tn9,k}$	-4.2	-1.3	-0.5	-4.3	0.0	0.2	-7.3	-5.0	-1.6	-1.0	-2.5	-2.0	0.6	0.7
$\Delta L_{tn10,k}$	-4.3	1.2	1.9	-5.1	-0.5	0.3	-5.9	-6.2	1.8	2.2	-3.2	-4.9	-1.0	-0.9
$\Delta L_{tn11,k}$	-14.9	-5.5	-17.3	-7.5	-1.0	-0.7	-5.1	-4.2	1.1	1.5	-2.4	-4.2	-2.5	-2.5
$\Delta L_{tn12,k}$	-4.1	-2.7	-1.8	-5.9	-1.7	-1.2	-14.5	-4.7	-1.3	-17.3	-5.2	-5.3	-1.4	-1.3
$\Delta L_k$ dB(A)	-5.3	-1.1	-1.7	-3.6	-2.3	-3.0	-5.1	-2.7	-1.1	-3.2	-4.3	-0.2	-4.5	-3.8
$\Delta L_{a,k}$ dB(A)	-2.7	2.2	1.5	-1.0	0.9	0.3	-2.6	-0.1	2.2	0.1	-1.8	2.5	-1.2	-0.5
$U_A$ dB(A)	6.3	2.1	3.4	4.5	3.4	4.4	6.1	3.6	2.4	5.1	5.3	1.5	6.3	5.0
$U_B$ dB(A)	2.0	1.9	1.9	2.0	1.9	1.9	2.1	2.1	1.9	1.9	1.9	2.0	1.9	1.9
$U_C$ dB(A)	6.6	2.8	3.9	4.9	3.9	4.7	6.4	4.1	3.0	5.4	5.6	2.5	6.6	5.3

## 6.5 Uncertainty

The Type A uncertainties for sound power levels, one-third octave levels, and tonality were calculated using the methods prescribed in the Standard.

The type B uncertainty components are shown in Table 8.

**Table 8. Type B uncertainty components for sound power levels and tonality**

<b>Variable</b>	<b>Description</b>	<b>Type B uncertainty for sound power level dB (A)</b>	<b>Type B uncertainty for one-third octave levels dB (A)</b>	<b>Type B uncertainty for tonality dB (A)</b>	<b>Comment</b>
U <sub>B1</sub>	Calibration	0.2	0.2	0.1	Assumption, used typical value
U <sub>B2</sub>	Instrument	0.2	0.2	0.2	Assumption, used typical value
U <sub>B3</sub>	Board	0.3	1.7	1.7	The board was placed well and used typical value.
U <sub>B4</sub>	Distance	0.1	0.1	0.1	Assumption, used typical value.
U <sub>B5</sub>	Impedance	0.1	0.1	0.1	Assumption, used typical value.
U <sub>B6</sub>	Turbulence	0.4	0.4	0.2	Assumption, used typical value.
U <sub>B7</sub>	Wind speed, measured	0.5 x slope	0.5 x slope	0.6	Calculated using an estimated 0.5 m/s uncertainty on the wind speed
U <sub>B8</sub>	Direction	0.3	0.3	0.3	Assumption, used typical value.
U <sub>B9</sub>	Background	Varies by bin	Varies by bin and one-third octave center frequency bin	Varies by tone.	Difference between the regression for turbine and background for sound power level.

## **7.0 Exceptions**

### **7.1 Exceptions to the Standard**

1. The tonality analysis for the 10m/s bin was not performed because the available data was not suitable. There were other turbines operating in the background and this would have caused unreliable tonality results.
2. Ten-second averages were used in the analysis instead of one-minute averages to better characterize the dynamic nature of this small wind turbine.

3. Pictures were not taken of the soundboard, turbine, and meteorological tower during the test. A picture of a soundboard is included that is representative of conditions during the test.

### ***7.2 Exceptions to the Quality Assurance System***

Meteorological instruments were used past the calibration due dates. The instruments were post-test calibrated to assure the instruments were within their tolerances.

## **8.0 References**

IEC 61400-11 Ed 2.1 2006-11 Wind Turbine Generator Systems – Part 11 Acoustic Noise Measurement Techniques

## Appendix A. Picture of the soundboard



Figure 6. Picture of sound board during the test. PIX #19420.

## **Appendix B. Equipment Calibration Sheets**

**Scantek, Inc.**  
CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1 and  
relevant requirements of ISO 9002:1994 ACCREDITED  
by NVLAP (an ILAC and APLAC signatory)



NVLAP Lab Code: 200625-0

## Calibration Certificate No.22815

<b>Instrument:</b> Sound Level Meter	<b>Date Calibrated:</b> 11/9/2010	<b>Cal Due:</b>				
<b>Model:</b> noiseLab3-NI-9233	<b>Status:</b>	<table border="1"><tr><td>Received</td><td>Sent</td></tr><tr><td>X</td><td>X</td></tr></table>	Received	Sent	X	X
Received	Sent					
X	X					
<b>Manufacturer:</b> Delta	<b>In tolerance:</b>	<table border="1"><tr><td>X</td><td>X</td></tr></table>	X	X		
X	X					
<b>Serial number:</b> 1258E43	<b>Out of tolerance:</b>	<table border="1"><tr><td></td><td></td></tr></table>				
<b>Tested with:</b> Mic. 4189 s/n 2395206 & 2395209	<b>See comments:</b>					
Preamp. 2671 s/n 2373719 & 2373721	<b>Contains non-accredited tests:</b> <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No					
<b>Type (class):</b> 1	<b>Calibration service:</b> <input type="checkbox"/> Basic <input checked="" type="checkbox"/> Standard					
<b>Customer:</b> National Renewable Energy Laboratory	<b>Address:</b> 16253 Denver West Parkway					
<b>Tel/Fax:</b> 303-384-7183 /	Golden, CO 80401-3393					

Tested in accordance with the following procedures and standards:  
Calibration of Sound Level Meters, Scantek Inc., 06/07/2005  
SLM & Dosimeters – Acoustical Tests, Scantek Inc., 06/15/2005

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence	Cal. Due
				Cal. Lab / Accreditation	
483B-Norsonic	SME Cal Unit	25747	Dec 24, 2009	Scantek, Inc./ NVLAP	Dec 24, 2010
DS-360-SRS	Function Generator	61646	Nov 13, 2009	ACR Env. / A2LA	Nov 13, 2011
34401A-Agilent Technologies	Digital Multimeter	MY41022043	Nov 12, 2009	ACR Env. / A2LA	Nov 12, 2010
DPI 141-Druck	Pressure Indicator	790/00-04	Nov 21, 2008	Transcat / NVLAP	Nov 21, 2010
HMP233-Vaisala Oyj	Humidity & Temp. Transmitter	V3820001	Nov 25, 2009	Transcat / NVLAP	May 25, 2011
PC Program 1019 Norsonic	Calibration software	v.5.0	Validated July 2009	-	-
1253-Norsonic	Calibrator	25726	Dec 7, 2009	Scantek, Inc./ NVLAP	Dec 7, 2010

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK).

**Environmental conditions:**

Temperature (°C)	Barometric Pressure (kPa)	Relative Humidity (%)
22.3 °C	100.105 kPa	54.1 %RH

Calibrated by	Valentin Buzduga	Checked by	Mariana Buzduga
Signature		Signature	
Date	11/09/2010	Date	11/10/2010

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.  
This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.  
Document stored as: Z:\Calibration Lab\SLM 2010\DeltaNoiseLab3-9233\_1258E43-Ch1\_M1.doc

# Scantek, Inc.

CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1 and  
relevant requirements of ISO 9002:1994 ACCREDITED  
by NVLAP (an ILAC and APLAC signatory)



NVLAP Lab Code: 200625-0

## Calibration Certificate No. 18951

**Instrument:** noiseLAB Platform  
**Model:** noiseLAB3-NI-9233  
**Manufacturer:** Delta  
**Serial number:** 1258E43\_3-0-16  
**Composed of:** Laptop s/n 54018537H w/ noiseLAB v. 3.0.16  
**Type (class):** 1  
**Customer:** National Renewable Energy Laboratory, Inc.  
**Tel/Fax:** 303-382-6987

**Date Calibrated:** 11/24/2008  
**Status:**

Received	Sent
X	X

  
**In tolerance:**

X	X
---	---

  
**Out of tolerance:**

--	--

  
**See comments:**  
**Contains non-accredited tests:** \_\_\_ Yes  No  
**Calibration service:** \_\_\_ Basic  Standard  
**Address:** 16253 Denver West Parkway  
Golden, CO 80401

**Tested in accordance with the following procedures and standards:**  
Calibration of Sound Level Meters, Scantek Inc., 06/07/2005  
Calibration of Analyzers, Scantek, Inc., 06/07/2005

**Instrumentation used for calibration:** Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence	Cal. Due
				Cal. Lab / Accreditation	
483B-Norsonic	SME Cal Unit	31052	Jan 15, 2008	Scantek, Inc.	Jan 15, 2009
DS-360-SRS	Function Generator	33584	Jan 3, 2008	Davis Calibration / AClass	Jan 3, 2009
34401A-Agilent Technologies	Digital Voltmeter	US36120731	Aug 19, 2008	ACR Env. / A2LA	Aug 14, 2009
HM30-Thommen	Meteo Station	1040170/39633	Dec 21, 2007	Transcat / A2LA	Jun 21, 2009
PC Program 1019 Norsonic	Calibration software	v.46	Validated Dec 2006	-	-

**Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK).**

**Environmental conditions:**

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
21 °C	99.54 kPa	34.8 %RH

Calibrated by	Javier Albarracin	Checked by	Mariana Buzduga
Signature	<i>Javier Albarracin</i>	Signature	<i>Mariana Buzduga</i>
Date	11/25/2008	Date	11/25/2008

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This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.  
Document stored as: C:\Nor1504\SI\mCal\2008\Delta\NoiseLab3-9233\_1258E43\_3-0-16\_M2.doc

Page 1 of 2

# Scantek, Inc.

CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540: 1994 Part 1  
and relevant requirements of ISO 9002: 1994

ACCREDITED by NVLAP  
(an ILAC and APLAC signatory)



NVLAP Lab Code: 200625-0

## Calibration Certificate No.21065

**Instrument:** Acoustical Calibrator  
**Model:** 4231  
**Manufacturer:** Brüel and Kjær  
**Serial number:** 2326144  
**Class (IEC 60942):** 1  
**Barometer type:**  
**Barometer s/n:**

**Date Calibrated:** 1/14/2010  
**Status:**

Received	Sent
X	X

  
**In tolerance:**

X	X
---	---

  
**Out of tolerance:**

--	--

  
**See comments:**

--	--

  
**Contains non-accredited tests:** Yes X No

**Customer:** National Renewable Energy Laboratory  
**Tel/Fax:** 303-384-6388/ -6391  
**Address:** 16253 Denver West Parkway  
Golden, CO 80401  
**beverly.kay@nrel.gov**

**Tested in accordance with the following procedures and standards:**  
Calibration of Acoustical Calibrators, Scantek Inc., 06/06/2005

**Instrumentation used for calibration:** Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence	Cal. Due
				Cal. Lab / Accreditation	
483B-Norsonic	SME Cal Unit	25747	Dec 24, 2009	Scantek, Inc./ NVLAP	Dec 24, 2010
DS-360-SRS	Function Generator	61646	Nov 13, 2009	ACR Env. / A2LA	Nov 13, 2011
34401A-Agilent Technologies	Digital Multimeter	MY41022043	Nov 12, 2009	ACR Env. / A2LA	Nov 12, 2010
DPI 141-Druck	Pressure Indicator	790/00-04	Nov 21, 2008	Transcat / NVLAP	Nov 21, 2010
8903A-HP	Audio Analyzer	2514A05691	Jan 2, 2008	Transcat/ NVLAP	Jan 2, 2011
HMP233-Vaisala Oyj	Humidity & Temp. Transmitter	V3820001	Nov 25, 2009	ACR Env. / A2LA	May 25, 2011
PC Program 1018 Norsonic	Calibration software	v.44	Validated May 2006	-	
1253-Norsonic	Calibrator	28326	Dec 7, 2009	Scantek, Inc. / NVLAP	Dec 7, 2010
1203-Norsonic	Preamplifier	14051	Jan 4, 2010	Scantek, Inc./ NVLAP	Jan 4, 2011
4180-Brüel&Kjær	Microphone	2246115	Mar 7, 2008	NPL (UK) / UKAS	Mar 7, 2010

**Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK)**

<b>Calibrated by</b>	Valentin Buzduga	<b>Checked by</b>	Mariana Buzduga
Signature		Signature	
Date	1/14/2010	Date	1/14/2010

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.  
This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.  
Document stored as: Z:\Calibration Lab\Cal 2009\BKNK4231\_2326144\_M1.doc

Page 1 of 2

# DEUTSCHER KALIBRIERDIENST **DKD**

Kalibrierlaboratorium für Strömungsgeschwindigkeit von Luft  
*Calibration laboratory for velocity of air flow*

Akkreditiert durch die / *accredited by the*  
 Akkreditierungsstelle des Deutschen Kalibrierdienstes



**DEWI GmbH**  
 Deutsches Windenergie-Institut



DKD-K-28901



**Kalibrierschein**  
*Calibration certificate*

Kalibrierzeichen  
*Calibration label*

1499_09
DKD-K-28901
15.07.09

Gegenstand <i>Object</i>	Cup Anemometer
Hersteller <i>Manufacturer</i>	Thies Clima D-37083 Göttingen
Typ <i>Type</i>	4.3350.00.000
Fabrikat/Serien-Nr. <i>Serial number</i>	body: 0707890 cup: -
Auftraggeber <i>Customer</i>	Thies Clima D-37083 Goettingen,
Auftragsnummer <i>Order No.</i>	AB0901617
Anzahl der Seiten des Kalibrierscheines <i>Number of pages of the certificate</i>	3+3
Datum der Kalibrierung <i>Date of calibration</i>	15.07.09

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).  
 Der DKD 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 DKD 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 Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

*This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.*

Stempel <i>Seal</i>	Datum <i>Date</i>	Stellv. Leiter des Kalibrierlaboratoriums <i>Deputy head of the calibration laboratory</i>	Bearbeiter <i>Person in charge</i>
	15.07.09	 Dipl.-Ing. (FH) P. Busche	 R. Kluin

**DEWI GmbH DEUTSCHES WINDENERGIE - INSTITUT**  
 Ebertstr. 96, D-26382 Wilhelmshaven  
 Tel. +49 (0)4421 4808-0, Fax. +49 (0)4421 4808-43



# DEUTSCHER KALIBRIERDIENST **DKD**

Kalibrierlaboratorium für Strömungsgeschwindigkeit von Luft  
*Calibration laboratory for velocity of air flow*

Akkreditiert durch die / *accredited by the*

Akkreditierungsstelle des DKD bei der  
 PHYSIKALISCH-TECHNISCHEN BUNDESANSTALT (PTB)



Deutsche WindGuard  
 Wind Tunnel Services GmbH  
 Varel



## Kalibrierschein *Calibration Certificate*

Kalibrierzeichen  
*Calibration label*

DKD-K- 36801
07_2411

Gegenstand  
*Object* Cup Anemometer

Hersteller  
*Manufacturer* Thies Klima  
 D-37083 Göttingen

Typ  
*Type* 4.3350.00.000

Fabrikat/Serien-Nr.  
*Serial number* Body: 0707892  
 Cup: 0707892

Auftraggeber  
*Customer* Thies Klima  
 D-37083 Göttingen

Auftragsnummer  
*Order No.* VT07255

Anzahl der Seiten des Kalibrierscheines  
*Number of pages of the certificate* 3

Datum der Kalibrierung  
*Date of calibration* 24.07.2007

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Der DKD ist Unterzeichner der multi-lateralen 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 DKD 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 Akkreditierungsstelle des DKD als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift und Stempel haben keine Gültigkeit.

*This calibration certificate may not be reproduced other than in full except with the permission of both the Accreditation Body of the DKD and the issuing laboratory. Calibration certificates without signature and seal are not valid.*

Stempel <i>Seal</i>	Datum <i>Date</i>	Leiter des Kalibrierlaboratoriums <i>Head of the calibration laboratory</i>	Bearbeiter <i>Person in charge</i>
	24.07.2007	 Dipl. Phys. D. Westermann	 Tech. Ass. Inf. H. Westermann

Deutsche WindGuard Wind Tunnel Services GmbH  
 Oldenburger Str. 65  
 26316 Varel ; Tel. ++49 (0)4451 9515 0



# Svend Ole Hansen ApS

SCT. JORGENS ALLÉ 7 · DK-1615 KOBENHAVN V · DENMARK  
 TEL: (+45) 33 25 38 38 · FAX: (+45) 33 25 38 39 · WWW.SOHANSEN.DK



WIND  
 ENGINEERING  
 FLUID  
 DYNAMICS

## CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

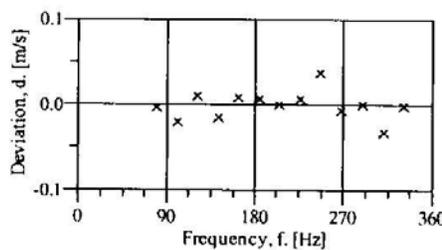
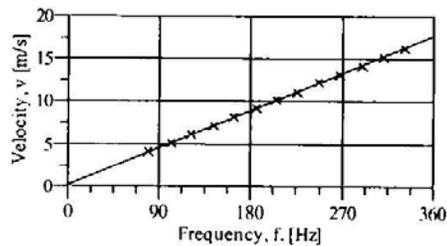
**Certificate number:** 10.02.6375      **Date of issue:** October 25, 2010  
**Type:** Thies 4.3350.00.000      **Serial number:** 0707892  
**Manufacturer:** ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany  
**Client:** NREL Meteorology and Calibration Laboratory, 1617 Cole Blvd, Golden, CO 80401 USA

**Anemometer received:** October 21, 2010      **Anemometer calibrated:** October 24, 2010  
**Calibrated by:** as      **Calibration procedure:** IEC 61400-12-1, MEASNET  
**Certificate prepared by:** jsa      **Approved by:** Calibration engineer, soh

**Calibration equation obtained:**  $v \text{ [m/s]} = 0.04848 \cdot f \text{ [Hz]} + 0.23944$  *Svend Ole Hansen*  
**Standard uncertainty, slope:** 0.00128      **Standard uncertainty, offset:** 0.05695  
**Covariance:** -0.0000008 (m/s)<sup>2</sup>/Hz      **Coefficient of correlation:**  $\rho = 0.999991$   
**Absolute maximum deviation:** 0.038 m/s at 12.231 m/s

**Barometric pressure:** 993.5 hPa      **Relative humidity:** 24.0%

Succession	Velocity pressure, q, [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v, [m/s]	Frequency, f, [Hz]	Deviation, d, [m/s]	Uncertainty $u_c$ (k=2) [m/s]
2	9.53	31.2	22.8	4.102	79.7246	-0.003	0.028
4	14.90	31.1	22.7	5.129	101.2622	-0.020	0.032
6	21.28	31.0	22.7	6.128	121.2465	0.010	0.037
8	28.98	30.9	22.7	7.150	142.8488	-0.015	0.043
10	37.92	30.8	22.7	8.178	163.5524	0.009	0.048
12	48.05	30.7	22.6	9.205	184.7626	0.007	0.054
13-last	58.92	30.7	22.6	10.193	205.2637	0.001	0.060
11	71.07	30.8	22.6	11.195	225.8104	0.008	0.066
9	84.82	30.8	22.7	12.231	246.5580	0.038	0.072
7	99.16	30.9	22.7	13.227	268.0057	-0.006	0.078
5	115.36	31.1	22.7	14.269	289.3657	0.001	0.084
3	132.33	31.2	22.8	15.285	310.9733	-0.031	0.090
1-first	150.50	31.4	22.8	16.307	331.4110	0.000	0.096



**DANAK**  
 CAL. Reg. nr. 452  
 Accreditation to ISO 17025



Page 1 of 2

## Wind Vane Calibration Report

**Calibration Laboratory:**  
 National Wind Technology Center - Cert. Team  
 National Renewable Energy Laboratory  
 1617 Cole Boulevard  
 Golden, Colorado 80401

**Customer:**  
 National Wind Technology Center - Certification Team  
 National Renewable Energy Laboratory  
 1617 Cole Boulevard  
 Golden, Colorado 80401

**Calibration Location:**  
 National Wind Technology Center  
 Room 101, Building 256

**Calibration Date:** 13-Sep-07

**Report Number:** X4357-070913

**Procedure:**  
 NWTCT-CT: G124-000613, Wind Vane Calibration

**Page:** 1 of 1

**Deviations from procedure:** Calibrated on 5V range  
 Calibrated in Volts (not mV)

**Item Calibrated:**  
 Manufacturer: Met One Instruments, Inc  
 Model: 020C  
 Serial Number: X4357  
 Vane Material: Aluminum  
 Condition: Refurbished

**Results:**  
**Slope:** 71.12 deg/V  
**Offset to boom:** 91.02 deg  
**Max error:** 0.78 deg

**Estimated Uncertainty:**

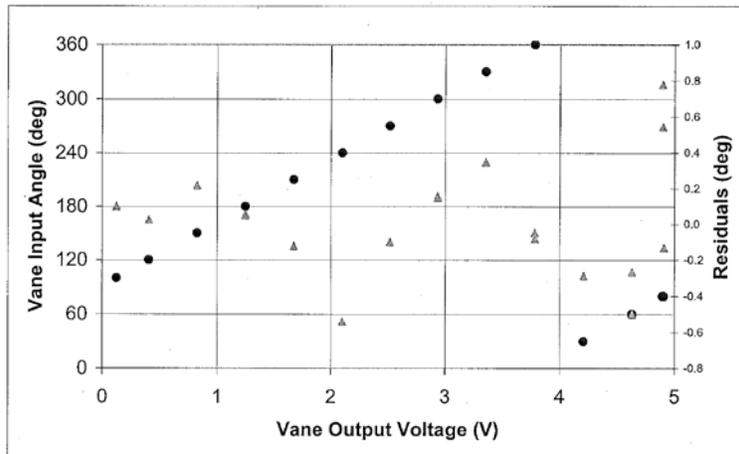
Inclinometer Uncertainty (deg)	Total Uncertainty (deg)
0.10	0.33

**Traceability:**

	Mfg & Model	Serial Number	Cal Date
Inclinometer:	Spi-Tronic	31-038-3	22-Mar-07
Voltmeter:	Fluke743B	6965608	10-May-07

Calibration by:   
 Mark Meadors

Date: 13-Sep-07



### Wind Vane Calibration Report

Calibration Laboratory:  
 National Wind Technology Center - Cert. Team  
 National Renewable Energy Laboratory  
 1617 Cole Boulevard  
 Golden, Colorado 80401

Customer:  
 National Wind Technology Center - Certification Team  
 National Renewable Energy Laboratory  
 1617 Cole Boulevard  
 Golden, Colorado 80401

Calibration Location:  
 National Wind Technology Center  
 Room 101, NWTC Bldg 256

Calibration Date: **13-Apr-10**

Report Number: X4357-100413

Procedure:  
 NWTC-CT: CI04 Calibrate Wind Vane\_091209.pdf

Page: 1 of 1

Deviations from procedure: Calibrated on 5V Range  
 Calibrated in Volts (not mV)  
 Post Calibration (Gaia)

Item Calibrated:  
 Manufacturer: Met One Instruments, Inc  
 Model: 020C  
 Serial Number: **X4357**  
 Vane Material: Aluminum  
 Condition: Refurbished

**Results:**  
 Slope: 71.0530 deg/V  
 Offset to boom: 90.7 deg  
 Max error: 1.1 deg

Estimated Uncertainty:  
 Inclometer  
 Uncertainty (deg)  
 0.10

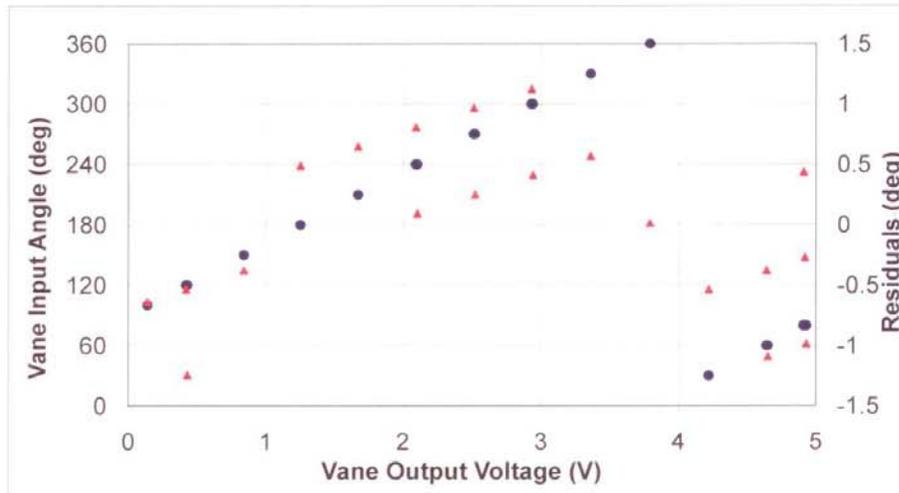
Total  
 Uncertainty (deg)  
 0.67

Traceability: Mfg & Mode Serial Number Cal Date  
 Inclometer: SPI-Tronic 31-038-3 19-May-09  
 Voltmeter: HP 3458A 2823A05145 5-May-09

Calibration by: Jerry Huf



13 APR 10  
 Date



### NREL METROLOGY LABORATORY

#### Test Report

Test Instrument: Pressure Transmitter

DOE #: 02729C

Model # : PTB101B

S/N : T5030003

Calibration Date: 08/26/2008

Due Date: 08/26/2009

No	Function Tested	Nominal Value (kPa)	Measured Output Voltage (VDC)		( )Mfr. Specs. OR (X)Data only (mb)
			As Found	As Left	
*	Absolute Pressure				
		65	0.282		
		70	0.555		
		75	0.827		
		80	1.099		
		85	1.371		
		90	1.644		
		95	1.915		
		100	2.188		
		105	2.462		
<p><b>Notes:</b></p> <p>1. Expanded Uncertainty of the nominal value is <math>\pm 0.2</math> kPa, with <math>k = 2</math>.</p> <p>2. Calibration was performed at 23°C and 37% RH.</p> <p>3. Calibration was performed using standards that are traceable to NIST. DOE numbers: 02625C, 02727C, and 02301C.</p>					

Calibrated By : Reda  
Date : 08/26/2008

Q.A. By: Bev  
Date : 08/26/2008

## NREL METROLOGY LABORATORY

### Test Report

Test Instrument: Pressure Transmitter

DOE #: 02729C

Model # : PTB101B

S/N : T5030003

Calibration Date: 04/14/2010

Due Date: 04/14/2011

N o	Function Tested	Nominal Value (kPa)	Measured Output Voltage (VDC)		( )Mfr. Specs. OR (X)Data only (mb)
			As Found	As Left	
*	Absolute Pressure				
		65	0.272		
		70	0.544		
		75	0.815		
		80	1.087		
		85	1.358		
		90	1.629		
		95	1.900		
		100	2.173		
Notes: 1. Expanded Uncertainty of the nominal value is $\pm 0.2$ kPa, with $k = 2$ . 2. Calibration was performed at 23°C and 40% RH. 3. Calibration was performed using standards that are traceable to NIST. DOE numbers: 02301C and 128120.					

Calibrated By : Reda  
Date : 04/14/2010

Q.A. By: Bev  
Date : 04/14/2010





**Board Information:**

Serial Number: 12CBC7A  
NI Part Number: 192580D-02  
Description: NI 9229

**Certificate Information:**

Certificate Number: 793243  
Date Printed: 20-NOV-08

Calibration Date: 14-AUG-07  
Recommended Calibration Due Date: 14-AUG-08\*

Ambient Temperature: 23 °C  
Relative Humidity: 60 %

*National Instruments certifies that at the time of manufacture, the above product was calibrated in accordance with applicable National Instruments procedures. These procedures are in compliance with relevant clauses of ISO 9001 and are designed to assure that the product listed above meets or exceeds National Instruments specifications.*

*National Instruments further certifies that the measurements standards and instruments used during the calibration of this product are traceable to National and/or International Standards administered by NIST or Euromet members or are derived from accepted values of natural physical constants.*

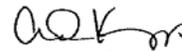
*The environment in which this product was calibrated is maintained within the operating specifications of the instrument and the standards.*

*The information shown on this certificate applies only to the instrument identified above and the certificate may not be reproduced, except in full, without prior written consent by National Instruments.*

*For questions or comments, please contact National Instruments Technical Support.*

*NI Hungary Software és  
Hardware Gyártó Kft.  
4031 Debrecen, Határ út  
1/A.  
HUNGARY*

Signed,



Andrew Krupp  
Quality Director

\* Recommended calibration due date is based on a combination of calibration interval and, when applicable, calibration shelf life. This date may vary depending on your application requirements.

**Board Information:**

Serial Number: 12BFEE2  
NI Part Number: 192547D-01  
Description: NI 9217

**Certificate Information:**

Certificate Number: 775348  
Date Printed: 20-NOV-08

Calibration Date: 20-JUL-07  
Recommended Calibration Due Date: 20-JUL-08\*

Ambient Temperature: 26 °C  
Relative Humidity: 45 %

*National Instruments certifies that at the time of manufacture, the above product was calibrated in accordance with applicable National Instruments procedures. These procedures are in compliance with relevant clauses of ISO 9001 and are designed to assure that the product listed above meets or exceeds National Instruments specifications.*

*National Instruments further certifies that the measurements standards and instruments used during the calibration of this product are traceable to National and/or International Standards administered by NIST or Euromet members or are derived from accepted values of natural physical constants.*

*The environment in which this product was calibrated is maintained within the operating specifications of the instrument and the standards.*

*The information shown on this certificate applies only to the instrument identified above and the certificate may not be reproduced, except in full, without prior written consent by National Instruments.*

*For questions or comments, please contact National Instruments Technical Support.*

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1/A.  
HUNGARY*

Signed,



Andrew Krupp  
Quality Director

\* Recommended calibration due date is based on a combination of calibration interval and, when applicable, calibration shelf life. This date may vary depending on your application requirements.

**Board Information:**

Serial Number: 12E9C99  
NI Part Number: 193299F-01  
Description: NI-9205

**Certificate Information:**

Certificate Number: 835019  
Date Printed: 20-NOV-08

Calibration Date: 08-OCT-07  
Recommended Calibration Due Date: 08-OCT-08\*

Ambient Temperature: 23 °C  
Relative Humidity: 38 %

*National Instruments certifies that at the time of manufacture, the above product was calibrated in accordance with applicable National Instruments procedures. These procedures are in compliance with relevant clauses of ISO 9001 and are designed to assure that the product listed above meets or exceeds National Instruments specifications.*

*National Instruments further certifies that the measurements standards and instruments used during the calibration of this product are traceable to National and/or International Standards administered by NIST or Euromet members or are derived from accepted values of natural physical constants.*

*The environment in which this product was calibrated is maintained within the operating specifications of the instrument and the standards.*

*The information shown on this certificate applies only to the instrument identified above and the certificate may not be reproduced, except in full, without prior written consent by National Instruments.*

*For questions or comments, please contact National Instruments Technical Support.*

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1/A.  
HUNGARY

Signed,



Andrew Krupp  
Quality Director

\* Recommended calibration due date is based on a combination of calibration interval and, when applicable, calibration shelf life. This date may vary depending on your application requirements.



# Certificate of Calibration

3214337

Certificate Page 1 of 1

## Instrument Identification

Company ID: 229037  
NATIONAL INSTRUMENTS

PO Number: 337683

11500 N. MOPAC EXPWY  
ATTN. RMA DEPT.  
AUSTIN, TX 78759

Instrument ID: 12CBC7A  
Manufacturer: NATIONAL INSTRUMENTS  
Description: 4-CHANNEL,  $\pm 60$  V, 24-BIT SIMULTANEOUS ANALOG INPUT

Model Number: NI 9229  
Serial Number: 12CBC7A

Accuracy: Mfr Specifications

## Certificate Information

Reason For Service: CALIBRATION  
Type of Cal: ACCREDITED 17025  
As Found Condition: IN TOLERANCE  
As Left Condition: LEFT AS FOUND

Technician: WAYNE GETCHELL  
Cal Date: 06May2009  
Cal Due Date: 06May2010  
Interval: 12 MONTHS  
Temperature: 23.0 C  
Humidity: 44.0 %

Procedure: NATIONAL INSTRUMENTS CAL EXECUTIVE REV 3.3.1

Remarks: Reference attached Data.

*The instrument on this certification has been calibrated against standards traceable to the National Institute of Standards and Technology (NIST) or other recognized national metrology institutes, derived from ratio type measurements, or compared to nationally or internationally recognized consensus standards.*

*A test uncertainty ratio (T.U.R.) of 4:1 (K=2, approx. 95% Confidence Level) was maintained unless otherwise stated.*

*Davis Calibration Laboratory is certified to ISO 9001:2000 by Eagle Registrations (certificate # 3046). Lab Operations meet the requirements of ANSI/NCISL Z540-1-1994, ISO 19012:2003, 10CFR30 AppB, and 10CFR21.*

*ISO/IEC 17025-2005 accredited calibrations are per ACLASS certificate # AC-1187 within the scope for which the lab is accredited.*

*All results contained within this certification relate only to item(s) calibrated. Any number of factors may cause the calibration item to drift out of calibration before the instrument's calibration interval has expired.*

*This certificate shall not be reproduced except in full, without written consent of Davis Calibration Laboratory.*

Approved By: VICTOR PENA  
Service Representative

## Calibration Standards

<u>NIST Traceable#</u>	<u>Inst. ID#</u>	<u>Description</u>	<u>Model</u>	<u>Cal Date</u>	<u>Date Due</u>
3143038	15-0271	MULTIFUNCTION CALIBRATOR	5700A	15Apr2009	14Jul2009

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# Certificate of Calibration

3214181

Certificate Page 1 of 1

## Instrument Identification

Company ID: 229037  
NATIONAL INSTRUMENTS

PO Number: 337683

11500 N. MOPAC EXPWY  
ATTN. RMA DEPT.  
AUSTIN, TX 78759

Instrument ID: 12BFEE2  
Manufacturer: NATIONAL INSTRUMENTS  
Description: 4-CH 100 OHM 24-BIT RTD ANALOG INPUT

Model Number: NI 9217  
Serial Number: 12BFEE2

Accuracy: Mfr. Specifications

## Certificate Information

Reason For Service: CALIBRATION  
Type of Cal: ACCREDITED 17025  
As Found Condition: IN TOLERANCE  
As Left Condition: LEFT AS FOUND  
Procedure: CAL EXEC 3.3.1 CAL EXEC 3.3.1

Technician: WAYNE GETCHELL  
Cal Date: 06May2009  
Cal Due Date: 06May2010  
Interval: 12 MONTHS  
Temperature: 23.0 C  
Humidity: 46.0 %

Remarks: Reference attached Data.

*The instrument on this certification has been calibrated against standards traceable to the National Institute of Standards and Technology (NIST) or other recognized national metrology institutes, derived from ratio type measurements, or compared to nationally or internationally recognized consensus standards.*

*A test uncertainty ratio (T.U.R.) of 4:1 [K=2, approx. 95% Confidence Level] was maintained unless otherwise stated.*

*Davis Calibration Laboratory is certified to ISO 9001:2000 by Eagle Registrations (certificate # 3046). Lab Operations meet the requirements of ANSI/NCCL Z540-1-1994, ISO 10012:2003, 10CFR50 AppB, and 10CFR21.*

*ISO/IEC 17025-2005 accredited calibrations are per ACLASS certificate # AC-1187 within the scope for which the lab is accredited. All results contained within this certification relate only to item(s) calibrated. Any number of factors may cause the calibration item to drift out of calibration before the instrument's calibration interval has expired.*

*This certificate shall not be reproduced except in full, without written consent of Davis Calibration Laboratory.*

Approved By: VICTOR PENA  
Service Representative

## Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
3078982	15-0011	DECADE RESISTOR	DB52	24Mar2009	24Mar2010
3004178	15-0060	DIGITAL MULTIMETER (GOLDEN CAL)	3458A OPT 002	17Feb2009	17May2009

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Certificate of Calibration

3214135

Certificate Page 1 of 1

Instrument Identification

Company ID: 229037  
NATIONAL INSTRUMENTS

PO Number: 337683

11500 N. MOPAC EXPWY  
ATTN. RMA DEPT.  
AUSTIN, TX 78759

Instrument ID: 12E9C99

Model Number: NI 9205

Manufacturer: NATIONAL INSTRUMENTS

Serial Number: 12E9C99

Description: 32-CH ±200 MV TO ±10 V, 16-BIT, 250 KS/S ANALOG INPUT MODULE

Accuracy: Mfr Specifications

Certificate Information

Reason For Service: CALIBRATION

Technician: WAYNE GETCHELL

Type of Cal: ACCREDITED 17025

Cal Date: 06May2009

As Found Condition: IN TOLERANCE

Cal Due Date: 06May2010

As Left Condition: LEFT AS FOUND

Interval: 12 MONTHS

Procedure: NATIONAL INSTRUMENTS CAL EXECUTIVE REV 3.3.1

Temperature: 23.0 C

Humidity: 47.0 %

Remarks: Reference attached Data.

The instrument on this certification has been calibrated against standards traceable to the National Institute of Standards and Technology (NIST) or other recognized national metrology institutes, derived from ratio type measurements, or compared to nationally or internationally recognized consensus standards.

A test uncertainty ratio (T.U.R.) of 4:1 [K=2, approx. 95% Confidence Level] was maintained unless otherwise stated.

Davis Calibration Laboratory is certified to ISO 9001:2000 by Eagle Registrations (certificate # 3046). Lab Operations meet the requirements of ANSI/NCSL Z540-1-1994, ISO 10012:2003, 10CFR59 AppxB, and 16CFR21.

ISO/IEC 17025-2005 accredited calibrations are per ACLASS certificate # AC-1187 within the scope for which the lab is accredited. All results contained within this certification relate only to item(s) calibrated. Any number of factors may cause the calibration item to drift out of calibration before the instrument's calibration interval has expired.

This certificate shall not be reproduced except in full, without written consent of Davis Calibration Laboratory.

Approved By: VICTOR PENA  
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
3143038	15-0271	MULTIFUNCTION CALIBRATOR	5700A	15Apr2009	14Jul2009

**Board Information:**

Serial Number: 140A596  
NI Part Number: 192580G-02L  
Description: NI 9229

**Certificate Information:**

Certificate Number: 1309509  
Date Printed: 03-APR-09

Calibration Date: 10-FEB-09  
Recommended Calibration Due Date: 10-FEB-10\*

Ambient Temperature: 23 °C  
Relative Humidity: 41 %

*National Instruments certifies that at the time of manufacture, the above product was calibrated in accordance with applicable National Instruments procedures. These procedures are in compliance with relevant clauses of ISO 9001 and are designed to assure that the product listed above meets or exceeds National Instruments specifications.*

*National Instruments further certifies that the measurements standards and instruments used during the calibration of this product are traceable to National and/or International Standards administered by NIST or Euromet members or are derived from accepted values of natural physical constants.*

*The environment in which this product was calibrated is maintained within the operating specifications of the instrument and the standards.*

*The information shown on this certificate applies only to the instrument identified above and the certificate may not be reproduced, except in full, without prior written consent by National Instruments.*

*For questions or comments, please contact National Instruments Technical Support.*

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1/A.  
HUNGARY

Signed,



Andrew Krupp  
Vice President, Quality and  
Continuous Improvement

\* Recommended calibration due date is based on a combination of calibration interval and, when applicable, calibration shelf life. This date may vary depending on your application requirements.



# Certificate of Calibration



4111865

Certificate Page 1 of 1

## Instrument Identification

Company ID: 120205  
NREL  
METROLOGY LAB / BEV KAY  
16253 DENVER WEST PARKWAY  
GOLDEN, CO, 80401

PO Number: CC-BEVERLY KAY

Instrument ID: **04074C** Model Number: NI 9229  
Manufacturer: NATIONAL INSTRUMENTS Serial Number: 140A596  
Description: 4-CHANNEL, ±60 V, 24-BIT SIMULTANEOUS ANALOG INPUT

Accuracy: Mfr Specifications

## Certificate Information

Reason For Service: CALIBRATION Technician: COREY CLAXTON  
Type of Cal: ACCREDITED 17025 WITH UNCERTAINTIES Cal Date 29Apr2010  
As Found Condition: IN TOLERANCE Cal Due Date: 29Apr2011  
As Left Condition: LEFT AS FOUND Interval: 12 MONTHS  
Procedure: NATIONAL INSTRUMENTS CAL EXECUTIVE REV 3.3.2 Temperature: 23.0 C  
Humidity: 58.0 %  
Remarks: CALIBRATED WITH DATA, REFER TO ATTACHED DATA FOR BEFORE AND AFTER READINGS.

*The instrument on this certification has been calibrated against standards traceable to the National Institute of Standards and Technology (NIST) or other recognized national metrology institutes, derived from ratio type measurements, or compared to nationally or internationally recognized consensus standards.*

*A test uncertainty ratio (T.U.R.) of 4:1 (K=2, approx. 95% Confidence Level) was maintained unless otherwise stated.*

*Davis Calibration Laboratory is certified to ISO 9001:2008 by Eagle Registrations (certificate # 3046). Lab Operations meet the requirements of ANSI/ISO/IEC 17025 (R2002), ISO 10012:2003, IEC/ISO AppB, and IEC/IEC 21.*

*ISO/IEC 17025-2005 accredited calibrations are per ACLASS certificate # AC-1187 within the scope for which the lab is accredited.*

*When uncertainty measurement calculations have been calculated per customer request, reported condition statements do not take into account uncertainty of measurement.*

*All results contained within this certification relate only to item(s) calibrated. Any number of factors may cause the calibration item to drift out of calibration before the instrument's calibration interval has expired.*

*This certificate shall not be reproduced except in full, without written consent of Davis Calibration Laboratory.*

Approved By: COREY CLAXTON  
Service Representative

## Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4047816	15-0048	MULTIFUNCTION CALIBRATOR	5700A	07Apr2010	06Jul2010

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**Board Information:**

Serial Number: 140DCB9  
NI Part Number: 192547E-01L  
Description: NI 9217

**Certificate Information:**

Certificate Number: 1313164  
Date Printed: 06-APR-09

Calibration Date: 12-FEB-09  
Recommended Calibration Due Date: 12-FEB-10\*

Ambient Temperature: 22 °C  
Relative Humidity: 42 %

*National Instruments certifies that at the time of manufacture, the above product was calibrated in accordance with applicable National Instruments procedures. These procedures are in compliance with relevant clauses of ISO 9001 and are designed to assure that the product listed above meets or exceeds National Instruments specifications.*

*National Instruments further certifies that the measurements standards and instruments used during the calibration of this product are traceable to National and/or International Standards administered by NIST or Euromet members or are derived from accepted values of natural physical constants.*

*The environment in which this product was calibrated is maintained within the operating specifications of the instrument and the standards.*

*The information shown on this certificate applies only to the instrument identified above and the certificate may not be reproduced, except in full, without prior written consent by National Instruments.*

*For questions or comments, please contact National Instruments Technical Support.*

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1/A.  
HUNGARY

Signed,



Andrew Krupp  
Vice President, Quality and  
Continuous Improvement

\* Recommended calibration due date is based on a combination of calibration interval and, when applicable, calibration shelf life. This date may vary depending on your application requirements.



# Certificate of Calibration



4111821

Certificate Page 1 of 1

## Instrument Identification

Company ID: 120205  
NREL  
METROLOGY LAB / BEV KAY  
16253 DENVER WEST PARKWAY  
GOLDEN, CO, 80401

PO Number: CC-BEVERLY KAY

Instrument ID: **04072C**  
Manufacturer: NATIONAL INSTRUMENTS  
Description: 4-CH 100 OHM 24-BIT RTD ANALOG INPUT

Model Number: NI 9217  
Serial Number: 140DCB9

Accuracy: Mfr. Specifications

## Certificate Information

Reason For Service: CALIBRATION  
Type of Cal: ACCREDITED 17025 WITH UNCERTAINTIES  
As Found Condition: IN TOLERANCE  
As Left Condition: LEFT AS FOUND  
Procedure: NATIONAL INSTRUMENTS CAL EXECUTIVE REV 3.3.2

Technician: COREY CLAXTON  
Cal Date: 29Apr2010  
Cal Due Date: 29Apr2011  
Interval: 12 MONTHS  
Temperature: 23.0 C  
Humidity: 58.0 %

Remarks: CALIBRATED WITH DATA, REFER TO ATTACHED DATA FOR BEFORE AND AFTER READINGS.

*The instrument on this certification has been calibrated against standards traceable to the National Institute of Standards and Technology (NIST) or other recognized national metrology institutes, derived from ratio type measurements, or compared to nationally or internationally recognized consensus standards.*

*A test uncertainty ratio (T.U.R.) of 4:1 [K=2, approx. 95% Confidence Level] was maintained unless otherwise stated.*

*Davis Calibration Laboratory is certified to ISO 9001:2008 by Eagle Registrations (certificate # 3046). Lab Operations meet the requirements of ANSI/NCCL Z540-1:1994 (R2002), ISO 10012:2003, 10CFR50 AppB, and 10CFR21.*

*ISO/IEC 17025:2005 accredited calibrations are per ACLASS certificate # AC-1187 within the scope for which the lab is accredited. When uncertainty measurement calculations have been calculated per customer request, reported condition statements do not take into account uncertainty of measurement. All results contained within this certification relate only to item(s) calibrated. Any number of factors may cause the calibration item to drift out of calibration before the instrument's calibration interval has expired.*

*This certificate shall not be reproduced except in full, without written consent of Davis Calibration Laboratory.*

Approved By: COREY CLAXTON  
Service Representative

## Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4085286	15-0060	DIGITAL MULTIMETER (GOLDEN CAL)	3458A OPT 002	15Apr2010	14Jul2010

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**Board Information:**

Serial Number: 140E2BD  
NI Part Number: 193299F-01  
Description: NI-9205

**Certificate Information:**

Certificate Number: 1308869  
Date Printed: 06-APR-09

Calibration Date: 10-FEB-09  
Recommended Calibration Due Date: 10-FEB-10\*

Ambient Temperature: 23 °C  
Relative Humidity: 40 %

*National Instruments certifies that at the time of manufacture, the above product was calibrated in accordance with applicable National Instruments procedures. These procedures are in compliance with relevant clauses of ISO 9001 and are designed to assure that the product listed above meets or exceeds National Instruments specifications.*

*National Instruments further certifies that the measurements standards and instruments used during the calibration of this product are traceable to National and/or International Standards administered by NIST or Euromet members or are derived from accepted values of natural physical constants.*

*The environment in which this product was calibrated is maintained within the operating specifications of the instrument and the standards.*

*The information shown on this certificate applies only to the instrument identified above and the certificate may not be reproduced, except in full, without prior written consent by National Instruments.*

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Signed,



Andrew Krupp  
Vice President, Quality and  
Continuous Improvement

\* Recommended calibration due date is based on a combination of calibration interval and, when applicable, calibration shelf life. This date may vary depending on your application requirements.



# Certificate of Calibration



4111826

Certificate Page 1 of 1

## Instrument Identification

Company ID: 120205  
NREL  
METROLOGY LAB / BEV KAY  
16253 DENVER WEST PARKWAY  
GOLDEN, CO, 80401

PO Number: CC-BEVERLY KAY

Instrument ID: **04071C** Model Number: NI 9205  
Manufacturer: NATIONAL INSTRUMENTS Serial Number: 140E2BD  
Description: 32-CH  $\pm 200$  MV TO  $\pm 10$  V, 16-BIT, 250 KS/S ANALOG INPUT MODULE

Accuracy: Mfr Specifications

## Certificate Information

Reason For Service: CALIBRATION Technician: COREY CLAXTON  
Type of Cal: ACCREDITED 17025 WITH UNCERTAINTIES Cal Date: 29Apr2010  
As Found Condition: IN TOLERANCE Cal Due Date: 29Apr2011  
As Left Condition: LEFT AS FOUND Interval: 12 MONTHS  
Procedure: NATIONAL INSTRUMENTS CAL EXECUTIVE REV 3.3.2 Temperature: 23.0 C  
Humidity: 58.0 %  
Remarks: CALIBRATED WITH DATA, REFER TO ATTACHED DATA FOR BEFORE AND AFTER READINGS.

*The instrument on this certification has been calibrated against standards traceable to the National Institute of Standards and Technology (NIST) or other recognized national metrology institutes, derived from ratio type measurements, or compared to nationally or internationally recognized consensus standards.*

*A test uncertainty ratio (T.U.R.) of 4:1 [K=2, approx. 95% Confidence Level] was maintained unless otherwise stated.*

*Davis Calibration Laboratory is certified to ISO 9001:2008 by Eagle Registrations (certificate # 3046). Lab Operations meet the requirements of ANSI/NCSL Z540-1-1994 (R2002), ISO 10012:2003, 10CFR50 AppxB, and 10CFR21.*

*ISO/IEC 17025-2005 accredited calibrations are per ACLASS certificate # AC-1187 within the scope for which the lab is accredited.*

*When uncertainty measurement calculations have been calculated per customer request, reported condition statements do not take into account uncertainty of measurement.*

*All results contained within this certification relate only to item(s) calibrated. Any number of factors may cause the calibration item to drift out of calibration before the instrument's calibration interval has expired.*

*This certificate shall not be reproduced except in full, without written consent of Davis Calibration Laboratory.*

Approved By: COREY CLAXTON  
Service Representative

## Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4047816	15-0048	MULTIFUNCTION CALIBRATOR	5700A	07Apr2010	06Jul2010

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