Acoustic Noise Test Report for the U.S. Department of Energy 1.5-Megawatt Wind Turbine

J. Roadman and A. Huskey
National Renewable Energy Laboratory

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Technical Report
NREL/TP-5000-63681
July 2015

Contract No. DE-AC36-08GO28308

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Prepared under Task No. WE15.1A02

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Acoustic Noise Test Report

for the

DOE 1.5-MW Wind Turbine

in

Golden, Colorado, USA

Conducted for

U.S. Department of Energy Office of Energy Efficiency and Renewable Energy
Wind and Water Power Program
Forrestal Building
1000 Independence Avenue, SW
Washington, DC 20585

Conducted by

National Wind Technology Center
National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, Colorado 80401

Jason Roadman and Arlinda Huskey

March 2011

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Approval By: Arlinda Huskey — 23 Apr 2015
Arlinda Huskey, NREL Test Engineer — Date

Review By: — 27 April 2015
Jeroen van Dam, NREL Test Engineer — Date

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Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Pressure Transmitter DOE #: 03466C

Model # : PTB101B S/N : B2130018

Calibration Date: 09/22/2010 Due Date: 09/22/2011

No	Function Tested	Nominal Value (kPa)	Measured Output Voltage (VDC)		( )Mfr. Specs. OR (X)Data only (mb)
			As Found	As Left	
*	Absolute Pressure				
		65	0.265		
		70	0.538		
		75	0.809		
		80	1.081		
		85	1.352		
		90	1.624		
		95	1.895		
		100	2.167		
		103	2.330		
	Notes: 1. Expanded Uncertainty of the nominal value is ± 0.2 kPa, with k = 2. 2. Calibration was performed at 24°C and 39% RH. 3. Calibration was performed using standards that are traceable to NIST. DOE numbers: 128120, and 02301C.				

Calibrated By: P. Morse
Date: 09/22/2010

Approved By: D. Myers
Date: 09/22/2010

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1 Background

The U.S. Department of Energy (DOE) acquired and installed a 1.5-megawatt (MW) wind turbine at the National Wind Technology Center (NWTC) at the National Renewable Energy Laboratory. This turbine (hereafter referred to as the DOE 1.5) is envisioned to become an integral part of the research initiatives for the DOE Wind Program, such as Atmosphere to Electrons (A2e). A2e is a multiyear DOE research initiative targeting significant reductions in the cost of wind energy through an improved understanding of the complex physics governing wind flow into and through wind farms. For more information, visit http://energy.gov/eere/wind/atmosphere-electrons.

To validate new and existing high-fidelity simulations, A2e must deploy several experimental measurement campaigns across different scales. Proposed experiments include wind tunnel tests, scaled field tests, and large field measurement campaigns at operating wind plants. Data of interest includes long-term atmospheric data sets, wind plant inflow, intra-wind plant flows (e.g., wakes), and rotor loads measurements. It is expected that new, high-fidelity instrumentation will be required to successfully collect data at the resolutions required to validate the high-fidelity simulations.

The large-scale field measurement campaigns are expected to use the DOE 1.5 as it is of sufficient enough size to represent current technology, and turbines of this size are widely deployed in U.S. wind plants.

Expected future use of the DOE 1.5 at the NWTC may include the following (leading up to the large files measurement campaigns at operating plants):

- Deployment and validation of high-fidelity instrumentation prior to large-scale deployment at a wind plant
- Deployment of advanced controls algorithms
- Characterization of inflow, aerodynamics, turbine loads, and wake propagation on an unwaked turbine.

A series of tests were conducted to characterize the baseline properties and performance of the DOE 1.5 to enable research model development and quantify the effects of future turbine research modifications.

The tests included:

- Power performance per International Electrotechnical Commission (IEC) 61400-12-1
- Power quality per IEC 61400-21
- Acoustic noise per IEC 61400-11
- Mechanical loads per IEC 61400-13
- Modal testing.

The DOE 1.5 is built on the platform of GE's 1.5-MW SLE commercial wind turbine model. It was installed in a nonstandard configuration at the NWTC with the objective of supporting DOE Wind Program research initiatives such as A2e. Therefore, the test results may not represent the performance capabilities of other GE 1.5-MW SLE turbines.

The acoustic noise test documented in this report is one of a series of tests carried out to establish a performance baseline for the DOE 1.5 in the NWTC inflow environment.

2 Test Summary

The turbine was tested in accordance with the International Electrotechnical Commission's (IEC) standard IEC 61400-11, Edition 2.1, 2006-11, *Wind Turbine Generator Systems—Part 11: Acoustic Noise Measurement Techniques*, hereafter referred to as the Standard. Turbine acoustic emissions and meteorological data were collected on 3 days: March 3, 2011; March 22, 2011; and April 4, 2011. The standardized wind speed (at 10 meters [m]) was derived from power when the turbine was operating at less than 95% rated power. When the turbine was operating above 95% rated power, standardized wind speed was determined from a correlation between the nacelle anemometer and the wind speed derived from power. For background measurements, the standardized wind speed was determined from a correlation between the wind speed measured at hub height (80 m) and the wind speed derived from power.

3 Test Turbine Configuration

Table 1 lists the general data configuration for the DOE 1.5 that was tested at the NWTC.

Table 1. General Data Configuration for the DOE 1.5

Turbine manufacturer and address	GE Energy 300 Garlington Rd., P.O. 648 Greenville, SC 29602-0648
Model	GE 1.5-MW SLE
Rated power (kW)	1,500
Rated wind speed (m/s)	14
Serial number	N000780-N
Blade make, type, and serial number	GE37c, fiberglass, S00028, S00029, S00030
Generator make, type, and serial number	Winergy, doubly-fed induction, JFEC-500SS-06A
Gearbox make, type, and serial number	GETS, multistage planetary/helical, 7GA87E2, EE0809404
Control software	WindSCADA
Wind turbine type	Horizontal axis, upwind
Tower type	Tubular
Number of blades	3
Hub height (m)	80
Rotor diameter (m)	77
Horizontal distance from rotor center to tower axis (m)	3.8
Speed control	Pitch control
Constant or variable speed	Variable
Rotational speeds at standardized integer wind speeds from 6 m/s to 10 m/s (rpm)	10–20
Pitch angle at standardized integer wind speeds from 6 m/s to 10 m/s (rpm)	Variable
Rotor control devices	None
Presence of vortex generators, stall	None

Figure 1. DOE 1.5 at the NWTC. ***Photo by Jeroen van Dam, NREL***

4 Test Site Description

The test turbine is located at site 4.0 at the NWTC, which is approximately 8 miles south of Boulder, Colorado. The terrain consists of mostly flat land with short vegetation (see Appendix A for photos). The site has prevailing winds bearing approximately 292 degrees relative to true north. Figure 2 shows the test turbine and meteorological (met) tower locations. Also shown are nearby obstructions and topographical features. Table 2 shows the nearby turbines and whether they were operating during data collection.

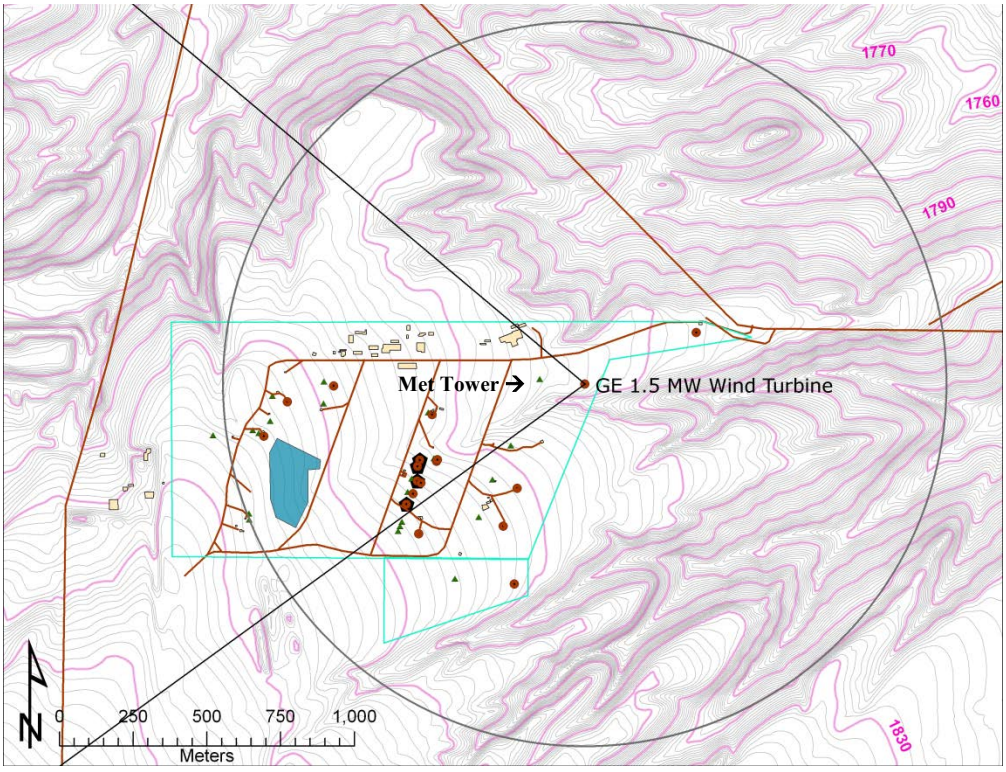

Figure 2. Map of the NWTC's 4.0 test site and area surrounding the DOE 1.5

Table 2. Structures Located Near the DOE 1.5

Source	Site	Operating
Alstom	4.1	No
Controls Advanced Research Turbine (CART)-3	4.2	No
CART-2	4.3	No
Siemens 2.3 MW	4.4	March 22, 2011 April 4, 2011

5 Description of Test Equipment

Table 3 lists the equipment used for the test. All instruments meet the requirements defined by the Standard [1].

Table 3. Test Equipment

Instrument	Manufacturer	Model Number	Serial Number	Calibration Due Date
Digital recorder and signal analyzer	Delta Acoustics	NoiseLab	1258E43	Nov. 9, 2012
Microphone	Brüel & Kjær	4189-A-21	2395206 2395209	Nov. 8, 2012 Nov. 8, 2012
Preamplifier	Brüel & Kjær	4012	2373719 2373721	Nov. 8, 2012 Nov. 8, 2012
Calibrator	Brüel & Kjær	4231	2326144	Nov. 8, 2011
Primary anemometer	Thies	First Class	0909219	Dec. 20, 2011
Wind vane	Met One Instruments	WD-201	K16689* J5950	Jan. 19, 2012 Mar. 31, 2012
Nacelle anemometer	Renewable NRG Systems	IceFree Hybrid XT	3734-0000726	n/a
Pressure sensor	Vaisala	PTB101B	B2130018	Dec. 22, 2011
Temperature sensor	Met One Instruments	T-200 RTD	0673552	Dec. 22, 2011
Power transducer	Ohio Semitronics	DWV-008D	09070337	Jan. 7, 2012
Data acquisition	National Instruments	Compact DAQ w/LabView cDAQ backplane NI 9229 NI 9217 NI 9205	1361570 12B6DD2 12BD192 12E9CD3	n/a Aug. 21, 2011 Aug. 21, 2011 Aug. 21 2011

* Replaced midtest with J5950

5.1 Instrument Locations

The anemometer and wind vane were located on a meteorological tower 153.4 m from the test turbine at a bearing of 276 degrees true north. The anemometer was at a hub height of 80 m. The meteorological tower distance is 2.0 rotor diameters from the test turbine, which is within the range of 2 and 4 rotor diameters specified in the Standard [1].

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

Table 4. Microphone Positions for Turbine and Background Measurements

Microphone	Distance Turbine (m)	Slant Distance (m)	Position Relative to Turbine (deg. true north)
Reference	117.9	145.6	271

6 Test Results

6.1 Test Conditions

The analysis was done using the measured wind speed, power, and 1-min averages of the data.

For the March 3, 2011, data, the standardized wind speeds and wind directions ranged from 6.8 meters per second (m/s) to 11.7 m/s and 258 degrees to 279 degrees, respectively. The temperature and pressure ranged from 10.2°C to 11.0°C and 80.0 kilopascals (kPa) to 80.1 kPa, respectively.

For the March 22, 2011, data, the standardized wind speeds and wind directions ranged from 4.3 m/s to 10.5 m/s and 256 degrees to 281 degrees, respectively. The temperature and pressure ranged from 4.0°C to 4.9°C and 79.5 kPa to 79.6 kPa, respectively.

For the April 4, 2011, data, the standardized wind speeds and wind directions ranged from 3.5 m/s to 8.6 m/s and 264 degrees to 285 degrees, respectively. The temperature and pressure ranged from -1.2°C to 1.7°C and 80.8 kPa to 80.9 kPa, respectively.

6.2 Standardized Wind Speed Calculation

For 1-min average periods when power was less than 95% of rated, the wind speed at hub height was derived from the power curve, as shown in Figure 3 [2]. These points were correlated to the nacelle wind speed, and the extrapolation of this correlation, as shown in Figure 4, was used to derive the wind speed at hub height when the turbine was operating above 95% rated power. Additionally, the points below 95% rated power were used to create a correlation between measured wind speed at hub height and the derived wind speed from power. This correlation, shown in Figure 5, was used to calculate the derived wind speed from the measured wind speed at hub height during background measurements. In this test, wind speed at a hub height of 80.0 m was standardized to a height of 10 m, assuming an idealized wind profile based on an assumed terrain roughness of 0.05 m.

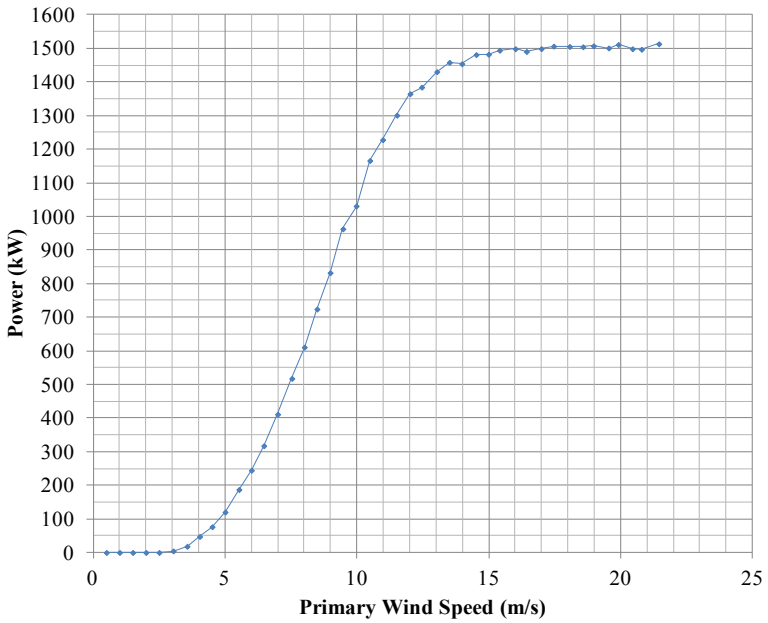

Figure 3. DOE 1.5 SLE site-specific power curve [2]

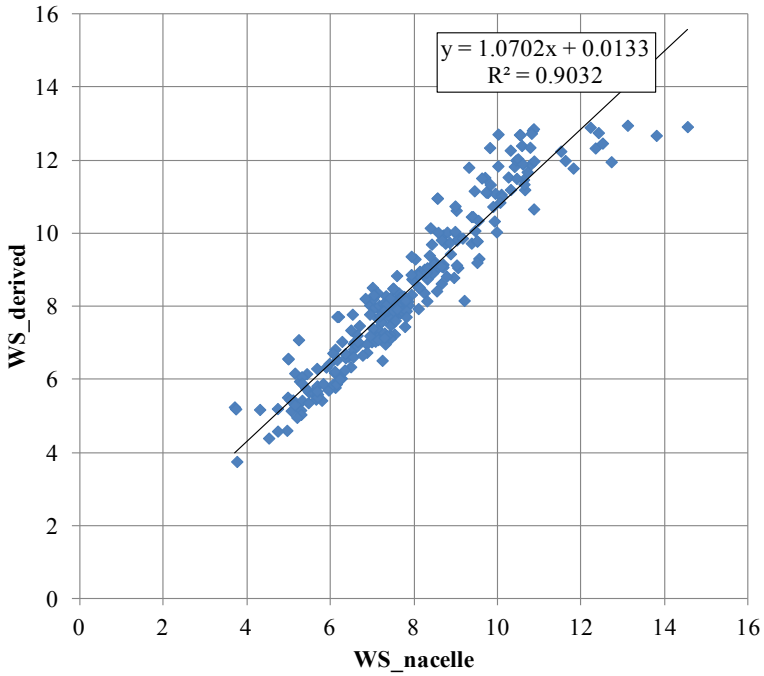

Figure 4. Wind speed from power compared to the nacelle wind speed

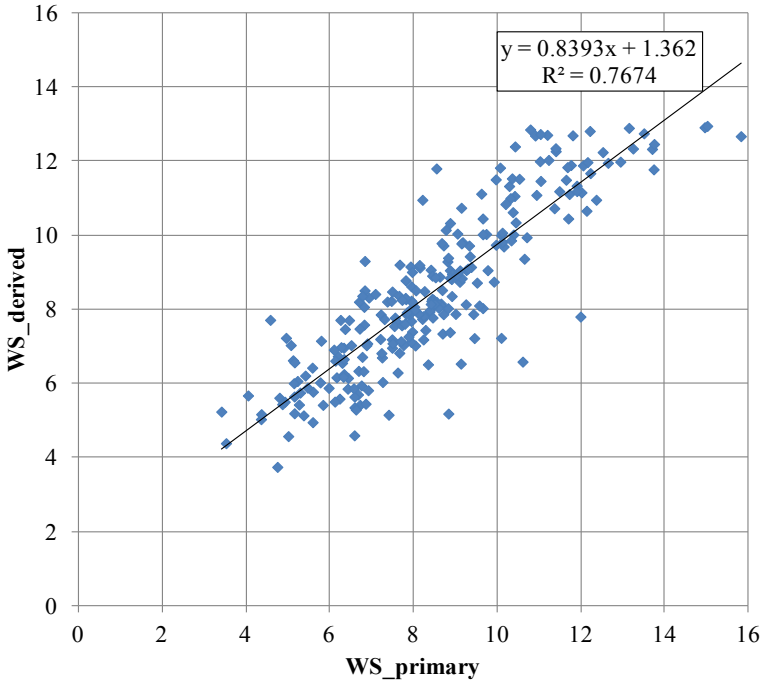

Figure 5. Wind speed from power compared to the primary wind speed

6.3 Apparent Sound Power Level

The sound pressure levels at the integer wind speeds were calculated from a fourth-order regression using the valid measured data. These levels were then background corrected to calculate the sound power levels. The apparent sound power level at standardized wind speeds of 5 m/s, 6 m/s, 7 m/s, 8 m/s, 9 m/s, and 10 m/s are shown in Table 5 and Figure 6.

Table 5. Sound Power Levels for Standardized Integer Wind Speeds 5 m/s through 10 m/s

Wind Speed Bin (m/s)	Sound Power Level (dBA)	Combined Standard Uncertainty (dBA)
5	99.9	3.8
6	102.9	2.8
7	104.1	1.1
8	103.9	1.6
9	102.7	2.5
10	101.2	2.4

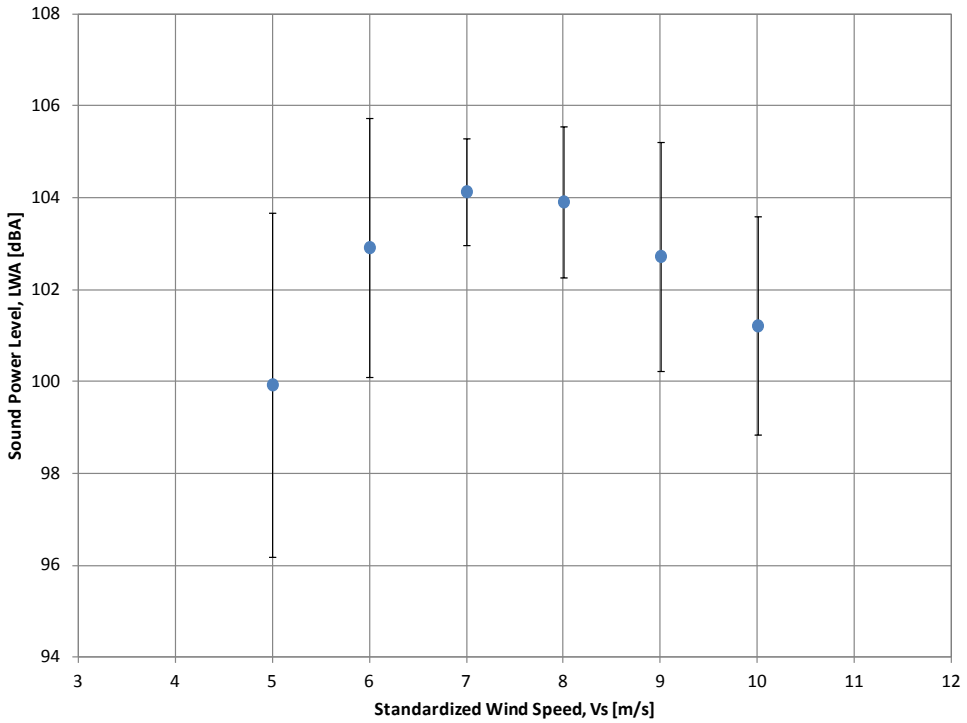

Figure 6. Sound power levels as a function of the standardized wind speed

Figure 7 shows a scatterplot of the sound pressure levels of the validated total (operating plus background) and background noise.

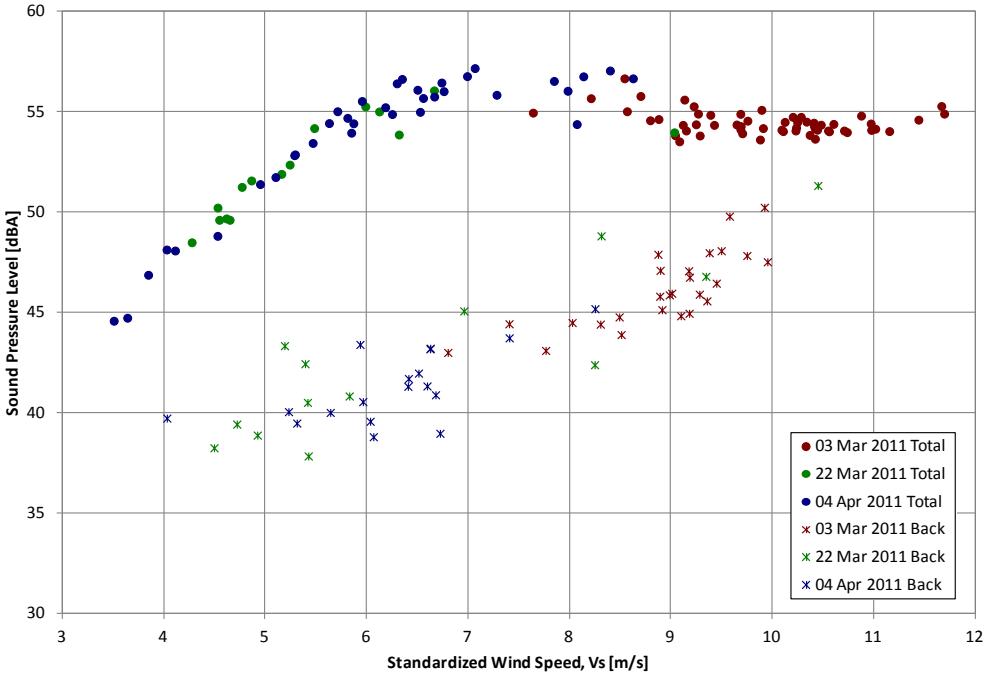

Figure 7. Measured sound pressure levels as a function of the standardized wind speed

6.4 One-Third Octave Analysis

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

Table 6. One-Third Octave Analysis for Wind Speeds 5 m/s through 7 m/s

Center Frequency	5 m/s One-Third Octave Levels (dBA)	6 m/s One-Third Octave Levels (dBA)	7 m/s One-Third Octave Levels (dBA)
50	22.8 ± 3.5	25.5 ± 2.9	26.4 ± 2.1
63	26.6 ± 3.2	29.0 ± 2.8	30.4 ± 2.2
80	31.7 ± 2.0	32.4 ± 2.3	34.1 ± 2.5
100	37.5 ± 4.8	41.3 ± 3.6	42.7 ± 2.1
125	34.3* ± 4.9	39.1 ± 3.9	41.0 ± 2.2
160	35.5 ± 4.7	39.7 ± 4.0	41.8 ± 2.3
200	37.9 ± 5.1	42.3 ± 3.9	43.8 ± 2.1
250	40.1 ± 5.0	44.3 ± 3.7	45.6 ± 1.9
315	41.9 ± 4.9	45.8 ± 3.5	46.9 ± 1.9
400	42.5 ± 4.5	45.9 ± 3.2	46.8 ± 1.8
500	42.7 ± 4.6	46.2 ± 3.3	47.1 ± 1.9
630	42.0 ± 4.1	45.0 ± 3.0	45.7 ± 1.9
800	41.6 ± 3.7	44.1 ± 2.7	44.7 ± 1.9
1,000	40.2 ± 3.6	42.7 ± 2.8	43.4 ± 2.1
1,250	38.6 ± 3.6	41.1 ± 2.8	42.0 ± 2.1
1,600	36.6 ± 3.8	39.3 ± 3.0	40.3 ± 2.2
2,000	33.9 ± 4.2	36.9 ± 3.0	37.6 ± 2.0
2,500	31.5 ± 4.2	34.7 ± 3.1	35.5 ± 2.0
3,150	29.3 ± 4.5	33.0 ± 3.3	33.8 ± 2.0
4,000	26.3* ± 4.5	30.3 ± 3.4	31.3 ± 2.0
5,000	24.1* ± 4.0	27.0* ± 3.4	28.5* ± 2.3
6,300	NR	NR	NR
8,000	NR	NR	NR
10,000	NR	NR	NR

* The difference between the 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 the total and background noise was less than 3 dB, so no results were reported.

Table 7. One-Third Octave Analysis for Wind Speeds 8 m/s through 10 m/s

Center Frequency	8 m/s One-Third Octave Levels (dBA)	9 m/s One-Third Octave Levels (dBA)	10 m/s One-Third Octave Levels (dBA)
50	26.2 ± 1.9	26.6 ± 1.8	25.7* ± 2.0
63	30.4 ± 1.9	30.0 ± 2.0	29.2 ± 2.0
80	34.6 ± 2.0	32.9 ± 2.4	32.3 ± 2.1
100	42.7 ± 2.4	40.0 ± 3.3	38.6 ± 2.3
125	40.5 ± 2.3	38.3 ± 2.9	37.1* ± 2.4
160	41.4 ± 2.4	39.0 ± 3.1	37.5* ± 2.5
200	43.5 ± 2.8	40.2 ± 4.0	38.2* ± 2.9
250	45.1 ± 3.1	41.6 ± 4.8	38.7* ± 3.6
315	46.4 ± 2.8	43.5 ± 4.1	41.0* ± 3.1
400	46.2 ± 2.9	43.1 ± 4.0	40.8* ± 2.9
500	46.9 ± 2.4	44.6 ± 3.0	42.9* ± 2.3
630	45.5 ± 1.9	44.4 ± 2.2	43.2* ± 2.1
800	44.6 ± 1.8	44.3 ± 1.9	43.5* ± 2.0
1,000	43.8 ± 2.1	44.7 ± 2.1	44.2* ± 2.0
1,250	42.4 ± 2.2	43.7 ± 2.3	43.1* ± 2.0
1,600	40.7 ± 2.2	41.9 ± 2.2	41.3* ± 2.0
2,000	37.7 ± 2.1	38.9 ± 2.2	38.3* ± 2.0
2,500	35.4 ± 2.0	36.2 ± 2.0	35.6* ± 2.0
3,150	33.4 ± 1.9	33.6 ± 1.9	NR
4,000	30.7* ± 2.1	31.1* ± 2.0	NR
5,000	NR	30.9* ± 2.9	NR
6,300	NR	NR	NR
8,000	NR	NR	NR
10,000	NR	NR	NR

* The difference between the 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 the total and background noise was less than 3 dB, so no results were reported.

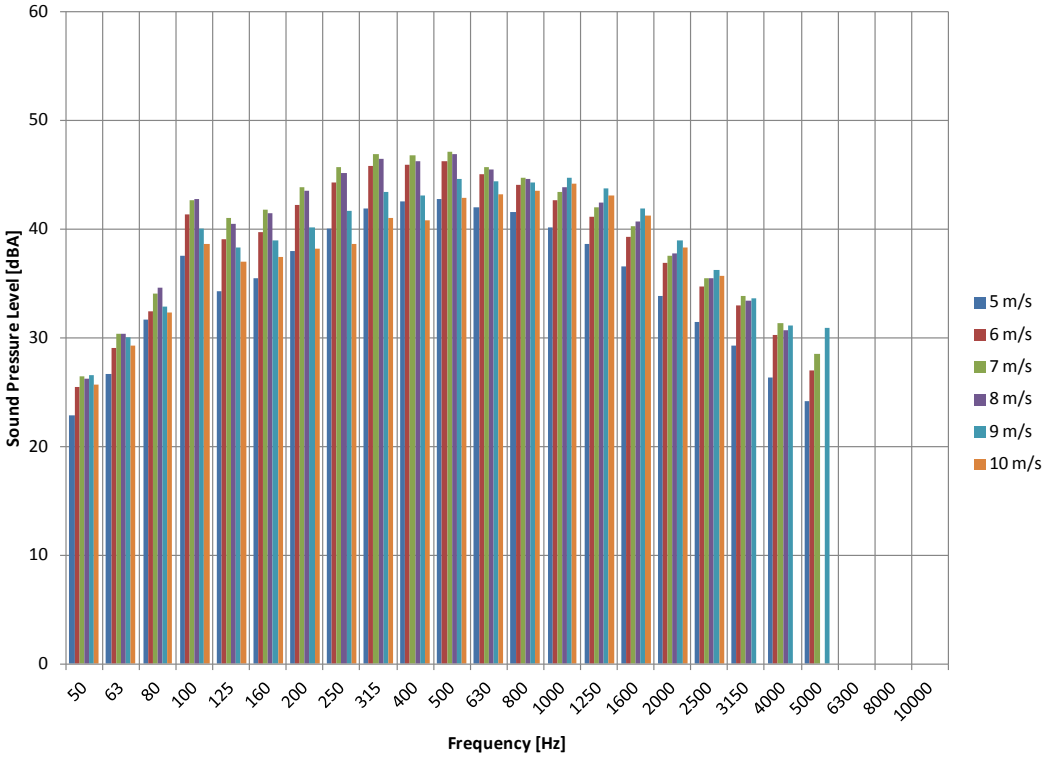

Figure 8. One-third octave levels

6.5 Tonality

The tonality analysis resulted in reportable tones for 5 m/s and 6 m/s. Table 8 shows the results for the tonality analysis.

Table 8. Tonality Results

k (m/s)	5		6
Freq (Hz)	90	99	105
$\Delta L_{tn1,k}$	-1.6	-13.6	-2.2
$\Delta L_{tn2,k}$	-0.8	-13.6	-0.1
$\Delta L_{tn3,k}$	-5.6	-5.6	-0.4
$\Delta L_{tn4,k}$	-3.5	-3.5	-0.2
$\Delta L_{tn5,k}$	-0.8	-0.8	-0.9
$\Delta L_{tn6,k}$	0.2	0.2	-1.4
$\Delta L_{tn7,k}$	-13.3	-0.5	-0.7
$\Delta L_{tn8,k}$	-13.3	1.4	-1.1
$\Delta L_{tn9,k}$	-0.8	-0.8	1.6
$\Delta L_{tn10,k}$	-1.9	-13.6	3.6
$\Delta L_{tn11,k}$	-13.3	-13.6	-3.3
$\Delta L_{tn12,k}$	-13.3	-13.6	-5.0
ΔL_k dB(A)	-3.2	-3.1	-0.3
$\Delta L_{a,k}$ dB(A)	-1.2	-1.1	1.7
U_A dB(A)	4.5	4.1	1.5
U_B dB(A)	2.2	2.2	2.2
U_C dB(A)	5.0	4.7	2.6

Figures 9 through Figure 11 show typical 10-s energy-averaged spectrums indicating the classifications of the spectral lines for each of the identified tones.

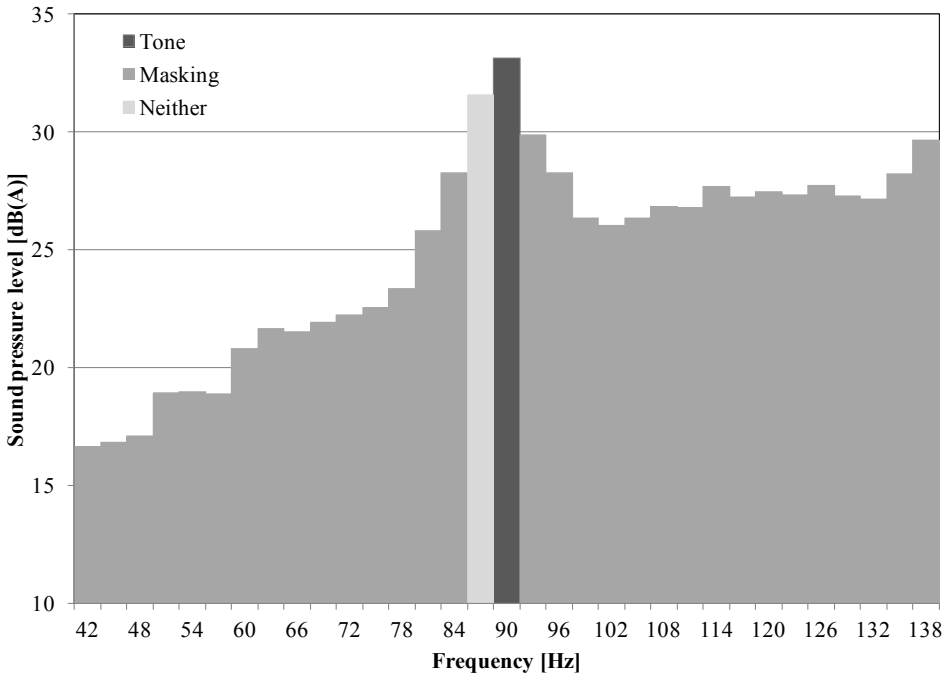

Figure 9. Classifications of the spectral lines for the 90-Hz tone typical in the 5-m/s bin

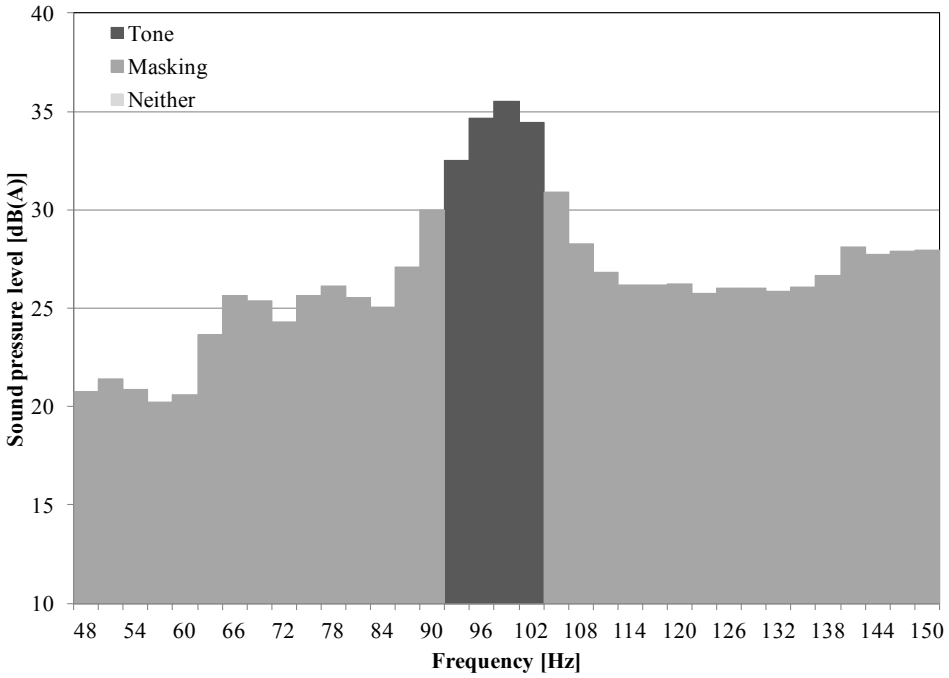

Figure 10. Classifications of the spectral lines for the 99-Hz tone typical in the 5-m/s bin

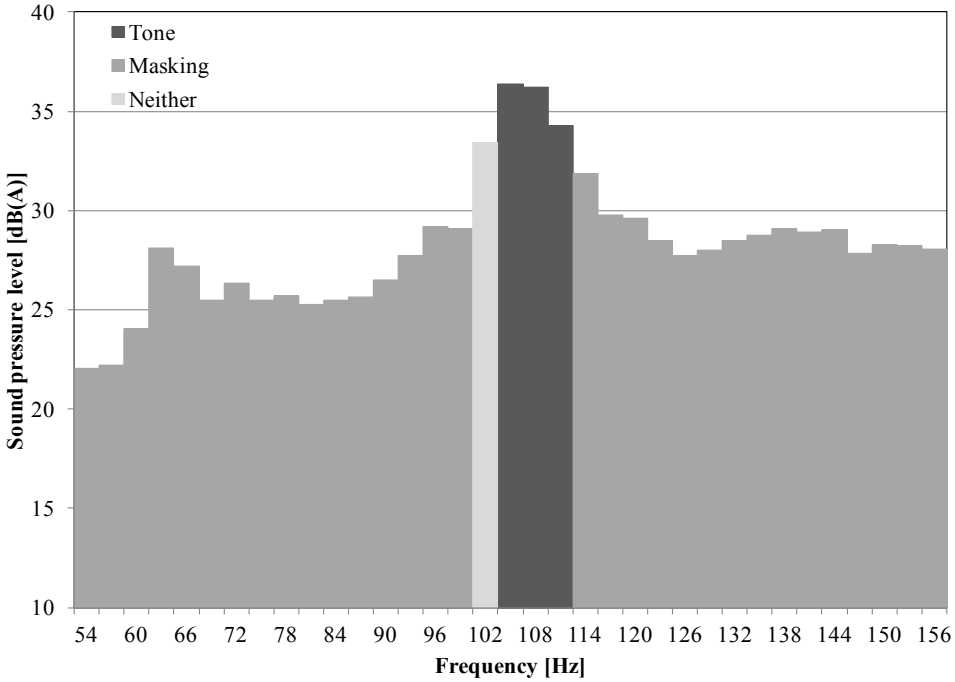

Figure 11. Classifications of the spectral lines for the 105-Hz tone typical in the 6-m/s bin

6.6 Uncertainty

The Type A uncertainties for sound power levels, one-third octave levels, and tonality were calculated using the methods prescribed in the Standard [1].

The Type B uncertainty components are shown in Table 9. Additional uncertainty, compared to the standard value, was incorporated in U_{B7} because the anemometer was boom mounted instead of top mounted. Also, it is suspected that the turbine itself influenced the primary anemometer reading. Again, additional uncertainty in U_{B7} was incorporated as a result.

Table 9. Type B Uncertainty Components for Sound Power Levels and Tonality

Variable	Description	Type B Uncertainty for Sound Power Level (dBA)	Type B Uncertainty for One-Third Octave Levels (dBA)	Type B Uncertainty for Tonality (dBA)	Notes
U_{B1}	Calibration	0.2	0.2	0.1	Assumption, used typical value
U_{B2}	Instrument	0.2	0.2	0.2	Assumption, used typical value
U_{B3}	Board	0.3	1.7	1.7	Board was placed well and used typical value
U_{B4}	Distance	0.1	0.1	0.05	Assumption, used typical value
U_{B5}	Impedance	0.1	0.1	0.1	Assumption, used typical value
U_{B6}	Turbulence	0.4	0.4	0.2	Assumption, used typical value
U_{B7}	Wind speed, measured	(Type A uncertainty on wind speed) x (slope)	(Type A uncertainty on wind speed) x (slope)	1.2	Type A uncertainty on wind speed combined with anemometer accuracy and slope of SPL curve
U_{B8}	Direction	0.3	0.3	0.3	Assumption, used typical value
U_{B9}	Background	Varied with wind speed	Varied with wind speed and one-third octave center frequency bin	Varied by tone	Difference between total and background for sound pressure levels

7 Exceptions

An exception to IEC 61400-11 Ed 2.1 2006-11 was as follows:

A picture of the soundboard is included in this document, but the microphone was not in place at the time. The microphone was placed in the center of the board in a wind screen and pointed directly at the turbine.

There were no exceptions to the quality assurance system or the test plan.

8 References

1. International Electrotechnical Commission. *Wind Turbine Generator Systems—Part 11: Acoustic Noise Measurement Techniques.* IEC 61400-11, Edition 2.1, 2006-11. Geneva, Switzerland, 2006.
2. Mendoza, Ismael, Hur, Jerry, Thao, Syhoune, Curtis, Amy. 2015. *Power Performance Test Report for the U.S. Department of Energy 1.5-Megawatt Wind Turbine*. NREL/TP-5000-63684. National Renewable Energy Laboratory (NREL), Golden, CO (US). http://www.nrel.gov/docs/fy15osti/63684.pdf

Appendix A. Pictures

Figure A-1. Picture of soundboard installation for test. ***Photo by Jason Roadman, NREL***

Figure A-2. Test turbine as viewed from the reference microphone position. ***Photo by Jason Roadman, NREL***

Figure A-3. Test turbine as viewed from the met tower. ***Photo by Jason Roadman, NREL***

Appendix B. Calibration Reports

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®
NVLAP Lab Code: 200625-0

Calibration Certificate No.22815

Instrument: **Sound Level Meter**
Model: **noiseLab3-NI-9233**
Manufacturer: **Delta**
Serial number: **1258E43**
Tested with: **Mic. 4189 s/n 2395206 & 2395209**
Preamp. 2671 s/n 2373719 & 2373721
Type (class): **1**

Date Calibrated: **11/9/2010** *Cal Due:*

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes _X_ No
Calibration service: __ Basic _X_ Standard

Customer: **National Renewable Energy Laboratory**
Tel/Fax: **303-384-7183 /**
Address: **16253 Denver West Parkway**
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. Lab / Accreditation	Cal. Due
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

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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: Z:\Calibration Lab\SLM 2010\DeltaNoiseLab3-9233_1258E43-Ch1_M1.doc Page 1 of 2

Figure B-1. Calibration sheet for the digital recorder and signal analyzer (page 1)

Results summary: Device complies with following clauses of mentioned specifications:

CLAUSES [1] FROM IEC/ANSI STANDARDS REFERENCED IN PROCEDURES:	MET[2,3]	NOT MET	MEASUREMENT EXPANDED UNCERTAINTY (coverage factor 2) [dB]
IEC 60651/ANSI S1.4:			
Level Linearity Test (#7.9/ 6.9)	X		0.15
Differential Level Linearity (#7.10/6.10)	X		0.21
Weighting Network Tests: A, C, Lin network (#7.2.1/ 6.2.1-electrical test)	X		0.15
Overload Detector Test: A-network (#9.3.1/8.3.1)	X		0.15
F/S/I/Peak Test: Steady State Response (#7.4/ 6.4)	X		0.15
Fast and Slow Overshoot Test (# 8.4.1)	X		0.15
Fast-Slow Test: Single Sine Wave Burst (9.4.1&9.4.3/8.4.1 & 8.4.3)	X		0.15
Peak Detector Tests: single square wave burst (# 9.4.4/8.4.4)	X		0.15
RMS Detector Test: Continuous Sine Wave Burst (#9.4.2/8.4.2)	X		0.15
RMS Detector Test: Crest Factor Test (#9.4.2/ 8.4.2)	X		0.15
IEC60804/ANSI S1.43			
Level linearity Test (# 9.3.3/8.3.3)	X		0.15
Time Averaging Test (#9.3.2/ 8.3.2) (Leq and LE)	X		0.15/0.17
Acoustical Test: Accuracy at selected frequencies	X		0.15
Filter Test: Octave Filters	X		0.15
Filter Test: 1/3 Octave Filters	X		0.15
Global Acoustical Response: Summation (ANSI S1.4 #5)	X		0.2

[1] The results of this calibration apply only to the instrument type with serial number identified in this report.

[2] Parameters are certified at actual environmental conditions.

[3] The tests marked with (*) are not covered by the current NVLAP accreditation.

Comments: The instrument was tested and met all specifications found in the referenced procedures.

Note: The instrument was tested for the parameters listed in the table above, using the test methods described in the listed standards. All tests were performed around the reference conditions. The test results were compared with the manufacturer's or with the standard's specifications, whichever are larger. Compliance with any standard cannot be claimed based solely on the periodic tests.

Tests made with the following attachments to the instrument:

X	Microphones: 4189 s/n 2395206 on Ch1&Ch2, 4189 s/n 2395209 on Ch3& Ch4, for acoustical tests
X	Preamplifiers: 2671 s/n 2373719 on Ch1&Ch2, 2671 s/n 2373719 on Ch3&Ch4, for all tests
X	Other: line adaptor ADP005 (18pF) for electrical tests

Measured Data: in Test Report # 22815 of five sections with 30 pages total.

Place of Calibration: Scantek, Inc.
6430 Dobbin Road, Suite C
Columbia, MD 21045 USA

Ph/Fax: 410-290-7726/ -9167
callab@scantekinc.com

Figure B-2. Calibration sheet for digital recorder and signal analyzer (page 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®
NVLAP Lab Code: 200625-0

Calibration Certificate No.22816

Instrument: **Microphone Unit**
Model: **4189-A-021**
Manufacturer: **Brüel & Kjær**
Serial number: **2406809**
Composed of: **Microphone 4189 s/n 2395206**
Preamplifier 2671 s/n 2373719

Date Calibrated: **11/8/2010** *Cal Due:*

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes _X_ No

Customer: **National Renewable Energy Laboratory**
Tel/Fax: **303-384-7183/**
Address: **16253 Denver West Parkway**
Golden, CO 80401-3393

Tested in accordance with the following procedures and standards:
Procedure for Calibration of Measurement Microphones, Scantek Inc., 06/15/2005
Procedure for Microphone calibration using acoustical calibrator, Scantek, Inc., June 2005

Instrumentation used for calibration: N-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
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	ACR Env./ A2LA	May 25, 2011
PC Program 1017 Norsonic	Calibration software	v.5.0	Validated July 2009	-	-
1253-Norsonic	Calibrator	28326	Dec 7, 2009	Scantek, Inc./ NVLAP	Dec 7, 2010
1203-Norsonic	Preamplifier	14059	Jan 4, 2010	Scantek, Inc./ NVLAP	Jan 4, 2011
4180-Brüel&Kjær	Microphone	2246115	Dec 14, 2009	NPL (UK) / UKAS	Dec 14, 2011

Instrumentation and test results are traceable to SI - BIPM through standards maintained by NPL (UK) and NIST (USA)

Calibrated by	Valentin Buzduga	Checked by	Mariana Buzduga
Signature		Signature	
Date	11/08/2010	Date	11/10/2010

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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.
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Page 1 of 2

Figure B-3. Calibration sheet for the microphone 2406809 (page 1)

Results summary: Device was tested and complies with following clauses of mentioned specifications:

CLAUSES / METHODS[1] FROM PROCEDURES		MET[2,3]	NOT MET	NOT TESTED	MEASUREMENT EXPANDED UNCERTAINTY (coverage factor 2)
Sensitivity (250 Hz)		X			See below
Frequency response	Actuator response	X			63 – 200 Hz: 0.3 dB 200 – 8000 Hz: 0.2 dB 8 – 10 kHz: 0.5 dB 10 – 20 kHz: 0.7 dB 20 – 50 kHz: 0.9 dB 50 – 100 kHz: 1.2 dB
	FF/Diffuse field responses	X			63 – 200 Hz: 0.3 dB 200 – 4000 Hz: 0.2 dB 4 – 10 kHz: 0.6 dB 10 – 20 kHz: 0.9 dB 20 – 50 kHz: 2.2 dB 50 – 100 kHz: 4.4 dB
	Scantek, Inc. acoustical method			X	31.5 – 125 Hz: 0.16 dB 250, 1000 Hz: 0.12 dB 2 – 8 kHz: 0.8 dB 12.5 – 16 kHz: 2.4 dB

[1] The results of this calibration apply only to the instrument type with serial number identified in this report.

[2] Parameters are certified at actual environmental conditions.

[3] The tests marked with (*) are not covered by the current NVLAP accreditation.

Note: The free field/diffuse field characteristics were calculated based on the measured actuator response and adjustment coefficients as provided by the manufacturer. The uncertainties reported for these characteristics may include assumed uncertainty components for the adjustment coefficients.

Comments: The instrument was tested and met all specifications found in the referenced procedures.

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
24.1 ± 1.0	99.76 ± 0.007	40.8 ± 2.8

Main measured parameters:

Tone frequency (Hz)	Measured[4] Sensitivity (dB)	Sensitivity (mV/Pa)
250	-25.78 ± 0.12	51.40

[4] The reported expanded uncertainty is calculated with a coverage factor k=2.00

Tests made with following attachments to instrument and auxiliary devices:

X	4102C Current Source
X	Actuator type: G.R.A.S. RA 0014
	Coupler type: G.R.A.S. 51 AB

Measured Data: Found on Microphone Test Report # 22816 of one page.

Place of Calibration: Scantek, Inc.
6430 Dobbin Road, Suite C
Columbia, MD 21045 USA
Ph/Fax: 410-290-7726/ -9167
callab@scantekinc.com

Figure B-4. Calibration sheet for the microphone 2406809 (page 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®
NVLAP Lab Code: 200625-0

Calibration Certificate No.22817

Instrument: **Microphone Unit**
Model: **4189-A-021**
Manufacturer: **Brüel & Kjær**
Serial number: **2406811**
Composed of: **Microphone 4189 s/n 2395209**
Preamplifier 2671 s/n 2373721

Date Calibrated: **11/8/2010** *Cal Due:*

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes _X_ No

Customer: **National Renewable Energy Laboratory**
Tel/Fax: **303-384-7183/**
Address: **16253 Denver West Parkway**
Golden, CO 80401-3393

Tested in accordance with the following procedures and standards:
Procedure for Calibration of Measurement Microphones, Scantek Inc., 06/15/2005
Procedure for Microphone calibration using acoustical calibrator, Scantek, Inc., June 2005

Instrumentation used for calibration: N-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
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	ACR Env./ A2LA	May 25, 2011
PC Program 1017 Norsonic	Calibration software	v.5.0	Validated July 2009	-	-
1253-Norsonic	Calibrator	28326	Dec 7, 2009	Scantek, Inc./ NVLAP	Dec 7, 2010
1203-Norsonic	Preamplifier	14059	Jan 4, 2010	Scantek, Inc./ NVLAP	Jan 4, 2011
4180-Brüel&Kjær	Microphone	2246115	Dec 14, 2009	NPL (UK) / UKAS	Dec 14, 2011

Instrumentation and test results are traceable to SI - BIPM through standards maintained by NPL (UK) and NIST (USA)

Calibrated by	Valentin Buzduga	Checked by	Mariana Buzduga
Signature		Signature	
Date	11/08/2010	Date	11/10/2010

Document stored as: Z:\Calibration Lab\Mic 2010\B&K4189_A_021_2406811_M1.doc

Figure B-5. Calibration sheet for the microphone 2406811 (page 1)

Results summary: Device was tested and complies with following clauses of mentioned specifications:

CLAUSES / METHODS[1] FROM PROCEDURES		MET[2,3]	NOT MET	NOT TESTED	MEASUREMENT EXPANDED UNCERTAINTY (coverage factor 2)
Sensitivity (250 Hz)		X			See below
Frequency response	Actuator response	X			63 – 200 Hz: 0.3 dB 200 – 8000 Hz: 0.2 dB 8 – 10 kHz: 0.5 dB 10 – 20 kHz: 0.7 dB 20 – 50 kHz: 0.9 dB 50 – 100 kHz: 1.2 dB
	FF/Diffuse field responses	X			63 – 200 Hz: 0.3 dB 200 – 4000 Hz: 0.2 dB 4 – 10 kHz: 0.6 dB 10 – 20 kHz: 0.9 dB 20 – 50 kHz: 2.2 dB 50 – 100 kHz: 4.4 dB
	Scantek, Inc. acoustical method			X	31.5 – 125 Hz: 0.16 dB 250, 1000 Hz: 0.12 dB 2 – 8 kHz: 0.8 dB 12.5 – 16 kHz: 2.4 dB

[1] The results of this calibration apply only to the instrument type with serial number identified in this report.

[2] Parameters are certified at actual environmental conditions.

[3] The tests marked with (*) are not covered by the current NVLAP accreditation.

Note: The free field/diffuse field characteristics were calculated based on the measured actuator response and adjustment coefficients as provided by the manufacturer. The uncertainties reported for these characteristics may include assumed uncertainty components for the adjustment coefficients.

Comments: The instrument was tested and met all specifications found in the referenced procedures.

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
24.9 ± 1.2	99.68 ± 0.012	38.1 ± 3.1

Main measured parameters:

Tone frequency (Hz)	Measured[4] Sensitivity (dB)	Sensitivity (mV/Pa)
250	-26.95 ± 0.12	44.95

[4] The reported expanded uncertainty is calculated with a coverage factor k=2.00

Tests made with following attachments to instrument and auxiliary devices:

X	4102C Current Source
X	Actuator type: G.R.A.S. RA 0014
	Coupler type: G.R.A.S. 51 AB

Measured Data: Found on Microphone Test Report # 22817 of one page.

Place of Calibration: Scantek, Inc.
6430 Dobbin Road, Suite C
Columbia, MD 21045 USA
Ph/Fax: 410-290-7726/ -9167
callab@scantekinc.com

Figure B-6. Calibration sheet for the microphone 2406811 (page 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®
NVLAP Lab Code: 200625-0

Calibration Certificate No.22818

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

Date Calibrated: **11/8/2010** *Cal Due:*

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes _X_ No

Customer: **National Renewable Energy Laboratory** *Address:* **16253 Denver West Parkway**
Tel/Fax: **303-384-7183 /** **Golden, CO 80401-3393**

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. Lab / Accreditation	Cal. Due
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.5.0	Validated July 2009	-	
1253-Norsonic	Calibrator	28326	Dec 7, 2009	Scantek, Inc./ NVLAP	Dec 7, 2010
1203-Norsonic	Preamplifier	14059	Jan 4, 2010	Scantek, Inc./ NVLAP	Jan 4, 2011
4180-Brüel&Kjær	Microphone	2246115	Dec 14, 2009	NPL (UK) / UKAS	Dec 14, 2011

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

Calibrated by	Valentin Buzduga	Checked by	Mariana Buzduga
Signature		Signature	
Date	11/08/2010	Date	11/10/2010

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Page 1 of 2

Figure B-7. Calibration sheet for the acoustical calibrator (page 1)

Results summary: Device was tested and complies with following clauses of mentioned specifications:

CLAUSES[1] FROM STANDARDS REFERENCED IN PROCEDURES:	MET	NOT MET	COMMENTS
Manufacturer specifications			
Manufacturer specifications: Sound pressure level	X		
Manufacturer specifications: Frequency	X		
Manufacturer specifications: Total harmonic distortion	X		
Current standards			
ANSI S1.40:2006 B.3 / IEC 60942: 2003 B.2 - Preliminary inspection	X		
ANSI S1.40:2006 B.4.4 / IEC 60942: 2003 B.3.4 - Sound pressure level	X		
ANSI S1.40:2006 A.5.4 / IEC 60942: 2003 A.4.4 - Sound pressure level stability	-	-	
ANSI S1.40:2006 B.4.5 / IEC 60942: 2003 B.3.5 - Frequency	X		
ANSI S1.40:2006 B.4.6 / IEC 60942: 2003 B.3.6 - Total harmonic distortion	X		

[1] The results of this calibration apply only to the instrument type with serial number identified in this report.
[2] The tests marked with (*) are not covered by the current NVLAP accreditation.

Main measured parameters[3]:

Measured[4]/Acceptable Tone frequency (Hz):	Measured[4]/Acceptable Total Harmonic Distortion (%):	Measured [4]/Acceptable Level (dB):
999.97 ± 1.0/1000.0 ± 10.0	0.3 ± 0.1/ < 3	114.06 ± 0.12/114.0 ± 0.4
999.97 ± 1.0/1000.0 ± 10.0	0.4 ± 0.1/ < 3	94.04 ± 0.12/94.0 ± 0.4

[3] Parameters are certified at actual environmental conditions.
[4] The above expanded uncertainties for frequency and distortion are calculated with a coverage factor k=2; for level k=2.00
[5] Acceptable parameter values are from the current standards.

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
23.2 ± 1.1	99.83 ± 0.010	43.7 ± 2.5

Tests made with following attachments to instrument:

X	Calibrator ½" Adaptor Type UC 0210
	Other

Adjustments: Unit was not adjusted.
Comments: The instrument was tested and met all specifications found in the referenced procedures.

Note: The instrument was tested for the parameters listed in the table above, using the test methods described in the listed standards. All tests were performed around the reference conditions. The test results were compared with the manufacturer's or with the standard's specifications, whichever are larger. Compliance with any standard cannot be claimed based solely on the periodic tests.

Measured Data: in Acoustical Calibrator Test Report # 22818 of two pages.

Place of Calibration: Scantek, Inc.
6430 Dobbin Road, Suite C
Columbia, MD 21045 USA
Ph/Fax: 410-290-7726/ -9167
callab@scantekinc.com

Figure B-8. Calibration sheet for the acoustical calibrator (page 2)

DEUTSCHER KALIBRIERDIENST DKD

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

Deutsche WindGuard
Wind Tunnel Services GmbH
Varel

Deutscher Akkreditierungs Rat
DAR
DKD-K- 36801

Kalibrierzeichen *Calibration label*	09/5843 DKD-K-36801 09/2009

Kalibrierschein
Calibration Certificate

Gegenstand *Object*	Cup Anemometer
Hersteller *Manufacturer*	Thies Clima D-37083 Göttingen
Typ *Type*	4.3351.10.000
Fabrikat/Serien-Nr. *Serial number*	Body: 0909219 Cup: 0909219
Auftraggeber *Customer*	Sky Power International LLC USA - Liberty, SC 29657
Auftragsnummer *Order No.*	VT09556
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	3
Datum der Kalibrierung *Date of calibration*	26.09.2009

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 *Seal*	Datum *Date*	Leiter des Kalibrierlaboratoriums *Head of the calibration laboratory*	Bearbeiter *Person in charge*
Deutscher Kalibrierdienst DKD-K- 36801	26.09.2009	Dipl. Phys. D. Westermann	Dipl.-Ing. (FH) M. Meyer zu Himmern

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

Figure B-9. Calibration sheet for the acoustic anemometer (page 1)

09/5843
DKD-K-36801
09/2009

Kalibriergegenstand
Object
Anemometer

Kalibrierverfahren
Calibration procedure
IEC 61400 12 1 - Wind Turbine Power Performance Testing 12 2005
MEASNET - Cup Anemometer Calibration Procedure – 09 1997
ISO 3966 – Measurement of fluid in closed conduits - 1977

Ort der Kalibrierung
Place of calibration
Windtunnel of Deutsche WindGuard, Varel

Messbedingungen
Test Conditions

wind tunnel area [1]	10000 cm²	
anemometer frontal area [2]	230 cm²	
diameter of mounting pipe [3]	34 mm	
blockage ratio [4]	0.023 [-]	
blockage correction [5]	1.000 [-]	
average WindGuard reference [6]	203.8 1/s (Thies First Class)	
present WindGuard reference [7]	203.7 1/s	

Umgebungsbedingungen
Test conditions

air temperature	23.3 °C	± 1.0 K
air pressure	1027.0 hPa	± 1.0 hPa
relative air humidity	47.6 %	± 2.5 %

Dateiinformation
File info

Anmerkungen
Remarks
-

Auswertesoftware
Software version
4.0

[1] Querschnittsfläche der Auslassdüse des Windkanals
[2] Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr
[3] Durchmesser des Montagerohrs
[4] Verhältnis von 2) zu 1)
[5] Korrekturfaktor durch die Verdrängung der Strömung durch den Prüfling
[6] Referenzwert des Referenzanemometers bei 10 m/s (Mittelwert)
[7] Aktueller Wert des Referenzanemometers

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

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Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 9515 0

Figure B-10. Calibration sheet for the acoustic anemometer (page 2)

09/5843
DKD-K-36801
09/2009

Kalibrierergebnis:
Result:

Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
86.363	4.193	0.10
129.019	6.143	0.10
170.212	8.052	0.10
210.679	9.898	0.10
253.862	11.878	0.10
297.703	13.858	0.10
339.982	15.828	0.11
317.337	14.775	0.10
276.809	12.867	0.10
232.163	10.870	0.10
190.126	8.932	0.10
148.153	7.021	0.10
108.825	5.222	0.10

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

Der Deutsche Kalibrierdienst 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 expanded uncertainty assigned to the mea-surement results is obtained by multiplying the standard uncertainty by the coverage factor k = 2. It has been determined in accordance with DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DKD is signatory to the multilateral agree-ments of the European co-operation for Accredita-tion (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

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Figure B-11. Calibration sheet for the acoustic anemometer (page 3)

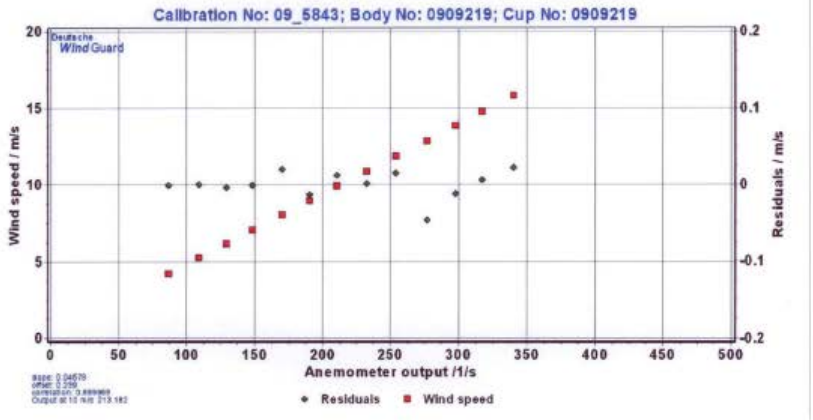
1 Detailed MEASNET[1] Calibration Results

DKD calibration no.	09/5843
Body no.	0909219
Cup no.	0909219
Date	26.09.2009
Air temperature	23.3 °C
Air pressure	1027.0 hPa
Humidity	47.6 %

Linear regression analysis

Slope	0.04579 (m/s)/(1/s) ±0.00006 (m/s)/(1/s)
Offset	0.239 m/s ±0.015 m/s
St.err(Y)	0.017 m/s
Correlation coefficient	0.999989

Remarks no



[1]) According to MEASNET Cup Anemometer Calibration Procedure 09/1997.
Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutscher Kalibrierdienst – DKD (German Calibration Service). Registration: DKD – K – 36801

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

Figure B-12. Calibration sheet for the primary anemometer (page 1)

2 Instrumentation

Pos.	Sensor	Manufa.	Identification	Year	Calibration
1	Pitot static tube	Airflow	483/8 Nr. 000142	02	06/02
2	Pitot static tube	Airflow	483/8 Nr. 000143	02	06/02
3	Pitot static tube	Airflow	483/8 Nr. 000144	02	06/02
4	Pitot static tube	Airflow	483/8 Nr. 000145	02	06/02
5	Pressure transducer	Setra	C 239 Nr. 1688081	02	DWG12/07
6	Pressure transducer	Setra	C 239 Nr. 1688082	02	DWG12/07
7	Pressure transducer	Setra	C 239 Nr. 1688083	02	03/07
8	Pressure transducer	Setra	C 239 Nr. 1688084	02	03/05
9	El. Barometer	Vaisala	100 A Nr. X2010004	02	DWG12/07
10	El. Thermometer	Galltec	KPK 1/6-ME	02	DWG12/07
11	El. Humidity sensor	Galltec	KPK 1/6-ME	02	DWG12/07
12	Wind tunnel control	-	-	-	-
13	CAN-BUS / PC	esd	-	04	05/04
14	Anemometer				
15	Universal Isolator	Knick	P2700 - 58285/8198430	05	01/06

Table 1 Description of the data acquisition system

3 Photo of the calibration set-up

Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel.
The anemometer shown is of the same type as the calibrated one.
Remark: The proportion of the set-up are not true to scale due to imaging geometry.

4 Deviation to MEASNET procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

[1] J. Mander, D. Westermann, 12/2007 - Verfahrensanweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
[2] IEC 61400-12-1 12/2005 - Wind Turbine Power Performance Testing
[3] ISO 3966 1977 - Measurement of fluid flow in closed conduits
[4] MEASNET 09 1997 - Cup Anemometer Calibration Procedure

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Oldenburger Str. 65
26316 Varel ; Tel. ++49 (0)4451 9515 0

Figure B-13. Calibration sheet for the primary anemometer (page 2)

Wind Direction

Met One Instruments, Inc.
1600 NW Washington Blvd.
Grants Pass, Oregon 97526
Telephone 541-471-7111
Facsimile 541-541-7116

Regional Service
3206 Main St. Suite 106
Rowlett, Texas 75088
Telephone 972-412-4715
Facsimile 972-412-4716

Test Certificate

Model: SD201 **Sensor Serial No:** K16689

Job Number: **Customer:**

Test Date: 12/10/2010 **Tested by:** D. Hoagland

Room Temperature: 24.6 °C **Room Relative Humidity:** 42.9 %

Recommended calibration interval is 12 months from the first day of use.

Calibration Standards

Standards	Manufacturer	Model	SN	Cal Due
DMM	HEWLETT PACKARD	3468B	2231A01057	April 7, 2011
TEMPERATURE	ROSEMONT	T-200	1171688	January 12, 2011
RH Sensor	Met One Instruments	083D-1-35	W3673	June 26, 2011
BAROMETRIC PRESSURE	MET ONE INSTRUMENTS	090B	H6507	July 2, 2011

Test Data

TEST	OUTPUT VOLTS	INDICATED °	ERROR °	SPEC	NOTES
0°	0.001	0.1	0.1	±5°	
30°	0.299	29.9	-0.1	±5°	
60°	0.601	60.1	0.1	±5°	
90°	0.905	90.5	0.5	±5°	
120°	1.204	120.4	0.4	±5°	
150°	1.503	150.3	0.3	±5°	
180°	1.804	180.4	0.4	±5°	
210°	2.109	210.9	0.9	±5°	
240°	2.416	241.6	1.6	±5°	
270°	2.723	272.3	2.3	±5°	
300°	3.030	303.0	3.0	±5°	
330°	3.337	333.7	3.7	±5°	

END PLAY	0.005
TORQUE	0.040

NOISE CW	N/A
NOISE CCW	N/A

Test Procedure #42062-6200

The standards used for this calibration have accuracies equal to or greater than the instruments tested. These standards are on record and traceable to NIST to the extent allowed by the institute's calibration facility. Unless otherwise stated hereon, all instruments are calibrated to meet the manufacturer's published specifications. The Calibration system complies with MIL-STD-45662A.

SD210-9600 Rev B

Figure B-14. Calibration sheet for the wind vane

NWTC Testing Group

SD-201 Wind Direction Sensor 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: 31-Mar-11

Report Number: J5950-110331

Page: 1 of 1

Procedure:
NWTC-CT: CIxx Calibrate SD-201 Wind Direction Sensor

Deviations from procedure: None

Item Calibrated:

Manufacturer	Met One Instruments, Inc
Model	SD-201
Serial Number	J5950
Vane Material	Aluminum
Condition	Refurbished

Results:

Slope:	**71.0250**	**deg/v**
Offset	**3.74**	**deg**
Max. residual	**1.2**	**deg**
Pass/Fail:	**Pass**	

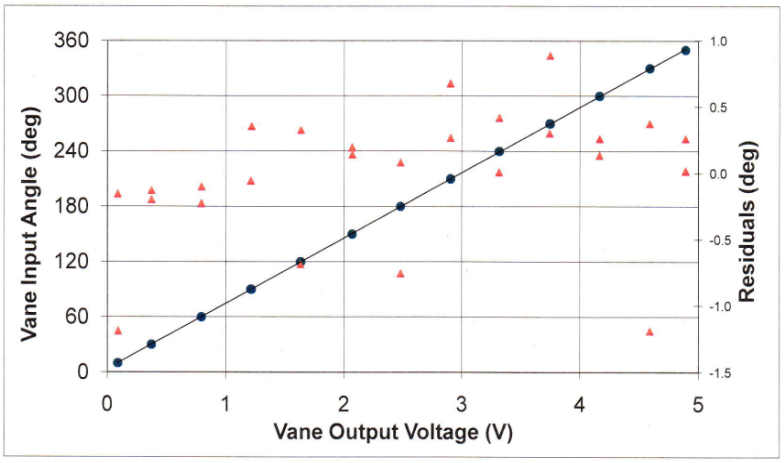
Estimated Standard Uncertainty: 0.51 deg

Acceptable max. residual 2 deg

Traceability:	Mfg & Model	Serial Number	Cal Date
Voltmeter:	HP 3458A	2823A05145	3-May-10

Power Supply:	Met One 48.11B	N3628	+12 VDC	12.025 VDC
			-12 VDC	-12.022 VDC
Processor:	Met One 21.22	M1025	Mode: LO	0.0001 VDC
			Mode: HI	5.0006 VDC

Calibration by: Syhoune Thao — Date: 3-31-2011



SD201 J5950 110330 — If printed, this document may be out of date. — Page 1 of 1

Figure B-15. Calibration sheet for the wind vane

Pressure

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Pressure Transmitter DOE #: 03466C

Model # : PTB101B S/N : B2130018

Calibration Date: 09/22/2010 Due Date: 09/22/2011

No	Function Tested	Nominal Value (kPa)	Measured Output Voltage (VDC)		( )Mfr. Specs. OR (X)Data only (mb)
			As Found	As Left	
*	Absolute Pressure				
		65	0.265		
		70	0.538		
		75	0.809		
		80	1.081		
		85	1.352		
		90	1.624		
		95	1.895		
		100	2.167		
		103	2.330		
	Notes: 1. Expanded Uncertainty of the nominal value is ± 0.2 kPa, with k = 2. 2. Calibration was performed at 24°C and 39% RH. 3. Calibration was performed using standards that are traceable to NIST. DOE numbers: 128120, and 02301C.				

Calibrated By: P. Morse
Date: 09/22/2010

Approved By: D. Myers
Date: 09/22/2010

Figure B-16. Calibration sheet for the pressure sensor

Temperature

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: RTD DOE #: 03507C

Model # : 78N01N00N04 S/N : 0673552

Calibration Date: 09/23/2010 Due Date: 09/23/2011

No	Function Tested	Nominal Value (°C)	Measured Values (Ω)		( )Mfr. Specs. OR (X)Data only
			AS Found	AS Left	
*	Temperature:	-15	94.118	Same	
		0	100.005	"	
		15	105.854	"	
		30	111.680	"	
		45	117.481	"	

Notes:
- Calibration was performed using instruments that are traceable to NIST. DOE#s 124272, 108603, and 108604.
- Calibration was performed at temperature = 23°C and relative humidity = 40%.
- Uncertainty of Nominal Values = ± 0.02 °C, k = 2.

Calibrated By: P. Morse
Date: 9/23/2010

Approved By: D. Myers
Date: 9/23/2010

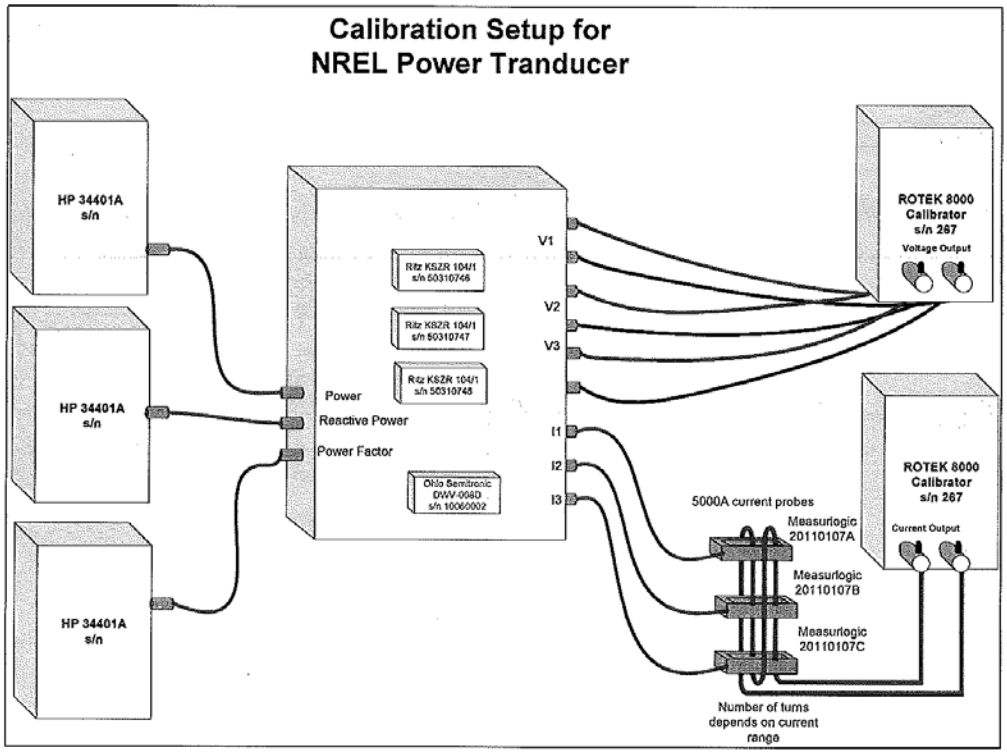
Figure B-17. Calibration sheet for the temperature sensor

National Renewable Energy Laboratory

Calibration Report

Report #: NREL Power Performance Sampling System Cal GE/DOE 1.5 (sn PP20110107)

Calibration of: NREL PP Sampling System



		Environmental Conditions During Calibration
Calibration Method:	GI28 010717	Temperature: 23C, +/- 1C
Calibration Results:	Within tolerance	Relative humidity: 40%, +/-10%
Device Condition:	good	
Date Calibrated:	01/07/11	
Calibration Due Date:	01/07/12	
Calibrated by:	Morse, Preston/Ismael Mendoza	
NREL Metrology Laboratory:	Ibrahim Reda	
	Sr. Scientist V	
	Date:	1/13/2011

Page 1 of 4

Power

Figure B-18. Calibration sheet for the power transducer (page 1)

Calibration Standard:

Model:	DOE#	Calibration Due Date:
8000A	126314	7/8/2011
34401A	01886C	1/12/2012
34401A	01888C	3/5/2011
34401A	02301C	3/5/2011

Accuracy

Current (<50A):	0.038	% of setting	+	0.005	% of range
Current (>50A):	0.05	% of reading	+	0.008	% of range
Voltage (Meter)	0.0035	% of reading	+	0.0005	% of range
Voltage(Calibrator): (0.03 + 0.004)		% of reading	+	0.01	V

Full Range

Full Scale Settings

Power Uncertainty, U95 (KW) 0.38

Rotek 8000A Current:	200 A
Rotek 8000A Voltage:	700 V

Unit Under Test (UUT):

Current sensors					
Model:	Measurlogic MLG-TP816			Output:	-5 to 5 V
Accuracy:		0.5 % of F.S.		Nominal Slope:	1000
Full scale:		-5000	5000 A	Nominal Offset:	0
Voltage sensors					
Model:	Ritz KSZR 104/1			Output:	-100 to 100 V
Accuracy:		0.5 % of F.S.		Nominal Slope:	10.00
Full scale:		-1000	1000 V	Nominal Offset:	0
Power Transducer					
Model:	OSI DWV-008D			Output:	-10 to 10 V
Accuracy:		0.5 % of F.S.		Nominal Slope:	300.00
		-3000	3000 KW		
Full scale:		-3000	3000 KVAR	Nominal Offset:	0

Uncertainty of UUT:

Watt Total Uncertainty = 25.98 KW

VAR Total Uncertainty = 25.98 KVAR

TUR 68.4 :1

Note:

1. The Test Uncertainty Ratio (TUR) = The uncertainty of the unit under test (UUT) divided by the uncertainty of the standard.
2. All uncertainties are calculated using the Volt or Amper values, not percentages.
3. The total uncertainty for the UUT is calculated as the RSS of the uncertainties of the current and voltage sensors, and A/D converter

Apparent Power			Rotek 8000 Settings
Watts(kW)	Voltage Output (V)	Error	Voltage: 333.33
2000	6.699	0.25	Power factor: 1
1400	4.689	0.00	
800	2.679	-0.24	
200	0.669	-0.49	
0	0.000197	-0.21	
-200	-0.666	0.84	
-800	-2.678	0.00	
-1400	-4.689	-0.55	
-2000	-6.695	0.40	

Slope	298.6295964
Offset	-0.2719852

Page 2 of 4

Figure B-19. Calibration sheet for the power transducer (page 2)

Reactive Power = SQRT[(Apparent Power)^2 - (Apparent Power * PF)^2]

Reactive Power				Rotek 8000 Settings
Power Factor	Reactive power (VAR)	Voltage Output (V)	Error	Voltage: 333.33
1	0.000	0.0154	-0.91	Apparent Power: 2000 kW
0.9	871.780	2.93	-0.59	
0.8	1200.000	4.026	-0.87	
0.7	1428.286	4.812	6.03	
0.6	1600.000	5.37	1.27	
0.5	1732.051	5.802	-1.52	
0.4	1833.030	6.138	-1.96	
0.3	1907.878	6.394	-0.21	
0.2	1959.592	6.572	1.34	
0.1	1989.975	6.665	-1.22	
0	2000.000	6.698	-1.37	

Slope	299.2167532
Offset	-5.519904617

Power Factor (PF)			Rotek 8000 Settings
Power Factor	Voltage Output (V)	Error	Voltage: 333.33
1	10.007	0.00	Apparent Power: 2000 kW
0.9	8.987	0.00	
0.8	8.004	0.00	
0.7	6.993	0.00	
0.6	5.999	0.00	
0.5	4.99	0.00	
0.4	3.985	0.00	
0.3	2.982	0.00	
0.2	1.993	0.00	
0.1	0.983	0.00	
0	0.02333	0.00	

Slope	0.099995543
Offset	0.000510174

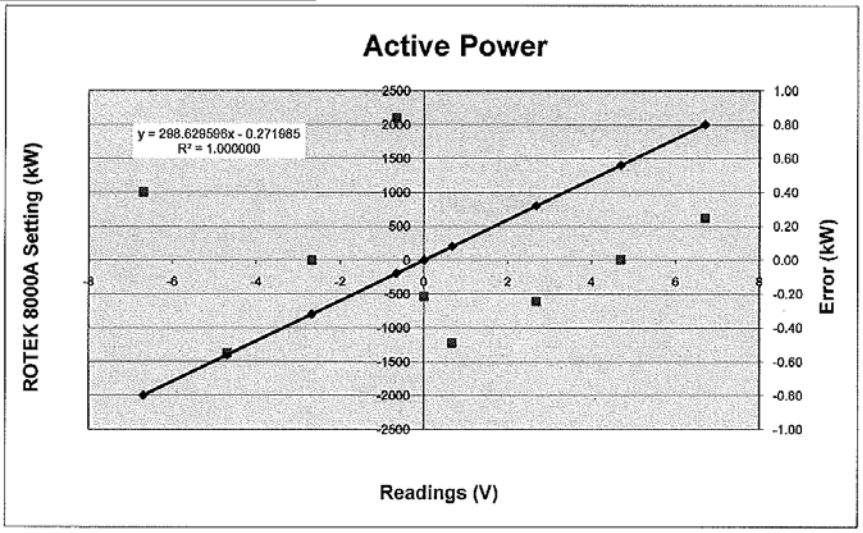


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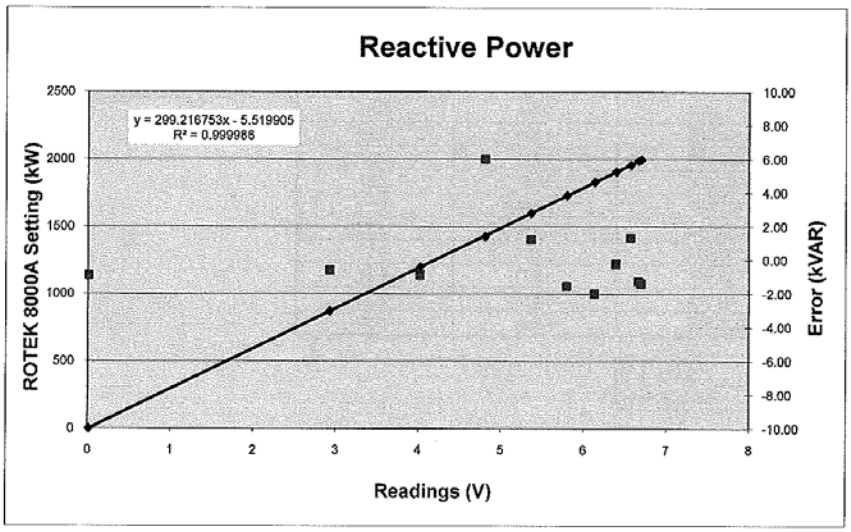
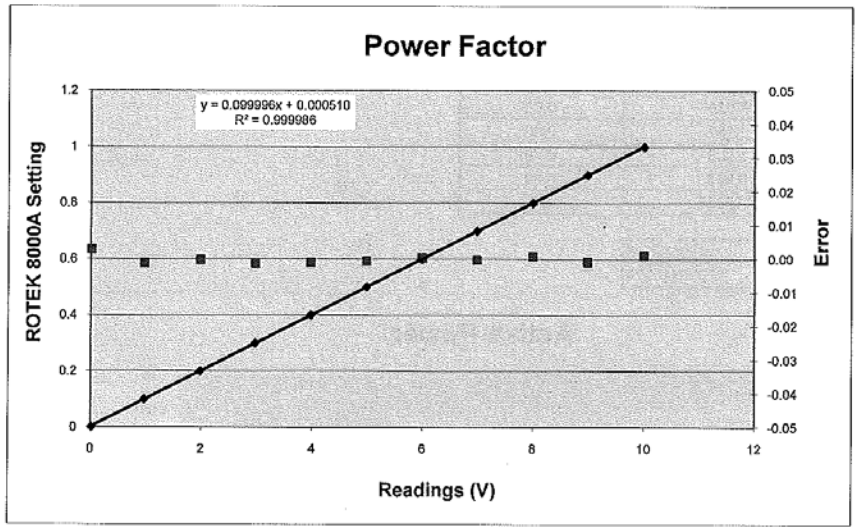
Figure B-20. Calibration sheet for the power transducer (page 3)





Page 4 of 4

Figure B-21. Calibration sheet for the power transducer (page 4)

Certificate of Conformance

		Date:	22-FEB-2012
Serial Number:	12B6DD2	**Part Number:**	192580D-02
Description:	CCA,NI 9229,PRECISION +/- 60V ISOLATION AMPLIFIER WITH ANTI-ALIAS FILTER		
Manufacture Date:			

National Instruments (NI) hereby certifies that the NI part numbers and quantity of this shipment are in accord with the Customer's Purchase Order. NI further certifies that the product(s) is/are new material; that the product(s) has/have been inspected and tested and conform(s) to quality and performance standards as documented in the National Instruments Quality Management System (QMS), in conformance with the ISO 9001:2000 standard.

National Instruments further certifies that the environment in which the products were tested is maintained within the operating specifications of the instrument and the standards. If any product requires calibration, the instruments used to perform the calibration are traceable to the National Institute of Standards and Technology (NIST) and/or other National Measurements Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) Mutual Recognition Arrangement (MRA).

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

Andrew Krupp
Vice President, Quality and Continuous Improvement

National Instruments Corporation
11500 N. Mopac Expressway
Austin, TX 78759-3504
USA
Tel: 512-683-0100

NATIONAL INSTRUMENTS

Figure B-22. Calibration sheet for NI signal module 12B6DD2

Certificate of Conformance

		Date:	22-FEB-2012
Serial Number:	12E9CD3	**Part Number:**	193299F-01
Description:	CCA,9205,16 BIT 32 CH VOLTAGE ANALOG INPUT MODULE (MIO CLASS)		
Manufacture Date:			

National Instruments (NI) hereby certifies that the NI part numbers and quantity of this shipment are in accord with the Customer's Purchase Order. NI further certifies that the product(s) is/are new material; that the product(s) has/have been inspected and tested and conform(s) to quality and performance standards as documented in the National Instruments Quality Management System (QMS), in conformance with the ISO 9001:2000 standard.

National Instruments further certifies that the environment in which the products were tested is maintained within the operating specifications of the instrument and the standards. If any product requires calibration, the instruments used to perform the calibration are traceable to the National Institute of Standards and Technology (NIST) and/or other National Measurements Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) Mutual Recognition Arrangement (MRA).

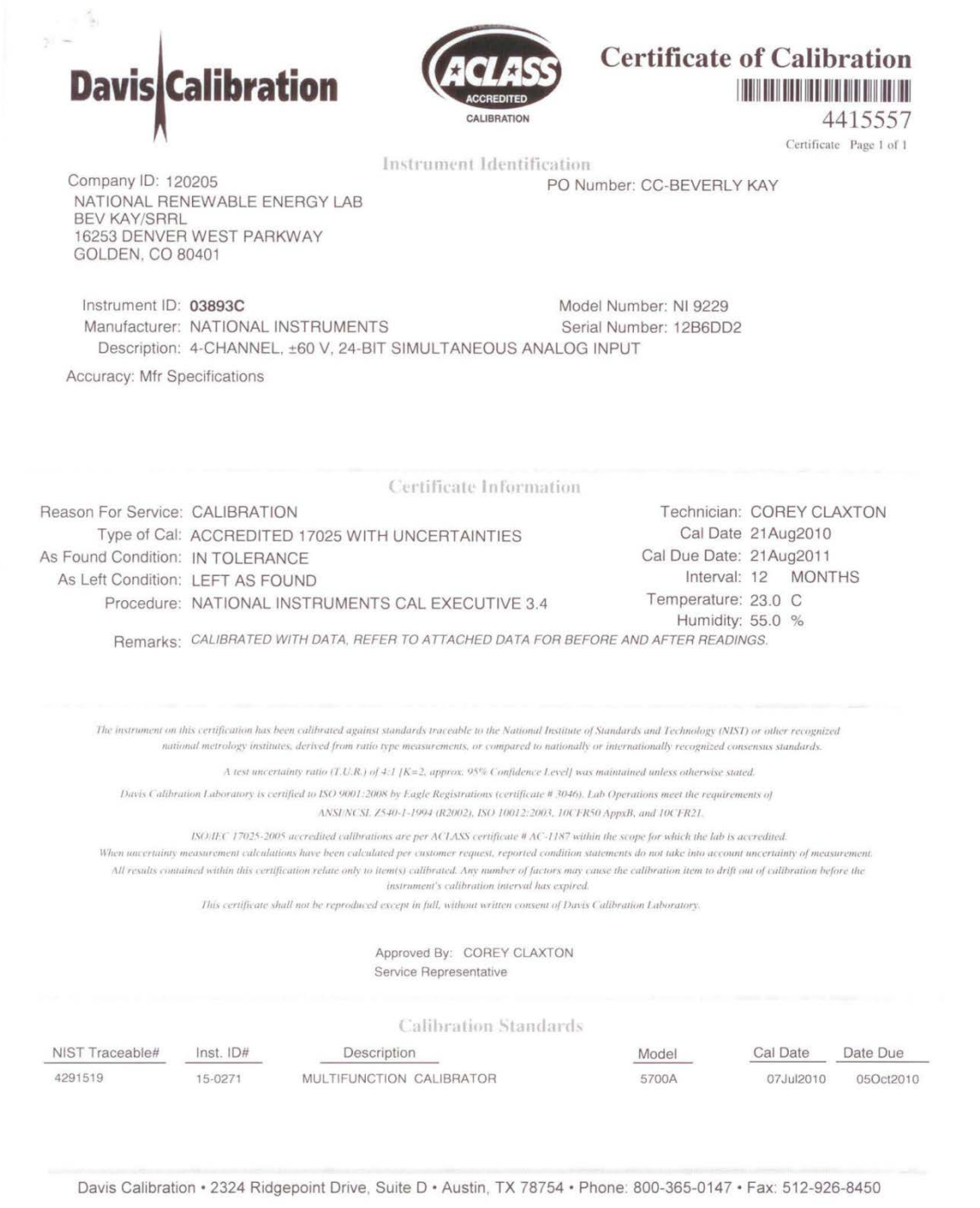
For questions or comments, please contact National Instruments Technical Support.

Andrew Krupp
Vice President, Quality and Continuous Improvement

National Instruments Corporation
11500 N. Mopac Expressway
Austin, TX 78759-3504
USA
Tel: 512-683-0100

NATIONAL INSTRUMENTS

Figure B-23. Calibration sheet for NI signal module 12E9CD3



Davis Calibration

ACCREDITED CALIBRATION

Certificate of Calibration

4415557

Certificate Page 1 of 1

Instrument Identification

Company ID: 120205
NATIONAL RENEWABLE ENERGY LAB
BEV KAY/SRRL
16253 DENVER WEST PARKWAY
GOLDEN, CO 80401

PO Number: CC-BEVERLY KAY

Instrument ID: **03893C**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CHANNEL, ±60 V, 24-BIT SIMULTANEOUS ANALOG INPUT
Model Number: NI 9229
Serial Number: 12B6DD2
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 3.4
Technician: COREY CLAXTON
Cal Date 21Aug2010
Cal Due Date: 21Aug2011
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 55.0 %
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.

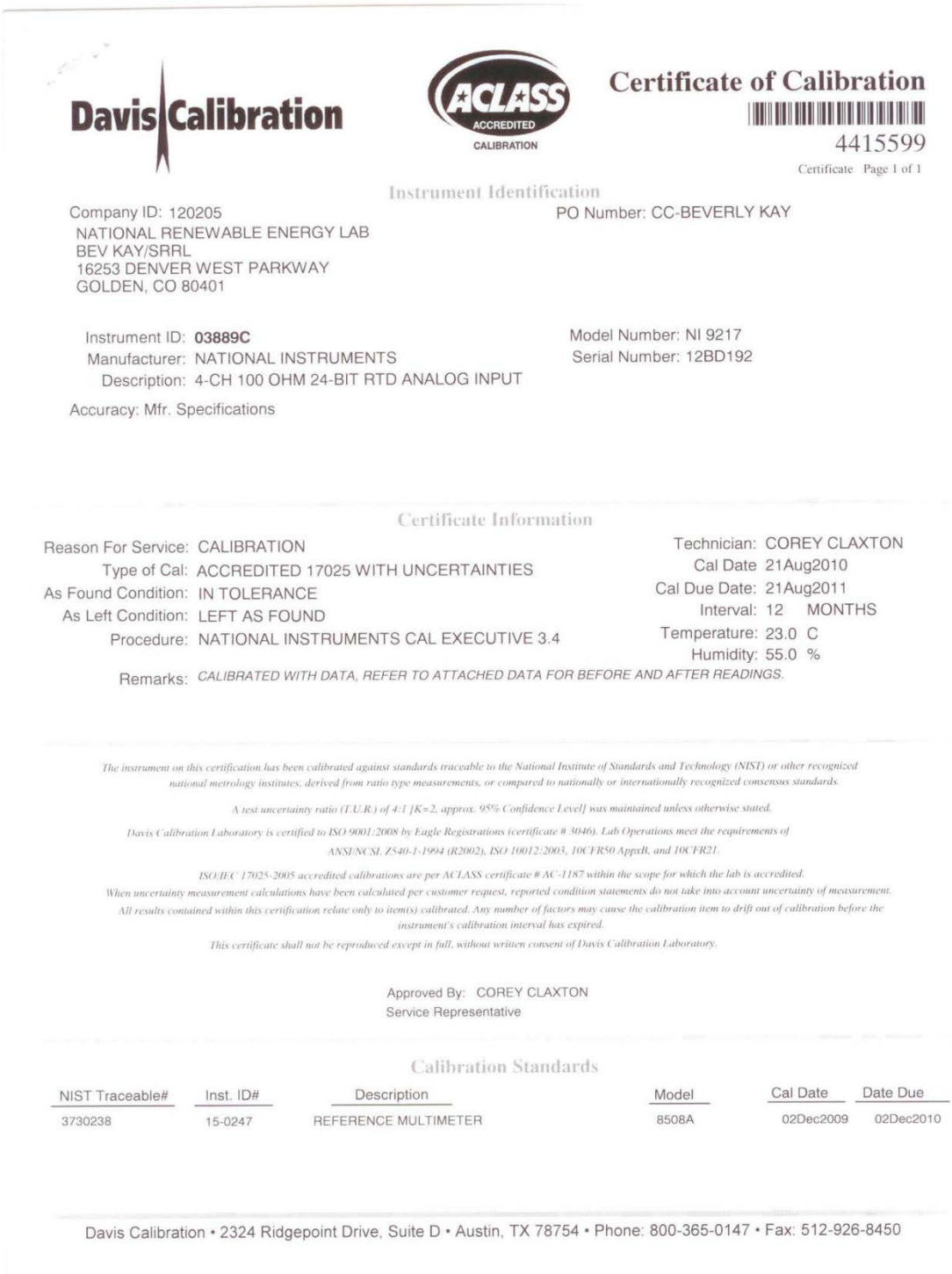
Approved By: COREY CLAXTON
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4291519	15-0271	MULTIFUNCTION CALIBRATOR	5700A	07Jul2010	05Oct2010

Davis Calibration • 2324 Ridgepoint Drive, Suite D • Austin, TX 78754 • Phone: 800-365-0147 • Fax: 512-926-8450

Figure B-24. Calibration sheet for NI signal module 12B6DD2



Davis Calibration

ACCREDITED CALIBRATION

Certificate of Calibration

4415599

Certificate Page 1 of 1

Instrument Identification

Company ID: 120205
NATIONAL RENEWABLE ENERGY LAB
BEV KAY/SRRL
16253 DENVER WEST PARKWAY
GOLDEN, CO 80401

PO Number: CC-BEVERLY KAY

Instrument ID: **03889C**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CH 100 OHM 24-BIT RTD ANALOG INPUT

Model Number: NI 9217
Serial Number: 12BD192

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 3.4

Technician: COREY CLAXTON
Cal Date 21Aug2010
Cal Due Date: 21Aug2011
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 55.0 %

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
3730238	15-0247	REFERENCE MULTIMETER	8508A	02Dec2009	02Dec2010

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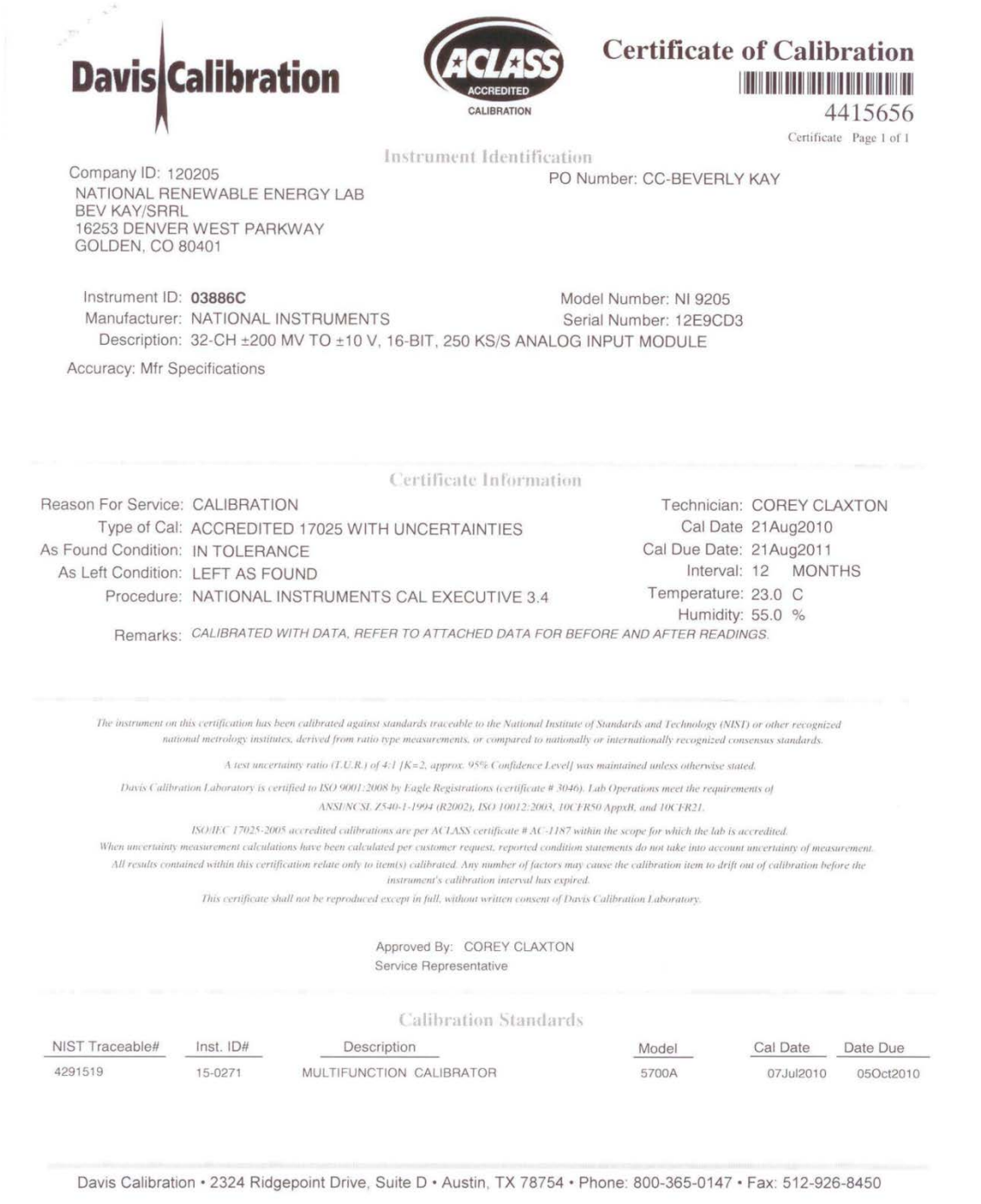
Figure B-25. Calibration sheet for NI signal module 12BD192



Davis Calibration

ACCREDITED CALIBRATION

Certificate of Calibration

4415656

Certificate Page 1 of 1

Instrument Identification

Company ID: 120205
NATIONAL RENEWABLE ENERGY LAB
BEV KAY/SRRL
16253 DENVER WEST PARKWAY
GOLDEN, CO 80401

PO Number: CC-BEVERLY KAY

Instrument ID: **03886C**
Manufacturer: NATIONAL INSTRUMENTS
Description: 32-CH ±200 MV TO ±10 V, 16-BIT, 250 KS/S ANALOG INPUT MODULE

Model Number: NI 9205
Serial Number: 12E9CD3

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 3.4

Technician: COREY CLAXTON
Cal Date 21Aug2010
Cal Due Date: 21Aug2011
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 55.0 %

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.
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Approved By: COREY CLAXTON
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4291519	15-0271	MULTIFUNCTION CALIBRATOR	5700A	07Jul2010	05Oct2010

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Figure B-26. Calibration sheet for NI signal module 12E9CD3