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Duration Test Report for the SWIFT Wind Turbine

I. Mendoza and J. Hur
National Renewable Energy Laboratory

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Technical Report
NREL/TP-5000-57126
January 2013

Contract No. DE-AC36-08GO28308

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Prepared under Task No WE11.0205

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Duration Test Report

for the

SWIFT Wind Turbine

In
Boulder, CO

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

For

Wind Energy Program
DOE/NREL

Ismael Mendoza, Jerry Hur

20 September 2012

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Approval By: Arlinda Huskey 22 Jan 2013

Arlinda Huskey, NREL Test Engineer Date

Review By: 22 January 2013

Jeroen van Dam, NREL Test Engineer Date

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1. Background

This test was conducted as part of the U.S. Department of Energy's (DOE) Independent Testing project. The project was established to help reduce the barriers of wind energy expansion by providing independent testing results for small turbines. Several turbines where selected for testing at the National Wind Technology Center (NWTC) as a part of the Small Wind Turbine Independent Testing project. Duration testing was one of up to five tests that could be performed on the turbines. Other tests included power performance, safety and function, noise, and power quality. Cascade Engineering, of Grand Rapids, Michigan, distributor of the Renewable Devices' SWIFT turbine in North America, was the recipient of the DOE grant and provided the turbine for testing.

The test equipment included a grid-connected SWIFT wind turbine mounted on a 13.7 meter (45-ft) free standing monopole. The system was installed by the NWTC Site Operations group with guidance and assistance from Cascade Engineering.

2. Test Objective and Requirements

The objective of this test is to assess the following aspects of the SWIFT in accordance with Clause 9.4 of the International Electrotechnical Commission's (IEC) standard, *Wind turbines - Part 2: Design requirements for small wind turbines*, IEC 61400-2 Ed. 2.0:2006-03 (throughout the report referred to as the Standard):

- Structural integrity and material degradation
- Quality of environmental protection
- The Dynamic behavior.

Based on the parameters defined in the Standard for small wind turbine classes, the manufacturer, Renewable Devices Ltd, identified the test turbine to be class II. This corresponds to a V_{ave} of 8.5 m/s.

The wind turbine will pass the duration test when it has achieved reliable operation for the following:

- 6 months of operation
- 2,500 hours of power production in winds of any velocity
- 250 hours of power production in winds of $1.2V_{ave}$ (10.2 m/s) and above
- 25 hours of power production in winds of $1.8V_{ave}$ (15.3 m/s) and above.

Reliable operation comprises these factors:

- Operational time fraction of at least 90%
- No major failure of the turbine or components in the turbine system
- No significant wear, corrosion, or damage to turbine components
- No significant degradation of produced power at comparable wind speeds

In addition, this test has been conducted in accordance with the NREL quality system procedures such that this report meets the full requirements of our accreditation by A2LA. Our quality system requires that we meet all applicable requirements specified by A2LA and ISO/IEC 17025 or to note any exceptions in the test report.

3. Description of Test Turbine

The SWIFT turbine (Figure 1) is an upwind, 5-bladed with an outer ring, fixed pitch, passive yaw, horizontal-axis wind turbine with a rated power of 1kW.
Table 1 lists the configuration and operational data of the SWIFT turbine that was tested at the NWTC.

Figure 1. SWIFT test turbine at the NWTC
Source: NREL 2012

The SWIFT wind turbine was mounted on a 13.7-m (45-ft) monopole tower manufactured for Cascade Engineering by Valmont Industries. The inverter was manufactured by KACO new energy. The concrete foundation was installed by a third party per JDH Engineering designs, under contract to Cascade Engineering. The system

was installed on 19 October 2010 by the NWTC Site Operations group with guidance and assistance from Cascade Engineering personnel.

The following components were considered part of the test turbine system:

1. The turbine system included a tower and foundation that have been designed for installation at the NWTC test site 3.1.
2. The turbine system included all control components including wiring between the up-tower components and the inverter housed inside the data shed.
3. The turbine system was connected to the electrical grid at the test site through a subpanel. All wiring and components on the turbine side of this subpanel were considered part of the turbine system.

Table 1. Test Turbine Configuration and Operational Data

Turbine manufacturer and address	Renewable Devices Ltd Bush Estate, Penicuik, EH26 0PH Scotland, UK
Turbine provider and address	Cascade Engineering, Inc. 4855 Thirty-Seventh St. SE Grand Rapids, MI 49512
Model name	SWIFT
Generator serial number	N000780-N
Design nominal voltage at terminals	240 Vac
Maximum current at terminals	10 A
Design frequency at terminals	60 Hz
SWT class	II
Design 50-year extreme wind speed, V_{e50}	59.5 m/s
Rotor diameter	2.1 m
Hub height (vertical center of rotor)	14.28 m
Tower type	13.7 m (45 ft) freestanding monopole
Rated electrical power	1 kW
Rated wind speed (lowest wind speed at which turbine produces rated power)	11 m/s
Rated rotor speed (lowest rotor speed at which turbine produces rated power)	390 rpm
Rotor speed range	0-450 rpm
Fixed or variable pitch	Fixed
Number of blades	5
Blade pitch angle (deg)	6˚ at the tip
Blade make, type, serial number	Injection molded nano-fiber reinforced polymer, n/a
Description of control system (device & software version)	Kaco Blueplanet 1502x (V2.05)

Figure 2 shows the general electrical arrangement of the test. The wire was run from the generator to the controller, which is the point of grid connection, and to the data shed, approximately 46 meters. The connection was made using #12 American Wire Gauge (AWG) wire for the two power lines and turbine signal, and #6 AWG for the ground. The data shed housed the inverter, power instrumentation; disconnect switch, and data acquisition system. The 240 volts alternative current power output from the turbine

inverter was hooked up to a series of insulating step up transformers that raised the voltage to 13.2 kilovolts, allowing the system to tie to the NWTC grid.

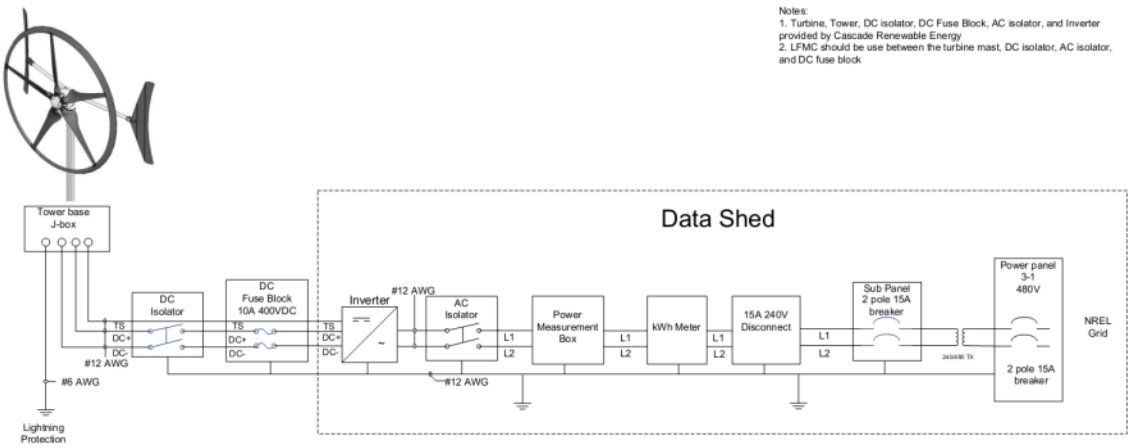


Figure 2. Electrical single-line drawing of SWIFT installation

4. Description of Test Site

The SWIFT wind turbine was located at test site 3.1 of the National Wind Technology Center, approximately 8 km south of Boulder, Colorado. The terrain consists of mostly flat terrain with short vegetation. The site has prevailing winds bearing 292 degrees relative to true north. Figure 3 shows the SWIFT turbine and meteorological tower locations. This figure also shows nearby obstructions of the site.

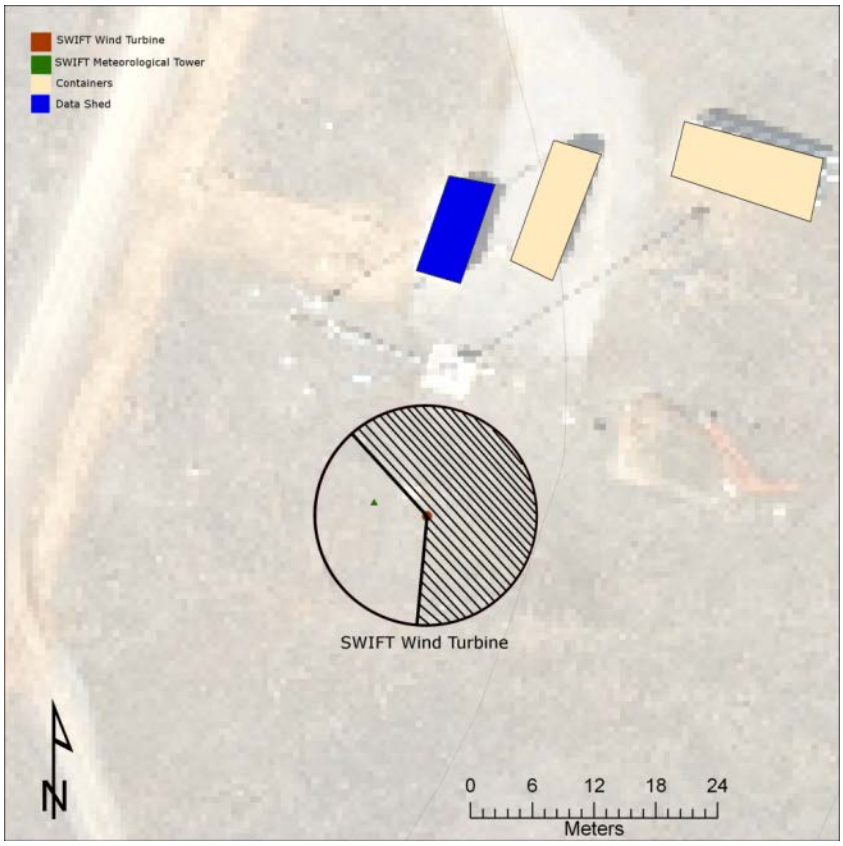


Figure 3. Map of area surrounding SWIFT at NWTC's 3.1 test site
Source: NREL 2012

5. Description of Instrumentation

Duration test instrumentation consisted of monitoring wind speed, wind direction, turbine power, air temperature, air pressure, precipitation, overall turbine system availability, and dynamic brake status. Figure 4 gives the location and height of the met tower instruments, and Table 2 gives an equipment list that provides the specifications for each of the instruments used.

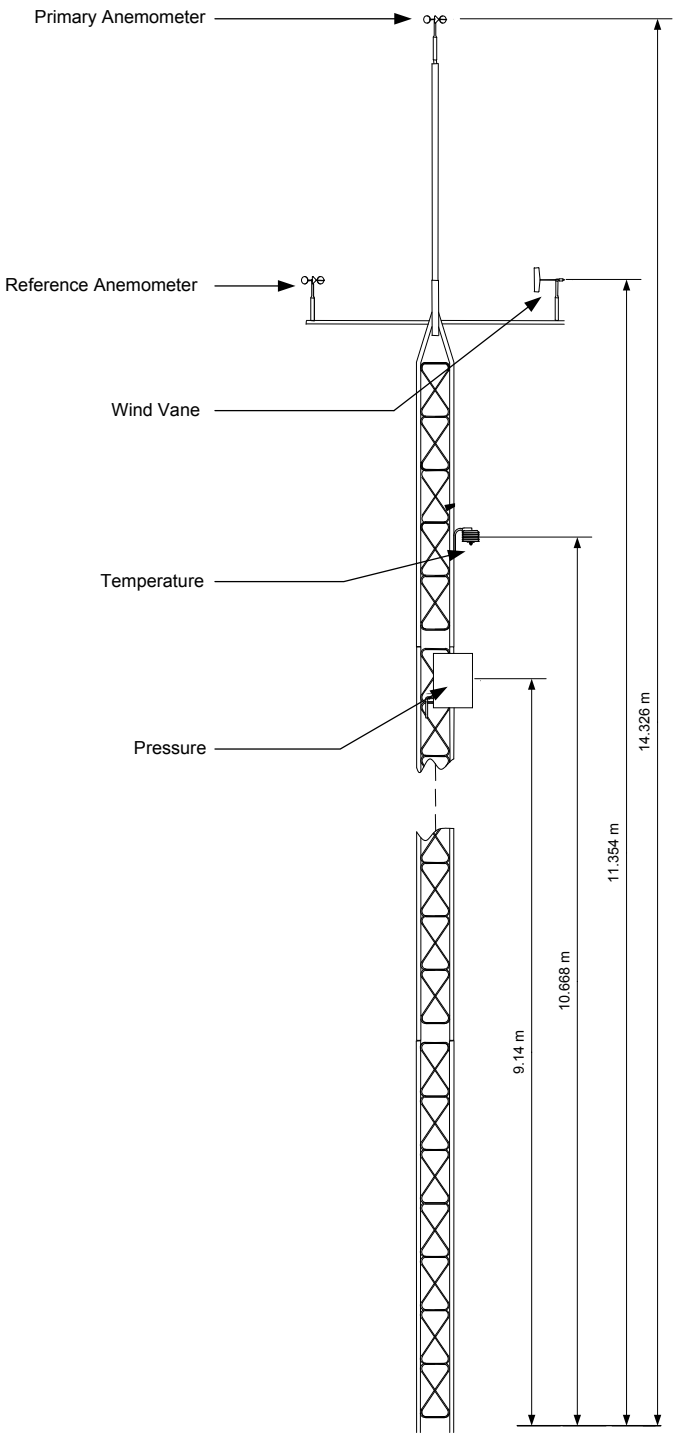


Figure 4. Meteorological tower and instruments (not to scale)

Table 2. Equipment List for Duration Test

Instrument	Make and Model	Serial Number	Calibration Due Dates
Power transducer	Secondwind Phaser 5FM-4A20	04607	20 October 2011 7 November 2012
Primary anemometer	Thies, First Class	0609005* 609006	13 October 2011 7 April 2012
Reference anemometer	Met One, 010	W2390	In situ
Wind vane	Met One, 020C with aluminum vane	U1478* W5515	13 October 2011 27 October 2012
Pressure sensor	Vaisala, PTB101B	C1020014* C1040008	10 August 2011 27 September 2012
Temperature sensor	Met One, T-200	0673553* 0603-1	13 October 2011 25 October 2012
Precipitation sensor	Campbell Scientific, 237	None	In situ
Data acquisition system	Compact DAQ w/LabView-based data acquisition cDAQ-9172 NI 9229 NI 9217 NI 9205 NI 9229 NI 9217 NI 9205	 13AB4F9 140DCB9* 140A596* 140E2BD* 14A34EE 1494F69 1496266	 29 April 2011 29 April 2011 29 April 2011 22 March 2012 22 March 2012 22 March 2012

*Replaced during testing

The power transducer was used out of calibration for 4 days during the last week of October during the test. The unit was removed on 24 October 2011 and sent out for calibration, was found within specification, and reinstalled in 8 November 2011 for the remainder of the test period. The calibration sheets can be found in Appendix B. The turbine was locked out until the power transducer was reinstalled. The time during that period was categorized as T_U due to maintenance of the test institute instrumentation.

The temperature and pressure sensor calibration expired during the test. The units were replaced with another calibrated unit. The initial units were sent out for post-test calibration and found to be within specification. The calibration sheets of the post-test calibrations are also inserted in Appendix B.

The first wind vane's calibration also expired during the test. The wind vane was not post-tested before it was sent out for refurbishing. Because the wind direction is not a required signal for the duration testing it did not affect the analysis. The unit was replaced with another calibrated unit for the remainder of the test. This was listed as an exception to our QA system.

The primary anemometer and data acquisition modules where replaced with another calibrated unit during the test before their calibration expired. The power measuring module failed its post-test calibration. An investigation was performed on the data acquired but there were no indications that the module failed during the test. The power reading versus wind speed relationship between both modules stayed consistent throughout the test as seen in Figure 5. The calibration center reported that no signal could be read for that channel as specified in the post-calibration report. Some loose parts could be heard when the module was returned from post calibration that were not present before being sent out for post calibration. It was concluded that it may have been damaged during shipping. This was also listed as an exception to our QA system. The calibration sheet of the post-test calibration is also inserted in Appendix B.

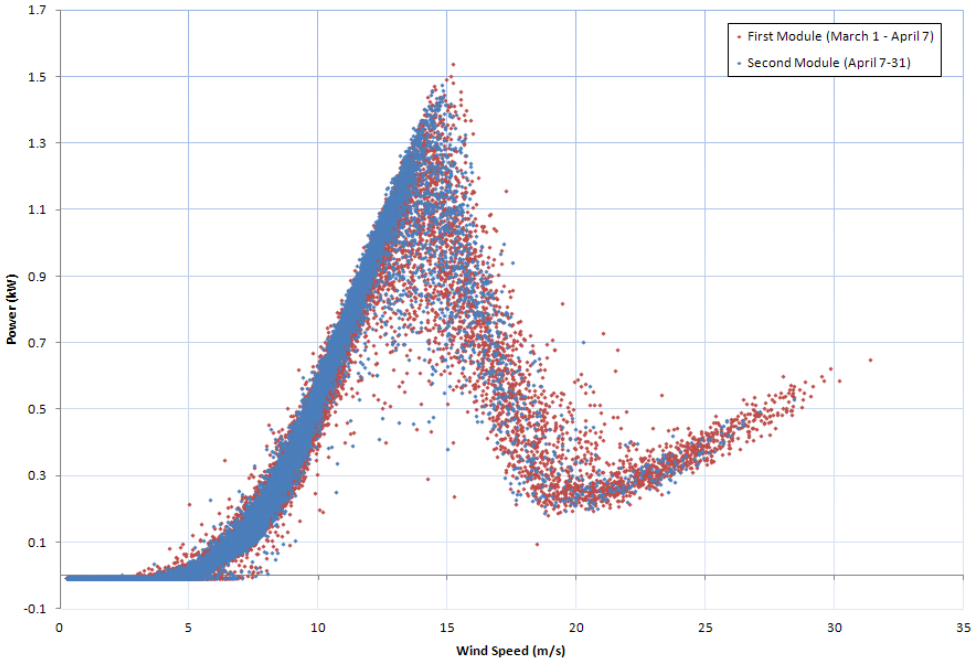


Figure 5. Powers vs. wind speed scatter plot comparison (1-minute average)

6. Results

The test turbine was delivered to the NWTC on 20 September 2010. The turbine system was installed on 19 October 2010 by the NWTC Site Operations group with guidance and assistance from Cascade Engineering. Testing began on 1 November 2010 after a commissioning period. The duration test was completed on 30 November 2011 after enough data was collected to demonstrate sufficient hours of operation as required by the standard. The turbine ran without any issues until it was decommissioned on 27 June 2012 when the turbine was removed for post inspection.

6.1. Months of Operation

The duration test was conducted over a period of 13 months from 1 November 2010 to 30 November 2011, thus exceeding the minimum of the 6 months required by the Standard. The turbine continued to operate without any problems until it was decommissioned on 27 June 2012.

6.2. Hours of Power Production

The hours of power production at any wind speeds: 2,732 hours (2,500 hours required)

The hours of power production above 1.2*V_{ave} (10.2 m/s): 533 hours (250 hours required)

The hours of power production above 1.8*V_{ave} (15.3 m/s): 112 hours (25 hours required)

Thus the turbine met the requirements for hours of power production during the test. Table 3 shows the overall and month-by-month results of the duration test.

Table 3. Monthly and Overall Results of the SWIFT Duration Test

Month	Hours of power production in wind speed above:			Environmental conditions			Operational time fraction				
	0 m/s	10.2 m/s	15.3 m/s	max gust m/s	Average % TI @ 15 m/s	# points	T_T (hours)	T_U (hours)	T_E (hours)	T_N (hours)	O [%]
Totals	*2732.9*	*533.6*	*112.6*	*42.0*	*19.3*	*231*	*9480.0*	*753.6*	*136.1*	*313.0*	*96.4*
Nov-2010	189.0	41.7	9.0	41.1	19.3	21	720	22.5	40.7	4.7	99.3
Dec	184.3	48.2	16.2	33.1	19.0	16	744	3.7	2.7	29.8	96.0
Jan-2011	349.3	115.5	21.8	41.4	20.9	44	744	18.1	0.5	38.2	94.7
Feb	246.5	69.0	9.2	31.5	18.3	44	672	93.7	19.0	11.7	97.9
Mar	295.7	70.0	25.0	42.0	20.4	31	744	37.7	0.0	86.0	87.8
Apr	340.8	91.5	16.2	37.0	18.4	40	720	20.3	20.3	5.2	99.2
May	244.0	28.0	7.3	34.1	17.8	6	744	2.7	17.2	30.3	95.8
Jun	142.7	7.2	0.3	26.9	-	0	720	39.8	26.8	28.8	95.6
Jul	118.7	4.8	0.2	27.2	34.9	1	744	43.3	6.0	11.0	98.4
Aug	168.8	2.7	0.2	24.6	20.9	2	744	0.2	0.3	29.0	96.1
Sep	114.3	0.8	0.2	23.8	17.7	2	720	6.9	0.5	27.0	96.2
Oct	124.3	8.7	1.0	28.8	18.6	4	744	239.3	1.8	3.3	99.3
Nov	214.5	45.5	6.0	38.8	17.9	20	720	225.4	0.3	8.0	98.4

6.3. Operational Time Fraction

The operational time fraction is defined as follows:

$$O = \frac{T_T - T_N - T_U - T_E}{T_T - T_U - T_E} \times 100\%$$

where:

T_T = total time period under consideration
T_N = time during which the turbine is known to be non-operational
T_U = time during which the turbine status is unknown
T_E = time which is excluded in the analysis

The overall operational time fraction of the combined wind turbine system in the total test period was 96.4%. The final column of Table 3 shows the operational time fraction per month. Figure 6 shows the operational time fraction for every month.

The SWIFT turbine system experienced non-operational time, or downtime (T_N), for several reasons. The significant events are detailed below:

- The Kaco Blueplanet 1502x inverter performed an automatic daily 5-minute system check causing the system to go offline for an average of 2.5 hours a month independent of wind conditions. This method overestimated TN because the entire 10 minute average was labeled non-operational even if the turbine started to produce power. Even with this overestimation the operational time fraction observed during the test period was 96.4%, still above the minimum requirement of 90%.
- On 29 December 2010 the turbine faulted because the inverter failed its daily system check and did not reset the fault until it re-ran the daily check 24 hours later. After discussions with Cascade Engineering it was identified that the inverter required a system firmware upgrade to correct the annoyance faults. Because the firmware upgrade could be considered a system change and forced a restart of the test, it was decided not to implement it. Several of these events occurred during the test period. The month of March 2011 was when most of these events occurred, causing a lower operating time fraction. These faults where the majority of the T_N events.
- On 16 December 2010 the turbine faulted due to an excessive vibration event, causing the turbine to be offline for almost 3 days because a manual reset was required. NWTC personnel reset the turbine per SWIFT owners' manual operating instructions. During the time of the fault, high wind conditions from a variety of wind directions were observed.

The main reasons for excluding time (T_E) in the duration test were the following:

- Time during power outages that prevented the turbine from running
- Noise or safety and function testing that required the turbine to be shut down
- NREL-initiated inspections of the SWIFT turbine or institute instrumentation.

If measurements were not available or reliable, the time was classified as unknown time (T_U) because the turbine's status was unknown. These events occurred primarily when the DAS was off (maintenance or power outage), or when failure or degradation of the test institute instrumentation took place due to environmental conditions such as icing events.

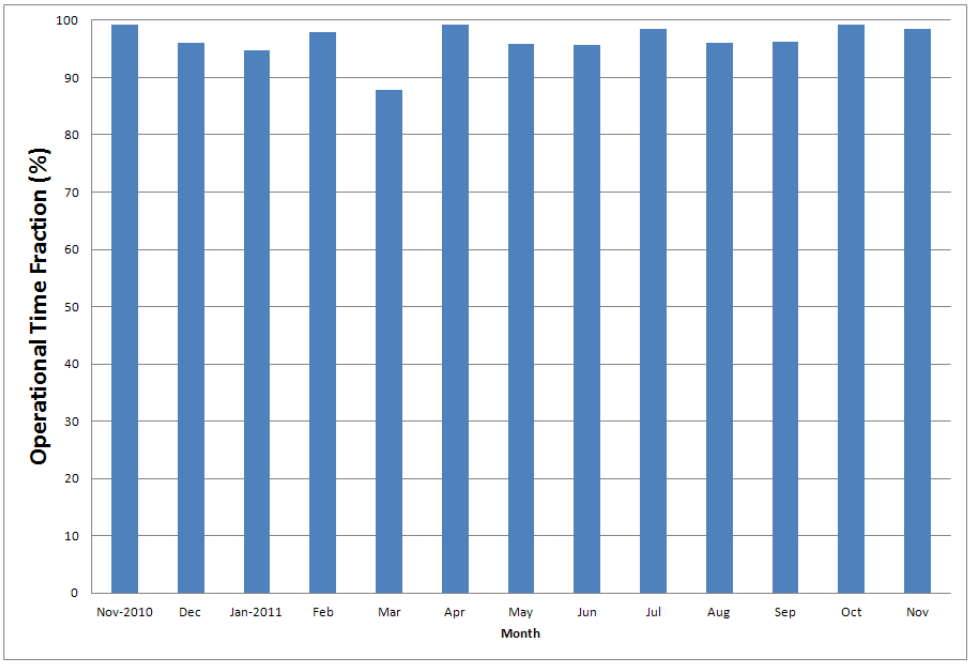


Figure 6. Operational time fraction for each month

6.4. Environmental Conditions

As an indication of the environmental conditions during the duration test, the Standard required reporting the highest instantaneous wind speed gust and the average turbulence intensity at 15 m/s. The highest instantaneous wind speed was 42 m/s at 23:48 on 22 March 2011. The average turbulence intensity at 15 m/s during the test period was 19.3%.

6.5. Power Degradation Checks

A factor of reliable operation is that the turbine should experience no significant power degradation. During the power degradation analysis, the average power level for each wind speed bin was plotted as a function of time over the entire test period. This plot was analyzed for any obvious trends in power production. Figure 7 shows the power degradation plot, which gave the power level in individual wind speed bins for each month. Variations of the power levels from season to season were caused by air density changes. The low point at 15 m/s in July 2011 was caused by a passing storm that brought very low to very high variable winds. The variations of wind speed caused the turbine to produce less power than expected.

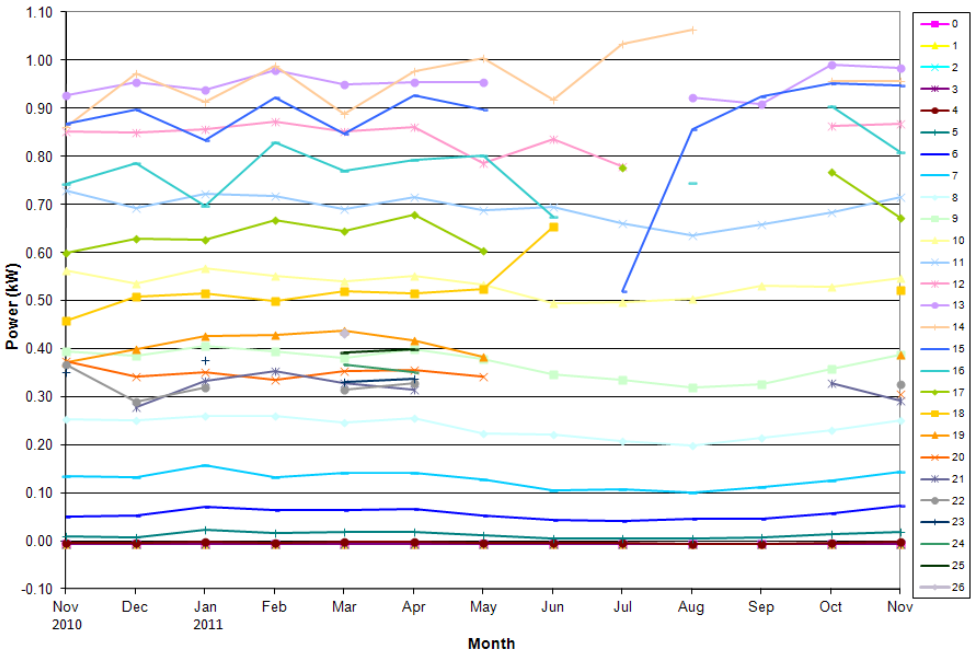


Figure 7. Power degradation for all wind speeds measured

Figure 8 shows a 10-minute average scatter plot of power versus wind speed during the test. The turbine had a furling mechanism that governed the rotor speed and power production at winds speeds above 10 m/s as shown in the figure. Figure 9 illustrates the turbine power level in individual wind speed bins up to 14 m/s for each month, just before the turbine's furling mechanism fully engages.

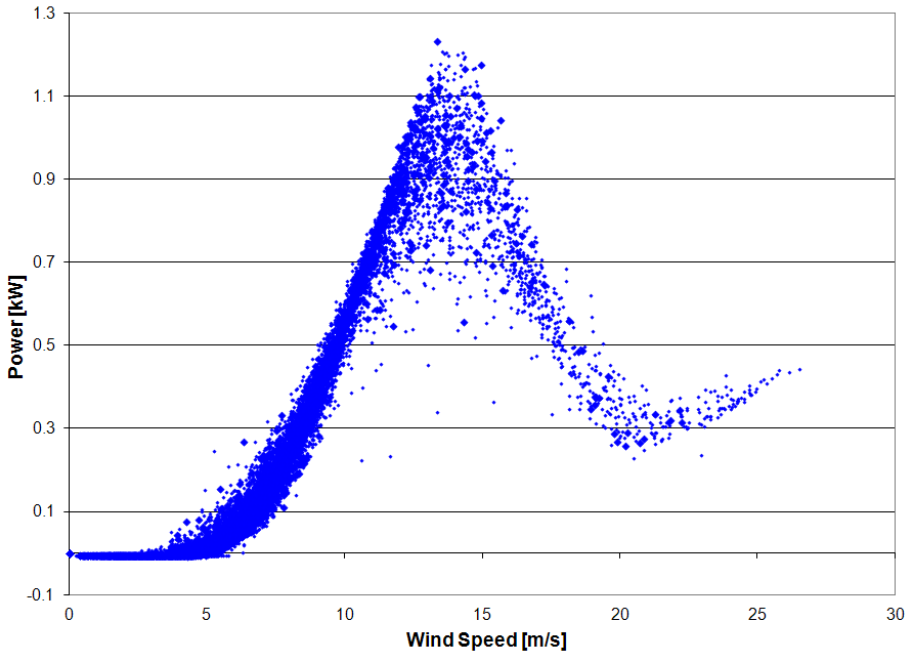


Figure 8. Scatter plot of power versus wind speed (10-minute averages)

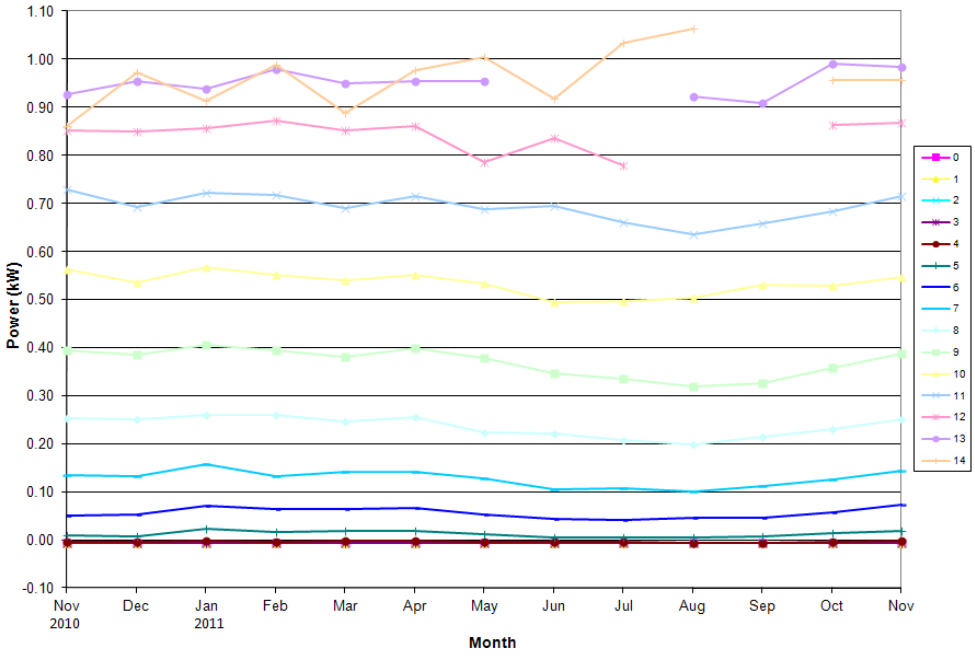


Figure 9. Power degradation plot for winds up to 14 m/s

6.6. Dynamic Behavior

The operation was observed by NWTC personnel for at least 5 minutes at wind speeds of approximately 5 m/s, 10 m/s, 15 m/s, and 20 m/s, for a total observation time of at least 1 hour.

The following observations were recorded in the log book during this time:

16 November 2010 **Wind Speed:** 5-15 m/s **Wind direction:** SW

"It was observed that the furling mechanism was fully engaged at wind speed greater than 14 m/s to reduce the rotor speed. The turbine turned slowly to the right, removing the rotor from direct wind."

30 March 2011 **Wind Speed:** 5-20 m/s **Wind direction:** W

"The unit was observed to track the wind well. The unit had a dynamic response due to its furling mechanism, which was engaged during high winds, causing the turbine to turn the rotor sideways away from the wind. Yaw oscillations could be severe at times, especially during gusty winds that caused the unit to furl immediately and then return to its normal orientation once wind speed was reduced. The rotor was seen to swing 60 degrees in approximately 1 second.

Some slight tower vibration and rattling was observed during high wind events when the turbine's furl mechanism was engaged. Although vibrations could be felt in the tower and sometimes seen, the vibrations were not deemed excessive. (Accelerations on the SWIFT were not measured)."

30 April 2011 **Wind Speed:** 1-5 m/s **Wind direction:** NW

"Turbine started up normally as the winds increased. The unit tracked the wind well even at low wind speeds."

19 January 2012 **Wind Speed:** 5-16 m/s **Wind direction:** WSW

"The turbine behavior was observed during a simulated grid outage by opening the breaker during the "Safety & Function" testing. The turbine was observed to immediately reduce the rotor speed to a slow idling speed."

The unit's passive yaw mechanism consisted of a side fin equipped with a spring that became fully engaged at wind speeds greater than 14m/s. Because the turbine was designed to free yaw, its furling mechanism was still active even if the turbine was shut down or faulted. A squeaking noise emanating from the furling fin was noticed after 8 months of operations when the turbine furled.

On 6 April 2012, after collecting turbine data for the acoustic noise test, grease was applied on the spring and hinges of the furling mechanism to silence the squeaking. This allowed us to acquire clean background data. The furling fin was completely engaged in order to expose the furling components inside the side boom to allow complete implementation of the lubricant. The manufacturer was informed of the noise.

After operating almost 12 months, a rattling sound was detected coming from the turbine's nose cone. The noise was consistent with each rotation of the rotor, and was more evident at low wind speeds than high. The nose cone was replaced with a new one, but after 3 high windy months the rattling started again. No cracks or breaks on the tabs of either nose cone were found. Some wear was noticed on the inside of the nose cone that could possibly reduce the tight fit to the rotor (see Figure A1). During the post-test inspection Cascade Engineering mentioned that the wear could possibly have been cause by the bonding edge that was left when the rotor was manufactured.

7. Tear Down and Post-Test Inspection

The SWIFT turbine was taken down from site 3.1 on 27 June 2012 after NREL completed all testing activities as part of the independent testing project. A tear-down inspection was performed as a part of the duration test. The post-test inspection was performed on 24 July 2012 with the assistance of a Cascade Engineering representative. No significant wear or damage was found. This section describes that tear-down inspection.

7.1. Nose Cone

The nose cone had some wear inside that caused it to rattle with every rotation of the rotor (see Figure A1). According to Cascade Engineering, the wear could have been caused by the bonding edge left when the rotor was manufactured.

7.2. Rotor

The rotor did not show any cracks or signs of damage. The rotor's glace coatings were worn out and felt somewhat rough due to exposure to the environment. No power degradation was observed for the duration of the test. The fastening nut torque was verified before removal and it was found to be at the manufacturer's recommended specifications.

7.3. Blades

No cracks were found when all five blades and outer ring were visually inspected.

7.4. Nacelle

The nacelle was in good condition. Some small paint chips were noticed on the top and on the side boom mountings (see Figure A2 and Figure A3).

7.5. Furling Assembly

Both tail fins were inspected visually and only some small paint chips—no cracks—were found. Grease applied by NREL inside the side boom left several grease spots. The grease was applied to the furling mechanism to silence the squeaking so that clean background data could be collected for the acoustic noise analysis (see Figure A4 through Figure A6). The furling booms did not have any cracks or signs of wear.

7.6. Generator

The turbine had a dynamic break that worked by shorting the generator windings. This was confirmed during the post-test inspection by rotating the rotor and observing a pulsating resistance. The generator itself could not be inspected because the nacelle could not be disassembled. The strong magnets in the generator made disassembly dangerous, and without proper reassembly the SWIFT turbine would be unusable for a future installation.

7.7. Inverter

The inverter was opened and inspected for any discoloration, loose wires, etc. Nothing out of the norm was observed.

7.8. Yaw System

The yaw bearing was manually tested before the turbine was removed from the tower. It was observed to rotate smoothly, and that there was no play in the bearing. All bolts for the yaw positioning clamp that connected the turbine to the tower were verified and had the manufacturer-recommended torque amount.

7.9. Tower

The welds and bolts on the tower were visually inspected. No abnormalities or cracks were observed.

7.10. Foundation

The foundation and anchors were visually inspected and no abnormalities or cracks were observed.

8. Uncertainty

The uncertainty is estimated for the following parameters:

- Hours of power production
- Operational time fraction
- Highest instantaneous wind speed.

No uncertainty analysis was done for the power degradation results. These results were used only to find relative trends that may have indicated hidden faults in the turbine.

8.1. Hours of Power Production

It was assumed that the turbine was producing power for the entire 10-minute period whenever the average power for that period was positive. This method overestimated time for power production in wind speeds between 4 and 6 m/s. At these wind speeds the turbine may have been producing power for about half the time recorded by NREL.

At higher wind speeds, this method continued to overestimate time for power production but to a smaller amount. NREL estimated that the reported time of power production in wind speeds greater than 0 m/s was 20% less than calculated.

However, the turbine continued to run through 27 June 2012 with no problems until it was decommissioned. Thus, NREL is confident that it achieved the 2,500 hours required by the standard.

For the hours of power production above 10.2 and 15.3 m/s, the uncertainty in the wind speed was assumed to be the dominant factor. Assuming an uncertainty in wind speed of 0.3 m/s, the hours of power production decreased to 494 (above 10.5m/s) and 100 (above 15.6 m/s), which is still well in excess of the 250 and 25 hours required.

8.2. Operational Time Fraction

The daily 5-minute inverter checks where labeled non-operational (T_N) for the entire 10-minute period, resulting in an overestimation. This means that the 96.4% was the lower bound of the operational time fraction, still above the minimum requirement of 90%.

8.3. Highest Instantaneous Wind Speed

The uncertainties in the wind speed measurements were 0.0179 m/s calibration uncertainty, 0.052 m/s + 0.52% operational characteristics, 1% mounting effects, and 2% terrain effects. For the maximum instantaneous gust of 42.0 m/s, the uncertainty was 0.98 m/s.

9. Deviations and Exceptions

9.1. Deviations from the Standard

There were no deviations from the Standard.

9.2. Deviations from Quality Assurance

The power transducer, wind vane, pressure, and temperature sensor were used beyond the calibration due date. The power transducer, pressure, and temperature sensor were calibrated post-test and found to be in compliance within the specifications. The initial wind vane was not post-calibrated before sending it out for refurbishing. The wind direction was not a required signal for the duration testing so it was not necessary to introduce any uncertainty to the duration analysis of the turbine. The initial power measuring data acquisition module failed its post-test calibration. The calibration agency reported that no signal output could be read for that channel as specified in the post-calibration report. An investigation was performed on the data acquired but there were no indications that the module failed during the test. The power reading versus wind speed relationship between both modules stayed consistent throughout the test as seen in Figure 5. When the module was returned from calibration some loose parts could be heard that were not present before being sent out. It was concluded that damage may have occurred during shipping. The calibration sheets of the post-test calibration are also inserted in Appendix B.

A. Appendix – Pictures of Post-Test Inspection

Figure A1. Wear marks inside the nose cone
Source: NREL 2012

Figure A2. Paint chips on the back of the nacelle
Source: NREL 2012

Figure A3. Paint chips on the side mounts of the nacelle
Source: NREL 2012

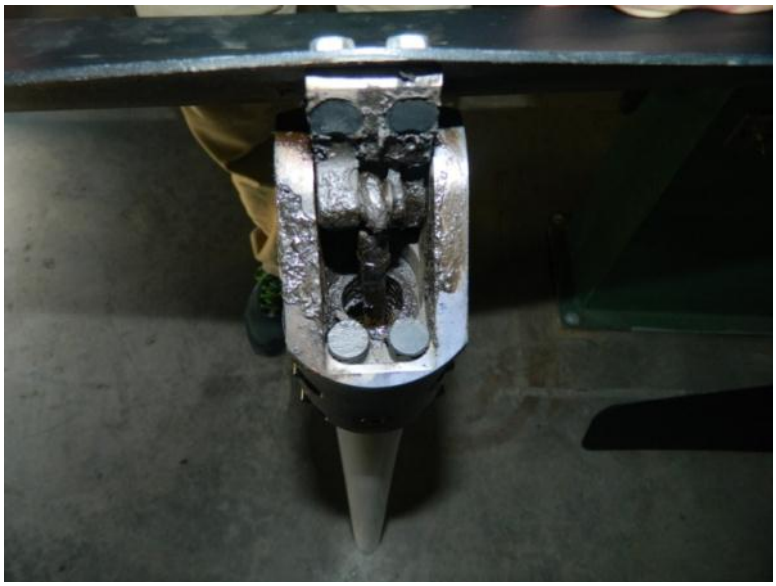


Figure A4. Inside side furling boom (grease residue from NREL's application)
Source: NREL 2012

Figure A5. Furling fin stained with grease residue (NREL applied the grease)
Source: NREL 2012

Figure A6. Paint chip on side fin
Source: NREL 2012

Figure A7. SWIFT rotor with nose cone removed
Source: NREL 2012

B. Appendix – Equipment Calibration Sheets

Power

Branch #: 5000

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Phaser Power Transducer DOE #: 03503C

Model # : Phaser-5-485-4A 20 S/N : 04607

Calibration Date: 10/20/2010 Due Date: 10/20/2012

A. Set-Up for Power Calibration:
A.1. Voltage is applied to phases A&B = 120 V @ 60 Hz.
A.2. Current is applied to phases A&B.
A.3. Analog Output-1 is measured across precision resistor = 250 Ω.

Calibrator Output		Transducer Input/Output		
Current (AAC)	Power 2*V*I (W)	Input Current (AAC)	Input Power 2*n*V*I (W)	Analog Output-1 (VDC)
-9	-2160	N/A	N/A	.997
-8	-1920	"	"	1.078
-6	-1440	"	"	1.557
-4	-960	"	"	2.037
-2	-480	"	"	2.516
-1	-240	"	"	2.754
0	0	"	"	2.994
1	240	"	"	3.234
2	480	"	"	3.473
4	960	"	"	3.953
6	1440	"	"	4.432
8	1920	"	"	4.911
9	2160	"	"	4.991

Page 1 of 3

Figure B1: Power transducer calibration sheet I, installed 20 October 2010 to 24 October 2011

B. Set-Up for Power Factor Calibration:
B.1. Voltage @120VAC and Current @ 4A @ 60Hz
B.2. Analog Output-2 is measured across precision resistor = 250 Ω.

Calibrator Output		Analog Output-2 (VDC)
Current (AAC)	Power Factor	
4	1	4.994
4	0.75	3.990
4	0.5	2.990
4	0.25	1.990
4	0.0	1.010

C. Set-Up for Total Harmonic Distortion (THD) Calibration:
C.1. Voltage & Current are applied as A.1 & A.2.
C.2. Analog Output-3 is set for Current THD
C.3. Analog Output-3 is measured across precision resistor = 250 Ω.

Current THD (%)	Analog Output-3 (VDC)
0	.999
10	1.395
20	1.796
30	2.191

D. Set-Up for A to B Voltage Measurement:
D.1. Voltage is applied as listed below @ 60Hz
D.3. Analog Output-4 is measured across precision resistor = 250 Ω.

Calibrator Output	Analog Output-4 (VDC)
0V	2.996
80V	3.611
160V	4.226
240V	4.680

Page 2 of 3

Figure B2: Power transducer calibration sheet II, installed 20 October 2010 to 24 October 2011

Notes:
- Calibration was performed using instruments that are traceable to NIST, DOE# 126410 and 01886C.
- Calibration was performed at temperature = 24 °C, ± 1 °C, and relative humidity =45%, ± 10%.
- Uncertainty of nominal values is ± 0.15% of reading.

Calibrated By: P. Morse

Date: 10/20/2010

Approved By : Reda

Date: 10/20/2010

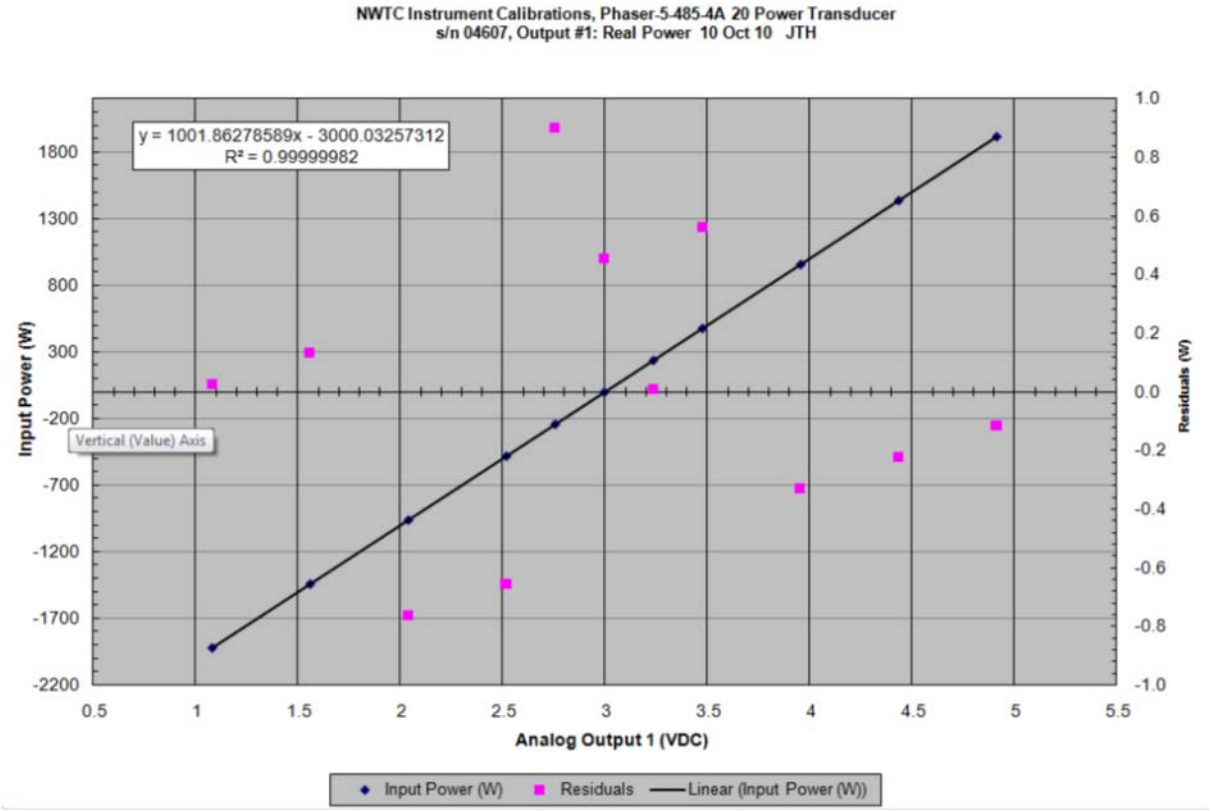


Figure B3: Power transducer calibration sheet III, installed 20 October 2010 to 24 October 2011

NREL METROLOGY LABORATORY

TEST REPORT

Test Instrument: Phaser Power Transducer DOE #: 03503C

Model #: Phaser-5-485-4A20 S/N: 04607

Calibration Date: 7/20/2012 Date Due: 7/20/2013

Test No.	Function Tested	Nominal Input	Measured Output at 250 Ohm (DCV)		( ) Mfr Specs (X)Data Only
			As Found	As Left	
1.	Analog Output 1: Power in Watt applied to Phase A&B with 120V @ 60 Hz				
		-1920	1.078		
		-1440	1.557		
		-960	2.037		
		-480	2.516		
		0	2.994		
		480	3.473		
		960	3.953		
		1440	4.432		
		1920	4.911		
2.	Analog Output 2: Power Factor at 960 W @ A&B with 120V @ 60 Hz				
		1	4.994		
		0.75	3.99		
		0.5	2.99		
		0.25	1.99		
		0	1.005		
3.	Analog Output 3: THD for current in % at 960 W @ A&B with 120V @ 60 Hz				
		0	0.999		
		10	1.395		
		20	1.796		
		30	2.195		
		40	2.599		
		50	3.001		
		60	3.399		
		70	3.793		
4.	Analog Output 4: Voltage in volts between A&B @ 60 Hz				
		0	2.996		
		80	3.611		
		160	4.226		
		240	4.682		

Figure B4: Power transducer calibration sheet I, installed 8 November 2011 to 18 July 2011

Notes:

- Calibration was performed using instruments that are traceable to NIST: DOE# 126410 and 01886C
- Calibration was performed at a temperature of 23°C and Relative Humidity of 39%
- Expanded uncertainity of the nominal value is ± 0.15% of Reading, with k=2

Calibrated By:	Reda			Approved By:	Preston
Date:	7/20/2012			Date:	7/20/2012

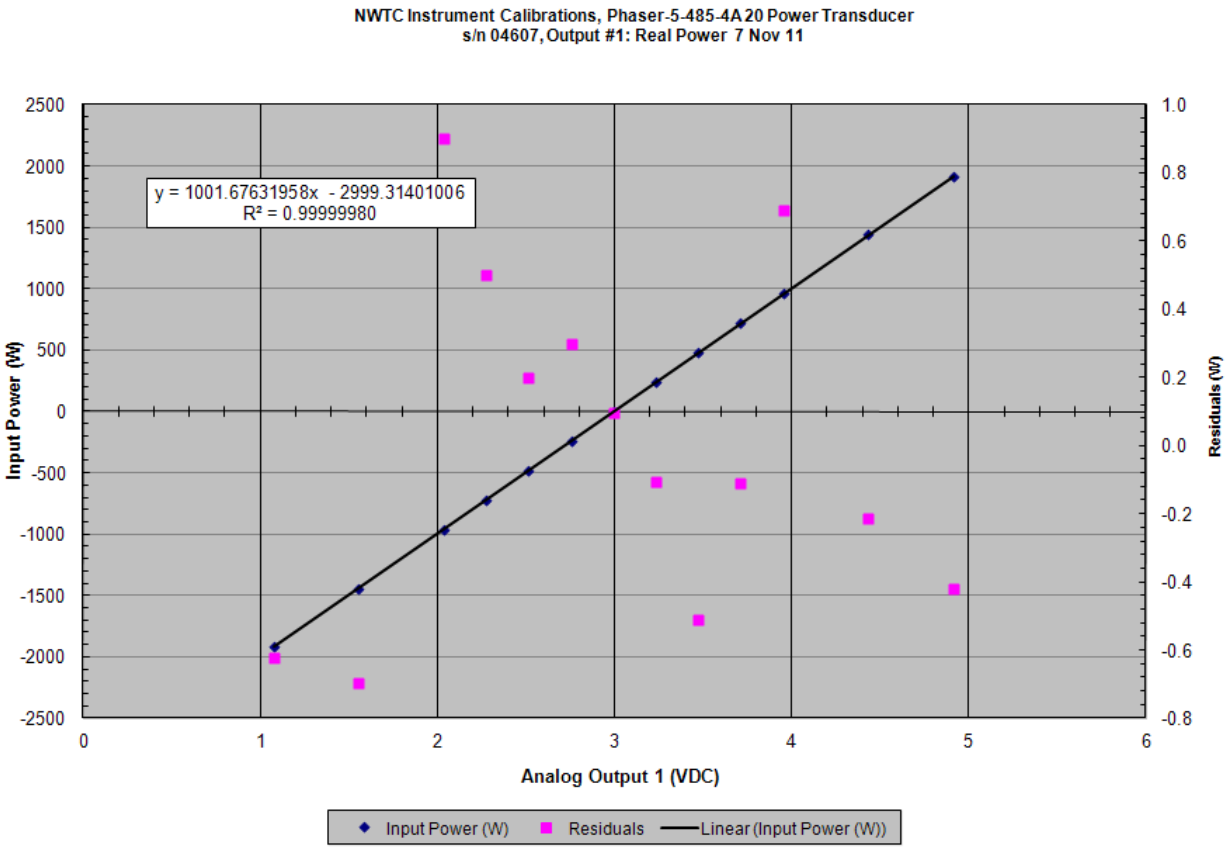
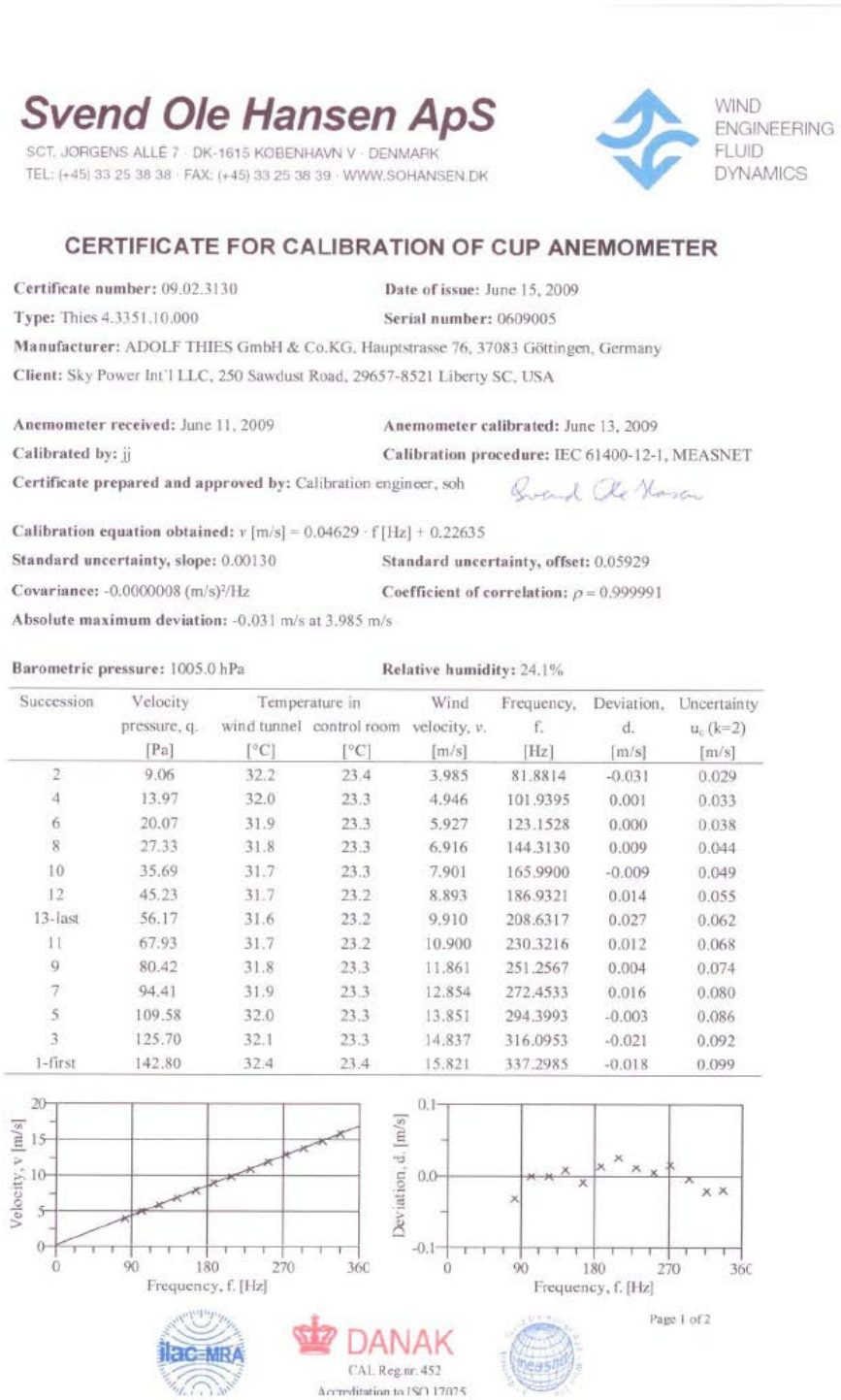


Figure B5: Power transducer calibration sheet II, installed 8 November 2011 to 18 July 2011

Wind Speed



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WIND ENGINEERING FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 09.02.3130 **Date of issue:** June 15, 2009

Type: Thies 4.3351.10.000 **Serial number:** 0609005

Manufacturer: ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany

Client: Sky Power Int'l LLC, 250 Sawdust Road, 29657-8521 Liberty SC, USA

Anemometer received: June 11, 2009 **Anemometer calibrated:** June 13, 2009

Calibrated by: jj **Calibration procedure:** IEC 61400-12-1, MEASNET

Certificate prepared and approved by: Calibration engineer, soh

Calibration equation obtained: v [m/s] = 0.04629 · f [Hz] + 0.22635

Standard uncertainty, slope: 0.00130 **Standard uncertainty, offset:** 0.05929

Covariance: -0.0000008 (m/s)²/Hz **Coefficient of correlation:** $\rho = 0.999991$

Absolute maximum deviation: -0.031 m/s at 3.985 m/s

Barometric pressure: 1005.0 hPa **Relative humidity:** 24.1%

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	9.06	32.2	23.4	3.985	81.8814	-0.031	0.029
4	13.97	32.0	23.3	4.946	101.9395	0.001	0.033
6	20.07	31.9	23.3	5.927	123.1528	0.000	0.038
8	27.33	31.8	23.3	6.916	144.3130	0.009	0.044
10	35.69	31.7	23.3	7.901	165.9900	-0.009	0.049
12	45.23	31.7	23.2	8.893	186.9321	0.014	0.055
13-last	56.17	31.6	23.2	9.910	208.6317	0.027	0.062
11	67.93	31.7	23.2	10.900	230.3216	0.012	0.068
9	80.42	31.8	23.3	11.861	251.2567	0.004	0.074
7	94.41	31.9	23.3	12.854	272.4533	0.016	0.080
5	109.58	32.0	23.3	13.851	294.3993	-0.003	0.086
3	125.70	32.1	23.3	14.837	316.0953	-0.021	0.092
1-first	142.80	32.4	23.4	15.821	337.2985	-0.018	0.099

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Figure B6: Primary anemometer calibration sheet I, installed 13 October 2010 to 7 April 2011

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WIND ENGINEERING FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 09.02.3131 **Date of issue:** June 15, 2009

Type: Thies 4.3351.10.000 **Serial number:** 0609006

Manufacturer: ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany

Client: Sky Power Int'l LLC, 250 Sawdust Road, 29657-8521 Liberty SC, USA

Anemometer received: June 11, 2009 **Anemometer calibrated:** June 13, 2009

Calibrated by: jj **Calibration procedure:** IEC 61400-12-1, MEASNET

Certificate prepared and approved by: Calibration engineer, soh

Calibration equation obtained: v [m/s] = 0.04630 · f [Hz] + 0.22992

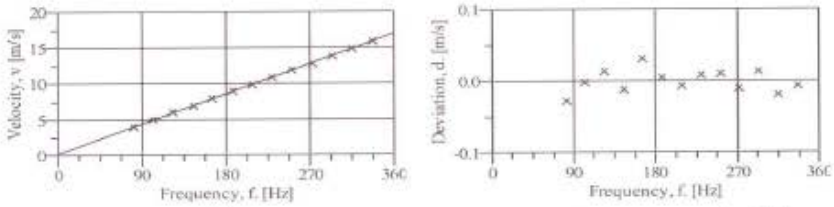
Standard uncertainty, slope: 0.00126 **Standard uncertainty, offset:** 0.05660

Covariance: -0.0000007 (m/s)²/Hz **Coefficient of correlation:** $\rho = 0.999991$

Absolute maximum deviation: 0.032 m/s at 7.911 m/s

Barometric pressure: 1005.4 hPa **Relative humidity:** 24.1%

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_v (k=2) [m/s]
2	9.03	32.3	23.3	3.978	81.5163	-0.027	0.029
4	14.04	32.1	23.2	4.958	102.1571	-0.002	0.033
6	20.23	32.0	23.2	5.950	123.2216	0.014	0.038
8	27.39	31.9	23.2	6.923	144.8197	-0.013	0.044
10	35.79	31.8	23.2	7.911	165.2051	0.032	0.050
12	45.41	31.8	23.2	8.910	187.3624	0.005	0.056
13-last	56.18	31.7	23.1	9.911	209.1977	-0.006	0.062
11	67.73	31.8	23.2	10.884	229.8895	0.009	0.068
9	80.53	31.9	23.2	11.869	251.1191	0.011	0.074
7	94.07	32.0	23.2	12.830	272.3620	-0.011	0.080
5	109.65	32.1	23.2	13.855	293.9411	0.014	0.086
3	125.49	32.2	23.3	14.825	315.6078	-0.019	0.092
1-first	143.09	32.4	23.3	15.838	337.2206	-0.007	0.099



Page 1 of 2

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Figure B7: Primary anemometer calibration sheet I, installed 7 April 2011 to 27 June 2012

DOE # 04390c

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WIND ENGINEERING FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 12.02.6727 **Date of issue:** August 24, 2012

Type: Thies 4.3351.10.000 **Serial number:** 0609006

Manufacturer: ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany

Client: National Renewable Energy Lab, 1617 Cole Boulevard, Golden, Colorado 80401-3393, USA

Anemometer received: August 13, 2012 **Anemometer calibrated:** August 23, 2012

Calibrated by: asj **Calibration procedure:** IEC 61400-12-1, MEASNET

Certificate prepared by: ca **Approved by:** Calibration engineer, ml

Calibration equation obtained: $v\,[m/s] = 0.04654 \cdot f\,[Hz] + 0.15404$

Standard uncertainty, slope: 0.00114 **Standard uncertainty, offset:** 0.07713

Covariance: -0.0000006 (m/s)²/Hz **Coefficient of correlation:** $\rho = 0.999993$

Absolute maximum deviation: -0.036 m/s at 13.844 m/s

Barometric pressure: 1009.3 hPa **Relative humidity:** 27.6%

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	9.65	33.4	25.5	4.112	85.1908	-0.007	0.021
4	14.95	33.3	25.5	5.119	106.6331	0.002	0.025
6	21.07	33.1	25.4	6.075	127.4800	-0.012	0.029
8	28.26	33.1	25.4	7.035	147.5747	0.012	0.033
10	36.34	33.0	25.4	7.977	168.1495	-0.003	0.037
12	45.88	33.0	25.4	8.962	189.1365	0.005	0.042
13-last	56.70	32.9	25.4	9.963	210.5526	0.009	0.046
11	68.46	33.0	25.4	10.948	231.7626	0.007	0.051
9	80.56	33.1	25.4	11.878	251.6408	0.012	0.055
7	94.56	33.1	25.4	12.870	273.2038	0.000	0.059
5	109.38	33.2	25.4	13.844	294.9135	-0.036	0.064
3	125.53	33.4	25.5	14.833	315.5930	-0.009	0.068
1-first	141.94	33.6	25.5	15.780	335.3141	0.020	0.073

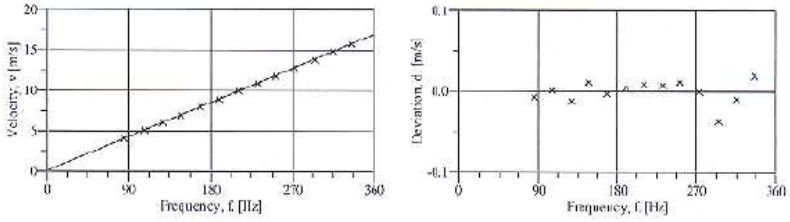

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Figure B8: Primary anemometer post test calibration sheet I, installed 7 April 2011 to 27 June 2012

Wind Direction

NWTC Testing Group

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: 6-Oct-10

Report Number: U1478-101006

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)

Item Calibrated:

Manufacturer	Met One Instruments, Inc
Model	020C
Serial Number	U1478
Vane Material	Aluminum
Condition	Refurbished

Results:

Slope:	**71.3248**	**deg/V**
Offset to boom:	**97.8**	**deg**
Max error:	0.5	deg

Estimated Uncertainty:

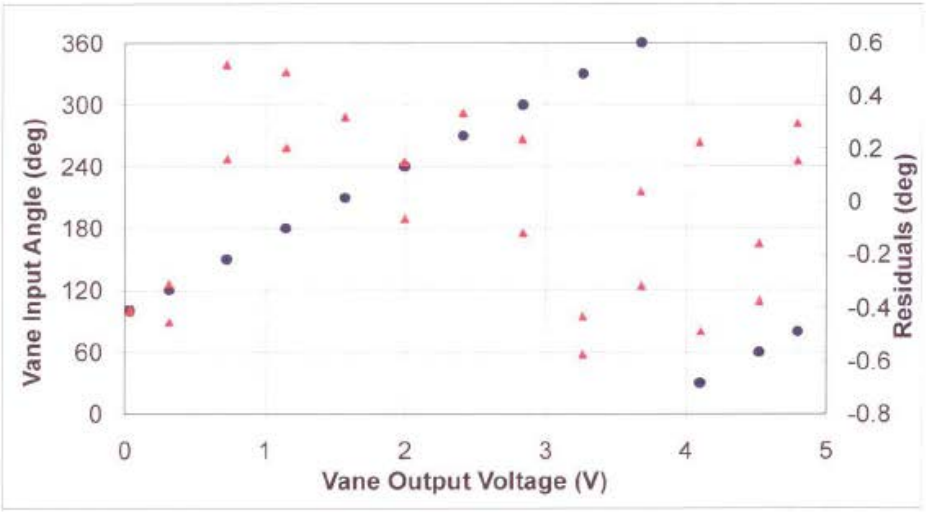
Inclinometer Uncertainty (deg)	Total Uncertainty (deg)
0.10	0.36

Traceability:

	Mfg & Mode	Serial Number	Cal Date
Inclinometer:	SPI-Tronic	31-038-3	2-Sep-11
Voltmeter:	HP 3458A	2823A05145	3-May-11

Calibration by: Jerry Hur

Date: 6 Oct 10



Vane Cal U1478 101006.xlsx — If printed, this document may be out of date. — Page 1 of 1

Figure B9: Wind vane calibration sheet, installed 13 October 2010 to 25 October 2011

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
Cert Lab

Calibration Date: 11-Oct-11

Report Number: W5515-111011

Procedure:
NWTC-CT: C104 Calibrate Wind Vane_091209.docx

Page: 1 of 1

Deviations from procedure:
Output of Wind vane was set for 5 Volts.Inclinometer out of calibration by 11 days.Inclinometer was sent out for a post cal.

Item Calibrated:

Manufacturer	Met One Instruments, Inc
Model	020C
Serial Number	**W5515**
Vane Material	Aluminum
Condition	Refurbished

Results:

Slope:	**71.96**	**deg/V**
Offset to boom:	**90.55**	**deg**
Max error:	0.90	deg

Estimated Uncertainty:

Inclinometer Uncertainty (deg)	Total Uncertainty (deg)
0.10	0.51

Traceability:

	Mfg & Model	Serial Number	Cal Date
Inclinometer:	Spi-Tronic	31-038-3	5-Oct-11
Voltmeter:	HP 3458A	2823A05145	15-Sep-11

Calibration by: Mark Murphy — 11-Oct-11 Date

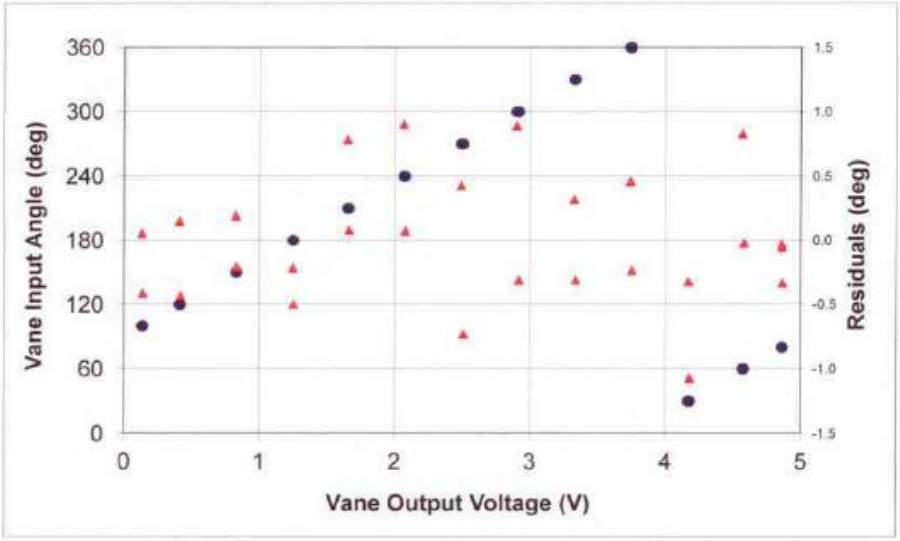


Figure B10: Wind vane calibration sheet, installed 25 October 2011 to 27 June 2012

Pressure

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Pressure Transmitter DOE #: 03509C

Model # : PTB101B S/N : C1020014

Calibration Date: 08/10/2010 Due Date: 08/10/2011

No	Function Tested	Nominal Value (kPa)	Measured Output Voltage (VDC)		( )Mfr. Specs. OR (X)Data only (mb)
			As Found	As Left	
*	Absolute Pressure				
		65	0.274		
		70	0.546		
		75	0.818		
		80	1.089		
		85	1.361		
		90	1.633		
		95	1.904		
		100	2.176		
	Notes: 1. Expanded Uncertainty of the nominal value is ± 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: 108685, 128120, and 02301C.				

Calibrated By: P. Morse
Date: 08/10/2010

QA By: Bev
Date: 08/10/2010

Figure B11: Pressure transducer calibration sheet, installed 13 October 2010 to 25 October 2011

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Pressure Transmitter DOE #: 03509C

Model # : PTB101B S/N : C1020014

Calibration Date: 11/16/2011 Due Date: 11/16/2012

No	Function Tested	Nominal Value (kPa)	Measured Output Voltage (VDC)		( )Mfr. Specs. OR (X)Data only (mb)
			As Found	As Left	
*	Absolute Pressure				
		65	0.269		
		70	0.541		
		75	0.813		
		80	1.085		
		85	1.357		
		90	1.629		
		95	1.901		
		100	2.173		
	Notes: 1. Expanded Uncertainty of the nominal value is ± 0.2 kPa, with k = 2. 2. Calibration was performed at 23°C and 42% RH. 3. Calibration was performed using standards that are traceable to NIST. DOE numbers: 108685, 128120, and 02301C.				

Calibrated By: P. Morse
Date: 11/16/2011

Approved By: Reda
Date: 11/16/2011

Figure B12: Pressure transducer post-test calibration sheet, installed 13 October 2010 to 25 October 2011

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Pressure Transmitter DOE #: 03511C

Model # : PTB101B S/N : C1040008

Calibration Date: 09/27/2011 Due Date: 09/27/2012

No	Function Tested	Nominal Value (kPa)	Measured Output Voltage (VDC)		( )Mfr. Specs. OR (X)Data only
			As Found	As Left	
*	Absolute Pressure				
		65	0.270		
		70	0.543		
		75	0.814		
		80	1.086		
		85	1.357		
		90	1.629		
		95	1.901		
		100	2.173		
		103	2.337		
	Notes: 1. Expanded Uncertainty of the nominal value is ± 0.2 kPa, with k = 2. 2. Calibration was performed at 23°C and 43% RH. 3. Calibration was performed using standards that are traceable to NIST. DOE numbers: 02301C and 128120.				

Calibrated By: P. Morse
Date: 09/27/2011

Approved By: Reda
Date: 09/27/2011

Figure B13: Pressure transducer calibration sheet, installed 25 October 2011 to 27 June 2012

Temperature

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: RTD-Probe DOE #: 03506C

Model # : 78N01N00N S/N : 0673553

Calibration Date: 11/08/2011 Due Date: 11/08/2012

No	Function Tested	Nominal Value (°C)	Measured Values (Ω)		( )Mfr. Specs. OR (X)Data only
			AS Found	AS Left	
*	Temperature:	-15	94.118		
		-10	96.077		
		0	99.996		
		10	103.897		
		15	105.842		
		30	111.667		
	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 = 43. - Uncertainty of Nominal Values = ± 0.03 °C, k = 2.				

Calibrated By: P. Morse
Date: 11/08/2011

Approved By: Reda
Date: 11/08/2011

Figure B14: RTD-probe calibration sheet, installed 13 October 2010 to 25 October 2012

NREL METROLOGY LABORATORY

TEST REPORT

Test Instrument: RTD DOE #: 03465C

Model #: T200A S/N: 0603-1

Calibration Date: 7/20/2012 Date Due: 7/20/2013

Test No.	Function Tested	Applied Value (°C)	Measured Values (Ω)		( ) Mfr Specs (X)Data Only
			As Found	As Left	
1.					
	Temperature	-15	94.126		
		0	100.025		
		15	105.892		
		30	111.724		

Notes:

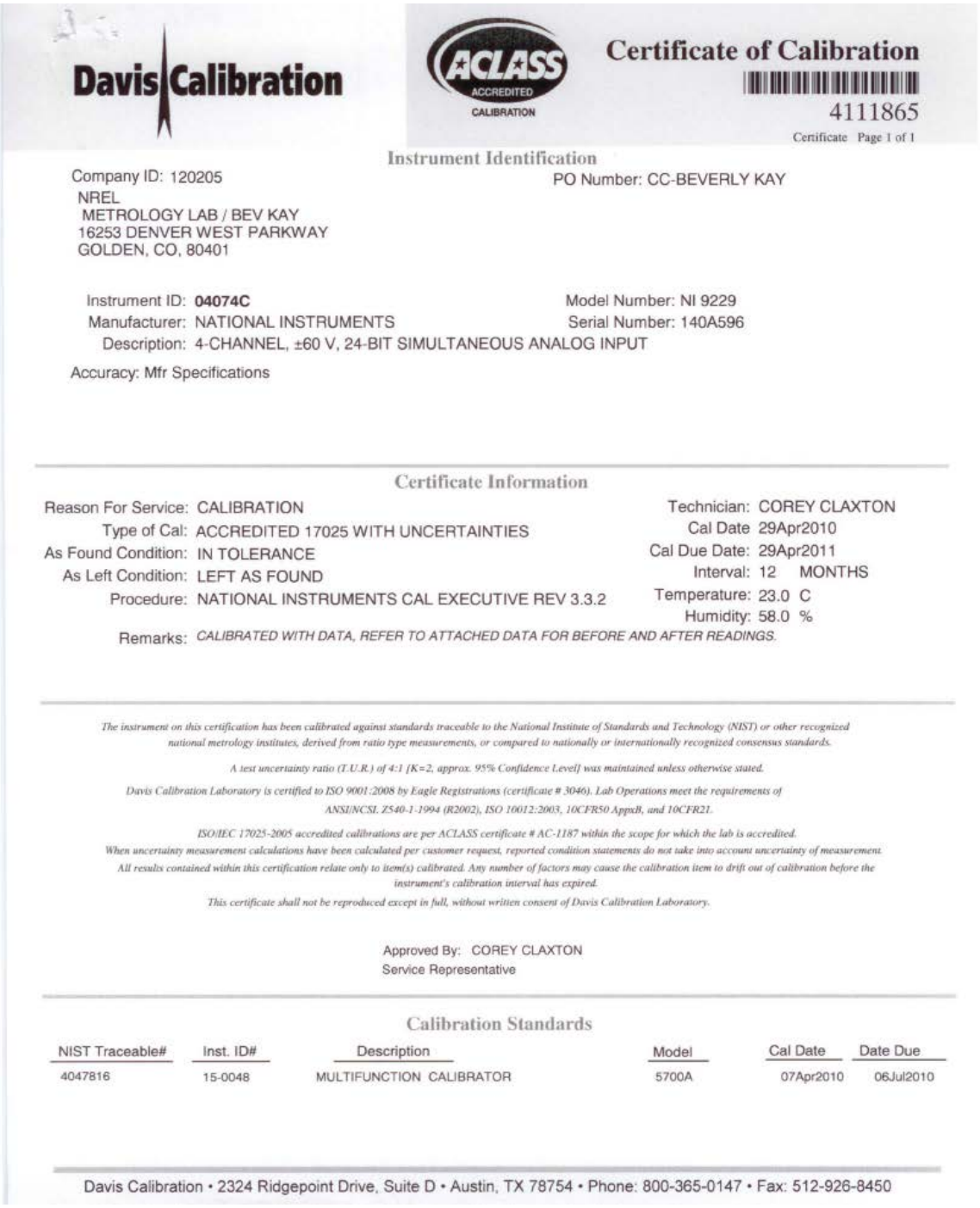
- Calibration was performed using instruments that are traceable to NIST. DOE# 124272, 108603, 108604.
- Calibration was performed at a temperature of 23°C and Relative Humidity of 41%
- Uncertainty of Nominal Values = ± 0.02°C, k = 2.

Calibrated By: Reda
Date: 7/20/2012

Approved By: Preston
Date: 7/20/2012

Figure B15: RTD-Probe calibration sheet, installed 25 October 2011 to 27 June 2012

DAS



Davis Calibration

ACCREDITED CALIBRATION

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**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CHANNEL, ±60 V, 24-BIT SIMULTANEOUS ANALOG INPUT
Accuracy: Mfr Specifications

Model Number: NI 9229
Serial Number: 140A596

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/NCSL 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
4047816	15-0048	MULTIFUNCTION CALIBRATOR	5700A	07Apr2010	06Jul2010

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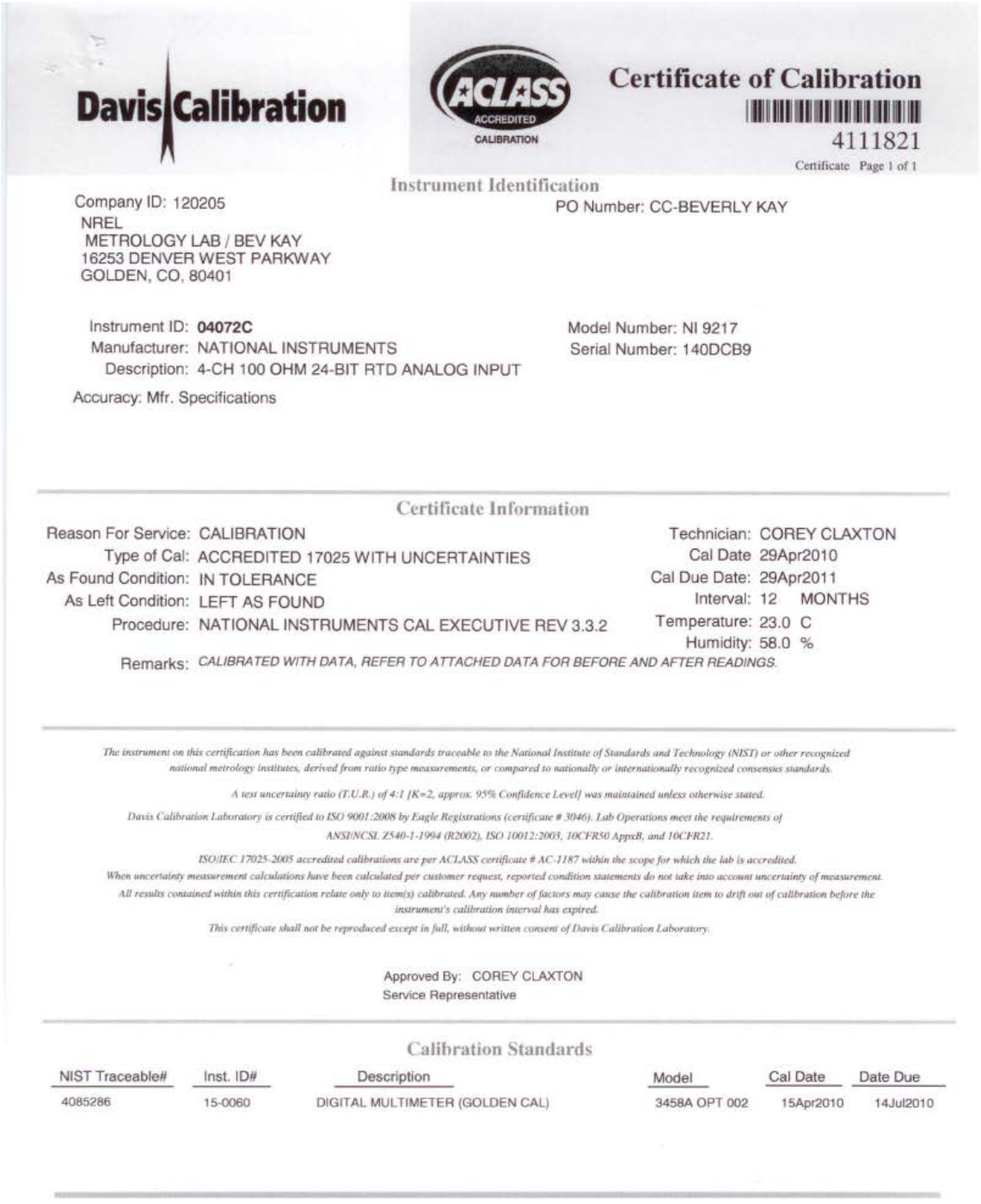
Figure B16: NI 9229 data acquisition module calibration sheet I, installed 20 October 2010 to 7 April 2011



Davis Calibration

ACCREDITED CALIBRATION

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/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
4085286	15-0060	DIGITAL MULTIMETER (GOLDEN CAL)	3458A OPT 002	15Apr2010	14Jul2010

Figure B17: NI 9217 data acquisition module calibration sheet I, installed 20 October 2010 to 7 April 2011

Davis Calibration

ACCREDITED CALIBRATION

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**
Manufacturer: NATIONAL INSTRUMENTS
Description: 32-CH ±200 MV TO ±10 V, 16-BIT, 250 KS/S ANALOG INPUT MODULE
Accuracy: Mfr Specifications

Model Number: NI 9205
Serial Number: 140E2BD

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/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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Figure B18: NI 9205 data acquisition module calibration sheet I, installed 20 October 2010 to 7 April 2011

Tektronix
Service Solutions

ACCREDITED
CALIBRATION
AC-1187

5100145516
Maintenance Record
5557968
Certificate Page 1 of 1

Instrument Identification

Company ID: 000031
TEKTRONIX-DENVER
Andrew Beckerdite
8020 SOUTHPARK CIRCLE
SUITE 300
LITTLETON, CO 80120

PO Number: FIFO

Instrument ID: **51-2050769**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CHANNEL, ±60 V, 24-BIT SIMULTANEOUS ANALOG INPUT

Model Number: NI 9229
Serial Number: 140A596

Accuracy: Mfr Specifications

Certificate Information

Reason For Service: CALIBRATION
Type of Cal: ACCREDITED 17025 WITH UNCERTAINTIES
As Found Condition: FUNCTIONAL FAILURE
As Left Condition: LEFT AS FOUND
Procedure: NATIONAL INSTRUMENTS CAL EXECUTIVE 3.4.1

Technician: COREY CLAXTON
Service Date 10Oct2011

Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 39.0 %

Remarks: *Unit failed calibration on channel ai0. Opened unit and found that input transfromers on all channels have been lifted from circuit board and are hanging by the circuit traces. Unit needs to be sent to National Instruments for repair.*

Tektronix Service Solutions certifies the performance of this instrument has been verified using equipment of known accuracy which are traceable to National Metrology Institutes (NIST, NPL, PTB) which are traceable to the International System of Units (SI), derived from ratio type measurements, compared to reference materials or recognized consensus standards. The policies and procedures used comply with ISO17025:2005.
Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage of k=2. The certificate and associated attachments relate only to the metrological quantities presented in this report. No representation is made about the long term stability of this unit; any number of factors may influence the calibration that may cause the unit to drift out of specification before the calibration interval has expired.
This certificate shall not be reproduced, except in full, without the written consent of Tektronix Service Solutions.

Approved By: COREY CLAXTON
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Manufacturer	Model	Cal Date	Date Due
5327332	15-0271	MULTIFUNCTION CALIBRATOR	FLUKE	5700A	21Jul2011	19Oct2011

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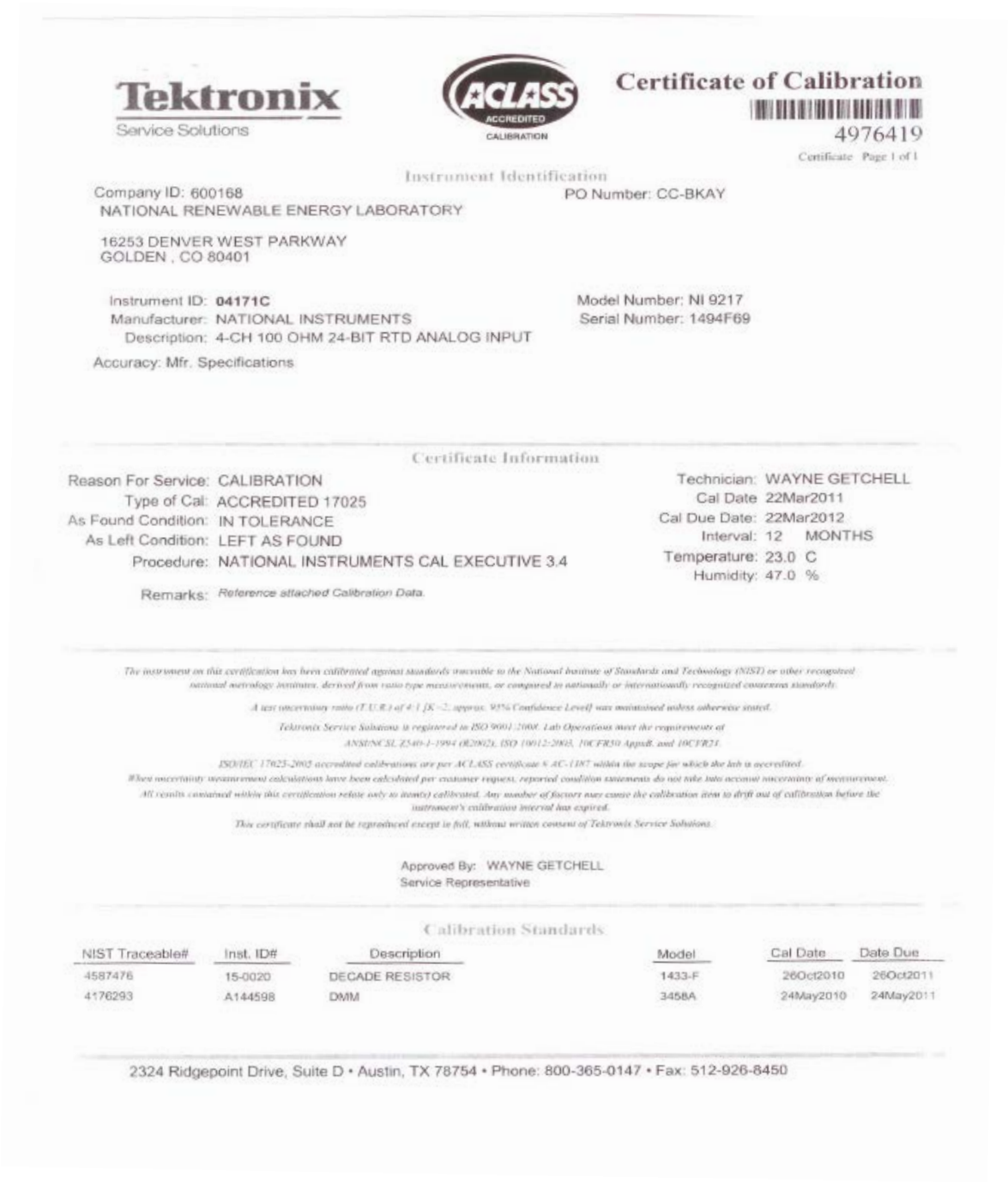
Figure B19: NI 9229 data acquisition module post-test calibration sheet I, installed 20 October 2010 to 7 April 2011



Tektronix
Service Solutions

ACCREDITED
CALIBRATION

Certificate of Calibration

4976419

Certificate Page 1 of 1

Instrument Identification

Company ID: 600168
NATIONAL RENEWABLE ENERGY LABORATORY

16253 DENVER WEST PARKWAY
GOLDEN , CO 80401

PO Number: CC-BKAY

Instrument ID: **04171C**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CH 100 OHM 24-BIT RTD ANALOG INPUT
Accuracy: Mfr. Specifications

Model Number: NI 9217
Serial Number: 1494F69

Certificate Information

Reason For Service: CALIBRATION
Type of Cal: ACCREDITED 17025
As Found Condition: IN TOLERANCE
As Left Condition: LEFT AS FOUND
Procedure: NATIONAL INSTRUMENTS CAL EXECUTIVE 3.4

Remarks: *Reference attached Calibration Data.*

Technician: WAYNE GETCHELL
Cal Date 22Mar2011
Cal Due Date: 22Mar2012
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 47.0 %

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.

Tektronix Service Solutions is registered to ISO 9001:2008. Lab Operations meet the requirements of ANSI/NCSL Z540-1-1994 (R2002), ISO 10012:2003, 10CFR50 Appdx. 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 Tektronix Service Solutions.

Approved By: WAYNE GETCHELL
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4587476	15-0020	DECADE RESISTOR	1433-F	26Oct2010	26Oct2011
4176293	A144598	DMM	3458A	24May2010	24May2011

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Figure B20: NI 9217 data acquisition module post-test calibration sheet I, installed 20 October 2010 to 7 April 2011

Tektronix
Service Solutions

ACCREDITED CALIBRATION

Certificate of Calibration

4976401

Certificate Page 1 of 1

Instrument Identification

Company ID: 600168
NATIONAL RENEWABLE ENERGY LABORATORY

PO Number: CC-BKAY

16253 DENVER WEST PARKWAY
GOLDEN , CO 80401

Instrument ID: **04170C**
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: 1496266

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: NATIONAL INSTRUMENTS CAL EXECUTIVE 3.4

Remarks: *Reference attached Calibration Data.*

Technician: WAYNE GETCHELL
Cal Date 22Mar2011
Cal Due Date: 22Mar2012
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 47.0 %

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.

Tektronix Service Solutions is registered to ISO 9001:2008. 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 Tektronix Service Solutions.

Approved By: WAYNE GETCHELL
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4837275	15-0048	MULTIFUNCTION CALIBRATOR	5700A	03Feb2011	04May2011

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Figure B21: NI 9205 data acquisition module post–test calibration sheet I, installed 20 October 2010 to 7 April 2011

Tektronix
Service Solutions

ACCREDITED CALIBRATION

Certificate of Calibration

4976433

Certificate Page 1 of 1

Instrument Identification

Company ID: 600168
NATIONAL RENEWABLE ENERGY LABORATORY

16253 DENVER WEST PARKWAY
GOLDEN , CO 80401

PO Number: CC-BKAY

Instrument ID: **04169C**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CHANNEL, ±60 V, 24-BIT SIMULTANEOUS ANALOG INPUT

Model Number: NI 9229
Serial Number: 14A34EE

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: NATIONAL INSTRUMENTS CAL EXECUTIVE 3.4
Remarks: *Reference attached Calibration Data.*

Technician: WAYNE GETCHELL
Cal Date 22Mar2011
Cal Due Date: 22Mar2012
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 47.0 %

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.

Tektronix Service Solutions is registered to ISO 9001:2008. Lab Operations meet the requirements of ANSI/NCSL 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 Tektronix Service Solutions.

Approved By: WAYNE GETCHELL
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4837275	15-0048	MULTIFUNCTION CALIBRATOR	5700A	03Feb2011	04May2011

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Figure B22: NI 9229 data acquisition module calibration sheet I, installed 7 April 2011to 27 June 2012

Tektronix
Service Solutions

ACCLASS ACCREDITED CALIBRATION

Certificate of Calibration

4976419

Certificate Page 1 of 1

Instrument Identification

Company ID: 600168
NATIONAL RENEWABLE ENERGY LABORATORY

16253 DENVER WEST PARKWAY
GOLDEN , CO 80401

PO Number: CC-BKAY

Instrument ID: **04171C**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CH 100 OHM 24-BIT RTD ANALOG INPUT

Model Number: NI 9217
Serial Number: 1494F69

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: NATIONAL INSTRUMENTS CAL EXECUTIVE 3.4

Remarks: *Reference attached Calibration Data.*

Technician: WAYNE GETCHELL
Cal Date 22Mar2011
Cal Due Date: 22Mar2012
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 47.0 %

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.

Tektronix Service Solutions is registered to ISO 9001:2008. Lab Operations meet the requirements of ANSI/NCSL Z540-1-1994 (R2002), ISO 10012:2003, 10CFR50 Appdx. 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 Tektronix Service Solutions.

Approved By: WAYNE GETCHELL
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4587476	15-0020	DECADE RESISTOR	1433-F	26Oct2010	26Oct2011
4176293	A144598	DMM	3458A	24May2010	24May2011

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Figure B23: NI 9217 data acquisition module calibration sheet I, installed 7 April 2011to 27 June 2012

Tektronix
Service Solutions

ACCREDITED CALIBRATION

Certificate of Calibration

4976401

Certificate Page 1 of 1

Instrument Identification

Company ID: 600168
NATIONAL RENEWABLE ENERGY LABORATORY

16253 DENVER WEST PARKWAY
GOLDEN , CO 80401

PO Number: CC-BKAY

Instrument ID: **04170C**
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: 1496266

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: NATIONAL INSTRUMENTS CAL EXECUTIVE 3.4

Remarks: *Reference attached Calibration Data.*

Technician: WAYNE GETCHELL
Cal Date 22Mar2011
Cal Due Date: 22Mar2012
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 47.0 %

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.

Tektronix Service Solutions is registered to ISO 9001:2008. Lab Operations meet the requirements of ANSI/NCSL Z540-1-1994 (R2002), ISO 10012:2003, 10CFR50 Appdx B, 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 conformance 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 Tektronix Service Solutions.

Approved By: WAYNE GETCHELL
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
4837275	15-0048	MULTIFUNCTION CALIBRATOR	5700A	03Feb2011	04May2011

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Figure B24: NI 9205 data acquisition module calibration sheet I, installed 7 April 2011to 27 June 2012

Dynamic Technology, Inc.

A Trescal Company

17025 Accredited Certificate of Calibration

Certificate #: 2261870002 F

ACCREDITED

Calibration Laboratory

Acct #:	101320
Customer:	National Renewable Energy Laboratory
Shipper #:	1892577
Address:	16253 Denver West Parkway Golden, CO, 80401
Contact:	NI RMA
PO #:	

Manufacturer:	National Instruments
Model:	9229
Description:	4 Channel Analog Input Module
Serial Number:	14A34EE
Asset Number:	14A34EE
Barcode:	

As Received	As Returned	Action Taken
In Tolerance X	In Tolerance X	Full Calibration X
Out of Tolerance	Out of Tolerance	Special Calibration
Malfunctioning	Malfunctioning	Spec. Verification
Operational	Operational	Adjusted
Damaged	N/A	Repaired
N/A		Charted
		Returned As Is

Cal Date:	08/16/2012
Due Date:	08/16/2013
Temperature:	73.60 deg. F
Humidity:	47.00 %
Baro. Press.:	
Procedure:	DCN 09375
Reference:	manufacturer's manual

Incoming Remarks:
Done for accredited Calibration
adjusted bag

Technical Remarks:

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
22502501103	Fluke	5700A	Multifunction Calibrator	08/10/2012	11/10/2012

The above identified unit was calibrated in our laboratory at the address shown below.

Technician Name/Date Andrew Bash, 08/16/2012 Signatory QA Approved:

3201 West Royal Lane, Suite 150, Irving, TX 75063 (214) 723-5600 FAX (214) 723-5601

Page 1 of 1

Figure B25: NI 9229 data acquisition module post-test calibration sheet I, installed 7 April 2011to 27 June 2012

Dynamic Technology, Inc.

A Trescal Company

17025 Accredited Certificate of Calibration

Certificate #: 2261870003 F

ilac-MRA ACCREDITED

Calibration Laboratory

Acct #:	101320
Customer:	National Renewable Energy Laboratory
Shipper #:	1892577
Address:	16253 Denver West Parkway Golden, CO, 80401
Contact:	NI RMA
PO #:	

Manufacturer:	National Instruments
Model:	9217
Description:	4 Channel 100ohm RTD Analog Input M
Serial Number:	1494F69
Asset Number:	1494F69
Barcode:	

As Received		As Returned		Action Taken			
In Tolerance	X	In Tolerance	X	Full Calibration	X	**Cal Date:**	08/15/2012
Out of Tolerance		Out of Tolerance		Special Calibration		**Due Date:**	08/15/2013
Malfunctioning		Malfunctioning		Oper. Verification		**Temperature:**	72.50 deg. F
Operational		Operational		Adjusted		**Humidity:**	51.00 %
Damaged		N/A		Repaired		**Baro. Press.:**	
N/A				Charted		**Procedure:**	DCN 09480
				Returned As Is		**Reference:**	manufacturer's manual

Incoming Remarks:

Domestic accredited Calibration
info in esd bag

Technical Remarks:

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
2062190010	LSI	RS925	Decade Resistance Standard	01/05/2012	01/05/2013
2182620007	Agilent Technologi	3458A	DMM	05/23/2012	08/23/2012

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Dynamic Technology, Inc. [illegible] Uncertainty Ratio (TUR) of greater than 4:1 [illegible] confidence level [illegible] Report of Calibration. The calibration was performed using references traceable to the SI through NIST [illegible] Dynamic Technology's calibration program is in compliance with:

ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994, ANSI/NCSL Z540.3-2006, MIL-STD-45662A, [illegible]

Dynamic Technology warrants all material and labor performed for ninety (90) days unless [illegible]

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Andrew Bush 08/15/2012 Signatory: [signature] QA Approved: [stamp]

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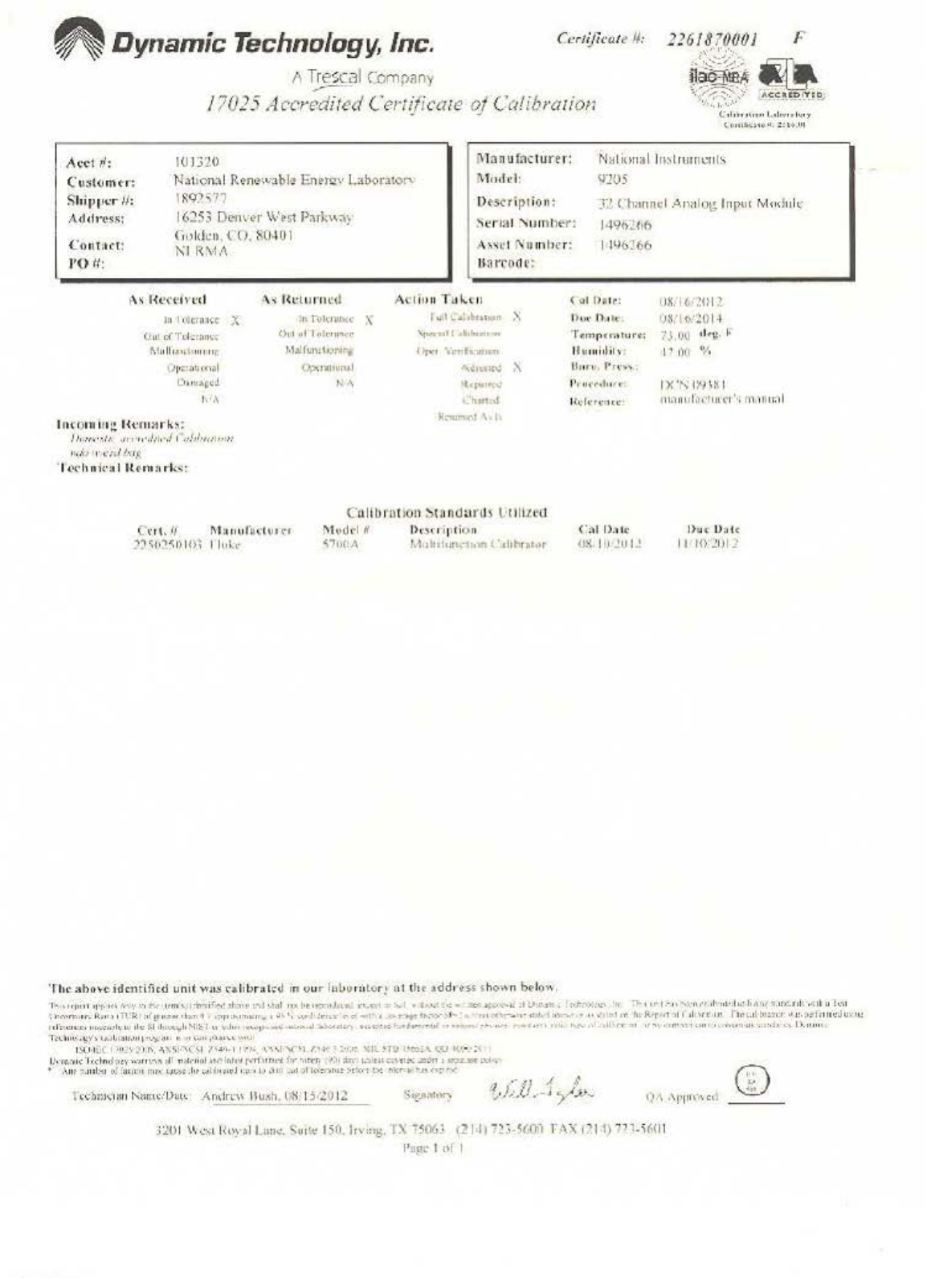
Figure B26: NI 9217 data acquisition module post-test calibration sheet I, installed 7 April 2011to 27 June 2012



Dynamic Technology, Inc.

A Trescal Company

17025 Accredited Certificate of Calibration

Certificate #: 2261870001 F

Calibration Laboratory Certificate #: 2330.01

Acct #:	101320	Manufacturer:	National Instruments
Customer:	National Renewable Energy Laboratory	Model:	9205
Shipper #:	1892577	Description:	32 Channel Analog Input Module
Address:	16253 Denver West Parkway Golden, CO, 80401	Serial Number:	1496266
Contact:	NI RMA	Asset Number:	1496266
PO #:		Barcode:	

As Received	As Returned	Action Taken	
In Tolerance X	In Tolerance X	Full Calibration X	
Out of Tolerance	Out of Tolerance	Special Calibration	
Malfunctioning	Malfunctioning	Oper. Verification	
Operational	Operational	Adjusted X	
Damaged	N/A	Repaired	
N/A		Charted	
		Returned As Is	

Cal Date:	08/16/2012
Due Date:	08/16/2014
Temperature:	73.00 deg. F
Humidity:	47.00 %
Baro. Press.:	
Procedure:	DCN 09381
Reference:	manufacturer's manual

Incoming Remarks:
Domestic accredited Calibration was in acid bag
Technical Remarks:

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
2250250103	Fluke	5700A	Multifunction Calibrator	08/10/2012	11/10/2012

The above identified unit was calibrated in our laboratory at the address shown below.

This report applies only to the item(s) identified above and shall not be reproduced, except in full, without the written approval of Dynamic Technology, Inc. This unit has been calibrated using standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 (approximating a 95% confidence level with a coverage factor of k=2 unless otherwise stated above or as stated on the Report of Calibration). The calibration was performed using reference materials to the SI through NIST or value assigned national laboratory, accepted fundamental or natural physical constants, ratio type of calibration, or by comparison to consensus standards. Dynamic Technology's calibration program is in compliance with:

ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994, ANSI/NCSL Z540-3-2006, MIL-STD-45662A, QD-9000-2011

Dynamic Technology warrants all material and labor performed for ninety (90) days unless covered under a separate policy.

* Any number of factors may cause the calibrated item to drift out of tolerance before the interval has expired.

Technician Name/Date: Andrew Bush, 08/15/2012 Signatory QA Approved

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Figure B27: NI 9205 data acquisition module post-test calibration sheet I, installed 7 April 2011to 27 June 2012