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Wind Turbine Generator System Power Performance Test Report for the Entegrity EW50 Wind Turbine

J. Smith, A. Huskey, D. Jager, and J. Hur

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Technical Report
NREL/TP-5000-51392
May 2011

Contract No. DE-AC36-08GO28308

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Prepared under Task No. WE10.2211

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Wind Turbine Generator System

Power Performance Test Report

for the

Entegrity EW50 Wind Turbine

Conducted for

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

Conducted by

National Wind Technology Center
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401

Joe Smith, Arlinda Huskey, Dave Jager, Jerry Hur

22 March 2011

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Approval By: Arlinda Huskey — 14 May 2011

Arlinda Huskey, NREL Test Engineer — Date

Review By: — 13 May 2011

Jeroen van Dam, NREL Test Engineer — Date

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1. Background

This test is being conducted as part of the U.S. Department of Energy's (DOE) Independent Testing project. This project was established to help reduce the barriers of wind energy expansion by providing independent testing results for small turbines. Five turbines are being tested at the National Wind Technology Center (NWTC) as a part of round 1 of this project. Power performance testing is one of up to five (5) tests that may be performed on the turbines, including duration, safety and function, noise, and power quality tests.

2. Test Summary

Figure 1 is a summary of the results of the power performance test that the National Renewable Energy Laboratory (NREL) conducted on Entegrity Wind System Inc.'s EW50 small wind turbine (shown in Figure 2). In this test, the EW50 turbine was installed at the NWTC near Boulder, Colorado. This test was conducted in accordance with the International Electrotechnical Commission (IEC) standard, Wind Turbine Generator Systems Part 12: Power Performance Measurements of Electricity Producing Wind Turbines, IEC 61400-12-1 Ed.1.0, 2005-12. Because the Entegrity EW50 is a small turbine according to the IEC definition, NREL also followed Annex H, which applies to small wind turbines. This test report refers to these procedures as the "Standard."

In the summary results shown in Figure 1, power is normalized to sea-level air density, as required by the Standard. However this method of density correction gives unrealistically high power output for sea-level. During installation the blades on the EW50 were pitched to accommodate the average density at the NWTC, in order to achieve the designed peak output of 65kW.

This test began on 1 November 2009 and ended on 31 December 2009. During that period 533 hours of valid data were collected. The highest bin filled was the 20.5 m/s bin. The amount of test data is sufficient to meet the requirements of the Standard.

National Renewable Energy Laboratory

Power Performance Test
Entegrity EW50

Sea-Level Density Power Curve

Turbine Specifications:

Serial Number:	CO812180024	
Rated Power:	50	kW
Cut-in Wind Speed:	4.0	m/s
Cut-out Wind Speed:	25	m/s
Rated Wind Speed:	11.3	m/s
Rotor Diameter:	15	m
Control Type:	Stall	
Pitch Setting:	Fixed	

Site Conditions:

Location:	NWTC, Boulder, CO	
Average Air Density:	1.03	kg/m^3
Measurement Sectors:	272-350	degrees true

Test Statistics:

Start Date:	1-Nov-2009	
End Date:	31-Dec-2009	
Amount of Data Collected:	532.6	hours
Highest Bin Filled:	20.5	m/s
Test Completed?	yes	

Bin Wind Speed (m/s)	Bin Power (kW)	Number Data Points	Cp
0.54	-0.46	636	-27.61
1.02	-0.50	1,485	-4.28
1.51	-0.63	2,203	-1.68
2.00	-0.69	2,562	-0.80
2.50	-0.80	2,435	-0.47
3.00	-1.03	2,506	-0.35
3.50	-1.30	2,535	-0.28
3.99	-1.76	2,233	-0.26
4.49	-2.06	1,872	-0.21
5.00	-1.80	1,718	-0.13
5.50	-0.18	1,610	-0.01
5.99	2.05	1,429	0.09
6.49	5.22	1,248	0.18
7.00	8.33	1,124	0.22
7.49	12.15	982	0.27
7.99	15.86	861	0.29
8.50	20.36	726	0.31
9.00	23.97	590	0.30
9.50	28.34	477	0.31
9.99	32.08	427	0.30
10.50	37.62	368	0.30
11.00	40.41	298	0.28
11.50	43.73	255	0.27
11.98	48.39	232	0.26
12.48	51.89	190	0.25
12.99	55.27	171	0.23
13.51	58.09	136	0.22
14.00	61.20	114	0.21
14.47	64.90	86	0.20
15.00	66.69	74	0.18
15.49	69.33	56	0.17
16.02	70.65	58	0.16
16.48	70.37	43	0.15
17.02	72.63	43	0.14
17.48	73.34	34	0.13
18.01	73.33	36	0.12
18.51	74.81	33	0.11
19.05	73.39	19	0.10
19.53	73.10	20	0.09
20.00	71.78	18	0.08
20.49	72.11	11	0.08

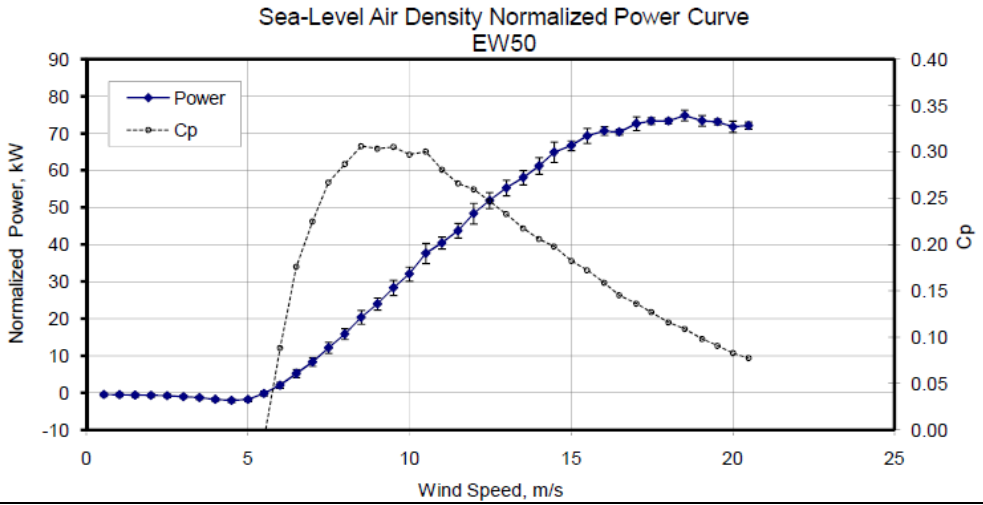


Figure 1. Power curve summary



Figure 2. Entegrity EW50 test turbine at the NWTC. PIX # 16390.

3. Test Turbine Configuration

Table 1 lists the configuration of the Entegrity EW50 that was tested at the NWTC.

Table 1. Test turbine configuration

Turbine make & model	Entegrity EW50
Gearbox serial number	543132-007
Generator serial number	C0812180024
Rotor diameter (m)	14.9
Hub height (m)	31.1
Tower type	30.5m (100ft) freestanding monopole
Rated electrical power (kW)	50
Rated wind speed (m/s)	11.3
Rotor speed range (rpm)	65
Fixed or variable pitch	Fixed
Number of blades	3
Blade pitch angle (deg)	5.14˚ to 5.17˚ at 75% span
Blade make, type, serial number	Entegrity, epoxy/glass fiber, 7.2m, 150kg, s/n: 284, 285, 283 with tip brakes
Control system (device and software version)	TMC microprocessor by Orbital A/S in Entegrity enclosure version: “EW15 2.031”

Measurements verified the rotor diameter and hub height. The blades were pitched at the most aggressive pitch setting. Rated power and rated wind speed are as published by Entegrity, and provided to NREL as required by the Independent Testing project.

Test Site Description

The EW50 turbine is located at site 1E1 at the NWTC, which is approximately 8 km south of Boulder, Colorado. The terrain consists of mostly flat terrain with short vegetation (see Appendix A for photos of the test site). The site has prevailing winds bearing approximately 290 degrees relative to true north. It is important to accurately measure wind speed; NREL uses data obtained when the wind direction is between 272 and 350 degrees true. In this measurement sector, the influence of terrain and obstructions on the anemometer is small. Figure 3 shows the turbine and meteorological tower locations as well as nearby obstructions and topographical features of the site.

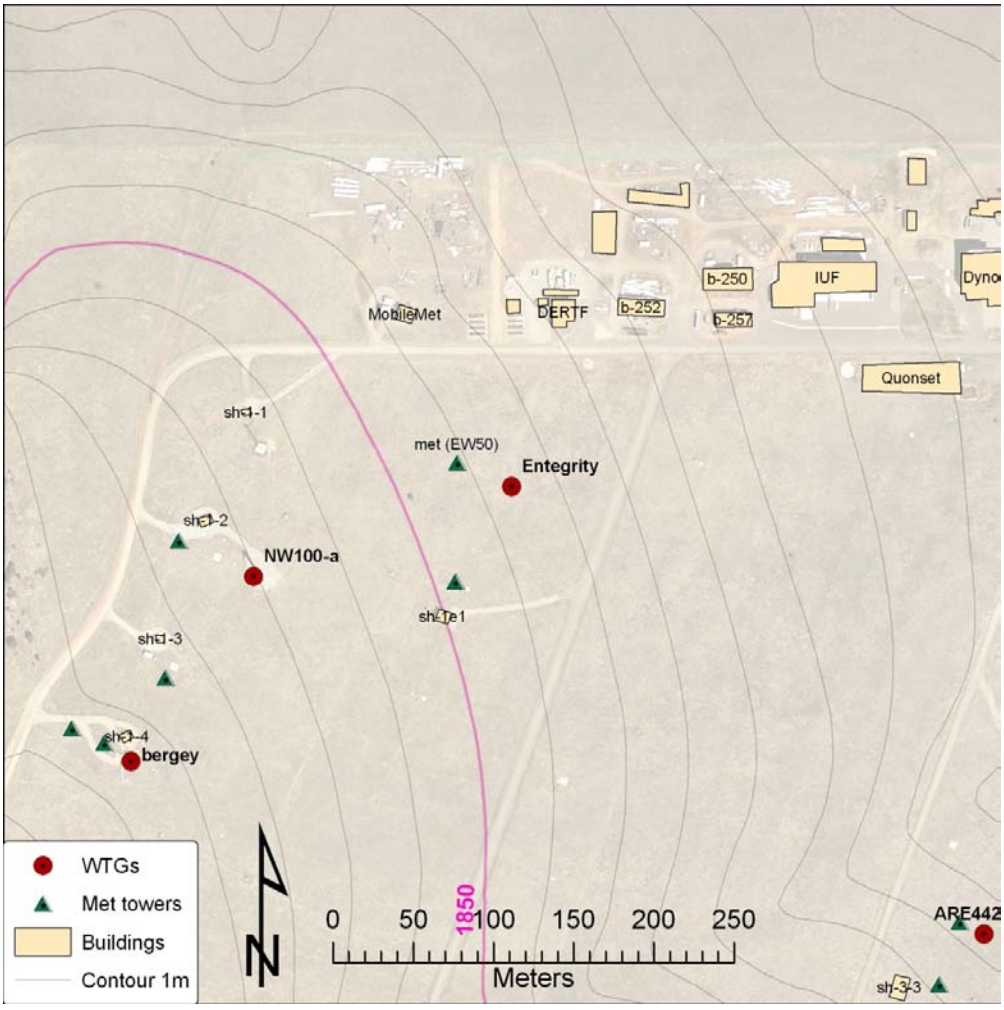


Figure 3. Map of area surrounding Entegrity's EW50 at NWTC's 1E1test site

Table 2 shows obstructions which affect the wind at the location of the EW50 or its met tower according to the Standard's obstacles assessment criteria in Annex A. The azimuth and

distance data are relative to the EW50. Several of these obstructions do not appear on the map in Figure 3.

Table 2. Structures close to test turbine

Description	azimuth [deg true]	distance [m]	height [m]	diam / width [m]
Blade Test Facility	36	137	8	20
NW100-a	251	170	25	19
Industrial Users Facility	56	231	15	50
Dynamometer Test Facility	66	322	15	20
Concrete factory	250	676	30	40
CART-3	119	705	37	43
CART-2	130	740	37	40
GE/DOE	90	851	80	77
Siemens	138	908	80	101

NREL completed a site assessment to determine if the site fails the requirements of Annex A and B of the Standard and would therefore require a site calibration. Table 3 shows the results from the site assessment, which confirm that a site calibration was not required.

Table 3. Criteria for test site without site calibration

EW50	**Site: 1e1**					
	Preliminary Measurement Sector:	**272**	to	**350**	deg True	
	Criteria for Test Site without Site Calibration Testing					
Criterion	Description	Distance	Sector (deg)	*allowable*	Test Site Condition	Pass/Fail
1	Maximum slope of best fit plane < 3%	<2L	360	*3%*	2.3%	Pass
2	Maximum variation from best fit plane < 0.04 (H + D)	<2L	360	*+/-1.8m*	0.3	Pass
3	Maximum slope of best fit plane < 5%	2-4L	In	*5%*	2.2%	Pass
4	Maximum variation from best fit plane < 0.08 (H + D)	2-4L	In	*+/-3.6m*	0.1	Pass
5	Steepest slope maximum < 10%	2-4L	Out	*10%*	2.6%	Pass
6	Maximum slope of best fit plane < 10%	4-8L	In	*10%*	2.2%	Pass
7	Maximum variation from best fit plane < 0.13 (H + D)	4-8L	In	*+/-5.9m*	1.9	Pass
8	No neighboring and operating turbines	$<2D_n$	360	*0*	0	Pass
9	No obstacles	$<2D_e$	360	*0*	0	Pass
	Site Calibration Required?					**no**
				absolute value used for site condition		
			In =	*Inside Preliminary Measurement Sector*		
			Out =	*Outside Preliminary Measurement Sector*		

D = test turbine rotor diameter
L = distance between test turbine and meteorological tower
D_e = equivalent diameter of obstacle

The EW50 was connected to the electrical grid at a nominal voltage of 480 VAC at a frequency of 60 Hz. The grid tolerances are 5% for voltage amplitude and 1% for frequency.

4. Description of Test Equipment

All test equipment was calibrated; Appendix B contains the calibration sheets. Table 4 shows the equipment used and calibration due dates. Figure 4 depicts the placement of the meteorological instruments on the tower. The primary anemometer was sent out for recalibration after the test period. The difference between the pre-test and post-test calibrations is less than 0.04m/s for the range of 6 to 12m/s, and this is within the tolerances allowed by the Standard (0.1m/s).

Table 4. Equipment used in the power performance test

Instrument	Make and Model	Serial Number	Calibration Due Date
Power transducer	Ohio Semitronics, DMT 1040E	07070473	12 Feb 10
Current transformers	Ohio Semitronics, 12974	001293045 001235428 001293049	Calibrated with power transducer
Primary anemometer	Thies, First Class	0707884	25 Feb 10
Reference anemometer	NRG, Max 40	179500049025	25 Feb 10
Wind vane	Met One, 020C with Aluminum Vane	U1477	25 Feb 10
Pressure sensor	Vaisala, PTB101B	C1020015	3 Sept 10
Temperature sensor	Met One, T200	0549828	10 Oct 09
Precipitation sensor	Campbell Scientific, 237	None	In situ
Data acquisition system	Compact DAQ w/LabView cDAQ backplane (9172) NI 9229 NI 9217 NI 9205	 12E4CEB 13DEC38 13FAE1C 13E3D05	 n/a 10 Nov 09 16 Dec 09 12 Nov 09

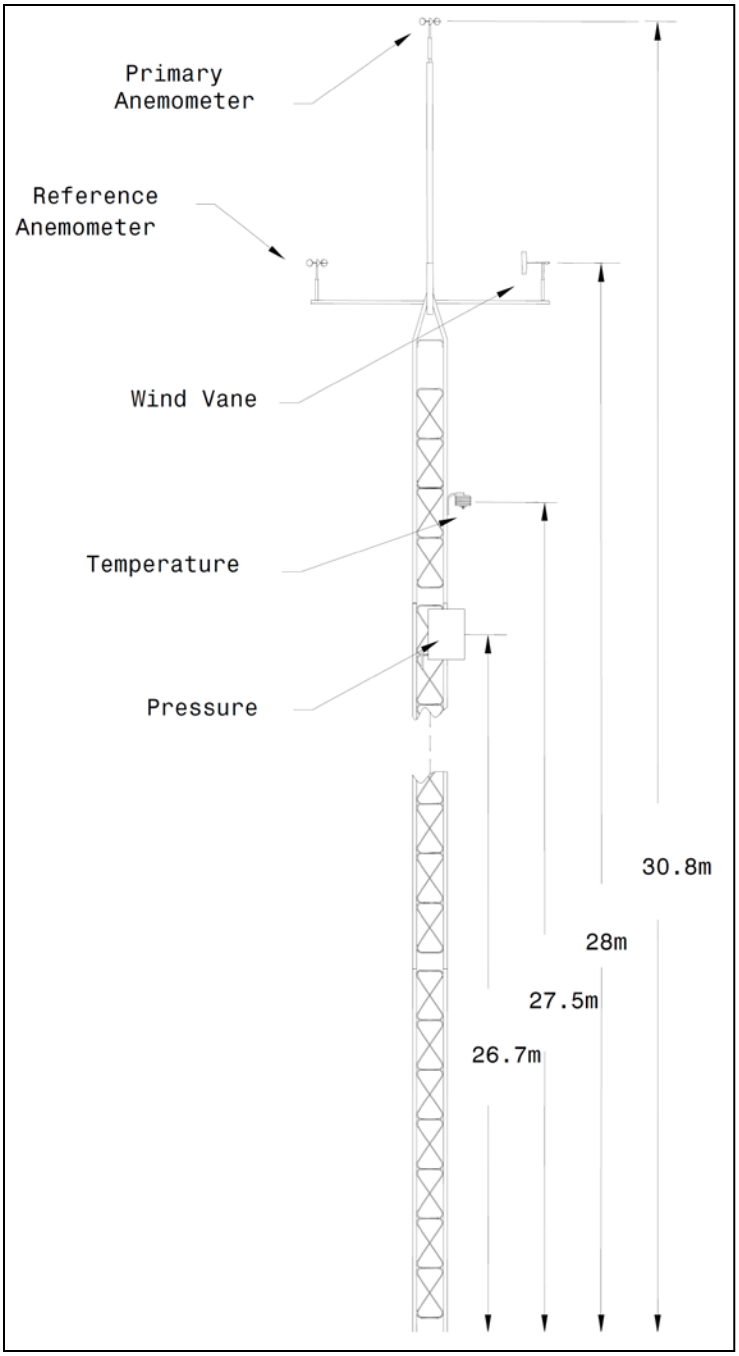


Figure 4. Meteorological tower and instruments

To ensure that only data obtained during normal operation of the turbine are used in the analysis, and to ensure that data are not corrupted, NREL excluded data sets from the database under the following circumstances:

- External conditions other than wind speed are out of the normal range for turbine operation
- The turbine cannot operate because of a turbine fault condition

- The turbine is manually shut down or in a test or maintenance operating mode.

The primary method for checking such events will be reviewing the logbook. The second method is to validate the data file before analysis[1].

[1] Prior to installation it was mutually agreed by Entegrity and NREL that the EW50 controller's log would be used as an additional means to validate data from the database (e.g. logging grid disturbances); the EW50 controller's log was sent to a server via cell phone reception, and then emailed daily to Entegrity and NREL staff. However this service was terminated by Entegrity and emails ceased after 11 July 09.

5. Description of Test Procedure

NREL conducted the test according to the procedures in the Standard. The sampling rate was 10 kHz, decimated to 40 Hz. The averaging time was 1 minute for the mean values. NREL also collected standard deviation, minimum, and maximum values for each averaging period.

Only database A is reported because the turbine did not reach cut-out wind speeds during the test period.

Table 5 gives the uncertainty sources and values used in the analysis.

Table 5. Uncertainty values used in the analysis

Component	*Uncertainty*	*Source*
Power		
power transducer w/ transformers	0.087%	calibration sheet
Data Acquisition System	0.45kW +0.075%	NI9229 specs
Resistor	0.006%	Specs
Wind Speed		
Calibration	0.006 m/s	calibration sheet
operational characteristics	0.052m/s +0.52%	IEC eq. (I.2)
mounting effects	1%	documented assumptions
terrain effects	2%	IEC
Data Acquisition System	0.001 m/s	calculations based on sampling frequency
Temperature		
temperature sensor	0.058 ˚C	calibration
radiation shielding	0.2 ˚C	calculations and assumptions
mounting effects	0.07 ˚C	calculations based on IEC assumptions
Data Acquisition System	0.2 ˚C	NI9217 specs
Air Pressure		
pressure sensor	0.1 kPa	calibration
mounting effects	0.004 kPa	IEC method
Data Acquisition System	0.034 kPa	NI 9205 specs

Test Results

5.1. Tabular Results of Power Performance Test

Table 6 through Table 9 list the power performance test results. Table 6 shows the binned power performance results at sea-level normalized air density. Table 7 shows the binned power performance results normalized to the site average air density for the NWTC.

Reporting power normalized to sea-level air density is required by the Standard. However the prescribed method of density correction gives unrealistically high power output for sea-level. For each EW50 installation, the blades should be pitched to accommodate the site's air density, such that the peak output is 65kW.

Table 6. Performance at sea-level air density, 1.225 kg/m^3

Measured power curve, database A (All valid data)							
	Reference air density:		1.225	kg/m^3			
Bin Number	Hub height wind speed m/s	Power output (kW)	C_P	Number of Data Sets	Category A Standard Uncertainty (kW)	Category B Standard Uncertainty (kW)	Combined Standard Uncertainty (kW)
1	0.54	-0.46	-27.61	636	0.00	0.45	0.45
2	1.02	-0.50	-4.28	1485	0.01	0.45	0.45
3	1.51	-0.63	-1.68	2203	0.02	0.45	0.45
4	2.00	-0.69	-0.80	2562	0.03	0.45	0.45
5	2.50	-0.80	-0.47	2435	0.04	0.45	0.45
6	3.00	-1.03	-0.35	2506	0.04	0.45	0.45
7	3.50	-1.30	-0.28	2535	0.05	0.45	0.46
8	3.99	-1.76	-0.26	2233	0.05	0.46	0.46
9	4.49	-2.06	-0.21	1872	0.05	0.46	0.46
10	5.00	-1.80	-0.13	1718	0.05	0.45	0.46
11	5.50	-0.18	-0.01	1610	0.05	0.63	0.63
12	5.99	2.05	0.09	1429	0.07	0.80	0.81
13	6.49	5.22	0.18	1248	0.09	1.09	1.09
14	7.00	8.33	0.22	1124	0.12	1.14	1.15
15	7.49	12.15	0.27	982	0.15	1.46	1.47
16	7.99	15.86	0.29	861	0.19	1.47	1.49
17	8.50	20.36	0.31	726	0.21	1.85	1.86
18	9.00	23.97	0.30	590	0.30	1.60	1.63
19	9.50	28.34	0.31	477	0.40	2.02	2.06
20	9.99	32.08	0.30	427	0.46	1.84	1.90
21	10.50	37.62	0.30	368	0.38	2.74	2.76
22	11.00	40.41	0.28	298	0.55	1.52	1.62
23	11.50	43.73	0.27	255	0.73	1.84	1.98
24	11.98	48.39	0.26	232	0.60	2.72	2.78
25	12.48	51.89	0.25	190	0.56	2.12	2.19
26	12.99	55.27	0.23	171	0.66	2.04	2.14
27	13.51	58.09	0.22	136	0.80	1.76	1.94
28	14.00	61.20	0.21	114	0.64	2.12	2.21
29	14.47	64.90	0.20	86	0.30	2.72	2.74
30	15.00	66.69	0.18	74	0.40	1.26	1.32
31	15.49	69.33	0.17	56	0.40	1.99	2.03
32	16.02	70.65	0.16	58	0.41	1.04	1.12
33	16.48	70.37	0.15	43	0.58	0.53	0.78
34	17.02	72.63	0.14	43	0.66	1.74	1.86
35	17.48	73.34	0.13	34	0.43	0.78	0.89
36	18.01	73.33	0.12	36	0.55	0.47	0.73
37	18.51	74.81	0.11	33	0.42	1.35	1.42
38	19.05	73.39	0.10	19	0.73	1.26	1.46
39	19.53	73.10	0.09	20	0.57	0.55	0.79
40	20.00	71.78	0.08	18	0.65	1.36	1.51
41	20.49	72.11	0.08	11	0.73	0.57	0.93

Table 7. Performance at site average density, 1.050 kg/m^3

Measured power curve, database A (All valid data)							
	Reference air density:		1.050	kg/m^3			
Bin Number	Hub height wind speed m/s	Power output (kW)	C_P	Number of Data Sets	Category A Standard Uncertainty (kW)	Category B Standard Uncertainty (kW)	Combined Standard Uncertainty (kW)
1	0.54	-0.40	-27.61	636	0.00	0.45	0.45
2	1.02	-0.43	-4.28	1485	0.01	0.45	0.45
3	1.51	-0.54	-1.68	2203	0.02	0.45	0.45
4	2.00	-0.59	-0.80	2562	0.02	0.45	0.45
5	2.50	-0.69	-0.47	2435	0.03	0.45	0.45
6	3.00	-0.89	-0.35	2506	0.04	0.45	0.45
7	3.50	-1.11	-0.28	2535	0.04	0.45	0.45
8	3.99	-1.51	-0.26	2233	0.05	0.46	0.46
9	4.49	-1.77	-0.21	1872	0.04	0.45	0.46
10	5.00	-1.54	-0.13	1718	0.04	0.45	0.46
11	5.50	-0.16	-0.01	1610	0.04	0.59	0.59
12	5.99	1.76	0.09	1429	0.06	0.73	0.73
13	6.49	4.47	0.18	1248	0.08	0.96	0.97
14	7.00	7.14	0.22	1124	0.10	1.00	1.01
15	7.49	10.41	0.27	982	0.13	1.27	1.28
16	7.99	13.59	0.29	861	0.16	1.28	1.29
17	8.50	17.45	0.31	726	0.18	1.60	1.61
18	9.00	20.55	0.30	590	0.25	1.39	1.41
19	9.50	24.29	0.31	477	0.34	1.75	1.78
20	9.99	27.50	0.30	427	0.39	1.60	1.65
21	10.50	32.25	0.30	368	0.32	2.36	2.38
22	11.00	34.64	0.28	298	0.47	1.32	1.40
23	11.50	37.49	0.27	255	0.62	1.59	1.71
24	11.98	41.48	0.26	232	0.51	2.34	2.40
25	12.48	44.47	0.25	190	0.48	1.83	1.89
26	12.99	47.37	0.23	171	0.57	1.76	1.85
27	13.51	49.79	0.22	136	0.69	1.53	1.68
28	14.00	52.46	0.21	114	0.55	1.83	1.91
29	14.47	55.63	0.20	86	0.26	2.35	2.36
30	15.00	57.17	0.18	74	0.34	1.11	1.16
31	15.49	59.43	0.17	56	0.34	1.73	1.76
32	16.02	60.56	0.16	58	0.35	0.92	0.99
33	16.48	60.32	0.15	43	0.49	0.51	0.71
34	17.02	62.26	0.14	43	0.57	1.51	1.61
35	17.48	62.86	0.13	34	0.37	0.71	0.80
36	18.01	62.85	0.12	36	0.47	0.47	0.67
37	18.51	64.13	0.11	33	0.36	1.18	1.24
38	19.05	62.90	0.10	19	0.62	1.11	1.27
39	19.53	62.65	0.09	20	0.49	0.52	0.72
40	20.00	61.52	0.08	18	0.56	1.19	1.31
41	20.49	61.81	0.08	11	0.63	0.54	0.83

Table 8 shows the annual energy production at sea-level normalized air density. Table 9 shows the annual energy production (AEP) at the site average air density at the NWTC.

Table 8. Annual energy production at sea-level air density, 1.225 kg/m3

Estimated annual energy production, database A (all valid data)					
Reference air density:	1.225	kg/m^3			
Cut-out wind speed:	25.00	m/s			
Hub height annual average wind speed (Rayleigh) m/s	**AEP-measured kWh**	**Standard Uncertainty in AEP-measured**		**AEP-extrapolated kWh**	**Complete if AEP measured is at least 95% of AEP extrapolated**
		kWh	**%**		
4	10,848	3,136	10%	10,848	Complete
5	42,283	5,243	7%	42,284	Complete
6	84,579	7,228	5%	84,645	Complete
7	131,784	8,799	4%	132,513	Complete
8	177,850	9,864	3%	181,216	Complete
9	217,719	10,454	3%	227,036	Complete
10	248,443	10,656	3%	267,162	Incomplete
11	269,306	10,570	2%	299,808	Incomplete
AEP measured assumes zero power between highest bin and cutout **AEP extrapolated assumes power in last bin between last bin and cutout**					

Table 9. Annual energy production at site average density, 1.050 kg/m^3

Estimated annual energy production, database A (all valid data)					
Reference air density:	1.050	kg/m^3			
Cut-out wind speed:	25.00	m/s			
Hub height annual average wind speed (Rayleigh) m/s	**AEP-measured kWh**	**Standard Uncertainty in AEP-measured**		**AEP-extrapolated kWh**	**Complete if AEP measured is at least 95% of AEP extrapolated**
		kWh	**%**		
4	9,298	2,745	10%	9,298	Complete
5	36,242	4,539	7%	36,243	Complete
6	72,497	6,231	5%	72,553	Complete
7	112,958	7,571	4%	113,582	Complete
8	152,443	8,479	3%	155,328	Complete
9	186,616	8,981	3%	194,602	Complete
10	212,951	9,152	3%	228,996	Incomplete
11	230,834	9,076	2%	256,978	Incomplete
AEP measured assumes zero power between highest bin and cutout **AEP extrapolated assumes power in last bin between last bin and cutout**					

5.2.Graphical Results Power Performance Test

Figure 5 through Figure 11 show the results of the power performance test.

Figure 5 shows a plot of the binned power curve normalized to sea-level air density.

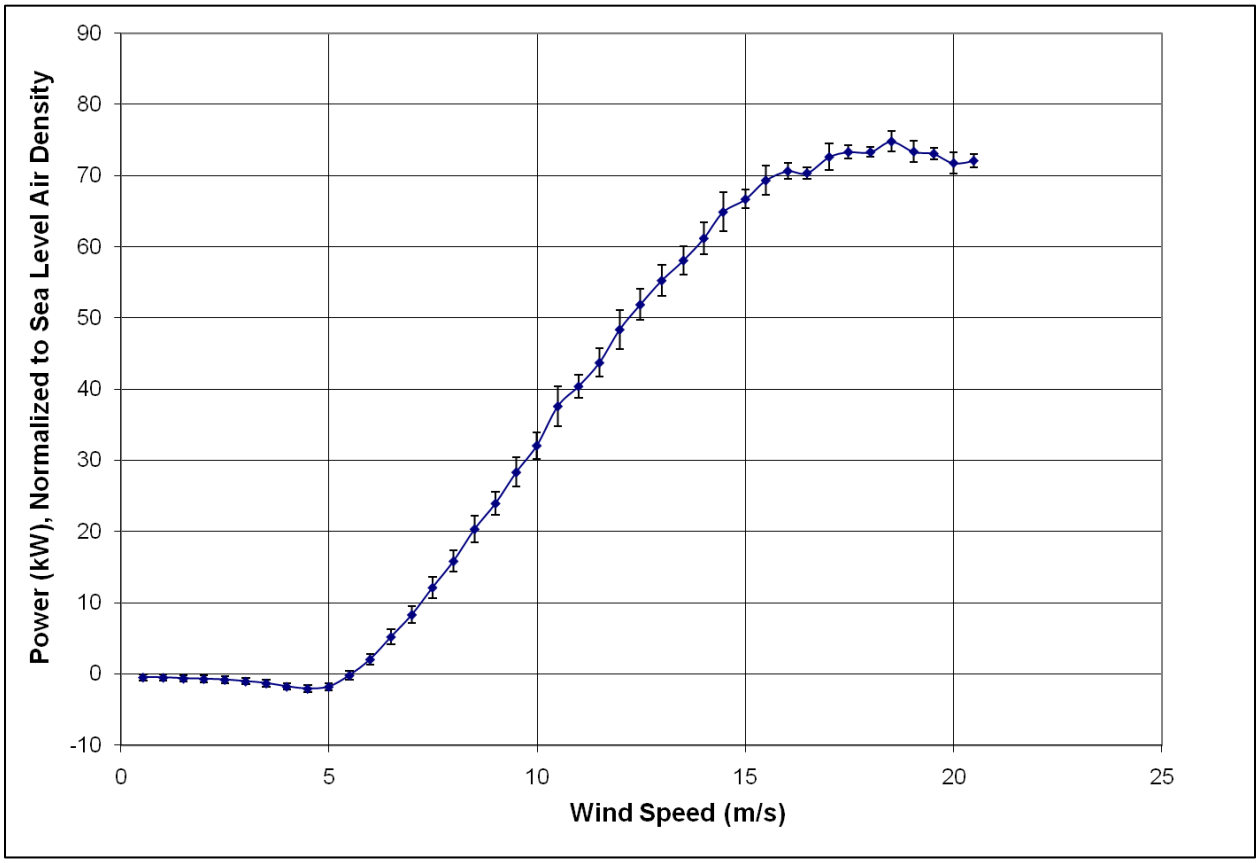


Figure 5. Power curve at sea-level density, 1.225 kg/m^3

Figure 6 shows a plot of the binned power curve at the site average air density during the test period.

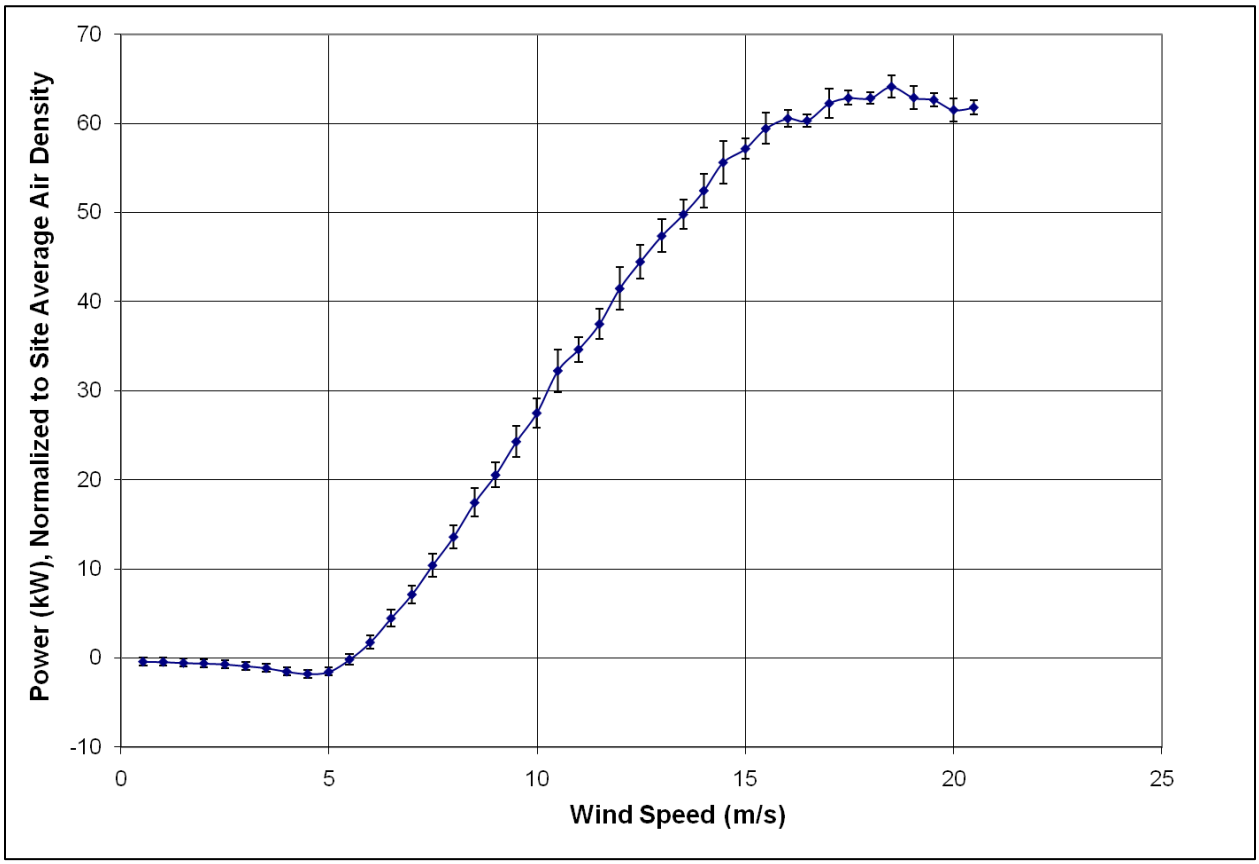


Figure 6. Power curve at site average density, 1.050 kg/m^3

Figure 7 shows a scatter plot of statistics for power for the turbine.

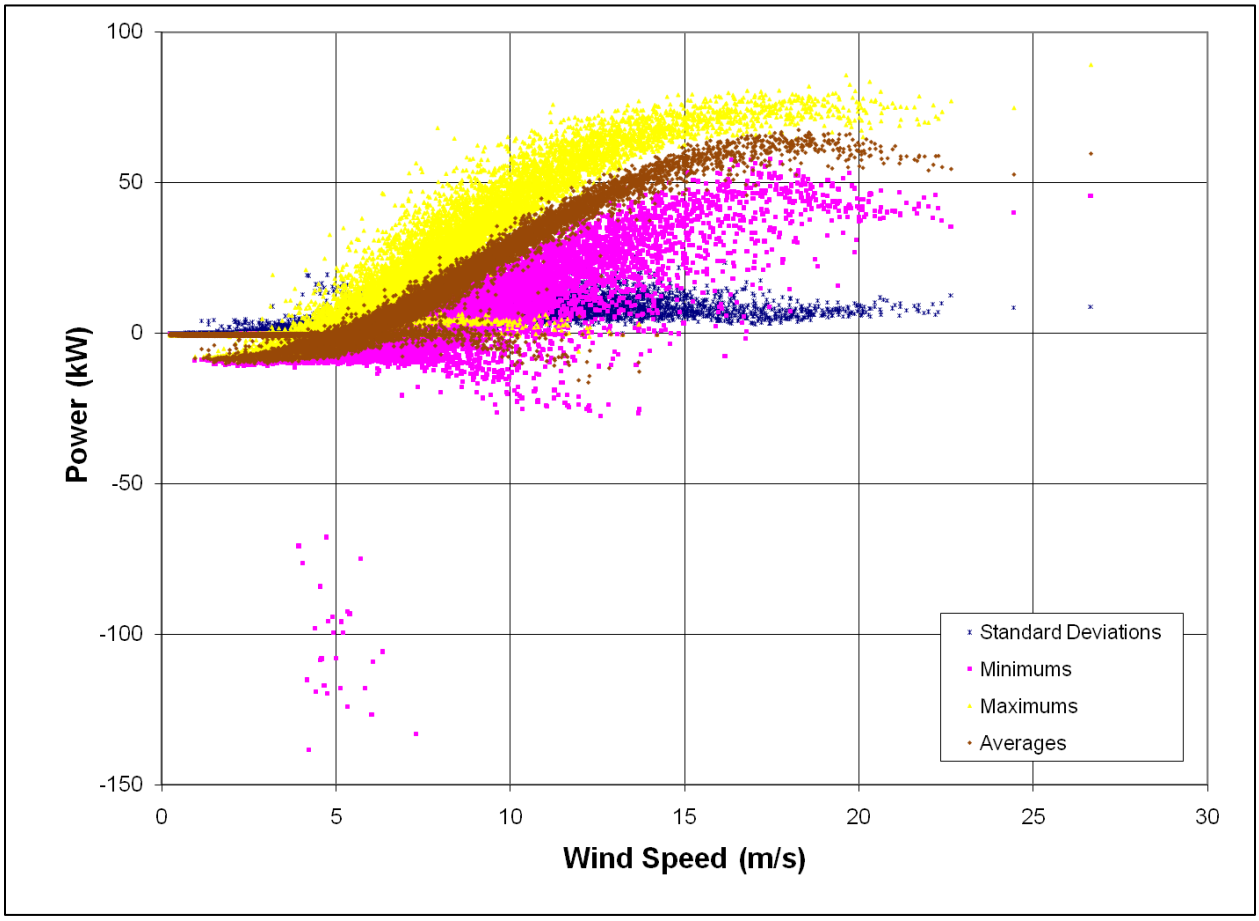


Figure 7. Scatter plot of mean, standard deviation, minimum, and maximum power data

There are several minimums around 5m/s, with power values between -60 and -140kW. These events are due to the EW50 motor starting, which is part of the normal & automatic operation.

There is also a second power curve, which is negative and most distinctive between 7 and 12m/s. Figure 8 shows the average power in this region. This power curve is due to the EW50 operating in the upwind position.

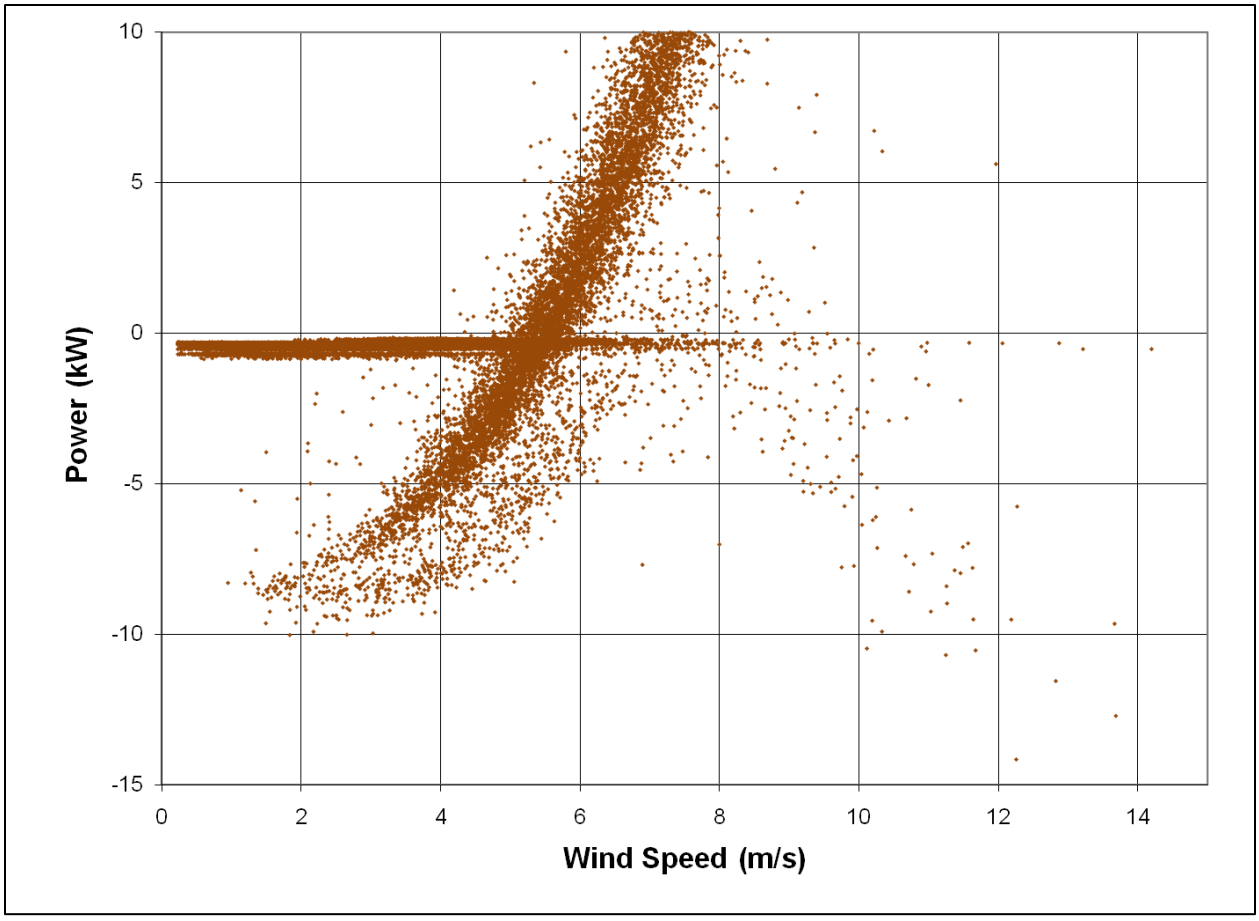


Figure 8. Scatter plot of mean power data, zoomed to show upwind power curve

Figure 9 shows a plot of the binned coefficient of performance as a function of wind speed at sea-level normalized air density.

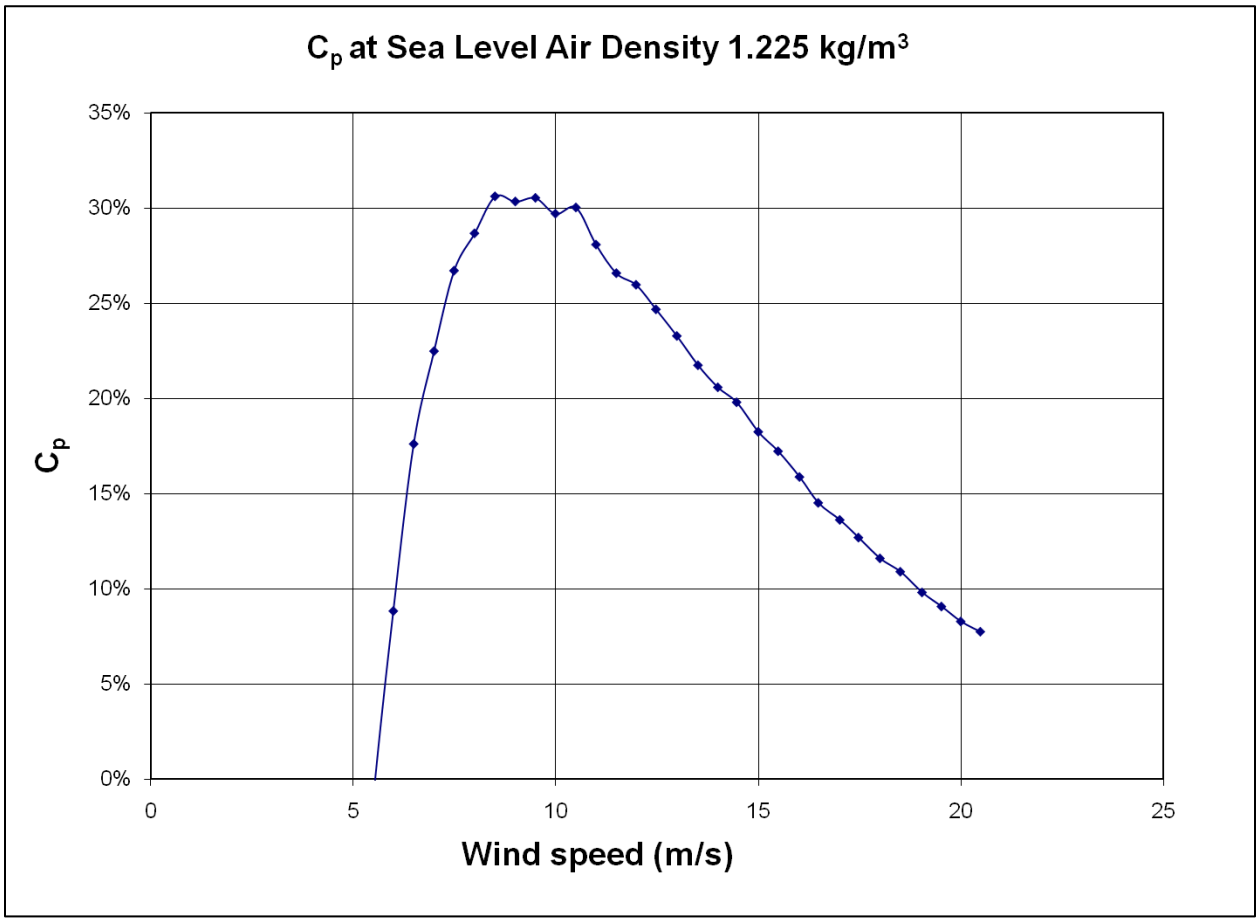


Figure 9. Coefficient of performance at sea-level density, 1.225 kg/m^3

Figure 10 shows a scatter plot and binned turbulence intensity as a function of wind speed.

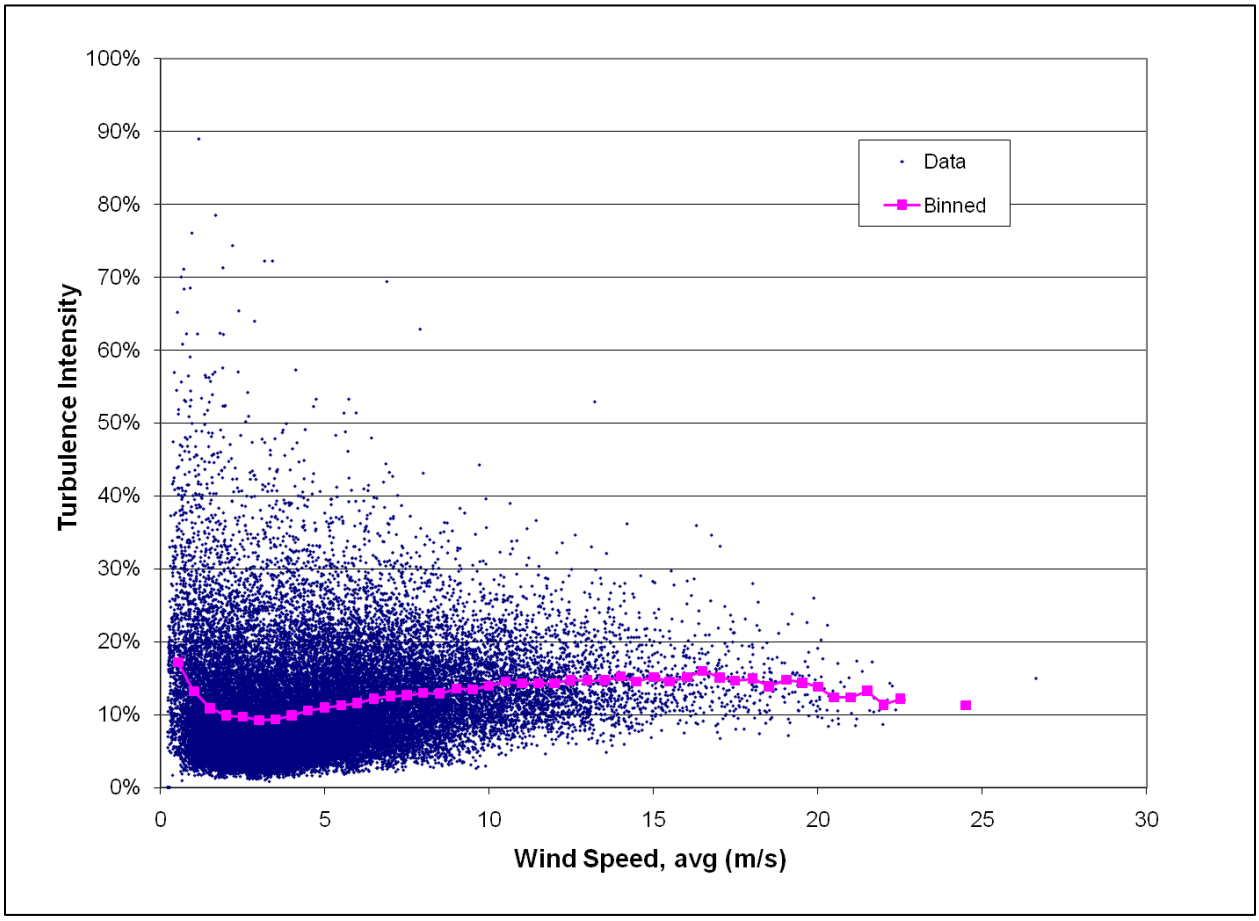


Figure 10. Wind turbulence intensity as a function of wind speed

Figure 11 shows a scatter plot of wind speed and turbulence intensity as a function of wind direction.

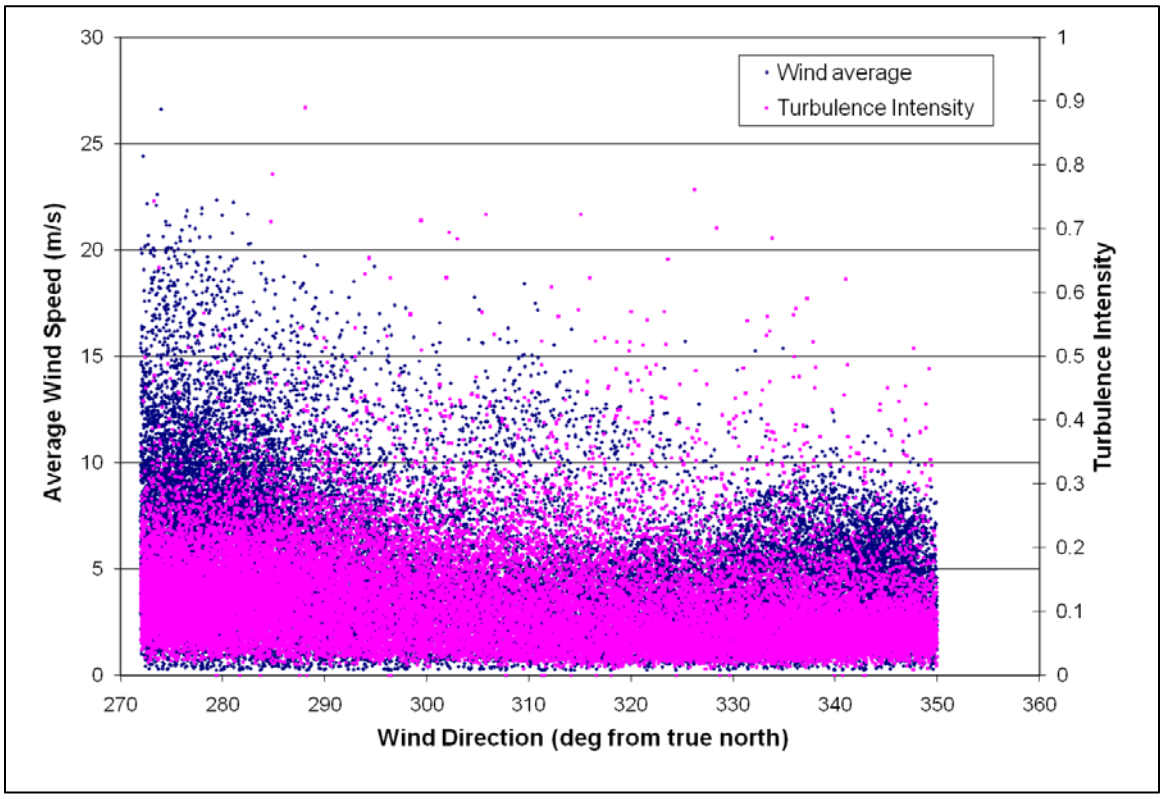


Figure 11. Wind speed and turbulence intensity as a function of wind direction

6. Exceptions

6.1.Exceptions to the Standard

The power transducers are not compliant with IEC 60688, but they do exceed the minimum accuracy required by the Standard. This should have no effect on results or uncertainty.

The current transformers are not compliant with IEC 60044-1, but they do exceed the minimum accuracy required by the Standard. This should have no effect on results or uncertainty.

The reference anemometer is mounted 2.8m below the primary. This exceeds the Standard's allowable 2.5m as shown in Annex G.5. This should have no effect on results or uncertainty, because the primary anemometer was post-test calibrated and the reference anemometer was not used for an in situ calibration.

The connection to the grid is approximately 100m from the turbine base. This exceeds the maximum of three times the tower height, as required by Annex H.e. This may slightly lower the power curve. The power cables were sized for this distance; 1/0 copper for 100m. The additional 7m of 1/0 copper cable to reach the grid, which are in excess of the distance allowed by the Standard, results in a power loss of 54Watts when the turbine is operating at 65kW or 0.08%.

The temperature sensor is 3.6m below hub height. This is not 1.5 rotor diameters below hub height as required by Annex H.j. The cross-sectional area of the sensor is small in comparison to the diameter, therefore inflow blockage is minimal. Measuring the temperature close to hub height will result in less uncertainty.

The air pressure sensor is 4.4m below hub height. This is not 1.5 rotor diameters below hub height as required by Annex H.j. The cross-sectional area of the sensor is small in comparison to the diameter, therefore inflow blockage is minimal. Measuring the pressure close to hub height will result in less uncertainty.

6.2.Exceptions to NWTC Quality Assurance System

The data acquisition modules were used beyond the calibration due date. The modules were post-test calibrated and found to be in compliance within the specifications. Appendix B includes the post-test calibration sheets.

The temperature sensor was used beyond its calibration due date. It was post-test calibrated and the calibration coefficients were found to match the initial calibration coefficients within the margin of uncertainty. Appendix B includes the post-test calibration sheet for the temperature senor.

A. Appendix - Photographs of the Test Site from the Turbine Base

Direction pictures are facing:

A.1. North

A.2. Northeast

A.3. East-northeast

A.4. East

A.5. Southeast

A.6. South

A.7. South-southwest

A.8. Southwest

A.9. West

A.10. Northwest

A.11. North-northwest



Figure A.1. Facing North. PIX #18724.



Figure A.2. Facing Northeast. PIX #18725.



Figure A.3. Facing East-northeast. PIX #18726.



Figure A.4. Facing East. PIX #18727.



Figure A.5. Facing Southeast. PIX #18728.



Figure Facing A.6. South. PIX #18729.



Figure A.7. Facing South-southwest. PIX #



Figure A.8. Facing Southwest. PIX #18731.



Figure A.9. Facing West. PIX #18732.



Figure A.10. Facing Northwest. PIX #18733.



Figure A.11. Facing North-northwest. PIX #18734.

B. Appendix - Equipment Calibration Sheets

B.1. Primary anemometer calibration sheet; installed 25Feb09, removed 24Feb10

B.2. Primary anemometer post-test calibration sheet

B.3. Primary anemometer pre- & post-test calibration comparison; the difference is less than 0.1m/s for the range of 6 to 12m/s

B.4. Power transducer calibration sheet; installed 25Feb09, removed 8Feb10

B.5. Wind vane calibration sheet; installed 25Feb09, removed 24Feb10

B.6. RTD probe calibration sheet; installed 25Feb09, removed 8Feb10

B.7. RTD probe post-test calibration sheet

B.8. RTD calibration comparison

B.9. Pressure transducer calibration sheet; installed 10Sep09, removed 17Aug10

B.10. NI 9229 data acquisition module calibration; installed 25Feb09, removed 3Feb10

B.11. NI 9217 data acquisition module calibration; installed 25Feb09, removed 3Feb10

B.12. NI 9205 data acquisition module calibration ; installed 25Feb09, removed 3Feb10

B.13. NI 9229 data acquisition module post-test calibration

B.14. NI 9217 data acquisition module post-test calibration

B.15. NI 9205 data acquisition module post-test calibration

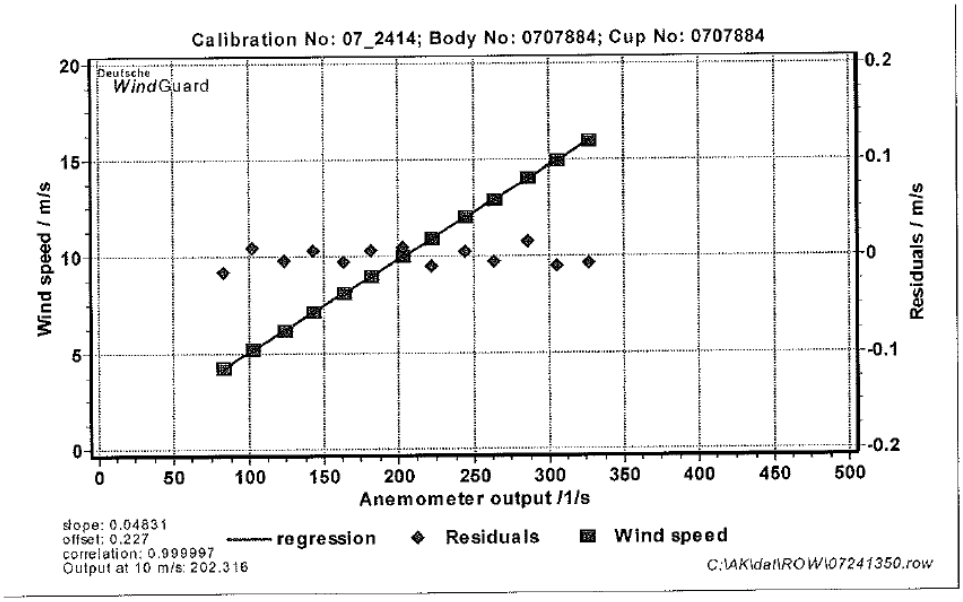
1 Detailed MEASNET[1] Calibration Results

DKD calibration no.	07_2414
Body no.	0707884
Cup no.	0707884
Date	24.07.2007
Air temperature	23.1 deg
Air pressure	995.6 hPa
Humidity	56.6 %

Linear regression analysis

Slope	0.04831 (m/s)/(1/s) ±0.00004 (m/s)/(1/s)
Offset	0.227 m/s ±0.008 m/s
St.err(Y)	0.006 m/s
Correlation coefficient	0.999997

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) and Physikalisch Technische Bundesanstalt – PTB (Federal Office for Physics and Technique). Registration: DKD – K – 36801

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

Figure B.1. Primary anemometer calibration sheet; installed 25Feb09, removed 24Feb10

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

WIND ENGINEERING FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 10.02.6374 **Date of issue:** October 25, 2010

Type: Thies 4.3350.00.000 **Serial number:** 0707884

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

Client: NREL Meterology and Calibration Laboratory, 1617 Cole Blvd, Golden, CO 80401 USA

Anemometer received: October 21, 2010 **Anemometer calibrated:** October 24, 2010

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

Certificate prepared by: jsa **Approved by:** Calibration engineer, soh

Svend Ole Hansen

Calibration equation obtained: v [m/s] = 0.04839 · f [Hz] + 0.24584

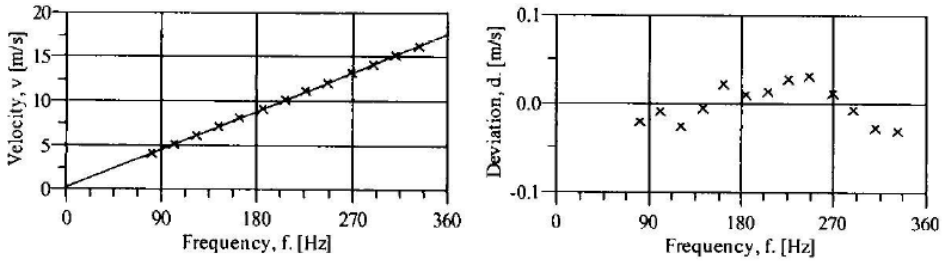
Standard uncertainty, slope: 0.00164 **Standard uncertainty, offset:** 0.07126

Covariance: -0.0000013 (m/s)²/Hz **Coefficient of correlation:** ρ = 0.999985

Absolute maximum deviation: 0.032 m/s at 12.219 m/s

Barometric pressure: 993.9 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	9.70	31.2	22.8	4.137	80.8256	-0.020	0.028
4	14.88	31.0	22.8	5.123	100.9651	-0.008	0.032
6	21.30	30.9	22.8	6.129	122.0926	-0.025	0.037
8	29.13	30.8	22.7	7.166	143.0869	-0.004	0.043
10	37.89	30.7	22.7	8.172	163.3293	0.022	0.048
12	47.90	30.7	22.7	9.188	184.5738	0.010	0.054
13-last	59.22	30.6	22.7	10.215	205.7189	0.014	0.060
11	71.27	30.7	22.7	11.207	225.9264	0.029	0.066
9	84.70	30.8	22.7	12.219	246.7675	0.032	0.072
7	99.66	30.9	22.8	13.256	268.6190	0.012	0.078
5	115.27	31.0	22.8	14.259	289.7302	-0.006	0.084
3	132.29	31.1	22.8	15.278	311.2080	-0.027	0.090
1-first	150.67	31.3	22.9	16.311	332.6236	-0.030	0.096



DANAK

Figure B.2. Primary anemometer post-test calibration sheet

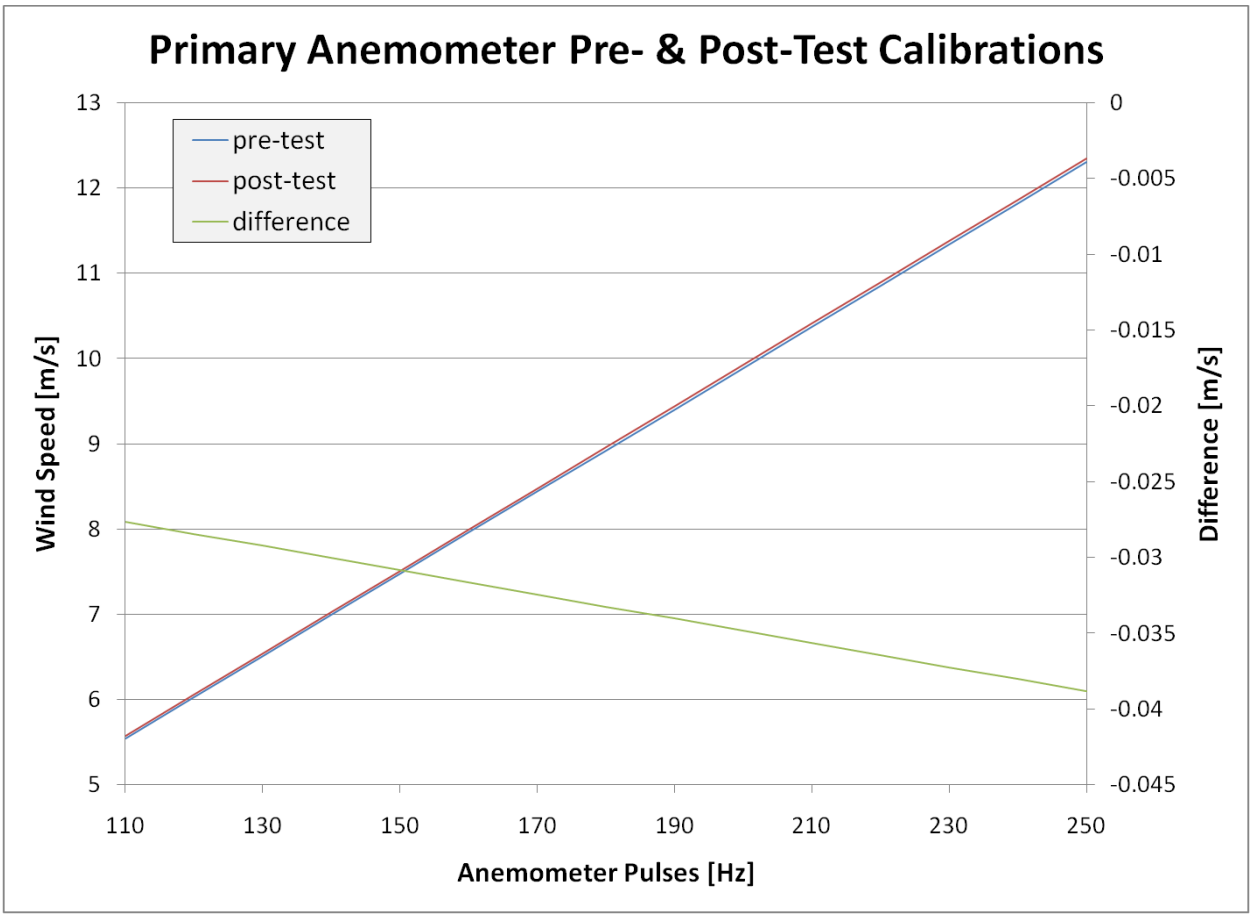


Figure B.3. Primary anemometer pre- and post-test calibration comparison; the difference is less than 0.1m/s for the range of 6 to 12m/s

Branch #: 5000

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Multifunction Transducer — DOE #: 03574C

Model # : DMT-1040E — S/N : 07070473

Calibration Date: 08/26/2008 — Due Date: 08/26/2010

A. Set-Up for Total Power Calibration:
A.1. Voltage is applied to Lines 1, 2, & 3 = 277.128 V @ 60 Hz.
A.2. Current is applied to n = 1-TURN through three current transformers that are connected to Lines 1, 2, & 3 .
A.3. Analog Output-1 is measured across precision resistor = 250 Ω.
A.4. Full Scale setting = -124.71KW to 124.71KW.

Input Current (AAC)	Input Power (KW)	Analog Output-1 (VDC)
150	124.71	5.022
105	87.30	3.517
60	49.88	2.009
0	0	0.001
-60	-49.88	-2.007
-105	-87.30	-3.515
-150	-124.71	-5.019

B. Set-Up for Power Factor Calibration:
B.1. Voltage & Current are applied as A.1 & A.2.
B.2. Analog Output-2 is measured across precision resistor = 250 Ω.

Power (KW)	Power Factor	Analog Output-2 (VDC)
49.88	1.0	5.001
"	0.8	3.999
"	0.6	3.000
"	0.4	1.998

Page 1 of 2

Figure B.4. Power transducer calibration sheet; installed 25Feb09, removed 8Feb10

Wind Vane Calibration Report

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

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

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

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

Report Number: U1477-070913

Procedure:
NWTC-CT: GI24-000613, Wind Vane Calibration

Page: 1 of 1

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

Item Calibrated:

Manufacturer	Met One Instruments, Inc
Model	020C
Serial Number	**U1477**
Vane Material	Aluminum
Condition	Refurbished

Results:

Slope:	**71.87**	**deg/V**
Offset to boom:	**86.96**	**deg**
Max error:	0.38	deg

Estimated Uncertainty:

Inclinometer Uncertainty (deg)	Total Uncertainty (deg)
0.10	0.28

Traceability:

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

Calibration by: Mark Meadors — 13-Sep-07 Date

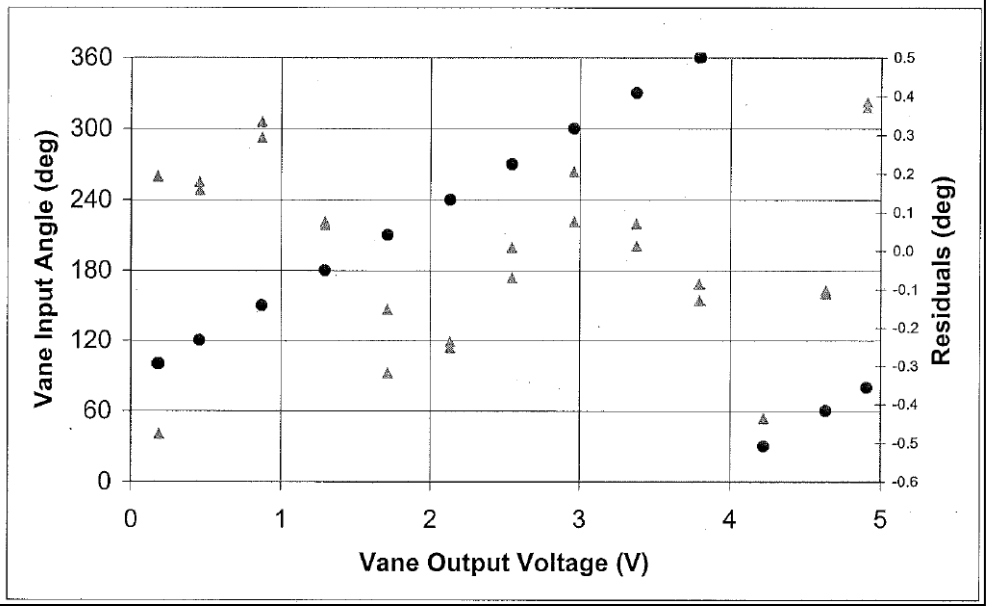


Figure B.5. Wind vane calibration sheet; installed 25Feb09, removed 24Feb10

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: RTD-Probe DOE #: 02466C

Model # : 68N01N00N040 S/N : 0549828

Calibration Date: 10/10/2008 Due Date: 10/10/2009

No	Function Tested	Nominal Value (°C)	Measured Values (Ω)		( )Mfr. Specs. OR (X)Data only
			AS Found	AS Left	
*	Temperature:	0	99.95	Same	
		25	109.69	"	
		50	119.35	"	
	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 = 38. - Uncertainty of Nominal Values = ± 0.03 °C, k = 2.				

Tested By: Reda

Date : 10/10/2008

Figure B.6. RTD probe calibration sheet; installed 25Feb09, removed 8Feb10

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: RTD Probe DOE #: 02466C

Model # : 68N01N00N040 S/N : 0549828

Calibration Date: 02/10/2010 Due Date: 02/10/2011

No	Nominal Values		Measured Values		
	Nominal Resistance	Equivalent Temperature	Measured Resistance	Equivalent Temperature	Temperature Error
1	96.09 Ω	-10 °C	96.027 Ω	-10.16 °C	0.16 °C
2	100.00 Ω	0 °C	99.948 Ω	-0.13 °C	0.13 °C
3	103.90 Ω	10 °C	103.855 Ω	9.88 °C	0.12 °C
4	107.79 Ω	20 °C	107.745 Ω	19.88 °C	0.12 °C
5	111.67 Ω	30 °C	111.618 Ω	29.87 °C	0.13 °C
6	115.54 Ω	40 °C	115.490 Ω	39.87 °C	0.13 °C

Notes:

1. Total Uncertainty of Nominal Values = ±0.02 °C
2. Calibration was performed at 23 °C and 40% RH
3. Resistance is measured using 4-wire technique

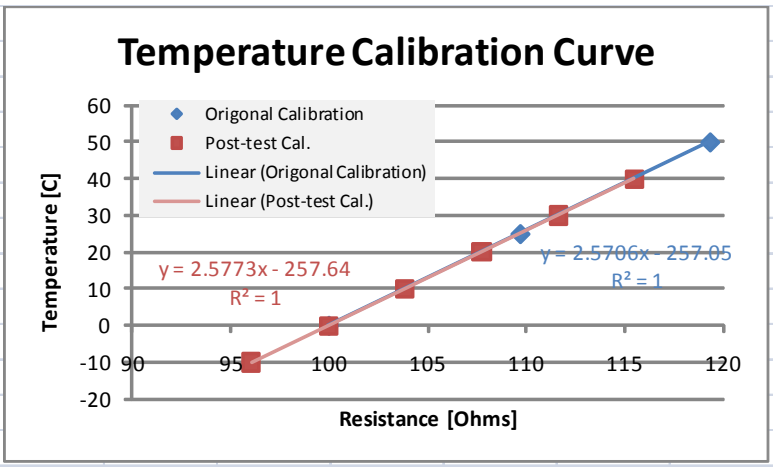
Calibrated by: Reda QA by: Bev

Date : 02/10/2010 Date : 02/10/2010

Figure B.7. RTD probe post-test calibration sheet

Origonal Calibration	
Temp	**Resistance**
0	99.95
25	109.69
50	119.35

m	**b**
2.577305	**-257.636**



Post-test Cal.	
Temp	**Resistance**
-10.16	96.027
-0.13	99.948
9.88	103.855
19.88	107.745
29.87	111.618
39.87	115.49

m	**b**
2.570556	**-257.046**

Figure B.8. RTD calibration comparison

Branch #: 5000 sheet: 1 of: 1

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Pressure Transmitter DOE #: 03508C

Model # : PTB101B S/N : C1020015

Calibration Date: 09/03/2009 Due Date: 09/03/2010

No	Function Tested	Nominal Value (kPa)	Measured Output Voltage (VDC)		( )Mfr. Specs. OR (X)Data only (mb)
			As Found	As Left	
*	Absolute Pressure				
		65	0.270		
		70	0.542		
		75	0.814		
		80	1.086		
		85	1.357		
		90	1.628		
		95	1.900		
		100	2.171		
		103	2.334		
	Notes: 1. Expanded Uncertainty of the nominal value is ± 0.2 kPa, with k = 2. 2. Calibration was performed at 23°C and 37% RH. 3. Calibration was performed using standards that are traceable to NIST. DOE numbers: 128120, and 02301C.				

Calibrated By: Reda
Date: 09/03/2009

QA By: Bev
Date: 09/03/2009

Figure B.9. Pressure transducer calibration sheet; installed 10Sep09, removed 17Aug10

Board Information:
Serial Number: 13DEC38
NI Part Number: 192580G-02L
Description: NI 9229

Certificate Information:
Certificate Number: 1222096
Date Printed: 31-MAR-09

Calibration Date: 10-NOV-08
Recommended Calibration Due Date: 10-NOV-09*

Ambient Temperature: 23 °C
Relative Humidity: 36 %

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

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

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

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

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

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

Signed,

Andrew Krupp
Vice President, Quality and
Continuous Improvement

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

Figure B.10. NI 9229 data acquisition module calibration; installed 25Feb09, removed 3Feb10

Board Information:
Serial Number: 13FAE1C
NI Part Number: 192547E-01L
Description: NI 9217

Certificate Information:
Certificate Number: 1267445
Date Printed: 31-MAR-09

Calibration Date: 16-DEC-08
Recommended Calibration Due Date: 16-DEC-09*

Ambient Temperature: 23 °C
Relative Humidity: 39 %

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

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

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

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

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4031 Debrecen, Határ út
1/A.
HUNGARY

Signed,

Andrew Krupp
Vice President, Quality and
Continuous Improvement

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

Figure B.11. NI 9217 data acquisition module calibration; installed 25Feb09, removed 3Feb10

Board Information:
Serial Number: 13E3D05
NI Part Number: 193299F-01
Description: NI-9205

Certificate Information:
Certificate Number: 1224953
Date Printed: 31-MAR-09

Calibration Date: 12-NOV-08
Recommended Calibration Due Date: 12-NOV-09*

Ambient Temperature: 22 °C
Relative Humidity: 37 %

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

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

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

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

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

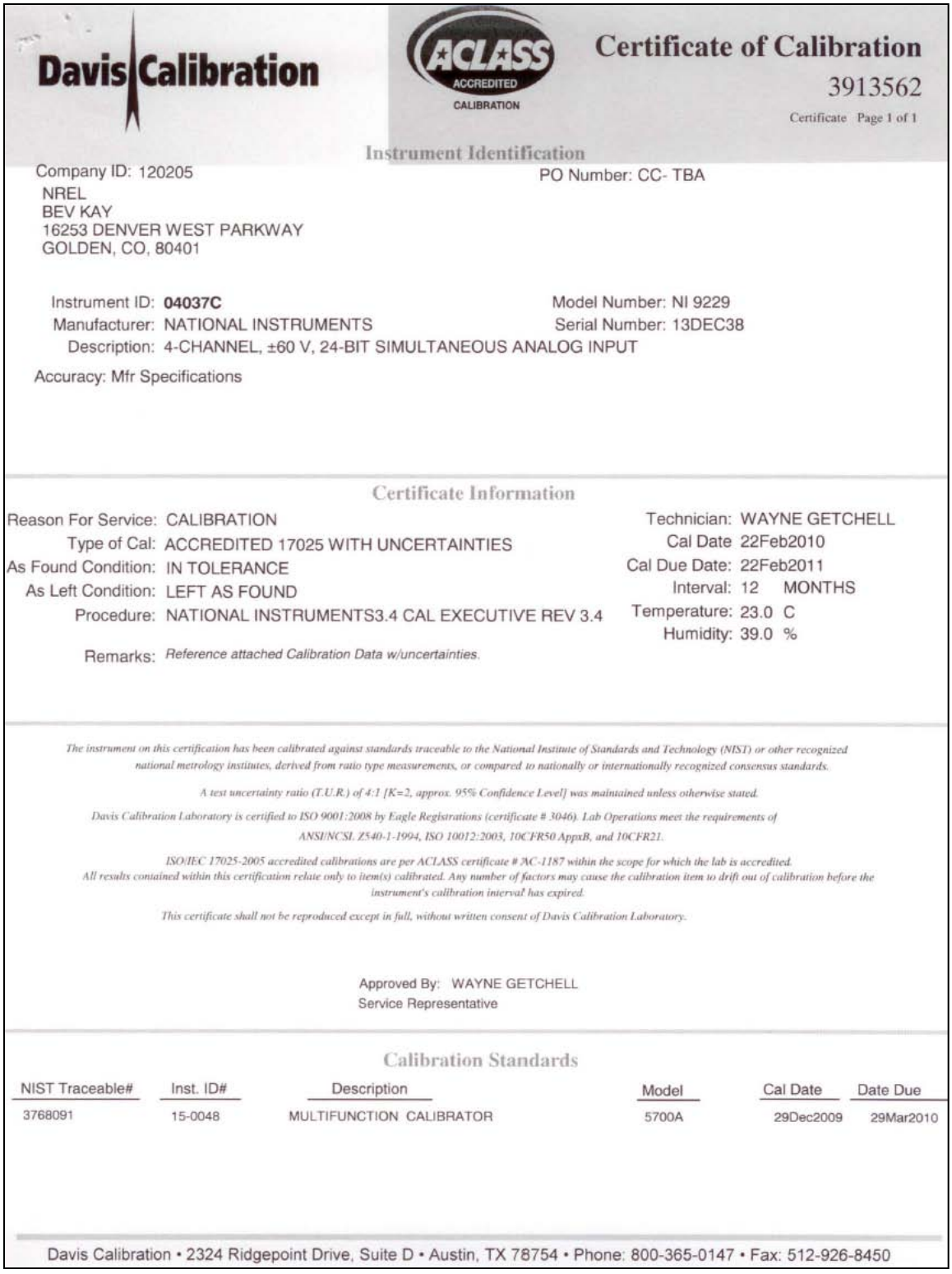
NI Hungary Software és
Hardware Gyártó Kft.
4031 Debrecen, Határ út
1/A.
HUNGARY

Signed,

Andrew Krupp
Vice President, Quality and
Continuous Improvement

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

Figure B.12. NI 9205 data acquisition module calibration; installed 25Feb09, removed 3Feb10



Davis Calibration

ACCREDITED CALIBRATION

Certificate of Calibration

3913562

Certificate Page 1 of 1

Instrument Identification

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

PO Number: CC- TBA

Instrument ID: **04037C**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CHANNEL, ±60 V, 24-BIT SIMULTANEOUS ANALOG INPUT

Model Number: NI 9229
Serial Number: 13DEC38

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 INSTRUMENTS3.4 CAL EXECUTIVE REV 3.4

Remarks: *Reference attached Calibration Data w/uncertainties.*

Technician: WAYNE GETCHELL
Cal Date 22Feb2010
Cal Due Date: 22Feb2011
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 39.0 %

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.

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, 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. 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.

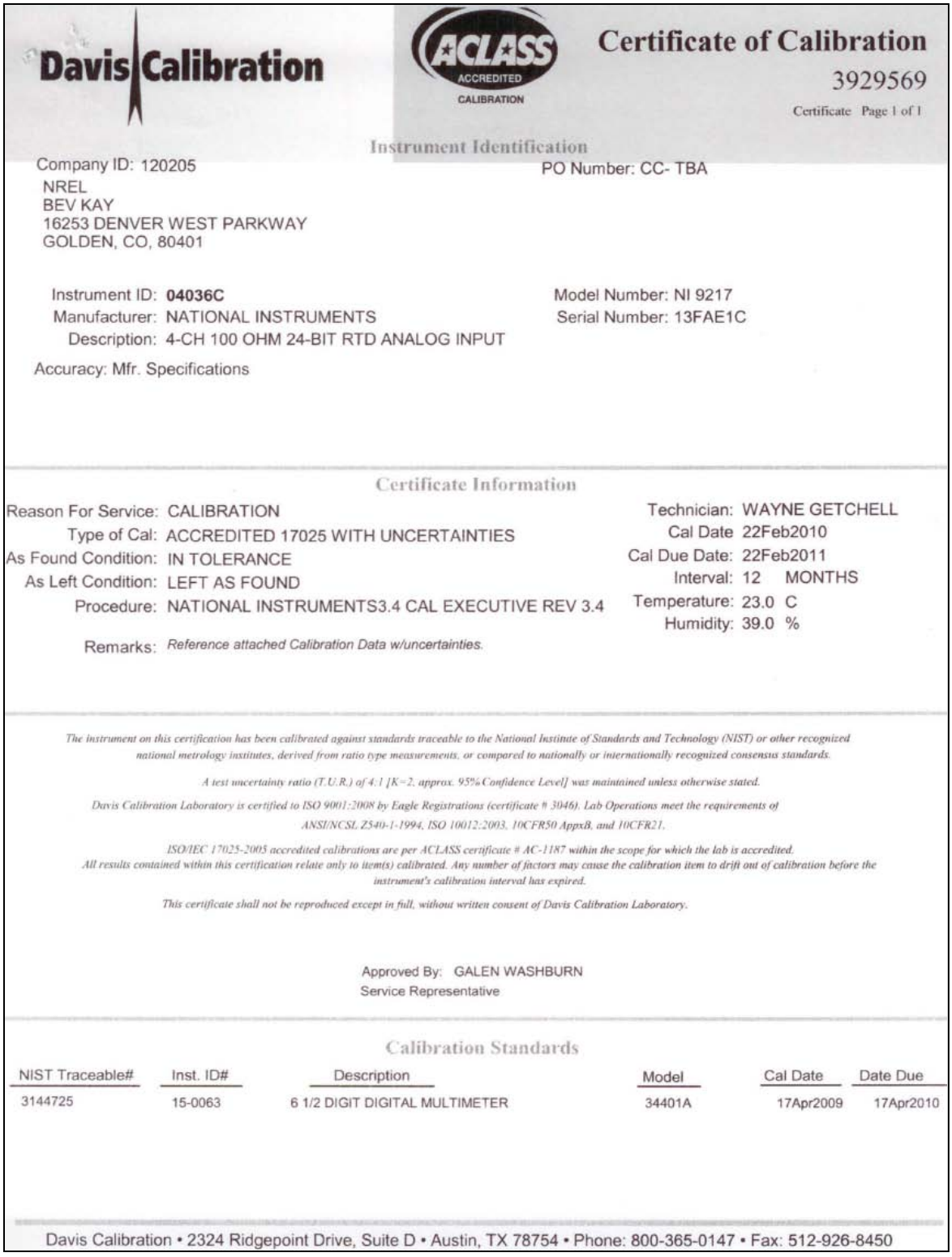
Approved By: WAYNE GETCHELL
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
3768091	15-0048	MULTIFUNCTION CALIBRATOR	5700A	29Dec2009	29Mar2010

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

Figure B.13. NI 9229 data acquisition module post-test calibration



Davis Calibration

ACCREDITED CALIBRATION

Certificate of Calibration

3929569

Certificate Page 1 of 1

Instrument Identification

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

PO Number: CC- TBA

Instrument ID: **04036C**
Manufacturer: NATIONAL INSTRUMENTS
Description: 4-CH 100 OHM 24-BIT RTD ANALOG INPUT

Model Number: NI 9217
Serial Number: 13FAE1C

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 INSTRUMENTS3.4 CAL EXECUTIVE REV 3.4

Remarks: *Reference attached Calibration Data w/uncertainties.*

Technician: WAYNE GETCHELL
Cal Date 22Feb2010
Cal Due Date: 22Feb2011
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 39.0 %

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.

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, 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. 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.

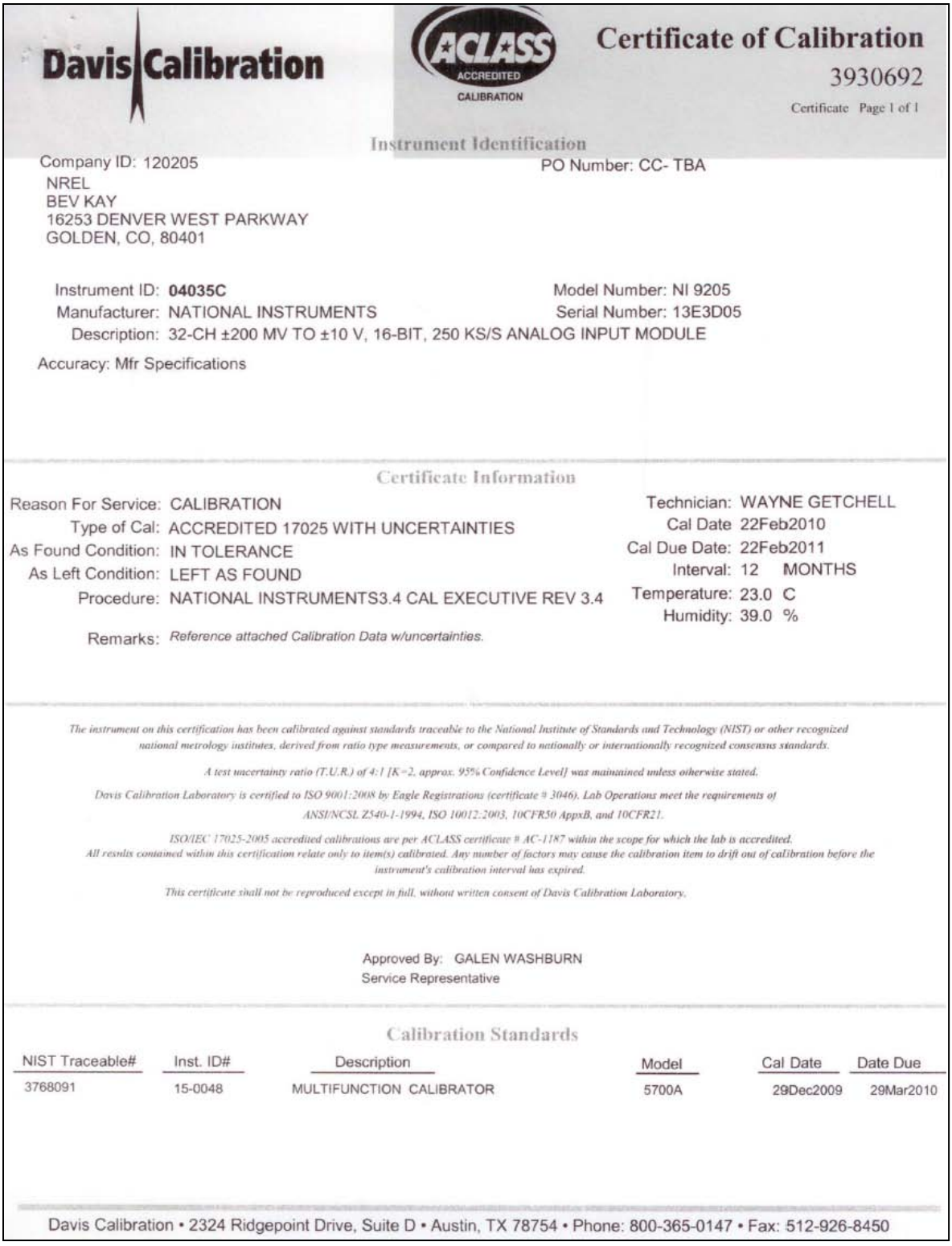
Approved By: GALEN WASHBURN
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
3144725	15-0063	6 1/2 DIGIT DIGITAL MULTIMETER	34401A	17Apr2009	17Apr2010

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Figure B.14. NI 9217 data acquisition module post-test calibration



Davis Calibration

ACCREDITED CALIBRATION

Certificate of Calibration

3930692

Certificate Page 1 of 1

Instrument Identification

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

PO Number: CC- TBA

Instrument ID: **04035C**
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: 13E3D05

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 INSTRUMENTS3.4 CAL EXECUTIVE REV 3.4

Technician: WAYNE GETCHELL
Cal Date 22Feb2010
Cal Due Date: 22Feb2011
Interval: 12 MONTHS
Temperature: 23.0 C
Humidity: 39.0 %

Remarks: *Reference attached Calibration Data w/uncertainties.*

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, 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. 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: GALEN WASHBURN
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
3768091	15-0048	MULTIFUNCTION CALIBRATOR	5700A	29Dec2009	29Mar2010

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Figure B.15. NI 9205 data acquisition module post-test calibration