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Duration Test Report for the Entegrity EW50 Wind Turbine

Joe Smith, Arlinda Huskey, Dave Jager, and Jerry Hur
National Renewable Energy Laboratory

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Technical Report
NREL/TP-5000-57141
December 2012

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Duration Test Report

for the

Entegrity EW50 Wind Turbine

Conducted for

Wind Energy Program
DOE/NREL

Conducted by

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

Joe Smith, Arlinda Huskey, Dave Jager, and Jerry Hur

25 October 2012

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1. Background

This test was conducted as part of the U.S. Department of Energy's (DOE) Independent Testing project. This project was established to help reduce the barriers to wind energy expansion by providing independent testing results for small turbines. Five turbines were tested at the National Wind Technology Center (NWTC) as a part of round one of this project. Duration testing is one of up to five tests that may be performed on the turbines, including safety & function, power performance, noise, and power quality tests. Test results provide manufacturers with reports that can be used to fulfill part of the requirements for small wind turbine certification.

The test equipment included a grid connected Entegrity Wind System's EW50 wind turbine mounted on a 30.5-m (100-ft) monopole.

2. Test Objective and Requirements

The objective of this test was to assess the following aspects of the Entegrity EW50 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).

The major parts of this test are to investigate:

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

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

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

Reliable operation means:

- 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.

Based on the parameters defined in the Standard for small wind turbine classes, Entegrity Wind Systems identified the Entegrity EW50 turbine as class II. This corresponds to a V_{ave} of 8.5 m/s.

In addition, this test was conducted in accordance with NREL's quality system procedures; this report will meet the full requirements of its accreditation by A2LA. NREL's quality system requires that this report 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 test turbine was an Entegrity EW50 wind turbine. It has an advertised rated power of 50 kilowatts (kW). The EW50 is manufactured by Entegrity Wind Systems Inc. and is a downwind, three-blade, passive-yaw, horizontal-axis wind turbine. The blades are fixed pitch, and the turbine employs an asynchronous generator that operates at a fixed speed to deliver three-phase electric power at 60 Hz. Table 1 lists the configuration of the Entegrity EW50 that was tested at the NWTC. Figure 1 is a picture of the EW50 at the NWTC.

Figure 1. Entegrity EW50 test turbine at the NWTC (PIX# 22243)

The EW50 wind turbine was mounted on a 30.5-m (100-ft) monopole tower manufactured for the Entegrity EW50 by Maico Industries, Inc. The test turbine used a controller manufactured by

Orbital A/S. The concrete mat foundation was installed per Entegrity designs by a third party, under contract to NREL. The system was installed in March 2009 by the NWTC Site Operations group with guidance and assistance from several Entegrity personnel.

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

- Tower and foundation designed for installation at the NWTC test site 1.E1
- All control components, including wiring between the up-tower components and the down-tower control panel
- All wiring and components on the turbine side of the subpanel, which connects the turbine to the NWTC site electrical grid at the 1.E1 data shed.

Table 1: Test Turbine Configuration and Operational Data

Turbine manufacturer and address	Entegrity Wind Systems Inc. 4855 Riverbend Rd.; Ste 100 Boulder, CO 80301
Model name	EW50
Gearbox serial number	543132-007
Generator serial number	C0812180024
Production date	January 2009
Design nominal voltage at terminals	480 Vac
Maximum current at terminals	108 A
Design frequency at terminals	60 Hz
SWT class	II
Design 50-year extreme wind speed, V_{e50}	59.5 m/s
Rotor Diameter	14.9 m
Hub Height (vertical center of rotor)	31.1 m
Tower Type	30.5m (100') freestanding monopole
Rated Electrical Power	50 kW
Rated Wind Speed (lowest wind speed at which turbine produces rated power)	11.3 m/s
Rated rotor speed (lowest rotor speed at which turbine produces rated power)	65 rpm
Rotor speed range	64-70 rpm
Cut-out Wind speed (m/s)	25
Fixed or variable pitch	Fixed w/ tip brake
Number of Blades	3
Blade Tip 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
Description of control system (device & software version)	TMC microprocessor by Orbital A/S in Entegrity enclosure version: “EW15 2.031”

Figure 3 shows the general electrical arrangement of the test. The wire run from the controller at the base of the tower, to the point of grid connection at the data shed was approximately 100 m. The connection was made using 1/0 American Wire Gauge (AWG) wire for the three hot lines plus the neutral line, and a #2 AWG for ground line. The data shed housed the power instrumentation, disconnect switch, and data acquisition system (DAS). The transformer was

located outside and adjacent to the data shed, which first stepped the voltage up to 480 V and then to 13.2 kV for the NREL grid.

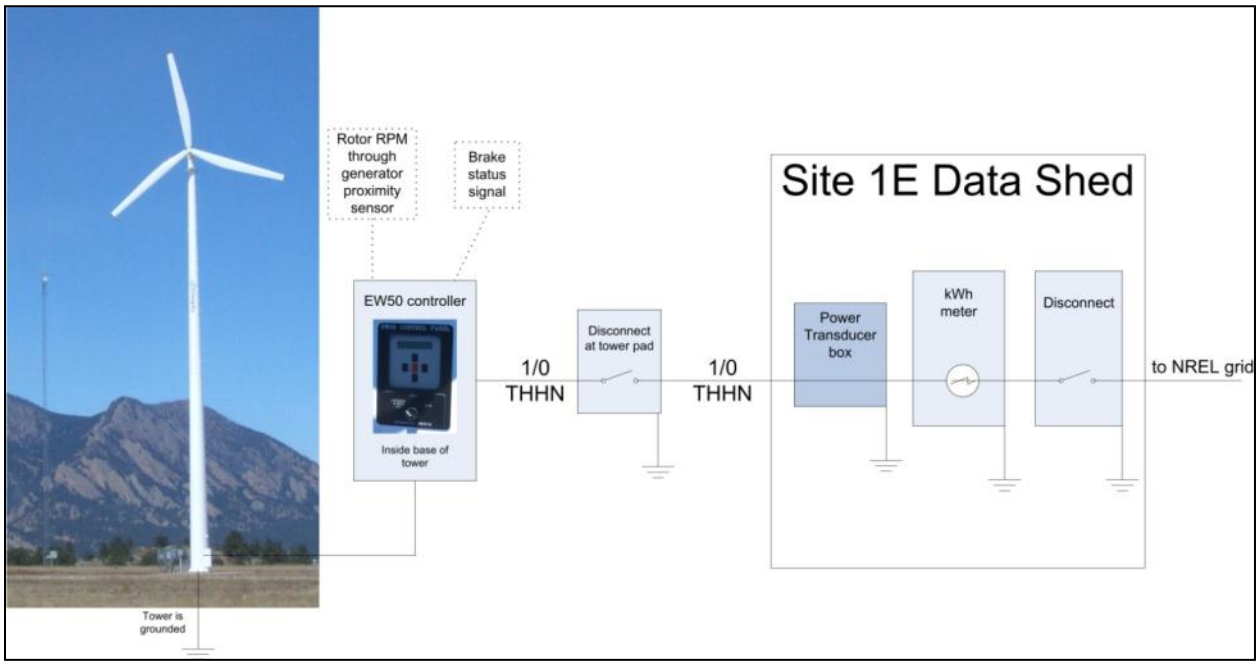


Figure 2. Electrical single-line drawing of Entegrity EW50 installation

4. Description of Test Site

The test turbine was located at site 1.E1 at the National Wind Technology Center, located 8 km (5 miles) south of Boulder, Colorado. The terrain primarily consists of mostly flat terrain with short vegetation. The test site has prevailing wind bearing 292° relative to true north. Figure 3 shows the turbine and meteorological tower locations. This figure also shows nearby obstructions and topographical features of the site.

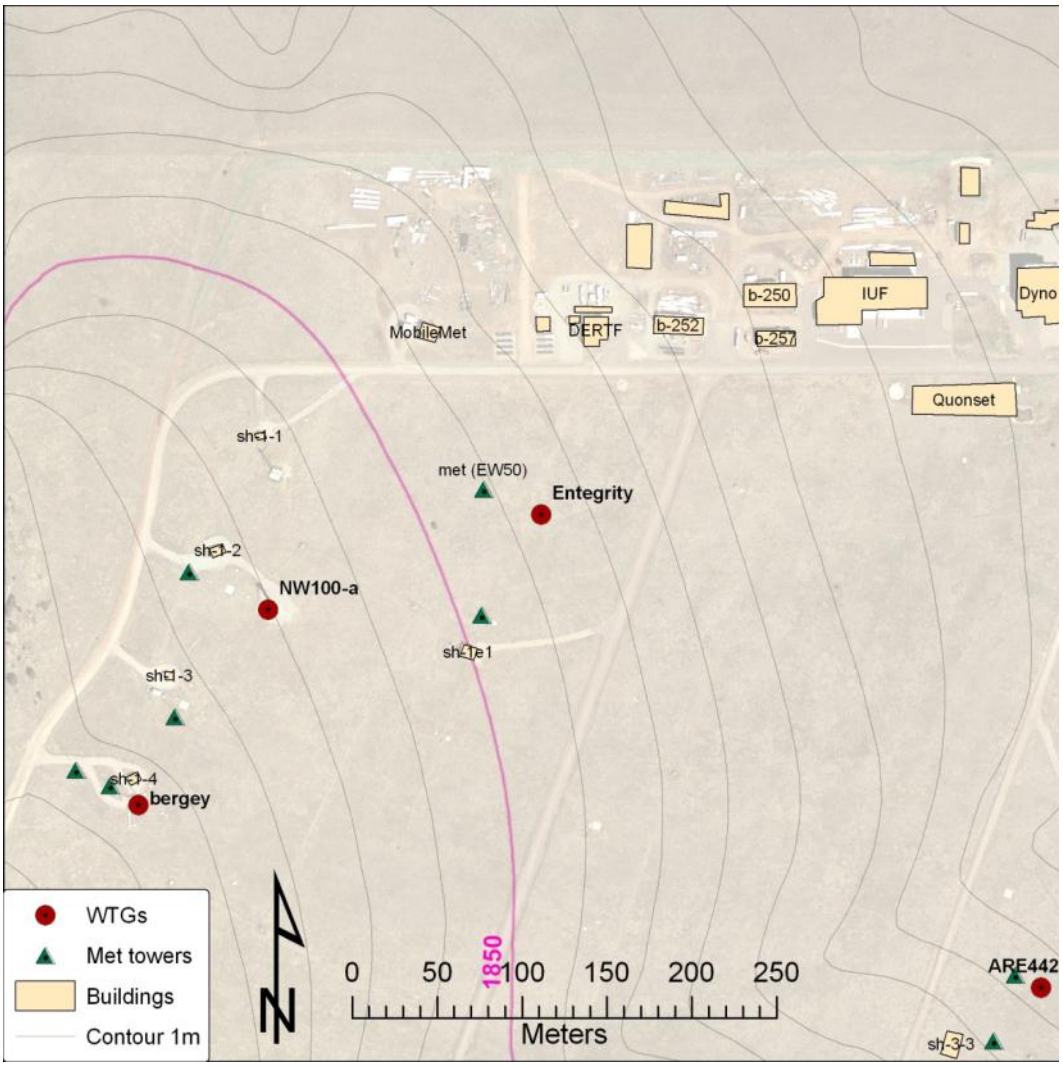


Figure 3. Map of area surrounding Entegrity's EW50 at NWTC's 1.E1 test site

5. Description of Instrumentation

Test instrumentation was installed in accordance to IEC 61400-12-1 for measuring wind speed, wind direction, turbine power, air temperature and air pressure. For duration testing, there were additional signals to monitor the rotor speed, generator speed, brake status, and overall turbine system availability. Figure 4 shows the location of the meteorological tower instruments and Table 2 provides an equipment list with the specifications for each of the instruments used.

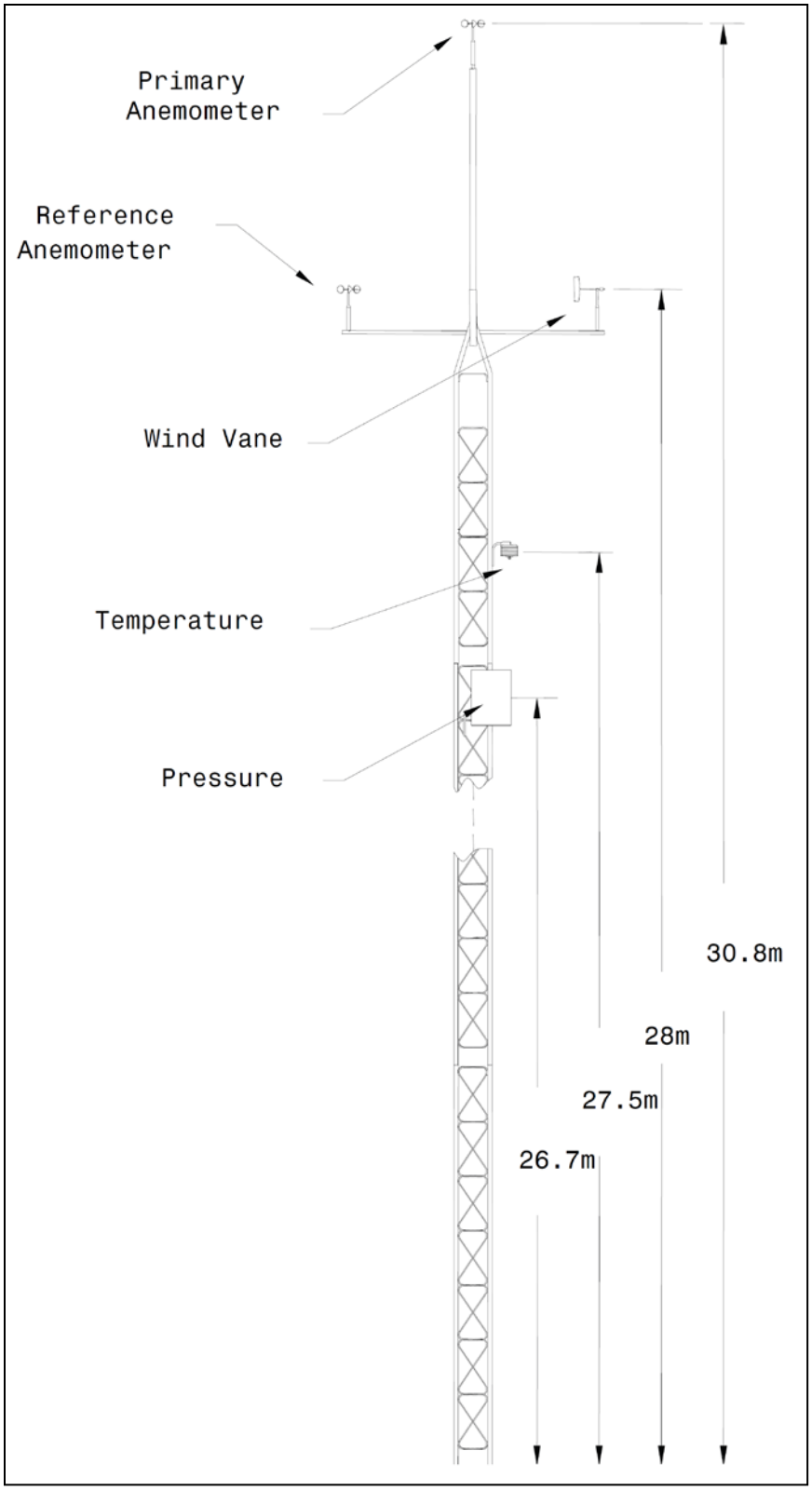


Figure 4. Meteorological tower and instruments

Table 2: Equipment List for Duration Test

Instrument	Make and Model	Serial Number	Calibration Due Dates
Power transducer	Ohio Semitronics, DMT 1040E	07070473	12 Feb 10 (recalibrated) 9 Feb 11
Current transformers	Ohio Semitronics, 12974	001293045 001235428 001293049	Calibrated with power transducer
Primary anemometer	Thies, First Class	0707884 0707885 0609010	24 Feb 10 23 Jul 10 22 Jul 11
Reference anemometer	NRG, Max 40	179500049025	–
Wind vane	Met One, 020C with Aluminum Vane	U1477	25 Feb 10 (post-test calibrated)
Pressure sensor	Vaisala, PTB101B	T0740016 C1020015 T3330002	9 Aug 09 3 Sept 10 10 Aug 11
Temperature sensor	Met One, T200	0549828	10 Oct 09 (recalibrated) 10 Feb 11
Precipitation sensor	Campbell Scientific, 237	None	In situ
Data acquisition system	Compact DAQ w/LabView cDAQ backplane (9172) NI 9229 NI 9217 NI 9205 Second set of modules NI 9229 NI 9217 NI 9205	 12E4CEB 13DEC38 13FAE1C 13E3D05 12CB7A 12C73B4 12ECB77	 N/A 10 Nov 09 16 Dec 09 12 Nov 09 18 Jan 11 18 Jan 11 18 Jan 11

The power transducers were not compliant with class 0.5 (or better) specifications of the IEC 60688 “Electrical measuring transducers for converting alternating current (AC) electrical quantities to analogue or digital signals,” but the transducers exceeded the minimum accuracy required by the Standard.

The current transformers were not compliant with class 0.5 (or better) specifications of the IEC 60044-1 “Instrumentation transformers – Part 1: Current transformers,” but the transformers exceeded the minimum accuracy required by the Standard.

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.

6. Results

The turbine was delivered to the NWTC in February 2009. The Entegrity EW50 was installed in March 2009. After a commissioning/shake-down period, which included replacing the parking brake solenoid, testing began on 2 April 2009.

6.1. Period of Testing

The Entegrity EW50 was under testing from 2 April 2009 until 23 August 2010, and from 14 October 2010 until 17 January 2011.

On 23 August 2010, the test team found capacitors in the power factor correction unit to be faulty and suspended the testing, preventing the EW50 from operating. On 14 October 2010, the test team decided to restart testing after determining that the failed capacitors did not constitute a major failure with reference to the Standard.

6.2. Months of Operation

The duration test was conducted over a period of approximately 18.5 months (not including the two months of suspended testing), exceeding the six month minimum required by the Standard.

The end of testing was determined by the need to recalibrate DAS modules. On 20 January, 2011 the Entegrity EW50 tip brakes would consistently deploy as soon as the rotor reached operational speed stopping the turbine. On that day, the Entegrity EW50 controller was turned off and the turbine did not operate again.

6.3. Hours of Power Production

The hours of power production at any wind speed: 2,807.6 hours (2,500 hours required)

The hours of power production above $1.2*V_{ave}$ (10.2 m/s): 686.2 hours (250 hours required)

The hours of power production above $1.8*V_{ave}$ (15.3 m/s): 161.9 hours (25 hours required)

The turbine therefore 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 Entegrity EW50 Duration Test

	Hours of power production in			Environmental conditions		Operational time fraction				
Month	0 m/s	1.2Vavg 10.2 m/s	1.8Vavg 15.3 m/s	max gust	TI @ 15 m/s	T_T	T_U	T_E	T_N	O [%]
Totals	***2807.6***	***686.2***	***161.9***	***44.2***	***19.7***	***15012.0***	***1222.1***	***522.1***	***148.8***	***98.9***
Minimum Met?	Yes	Yes	Yes			Yes				Yes
Apr 2009	164.2	29.3	5.5	31	18.2	684	0.1	5.7	0	100
May	148.2	9.8	0	21.5		744	0.5	6	0	100
Jun	105.7	11.2	1.2	30	17.6	720	0	0.2	0	100
Jul	81.5	7.7	0.7	28.1	24	744	14.3	0	0	100
Aug	32.5	0.5	0	18		744	370.9	14.3	70.7	80.3
Sep	70.8	13.3	1.3	27.4	16.4	720	134.6	31.5	0	100
Oct	163.7	44.2	1.7	30.5	18.1	744	11.7	49.2	0.5	99.9
Nov	121.2	8	0	22.3		720	-0.9	6.3	0	100
Dec	207.5	62.7	12.2	36.1	19	744	0.7	0	0	100
Jan 2010	111.7	46.2	14.2	33.2	21.6	744	29.2	2.7	68.8	90.3
Feb	38.3	12.2	3.2	28.9	19.7	672	393.8	0.3	0	100
Mar	137.7	21	0.3	25.1	18.1	744	63.6	0.3	0	100
Apr	223	62.7	19.7	32.7	19	720	2.7	0	8.5	98.8
May	169.2	51	17.8	39	18.4	744	4.1	0.7	0	100
Jun	100	6.7	0	22.9	16.9	720	0.1	0	0	100
Jul	136.5	10.5	0.3	26.9	19.3	744	1.2	1.5	0	100
Aug	105.2	17.2	1.7	28.8	18	744	29.2	213.8	0	100
Sep	0	0	0	0	0	0	0	0	0	0
Oct	134.8	54.3	18.7	38	20.2	744	142.1	186.3	0	100
Nov	169.5	55.7	16	44.2	20.6	720	-0.5	0.8	0	100
Dec	184.2	57	20.2	35.1	19.4	744	2.5	2.5	0.3	100
Jan 2011	202.2	105	27.2	42.9	20.9	408	22.2	0	0	100

6.4. 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 98.9%. The final column of Table 3 shows the operational time fraction per month.

The total test time (T_T) was 15,012 hours, not including the 1,250 hours in which testing was suspended from August to October 2010. The total environmental exposure from beginning of test to completion was approximately 16,262 hours.

The Entegrity EW50 turbine system experienced non-operational time, or downtime (T_N), for several reasons. The significant events are detailed below:

- ***4 August, 2009***
  Four months into the testing, the controller universal power supply (UPS) failure resulted in three days of down time. To restore the EW50 to an operational state, Entegrity personnel bypassed the UPS and the EW50 was returned to normal operation.
- ***15 January, 2010***
  A surge suppressor and a fuse failed. These were replaced by Entegrity personnel and the turbine was put back into service.
- ***April 2010***
  Two generator over-speed faults resulted in a total of about eight hours and 45 minutes of non-operational time. In each case this required a manual reset. NWTC personnel reset the turbine per EW50 operating instructions.
- ***12 December, 2010***
  Over-current fault. This fault was automatically reset by the EW50 controller, and the EW50 resumed normal operation within 10 minutes from the time of the fault.

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

- Suspension of testing between 23 August 2010 and 14 October 2010, as mentioned above in section 6.1 Period of Testing
- Time during power outages that prevented the turbine from running
- Noise or safety and function testing that required the turbine to be shutdown
- NWTC initiated inspections of the EW50.

If no reliable measurements were available, the time was classified as unknown (T_U) because the turbine's status was unknown. These were primarily when the DAS was off (maintenance or power outage) or when both anemometers were iced.

6.5. Environmental Conditions

During the test period, the highest instantaneous wind speed was 44 m/s during November 2010. The average turbulence intensity at 15 m/s during the test was 19.7%.

6.6. Power Degradation Checks

For the power degradation analysis, the average power for each wind speed bin is plotted as a function of time over the whole test period. This plot is analyzed for any obvious trends in power production. This plot is shown in Figure 5.

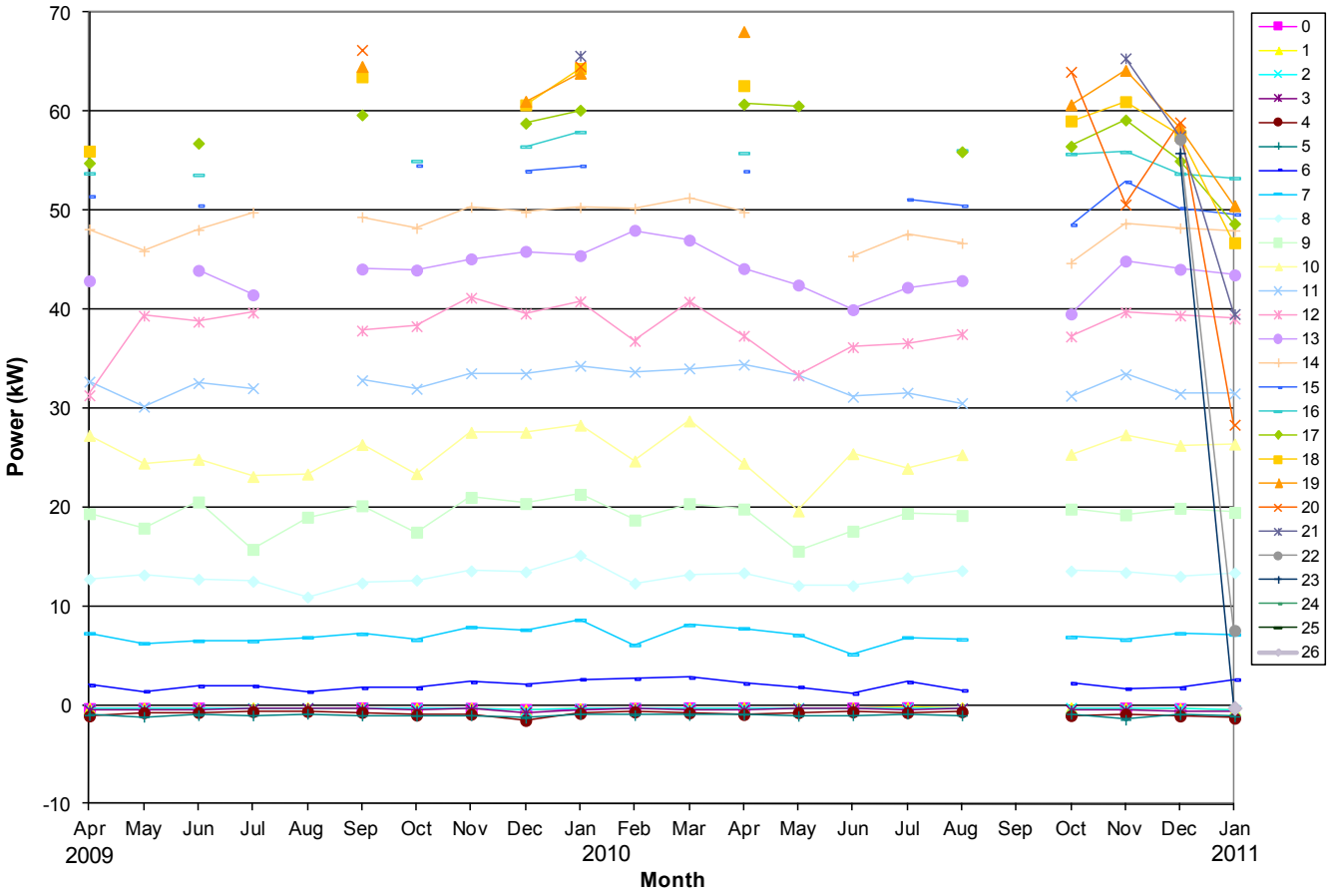


Figure 5. Power in each wind speed bin [m/s] vs. time

Figure 5 shows the power level in individual wind speed bins for each month. The apparent degradation in power at 22 m/s for November 2010 is due to the EW50 reaching its high-wind cut-out twice in one wind event. This cut-out data was not filtered-out and the 10-minute delay before resuming power production lowered the 22-m/s average power value.

The lower power production for wind speed above 17 m/s in January 2011 is attributed to high-wind cut-outs. During January 2011, there were seven instances in which winds exceeded the EW50's high-wind cut-out (25 m/s) several times during each event. During each cut-out, the EW50 did not operate for at least 10 minutes. If the average wind speed during the 10-minute shut-down period was less than 20 m/s, the turbine would resume operation. However, these non-operational periods were not filtered out from the power degradation plot because they are not considered faults since the turbine is designed to shut down in very high winds and wait for winds below 20 m/s. Inclusion of these shut-down periods therefore lowered the average power for several wind speed bins.

Figure 5 illustrates some power degradation emerging in January 2011.

6.7. Dynamic Behavior

NWTC personnel observed the turbine operation for at least five 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 one hour.

NWTC recorded the following observations during this time:

- The EW50 produces a significant gearbox noise. When the generator was operating exactly at synchronous speed, the turbine was relatively quiet, but was not quiet when operating sub-synchronously or super-synchronously. When the brakes were deployed, there was a significant amount of noise. The parking brake deployment brought the rotor to stop very quickly and slammed the tip brakes back to their stow/operate position, causing a shudder through the entire tower. Although vibrations could be felt in the tower and sometimes seen, the vibrations were not deemed excessive. (Accelerations on the EW50 were not measured.)
- Yaw oscillations can be severe at times, particularly in gusty winds. The rotor would occasionally swing 60° in approximately one second.
- In gusty winds, the rotor can get stuck upwind, which, in winds below approximately 10 m/s, appeared almost as dynamically stable as downwind. In winds above 15 m/s the turbine rarely operated in the upwind position.
- In winds around 4.5 m/s, the brakes release. This could be heard near the tower. The turbine requires winds greater than approximately 5.5 m/s to freewheel up to synchronous speed.
- In winds around 5 m/s, the generator may motor up the rotor. Witnessed motoring up events lasted up to about three seconds. These were loud and caused some vibration to the turbine. With the inertia of a spinning rotor, if winds were above 6 m/s the turbine rotor could quickly increase to operational speed. If winds were less than 5.5 m/s the rotor speed gradually fell, never reaching synchronous speed.

6.8. Post-test Inspection

NWTC conducted part of the post-test inspection on 25 January 2011, while the EW50 was still installed. The rest of the post test inspection was conducted after 18 August 2011, when the EW50 was decommissioned and partially disassembled.

The EW50 tip-brakes are aluminum and a circular steel plate attached to the tip brake is attracted to the electromagnetic, which keeps the brakes in place during normal operation. On 25 January 2011, the rubber bushing that connects the tip-brake to the steel plate was discovered to have deteriorated on one tip brake (see Figure 7 and Figure 8 in Appendix A). Without a properly fitting rubber bushing, the tip brake can move a few degrees around its hinge point, which changes its aerodynamics. However, when the bushings were replaced at the end of January 2011, the EW50 still experienced premature tip brake deployment.

During the 18 August 2011 tear-down and inspection, corrosion was found in the electrical connections to the tip brake's electrical magnet. This could be the cause of the early tip brake

deployment failures, but this was not tested. The blades were in good condition and no cracks were found.

On 24 August 2011, the gearbox oil was drained. The oil contained significant contamination. The gears were not inspected because it was difficult to access them without taking the gearbox apart.

Pictures of the inspections are provided in Appendix A.

7. Uncertainty

The uncertainty is estimated for the following parameters:

- Hours of power production
- Operational time fraction
- Environmental conditions

No uncertainty analysis was done for the power degradation results. These results were used only to find relative trends, which might indicate deterioration in the turbine's performance.

7.1. Hours of Power Production

The turbine can be assumed to be producing power for the entire 10-minute period whenever the average power for that period is positive and winds are below the 25 m/s threshold. This method overestimates time for power production in average wind speeds around 6 m/s. When the 10-minute average wind speed is close to 6 m/s, the turbine may have been producing power for less than half of the time recorded. At higher wind speeds, this method produces less of an overestimate. However, this overestimate is offset because in low wind speeds, the EW50 continues to operate at rated rotor speed by consuming power for 10 minutes before the controller disconnects the generator form the grid. Therefore, any 10-minute period that has positive power and winds below cut-out represents at least a continuous 10-minute period in which the EW50 was operating. While the EW50 was operating (generating or consuming power), wear accumulated on the entire turbine system.

For the hours of power production above 10.2 m/s and 15.3 m/s, the uncertainty in the wind speed is assumed to be the dominant uncertainty factor. Assuming an uncertainty in wind speed of 0.3 m/s, the hours of power production reduces to 664.67 (above 10.5 m/s) and 157.67 (above 15.6 m/s); this is still well over the 250 and 25 hours that are required.

The tool used at the NWTC does not accurately account for switching from standard to daylight savings times, even though the time stamp on the data reflects this switch. It is assumed the net effect on results is negligible, even though its affects can be seen in the values of T_U for November 2009 and 2010 and March 2010.

7.2. Operational Time Fraction

If there was a failure at any time during a 10-minute period, the entire 10-minute period was classified as downtime (T_N). This means that the 98.9% is the lower bound of the operational time fraction.

7.3. Environmental Conditions

The maximum deviation in anemometer measurements for the calibration range is 0.032 m/s, which results in a standard uncertainty of 0.02 m/s. The calibration range was only to 16 m/s; thus, an extrapolation to 44 m/s could be unreliable. However, it is assumed that the standard uncertainty of calibration is consistent at 0.02 m/s. Combining the calibration uncertainty with operational characteristics (0.052 m/s + 0.52%), mounting effects (1%), and terrain effects (2%), while assuming DAS uncertainty is negligible for the maximum instantaneous gust of 44 m/s, the resulting cumulative uncertainty is 1 m/s.

Standard deviation of wind speed is used for the Turbulence Intensity (TI) calculation. Average wind speed at 15 m/s has an uncertainty of 0.4 m/s, resulting in a TI estimate of between 19.2% and 20.2%.

8. Deviations and Exceptions

8.1. Deviations from the Standard

As explained in Section 5, Description of Instrumentation:

- The power transducer was not compliant with IEC 60688, but exceeded the minimum accuracy required by the Standard. This should have no effect on results or uncertainty, but it is in exception to the Standard.
- The current transformers were not IEC 60044-1, but exceeded the minimum accuracy required by the Standard. This should have no effect on results or uncertainty, but it is in exception to the Standard.

8.2. Deviations from Quality Assurance

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

A. Appendix: Pictures of Post-Test Inspection

Figure 6. Tip brake #1 bushing has disintegrated, allowing for some play in the tip brake (PIX# 22238)

Figure 7. Tip brake #3, the rubber bushing is still intact (PIX# 22239)

Figure 8. Rust and oil marks near the generator and gearbox connection (PIX# 22248)

Figure 9. Corrosion around electrical connector to tip brake's electromagnet (PIX# 22241)

Figure 10. Draining earbox oil; significant contaminints were seen, such as the dark spots inside the clear tube (PIX# 22246)

B. Appendix: Equipment Calibration Sheets

11. Anemometer #1; installed on 1 April 2009, used until 24 February 2010
12. Anemometer #2; installed on 24 February 2010, used until 23 July 2010
13. Anemometer #3; installed on 23 July 2010, used until end of test
14. Power transducer calibration #1; installed 25 February 2009, removed 8 February 2010
15. Power transducer calibration #2; installed 9 February 2010, used until end of test
16. NI 9229 data acquisition module #1; installed 25 February 2009, removed 3 February 2010
17. NI 9229 data acquisition module #1; post-test calibration
18. NI 9229 data acquisition module #2; installed 18 January 2010 used until end of test
19. NI 9217 data acquisition module #1; installed 25 February 2009, removed 3 February 2010
20. NI 9217 data acquisition module #1; post-test calibration
21. NI 9217 data acquisition module #2; installed 18 January 2010 used until end of test
22. NI 9205 data acquisition module #1; installed 25 February 2009, removed 3 February 2010
23. NI 9205 data acquisition module #1; post-test calibration
24. NI 9205 data acquisition module #2; installed 18 January 2010 used until end of test

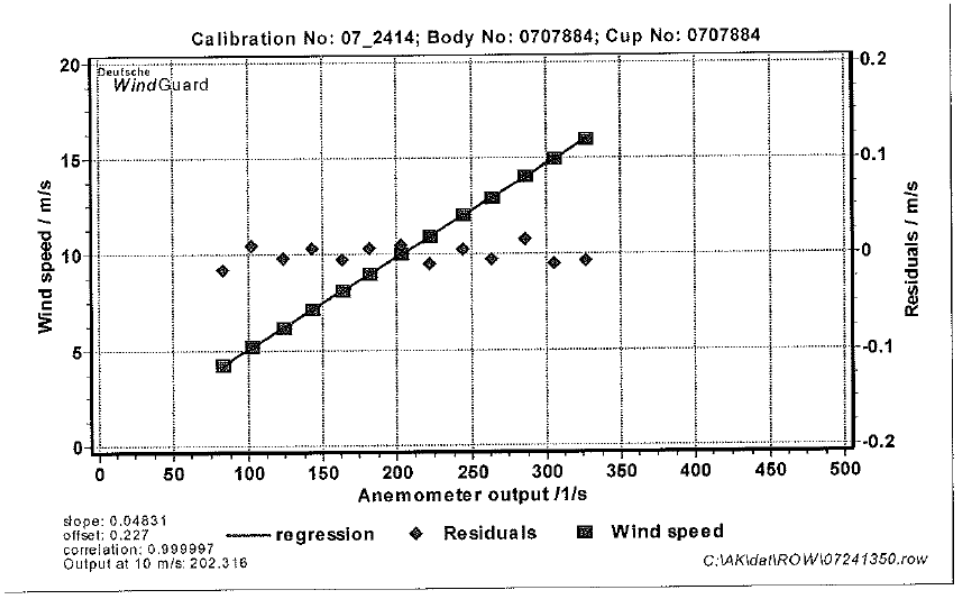
1 Detailed MEASNET [1] Calibration Results

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 11. Anemometer #1; installed on 1 April 2009, used until 24 February 2010

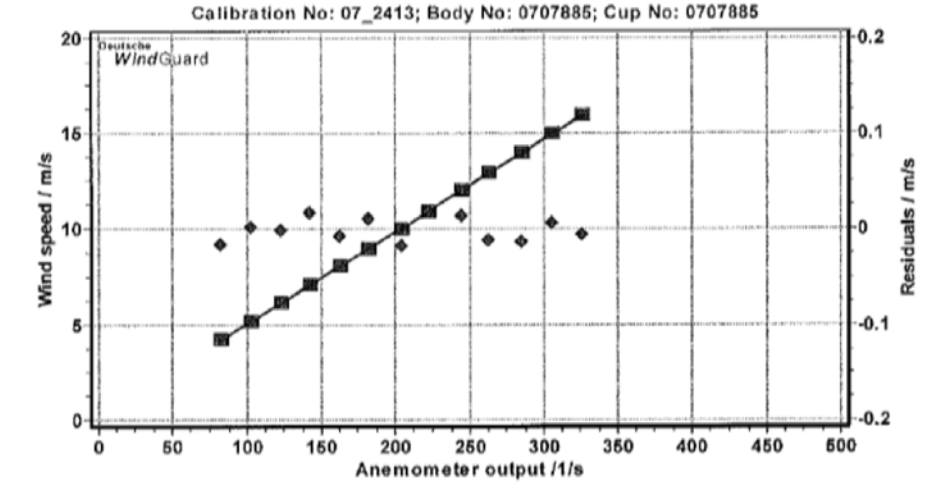
1 Detailed MEASNET[1] Calibration Results

DKD calibration no.	07_2413
Body no.	0707885
Cup no.	0707885
Date	24.07.2007
Air temperature	22.9 deg
Air pressure	995.0 hPa
Humidity	56.9 %

Linear regression analysis

Slope	0.04834 (m/s)/(1/s) ±0.00005 (m/s)/(1/s)
Offset	0.230 m/s ±0.010 m/s
St.err(Y)	0.011 m/s
Correlation coefficient	0.999995

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 12. Anemometer #2; installed on 24 February 2010, used until 23 July 2010

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

WIND ENGINEERING FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 09.02.3146 **Date of issue:** June 15, 2009

Type: Thies 4.3351.10.000 **Serial number:** 0609010

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 12, 2009

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

Certificate prepared and approved by: Calibration engineer, soh Svend Ole Hansen

Calibration equation obtained: v [m/s] = 0.04639 · f [Hz] + 0.22041

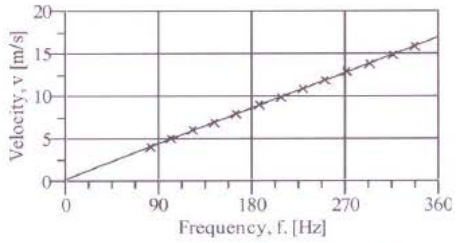
Standard uncertainty, slope: 0.00125 **Standard uncertainty, offset:** 0.05885

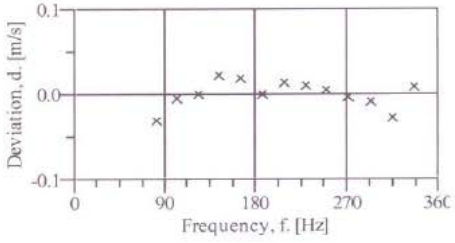
Covariance: -0.0000007 (m/s)²/Hz **Coefficient of correlation:** $\rho = 0.999991$

Absolute maximum deviation: -0.032 m/s at 3.986 m/s

Barometric pressure: 1004.0 hPa **Relative humidity:** 24.2%

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	9.07	31.9	23.8	3.986	81.8715	-0.032	0.029
4	13.98	31.7	23.7	4.947	102.0168	-0.006	0.033
6	20.26	31.6	23.7	5.954	123.6056	0.000	0.038
8	27.44	31.5	23.7	6.929	144.1422	0.022	0.044
10	35.72	31.4	23.7	7.904	165.2496	0.018	0.049
12	45.28	31.4	23.7	8.899	187.0774	0.000	0.055
13-last	56.04	31.3	23.7	9.898	208.3476	0.013	0.061
11	67.93	31.4	23.7	10.900	230.0186	0.010	0.067
9	80.35	31.5	23.7	11.855	250.6971	0.006	0.073
7	94.30	31.6	23.7	12.846	272.2475	-0.004	0.080
5	109.47	31.7	23.7	13.843	293.8560	-0.009	0.086
3	125.82	31.8	23.7	14.844	315.8145	-0.027	0.092
1-first	143.41	32.0	23.8	15.855	336.8582	0.008	0.099





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Page 1 of 2

Figure 13. Anemometer #3; installed on 23 July 2010, used until end of test

Branch #: 5000

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Multifunction Transducer — DOE #: 03574C

Model # : DMT-1040E — S/N : 07070473

Calibration Date: 02/12/2009 — Due Date: 02/12/2011

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	5.019
105	87.30	3.516
60	49.88	2.008
0	0	0.001
-60	-49.88	-2.009
-105	-87.30	-3.516
-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	4.002
"	0.6	3.000
"	0.4	2.001

Page 1 of 2

Figure 14. Power transducer calibration #1; installed 25 February 2009, removed 8 February 2010

Branch #: 5000

NREL METROLOGY LABORATORY

Test Report

Test Instrument: Multifunction Transducer — DOE #: 03574C

Model # : DMT-1040E — S/N : 07070473

Calibration Date: 02/09/2010 — Due Date: 02/09/2012

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	5.018
105	87.30	3.513
60	49.88	2.006
0	0	0.001
-60	-49.88	-2.005
-105	-87.30	-3.514
-150	-124.71	-5.018

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	4.998
"	0.8	3.999
"	0.6	2.997
"	0.4	1.996

Page 1 of 2

Figure 15. Power transducer calibration #2; installed 9 February 2010, used until end of test

NATIONAL INSTRUMENTS

Certificate of Calibration

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.

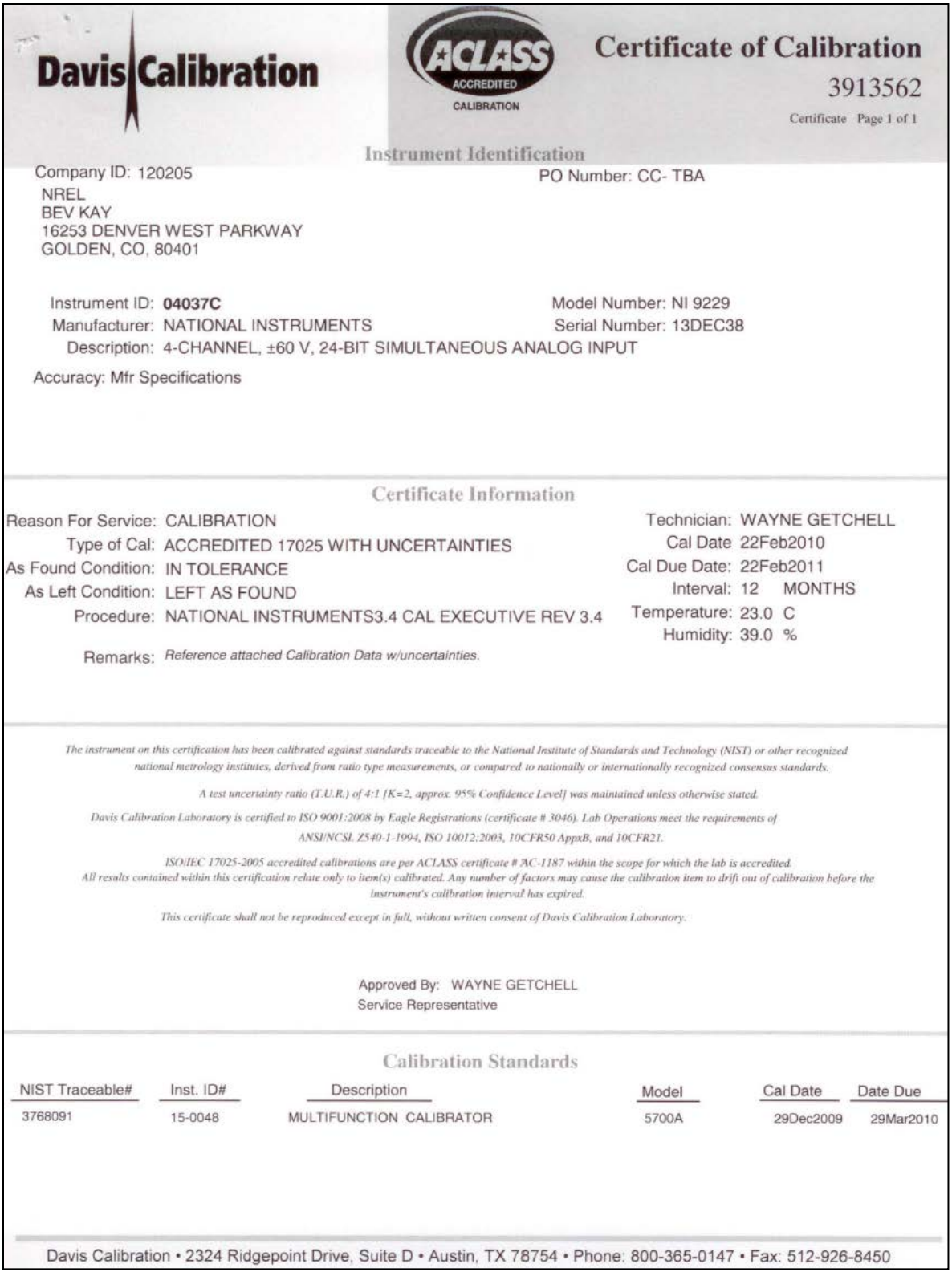
NI Hungary Software és
Hardware Gyártó Kft.
4031 Debrecen, Határ út
1/A.
HUNGARY

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 16. NI 9229 data acquisition module #1; installed 25 February 2009, removed 3 February 2010



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

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.

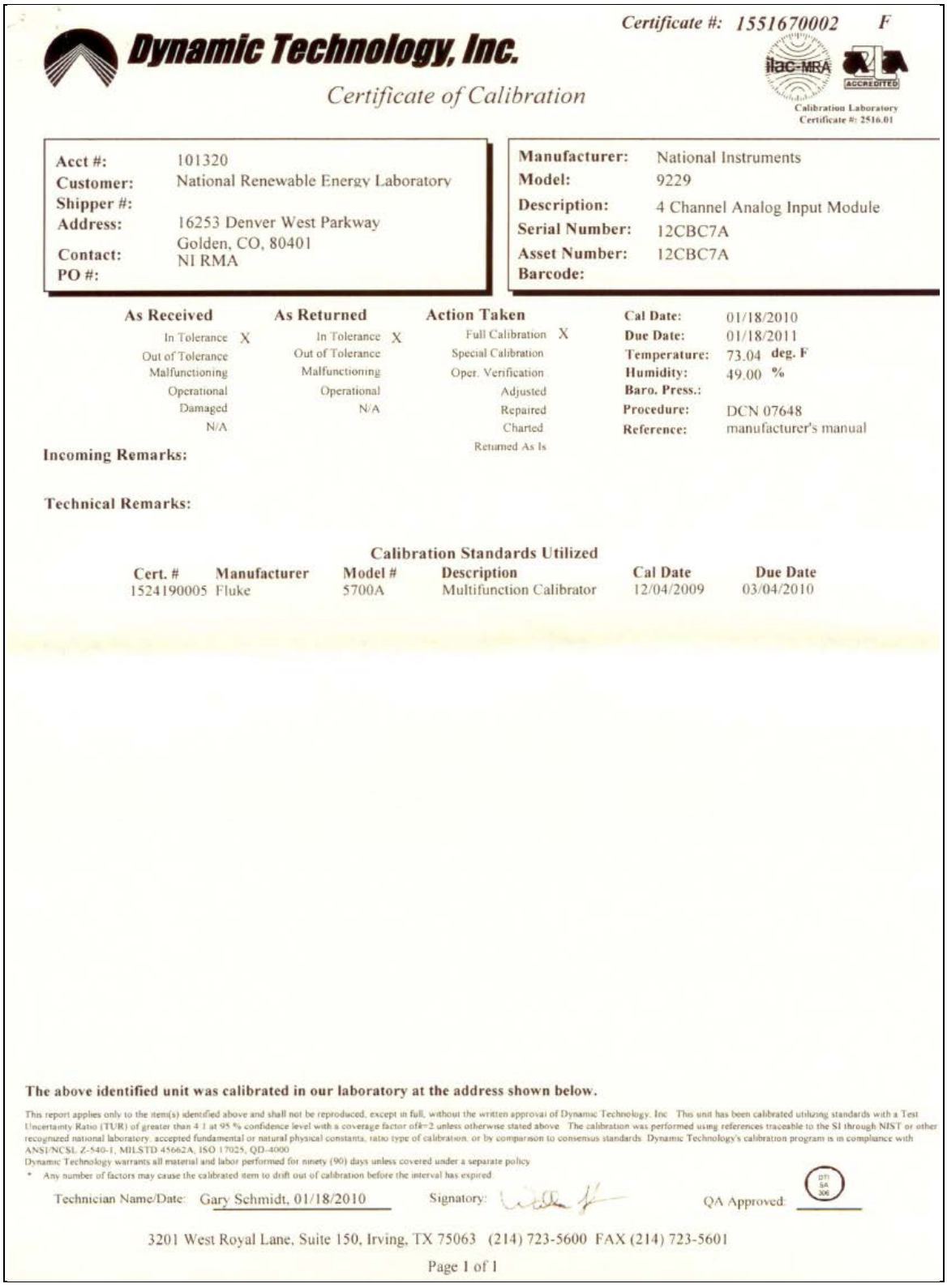
Approved By: WAYNE GETCHELL
Service Representative

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 17. NI 9229 data acquisition module #1; post-test calibration



Certificate #: 1551670002 F

Dynamic Technology, Inc.

Certificate of Calibration

ilac-MRA ACCREDITED
Calibration Laboratory
Certificate #: 2516.01

Acct #:	101320
Customer:	National Renewable Energy Laboratory
Shipper #:	
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:	12CBC7A
Asset Number:	12CBC7A
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	
Damaged		N/A		Repaired	
N/A				Charted	
				Returned As Is	

Cal Date:	01/18/2010
Due Date:	01/18/2011
Temperature:	73.04 deg. F
Humidity:	49.00 %
Baro. Press.:	
Procedure:	DCN 07648
Reference:	manufacturer's manual

Incoming Remarks:

Technical Remarks:

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
1524190005	Fluke	5700A	Multifunction Calibrator	12/04/2009	03/04/2010

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 utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 at 95 % confidence level with a coverage factor of k=2 unless otherwise stated above. The calibration was performed using references traceable to the SI through NIST or other recognized 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 ANSI/NCSL Z-540-1, MILSTD 45662A, ISO 17025, QD-4000

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 calibration before the interval has expired.

Technician Name/Date: Gary Schmidt, 01/18/2010 Signatory: QA Approved:

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

Page 1 of 1

Figure 18. NI 9229 data acquisition module #2; installed 18 January 2010 used until end of test

NATIONAL INSTRUMENTS

Certificate of Calibration

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.

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

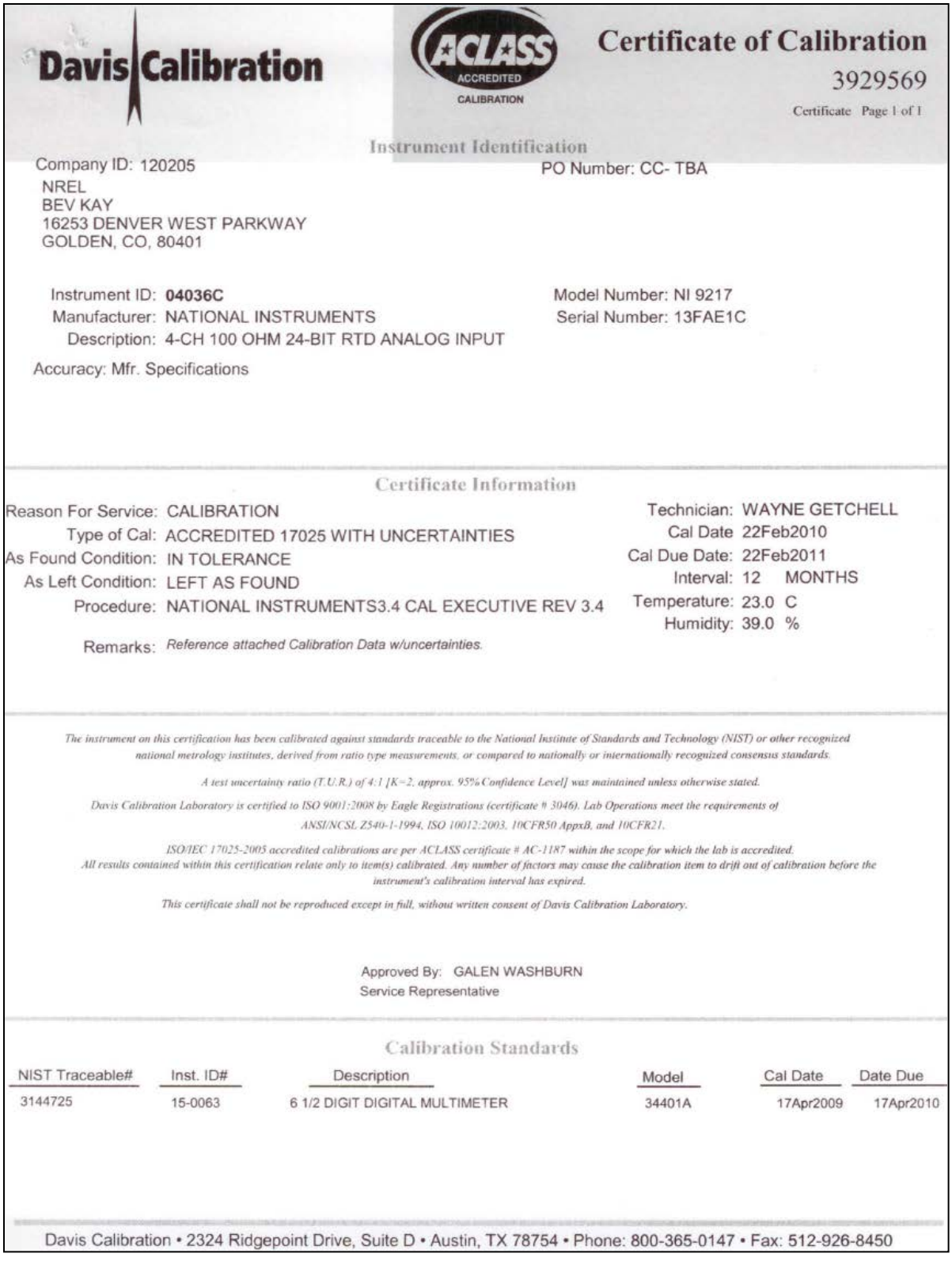
NI Hungary Software és
Hardware Gyártó Kft.
4031 Debrecen, Határ út
1/A.
HUNGARY

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 19. NI 9217 data acquisition module #1; installed 25 February 2009, removed 3 February 2010



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

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.

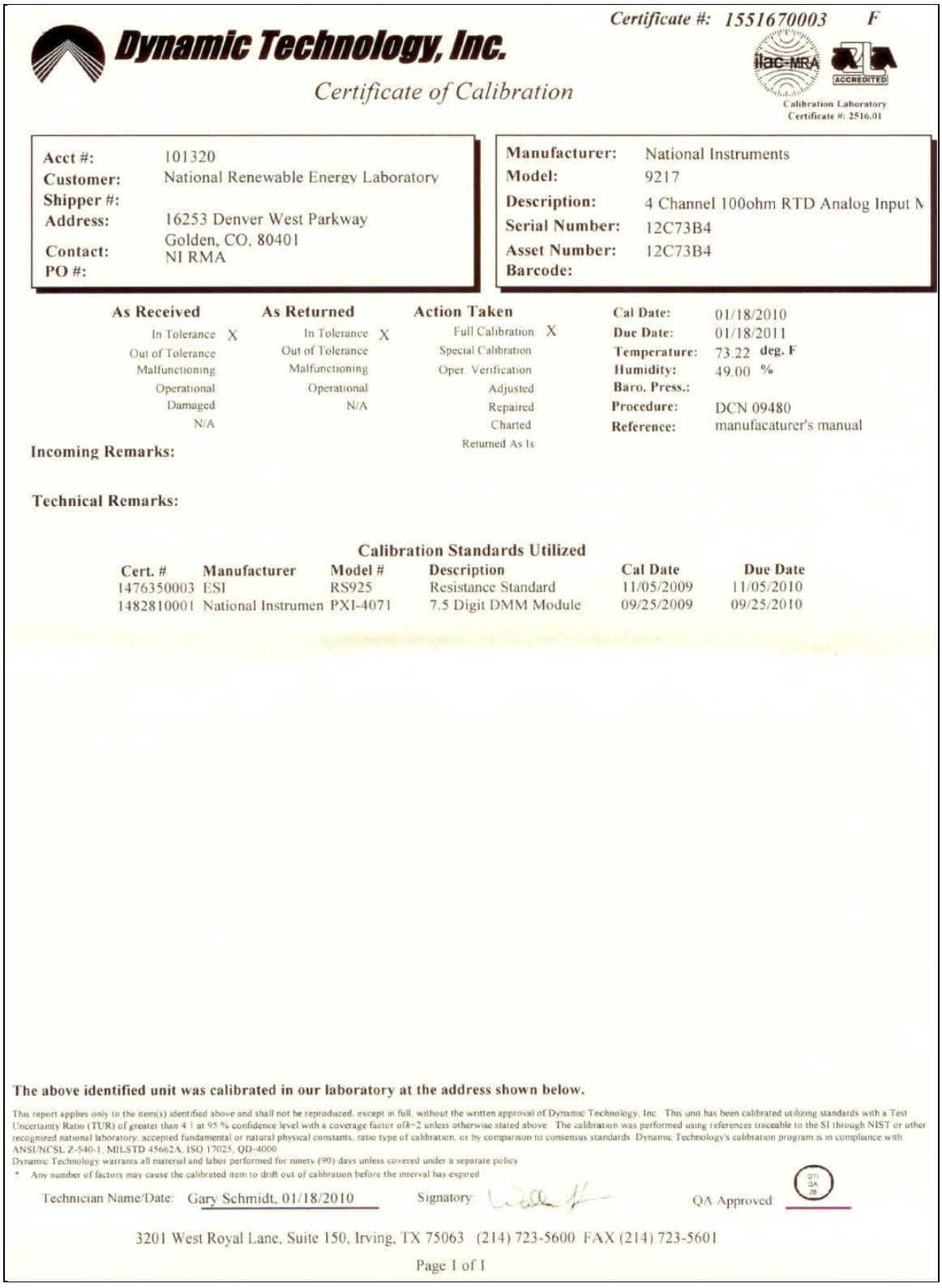
Approved By: GALEN WASHBURN
Service Representative

Calibration Standards

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

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

Figure 20. NI 9217 data acquisition module #1; post-test calibration



Certificate #: 1551670003 F

Dynamic Technology, Inc.

Certificate of Calibration

Calibration Laboratory
Certificate #: 2516.01

Acct #:	101320
Customer:	National Renewable Energy Laboratory
Shipper #:	
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:	12C73B4
Asset Number:	12C73B4
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
Damaged	N/A	Repaired
N/A		Charted
		Returned As Is

Cal Date:	01/18/2010
Due Date:	01/18/2011
Temperature:	73.22 deg. F
Humidity:	49.00 %
Baro. Press.:	
Procedure:	DCN 09480
Reference:	manufacaturer's manual

Incoming Remarks:

Technical Remarks:

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
1476350003	ESI	RS925	Resistance Standard	11/05/2009	11/05/2010
1482810001	National Instrumen	PXI-4071	7.5 Digit DMM Module	09/25/2009	09/25/2010

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 utilizing standards with a Test Uncertainty Ratio (TUR) of greater than 4:1 at 95 % confidence level with a coverage factor of k=2 unless otherwise stated above. The calibration was performed using references traceable to the SI through NIST or other recognized 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 ANSI/NCSL Z-540-1, MILSTD 45662A, ISO 17025, QD-4000.

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 calibration before the interval has expired.

Technician Name/Date: Gary Schmidt, 01/18/2010 Signatory: QA Approved:

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

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Figure 21. NI 9217 data acquisition module #2; installed 18 January 2010 used until end of test

NATIONAL INSTRUMENTS

Certificate of Calibration

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.

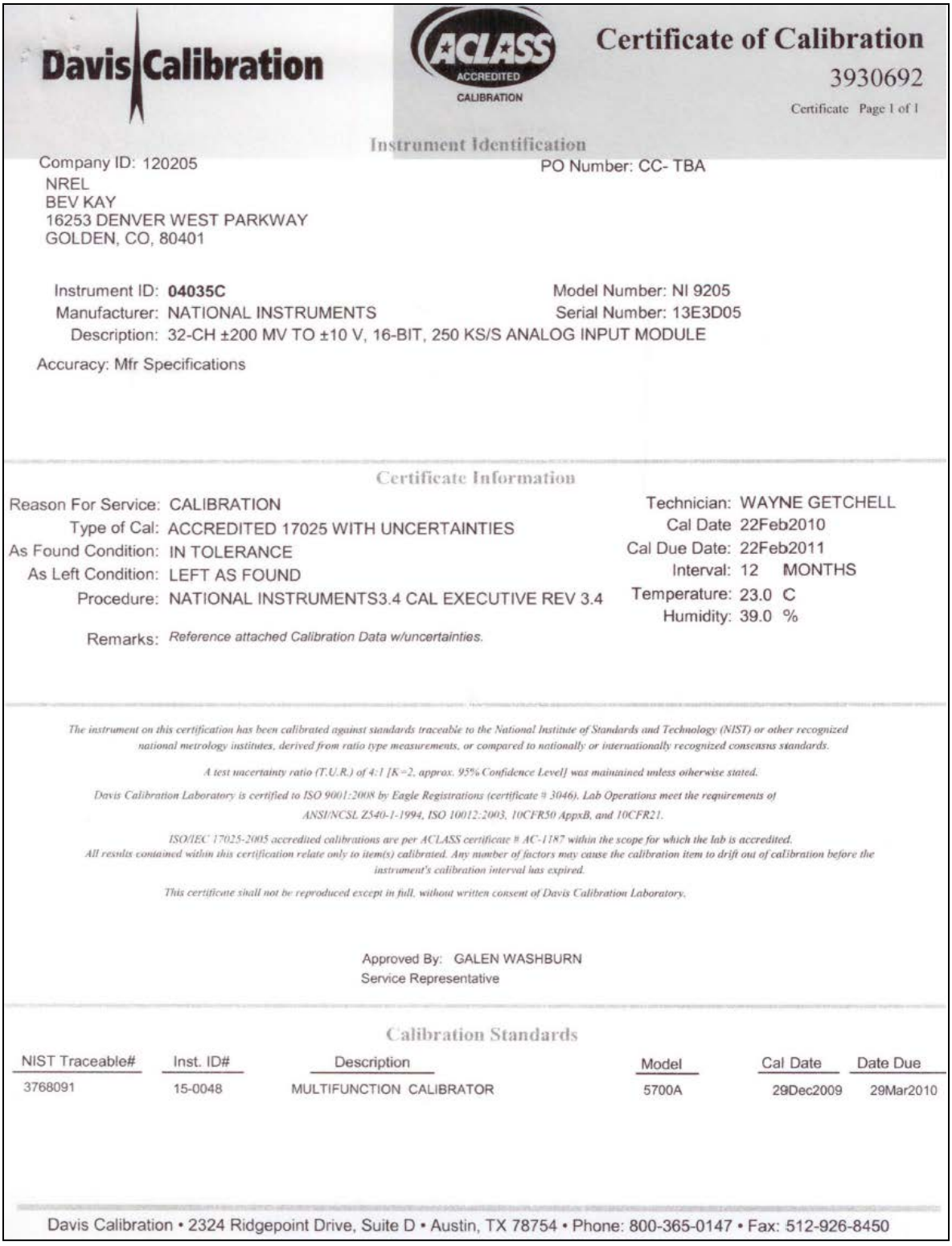
NI Hungary Software és Hardware Gyártó Kft.
4031 Debrecen, Határ út 1/A.
HUNGARY

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 22. NI 9205 data acquisition module #1; installed 25 February 2009, removed 3 February 2010



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.

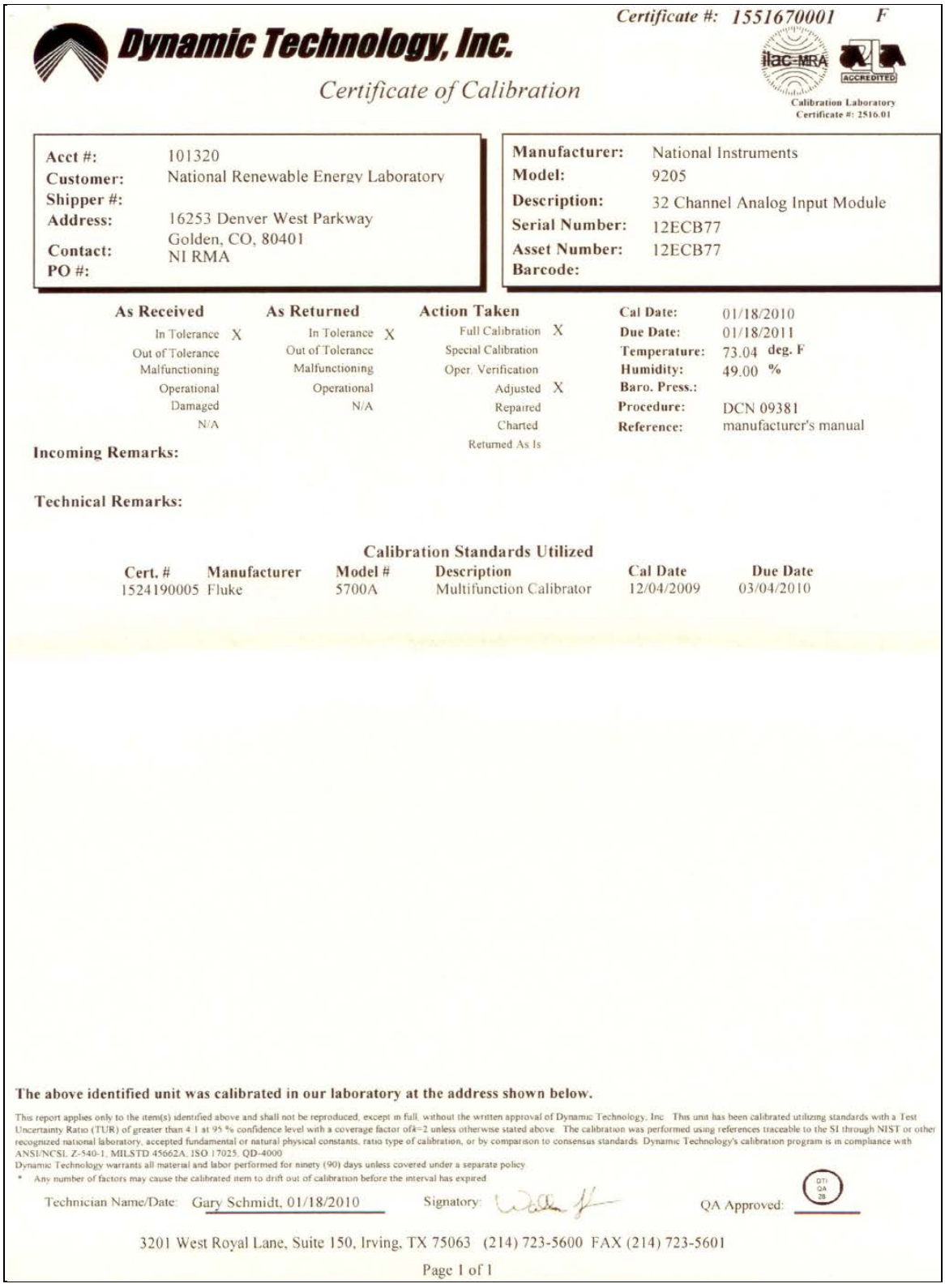
Approved By: GALEN WASHBURN
Service Representative

Calibration Standards

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

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

Figure 23. NI 9205 data acquisition module #1; post-test calibration



Certificate #: 1551670001 F

Dynamic Technology, Inc.

Certificate of Calibration

Calibration Laboratory
Certificate #: 2516.01

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

Manufacturer:	National Instruments
Model:	9205
Description:	32 Channel Analog Input Module
Serial Number:	12ECB77
Asset Number:	12ECB77
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:	01/18/2010
Due Date:	01/18/2011
Temperature:	73.04 deg. F
Humidity:	49.00 %
Baro. Press.:	
Procedure:	DCN 09381
Reference:	manufacturer's manual

Incoming Remarks:

Technical Remarks:

Calibration Standards Utilized

Cert. #	Manufacturer	Model #	Description	Cal Date	Due Date
1524190005	Fluke	5700A	Multifunction Calibrator	12/04/2009	03/04/2010

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

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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 calibration before the interval has expired.

Technician Name/Date: Gary Schmidt, 01/18/2010 Signatory: QA Approved:

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

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Figure 24. NI 9205 data acquisition module #2; installed 18 January 2010 used until end of test