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Report Number 100386839CRT-001b
Intertek Project No: G100386839

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Subject: Summary Test Report for the Sonkyo Energy Windspot 3.5 tested at the CIEMAT/CEDER testing location in Northern Spain.

Dear Mr. Crespo,

This test report summarises the results of the evaluation and tests of the above referenced equipment to the requirements contained in the following standards:

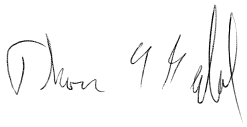
Title	Reference	Date	Revision
AWEA Small Wind Turbine Performance and Safety Standard	*AWEA 9.1*	*December 2009*	*First edition*

Original testing was authorized by Intertek Purchase Order No 2011-139, dated April 11, 2011. A production sample was installed at the test location in Spain on October 4, 2011. Duration testing was completed on May 13, 2012. All testing on the Windspot 3.5 turbine was conducted under Intertek Project No. G100386839.

If there are any questions regarding the results contained in this report, or any of the other services offered by Intertek, please do not hesitate to contact the signatories on this report.

Please note, this Test Report on its own does not represent authorization for the use of any Intertek certification marks. Completed test reports for Duration, Power Performance, Acoustic, and Strength and Safety, are required to complete the AWEA certification process.

Completed by:	Joseph M Spossey
Title:	Project Engineer
Signature:	

Reviewed by:	Tom Buchal
Title:	Senior Staff Engineer
Signature	

Wind Turbine Generator System
Summary Test Report
for the
Sonkyo Energy Windspot 3.5

Master Reports

Report	Report Title	Date
P2011-0708-DUR-IEC	Duration Test Report	September 17, 2012
P2011-0708-FUN-IEC	Safety and Function Test Report	September 18, 2012
P2011-0708-RUI-AWEA	Acoustic Noise Test Report	October 05, 2012
P2011-0708-CUR-AWEA	Power Performance Test Report	September 17, 2012

1.0 Background

1.1 Background

This testing was conducted as part of the full AWEA Certification test program for the Sonkyo Energy Windspot 3.5 horizontal-axis wind turbine. The Windspot 3.5 was installed at the CIEMAT/CEDER test location in Northern Spain. Test reports were produced by CIEMAT/CEDER and reviewed and accepted by Intertek.

1.2 Description of the wind turbine

The Windspot 3.5 is rated for operation at 3500 W at wind speeds of 11-12 m/s (24.6 mph – 26.8 mph). The turbine is a 3-bladed upwind horizontal-axis wind turbine (HAWT) with passive yaw and pitch control. The pitch system utilizes the centrifugal forces of the turbine to pitch the blades to prevent overspeed of the turbine and generator and regulate the power output. The generator is a Ginlong GL-PMG-3500 synchronous permanent magnet generator. It is available as a 3 phase 24-48-110-220 VAC output at 50-60 hz at 200 RPM. A Ginlong rectifier box (W4G-20K) is used to convert the 3 phase AC from the generator to DC voltage input to the Power One PVI-4.2-OUTD-FR-W Inverter, and also to divert power to the dump load. The Inverter is rated for operation at 4.2 kW, and operates on a Maximum Power Point Tracking (MPPT) algorithm for load control of the turbine

A summary of the test turbine configuration and manufacturer's declared ratings can be found in Table 1 below.

General Information	
Wind Turbine Serial Number	001761
Manufacturer	SONKYO ENERGY
Model	WINDSPOT 3.5
Type	Horizontal axis
Year of production	2011
Owner	SONKYO ENERGY
Installation Date	04/10/2011
First operation Date	28/10/2011
Design parameters	
Rated Power	3.5 kW
Rated Wind Speed	12 m/s
Designed Wind Speed (m/s)	14 m/s
Power Regulation	Centrifugal and damped passive pitch control.
Cut-in Wind Speed	3 m/s
Cut-out Wind Speed	None
Rotor	
Position (Upwind or Downwind)	Upwind
Rotor Diameter	4.1 m
Horizontal distance from the rotor centre to the tower axis	0.3 m

Rated Rotational Speed	250 rpm
Rotational Speed Range	0-300 rpm
Swept Area	13.2 m^2
Yaw Orientation	Passive System: Tail boom
Blades	
Number of Blades	3
Manufacturer	Sonkyo energy
Blade set identification	001761
Model	Design by manufacturer
Pitch	Passive variable pitch
Pitch Angle	Fixed
Material	Polyester/Glass Fiber
Length	1.75 m
Generator	
Manufacturer	GINLONG
Model	GL-PMG-3500
Type	Synchronous PMG
Nominal Speed (r.p.m.)	250
Number of phases / Vout	3 phases, 400V_{ac}
Number of poles	20
Nominal Power (W)	3500
Rotor Inertia (Kg.m^2)	0.066
Phase Resistance (Ohms)	2.7
Tower	
Type	Tilt-up tubular
Height	18.15 m
Wind Turbine Control System	
Device	Inverter: Power-one Aurora
Software Version	Aurora Installer v.3.1.4
Status Signals	None
Connection	
Grid-connected	
Voltage and tolerance (V)	230 ± 5 %
Frequency and tolerance (Hz)	50 ± 2.5 %

Voltage Regulation System	
Manufacturer	GINLONG Technologies
Model	W4G-20K
Serial Number	001761
Nominal Voltage	V_{max}= 500 V_{AC}
Inverter	
Manufacturer	POWER ONE
Model	PVI-4.2-OUTD-FR-W
Serial Number	655094
Nominal Power	4.2 kW
Efficiency	≈ 95%
Inverter Adjustment	MPPT Algorithm
Resistance between inverter and charge *	0.004 Ohms
* It has been measured with a multimeter between the wire extremes which length was around 1 m.	
Dumping Resistance	
Voltage Range	400 VDC
Resistive Power	4 kW
Voltage Adjustments	
Over Voltage	245 V
Under Voltage	200 V
Electrical Connection	
Type	RZ1-K (AS)
Voltage	0.6 / 1 KV
Conductor	Copper, flexible wire
Insulation	Cross-linked Polyethylene, XLPE
Dimensions	4x16 mm^2/ 52 m length
Connections between wind turbine and charge	See Electrical Layout (point 3.2)

Table 1 – Test Turbine Configuration

2.0 Objective

The purpose of this test report is to provide a summary of the following:

Section	Summary Results	Reference[1]
3.0	Power Performance Test Summary	6.1.2
4.0	Acoustic Test Summary	6.1.3
5.0	AWEA Rated Annual Energy	6.1.4
6.0	AWEA Rated Sound Level	6.1.5
7.0	AWEA Rated Power	6.1.6
8.0	Wind Turbine Strength and Safety Summary	6.1.7
9.0	Tower Design Summary	6.1.8
10.0	Duration Test Summary	6.1.9

Table 2 – Report content

Note 1: Reference – *AWEA 9.1 Small Wind Turbine Performance and Safety Standard December 2009*

3.0 Power Performance Test Summary

Below is a summary of the power performance test results. Table 3 shows the tabulated power performance results with measurement uncertainty, and Figure 1 shows the power curve normalized to sea-level air density.

POWER PERFORMANCE							
Measured Power Curve Air density 1.225 kg/m^3					Category A Uncertainty	Category B Uncertainty	Combined Uncertainty
Bin Nº	Hub height wind speed V_i (m/s)	Output power P_i (W)	Cp_i (Rotor swept area 13.2 m^2)	Number of 1-minute data set N_i	Standard Uncertainty S_i (W)	Standard Uncertainty U_i (W)	Standard Uncertainty Uc_i (W)
1	0.24	1.04	8.85	7	0.13	0.3	0.33
2	0.51	1.04	0.98	290	0.02	0.01	0.02
3	1.02	1.1	0.13	381	0.03	0.01	0.04
4	1.52	1.22	0.04	621	0.06	0.02	0.06
5	2.01	1.38	0.02	703	0.1	0.03	0.1
6	2.5	4.03	0.03	759	0.37	0.47	0.6
7	3	13.75	0.06	675	0.82	1.77	1.95
8	3.5	40.75	0.12	652	2.02	5.14	5.53
9	3.99	95.48	0.19	615	3.39	11.12	11.62
10	4.5	184.36	0.25	667	4.02	18.44	18.87
11	4.99	282.74	0.28	658	4.41	22.76	23.18
12	5.5	411.76	0.31	645	4.18	29.8	30.09
13	5.99	553.36	0.32	638	3.09	36.24	36.37
14	6.49	709.09	0.32	556	3.39	40.57	40.71
15	7	874.1	0.32	460	4.33	44.83	45.03
16	7.51	1044.12	0.31	457	6.23	48.56	48.96
17	8.01	1272.56	0.31	520	6.44	68.85	69.15
18	8.51	1513.32	0.3	541	7.2	75.06	75.41
19	9.01	1814.93	0.31	614	6.77	99.98	100.21
20	9.51	2130.14	0.31	730	7.09	107.01	107.24
21	10.01	2485.91	0.31	792	7	128.27	128.46
22	10.5	2839.74	0.3	845	7.82	132.6	132.83
23	11	3201.95	0.3	786	8.64	139.62	139.88
24	11.49	3498.7	0.29	700	6.71	122.33	122.51
25	12	3688.02	0.26	518	5.83	83.99	84.19
26	12.49	3781.71	0.24	428	6.5	53.77	54.16
27	12.98	3868.5	0.22	320	4.81	52.47	52.69
28	13.47	3925.3	0.2	254	4.05	45.23	45.41
29	13.99	3959.16	0.18	236	4.41	40.12	40.36
30	14.49	4003.58	0.16	167	4.06	43.25	43.44
31	14.99	4047.24	0.15	169	4.1	43.63	43.82
32	15.49	4082.02	0.14	114	4.97	42.12	42.41
33	16	4109.02	0.12	85	5.96	41.05	41.48
34	16.5	4133.65	0.11	77	5.18	40.96	41.29
35	17.02	4164.58	0.1	62	5.76	42.36	42.75
36	17.5	4195.63	0.1	81	2.51	43.51	43.58
37	17.98	4201.36	0.09	59	2.63	39.53	39.62
38	18.49	4215.85	0.08	52	1.78	40.42	40.46
39	19	4219.49	0.08	49	1.61	39.61	39.64
40	19.51	4222.64	0.07	35	1.9	39.62	39.67
41	19.99	4222.3	0.07	24	2.28	39.57	39.64
42	20.55	4227.18	0.06	26	1.8	39.72	39.76
43	21.02	4226.97	0.06	22	1.25	39.62	39.64
44	21.47	4229.74	0.05	12	2.41	39.7	39.77

Table 3 – Power performance tabulated data for the Windspot 3.5

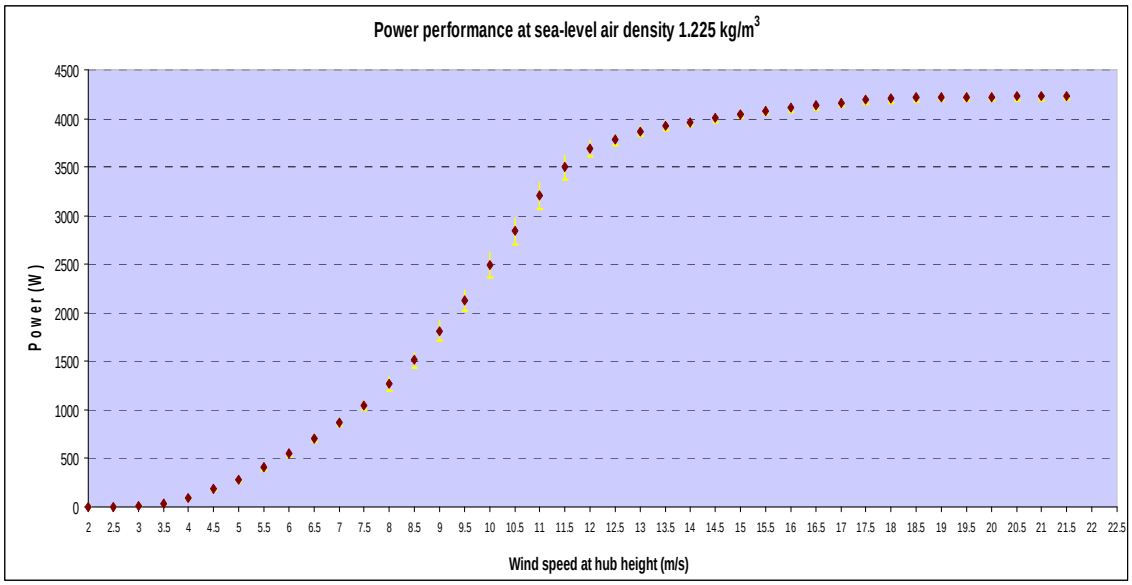


Figure 1 – Normalized sea-level air density power curve for the Windspot 3.5

4.0 Acoustic Test Summary

Below is a summary of the test results for the Windspot 3.5 wind turbine noise over a range of wind speeds and directions. Characterizations or the turbines apparent sound power level and 1/3 octave bands are made.

Table 4 below shows tabulated results form the acoustic test.

Standardized wind speed m/s	6	7	8	9	10
Total Sound Pressure Level, T+B dB(A)	46.6	47.5	49.1	50.7	52.4
Number of measurements T+B	42	74	72	42	24
Background Sound Pressure Level, B dB(A)	45.3	46.6	46.4	47.8	49.1
Number of measurements B	38	40	38	25	15
Corrected Wind turbine Sound Pressure Level dB(A)	46.6	47.5	49.1	50.7	51.1
Apparent Sound Power Level dB(A)	81.3	82.1	83.7	85.3	85.7
Deviations	**	**	**	**	*

Table 4 – Tabulated acoustic data for the Windspot 3.5

In Table 4 above:

* indicates the difference between total noise and background noise is between 3 and 6 dB, Ls is corrected subtracting 1.3dB.

** indicates the difference between total noise and background noise is less than 3 dB, Ls is not corrected, due to wind turbine noise was less than background noise.

Figure 2 below shows a plot of integer wind speed versus sound pressure level.

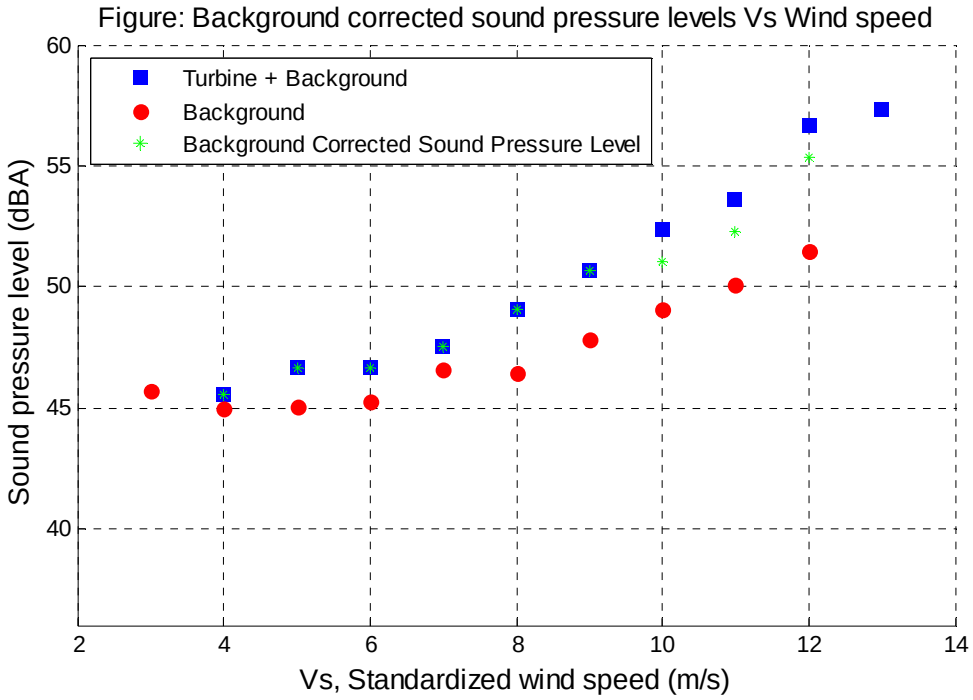


Figure 2 – Background corrected sound pressure levels versus wind speed for the Windspot 3.5

Figures 3 through 7 show the third octave spectrum at the standardized wind speeds 6 m/s to 10 m/s. A tone appears at 5k Hz due to crickets. In Figures 3 through 7:

{empty} indicates the difference between total noise and background noise is more than 6 dB, Ls is corrected with the equation (8) of IEC 61400-11 Standard

* indicates the difference between total noise and background noise is between 3 and 6 dB, Ls is corrected subtracting 1.3dB.

** indicates the difference between total noise and background noise is less than 3 dB, Ls is not corrected, due to wind turbine noise was less than background noise.

Frequency	Lp-A per 1/3 octave (dB)			Deviations
	Total Noise (T+B)	**Background Noise (B)**	**Corrected Noise (T)**	
Hz	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	
50	18.5	18.5	18.5	**
63	20.9	21.4	20.9	**
80	23.2	23.2	23.2	**
100	26.1	26.4	26.1	**
125	29.0	28.3	29.0	**
160	35.0	28.0	34.0	
200	31.7	30.8	31.7	**
250	32.9	32.4	32.9	**
315	32.6	31.4	32.6	**
400	31.4	31.1	31.4	**
500	31.8	30.9	31.8	**
630	31.4	29.2	31.4	**
800	31.6	28.7	31.6	**
1 k	33.8	28.9	32.5	*
1.25 k	34.8	28.4	33.7	
1.6 k	34.4	29.3	33.1	*
2 k	33.8	30.2	32.5	*
2.5 k	34.5	31.2	33.2	*
3.15 k	36.0	32.7	34.7	*
4 k	37.3	33.8	36.0	*
5 k	34.6	33.3	34.6	**
6.3 k	32.5	32.5	32.5	**
8 k	32.2	32.5	32.2	**
10 k	31.8	32.1	31.8	**

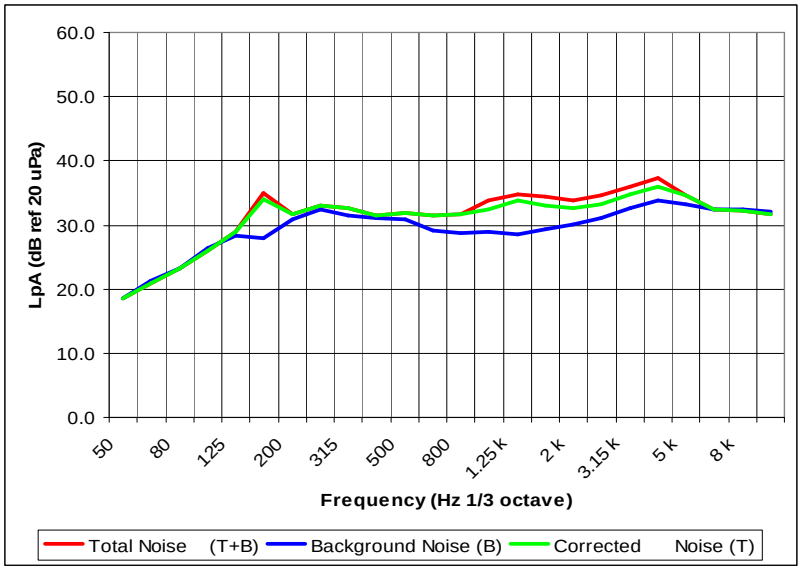


Figure 3 – Third octave spectrum at the standardized wind speed 6 m/s

Frequency	Lp-A per 1/3 octave (dB)			Deviations
	Total Noise (T+B)	**Background Noise (B)**	**Corrected Noise (T)**	
Hz	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	
50	20.1	18.8	20.1	**
63	21.7	21.1	21.7	**
80	23.3	23.2	23.3	**
100	25.8	26.2	25.8	**
125	27.8	27.7	27.8	**
160	33.9	27.5	32.8	
200	32.0	30.6	32.0	**
250	33.0	32.3	33.0	**
315	33.1	31.2	33.1	**
400	32.4	30.8	32.4	**
500	32.6	30.9	32.6	**
630	32.8	29.5	31.5	*
800	33.3	29.4	32.0	*
1 k	35.3	28.9	34.2	
1.25 k	36.4	28.7	35.6	
1.6 k	35.8	29.0	34.8	
2 k	35.2	29.7	33.9	*
2.5 k	36.3	31.2	35.0	*
3.15 k	37.9	34.4	36.6	*
4 k	39.7	35.9	38.4	*
5 k	37.2	34.4	37.2	**
6.3 k	33.3	32.5	33.3	**
8 k	32.4	32.4	32.4	**
10 k	31.8	32.0	31.8	**

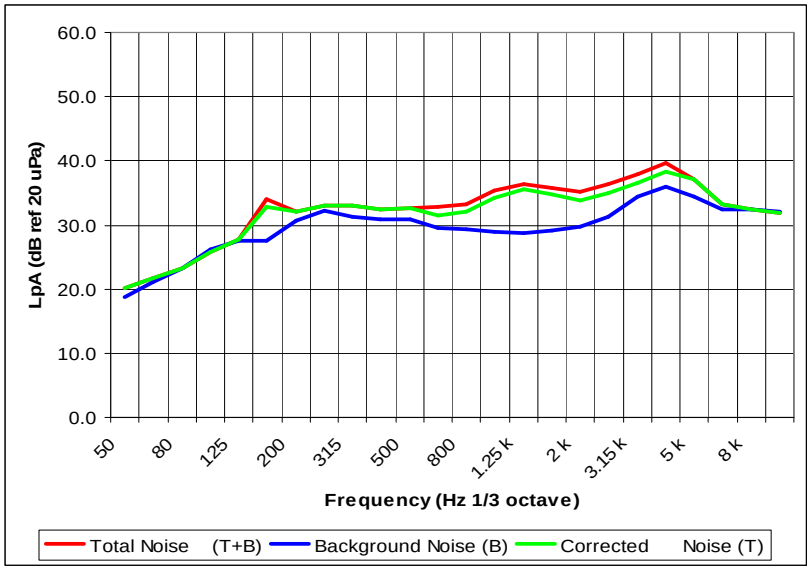


Figure 4 – Third octave spectrum at the standardized wind speed 7 m/s

Frequency	Lp-A per 1/3 octave (dB)			Deviations
	Total Noise (T+B)	**Background Noise (B)**	**Corrected Noise (T)**	
Hz	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	
50	22.7	23.3	22.7	**
63	24.2	23.3	24.2	**
80	24.7	24.9	24.7	**
100	26.5	26.9	26.5	**
125	28.1	28.9	28.1	**
160	30.6	28.9	30.6	**
200	33.2	31.7	33.2	**
250	33.3	33.3	33.3	**
315	33.2	32.9	33.2	**
400	33.4	32.5	33.4	**
500	33.1	32.5	33.1	**
630	33.8	31.3	33.8	**
800	34.1	31.3	34.1	**
1 k	36.1	30.9	34.8	*
1.25 k	37.2	30.1	36.3	
1.6 k	36.8	29.9	35.8	
2 k	35.9	30.5	34.6	*
2.5 k	37.2	31.4	35.9	*
3.15 k	39.1	33.8	37.8	*
4 k	41.0	34.8	39.8	
5 k	38.9	33.7	37.6	*
6.3 k	34.0	32.5	34.0	**
8 k	32.6	32.4	32.6	**
10 k	31.8	32.0	31.8	**

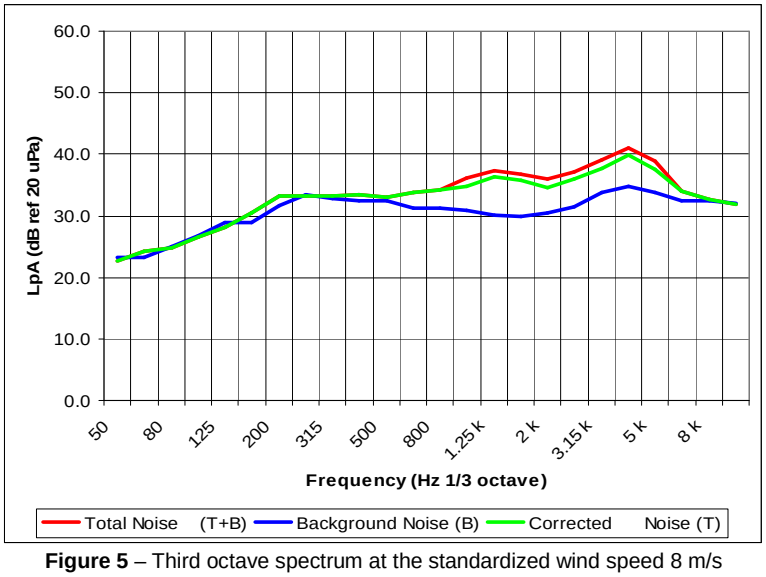


Figure 5 – Third octave spectrum at the standardized wind speed 8 m/s

Frequency	Lp-A per 1/3 octave (dB)			Deviations
	Total Noise (T+B)	**Background Noise (B)**	**Corrected Noise (T)**	
Hz	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	
50	21.5	23.8	21.5	**
63	23.9	24.9	23.9	**
80	25.3	26.1	25.3	**
100	27.0	27.5	27.0	**
125	29.2	29.2	29.2	**
160	31.2	29.2	31.2	**
200	33.7	32.3	33.7	**
250	34.4	34.3	34.4	**
315	34.4	34.2	34.4	**
400	36.8	33.8	35.5	*
500	34.1	33.5	34.1	**
630	34.8	32.7	34.8	**
800	35.1	32.8	35.1	**
1 k	36.8	32.7	35.5	*
1.25 k	38.2	31.6	37.1	
1.6 k	37.7	31.2	36.5	
2 k	36.8	31.3	35.5	*
2.5 k	37.9	32.0	36.6	*
3.15 k	38.9	33.5	37.6	*
4 k	40.1	34.5	38.8	*
5 k	38.4	34.4	37.1	*
6.3 k	35.1	32.5	35.1	**
8 k	33.2	32.4	33.2	**
10 k	31.9	32.0	31.9	**

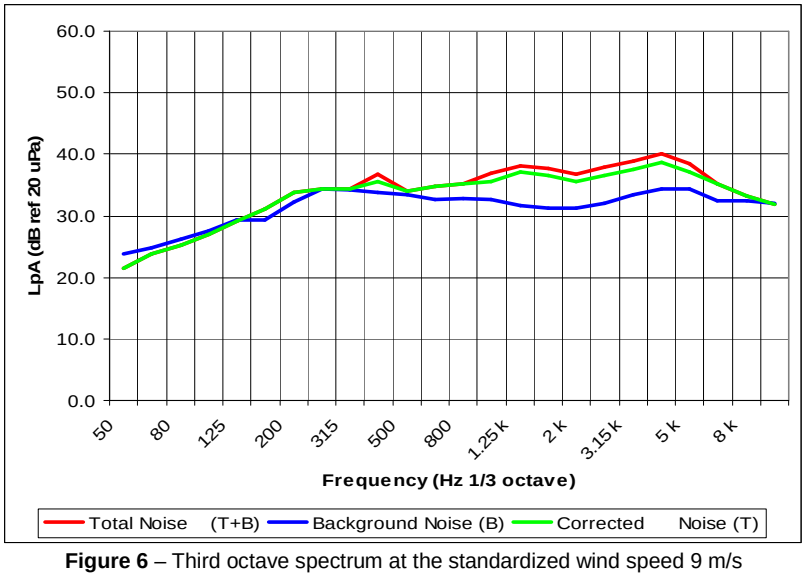


Figure 6 – Third octave spectrum at the standardized wind speed 9 m/s

Frequency	Lp-A per 1/3 octave (dB)			Deviations
	Total Noise (T+B)	**Background Noise (B)**	**Corrected Noise (T)**	
Hz	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	dB(A) [2.000e-05 Pa]	
50	24.0	22.8	24.0	**
63	25.9	24.5	25.9	**
80	27.3	25.9	27.3	**
100	29.5	27.6	29.5	**
125	29.7	28.6	29.7	**
160	30.9	29.3	30.9	**
200	33.6	32.5	33.6	**
250	40.2	33.9	39.0	
315	36.8	34.1	36.8	**
400	36.2	35.1	36.2	**
500	38.4	35.0	37.1	*
630	39.3	34.6	38.0	*
800	39.3	35.1	38.0	*
1 k	41.3	35.8	40.0	*
1.25 k	41.8	34.8	40.8	
1.6 k	40.7	34.4	39.6	
2 k	39.4	33.9	38.1	*
2.5 k	40.1	33.8	38.9	
3.15 k	41.6	35.9	40.3	*
4 k	43.2	38.0	41.9	*
5 k	45.6	42.9	45.6	**
6.3 k	38.3	32.9	37.0	*
8 k	35.4	32.5	35.4	**
10 k	33.1	32.2	33.1	**

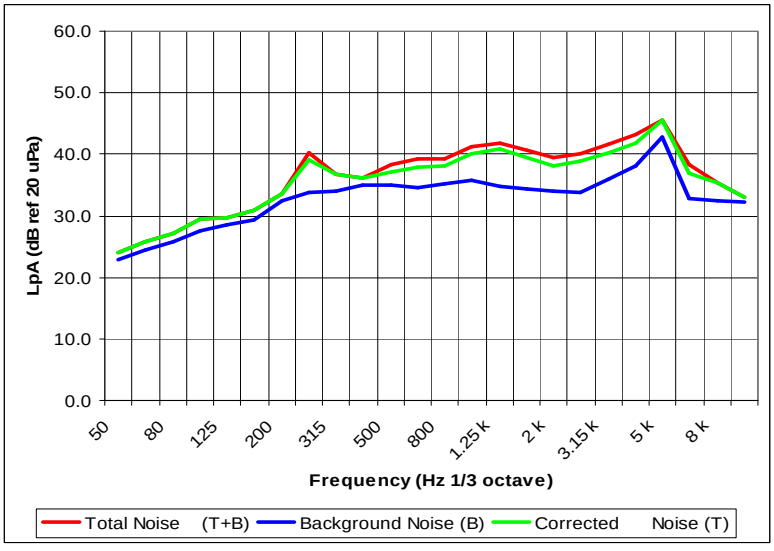


Figure 7 – Third octave spectrum at the standardized wind speed 10 m/s

5.0 AWEA Rated Annual Energy

Table 5 below summarizes the estimation of expected annual energy production (AEP) at sea-level air density.

Estimated Annual Energy Production Sea-level air density 1.225 kg/m^3 Cut-out wind speed 25 m/s					
Hub height annual average wind speed	AEP- Measured (Measured Power Curve)	Standard Uncertainty in AEP-Measured Combined Uncertainty		AEP-Extrapolated	Complete
m/s	kWh	kWh	%	kWh	
4	2447	154.68	6	2447	Complete
5	**4824**	**256.98**	**5**	**4824**	**Complete**
6	7748	350.23	5	7750	Complete
7	10828	418.01	4	10849	Complete
8	13713	458.97	3	13825	Complete
9	16151	478.14	3	16489	Complete
10	18003	481.33	3	18723	Complete
11	19243	473.44	2	20462	Incomplete

Table 5 – Estimated annual energy production of the Windspot 3.5 at sea-level air density

An indication of "incomplete" in the far-right column of Table 2 does not imply that the database for the test is incomplete. "Incomplete" means that AEP-Measured is not within 95% of AEP-extrapolated. AEP-extrapolated is an estimated extrapolation of annual energy production, where:

- AEP-Measured assumes zero power below cut-in wind speed and between the highest valid wind speed bin and cut-out wind speed, and
- AEP-Extrapolated assumes zero power below cut-in wind speed and constant power between the highest valid wind speed bin and cut-out wind speed.

From the above table: **AWEA Rated Annual Energy** **4,824 kWh**

Figure 8 below is a plot of estimated annual energy production at sea level air density for the Windspot 3.5.

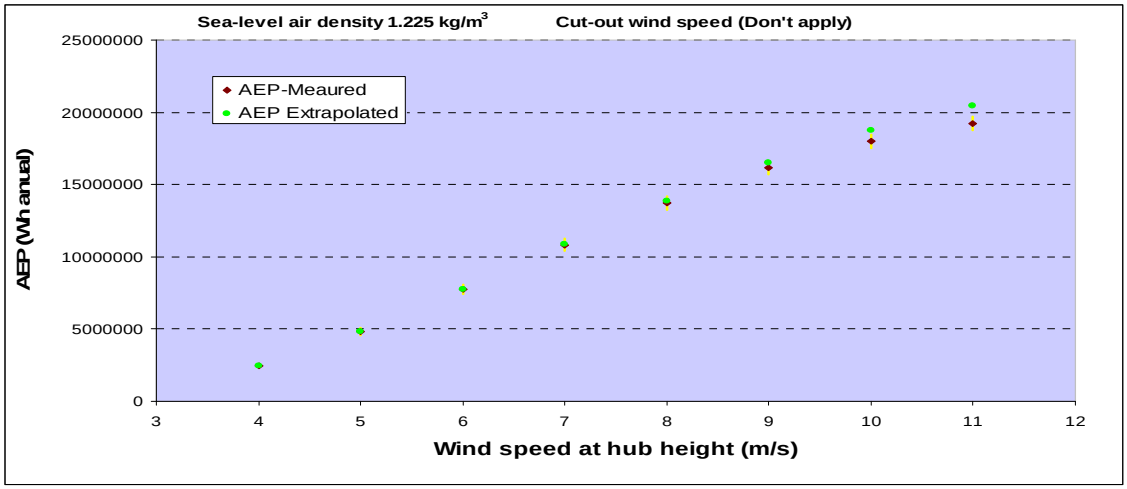


Figure 8 – Estimated AEP at sea-level air density for the Windspot 3.5

6.0 AWEA Rated Sound Level

The AWEA Rated Sound Level, L_{AWEA}, is the sound level that will not be exceeded 95% of the time, assuming an average wind speed of 5 m/s (11.2 mph), a Rayleigh wind speed distribution, 100% availability, and an observer location 60 m (~ 200 ft.) from the rotor center. That means the sound pressure level at a distance of 60 m and at a wind speed of 9.8 m/s using the equation (9) in IEC 61400-11 of the sound power level.

First, the sound pressure level at 9.8 m/s is obtained interpolating between the 9 & 10 m/s bins. Then L_{AWEA} is calculated using the following equations:

$$L_{WA,(9.8m/s)} = L_{S(9.8m/s)} - 6 + 10\log\left(4\pi R_1^{\,2}\right)$$

$$L_{AWEA} = L_{WA,(9.8m/s)} - 10\log\left(4\pi 60^2\right)$$

Using the equations above: **AWEA Rated Sound Level, L_{AWEA}: 39.1 dB(A)**

Figure 9 shows a plot of sound levels as a function of distance and background noise levels for the L_{AWEA} of 39.1 dB(A).

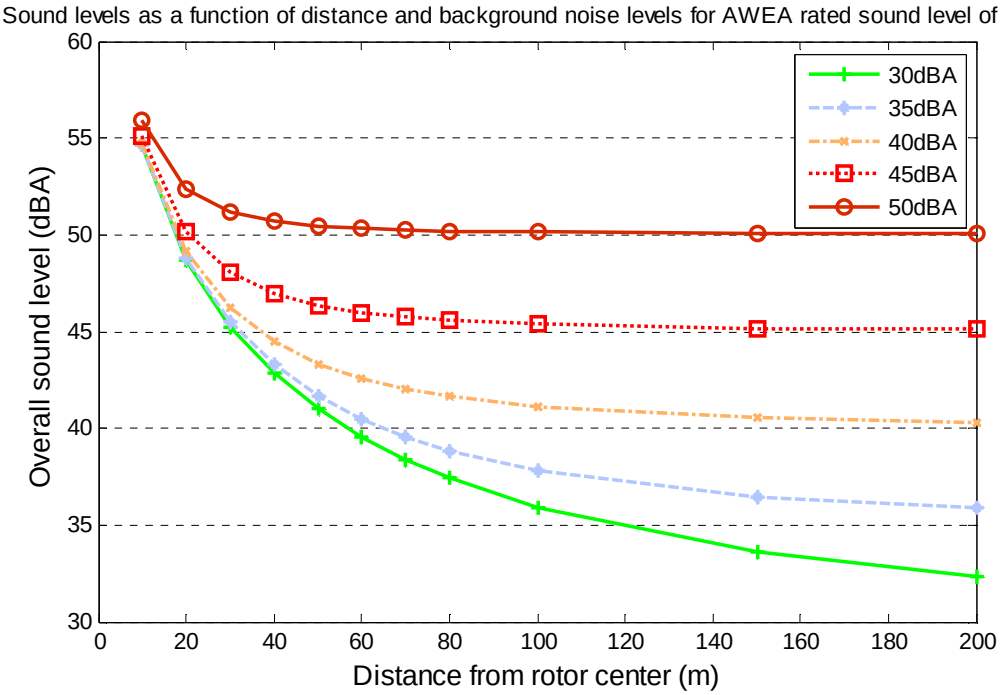


Figure 9. Sound levels as a function of distance and background noise levels for AWEA rated sound level of 39.1 dB(A).

7.0 AWEA Rated Power

The AWEA Rated Power is the wind turbine's power output at 11 m/s (24.6 mph) per the power curve from IEC 61400-12-1. From Table 3 above:

AWEA Rated Power: 3.202 kW

8.0 Strength and Safety Test Results

The Sonkyo Energy design file was evaluated during the months of July and October 2012. The design file is with regards to simplified load model compliance. The design file indicates ultimate and fatigue loading analysis, as well as final material and load factors of safety, for the Windspot 3.5 horizontal-axis wind turbine. The design file was found to be in compliance with all requirements of the above referenced standard regarding structural design. All supporting documentation is maintained within the project file.

Strength and Safety of the Windspot 3.5 was confirmed via the combination of the CIEMAT/CEDER Safety and Function Test Report in compliance with clause 9.6 of *IEC 61400-2 Wind Turbines – Part 2: Design requirements for small wind turbines; second edition dated Marcy 2006,* and the Intertek Letter of Conformance (Report No 100386839CRT-001a) for the design documentation and calculation provided by Sonkyo Energy with the structural design requirements of the above referenced standard.

The Windspot 3.5 has met all of the design requirements for a **Class IV** small wind turbine.

9.0 Tower Top Loads

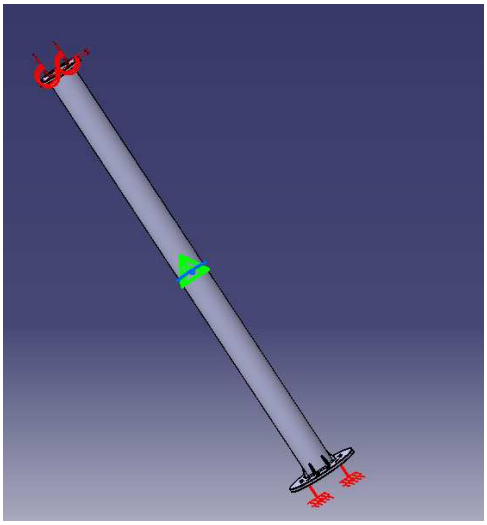
Table 6 below summarizes the top tower top loads and tower data. This data has been supplied by Sonkyo Energy.

PART		
NAME	TOWER TOP	
REFERENCE	20030062	
REVISION	B	
MATERIAL		
DESIGNATION	STEEL S275	According to --
TENSILE STRENGHT, YIELD	275.00	MPa
FATIGUE SAFETY FACTOR	1.90	-

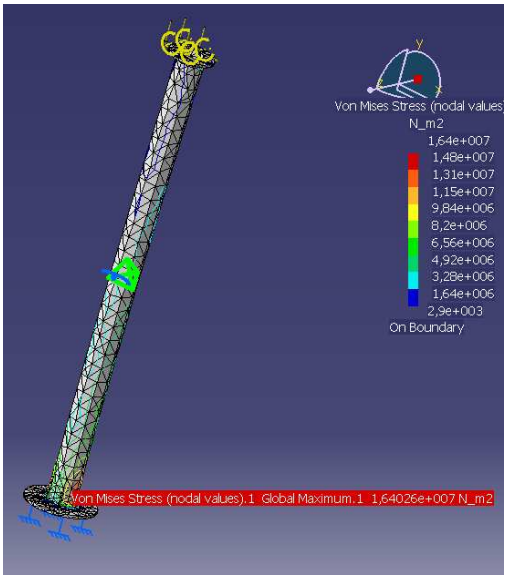
Euronorm	Germany	UK	USA	France							
EN10025	Din 17100	BS4360	ASTM	NFA 35-501	%C	%Mn	%Si	%S	%P	Yield min	Tensile
S185	St33		A283B	A33							
S235		40A	A283C		0.22max	1.60 max	0.50 max	.050 max	.050 max	185	310/540
S235JR	St37-2	40B	A283C-A		0.17max	1.40max	-	0.045	0.045	235	360/510
S235JO	St37-3 U	40C		E 24-2	0.17max	1.40max	-	0.040	0.040	235	360/510
S235J2G3	St37-3 N	40D		E24-4	0.17max	1.40max	-	0.035	0.035	235	360/510
S275		43A			0.25max	1.60 max	0.50 max	050 max	050 max	275	430/580
S275JR	St44-2	43B	A283D-A		0.21max	1.50max	-	0.045max	0.045max	275	430/580
S275JO	St44-3 U	43C	A678Gr70	E28-3	0.18max	1.50max	-	0.040max	0.040max	275	430/580
S355		50A	A572Gr50		0.23max	1.60max	0.50max	0.050max	0.050max	355	490/630
S355JR		50B	-		0.23max	1.60max	0.55max	0.045max	0.045max	355	490/630
S355JO	St52-3 U	50C	A441		0.22max	1.60 max	0.60 max	0.40 max	0.040 max	355	490/630
S355J2G3	St 52-3 N	50D			0.20max	1.60max	0.55max	0.035max	0.035max	355	490/630
S355J2G4					0.20max	1.60max	0.55max	0.035max	0.035max	355	490/630

GEOMETRY		
EXTERNAL DIAMETER	121.00	mm
INTERNAL DIAMETER	101.00	mm
THICKNESS	10.00	mm
HEIGTH	2030.00	mm

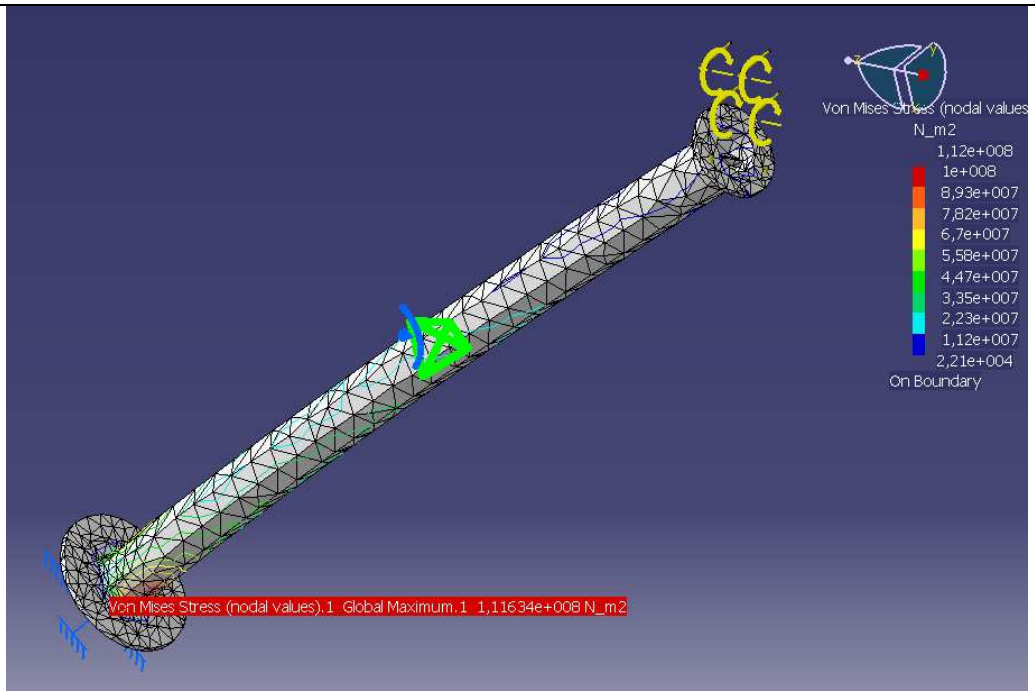
RESTRAINTS		
Clamp in contact surface with TOWER		
LOADS		
Aero generator weight	1850	N
Fatigue		
Fy	1850	N
Fx	650.00	N
Mz	227.50	Nm
Tensile strength, ultimate		
Fy	1850	N
Fx	4500	N
Mz	1700.00	Nm
FINITE ELEMENT SIMULATION		
Loads modeling		



Fatigue



Tensile strength, ultimate



RESULTS		
Maximum tensile stress (fatigue)	16.40	MPa
Fatigue safety factor	16.77	-
Maximum tensile stress	111	MPa
Safety factor	2.48	-
Date		2/14/2011
APROVED		**OK**

Table 6 – Tower top loads and design data for the test turbine for the Windspot 3.5

10.0 Duration Test Summary

10.1 Operational Time

The test turbine system was installed on October 4, 2012. The system was ready for testing on November 11, 2012. The duration test was completed on May 13, 2012, after sufficient data was collected to satisfy the hourly test requirements

10.2 Months of Operation

The duration test was conducted over a period of 6 months, or 184 days, from November 11, 2012 through May 13, 2012. .

10.3 Hours of Power Production

Table 7 below indicates the number of power production hours that were observed during the 6 month test duration. Note that the duration test hours are with reference to Class I results; even though the design conformity is for a Class IV turbine.

Hours of Power Production IEC SWT Class I {10 m/s – Vave}			
Wind Speed	**Measured**	**Required**	**Pass/Fail**
> cut in	3307.83	2500	Pass
> 1.2 V_{ave}	849.33	250	Pass
> 1.8 V_{ave}	330.83	25	Pass
> 15 m/s	529.00	25	Pass

Table 7 – Duration test hourly power production results for the Windspot 3.5

10.4 Operational Time Fraction

The operational time fraction is defined by the following equation:

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

where:

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

The **overall operational time fraction** of the combined wind turbine system in the total test period was **100.0 %.** The pass criteria for this parameter is 90% (*IEC 61400-2 Wind turbines – Part 2:Design requirements for small wind turbine Clause 9.4.2.1);* therefore the Windspot 3.5 is deemed to **PASS the Duration Test.**

Table 8 below displays the values that were used for determination of overall operational time fraction.

Operational Time Fraction Values	
Variable	**Hours**
T_T	4402.80
T_N	0.00
T_U	237.98
T_E	529.74

Table 8 – Hourly results for operational time fraction values for the {Model} turbine

No operational time was detected during which the turbine was non-operational (T_N). Total operational time amounts to 4402.8 hours. As for the time excluded from the analysis, T_E, which totalled 237.98 hours, the most prominent problem was due to failure of the grid. It was observed that these failures occurred almost always at the same time. This happened because the circuit breaker protecting the wind turbine disconnected the circuit when the public lighting of the wind farm control booth was switched on for the adjacent wind farm. Likewise, some T_E data have been discarded since other tests were being performed while collecting data for the test duration. Some time lost due to DAS inspection was also detected. There were 529.73 hours of unknown time (T_U).

10.5 Environmental Conditions

In order to understand environmental conditions over the testing period, several wind speed statistics were required by the Standard. These values are summarized in Table 9 below.

Environmental Conditions During Test Period	
Description	**Value**
Highest instantaneous wind speed	43.95 m/s
Average turbulence intensity at 15 m/s	8.18 %

Table 9 – Environmental conditions during test

10.6 Power Degradation

No significant power degradation over the test period at comparable wind speeds was recorded.

10.7 Dynamic Behavior

During the test period the turbine and tower were observed for any potentially harmful turbine or tower dynamics. The turbine was observed over a wide range of wind speeds. During these observations there was no presence of any observable problems.

10.8 Post-Test Inspection

The post test inspection was performed on June 26, 2012. There were no significant findings that would relate to excessive wear, degradation, or corrosion that would lead to potentially harmful situations over the expected 20 year life of the Windspot 3.5.