Bl. No. 86, 1198 Qinzhou Road
(North), Shanghai, China 200233

Telephone： 86 21 6127 8200
Facsimile： 86 21 5426 2346
www.intertek.com

Date Issued: May 20, 2013

Report Number 12100246SHA-001
Intertek Project No: SH12100246

Miss. Zhang Qian
SUMEC HARDWARE & TOOLS Co.,Ltd
1# Xinghuo Road, National Level Nanjing High-Tech Zone,
Nanjing,
Jiangsu, P.R.China.

Ph: (+86) 025-58638359
Fx: (+86) 025-58638017

email: zhangq@sumec.com.cn

Subject: Summary Test Report for the SUMEC PWB01-30-48 tested at DaFeng test site of Jiangsu, China for power performance test and duration test, and at Sunite test site of Inner Mongolia, China for acoustic test.

Dear Miss. Zhang Qian,

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 performed by Intertek. A production sample was installed at the test location in Dafeng on November 22, 2010, and in Sunite on May 12, 2013. Duration testing was completed on May 02, 2012. All testing on the PWB01-30-48 turbine was conducted under Intertek Project No. SH12100246.

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:	Mark Dai
Title:	Technical Supervisor
Signature:	[signature]

Reviewed by:	Joseph M Spossey
Title:	Small Wind Team Leader
Signature	[signature]

SUMEC HARDWARE & TOOLS Co.,Ltd

Test Report No. 12100246SHA-001
Issued: May 20, 2013

Wind Turbine Generator System
Summary Test Report
for the
Sumec PWB01-30-48

Master Reports

Report	Report Title	Date
12061560SHA-001	Duration Test Report	June 27, 2012
Annex clause 9.6 of SH10070988-005	Safety and Function Test Report	December 15, 2011
12061560SHA-009	Acoustic Noise Test Report	May 20, 2013
12061560SHA-005	Power Performance Test Report	June 27, 2012

1.0 Background

1.1 Background

This testing was conducted as part of the full AWEA Certification test program for the Sumec PWB01-30-48 horizontal-axis wind turbine. The PWB01-30-48 was installed at DaFeng test site of Jiangsu, China for power performance test and duration test, and at Sunite test site of Inner Mongolia, China for acoustic test. Test reports were produced by Intertek.

1.2 Description of the wind turbine

The PWB01-30-48 is rated for operation at 1000 W at wind speeds of 10 m/s (22.4 mph). The turbine is a 3-bladed upwind horizontal-axis wind turbine (HAWT) with passive yaw. The tail system is used to prevent overspeed of the turbine and generator and regulate the power output. The generator is a SUMEC PWG01-10-90 synchronous permanent magnet generator. It is available as a 3 phase 90 VAC output at 31.66 Hz at 380 RPM from generator. A diode bridge (MSD100-16) is used to rectify the 3 phase AC from the generator to DC voltage, then a DC voltage controller used to control the charging voltage to the storage batteries, and also to divert power to the dump load.

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

Item	Description
General Configuration	
Manufacturer	SUMEC Manufacturing Venture Co., Ltd.
Type/ technology	Direct-drive
Wind Turbine Class	Class III
Orientation (upwind / downwind)	upwind
Rotor Diameter (m)	3
Hub Height (m)	10.181
Performance	
Rated Electrical Power (kW)	1
Rated Wind Speed (m/s)	10
Cut-in Wind Speed (m/s, 10 min. mean)	3
Calculated lifetime [y]	20
Ambient temperature range for operation [°C]	-30°C – +50°C
Annual average wind speed Vave (10 min) [m/s]	7.5
Reference wind speed Vref (10 min) [m/s]	37.5
50 year extreme wind speed Ve50 (3s) [m/s]	52.5
Rotor	
Number of Blades	3
Swept Area (m^2)	7.065
Rated Rotational Speed (rpm)	380
Design Maximum Rotational Speed (rpm)	580
Rotor Hub Type (e.g. rigid, teeter)	rigid
Coning Angle (deg)	0
Tilt Angle (deg)	0
Rated Blade Set Angle (deg)	10.75
Direction of Rotation (clockwise or counter-clockwise looking downwind)	clockwise
Blade	
Manufacturer	Jiangyin Zhiyuan Blade manufacturing Co., Ltd

Model	PWB01.2.1
Length (m)	1.5
Material / Construction	Wood core with epoxy fiber glass coated
Mass (kg)	3.58
Tip speed (m/s)	70.4
Serial number	ZY09090608
Yaw System	
Wind Direction Sensor (type, location)	PWB01-30-48 wind turbine use tail to yaw at the high wind speed, this is passive yawing method and has no active control component.
Yaw Actuator (electric, hydraulic)	
Yaw rate	
Yaw Brake manufacturer, type, location	
Generator	
Manufacturer	SUMEC Manufacturing Venture Co., Ltd.
Model	PWG01-10-90
Type/technology	Permanent-Magnet Synchronous Generator
Rated voltage	90 VAC
Rated power / speed	31.66 Hz
Speed range	0 – 580 RPM
Number of poles	5
Stator rated current	6.7 A
Rotor rated current	N/A
Generator insulation class	Class A
Generator Phase Connection (Delta/Wye)	Y
IP Protection	IP54
Cooling	Nature air cooling
Power factor	90%
Serial number	20100900015
Controller	
Manufacturer	SUMEC Manufacturing Venture Co., Ltd.
Model	PWC01-B-48
Software version	Wind version 2011010102
Type/technology	Full power
Rated voltage	48 VDC
Frequency	31.66Hz
Capacity	1KVA
Rated current	16 A
Cooling method	Nature air cooling
IP Protection	IP54
Serial number	2011012000031
Control / Electrical System	
Power Regulation (e.g. pitch, stall, active stall)	Use yawing to control power. For PWB01-30-48 wind turbine, there is offsetting between rotor center and yawing center, the mechanical tail can passive yawing according to different wind speed when the wind speed exceed the yawing wind speed.
Over speed Control	Passive yawing
Tower	
Tower Type (lattice, tubular steel, tubular concrete), manufacturer	Octagonal tubular steel
Height (m)	10
Diameter of head flange	165 mm

Diameter of bottom flange	500 mm
Battery Bank	
Manufacturer	Jiangsu Huafu Energy Co., Ltd
Type	6-CN-150
Voltage	48V
Battery capacity	150AH

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.

Measured power curve(Database A)							
Reference air density: 1.225kg/m^3					Uncertainty Category A(kW)	Uncertainty Category B(kW)	Combined Uncertainty(kW)
Bin no.	Hub height wind speed[m/s]	Power Output[kW]	Cp	No. of Datasets(1 min. avg.)			
1	1.01	0.00	-	335	0.00	0.01	0.01
2	1.54	0.00	-	587	0.00	0.01	0.01
3	2.02	0.00	-	1515	0.00	0.01	0.01
4	2.48	0.02	0.30	1576	0.00	0.01	0.01
5	3.00	0.05	0.43	1670	0.00	0.01	0.01
6	3.50	0.08	0.43	1673	0.00	0.01	0.01
7	3.99	0.12	0.44	1623	0.00	0.01	0.01
8	4.50	0.17	0.43	1353	0.00	0.01	0.01
9	5.00	0.23	0.42	1189	0.00	0.02	0.02
10	5.49	0.30	0.42	1101	0.00	0.02	0.02
11	5.99	0.39	0.42	941	0.00	0.03	0.03
12	6.49	0.49	0.41	799	0.00	0.03	0.03
13	6.99	0.60	0.41	563	0.00	0.04	0.04
14	7.46	0.72	0.40	332	0.00	0.04	0.04
15	7.96	0.84	0.38	192	0.01	0.04	0.05
16	8.46	0.97	0.37	110	0.01	0.05	0.05
17	8.96	1.09	0.35	44	0.01	0.05	0.05
18	9.51	1.17	0.31	34	0.01	0.03	0.04
19	9.99	1.22	0.28	29	0.02	0.03	0.03
20	10.44	1.19	0.24	22	0.04	0.02	0.05
21	10.96	1.17	0.21	22	0.03	0.02	0.03
22	11.42	1.08	0.17	16	0.04	0.05	0.07
23	11.94	0.90	0.12	15	0.03	0.09	0.10
24	12.48	0.93	0.11	11	0.02	0.02	0.03
25	12.97	0.93	0.10	22	0.02	0.01	0.02
26	13.52	0.95	0.09	10	0.03	0.02	0.03
27	14.03	0.87	0.07	19	0.01	0.05	0.05
28	14.45	0.82	0.06	11	0.02	0.04	0.05
29	14.92	0.97	0.07	4	0.08	0.11	0.14
30	15.54	1.01	0.06	4	0.11	0.03	0.12
31	15.91	0.94	0.05	2	0.13	0.07	0.15
-	-	-		-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-

Manufacture:	SUMEC	**Standard Power Output:**	1	**kW**
Total Number:	15824	**Diameter of Wind Turbine:**	3	**m**
Report Date:	Jul 2012	**1 min Averages**		

Intertek
Valued Quality. Delivered.

Table 3 – Performance at sea-level air density for the PWB01-30-48; 1.225 kg/m^3

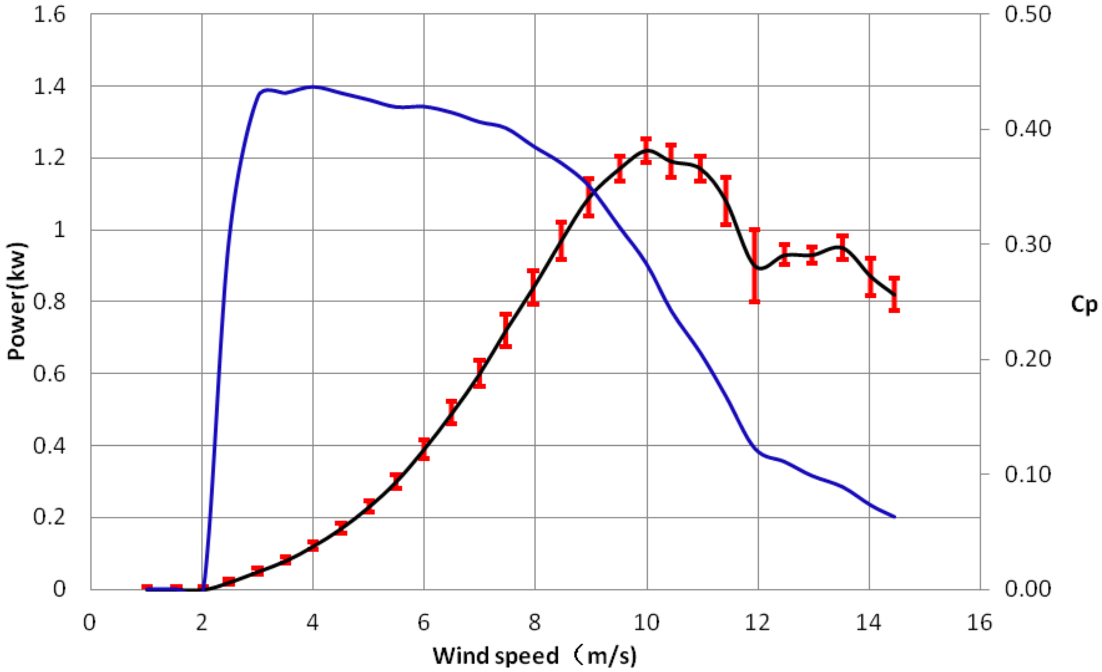

Figure 1 – Normalized Power curve and Coefficient of performance at sea-level density for the PWB01-30-48; 1.225 kg/m^3

4.0 Acoustic Test Summary

Below is a summary of the test results for the PWB01-30-48 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.

Figure 2 below shows the measured data pairs. The method of bins was used to calculate the bin average turbine and background sound pressure level. The sound pressure levels at the integer wind speeds were interpolated between bins. The background correction was then applied to the bin averaged values at the integer wind speeds.

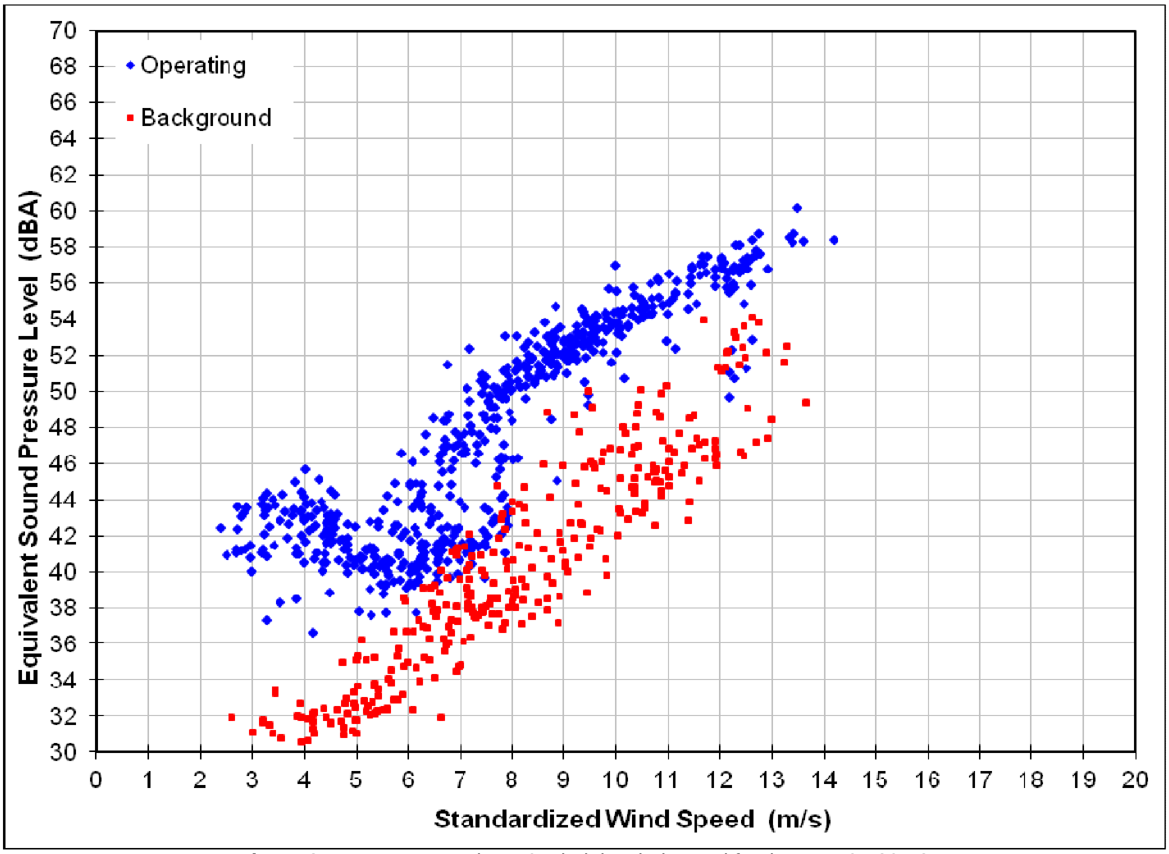

Figure 2 – Ls+n & Ln against 10m height wind speed for the PWB01-30-48

Figures 3 through 4 show the A-weighted one-third octave spectra were calculated for each bin. For several wind speeds, at the high and low frequencies, the separation between turbine and background was insufficient to report a value. Only spectra for bins, in which at least 10 data points were recorded for both turbine and background, are reported. For bands that have no value listed, the background noise was within 3dB of the overall noise. Tables 4 and 5 show one-third octave results and associated uncertainties in tabular format.

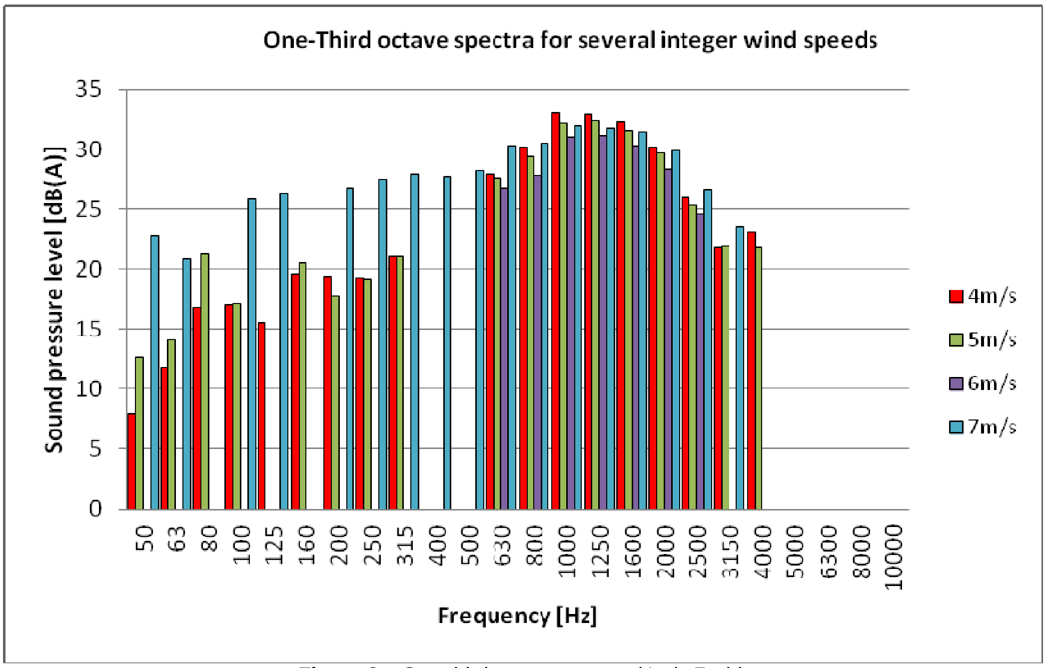

Figure 3 – One-third octave spectra (4m/s-7m/s)

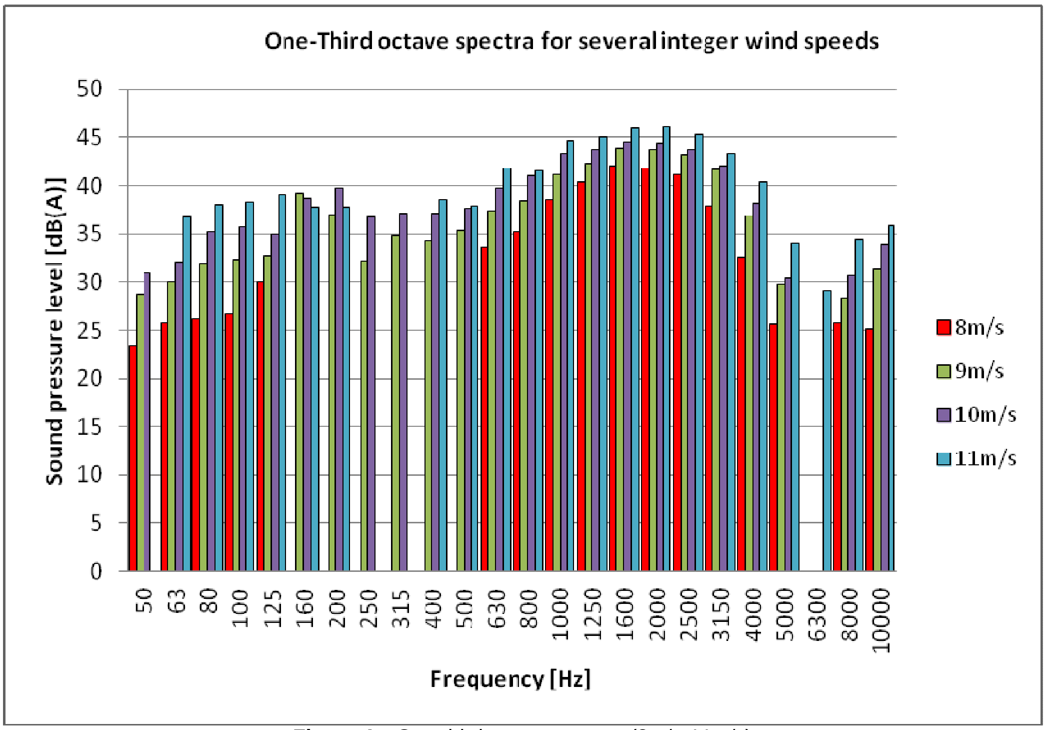

Figure 4 – One-third octave spectra (8m/s-11m/s)

	4m/s		5m/s		6m/s		7m/s	
Freq [Hz]	Ls [dB(A)]	Uc [dB(A)]	Ls [dB(A)]	Uc [dB(A)]	Ls [dB(A)]	Uc [dB(A)]	Ls [dB(A)]	Uc [dB(A)]
50	*8.0	2.8	12.6	2.6	-	-	22.9	3.4
63	*11.8	2.5	*14.1	2.4	-	-	*20.9	4.2
80	16.8	3.0	21.3	2.5	-	-	-	-
100	17.0	5.3	*17.1	1.7	-	-	25.8	1.4
125	*15.6	3.3	15.6	1.5	-	-	*26.3	5.7
160	*19.6	1.4	*20.5	2.2	-	-	-	-
200	*19.4	4.2	*17.7	1.2	-	-	*26.7	3.1
250	*19.3	2.1	*19.2	1.4	-	-	*27.5	4.1
315	*21.1	2.2	*21.0	1.3	-	-	*27.9	2.5
400	-	-	-	-	-	-	*27.7	2.6
500	-	-	-	-	-	-	*28.2	2.3
630	27.9	1.3	27.6	1.2	*26.8	1.4	30.3	1.7
800	30.2	1.8	29.3	1.3	*27.8	1.4	30.5	1.6
1000	33.0	1.7	32.2	1.3	31.0	1.6	32.0	1.4
1250	32.9	1.2	32.4	1.4	31.1	1.5	31.8	1.3
1600	32.3	1.4	31.6	1.3	30.3	1.4	31.4	1.2
2000	30.2	1.6	29.7	1.3	28.3	1.3	29.8	1.2
2500	26.0	2.0	25.3	1.2	*24.6	1.2	26.7	1.2
3150	*21.8	1.8	*21.8	1.2	-	-	*23.5	1.3
4000	*23.1	2.0	*21.7	1.2	-	-	-	-
5000	-	-	-	-	-	-	-	-
6300	-	-	-	-	-	-	-	-
8000	-	-	-	-	-	-	-	-
10000	-	-	-	-	-	-	-	-

Table 4 – One-third octave spectra in dB (A) for several integer wind speeds (4m/s~7m/s) in 10 m height

	8m/s		9m/s		10m/s		11m/s	
Freq [Hz]	Ls [dB(A)]	Uc [dB(A)]	Ls [dB(A)]	Uc [dB(A)]	Ls [dB(A)]	Uc [dB(A)]	Ls [dB(A)]	Uc [dB(A)]
50	*23.4	1.3	28.7	1.3	31.0	1.5	-	-
63	*25.8	1.6	30.1	1.2	*32.1	1.5	36.8	1.2
80	*26.1	1.7	31.8	1.3	35.2	1.3	38.1	1.2
100	*26.7	1.2	32.4	1.4	35.8	1.3	38.4	1.2
125	*30.1	2.9	*32.7	1.5	34.9	1.3	39.1	1.2
160	-	-	39.2	1.3	38.8	1.2	*37.9	1.2
200	-	-	37.1	1.6	39.8	1.4	*37.8	1.4
250	-	-	*32.3	1.4	*36.8	1.3	-	-
315	-	-	*34.8	1.2	*37.1	1.3	-	-
400	-	-	*34.3	1.3	*37.1	1.4	*38.6	1.3
500	-	-	*35.4	1.3	*37.7	1.3	*38	1.3
630	*33.7	1.2	37.4	1.2	39.8	1.3	41.8	1.3
800	35.3	1.3	38.5	1.2	41.0	1.3	41.5	1.3
1000	38.5	1.2	41.1	1.2	43.4	1.2	44.7	1.2
1250	40.5	1.2	42.4	1.2	43.8	1.2	45.1	1.2
1600	42.0	1.3	43.8	1.2	44.5	1.2	45.9	1.2
2000	41.9	1.4	43.8	1.2	44.4	1.2	46.1	1.2
2500	41.2	2.4	43.3	1.2	43.8	1.3	45.4	1.2
3150	38.0	3.0	41.7	1.3	42.0	1.3	43.3	1.2
4000	32.7	2.5	36.9	1.3	38.1	1.4	40.4	1.2
5000	*25.6	2.2	*29.8	1.3	*30.4	1.2	34.0	1.2
6300	-	-	-	-	-	-	29.1	1.2
8000	*25.7	1.7	*28.4	1.2	30.7	1.3	34.4	1.2
10000	*25.2	2.2	31.4	1.2	34.0	1.3	35.9	1.2

Table 5 – One-third octave spectra in dB (A) for several integer wind speeds (8m/s~11m/s) in 10 m height

5.0 AWEA Rated Annual Energy

Table 6 below summarizes the estimation of expected annual energy production (AEP) at sea-level air density.

Estimated annual energy production, database A (all valid data)					
Reference air density: 1.225kg/m^3					
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	1775.87	119.68	6.74%	1776.13	Complete
5	2920.58	166.57	5.70%	2930.75	Complete
6	3918.66	200.91	5.13%	3994.15	Complete
7	4588.87	220.56	4.81%	4841.37	Incomplete
8	4915.94	227.26	4.62%	5466.56	Incomplete
9	4972.72	224.39	4.51%	5904.46	Incomplete
10	4849.10	215.44	4.44%	6189.57	Incomplete
11	4619.83	203.14	4.40%	6347.83	Incomplete

Table 6 – Estimated annual energy production of the PWB01-30-48 at sea-level air density

An indication of "incomplete" in the far-right column of Table 6 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** **2,920.58 kWh**

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}: 41.1 dB(A)**

Table 7 gives the calculated apparent sound power levels, with the combined uncertainty for each integer wind speed.

WS 10m	WS Ave	Ls+n [dB]	Ln [dB]	Laeq,c,k [dB]	LWA,k[dB]	Uc[dB]
4	4.1	41.8	32.5	41.3	70.1	1.8
5	5.0	42.0	33.7	41.4	70.1	1.4
6	6.0	42.8	35.8	41.8	70.6	2.1
7	7.0	45.2	38.3	44.2	73.0	3.4
8	7.9	48.5	41.2	47.6	76.4	4.3
9	9.0	51.5	43.3	50.7	79.5	1.6
10	9.9	53.8	45.1	53.2	82.0	1.3
11	10.9	55.1	48.1	54.2	83.0	1.3
12	12.1	56.5	49.1	55.7	84.5	2.0

Table 7. Apparent sound power level.

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: 1.17 kW

8.0 Strength and Safety Test Results

The SUMEC PWB01-30-48 design file was evaluated during the months of September and December 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 PWB01-30-48 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 PWB01-30-48 was confirmed via the combination of the Intertek Safety and Function Test Report (Report No SH10070988-005) in compliance with clause 9.6 of *IEC 61400-2 Wind Turbines – Part 2: Design requirements for small wind turbines; second edition dated March 2006,* and the Intertek Mechanical system Report (Report No SH10070988-001) for the design documentation and calculation provided by Sumec with the structural design requirements of the above referenced standard.

The PWB01-30-48 has met all of the design requirements for a **Class III** small wind turbine.

9.0 Tower Design Requirements

The report of tower design requirements has been supplied by Sumec. The following table summarizes the tower top loads and tower data from SUMEC Wind Turbine Tower Design Specification.

Tower Code	1kW Tower
Tower Type	Octagonal tubular steel
Height	10m
Diameter of head flange	165 mm
Diameter of bottom flange	500 mm
Quality	320 kg
Thickness	6mm

Table 8 –Tower design data for the test turbine for the PWB01-30-48

Wind Turbine Type	-	PWB01-30-48
Maximum tower top forces Load Case H	$F_{x\text{-}shaft}$ (N)	4419.125
	F_{tower} (N) *	11547.31
	$F_{front, nacelle}$ (N) **	518.87
Maximum tower top bending moment (fore - aft) Load Case B	M_{shaft} (Nm)	1410.74
Maximum tower top bending moment (side - side) Load Case G	$M_{x\text{-}shaft}$ (Nm)	346.68
* Drag force on the tower, details see load report ** Drag force on the nacelle, details see load report		

Table 9 – Tower top loads for the test turbine for the PWB01-30-48

10.0 Duration Test Summary

10.1 Operational Time

The test turbine system was installed on November 22, 2010. The duration test was started on April 01, 2011. The duration test was completed on May 02, 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 13 months, or 395 days, from April 01, 2011 through May 02, 2012. .

10.3 Hours of Power Production

Table 10 below indicates the number of power production hours that were observed during the 13 month test duration.

	Hours of Power Production Above(hour):			*Max Wind Speed*	*TI @15m/s*	*Data Points*	T_T	T_U	T_E	T_N	*O*
Month	***0m/s***	***9m/s***	***15m/s***	***m/s***	***%***	***Points***	***(hours)***	***(hours)***	***(hours)***	***(hours)***	***%***
Overall	**5309.7**	**487.1**	**28.4**	**19.1**	**0.64**	**100**	**9203.7**	**744.2**	**194**	**613.5**	**92.6**
2011											
Apr	**456.3**	**92.3**	**1.7**	**16.8**	**0.94**	**4**	**686.3**	**75.5**	**24**	**40**	**93.2**
May	**380.2**	**37.2**	**1.8**	**16.7**	**0.77**	**15**	**724.8**	**70.7**	**22**	**55.8**	**91.2**
Jun	**414.8**	**19**	**0.3**	**16.4**	**0**	**0**	**697.8**	**68.8**	**11**	**32.8**	**94.7**
Jul	**342.5**	**4.5**	**0**	**13.9**	**1.15**	**13**	**715**	**62.2**	**16**	**42.2**	**93.4**
Aug	**389.3**	**18.2**	**1.7**	**16.5**	**0.85**	**20**	**733.7**	**65.7**	**24**	**18.8**	**97.1**
Sep	**415**	**49.3**	**0.2**	**15.8**	**1.02**	**10**	**716.5**	**44.8**	**66**	**35.2**	**94.2**
Oct	**397.3**	**41.8**	**0**	**13.9**	**0**	**0**	**732.7**	**47.5**	**20**	**55.3**	**91.7**
Nov	**389.4**	**45.7**	**10.4**	**19.1**	**0.79**	**16**	**664.8**	**43.8**	**11**	**50.2**	**91.8**
Dec	**361.8**	**15.2**	**1.2**	**15.6**	**1.00**	**7**	**634.8**	**57.8**	**0**	**51.2**	**91.1**
2012											
Jan	**361.2**	**25.3**	**0**	**11.3**	**0.00**	**0**	**743.3**	**51**	**0**	**42.2**	**93.9**
Feb	**439.2**	**37**	**3.5**	**17.6**	**0.80**	**4**	**682**	**48.5**	**0**	**48**	**92.4**
Mar	**526.3**	**45.8**	**4.3**	**17.2**	**0.90**	**6**	**737.2**	**52.8**	**0**	**60.7**	**91.1**
Apr	**414.7**	**55.8**	**3.3**	**17**	**0.80**	**5**	**687**	**52.3**	**0**	**76.8**	**87.9**
May	**21.7**	**0**	**0**	**8.1**	**0.00**	**0**	**47.8**	**2.8**	**0**	**4.3**	**90.4**

Table 10 – Monthly and overall results of the duration test for the PWB01-30-48

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 **92.6%.** 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 PWB01-30-48 is deemed to **PASS the Duration Test.**

Figure 5 and Table 10 show the operational time fraction per month.

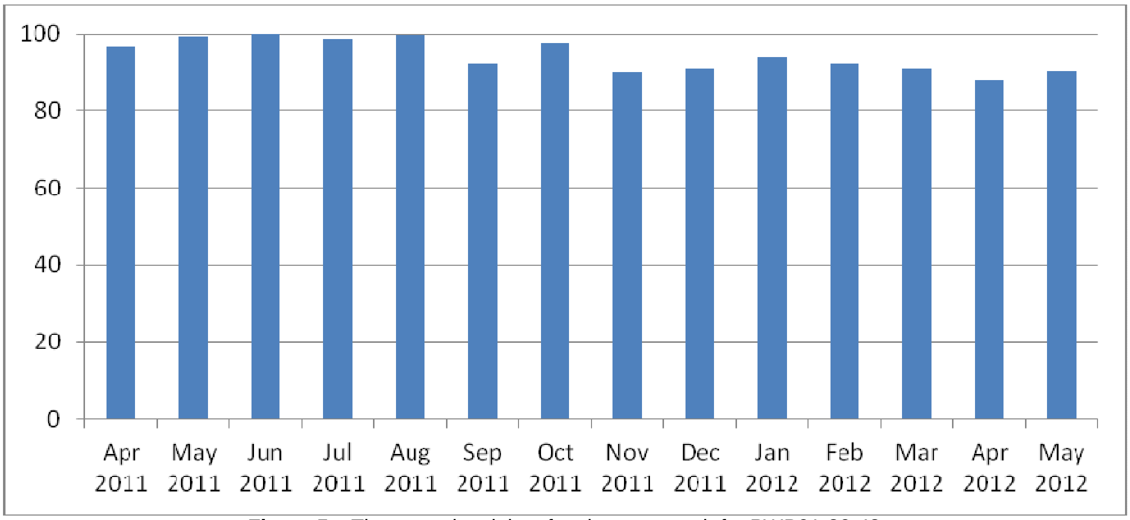

Figure 5 – The operational time fraction per month for PWB01-30-48

The operational time was 613.5 hours during which the turbine was non-operational (T_N). Total operational time amounts to 9203.7 hours. As for the time excluded from the analysis, T_E, which totalled 194 hours, the most prominent problem was due to failure of the grid and noise testing. 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 744.2 hours of unknown time (T_U).

Table 11 shows the fault condition assignments for different situations.

Condition	T_N	T_U	T_E	No Fault
Grid Fault			X	
Over speed/Furling	X			
Emergency Stop	X			
Unwrapping of droop cable	X			
Turbine inspections	X			
Fault conditions	X			
DAS disable		X		
Lost or irresolvable data		X		
Routine maintenance	X			
Turbine in test mode			X	
Failure of external system			X	
Inspection of data acquisition			X	
Other than routine maintenance			X	
External weather conditions			X	

Table 11 – Fault condition assignments

10.5 Environmental Conditions

As an indication of the environmental conditions during the duration test, the standard requires reporting of the highest instantaneous wind speed gust and the average turbulence intensity at 15 m/s. The highest instantaneous wind speed was 23.1 m/s at 18:30 on 8th November 2011. The average turbulence intensity at 15 m/s during the duration test was 0.64%.

10.6 Power Degradation

A factor of reliable operation is that the turbine should experience no significant power degradation. During the power degradation analysis, the average power level for each wind speed bin was plotted as a function of time over the whole test period. This plot is analyzed for any obvious trends in power production.

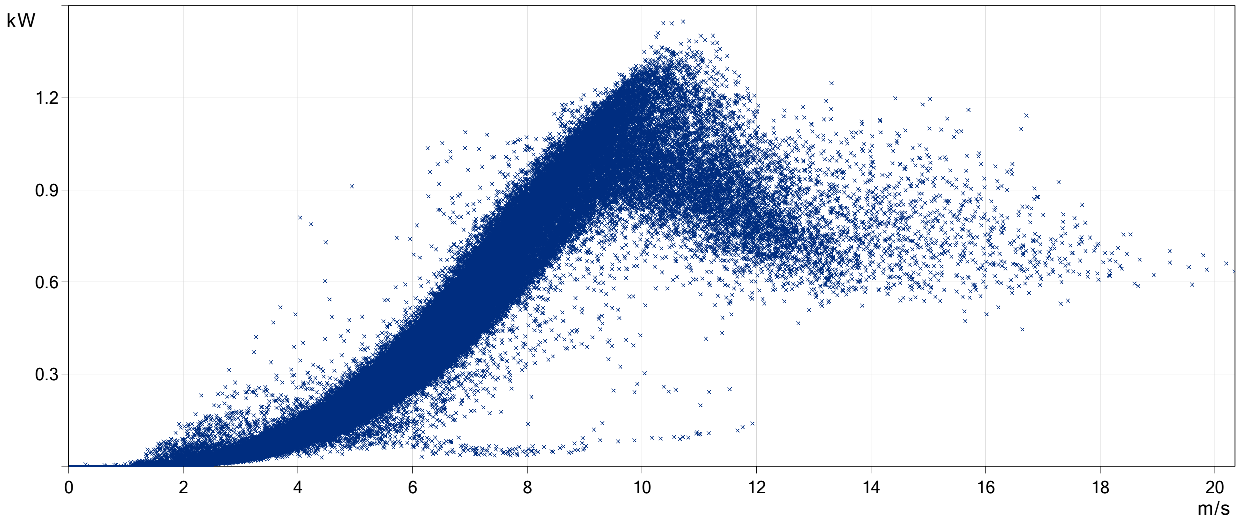

Figure 6 – Scatter plot of power curve

Figure 7 shows the power degradation plot, which gives the power level in individual wind speed bins for each month. Variations in the power levels from month-to-month are caused by air density variations. The unstable power output under high wind speed was caused by the small database.

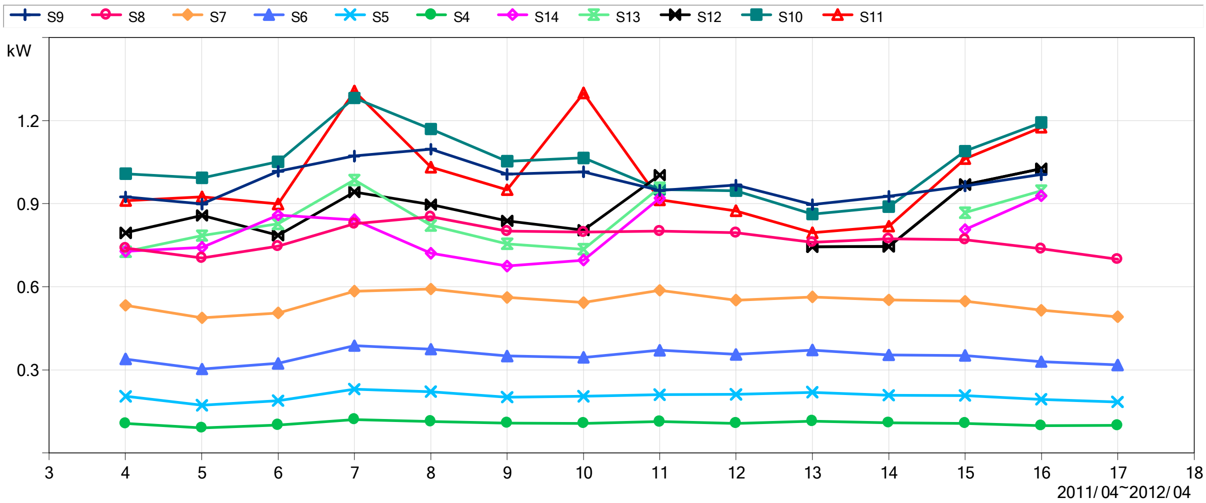

Figure 7 – Power level in several wind speed bins (in m/s) as a function of time

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 12, 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 PWB01-30-48.