



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-002
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 PWB02-40-48 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
<i>AWEA Small Wind Turbine Performance and Safety Standard</i>	<i>AWEA 9.1</i>	<i>December 2009</i>	<i>First edition</i>

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 7, 2013. Duration testing was completed on March 04, 2012. All testing on the PWB02-40-48 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:	

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

This report is for the exclusive use of Intertek's Client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this report. Only the Client is authorized to permit copying or distribution of this report and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. The observations and test results in this report are relevant only the sample tested. This report by itself does not imply that the material, product or service is or has ever been under an Intertek certification program.



Wind Turbine Generator System Summary Test Report for the Sumec PWB02-40-48





Master Reports

Report	Report Title	Date
12061560SHA-002	Duration Test Report	June 27, 2012
Annex clause 9.6 of SH10070988-005	Safety and Function Test Report	December 15, 2011
12061560SHA-010	Acoustic Noise Test Report	May 20, 2013
12061560SHA-006	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 PWB02-40-48 horizontal-axis wind turbine. The PWB02-40-48 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 PWB02-40-48 is rated for operation at 2000 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. The tail system is used to prevent overspeed of the turbine and generator and regulate the power output. The generator is a SUMEC PWG02-10-90 synchronous permanent magnet generator. It is available as a 3 phase 90 VAC output at 27.5 Hz at 330 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)	4
Hub Height (m)	10.2
Performance	
Rated Electrical Power (kW)	2
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)	12.56
Rated Rotational Speed (rpm)	330
Design Maximum Rotational Speed (rpm)	535
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	PWB02.2.1
Length (m)	2
Material / Construction	Wood core with epoxy fiber glass coated
Mass (kg)	8.45
Tip speed (m/s)	72.05
Serial number	ZY09100102
Yaw System	
Wind Direction Sensor (type, location)	PWB02-40-48 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	PWG02-10-90
Type/technology	Permanent-Magnet Synchronous Generator
Rated voltage	90 VAC
Rated power / speed	27.5 Hz
Speed range	0 – 535 RPM
Number of poles	5
Stator rated current	13 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	20100900245
Controller	
Manufacturer	SUMEC Manufacturing Venture Co., Ltd.
Model	PWC02-B-48
Software version	Wind version 2011010102
Type/technology	Full power
Rated voltage	48 VDC
Frequency	27.5Hz
Capacity	2KVA
Rated current	32 A
Cooling method	Nature air cooling
IP Protection	IP54
Serial number	2011012000262
Control / Electrical System	
Power Regulation (e.g. pitch, stall, active stall)	Use yawing to control power. For PWB02-40-48 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	210 mm



Diameter of bottom flange	550 mm
Battery Bank	
Manufacturer	Jiangsu Huafu Energy Co., Ltd
Type	6-CN-200
Voltage	48V
Battery capacity	400AH

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

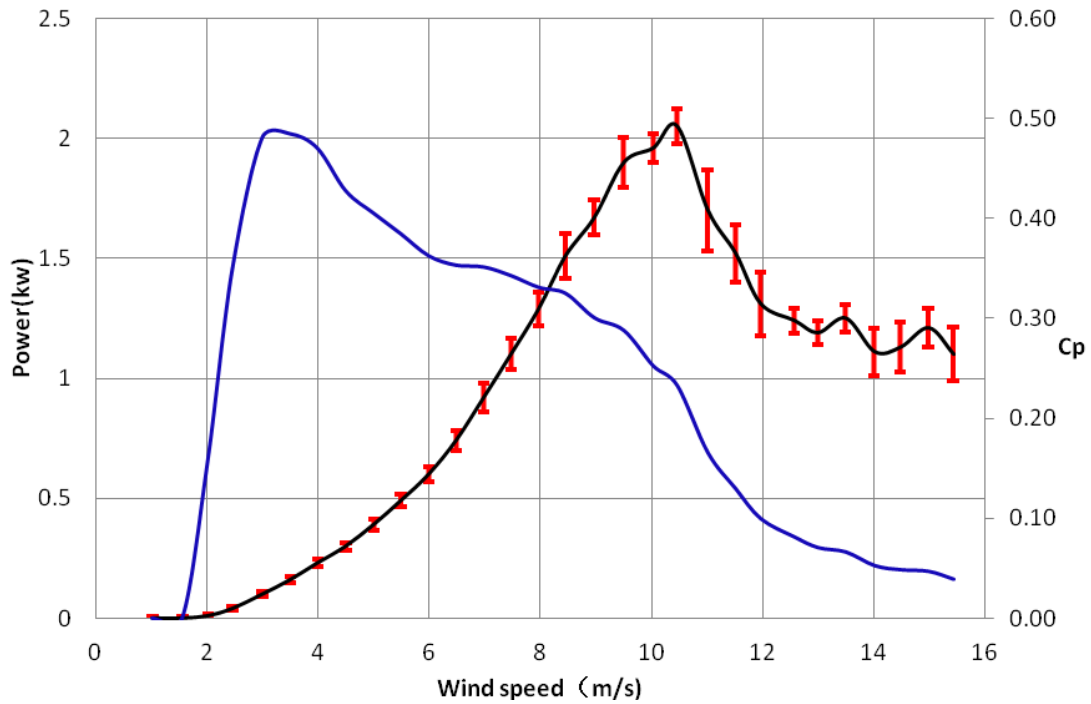


Figure 1 – Normalized Power curve and Coefficient of performance at sea-level density for the PWB02-40-48; 1.225 kg/m³

4.0 Acoustic Test Summary

Below is a summary of the test results for the PWB02-40-48 wind turbine noise over a range of wind speeds and directions. Characterizations of 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.

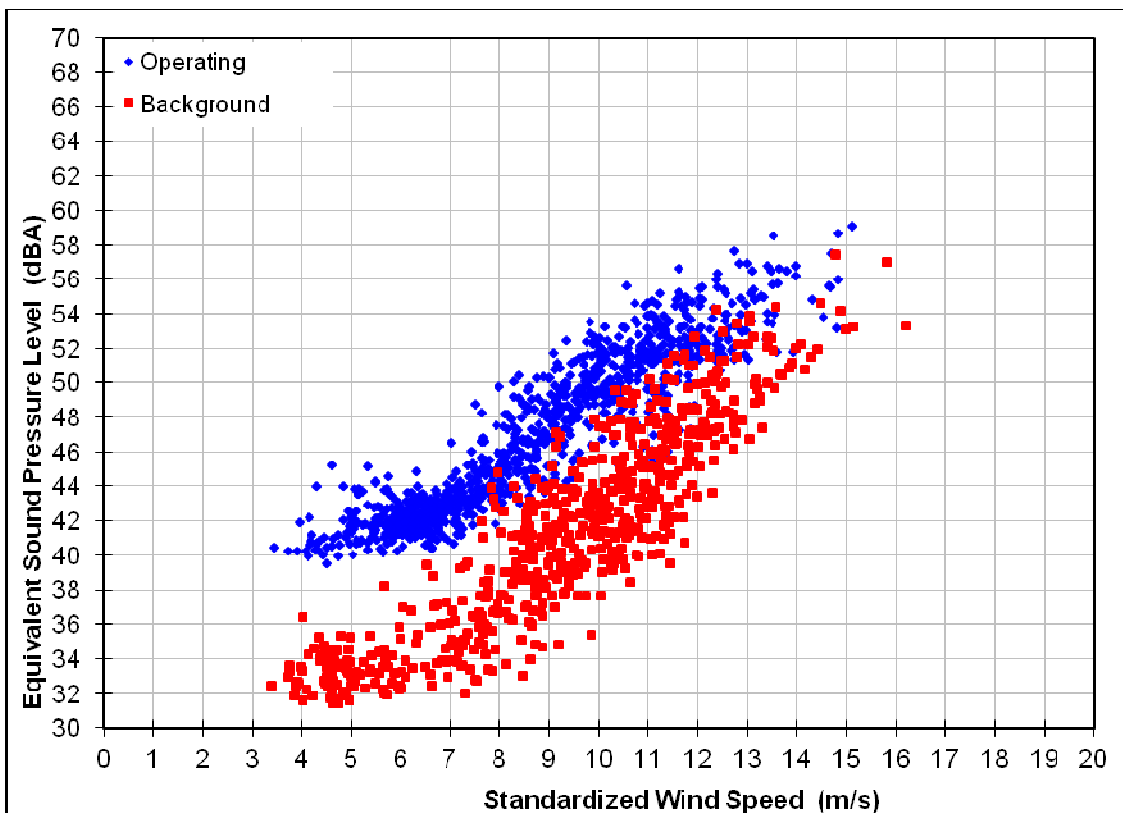


Figure 2 – Ls+n & Ln against 10m height wind speed for the PWB02-40-48

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.

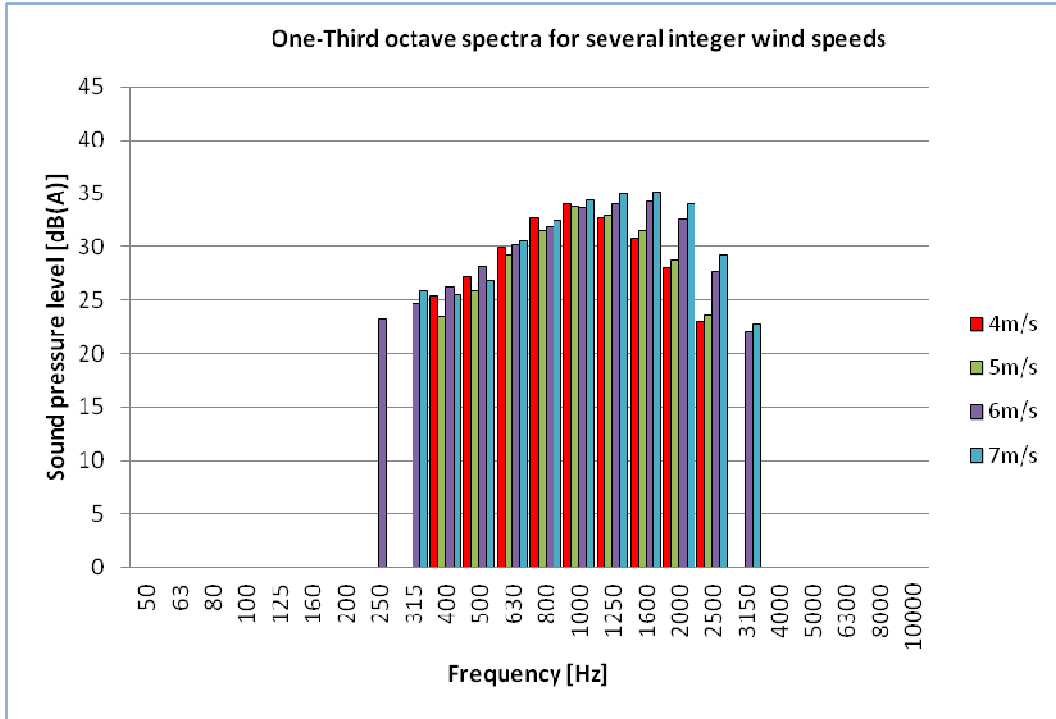


Figure 3 – One-third octave spectra (4m/s-7m/s)

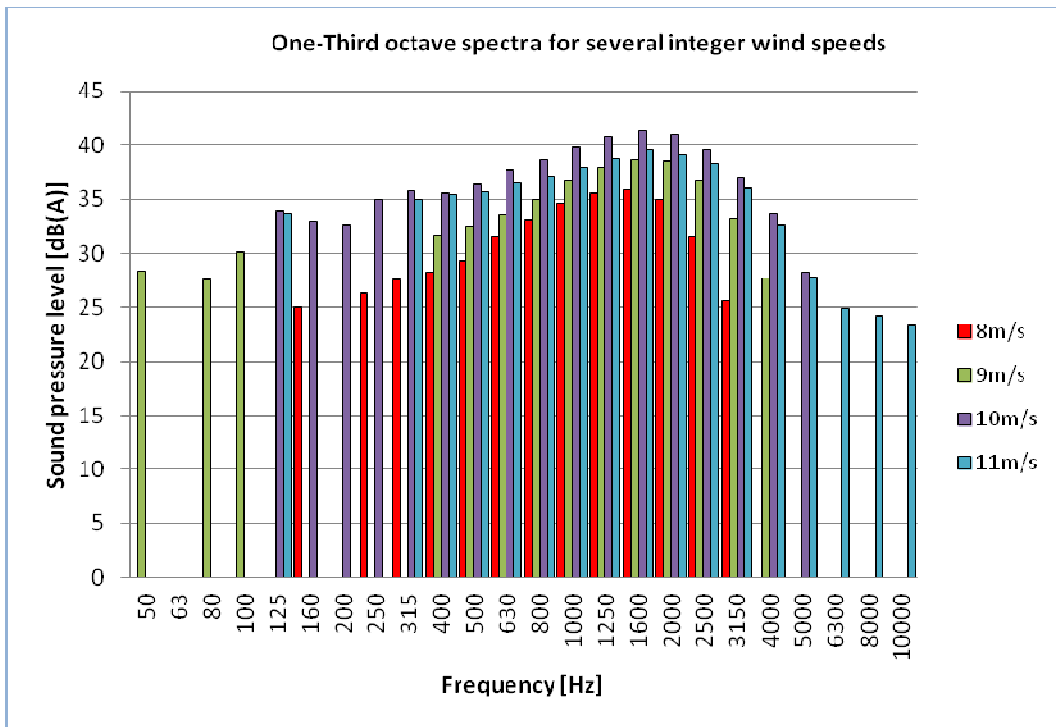


Figure 4 – One-third octave spectra (8m/s-11m/s)

Freq [Hz]	4m/s		5m/s		6m/s		7m/s	
	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	-	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-
100	-	-	-	-	-	-	-	-
125	-	-	-	-	-	-	-	-
160	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-
250	-	-	-	-	*23.2	1.7	-	-
315	-	-	-	-	*24.7	1.3	*25.9	1.6
400	25.3	2.2	*23.5	1.3	*26.2	1.9	*25.5	1.4
500	27.3	1.7	25.8	1.2	28.2	1.7	26.9	1.3
630	29.9	1.3	29.3	1.2	30.2	1.2	30.5	1.2
800	32.7	1.6	31.6	1.3	31.9	1.2	32.5	1.2
1000	34.0	1.3	33.8	1.3	33.7	1.2	34.4	1.2
1250	32.7	1.4	33.0	1.4	34.1	1.2	34.9	1.2
1600	30.8	1.5	31.5	1.6	34.2	1.2	35.2	1.2
2000	28.0	1.4	28.7	1.7	32.7	1.2	34.0	1.3
2500	*23.0	1.3	*23.6	1.5	27.7	1.3	29.2	1.3
3150	-	-	-	-	*22.1	1.3	*22.8	1.2
4000	-	-	-	-	-	-	-	-
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

Freq [Hz]	8m/s		9m/s		10m/s		11m/s	
	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	-	-	*28.4	3.2	-	-	-	-
63	-	-	-	-	-	-	-	-
80	-	-	*27.6	2.9	-	-	-	-
100	-	-	*30.1	1.9	-	-	-	-
125	-	-	-	-	*33.9	1.3	*33.7	1.9
160	*25.1	1.2	-	-	*33.0	2.6	-	-
200	-	-	-	-	*32.6	2.0	-	-
250	*26.3	1.2	-	-	*35.0	1.8	-	-
315	*27.6	1.2	-	-	*35.7	2.1	*35.0	1.3
400	*28.3	1.2	*31.6	1.4	*35.5	1.8	*35.4	1.2
500	29.3	1.2	*32.6	1.4	36.4	1.7	*35.6	1.2
630	31.5	1.3	*33.6	1.3	37.7	1.9	*36.5	1.4
800	33.1	1.5	35.0	1.4	38.6	1.8	*37.2	1.5
1000	34.6	1.6	36.8	1.5	39.7	1.7	*37.9	1.8
1250	35.5	1.4	37.9	1.4	40.8	1.5	*38.7	2.3
1600	35.8	1.3	38.7	1.4	41.4	1.5	39.6	2.9
2000	34.9	1.3	38.5	1.3	41.1	1.4	39.1	3.1
2500	31.4	1.2	36.8	1.2	39.6	1.3	38.3	3.1
3150	*25.6	1.2	33.2	1.3	37.0	1.2	36.0	2.6
4000	-	-	*27.6	1.3	33.7	1.2	32.6	2.0
5000	-	-	-	-	*28.3	1.3	27.8	1.9
6300	-	-	-	-	-	-	*25.0	2.5
8000	-	-	-	-	-	-	*24.3	2.1
10000	-	-	-	-	-	-	*23.3	1.9

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	2901.01	177.53	6.12%	2901.09	Complete
5	4655.00	262.19	5.63%	4660.44	Complete
6	6188.21	335.40	5.42%	6241.67	Complete
7	7238.80	385.77	5.33%	7450.49	Complete
8	7780.18	411.75	5.29%	8294.49	Incomplete
9	7910.14	417.64	5.28%	8845.54	Incomplete
10	7755.97	409.40	5.28%	9170.11	Incomplete
11	7428.07	392.37	5.28%	9316.02	Incomplete

Table 6 – Estimated annual energy production of the PWB02-40-48 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** **4,655.00 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:

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

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

Using the equations above: **AWEA Rated Sound Level, L_{AWEA} : 36.9 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	4.2	41.0	32.8	40.3	69.3	1.3
5	5.1	41.5	33.8	40.7	69.7	1.5
6	6.1	42.5	34.7	41.7	70.7	1.0
7	6.9	43.8	36.7	42.9	71.9	1.3
8	8.0	45.5	38.5	44.5	73.5	2.0
9	9.0	48.0	41.3	47.0	76.0	2.1
10	10.0	49.9	43.4	48.8	77.8	1.9
11	11.0	51.7	46.0	*50.4	*79.4	2.2
12	12.0	53.1	48.1	*51.8	*80.9	2.3

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: 1.70 kW

8.0 Strength and Safety Test Results

The SUMEC PWB02-40-48 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 PWB02-40-48 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 PWB02-40-48 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 SH10070988-002) for the design documentation and calculation provided by Sumec with the structural design requirements of the above referenced standard.

The PWB02-40-48 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	2kW Tower
Tower Type	Octagonal tubular steel
Height	10m
Diameter of head flange	210 mm
Diameter of bottom flange	550 mm
Quality	480 kg
Thickness	8 mm

Table 8 –Tower design data for the test turbine for the PWB02-40-48

Wind Turbine Type	-	PWB02-40-48
Maximum tower top forces Load Case H	$F_{x-shaft}$ (N)	9287.227
	F_{tower} (N) *	13674.75
	$F_{front, nacelle}$ (N) **	699.68
Maximum tower top bending moment (fore - aft) Load Case B	M_{shaft} (Nm)	3605.71
Maximum tower top bending moment (side - side) Load Case G	$M_{x-shaft}$ (Nm)	654.64
* 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 PWB02-40-48



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 March 04, 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 11 months, or 334 days, from April 01, 2011 through March 04, 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.

Month	Hours of Power Production Above(hour):			Max Wind Speed	TI @15m/s	Data Points	T _T	T _U	T _E	T _N	O
	0m/s	9m/s	15m/s	m/s	%	Points	(hours)	(hours)	(hours)	(hours)	%
Overall	4444.7	342.4	27.5	18.2	0.73	82	7718.9	665.9	196	343.8	95.5
2011											
Apr	418.7	25.3	1.7	17.1	0.83	6	686.3	75.3	34	64	88.9
May	372.2	43	1.8	17	0.95	14	724.8	71	33	52.8	91.5
Jun	388.2	52.8	0.5	16.6	1.06	15	697.8	68.7	11	43.8	92.9
Jul	331.3	17	0	13.4	0	0	715	61.2	17	31.3	95.1
Aug	364.3	4.3	1.7	16.6	1.01	18	733.7	65.7	20	33.5	94.8
Sep	415	20.7	0.2	15.9	1.09	7	716.5	44.5	48	5.5	99.1
Oct	402.7	44.8	0	13.5	0	1	732.7	47.7	22	43	93.5
Nov	417.2	35	11.8	19.4	1.10	9	664.8	43.5	11	46.2	94.2
Dec	407.3	22	1.8	16.4	1.00	3	634.8	57.8	0	8.2	98.6
2012											
Jan	400.2	29.8	0	11.3	1.00	3	634.8	57.8	0	8.2	98.6
Feb	461.8	44.2	4.7	18.4	0.70	6	682	48.7	0	18	97.2
Mar	65.7	3.5	3.3	18.2	0.00	0	95.7	24	0	0.3	99.5

Table 10 – Monthly and overall results of the duration test for the PWB02-40-48

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 **95.5%**. 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 PWB02-40-48 is deemed to **PASS the Duration Test.**

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

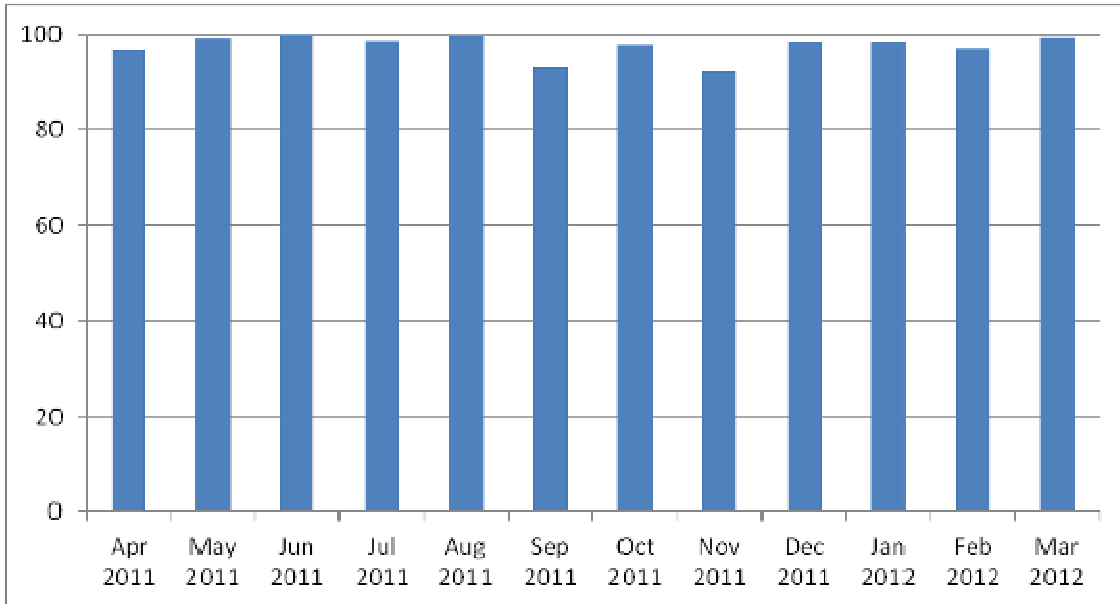


Figure 5 – The operational time fraction per month for PWB02-40-48

The operational time was 343.8 hours during which the turbine was non-operational (T_N). Total operational time amounts to 7718.9 hours. As for the time excluded from the analysis, T_E , which totalled 196 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 665.9 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 0.73%.

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.

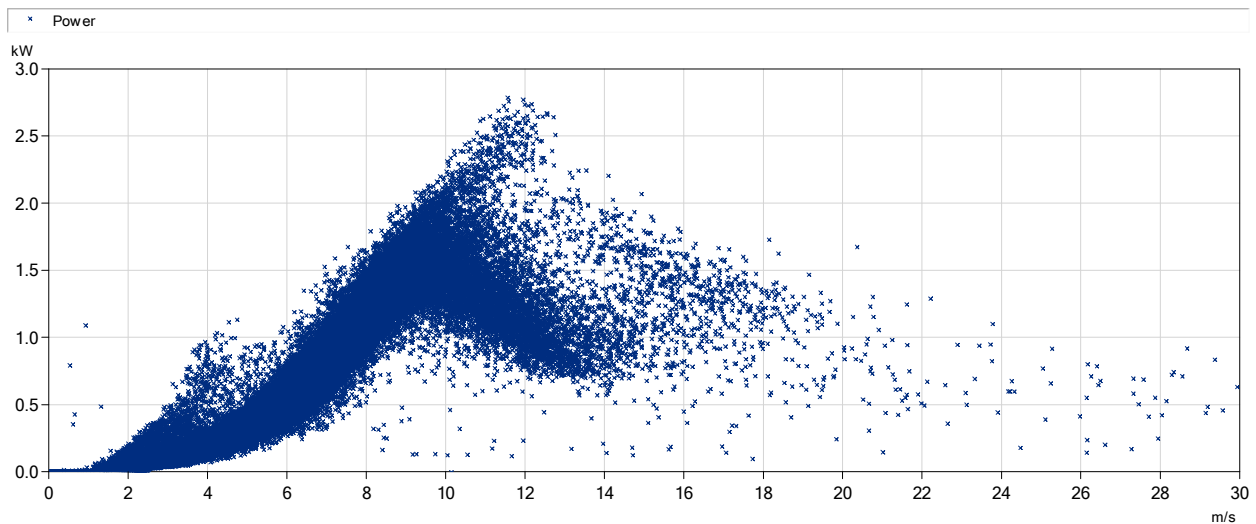


Figure 6 – Scatter plot of power curve

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.

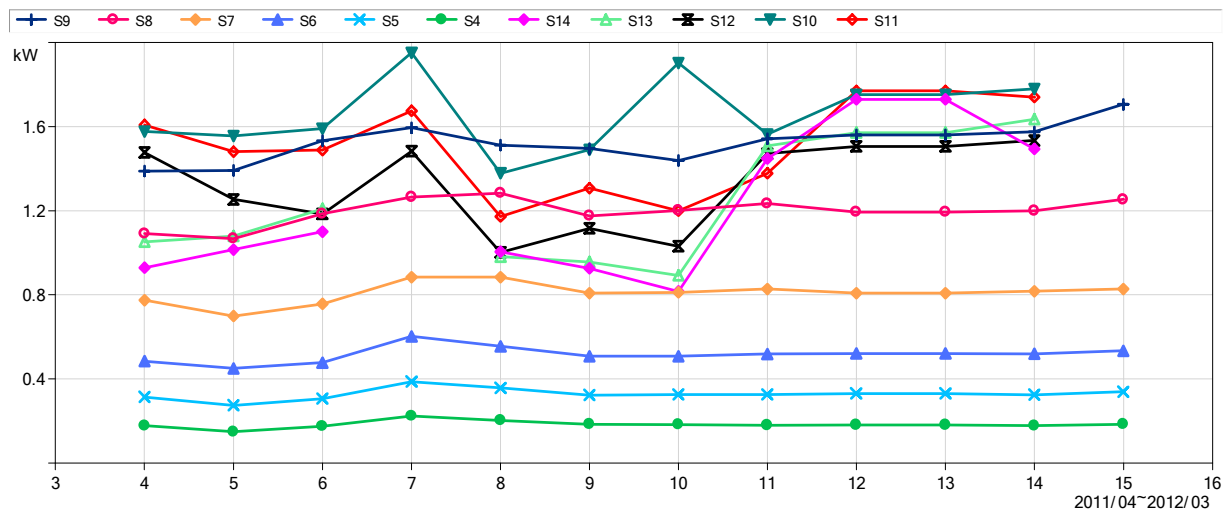


Figure 7 – Power level in several wind speed bins (in m/s) as a function of time



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 PWB02-40-48.