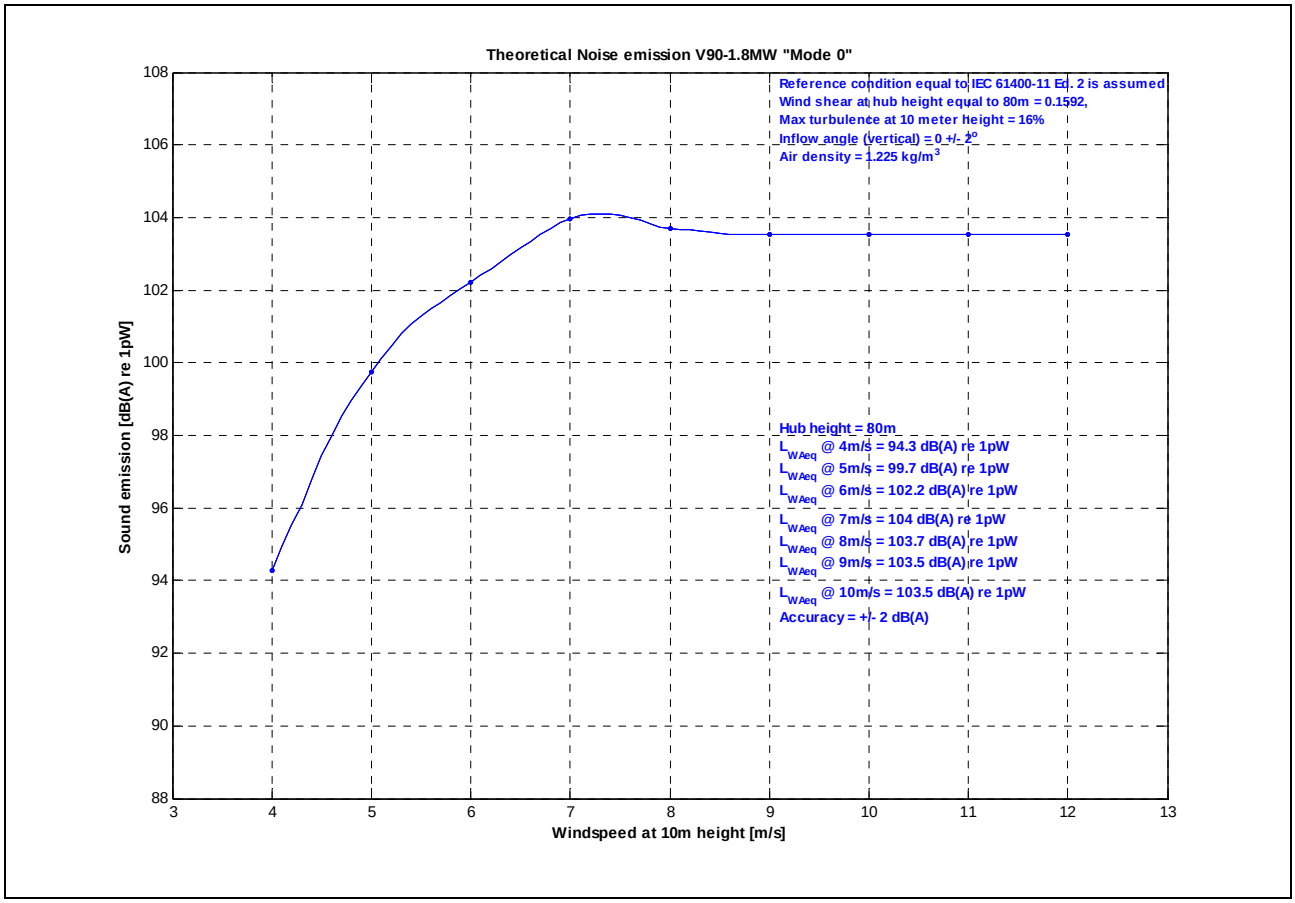
WIND TURBINE GENERATOR (WTG)

SOUND POWER LEVEL SPECIFICATION

AS PER IEC-61400-11:2002 (WIND TURBINE GENERATOR SYSTEMS – PART 11: ACOUSTIC NOISE MEASUREMENT TECHNIQUES)

The following are the official test reports from Vestas for the V90, V100 and V112 models. This data forms the basis of the noise predictions for Paling Yards Wind Farm. The data is considered commercial in confidence and may not be reproduced without the permission of the manufacturer.

2.4 Noise Curves, Calculated



	Theoretical Sound Power Level at Hub Height, V90-1.8MW "Mode 0"				
	Conditions for Sound Power Level	Verification standard : IEC 61400-11 Ed. 2 Wind shear as described in table below. Max turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2° Air density: 1.225 kg/m^3 Accuracy: ± 2 dB(A)			
	Hub height	HH 80 m			
	Wind shear	0.1592			
	Verification Report: "Theoretical"				
		dB(A) re 1pW			
	L_{WA} @ 4m/s (10 meter above ground)	94.3			
	L_{WA} @ 5m/s (10 meter above ground)	99.7			
	L_{WA} @ 6m/s (10 meter above ground)	102.2			
	L_{WA} @ 7m/s (10 meter above ground)	104.0			
	L_{WA} @ 8m/s (10 meter above ground)	103.7			
	L_{WA} @ 9m/s (10 meter above ground)	103.5			
	L_{WA} @ 10m/s (10 meter above ground)	103.5			
	L_{WA} @ 11m/s (10 meter above ground)	103.5			
	L_{WA} @ 12m/s (10 meter above ground)	103.5			
	L_{WA} @ 95% Rated Power (7.6 m/s, 10 meter above ground)	104.0			

Annex 4.3: A-weighted sound pressure 1/3-octave spectrum at 8 m/s

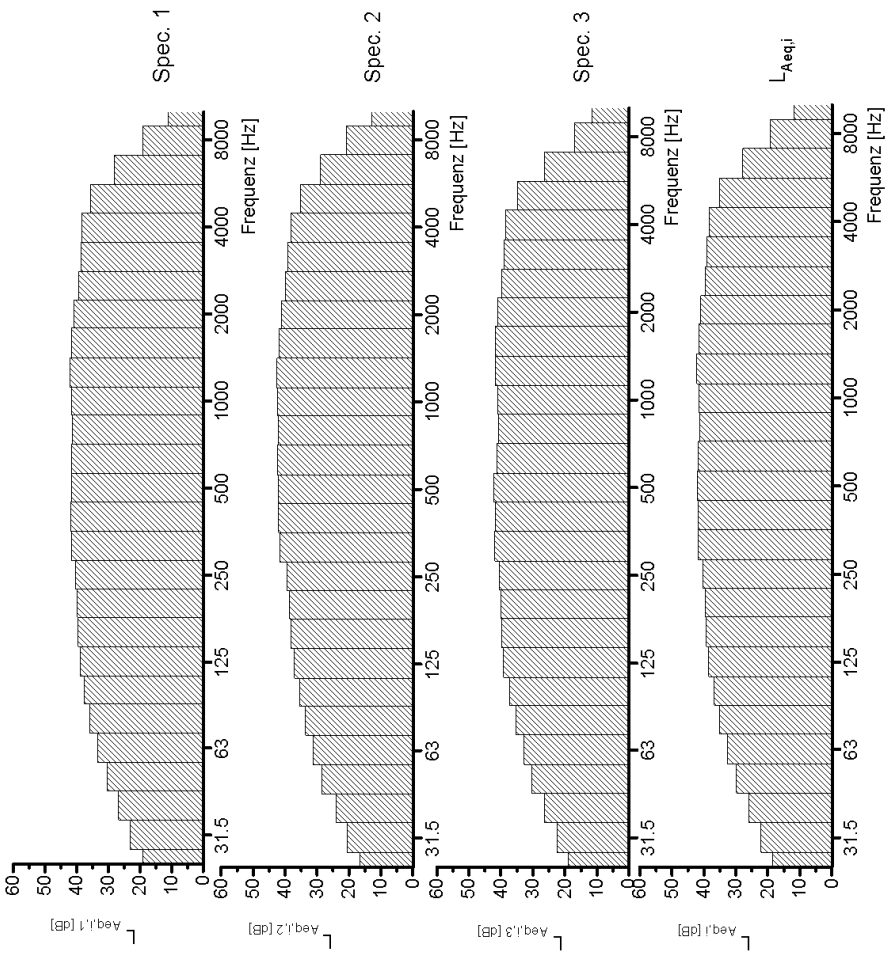
reference sound pressure/
Referenz - Schalldruck - Betrieb $L_{Aeq,c}$ = 52.6 dB

reference background sound pressure
Referenz - Schalldruck - Hintergrund $L_{Aeq,n}$ = 44.2 dB

reference sound power
Referenz - Schallleistung L_{WA} = 102.8 dB

reference wind speed
Referenz - Windgeschwindigkeit WS 10m = 8 m/s

f [Hz]	Spec. 1 [dB]	Spec. 2 [dB]	Spec. 3 [dB]	$L_{Aeq,i}$ [dB]	$L_{WA,i}$ [dB]	U_a [dB]	U_c [dB]
25	19.1	16.7	19.1	18.4	68.0	1.4	2.4
31.5	23.1	20.5	22.5	22.1	71.7	1.3	2.4
40	26.8	24.1	26.4	25.9	75.5	1.5	2.5
50	30.2	28.6	30.5	29.9	79.5	1.0	2.2
63	33.3	31.2	32.8	32.5	82.1	1.1	2.3
80	35.9	33.5	35.5	35.1	84.7	1.3	2.4
100	37.5	35.4	37.4	36.9	86.5	1.2	2.3
125	39.0	37.0	39.2	38.5	88.1	1.2	2.3
160	39.5	38.1	39.8	39.2	88.8	0.9	2.2
200	39.8	38.6	40.1	39.5	89.1	0.8	2.1
250	40.5	39.5	40.7	40.2	89.8	0.7	2.1
315	41.8	41.5	41.9	41.8	91.4	0.2	2.0
400	41.8	42.0	41.8	41.9	91.5	0.1	2.0
500	41.8	42.2	42.4	42.1	91.7	0.3	2.0
630	41.5	42.4	41.2	41.7	91.3	0.7	2.1
800	41.4	42.1	40.8	41.5	91.1	0.7	2.1
1000	41.6	42.3	41.0	41.7	91.3	0.7	2.1
1250	42.2	42.6	41.8	42.2	91.8	0.4	2.0
1600	41.6	41.9	41.6	41.7	91.3	0.2	2.0
2000	40.7	41.2	41.1	41.0	90.6	0.2	2.0
2500	39.4	40.0	39.8	39.7	89.3	0.3	2.0
3150	38.7	39.2	39.1	39.0	88.6	0.3	2.0
4000	38.4	38.2	38.5	38.4	88.0	0.2	2.0
5000	35.7	35.2	34.9	35.3	84.9	0.4	2.0
6300	28.2	28.9	26.4	28.0	77.6	1.3	2.4
8000	19.2	20.7	16.9	19.2	68.8	1.9	2.8
10000	11.2	12.9	11.6	12.0	61.6	0.9	2.2



WINDTEST
Kaiser-Wilhelm-Koog GmbH

V90-2MW (Mode 0) V18864

One third octave analysis / Terzanalyse

Site / Standort: Schönhagen
Measurem. / Messdatum: 2005-03-11
Standard / Messung: FGW / IEC
In charge / Bearbeiter: Dipl.-Ing. Jörg Dedert

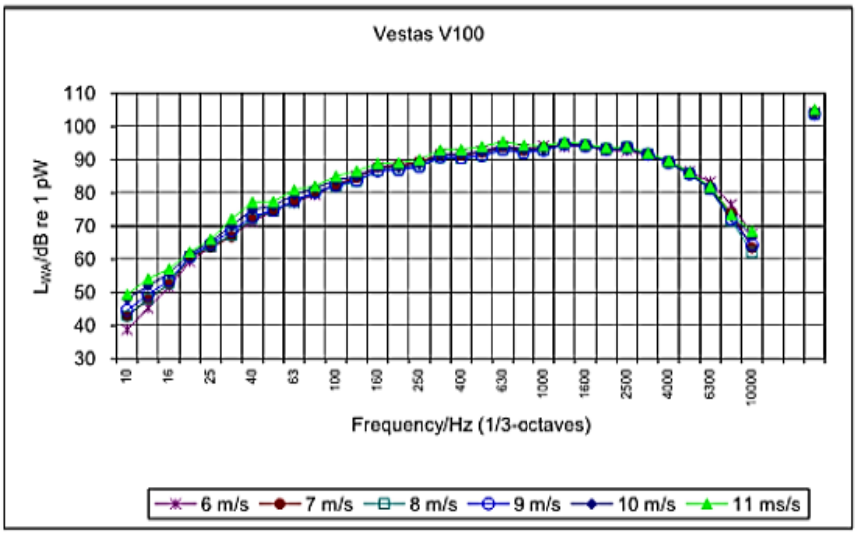
12.1.3 Mode 0, Sound Power Levels

Sound Power Level at Hub Height, Mode 0		
Conditions for Sound Power Level	**Verification standard: IEC 61400-11 Ed. 2. Wind shear 0.15. Max turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2° Air density: 1.225 kg/m^3**	
Hub Height	80 m	95 m
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	94.0 4.2	94.1 4.3
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	96.2 5.6	96.6 5.7
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	100.1 7.0	100.7 7.2
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.9 8.4	104.4 8.6
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 9.8	105.0 10.0
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 11.2	105.0 11.5
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 12.6	105.0 12.9
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 13.9	105.0 14.3
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 15.3	105.0 15.8
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 16.7	105.0 17.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	105.0 18.1	105.0 18.6

Table 12-3: Sound power level at hub height: Mode 0.

Graph Sheet 4: 1/3-octave band spectra from reference position

Numbers in *Italic* indicates that the difference between total noise and background noise was less than 3 dB.



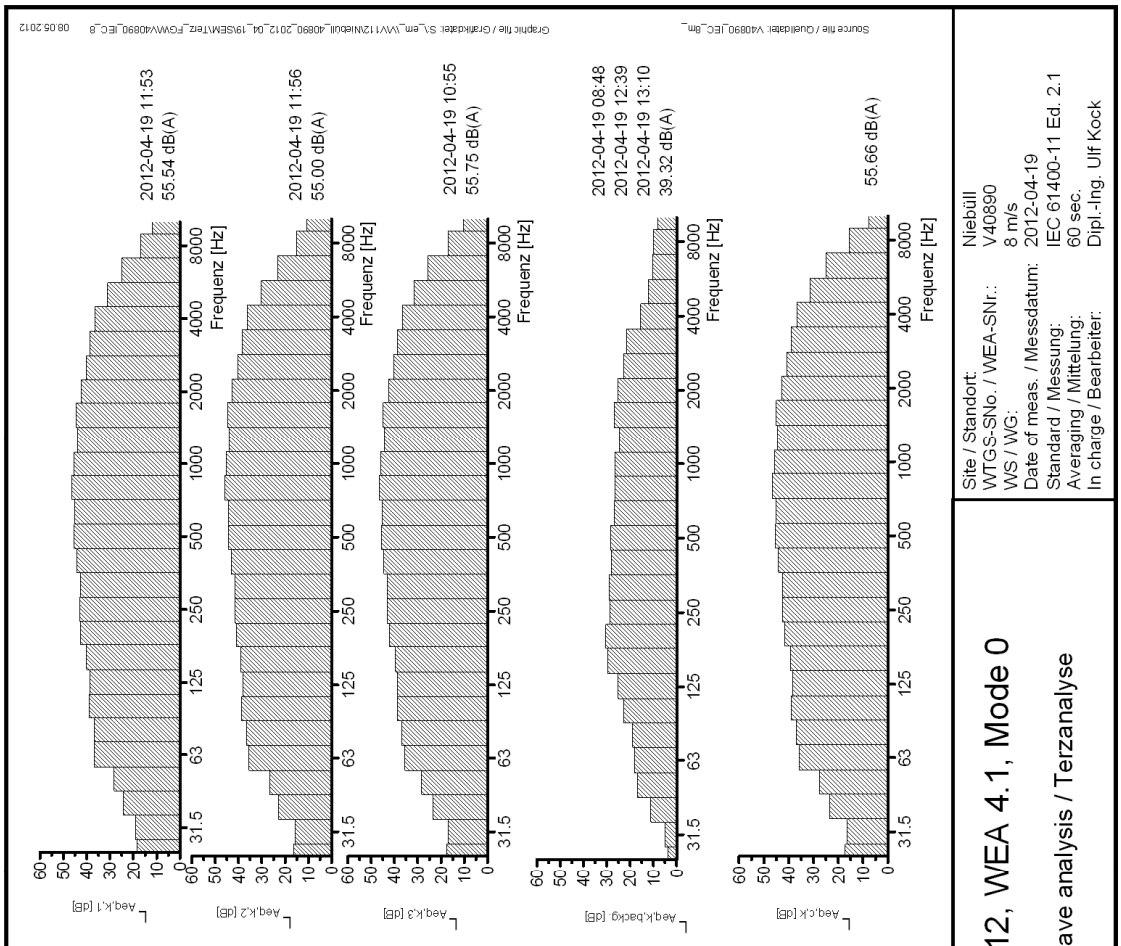
Frequency	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 ms/s
10	38.8	42.8	43.0	44.7	48.1	49.5
12.5	45.4	47.9	48.1	49.4	52.0	54.1
16	51.6	52.6	52.7	53.7	55.8	57.1
20	59.4	60.6	60.7	60.9	61.6	62.2
25	63.9	63.6	64.1	64.7	65.4	66.0
31.5	67.2	66.9	67.3	68.7	70.2	72.2
40	71.4	72.3	72.4	72.9	75.0	77.3
50	74.4	74.7	74.7	74.8	76.1	77.4
63	77.2	77.5	77.3	77.7	79.5	80.9
80	79.4	80.3	80.2	80.2	81.5	82.1
100	82.6	82.5	82.1	82.4	83.9	85.1
125	85.0	84.6	83.5	83.9	85.1	86.7
160	87.9	87.8	86.8	86.7	87.7	89.0
200	88.5	88.2	87.1	87.0	87.8	89.1
250	89.3	89.4	88.1	88.0	88.7	90.1
315	91.5	91.7	90.7	90.9	91.6	93.0
400	91.6	91.4	90.5	90.7	91.7	93.1
500	92.7	92.2	91.2	91.3	92.4	94.0
630	94.2	93.8	93.2	93.1	94.0	95.5
800	93.3	92.7	92.1	92.2	93.0	94.4
1000	94.3	93.6	92.9	92.8	93.3	94.3
1250	94.0	94.8	94.9	94.6	94.8	95.4
1600	94.2	94.5	94.4	94.1	94.2	94.8
2000	93.0	93.3	93.3	93.1	93.2	93.7
2500	92.7	93.5	93.8	93.6	93.7	93.9
3150	91.6	91.7	91.7	91.6	91.8	92.0
4000	89.5	89.2	89.2	89.2	89.5	89.7
5000	86.5	85.8	85.7	85.8	86.0	86.3
6300	83.3	81.9	81.2	81.3	81.7	81.9
8000	76.5	73.8	71.6	72.2	73.0	73.6
10000	67.7	63.4	*62.1*	64.3	67.0	68.5
L_{WA}	104.3	104.3	103.9	103.8	104.4	105.3

12.1.3 Noise Curve, Noise Mode 0

Sound Power Level at Hub Height, Noise Mode 0			
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 2 2002** **Wind shear: 0.16** **Maximum turbulence at 10 metre height: 16%** **Inflow angle (vertical): 0 ±2°** **Air density: 1.225 kg/m^3**		
Hub Height	**84 m**	**94 m**	**119 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	94.5 4.2	94.5 4.3	94.7 4.5
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	97.3 5.6	97.5 5.7	98.1 5.9
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	100.9 7.0	101.2 7.2	101.9 7.4
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.3 8.4	104.6 8.6	105.1 8.9
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.0 9.8	106.5 10.0	106.5 10.4
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 11.2	106.5 11.4	106.5 11.9
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 12.7	106.5 12.9	106.5 13.4
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 14.1	106.5 14.3	106.5 14.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 15.5	106.5 15.7	106.5 16.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 16.9	106.5 17.2	106.5 17.8
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 18.3	106.5 18.6	106.5 19.3

Table 12-3: Noise curve, noise mode 0

Annex 4.3: A-weighted sound pressure 1/3-octave spectrum at 8 m/s



f	Spec. 1	Spec. 2	Spec. 3	Backg.	$L_{Aeq,c,k}$	$L_{WA,k}$	U_a	U_c
[Hz]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]
10	-5.5	-8.6	-6.5	-16.5	-7.6	41.8	1.6	2.5
13	2.9	0.0	1.7	-9.0	0.9	50.3	1.5	2.5
16	4.8	0.8	2.7	-9.1	1.9	51.3	2.0	2.8
20	17.1	16.7	16.1	-0.2	16.7	66.0	0.5	2.1
25	18.5	16.4	17.6	3.7	17.2	66.6	1.0	2.2
32	18.9	15.5	17.0	4.9	16.4	65.8	1.7	2.6
40	24.4	22.9	23.5	11.1	23.3	72.7	0.8	2.1
50	28.3	26.7	28.4	16.9	27.6	77.0	1.0	2.2
63	36.8	35.4	35.5	18.1	35.8	85.2	0.8	2.1
80	36.8	36.6	37.0	18.9	37.1	86.5	0.2	2.0
100	39.0	38.7	38.7	22.8	39.0	88.4	0.2	2.0
125	38.6	38.1	38.7	25.1	38.6	88.0	0.3	2.0
160	40.0	39.1	39.6	29.6	39.3	88.6	0.5	2.0
200	42.6	41.0	42.1	30.4	41.6	91.0	0.8	2.1
250	43.0	41.5	43.1	28.8	42.6	92.0	0.9	2.2
315	42.9	41.5	43.1	29.0	42.6	92.0	0.9	2.2
400	44.2	43.2	44.5	28.2	44.2	93.5	0.7	2.1
500	45.3	44.5	45.7	28.5	45.4	94.8	0.6	2.1
630	45.0	44.4	45.4	26.9	45.2	94.6	0.5	2.0
800	46.4	45.9	46.6	26.5	46.6	96.0	0.4	2.0
1000	45.5	45.2	45.9	26.5	45.9	95.2	0.3	2.0
1250	43.9	43.9	44.3	24.6	44.4	93.8	0.2	2.0
1600	44.4	44.7	44.9	26.9	45.1	94.5	0.2	2.0
2000	42.4	42.7	42.6	25.2	42.9	92.3	0.2	2.0
2500	40.1	40.2	40.3	22.7	40.6	89.9	0.1	2.0
3150	38.6	38.5	38.8	21.6	38.9	88.3	0.2	2.0
4000	36.5	36.2	36.4	15.4	36.7	86.0	0.2	2.0
5000	31.1	30.1	31.6	12.1	31.3	80.6	0.8	2.1
6300	25.0	23.3	25.6	10.2	24.8	74.2	1.2	2.3
8000	16.8	15.0	17.2	9.9	15.5	64.9	1.1	2.3
10000	11.9	10.7	10.4	8.2	7.6	57.0	0.8	2.1
12500	9.2	8.1	7.3	5.7	4.4	53.7	1.0	2.2
16000	5.7	4.9	4.0	2.6	1.0	50.4	0.8	2.2

created with WINDTEST TuNES version: 11.1-0004

GL Garrad Hassan

Vestas V112, WEA 4.1, Mode 0

One third octave analysis / Terzanalyse

Site / Standort: Niebüll
WTGS-SNo. / WEA-SNr.: V40890
WS / WG: 8 m/s
Date of meas. / Messdatum: 2012-04-19
Standard / Messung: IEC 61400-11 Ed. 2.1
Averaging / Mittelung: 60 sec.
In charge / Bearbeiter: Dipl.-Ing. Ulf Kock

5 Summary

As ordered by Vestas Wind Systems A/S, 8940 Randers, Denmark, GL Garrad Hassan Deutschland GmbH took measurements of the acoustic noise emissions on the WTGS Vestas V112 - 3.0 MW with a hub height of 94 m.

All measurements and analysis of the sound power level and tonality described in this report were made on the basis of the international standard [IEC 61400-11 Ed. 2.1]. The analysis of the sound power level was carried out using the standardised wind speed which was calculated from the calculated power curve provided by the customer (see annex).

The data of the WTGS Vestas V112 - 3.0 MW (mode 0) have been evaluated by using a fourth order regression because this is the best fitting approximation over all relevant points.

The results of this measurement are given in table 4.

Table 4: Summary of results

wind speed in 10 m height [m/s]	***6***	***7***	***8***	***9***	***10***
electrical power output calculated from the power curve [kW]	*1676*	*2548*	*3032*	*3074*	*3075*
measured pitch angle [degrees]	*-2,1*	*-3,4*	*0*	*5*	*8*
measured rotor speed [min^{-1}]	*12,3*	*12,7*	*12,9*	*12,9*	*12,9*
sound power level [dB]	*103,6*	*104,7*	*103,3*	*101,3*	*103,0**
combined uncertainty in the sound power level, U_C [dB]	*1,1*	*1,2*	*1,8*	*2,3*	*1,9*
tonality, ΔL_k [dB]	*-5,31*	*-5,05*	*-15,28*	*-13,9*	*-11,21*
tonal audibility, $\Delta L_{a,k}$ [dB]	*-1,97*	*-3,04*	*-13,27*	*-11,88*	*-9,19*
frequency of the most prevalent tone [Hz]	*1690*	*126*	*126*	*126*	*126*

* The sound power level has to be calculated by used of the 4th order regression. This leads to an unexpected high value for the sound power level. (see annex 2.1)

It is assured that this report has been drawn up impartially and with best knowledge and conscience.