



TESTING CERT #2564.01



Acoustic Noise Measurement Summary

Northern Power Systems NW100 at Concordia, Kansas

Report No. ANRP0103

Version: A

This measurement was conducted in accordance with the IEC 61400-11 Ed 2.1:
Wind turbine generator systems – Part 11: Acoustic noise measurement techniques (2006)

Issue Date: February 9, 2011

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Turbine Information

Turbine Model:	Northern Power Systems NW100
Turbine Location:	Concordia, Kansas
Turbine ID:	75
Rated Power:	100 kW
Rated Wind Speed:	15 m/s
Cut-in Wind Speed (ref air density):	4.0 m/s
Cut-out Wind Speed:	25 m/s
Rotor Speed:	35 – 60 rpm
Rotor Diameter:	20.9 m
Hub Height:	30 m
Blade Model:	Knight and Carver
Pitch Angle:	Fixed

Measurement Details

Sound Level Meter:	Delta Noiselab 3.0.16
Sound Level Meter Calibration:	Scantek January 21, 2011
Microphone with Preamplifier:	PCB 378B02
Microphone Calibration:	Scantek November 12, 2010
Anemometer:	Windsensor P2546A 2348
Anemometer Calibration:	Svend Ole Hansen March 29, 2010
Acoustic Calibrator:	Larson Davis CAL200
Acoustic Calibrator Date, Lab:	Scantek December 12, 2010
Test Period:	December 12, 2010 00:21 – 07:59
Average Air Density:	1.292 kg/m ³
Average Air Temperature:	-12.2°C
Test Site Description:	Gently rolling terrain, high plains, roughness z ₀ = 0.05m

Exceptions to the Test Standard:

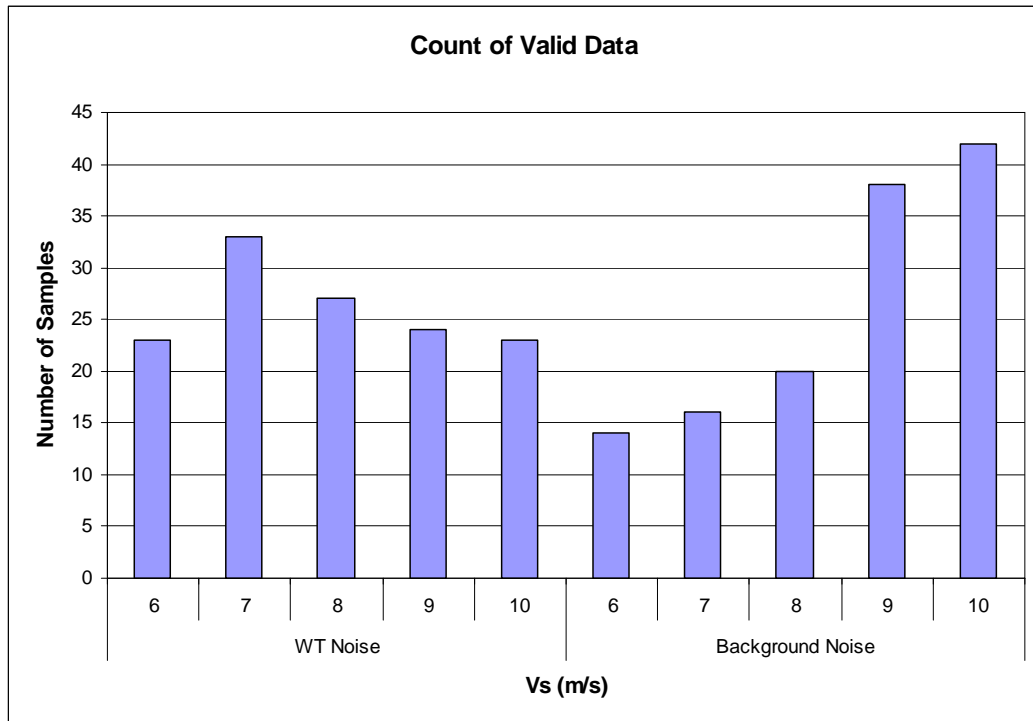
1. Wind direction was determined from the nacelle yaw position instead of a wind direction transducer. Utilizing yaw position often provides better correlation to noise than does a wind direction transducer.
2. The power curve used to determine wind speed for turbine operating measurements was measured on the same type of wind turbine although with different controller parameter settings than those in use during the measurement. Additional uncertainty was assigned to the calculated sound power levels reported herein to accommodate this limitation.
3. The power signal was obtained from the turbine controller, instead of from an independent measurement system. Previous performance testing on this type of turbine determined the power signal to be a reliable measure.
4. Uncertainty on tonality levels has not been included.

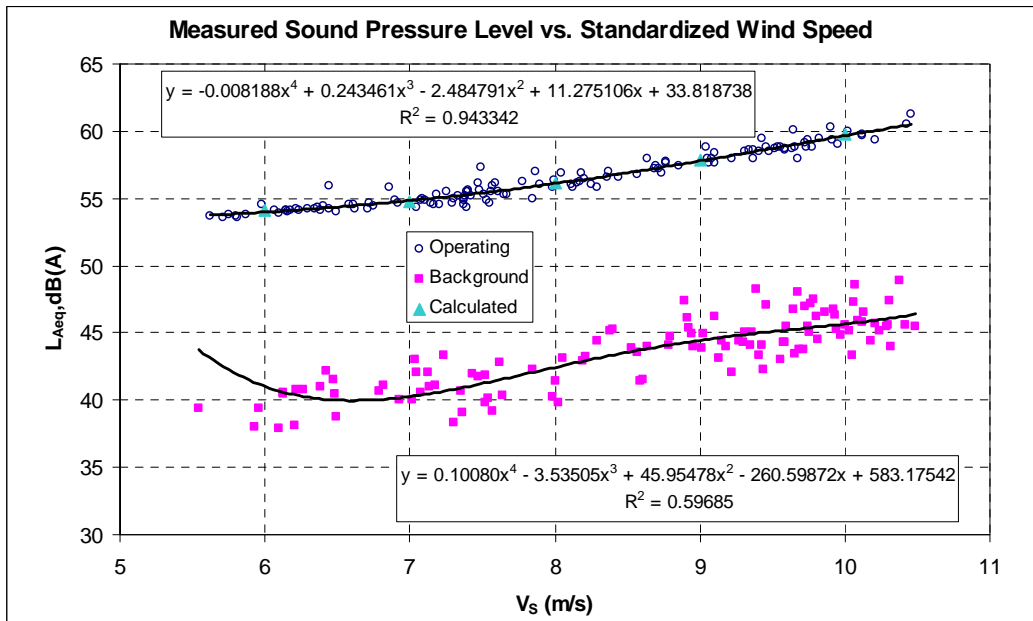
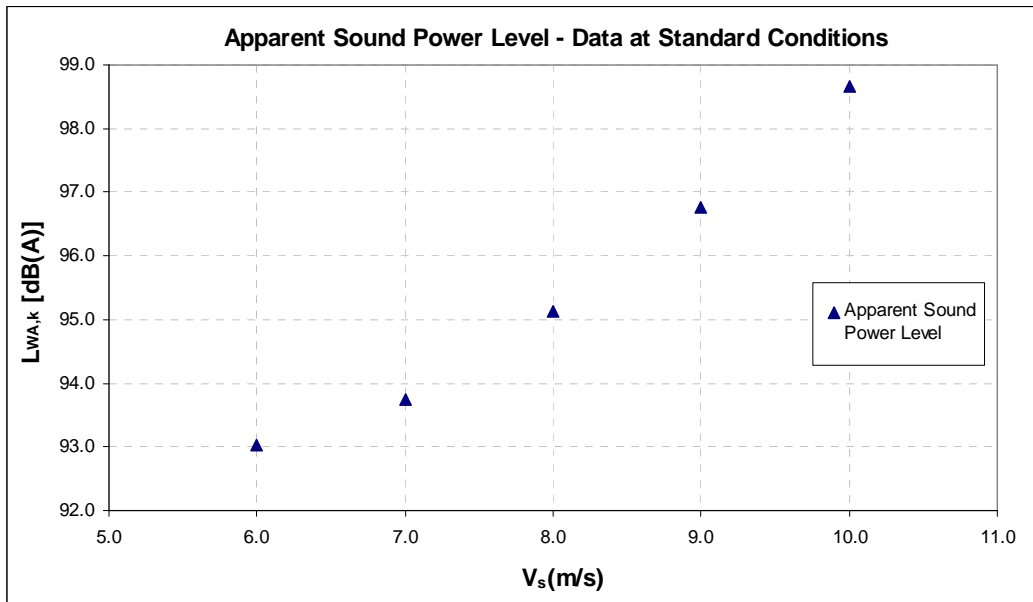
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Wind Turbine Noise Summary for NW100 at Cloud County Community College					
Integer Wind Speed, V_s (m/s)	6	7	8	9	10
Wind Turbine + Background Sound Pressure Levels, $L_{Aeq,k}$ (dB)	54.1	54.8	56.2	58.0	59.9
Background Sound Pressure Levels, $L_{Aeq,k}$ (dB)	39.6	40.5	42.0	44.3	45.5
Wind Turbine Sound Pressure Levels, $L_{Aeq,c,k}$ (dB)	53.9	54.6	56.1	57.8	59.7
Wind Turbine Apparent Sound Power Levels, $L_{WA,k}$ (dB)	93.1	93.8	95.2	96.9	98.8
Total Uncertainty of Apparent Sound Power Level, U_C (dB)	0.9	1.0	1.0	0.9	0.9

Summary of Data Collected

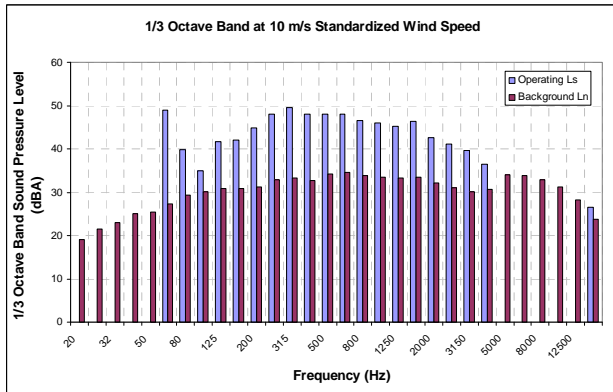
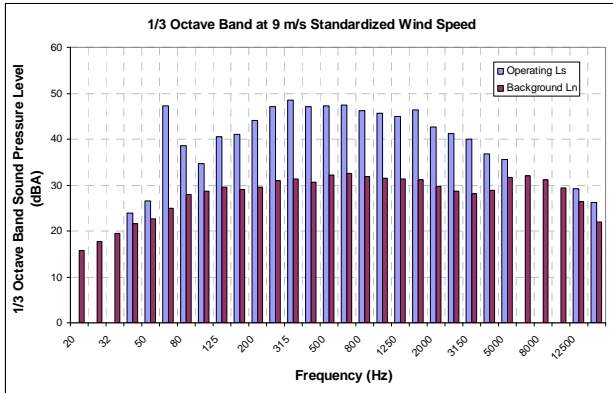
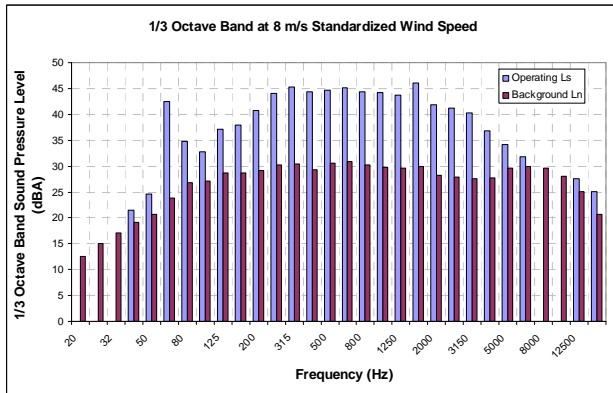
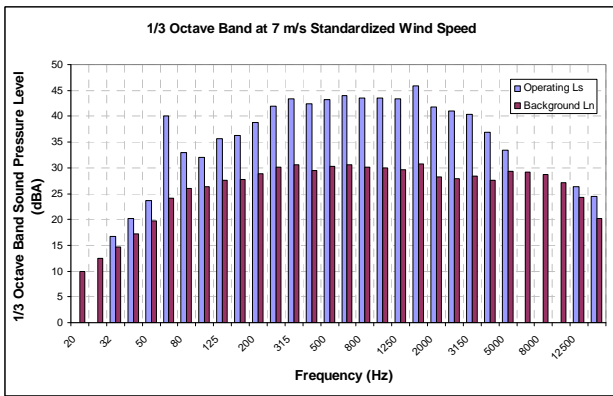
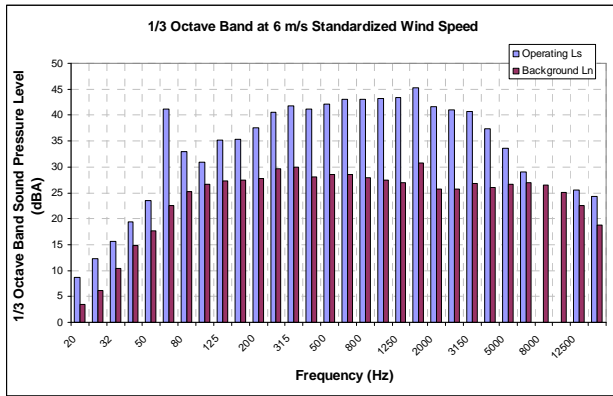
Item	Number of 1-Minute Data Points
Total collected data	559
Removed for hysteresis control scheme, invalid wind direction, turbine startup/shutdown/faults, spurious noises, high or low wind speed, etc.	334
Valid data used, turbine operating	121
Valid data used, background	104





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**A-Weighted One-Third Octave Sound Pressure Levels for 6 m/s Standardized Wind Speed,
 Corrected for Background Noise**

Frequency (Hz)	Sound Pressure Level (dB)	Frequency (Hz)	Sound Pressure Level (dB)
12.5	8.7	400.0	43.2
16.0	12.4	500.0	43.1
20.0	15.7	630.0	43.4
25.0	19.5	800.0	43.4
31.5	23.8	1000.0	45.5
40.0	41.2	1250.0	41.8
50.0	33.1	1600.0	41.2
63.0	31.1	2000.0	41.0
80.0	35.3	2500.0	37.6
100.0	35.4	3150.0	34.0
125.0	37.6	4000.0	29.1*
160.0	40.4	5000.0	+
200.0	41.9	6300.0	+
250.0	41.2	8000.0	25.6*
315.0	42.2	10000.0	24.7

**A-Weighted One-Third Octave Sound Pressure Levels for 7 m/s Standardized Wind Speed,
 Corrected for Background Noise**

Frequency (Hz)	Sound Pressure Level (dB)	Frequency (Hz)	Sound Pressure Level (dB)
12.5		400.0	44.1
16.0		500.0	43.7
20.0	16.8*	630.0	43.8
25.0	20.2*	800.0	43.5
31.5	23.8*	1000.0	46.1
40.0	40.2	1250.0	41.8
50.0	33.3	1600.0	41.2
63.0	32.2	2000.0	40.6
80.0	35.9	2500.0	37.1
100.0	36.6	3150.0	33.9
125.0	39.1	4000.0	+
160.0	42.0	5000.0	+
200.0	43.6	6300.0	+
250.0	42.7	8000.0	26.4*
315.0	43.4	10000.0	24.6

**A-Weighted One-Third Octave Sound Pressure Levels for 8 m/s Standardized Wind Speed,
 Corrected for Background Noise**

Frequency (Hz)	Sound Pressure Level (dB)	Frequency (Hz)	Sound Pressure Level (dB)
12.5	12.9*	400.0	45.3
16.0	15.4*	500.0	44.5
20.0	18.4*	630.0	44.2
25.0	21.5*	800.0	43.8
31.5	24.9	1000.0	46.2
40.0	42.6	1250.0	41.9
50.0	35.1	1600.0	41.1
63.0	32.9	2000.0	40.3
80.0	37.3	2500.0	36.8
100.0	38.1	3150.0	34.4
125.0	40.9	4000.0	30.8*
160.0	44.1	5000.0	+
200.0	45.4	6300.0	28.2*
250.0	44.4	8000.0	27.4*
315.0	44.8	10000.0	25.2

**A-Weighted One-Third Octave Sound Pressure Levels for 9 m/s Standardized Wind Speed,
 Corrected for Background Noise**

Frequency (Hz)	Sound Pressure Level (dB)	Frequency (Hz)	Sound Pressure Level (dB)
12.5		400.0	47.4
16.0		500.0	46.1
20.0		630.0	45.6
25.0	24*	800.0	44.9
31.5	26.5*	1000.0	46.4
40.0	47.2	1250.0	42.6
50.0	38.6	1600.0	41.2
63.0	34.8	2000.0	40.0
80.0	40.5	2500.0	36.8
100.0	41.1	3150.0	35.5*
125.0	44.0	4000.0	+
160.0	47.1	5000.0	+
200.0	48.5	6300.0	+
250.0	47.2	8000.0	29.3*
315.0	47.2	10000.0	26.3*

A-Weighted One-Third Octave Turbine Sound Pressure Levels for 10 m/s Standardized Wind Speed, Corrected for Background Noise

Frequency (Hz)	Sound Pressure Level (dB)	Frequency (Hz)	Sound Pressure Level (dB)
12.5		400.0	48.0
16.0		500.0	46.6
20.0		630.0	45.9
25.0		800.0	45.3
31.5	26.8*	1000.0	46.3
40.0	48.9	1250.0	42.7
50.0	39.7	1600.0	41.1
63.0	35.2	2000.0	39.6
80.0	41.8	2500.0	36.5
100.0	42.0	3150.0	35.3*
125.0	45.0	4000.0	+
160.0	48.0	5000.0	+
200.0	49.5	6300.0	+
250.0	48.0	8000.0	+
315.0	48.0	10000.0	26.5*

Overall One-Third Octave Uncertainties

Spectra (Hz)	Combined Uncertainty for One-Third Octave Bands 6 m/s Bin (dB)	Combined Uncertainty for One-Third Octave Bands 7 m/s Bin (dB)	Combined Uncertainty for One-Third Octave Bands 8 m/s Bin (dB)	Combined Uncertainty for One-Third Octave Bands 9 m/s Bin (dB)	Combined Uncertainty for One-Third Octave Bands 10 m/s Bin (dB)
20	2.9	2.9	3.6	3.0	2.2
25	2.5	2.5	3.0	2.8	2.2
31.5	2.2	2.3	2.7	2.6	2.1
40	2.1	2.1	2.5	2.4	2.0
50	2.2	2.1	2.3	2.2	2.0
63	2.8	2.7	4.5	3.1	2.0
80	2.1	2.3	3.1	2.6	2.0
100	2.2	2.2	2.4	2.2	1.9
125	2.2	2.2	2.9	2.4	2.0
160	2.3	2.3	3.0	2.4	2.0
200	2.4	2.5	3.4	2.4	2.0
250	2.5	2.5	3.7	2.3	1.9
315	2.6	2.5	3.7	2.4	1.9
400	2.5	2.4	3.6	2.4	1.9
500	2.3	2.2	3.3	2.3	1.9
630	2.1	2.1	3.2	2.2	1.9
800	2.0	2.0	3.0	2.1	1.9
1000	1.9	1.9	2.9	2.1	1.9
1250	1.9	1.9	2.8	2.0	1.9
1600	2.0	2.0	3.2	2.0	1.9
2000	1.9	1.9	2.9	2.0	1.9
2500	1.9	1.9	2.9	2.0	1.9
3150	2.0	1.9	2.9	1.9	1.9
4000	2.0	2.0	2.4	2.0	1.9
5000	1.9	2.0	2.3	2.3	1.9
6300	2.1	2.1	2.4	2.4	2.0
8000	2.1	2.3	2.4	2.4	2.0
10000	2.1	2.2	2.4	2.3	2.0
12500	2.0	2.1	2.3	2.1	1.9
16000	1.9	1.9	2.2	2.0	1.9

Tonality and Tonal Audibility Results

Item	Frequency (Hz)	ΔL_k (dB)	ΔL_a (dB)	$\Delta L_{a,k}$ (dB)
6 m/s, Tone 1	66	7.57	-2.00	9.58
7 m/s, Tone 1	66	1.70	-2.00	3.71
8 m/s, Tone 1	66	1.70	-2.00	3.71
9 m/s, Tone 1	66	10.4	-2.00	12.42
10 m/s, Tone 1	66	8.27	-2.00	10.27
6 m/s, Tone 2	1533	-1.42	-3.24	1.82
7 m/s, Tone 2	1467	-0.88	-3.19	2.31
8 m/s, Tone 2	1533	-3.65	-4.38	0.73
9 m/s, Tone 2	1467	0.15	-3.19	3.35
10 m/s, Tone 2	1533	-0.48	-3.2	2.76
6 m/s, Tone 3	4533	-3.23	-4.39	1.16
7 m/s, Tone 3	4491	-3.65	-4.38	0.73
8 m/s, Tone 3	4491	-3.65	-4.38	0.73
9 m/s, Tone 3	4491	-1.93	-4.38	2.45
10 m/s, Tone 3	4533	-3.03	-4.39	1.36

