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ASSESSMENT REPORT - **Project: 14285.00**

K2 Wind
Tonality Assessment Report

Prepared for:

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Revision History

Revision Number	Description	Date
1	- Tonality Investigation Noise Report	01/28/2019
2	- Update to Tonal Adjustment as per 2017 Compliance Protocol	11/08/2019
3	- Update to Tonality Calculation method as per 2017 Compliance Protocol	12/12/2019

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Executive Summary

The Ministry of Environment, Conservation and Parks ("MECP") has ordered (Provincial Officer's Order #5736-B4ZHSA) the K2 Wind Power Project to conduct a tonal audibility assessments at receptor locations most impacted by turbines WTG226, WTG315 and WTG207.

Aercoustics Engineering Limited ("Aercoustics") has been retained by Pattern Energy to complete this tonal audibility assessment at receptor locations R041, R314 and R856. The report has been prepared to facilitate submission to the MECP, in compliance with the Provincial Officer's Order #5736-B4ZHSA.

K2 operates under REA #3259-98EQ3G, issued on July 23, 2013.

The tonality investigation has been completed as per the methodology outlined in Parts D 3.8.3 of the "*MECP Compliance Protocol for Wind Turbine Noise*" (Updated: April 21, 2017) and the tonal assessment plan of the "*K2 Wind Power Project Emission Testing – Tonality Assessment – Detailed Tonal Audibility Assessment Plan*" dated August 03, 2018.

The tonal audibility calculation methodology followed that of IEC 61400-11 Edition 3.0 with modifications to adapt the method to wind turbine immission measurements. The measured tonal audibility at the audit locations were compared to the Tonal adjustment structure from ISO1996-2:2007 Annex C.

Relevant tones from WTG 226 and WTG 207 were not present at receptor R041 and R856 respectively and as such no tonal adjustment was found to be applicable.

Relevant tones from WTG 315 were found to be present at receptor R314 but was not prominent enough for a tonal penalty to be applicable.

1 Introduction

The Ministry of Environment, Conservation and Parks ("MECP") has ordered (Provincial Officer's Order #5736-B4ZHSA) the K2 Wind Power Project to conduct a tonal audibility assessments at receptor locations most impacted by turbines WTG226, WTG315 and WTG207.

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The tonal audibility calculation methodology followed that of IEC 61400-11 Edition 3.0 with modifications to adapt the method to wind turbine immission measurements. The measured tonal audibility at the audit locations were compared to the Tonal adjustment structure from ISO1996-2:2007 Annex C.

This report outlines the measurement methodology, results, and a comparison of the measured turbine tonal audibility to the tonal adjustment structure from ISO1996-2:2007 Annex C.

2 Noise Source Summary

Aercoustics was retained before this assessment to conduct E-Audits to verify the noise emission of turbines at the K2 Wind Power Project.

The purpose of the E-Audits was to confirm whether equipment was operating as per manufacturer's specifications and satisfies the sound power level specified in the REA Appendix B. The E-Audits reports have been prepared to facilitate submission to the MECP, in compliance with acoustic audit conditions outlined in the REA (Specifically, Section F – Wind Turbine Acoustic Audit – Emission).

Wind Turbine Generators WTG 226, WTG 315 and WTG 207 were audited utilizing International Standard IEC 61400-11 (Edition 3.0, released 2012-11), "Wind Turbine generator systems – Part 11: Acoustic noise measurement techniques".

Table 1: Summary of Wind Turbine Noise Emission Audit

Turbine ID	Turbine Model	Report ID
WTG226	Siemens SWT-2.3-101 2.126MW, hub 99.5m	14285.00.T226.RP2
WTG315	Siemens SWT-2.3-101 1.903MW, hub 99.5m	14285.00.T315.RP2
WTG207	Siemens SWT-2.3-101 2.300MW, hub 99.5m	14285.00.T207.RP3

Detailed measurement reports for WTG 226 (Report ID: 14285.00.T226.RP2), WTG 315 (Report ID: 14285.00.T315.RP2) and WTG 207 (Report ID: 14285.T226.RP2) outline the apparent sound power level, measurement uncertainties and tonal audibility results.

2.1 Tonal Audibility Results from E-Audit

Results of the tonality assessment of the acoustic audit for WTG 226, WTG 315 and WTG 207 are summarised in Tables 2, Table 3 and Table 4 respectively.

Table 2: WTG 226 - Tonality Assessment Summary

Wind Speed (m/s)	Frequency (Hz)	Tonality, ΔL_{tn} (dB)	Tonal audibility, ΔL_a (dB)	FFT's with tones	Total # of FFT's	Presence (%)
8	426	-4.3	-2.1	36	95	38%
8.5	475	-3.0	-0.7	59	69	86%
9	474	-1.6	0.7	53	53	100%
9.5	474	-0.3	1.9	35	37	95%
10	478	0.8	3.1	31	33	94%
10.5	484	1.4	3.7	16	19	84%
11	488	1.3	3.5	21	26	81%
11.5	486	1.7	4.0	16	27	59%
12	484	2.5	4.8	12	24	50%
12.5	500	2.6	4.8	14	14	100%

Table 3: WTG 315 - Tonality Assessment Summary

Wind Speed (m/s)	Frequency (Hz)	Tonality, ΔL_{tn} (dB)	Tonal audibility, ΔL_a (dB)	FFT's with tones	Total # of FFT's	Presence (%)
8.5	420	-4.5	-2.3	11	11	100%
9	421	-1.3	0.9	34	34	100%
9.5	423	0.9	3.1	29	29	100%
10	424	2.5	4.7	43	44	98%
10.5	436	2.6	4.8	159	174	91%
11	437	3.2	5.5	179	206	87%
11.5	111	-4.7	-2.7	66	207	32%
11.5	438	3.3	5.5	166	207	80%
12	112	-4.9	-2.9	47	121	39%
12	438	3.3	5.5	90	121	74%

Table 4: WTG 207 - Tonality Assessment Summary

Wind Speed (m/s)	Frequency (Hz)	Tonality, ΔL_{tn} (dB)	Tonal audibility, ΔL_a (dB)	FFT's with tones	Total # of FFT's	Presence (%)
8	481	-3.1	-0.8	38	85	45%
8.5	488	-2.2	0.1	89	104	86%
9	499	-3.0	-0.7	66	68	97%
9.5	513	-4.4	-2.1	46	51	90%
10	517	-2.7	-0.4	25	26	96%
10.5	531	1.2	3.5	168	172	98%
11	533	1.4	3.7	131	137	96%
11.5	534	1.6	3.9	58	58	100%
12	530	1.5	3.8	24	24	100%
12.5	533	2.4	4.7	11	11	100%

Table 5 presents a summary of the relevant tones for this assessment noted from the E-audits and includes the frequency range, tonal audibilities and the corresponding turbine operational parameters during which elevated tonal audibility levels were observed.

Table 5: Summary of Relevant Tones WTG 226, WTG 315 and WTG 207

Turbine ID	Frequency Range (Hz)	Tonal Audibility (dB)	Hub Height Wind Speed Range (m/s)	Electrical Power Output Range (kW)
WTG226	474 - 500	0.7 – 4.8	9.0 – 12.5	1654 - 2126
WTG315	423 - 438	0.9 – 5.5	9.0 – 12.0	1701 - 1903
WTG207	531 - 533	3.5 – 4.7	10.5 – 12.5	2119 - 2300

3 Tonal Assessment Details

The acoustic audit was conducted at receptors R041, R314 and R856[1]. These locations are closest to turbines WTG 226, WTG 315 and WTG 207 and have been chosen based on consultation with the MECP to determine the tonal audibility impact at the receptor location.

Monitoring at R041, R314 and R856 spanned the following dates, summarized in Table 6.

Table 6: Monitoring Period for Each Receptor (DD/MM/YYY)

Location	Monitoring Start Date	Monitoring End Date
R041	20/11/2018	04/02/2019
R314	20/11/2018	04/02/2019
R856	20/11/2018	18/03/2019

3.1 Test Equipment

The measurement equipment used for the Tonal Assessment, both acoustic and environmental, is detailed below. Equipment specifications and measurement positions comply with MOECC Compliance Protocol sections *D2 – Instrumentation* and *D3 – Measurement* Procedure, respectively. Each remote monitoring unit is comprised of the following:

- One (1) Type 1 sound level meter, with microphone and pre-amplifier mounted at a height of 4.5 meters, at least 5 meters from any large reflecting surfaces.
- One (1) primary and one (1) secondary windscreen for the microphone. The 1/3 octave band insertion loss of the secondary windscreen has been tested and was accounted for in the data analysis.
- One (1) anemometer, mounted at a height of 10 metres above ground level (“10-m AGL”).

[1] Receptor IDs taken from the Noise Assessment Report by J.R Salmon and S.J. Corby dated January 3, 2013 [3]

Table 7 provides the specific model and serial numbers for the measurement equipment used during the measurement campaign.

Table 7: Equipment Details

Location	Equipment	Make/Model	Serial Number
R41	Data Acquisition Card	NI 9234	1CAF790
	Signal Conditioner	PCB 480E09	33659
	Microphone	PCB 377B02	118497/150759
	Pre-Amplifier	PCB 426E01	037483
	Weather Anemometer	Vaisala WXT 520	M4910195
R314	Data Acquisition Card	NI 9234	1C009C6
	Signal Conditioner	PCB 480E09	34590
	Microphone	PCB 377B02	132224/177739
	Pre-Amplifier	PCB 426E01	049781
	Weather Anemometer	Vaisala WXT 520	K2420011
R856	Data Acquisition Card	NI 9234	19A4D82
	Signal Conditioner	PCB 480E09	34592
	Microphone	PCB 377B02	132221/1757777
	Pre-Amplifier	PCB 426E01	049762
	Weather Anemometer	Vaisala WXT 520	M4910196

The measurement chain was calibrated before and after the measurement campaign using a type 4231 Brüel & Kjær acoustic calibrator.

3.2 **Measurement Methodology**

For the duration of the measurement campaign, acoustic and anemometer data was logged simultaneously in one-minute intervals. The acoustic data included A-weighted overall equivalent sound levels (LAeq), percentile statistical levels (L90), and 1/3 octave band levels between 20 Hz and 10,000 Hz. The recorded weather data included average wind direction, wind speed, temperature, relative humidity, and atmospheric pressure. The maximum wind speed for each one-minute interval was also stored.

To account for the effect of wind speed on the measured sound level, measurement intervals are sorted into integer wind bins based on the measured 10 m wind speeds. Each bin ranges from 0.5 m/s below to 0.5 m/s above each respective wind bin (i.e. 5 m/s wind bin represents all intervals with average wind speeds between 4.5 m/s and 5.5 m/s).

3.3 Data Reduction and Filtering

The data reduction procedures used on the measurement data to remove invalid data points from the assessment are detailed below. These procedures are in accordance with Section D5.2 of the Protocol and in accordance with the measurement equipment specifications. An additional filter based on the difference between LAeq and L90 level is included to automatically exclude transient noise contamination.

A measurement interval is excluded if any one of the following criteria are not satisfied:

- The interval occurred between 10pm – 5am
- No precipitation was detected 60 minutes before and 60 minutes after the interval
- The ambient temperature was above -20˚C
- The measured LA_{eq} was no more than 10 dB greater than the L90 value

The purpose of the filters listed above is to exclude intervals where the data quality is reduced due to extraneous events (such as vehicle pass-bys), unusable environmental conditions (such as rain), or equipment operating outside of its specifications. Intervals that pass the filtering criteria listed above are sorted into Turbine ON or Background periods based according to the conditions listed below. If neither Turbine ON or Background conditions are met, the data point is excluded.

- Turbine ON: K2 turbines must be rotating and generating power
- Background: K2 turbines must be parked and not generating power

The Protocol also requires additional criteria be met by each Turbine ON data point based on the conditions of the nearest turbine to each receptor. Specifically,

> "*Only downwind data will be considered in the analysis. With reference to the Turbine location, downwind directions are ±45 degrees from the line of sight between the Turbine and receptor/measurement location*." *{Section D5.2 (4)}*

The following additional power filters were applied to specifically assess operational conditions when the highest tonal audibility values were measured during the E-audit testing at WTG226, WTG315and WTG207.

Table 8 Power Filtering Summary

Location	Turbine	Power Output (kW)
R041	WTG226	≥ 1654
R314	WTG315	≥ 1701
R856	WTG207	≥ 2119

3.4 Measurement Location

Monitoring was conducted at Receptors R041, R314 and R856.These locations were chosen based on consultation with the MECP and detailed in the tonal assessment plan of the "K2 Wind Power Project Emission Testing – Tonality Assessment – Detailed Tonal Audibility Assessment Plan" dated August 03, 2018. R041, R314 and R856 have a predicted impact of 39.5, 37.8 dBA and 38.0 dBA respectively, as per level predicted from an "As Built" noise model based on the original CadnaA noise prediction model. The following table provides a summary of the receptor locations. Detailed site plans showing the receptor and audit locations are attached in Appendix A.

Table 9: Receptor Measurement Locations

	Audit Receptor ID Turbine ID	R041 WTG226	R314 WTG315	R856 WTG207
Receptor	UTM Coordinates (X,Y)	17T 450222mE 4859872mN	17T 445350mE 4869092mN	17T 445407mE 4853332mN
	Distance to Turbine (m)	729	629	685
	Receptor Height (m)	4.5	1.5	1.5
	Predicted Level (dBA)*	39.5	37.8	38.0
Monitor	UTM Coordinates (X,Y)	17T 450242mE 4859857mN	17T 445308mE 4869020mN	17T 445443mE 4853384mN
	Distance to Turbine (m)	712	552	626
	Monitor Height (m)	4.5	1.5	1.5
	Predicted Level (dBA)*	39.6	38.1	39.0

*Predicted Level from Aercoustics' acoustic model

3.5 Sample size Reporting Requirements

As per Section D3.8.3 Tonality (tonal assessment) of the MECP protocol, at least 5 one-minute intervals are required for wind turbine noise and background noise (wind turbines parked). These intervals shall be as close as possible to the integer wind speed.

3.6 Operational Conditions

Turbine operational data for the duration of the measurement campaign was supplied by K2. Measurement data at each receptor was filtered to include only intervals when all turbines in the immediate vicinity were operational, or, in the case of the ambient noise measurements, were not operational. The turbines included in this study were chosen such that when they are turned off, the partial impact of the remaining turbines was less than 30dBA; 10dB below the sound level limit. The specific turbines parked for ambient measurements were WTG207, WTG223, WTG225, WTG226, WTG227, WTG228, WTG230, WTG231, WTG233, WTG236, WTG296, WTG299, WTG309, WTG312, WTG313, WTG314, WTG315, WTG317, WTG318, WTG319, WTG326, WTG327, WTG334, WTG336, WTG338 and WTG362.

4 Tonal Assessment Results

Acoustic and weather data measured during the Tonal Assessment are summarized in the following section.

4.1 Weather Conditions

General weather conditions measured over the course of the tonality investigation are summarized in Table 10.

Table 10: General Weather Conditions – Range of Measured Values

	10-m AGL				*Hub height*
	Atmospheric Pressure [hPa]	Wind Speed [m/s]	Relative Humidity [%]	Temperature [°C]	Wind speed [m/s]
Minimum	963	0.1	38	-19	0.1
Maximum	1003	14.6	96	7.8	23.9

4.2 Wind Direction

Wind roses representing the recorded wind directions during the audit are reported in Appendix B. Wind direction recorded from the turbine yaw angle, and wind speeds measured from the 10-m AGL anemometer, were combined to prepare the wind roses. The wind speeds from 1-7 m/s at 10-m AGL represent the I-audit wind bins as per Section E5.5 of the Protocol.

4.3 Measured Sound Levels

Tables 11-13 detail the sound levels measured at the receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). The Turbine ON and Turbine OFF sound level presented are filtered as per the filters detailed in Section 3.3.

Table 11: R041 Sound levels measured for Turbine ON and OFF (Downwind - WTG-226)

I-Audit Wind Bins (m/s)	Turbine ON			Turbine OFF		
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]
3	5	41.6	3.7	62	27.4	3.4
4	22	40.6	1.2	23	32.6	1.5
5	189	41.7	0.8	143	37.0	1.8
6	246	44.6	1.6	81	42.9	1.9
7	186	48.4	1.6	51	47.2	1.4

Table 12: R314 Sound levels measured for Turbine ON and OFF (Downwind - WTG-315)

I-Audit Wind Bins (m/s)	Turbine ON			Turbine OFF		
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]
3	0	-	-	35	25.3	3.4
4	4	38.6	0.2	19	26.1	3.7
5	74	39.4	0.4	11	29.7	1.0
6	215	40.2	0.7	134	32.9	1.5
7	186	42.3	1.1	87	37.6	1.6

Table 13: R856 Sound levels measured for Turbine ON and OFF (Downwind -WTG-207)

I-Audit Wind Bins (m/s)	Turbine ON			Turbine OFF		
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]
3	0	-	-	51	31.4	3.5
4	1	36.2	-	161	33.5	3.4
5	23	41.4	2.1	119	35.0	2.7
6	24	43.1	1.3	25	36.0	1.9
7	122	47.8	1.6	2	39.0	2.2

The following figures present the scatter plots showing each valid 1-minute interval measured sound level at R041, R314 and R856 when all the nearby turbines were ON (Turbine ON + Background) and when all the nearby turbines were OFF (Turbine OFF). The Turbine ON and Turbine OFF sound level presented was using the filter outlined in section 3.3.

Figure 1: R041 - Measured Sound Levels for Turbine ON and Background vs Wind Speed (Downwind - WTG-226)

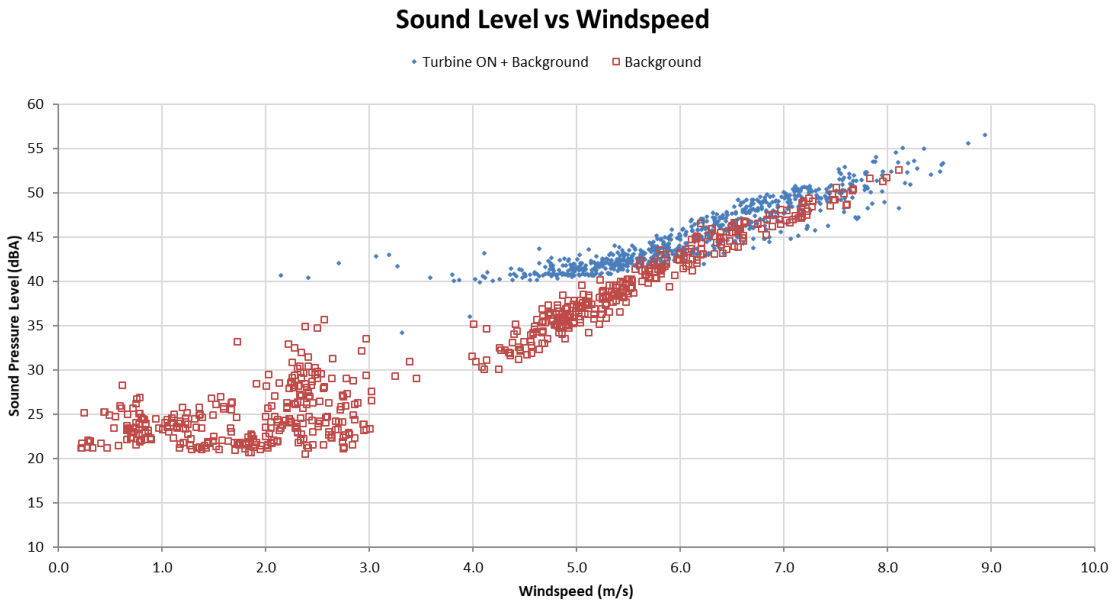


Figure 2: R314 - Measured Sound Levels for Turbine ON and Background vs Wind Speed (Downwind - WTG-315)

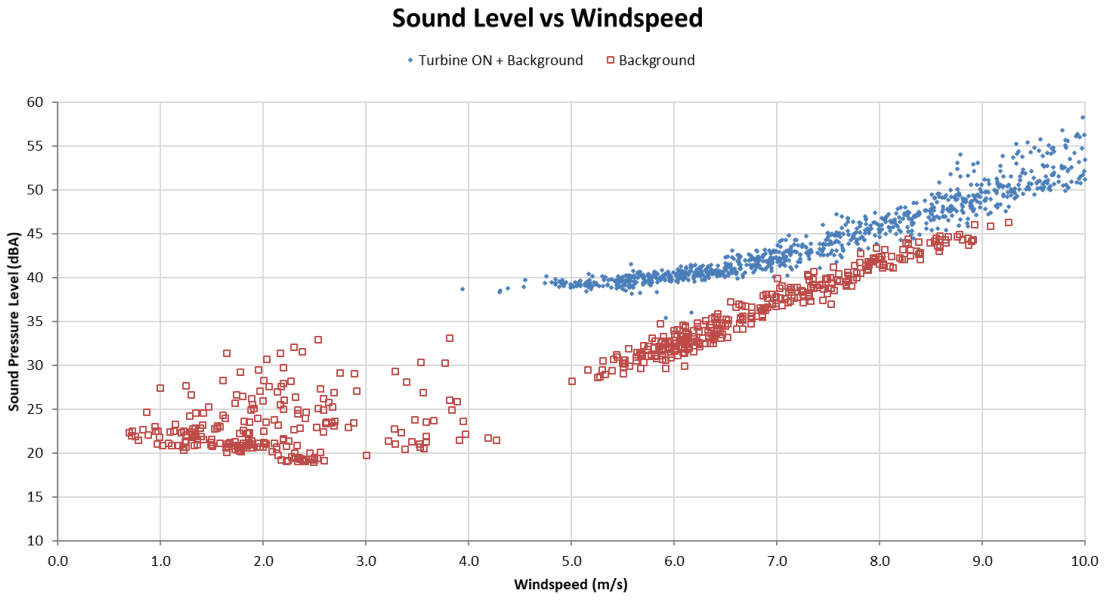
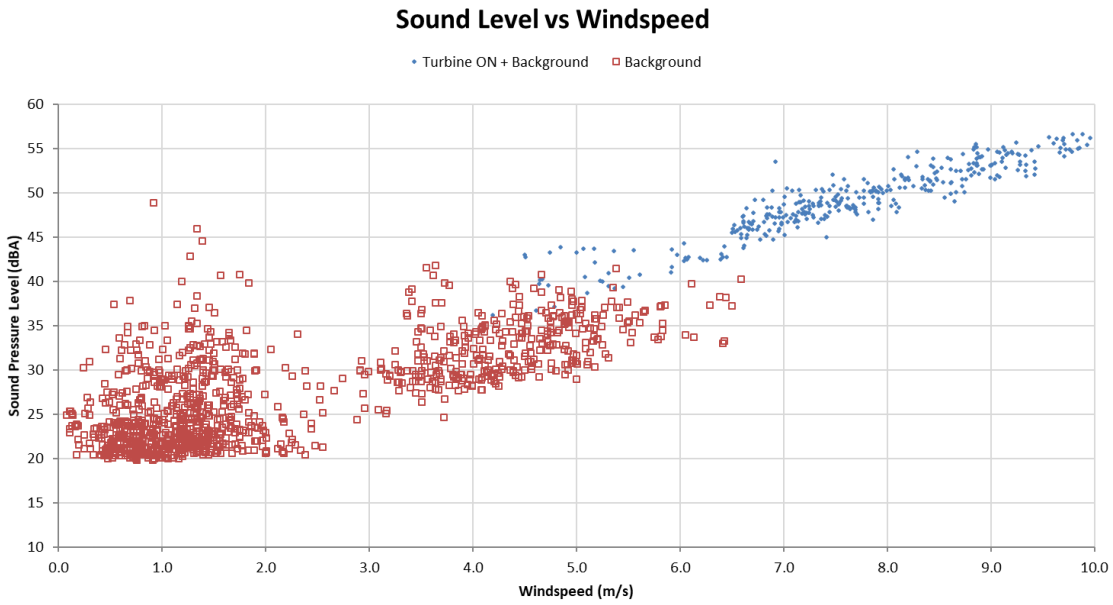


Figure 3: R856 - Measured Sound Levels for Turbine ON and Background vs Wind Speed (Downwind - WTG-207)



4.4 Measured Tonality

The assessment of tones was conducted using IEC 61400-11 Edition 3.0, with modifications to adapt the method to immission measurements and the tonal penalty structure was conducted using ISO 1996-2:2007 Annex C. This standard requires that the tonal penalty would be a positive number between 0 dB and 6 dB based on the degree of tonal audibility of the worst-case tone. A tonal penalty is calculated as Lta – 4 dB i.e. a tonal audibility of 6.5 would incur a penalty of 2.5 dBA on the overall Turbine Only level.

The tonality analysis results of the Emission audit measurements for WTG226, WTG315 and WTG207 were used as a basis for tones at receptors which were likely to have been generated by the closest turbine rather than an external source.

Tonality analysis was completed based on 1-minute narrow band spectra, ranging from 20 Hz to 3000 Hz with a frequency resolution of 2 Hz. Narrowband data was acquired and calculated for each 1-minute interval used in the immission analysis and binned by wind speed. The mean tonal audibility of spectra in each wind bin was then evaluated.

Similar to the methodology in IEC 61400-11, a tone would have to be present in at least 20% of the sample to be deemed as relevant. This reduces the possibility of intermittent tones related to either the unsteady operation of the turbines, or from other contaminating sources, being attributed to the steady state operation of the turbines. The tonal audibility

for the most prominent tones in each wind bin were then evaluated to determine if a tonal penalty would be applicable.

Tonal assessment summary tables are provided in Table 15, Table 16 and Table 17.

Table 14: Tonality Summary – R041 - Downwind of WTG226 – 484-500Hz

Wind Speed (m/s)	Turbine ON Data points	# of Data Points with detected Tone	Tonal Presence	Mean Audibility, ΔL (dB)	Tonal Adjustment, K_T (dB)
3	5	0	0%	-	0
4	22	9	41%	-5.5	0
5	189	31	16%	-5.2	0
6	246	3	1%	-6.2	0
7	186	0	0%	-	0

Table 15: Tonality Summary – R314 - Downwind of WTG315 - 423-438Hz

Wind Speed (m/s)	Turbine ON Data points	# of Data Points with detected Tone	Tonal Presence	Mean Audibility, ΔL (dB)	Tonal Adjustment, K_T (dB)
3	0	0	0%	-	-
4	4	2	50%	-2.7	0
5	74	56	76%	1.9	0
6	215	124	58%	0.7	0
7	186	52	28%	0.2	0

Table 16: Tonality Summary – R856 - Downwind of WTG207 – 531–533Hz

Wind Speed (m/s)	Turbine ON Data points	# of Data Points with detected Tone	Tonal Presence	Mean Audibility, ΔL (dB)	Tonal Adjustment, K_T (dB)
3	0	0	0%	-	-
4	1	0	0%	-	-
5	23	0	0%	-	-
6	24	0	0%	-	-
7	122	0	0%	-	-

Relevant tones from WTG 207 (531-533Hz) were not present at receptor R856.

Relevant tones from WTG 226 (484-500Hz) and WTG 315 (423-438Hz) were found to be present at receptor R041 and R314 respectively, but were not prominent enough for a tonal penalty to be applicable.

5 Assessment of Compliance

As per Section D5.6 of the Protocol, if a tone is identified at any of the wind speed bins, the average tonal audibility correction shall be added to the final noise contribution of the wind turbine at those wind speed bins.

Based on the results of the tonal assessment measurements a tonal adjustment is not applicable to the calculated Turbine Only LAeq levels and the K2 Wind facility is considered to be in compliance with the MECP sound level limits.

References

[1] V. Schroter, “Renewable Energy Approval #3259-98EQ3G”, Ontario Ministry of the Environment, Toronto, ON, July 23, 2013.

[2] Ministry of the Environment and Climate Change, *“Compliance Protocol for Wind Turbine Noise”*, Ontario Ministry of the Environment, Toronto, ON, April 21, 2017.

[3] J.R. Salmon and S.J. Corby, “Noise assessment Report – Revision 5”, Zephyr North, Burlington, ON, January 2013.

[4] D.A. Bies and C.H. Hansen, “Engineering Noise Control – Theory and practice – Fourth Edition” ; 2009.

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Appendix A
Location Details

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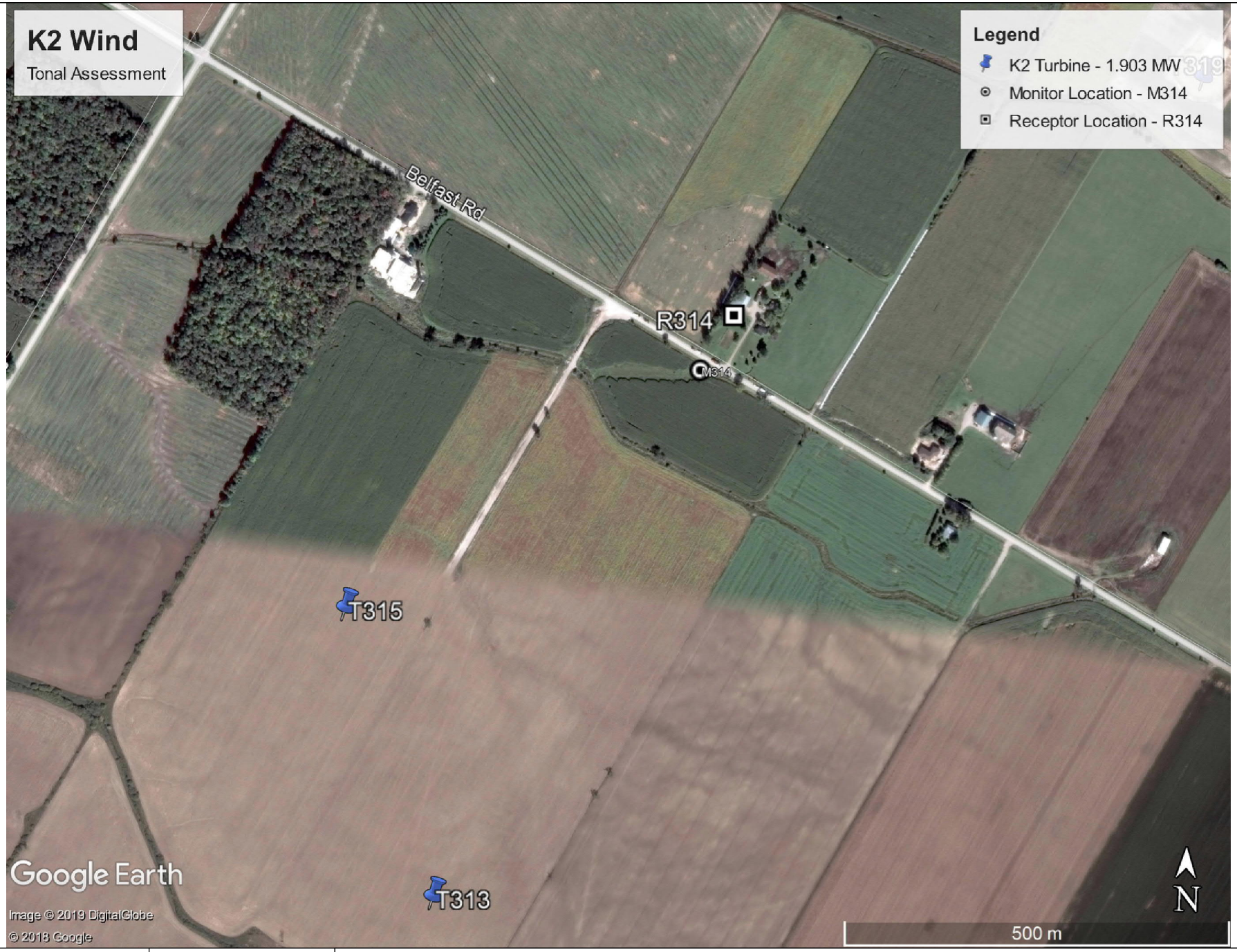
14285.00	**Project Name**
Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	K2 Wind Project - Tonal Assessment
	Figure Title Monitor and Receptor Location - R41

Figure A.01



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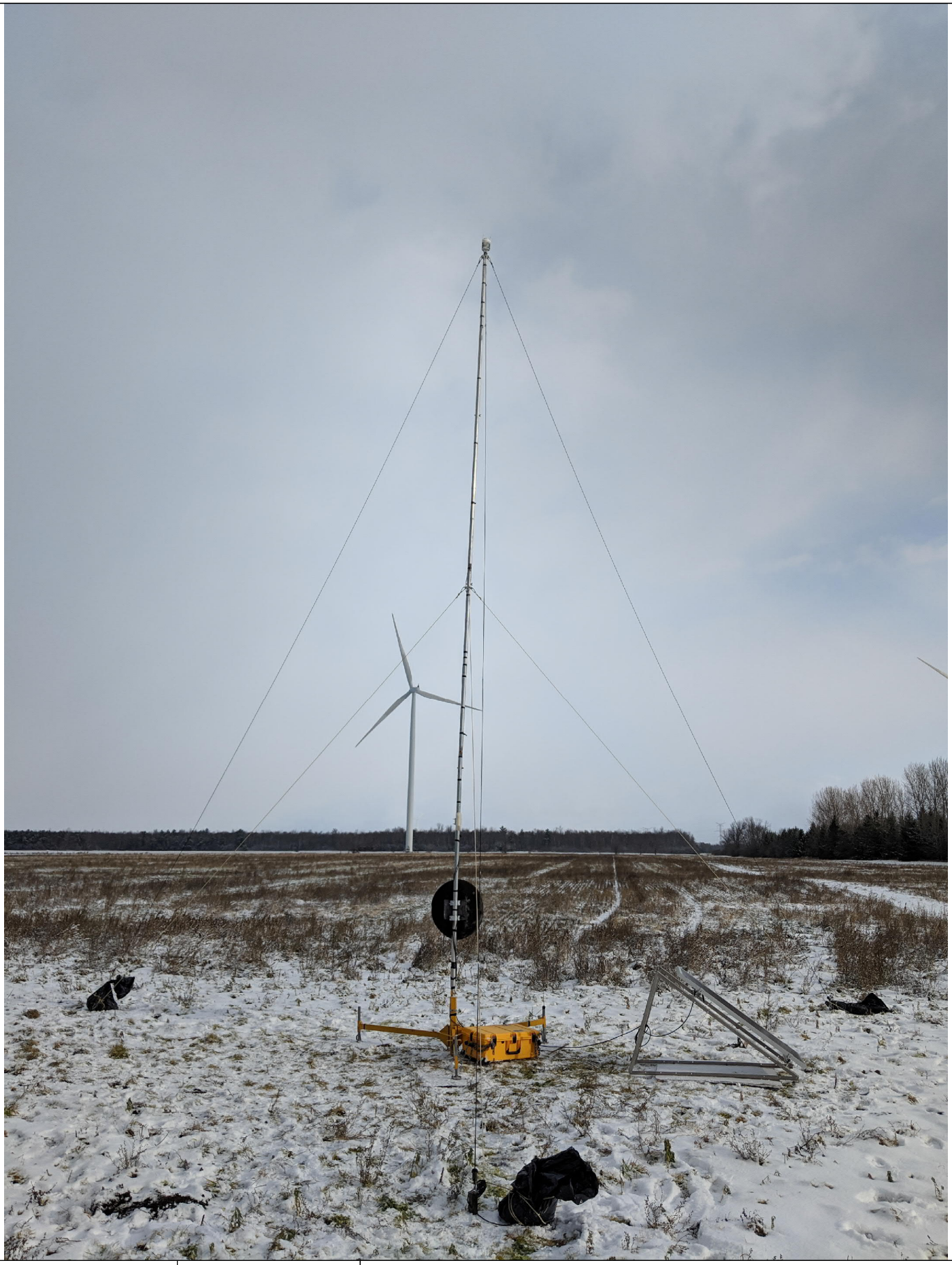
14285.00	**Project Name**
Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	K2 Wind Project - Tonal Assessment
	Figure Title Monitor and Receptor Location - R314

Figure A.02

aercoustics	14285.00	**Project Name**
	Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	K2 Wind Project - Tonal Assessment
		Figure Title Monitor and Receptor Location - R856
		Figure A.03

aercoustics	14285.00	**Project Name**	
	Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	K2 Wind Project - Tonal Assessment	
		Figure Title Site Photos - R041	**Figure A.04**

aercoustics	14285.00	**Project Name** K2 Wind Project - Tonal Assessment	
	Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	**Figure Title** Site Photos - R314	**Figure A.05**



aercoustics	14285.00	**Project Name** K2 Wind Project - Tonal Assessment	
	Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	**Figure Title** Site Photos - R856	**Figure A.06**

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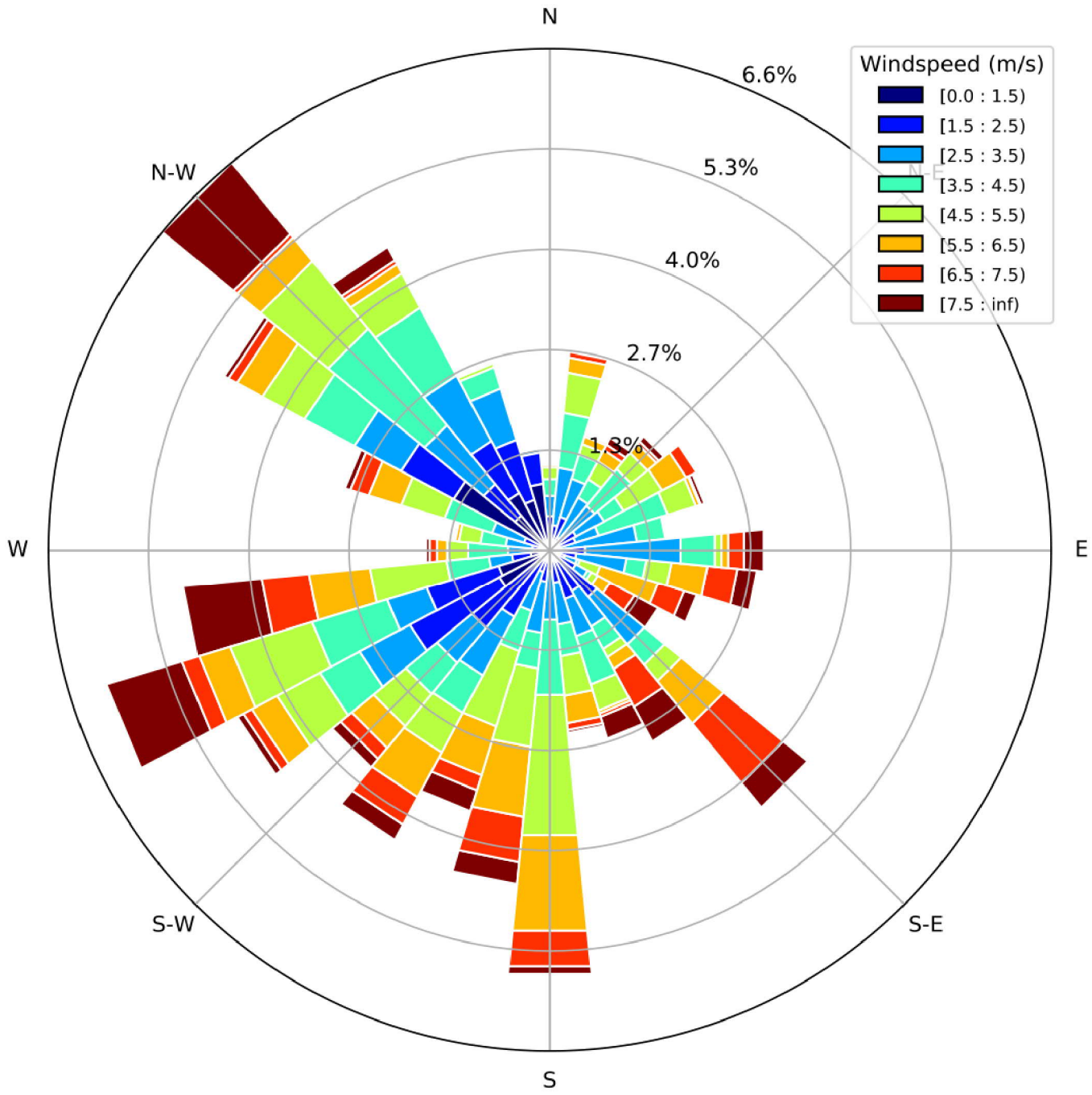
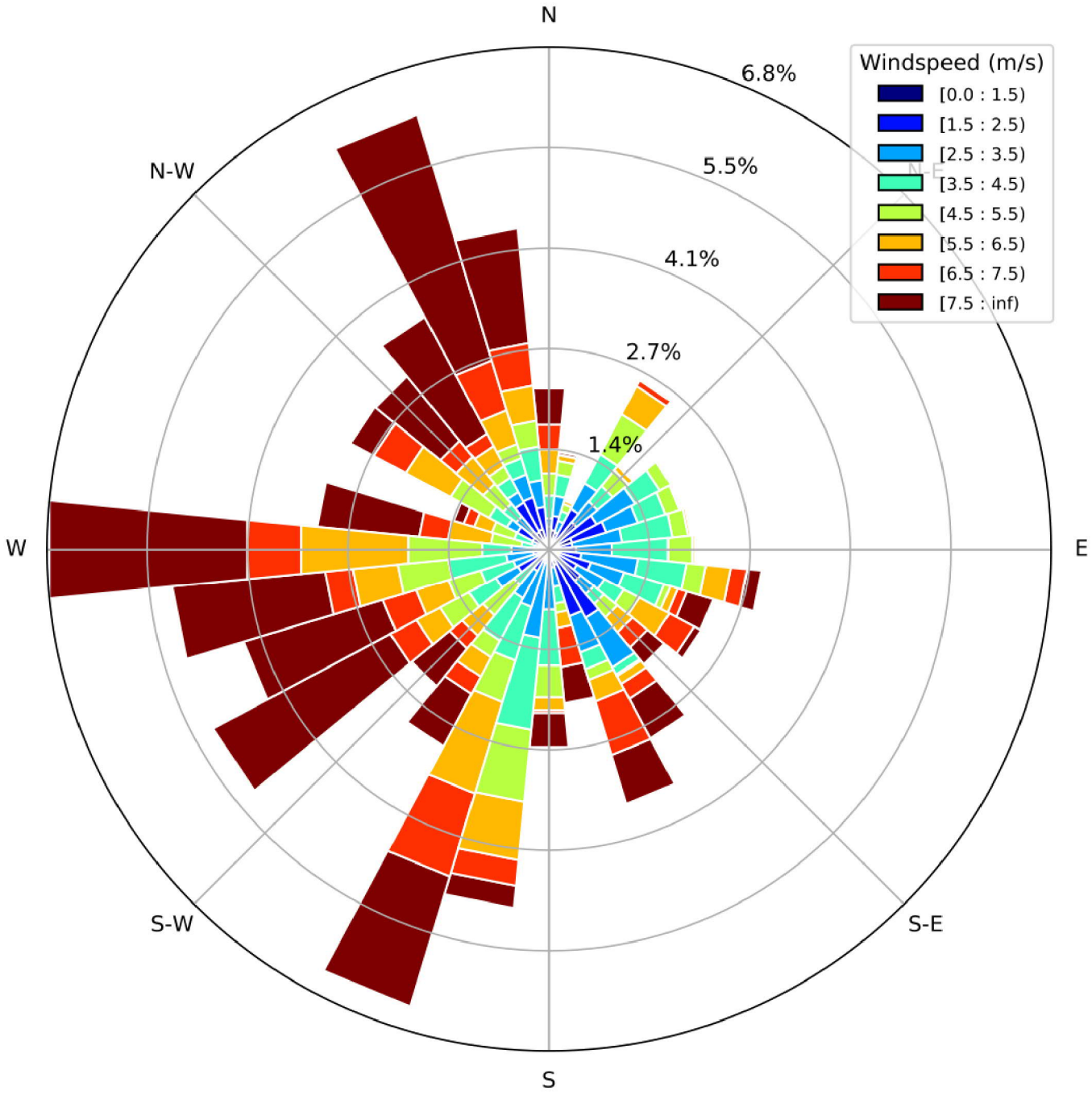
Appendix B
Wind Roses



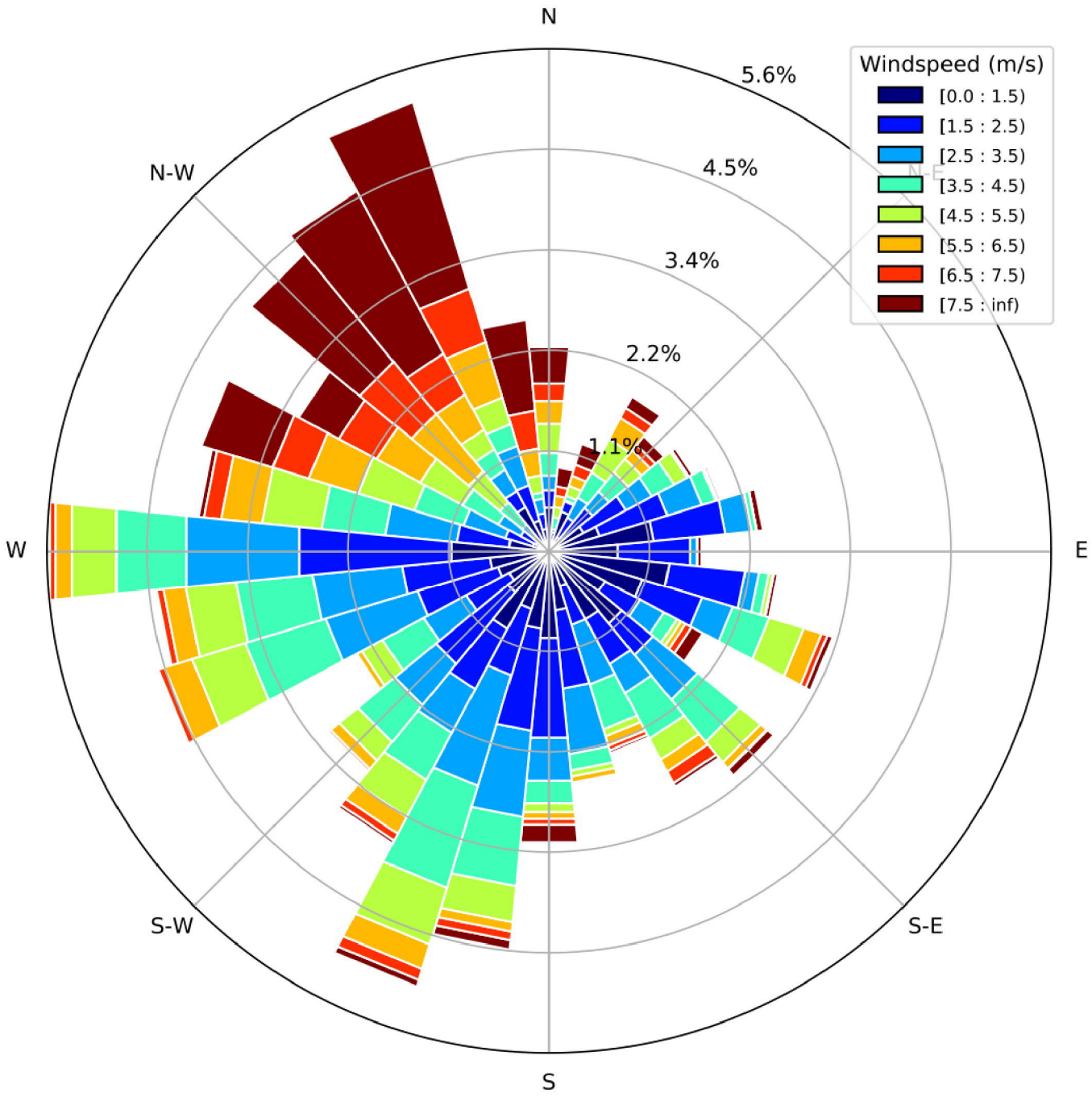
aercoustics	14285.00 Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	**Project Name** K2 Wind Project - Tonal Assessment **Figure Title** Wind Rose - R041

Figure B.01



aercoustics	14285.00 Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	**Project Name** K2 Wind Project - Tonal Assessment **Figure Title** Wind Rose - R314

Figure B.02



aercoustics	14285.00 Scale: NTS Drawn by: AM Reviewed by: DH Date: Mar 27, 2019 Revision: 1	**Project Name** K2 Wind Project - Tonal Assessment **Figure Title** Wind Rose - R856

Figure B.03

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix C
Calibration Certificates

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	152586
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	00034592	P. Order :	2018.05.01C
Asset # :	01043		

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-9001-2008 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : May 03, 2018 By: Petro Onasko

Cal. Due : May 03, 2019

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-255 J-367 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7 http: // www.navair.com

Phone : 905 565 1584 Fax: 905 565 8325 e-Mail: service @ navair.com

NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit# 7,
Mississauga, ON L5T 2E7
Tel: (905)565-1583
Fax: (905)565-8325

Form:480E09	Approved by:jr	Date:Feb/18	ver 1.1

Calibration Report for Certificate : **152586**

Make	Model	Serial	Asset
PCB Piezotronics	480E09	00034592	01043

Test	Min	Reading	Max		In/Out

Gain accuracy at 1kHz

Gain Set	Input		V			
x1	1.000 V	0.9800	1.0000	1.0200		In
x10	0.050 V	0.4900	0.5002	0.5100		In
x100	0.005 V	0.4900	0.4999	0.5100		In

Gain Flatness

X1

I/P Hz			%			
10	1.000 V	-5.0	0.0	5.0		In
10000	1.000 V	-5.0	0.0	5.0		In
50000	1.000 V	-5.0	0.0	5.0		In
100000	1.000 V	-5.0	0.0	5.0		In

X10

I/P Hz			%			
10	0.050 V	-5.0	0.0	5.0		In
10000	0.050 V	-5.0	0.0	5.0		In
50000	0.050 V	-5.0	0.0	5.0		In
100000	0.050 V	-5.0	0.0	5.0		In

X100

I/P Hz			%			
10	0.005 V	-5.0	0.0	5.0		In
10000	0.005 V	-5.0	0.0	5.0		In
50000	0.005 V	-5.0	0.1	5.0		In

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	152867
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	00034590	P. Order :	2018.06.04C
Asset # :	01021		

Cal. status : Received in spec's, no adj. made, minor repair.
3x9V batteries replaced

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-9001-2008 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Jun 07, 2018 By : Petro Onasko

Cal. Due : Jun 07, 2019

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-255 J-367 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7 http: // www.navair.com
Phone : 905 565 1584 Fax: 905 565 8325 e-Mail: service @ navair.com

NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit# 7,
Mississauga, ON L5T 2E7
Tel: (905)565-1583
Fax: (905)565-8325

Form:480E09	Approved by: JR	Jun-18	ver 1.2

Calibration Report for Certificate : **152867**

Make	Model	Serial	Asset
PCB Piezotronics	480E09	00034590	01021

Test	Min	Reading	Max	In/Out

Gain accuracy at 1kHz

Gain Set	Input		V			
x1	1.000 V	0.9800	0.9966	1.0200		In
x10	0.100 V	0.9800	0.9973	1.0200		In
x100	0.010 V	0.9800	0.9964	1.0200		In

Gain Flatness

X1

I/P Hz			%			
10	1.000 V	-5.0	-4.3	5.0		In
10000	1.000 V	-5.0	0.1	5.0		In
50000	1.000 V	-5.0	0.2	5.0		In
100000	1.000 V	-5.0	0.6	5.0		In

X10

I/P Hz			%			
10	0.100 V	-5.0	-4.4	5.0		In
10000	0.100 V	-5.0	0.0	5.0		In
50000	0.100 V	-5.0	-0.3	5.0		In
100000	0.100 V	-5.0	-1.2	5.0		In

X100

I/P Hz			%			
10	0.010 V	-5.0	-4.0	5.0		In
10000	0.010 V	-5.0	-0.2	5.0		In
50000	0.010 V	-5.0	-5.0	5.0		In

SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

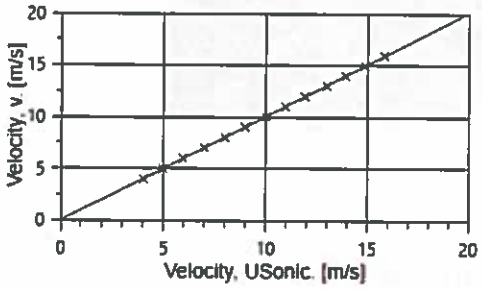
Certificate number: 18.US1.02882 **Date of issue:** July 02, 2018
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** K2420011
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

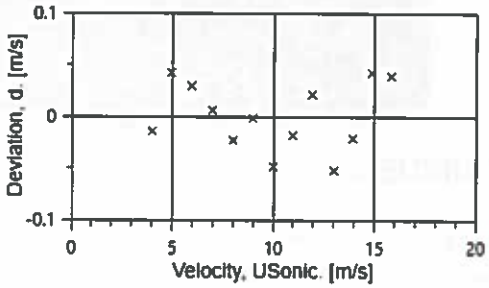
Anemometer received: June 29, 2018 **Anemometer calibrated:** June 29, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.00630 · f [m/s] + -0.03633

Standard uncertainty, slope: 0.00256 **Standard uncertainty, offset:** -0.75225
Covariance: -0.0000659 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999964
Absolute maximum deviation: -0.052 m/s at 12.990 m/s
Barometric pressure: 999.8 hPa **Relative humidity:** 51.4%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.08	27.6	27.5	3.974	4.0000	-0.015	0.021
4	14.29	27.6	27.5	4.985	4.9483	0.042	0.023
6	20.56	27.6	27.5	5.980	5.9500	0.029	0.026
8	28.15	27.6	27.5	6.997	6.9833	0.006	0.029
10	36.71	27.6	27.5	7.991	8.0000	-0.023	0.033
12	46.59	27.6	27.5	9.002	8.9833	-0.002	0.037
13-last	57.24	27.6	27.5	9.978	10.0000	-0.049	0.041
11	69.32	27.6	27.5	10.981	10.9667	-0.018	0.045
9	82.45	27.6	27.5	11.976	11.9167	0.021	0.049
7	96.99	27.6	27.5	12.990	12.9967	-0.052	0.053
5	112.02	27.6	27.5	13.960	13.9300	-0.021	0.057
3	128.74	27.6	27.5	14.966	14.8667	0.042	0.061
1-first	146.05	27.5	27.5	15.939	15.8367	0.039	0.065





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP005	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Essco Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was calibrated at 0°.

Certificate number: 18.US1.02882

SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

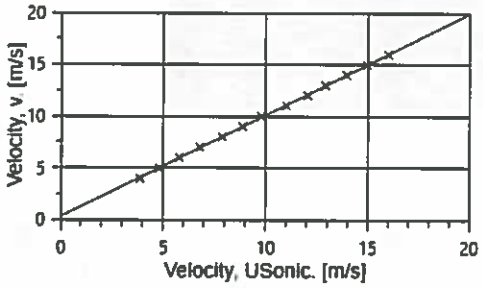
Certificate number: 18.US1.02885 **Date of issue:** July 02, 2018
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** K2420011
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

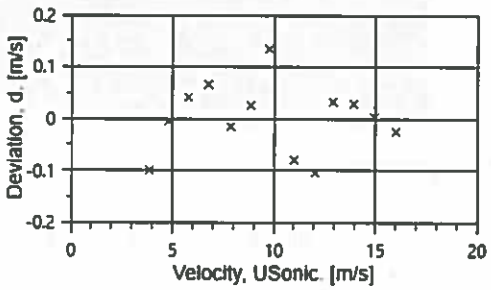
Anemometer received: June 29, 2018 **Anemometer calibrated:** July 02, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.98052 · f [m/s] + 0.27919

Standard uncertainty, slope: 0.00524 **Standard uncertainty, offset:** 0.19513
Covariance: -0.0002612 $(m/s)^2/m/s$ **Coefficient of correlation:** $\rho = 0.999849$
Absolute maximum deviation: 0.135 m/s at 9.993 m/s
Barometric pressure: 1003.0 hPa **Relative humidity:** 54.2%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.07	28.3	28.1	3.971	3.8667	-0.100	0.021
4	14.27	28.3	28.1	4.981	4.8000	-0.005	0.023
6	20.64	28.3	28.1	5.991	5.7833	0.041	0.026
8	28.17	28.3	28.1	6.999	6.7867	0.066	0.029
10	36.71	28.3	28.1	7.990	7.8800	-0.016	0.033
12	46.53	28.3	28.1	8.995	8.8633	0.025	0.037
13-last	57.42	28.3	28.1	9.993	9.7690	0.135	0.041
11	69.47	28.3	28.1	10.992	11.0067	-0.080	0.045
9	82.65	28.3	28.1	11.990	12.0500	-0.104	0.049
7	96.85	28.3	28.1	12.980	12.9200	0.032	0.053
5	112.44	28.3	28.1	13.986	13.9500	0.028	0.057
3	128.54	28.3	28.1	14.954	14.9633	0.003	0.061
1-first	146.43	28.2	28.1	15.959	16.0167	-0.025	0.065





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP005	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Essco Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

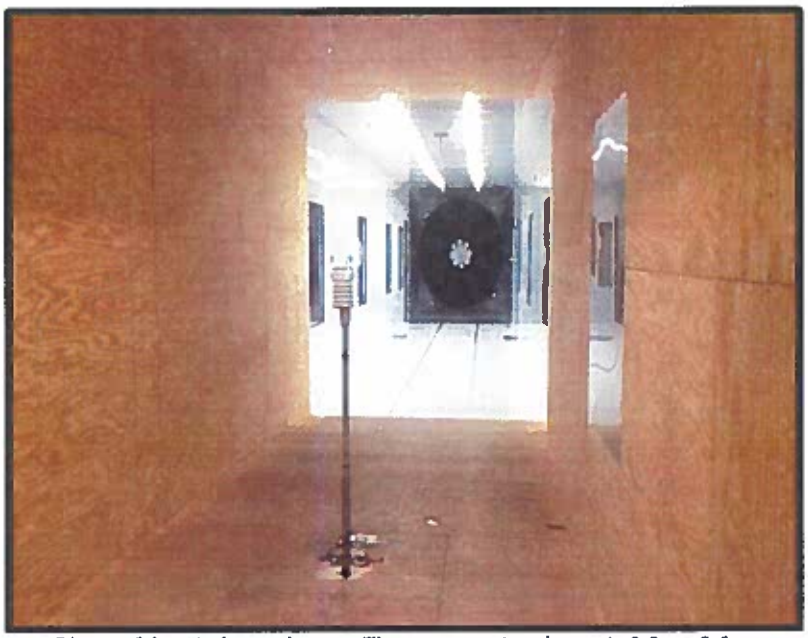


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was calibrated at 90°.

Certificate number: 18.US1.02885

SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

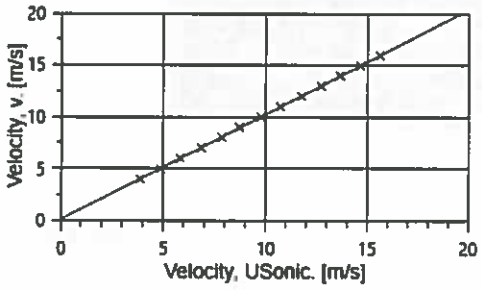
Certificate number: 18.US1.03713 **Date of issue:** July 27, 2018
Type: Vaisala Weather Transmitter, WXT536 **Serial number:** M4910196
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

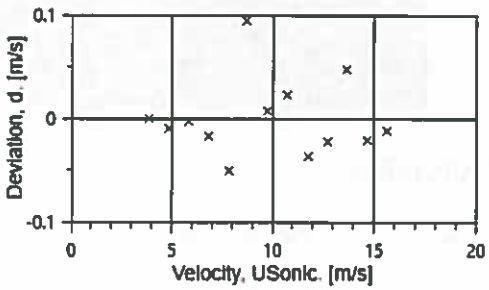
Anemometer received: July 27, 2018 **Anemometer calibrated:** July 27, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.01545 · f [m/s] + 0.06149

Standard uncertainty, slope: 0.00293 **Standard uncertainty, offset:** 0.50502
Covariance: -0.0000865 $(m/s)^2/m/s$ **Coefficient of correlation:** $\rho = 0.999953$
Absolute maximum deviation: 0.094 m/s at 9.000 m/s
Barometric pressure: 999.5 hPa **Relative humidity:** 54.7%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.01	29.4	27.9	3.974	3.8533	0.000	0.021
4	14.12	29.5	27.9	4.975	4.8483	-0.010	0.023
6	20.42	29.5	27.9	5.982	5.8333	-0.003	0.026
8	27.82	29.5	27.9	6.983	6.8333	-0.017	0.029
10	36.44	29.5	27.9	7.992	7.8600	-0.050	0.033
12	46.21	29.5	27.9	9.000	8.7100	0.094	0.037
13-last	56.79	29.5	27.9	9.978	9.7586	0.007	0.041
11	68.73	29.5	27.9	10.977	10.7267	0.023	0.045
9	81.96	29.5	27.9	11.987	11.7800	-0.037	0.049
7	95.99	29.4	27.9	12.973	12.7367	-0.022	0.053
5	111.52	29.4	27.9	13.983	13.6633	0.048	0.057
3	127.30	29.4	27.9	14.941	14.6733	-0.021	0.061
1-first	144.70	29.3	27.9	15.928	15.6367	-0.012	0.065





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP005	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Esseo Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

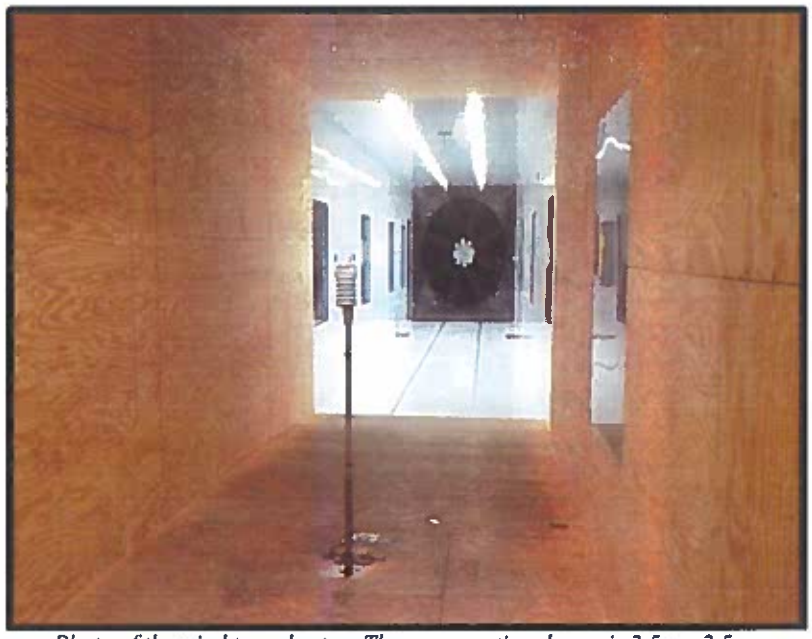


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was calibrated at the 0° position.

Certificate number: 18.US1.03713

SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

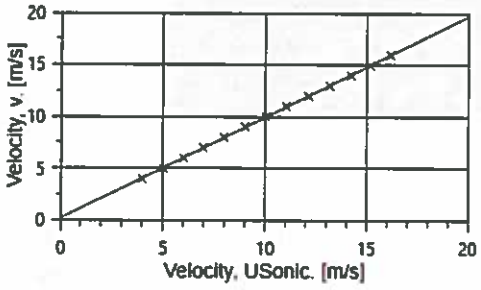
Certificate number: 18.US1.03717 **Date of issue:** July 27, 2018
Type: Vaisala Weather Transmitter, WXT536 **Serial number:** M4910196
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

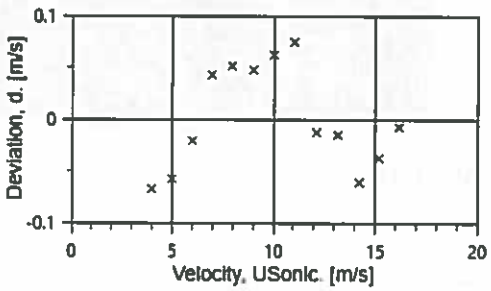
Anemometer received: July 27, 2018 **Anemometer calibrated:** July 27, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.97569 · f [m/s] + 0.15701

Standard uncertainty, slope: 0.00388 **Standard uncertainty, offset:** 0.25972
Covariance: -0.0001444 (m/s)²/m/s **Coefficient of correlation:** $\rho = 0.999917$
Absolute maximum deviation: 0.075 m/s at 10.987 m/s
Barometric pressure: 999.6 hPa **Relative humidity:** 55.0%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.01	29.2	27.7	3.973	3.9800	-0.067	0.021
4	14.13	29.3	27.7	4.975	4.9966	-0.058	0.023
6	20.47	29.3	27.7	5.987	5.9967	-0.021	0.026
8	27.88	29.3	27.7	6.988	6.9569	0.043	0.029
10	36.37	29.3	27.8	7.982	7.9667	0.052	0.033
12	46.20	29.3	27.8	8.996	9.0100	0.048	0.037
13-last	56.97	29.3	27.8	9.989	10.0138	0.062	0.041
11	68.91	29.3	27.8	10.987	11.0233	0.075	0.045
9	81.83	29.3	27.7	11.973	12.1233	-0.012	0.049
7	96.20	29.3	27.7	12.982	13.1600	-0.015	0.053
5	111.44	29.3	27.7	13.974	14.2233	-0.061	0.057
3	127.23	29.2	27.7	14.931	15.1800	-0.037	0.061
1-first	144.86	29.2	27.7	15.930	16.1733	-0.008	0.065





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP005	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Essco Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

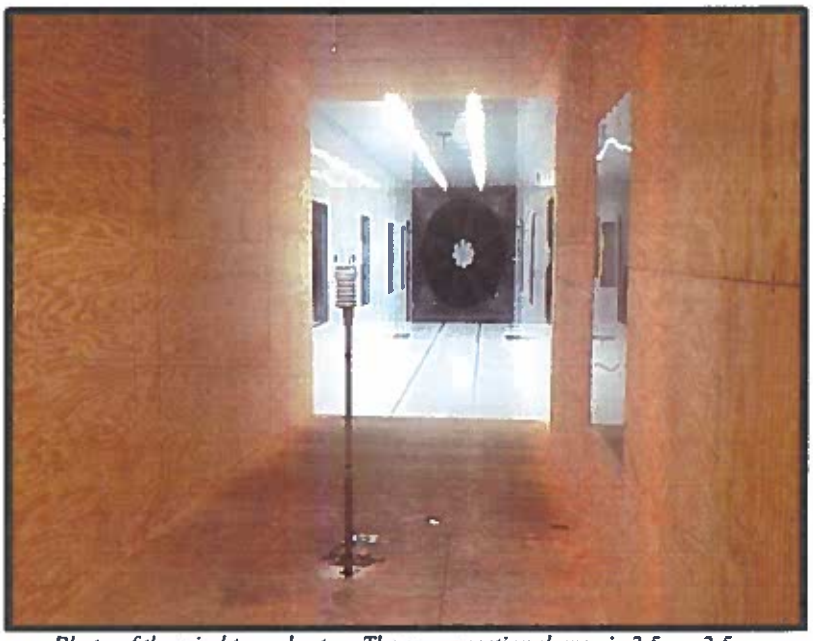


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was calibrated at the 90° position.

Certificate number: 18.US1.03717

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	153594
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	132221	P. Order :	2018.08.03C
Asset # :	01166		

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-9001-2008 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Aug 08, 2018 By : Petro Onasko

Cal. Due : Aug 08, 2020

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-325 J-333 J-420 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7 http: // www.navair.com

Phone : 905 565 1584 Fax: 905 565 8325 e-Mail: service @ navair.com

NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit# 7,
Mississauga, ON L5T 2E7
Tel: (905)565-1583
Fax: (905)565-8325

Form:378B02	Approved by: JR	Feb-16	Ver 1.0

Calibration Report for Certificate : **153594**

Make			Model	Serial		Asset
PCB Piezotronics			378B02	132221		01166
PCB Piezotronics			377B02	175777		

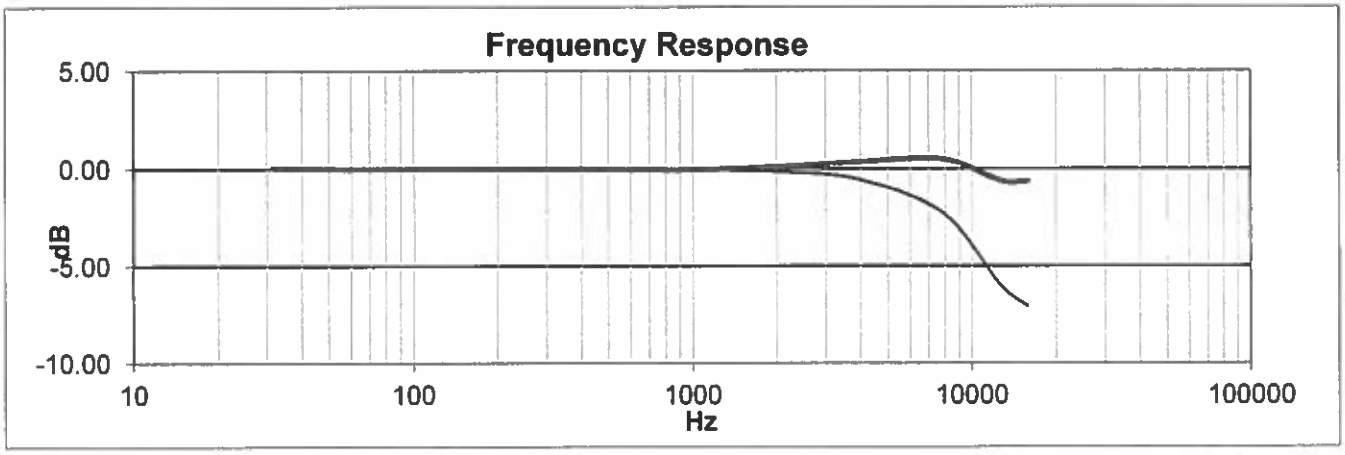
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	49.37	62.94	In
-26.02	dB re 1V/Pa	-28.02	-26.13	-24.02	In
0	dB re 50mV/Pa	-2	-0.11	2	In

Ambient Conditions:
Static Pressure 99.0 kPa
Temperature 23.5°C
Rel.Humidity 55.0%

Frequency response

Freq	Lower Pressure	Upper Free Field	
Hz	dB	dB	
31.5	0.04	0.04	
63.1	0.01	0.00	
125.9	0.01	0.00	
251.3	0.00	0.00	ref
502.5	-0.01	-0.02	
1005.1	-0.06	-0.04	
1978.7	-0.14	0.10	
3957.5	-0.56	0.34	
7914.9	-2.29	0.48	
12663	-6.01	-0.62	
15830	-7.08	-0.64	



CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	153771
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	118497	P. Order :	2018.08.10C
Asset # :	00183		

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-9001-2008 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Aug 14, 2018 By : Petro Onasko

Cal. Due : Aug 14, 2020

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-325 J-333 J-420 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 905 565 1584 Fax: 905 565 8325
http: // www.navair.com
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NT NAVAIR TECHNOLOGIES

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Mississauga, ON L5T 2E7
Tel: (905)565-1583
Fax: (905)565-8325

Form:378B02	Approved by: JR	Feb-16	Ver 1.0

Calibration Report for Certificate : **153771**

Make			Model	Serial		Asset
PCB Piezotronics			378B02	118497		00183
PCB Piezotronics			377B02	150759		

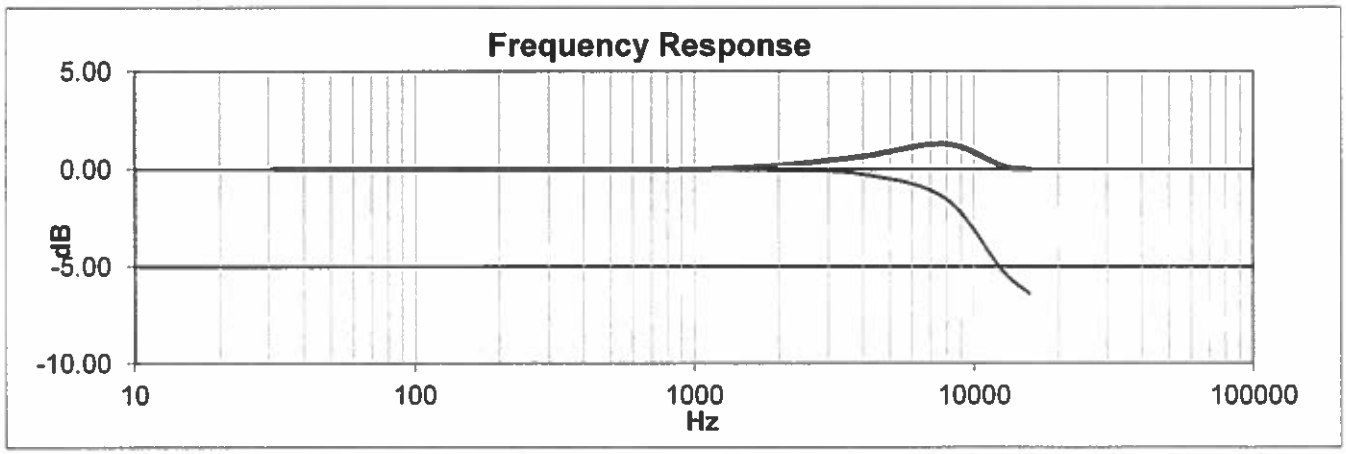
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	46.97	62.94	In
-26.02	dB re 1V/Pa	-28.02	-26.56	-24.02	In
0	dB re 50mV/Pa	-2	-0.54	2	In

Ambient Conditions: Static Pressure 99.2 kPa
Temperature 24.1°C
Rel.Humidity 50.0%

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	0.02	0.03	
63.1	0.00	0.00	
125.9	0.00	0.00	
251.3	0.00	0.00	ref
502.5	-0.01	-0.01	
1005.1	-0.04	-0.01	
1978.7	-0.06	0.19	
3957.5	-0.26	0.65	
7914.9	-1.50	1.29	
12663	-5.24	0.15	
15830	-6.42	-0.01	



CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	153768
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	132224	P. Order :	2018.08.10C
Asset # :	01169		

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-9001-2008 and is registered under certificate CA96/269, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Aug 14, 2018 By : Petro Onasko

Cal. Due : Aug 14, 2020

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-325 J-333 J-420 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST
6375 Dixie Rd. Mississauga, ON, L5T 2E7
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e-Mail: service @ navair.com

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6375 Dixie Rd Unit# 7,
Mississauga, ON L5T 2E7
Tel: (905)565-1583
Fax: (905)565-8325

Form:378B02	Approved by: JR	Feb-16	Ver 1.0

Calibration Report for Certificate : **153768**

Make			Model	Serial		Asset
PCB Piezotronics			378B02	132224		01169
PCB Piezotronics			377B02	177739		

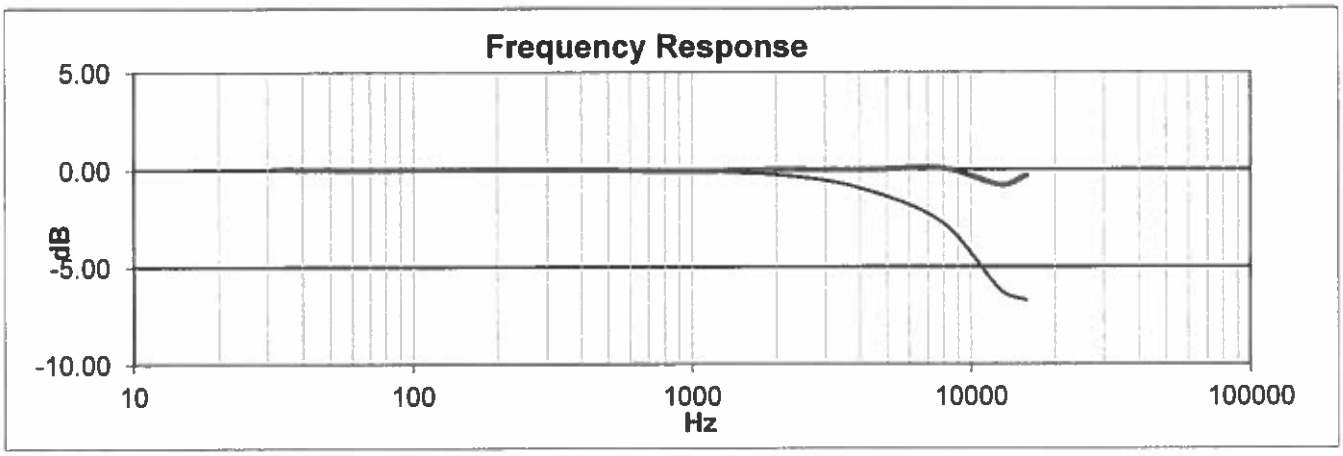
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	51.55	62.94	In
-26.02	dB re 1V/Pa	-28.02	-25.76	-24.02	In
0	dB re 50mV/Pa	-2	0.27	2	In

Ambient Conditions: Static Pressure 99.2 kPa
Temperature 24.1°C
Rel.Humidity 50.0%

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	0.03	0.03	
63.1	0.00	0.01	
125.9	0.00	0.00	
251.3	0.00	0.00	ref
502.5	-0.02	-0.02	
1005.1	-0.11	-0.07	
1978.7	-0.26	0.00	
3957.5	-0.94	-0.02	
7914.9	-2.75	0.05	
12663	-6.17	-0.77	
15830	-6.75	-0.31	



SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

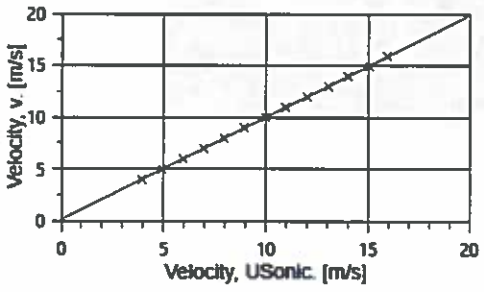
Certificate number: 18.US1.04605 **Date of issue:** August 23, 2018
Type: Vaisala Weather Transmitter, WXT536 **Serial number:** M4910195
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

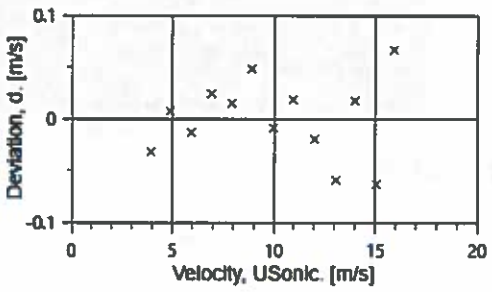
Anemometer received: August 21, 2018 **Anemometer calibrated:** August 23, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: RDS **Approved by:** Calibration engineer, RDS

Calibration equation obtained: v [m/s] = 0.98798 · f [m/s] + 0.11112

Standard uncertainty, slope: 0.00296 **Standard uncertainty, offset:** 0.28088
Covariance: -0.0000855 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999952
Absolute maximum deviation: 0.067 m/s at 15.913 m/s
Barometric pressure: 999.1 hPa **Relative humidity:** 42.2%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.10	26.4	26.3	3.968	3.9367	-0.032	0.021
4	14.29	26.5	26.3	4.973	4.9138	0.007	0.023
6	20.61	26.5	26.3	5.973	5.9467	-0.013	0.026
8	28.19	26.4	26.3	6.985	6.9333	0.024	0.029
10	36.74	26.4	26.3	7.974	7.9433	0.015	0.033
12	46.58	26.4	26.3	8.979	8.9267	0.048	0.037
13-last	57.46	26.4	26.3	9.972	9.9897	-0.009	0.041
11	69.42	26.4	26.3	10.961	10.9633	0.018	0.045
9	82.60	26.4	26.3	11.957	12.0100	-0.020	0.049
7	96.97	26.4	26.3	12.957	13.0617	-0.059	0.053
5	112.51	26.4	26.3	13.957	13.9967	0.017	0.057
3	128.46	26.4	26.3	14.914	15.0467	-0.063	0.061
1-first	146.26	26.4	26.3	15.913	15.9267	0.067	0.065





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP005	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Essco Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was calibrated at the 0° position.

Certificate number: 18.US1.04605

SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

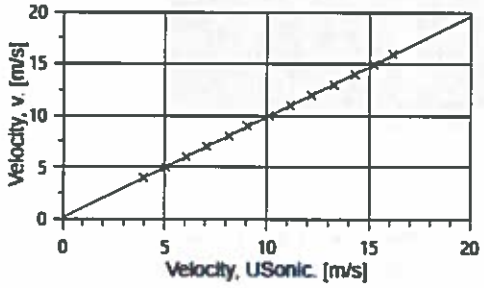
Certificate number: 18.US1.04606 **Date of issue:** August 23, 2018
Type: Vaisala Weather Transmitter, WXT536 **Serial number:** M4910195
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

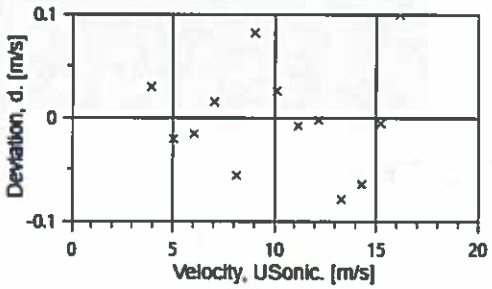
Anemometer received: August 21, 2018 **Anemometer calibrated:** August 23, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: RDS **Approved by:** Calibration engineer, RDS

Calibration equation obtained: v [m/s] = 0.97380 · f [m/s] + 0.10153

Standard uncertainty, slope: 0.00405 **Standard uncertainty, offset:** 0.42105
Covariance: -0.0001578 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999910
Absolute maximum deviation: 0.099 m/s at 15.934 m/s
Barometric pressure: 998.9 hPa **Relative humidity:** 42.4%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	d.p. box [°C]	Wind velocity, v. [m/s]	Anemometer Output, f. [m/s]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.13	26.4	26.3	3.974	3.9467	0.030	0.021
4	14.33	26.4	26.3	4.980	5.0310	-0.021	0.023
6	20.67	26.4	26.3	5.980	6.0533	-0.016	0.026
8	28.24	26.4	26.3	6.992	7.0600	0.015	0.029
10	36.85	26.4	26.3	7.985	8.1533	-0.056	0.033
12	46.70	26.4	26.3	8.990	9.0433	0.082	0.037
13-last	57.47	26.3	26.3	9.973	10.1103	0.026	0.041
11	69.42	26.4	26.3	10.961	11.1600	-0.008	0.045
9	82.60	26.4	26.3	11.957	12.1767	-0.002	0.049
7	97.14	26.4	26.3	12.968	13.2933	-0.079	0.053
5	112.65	26.4	26.3	13.965	14.3033	-0.065	0.057
3	128.63	26.3	26.3	14.924	15.2267	-0.005	0.061
1-first	146.65	26.3	26.3	15.934	16.1567	0.099	0.065





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP005	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP003	Setra M278, 0-5VDC Output, barometer
PL8	Pitot tube
XB002	Computer Board. 16 bit A/D data acquisition board
9PRZRW1	PC dedicated to data acquisition

Traceable calibrations of the equipment are carried out by external accredited institutions: Atlantic Scale, Essco Calibration Labs & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

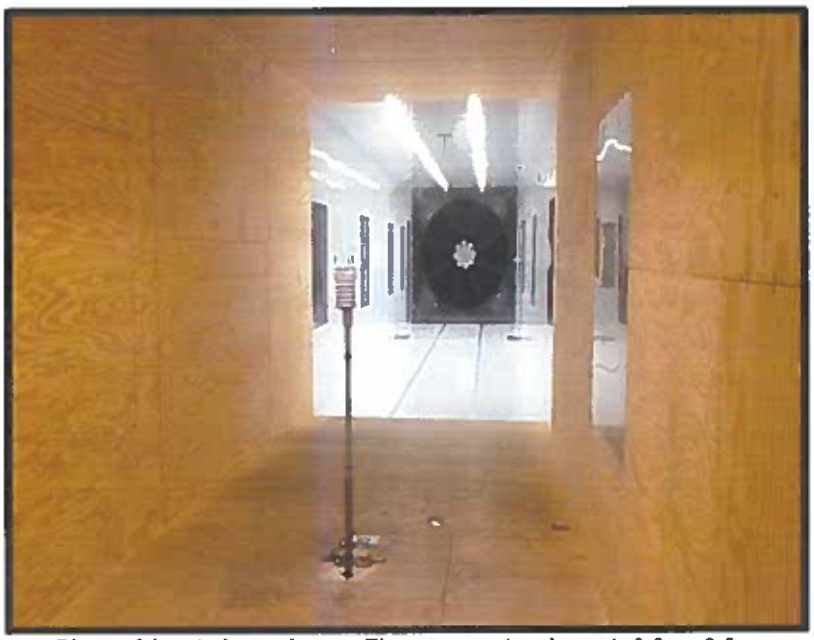


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.12.01.004 for further details.

COMMENTS

This sensor was calibrated at the 90° position.

Certificate number: 18.US1.04606

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	154526
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	00033659	P. Order :	2018.10.15C
Asset # :	00209		

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Oct 23, 2018 By : Petro Onasko

Cal. Due : Oct 23, 2020

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-255 J-301 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
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NT NAVAIR TECHNOLOGIES

6375 Dixie Rd Unit# 7
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Tel: (905)565-1583
Fax: (905)565-8325

Form:480E09	Approved by: JR	Jun-18	ver 1.2

Calibration Report for Certificate : **154526**

Make	Model	Serial	Asset
PCB Piezotronics	480E09	00033659	00209

Test	Input		Min	Reading	Max		In/Out

Gain accuracy at 1kHz

Gain Set				V			
• 1	1.000 V		0.9800	1.0000	1.0200		In
• 10	0.100 V		0.9800	1.0003	1.0200		In
• 100	0.010 V		0.9800	0.9985	1.0200		In

Gain Flatness

Gain • 1

10 Hz	1.000 V		-5.0	0.0%	5.0		In
10 kHz	1.000 V		-5.0	0.0%	5.0		In
50 kHz	1.000 V		-5.0	0.0%	5.0		In
100 kHz	1.000 V		-5.0	0.2%	5.0		In

Gain • 10

10 Hz	0.100 V		-5.0	0.0%	5.0		In
10 kHz	0.100 V		-5.0	0.0%	5.0		In
50 kHz	0.100 V		-5.0	-0.3%	5.0		In
100 kHz	0.100 V		-5.0	-1.1%	5.0		In

Gain • 100

10 Hz	0.010 V		-5.0	0.0%	5.0		In
10 kHz	0.010 V		-5.0	-0.2%	5.0		In
50 kHz	0.010 V		-5.0	-4.9%	5.0		In

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

Appendix D
Provincial Officer's Order #5736-B4ZHSA

Ontario

Ministry of the Environment, Conservation and Parks
Ministère de l'Environnement, de la Protection de la nature et des Parcs

Provincial Officer's Order

Environmental Protection Act, R.S.O. 1990, c. E.19 (EPA)
Ontario Water Resources Act, R.S.O. 1990, c. O.40 (OWRA)
Pesticides Act, R.S.O. 1990, c. P.11 (PA)
Safe Drinking Water Act, 2002, S.O. 2002, c.32 (SDWA)
Nutrient Management Act, 2002, S.O. 2002, c.4 (NMA)

Order Number
5736-B4ZHSA-1

Incident Report No.
4554-B4WPF4

To: K2 Wind Ontario Inc. operating as a general partner of and on behalf of K2 Wind Ontario Limited Partnership
Suite 105 - 100 Simcoe St
Toronto, Ontario, M5H 3G2
Canada

Site: Various Locations
Ashfield-Colborne-Wawanosh, County of Huron

Pursuant to my authority under EPA Section 157.1, EPA Section 196(1) and EPA Section 157, I order you to do the following:

Work Ordered

Item No. 2 **Compliance Date** 2019/03/01 (YYYY/MM/DD)

By March 1, 2019, submit to the undersigned Provincial Officer the results of the implementation of the Assessment Plan in Item No. 1 of this Order, including an updated E-Audit with Tonality Assessments and UTMs of the monitoring locations. A copy of this information shall also be submitted to the District Manager and the Director as described in Condition F2 of the REA.

A. While this Order is in effect, a copy or copies of this order shall be posted in a conspicuous place.

B. While this Order is in effect, report in writing, to the District or Area office, any significant changes of operation, emission, ownership, tenancy or other legal status of the facility or operation.

C. Unless otherwise specified, all requirements of this Order are effective upon service of this Order.

This Order amends and constitutes part of Provincial Officer Order Number 5736-B4ZHSA, issued on 05/10/2018.

This Order is being issued for the reasons set out in the annexed Provincial Officers Report which forms part of this Order.

Issued at Owen Sound this 5th day of February, 2019.

Scott Gass
Badge No:
Owen Sound District Office
Tel: (519) 371-5517

REQUEST FOR REVIEW

You may request that this Order be reviewed by a Director.

Your request must be made (i) in writing (or if made orally, with written confirmation) and (ii) served on the Director at the address below within seven (7) calendar days after being served with a copy of this Order.

In the written request or written confirmation of an oral request, you must include:

(a) the portions of the Order in respect of which the review is requested;
(b) any submissions that you wish the Director to consider; and
(c) an address for service to be used by the Director.

In response to your request for review, the Director may confirm, alter or revoke this Order and will serve you with a copy of the Director's decision or Order.

A request for review does not automatically stay this Order. If you wish to have the Director stay the Order you must also include this in your request and the Order is not stayed unless the Director makes an order granting a stay.

DEEMED CONFIRMATION OF THIS ORDER

If you do not receive oral or written notice of the Director's decision on your request for review within (7) calendar days of receipt of your request, and the Director has not stayed the Order, this Order shall be deemed to be confirmed by order of the Director and deemed to be served upon you.

In the case of a deemed confirmation, you may require a hearing before the Environmental Review Tribunal (Tribunal), if, within fifteen (15) calendar days from the deemed date of service of the Director's order, you serve written notice of your appeal on the Tribunal and the Director. Your notice must state:

(a) the portion(s) of the Order in respect of which the hearing is required; and
(b) the grounds on which you intend to rely at the hearing.

Except with leave of the Tribunal, you are not entitled to appeal a portion of the Order or to rely on a ground that is not stated in the notice requiring the hearing. Unless stayed by the Tribunal, the Order remains in effect from the date of service.

Written notice requiring a hearing can be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5
Fax: (416) 326-5370
Email: ERTTribunalsecretary@ontario.ca

and

Director
Ministry of the Environment, Conservation and Parks
Owen Sound District Office
3rd Flr
101 17th St
Owen Sound ON N4K 0A5
Fax: (519) 371-2905
Tel:

Further information on the Tribunal and requirements for an appeal can be obtained directly from the Tribunal by:

Tel: (416) 212-6349 or 1(866) 448-2248
TTY 1-800-855-1155 via Bell Relay
Fax: (416) 326-5370 or 1(844) 213-3474
Web: www.ert.gov.on.ca

FOR YOUR INFORMATION

The following is for your information:

Service of the documentation referred to above can be made personally, by mail, by fax, by commercial courier or by email in accordance with the legislation under which the Order is made and any corresponding Service Regulation . Further information can be obtained from e- Laws at www.e-laws.gov.on.ca. Please note that choosing service by mail does not extend any of the

above mentioned timelines.

Unless stayed, this Order is effective from the date of service. Non-compliance with the requirements of this Order constitutes an offence.

The requirements of this Order are minimum requirements only and do not relieve you from complying with the following:

(a) any applicable federal legislation,
(b) any applicable provincial legislation or requirements that are not addressed in this Order, and
(c) any applicable municipal law.

The requirements of this Order are severable. If any requirement of this Order or the application of any requirement to any circumstances is held invalid, the application of such requirement to other circumstances and the remainder of the Order are not affected.

Further orders may be issued in accordance with the legislation as circumstances require.

The procedures and other information provided above are intended as a guide. The legislation and/or regulations should be consulted for additional details and accurate reference.

Ontario

Ministry of the Environment, Conservation and Parks
Ministère de l'Environnement, de la Protection de la nature et des Parcs

Provincial Officer's Order

Environmental Protection Act, R.S.O. 1990, c. E.19 (EPA)
Ontario Water Resources Act, R.S.O. 1990, c. O.40 (OWRA)
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Nutrient Management Act, 2002, S.O. 2002, c.4 (NMA)

Order Number
5736-B4ZHSA

Incident Report No.
4554-B4WPF4

To: K2 Wind Ontario Inc. operating as a general partner of and on behalf of K2 Wind Ontario Limited Partnership
Suite 105 - 100 Simcoe St
Toronto, Ontario, M5H 3G2
Canada

Site: Various Locations
Ashfield-Colborne-Wawanosh, County of Huron

Pursuant to my authority under EPA Section 157.1 and EPA Section 196(1), I order you to do the following:

Work Ordered

Item No. 1 **Compliance Date** 2018/12/31
(YYYY/MM/DD)

By December 31, 2018, ensure that an Acoustical Consultant implements the Assessment Plan, in accordance with the Compliance Protocol and the EAPB September 14th Letter.

Item No. 2 **Compliance Date** 2018/12/31
(YYYY/MM/DD)

By December 31, 2018, submit to the undersigned Provincial Officer the results of the implementation of the Assessment Plan in Item No. 1 of this Order, including an updated E-Audit with Tonality Assessments and UTMs of the monitoring locations. A copy of this information shall also be submitted to the District Manager and the Director as described in Condition F2 of the REA.

A. While this Order is in effect, a copy or copies of this order shall be posted in a conspicuous place.

B. While this Order is in effect, report in writing, to the District or Area office, any significant changes of operation, emission, ownership, tenancy or other legal status of the facility or operation.

C. Unless otherwise specified, all requirements of this Order are effective upon service of

this Order.

This Order is being issued for the reasons set out in the annexed Provincial Officers Report which forms part of this Order.

Issued at Owen Sound this 5th day of October, 2018.

Scott Gass
Badge No: 956
Owen Sound District Office
Tel: (519) 371-4409

REQUEST FOR REVIEW

You may request that this Order be reviewed by a Director.

Your request must be made (i) in writing (or if made orally, with written confirmation) and (ii) served on the Director at the address below within seven (7) calendar days after being served with a copy of this Order.

In the written request or written confirmation of an oral request, you must include:

(a) the portions of the Order in respect of which the review is requested;
(b) any submissions that you wish the Director to consider; and
(c) an address for service to be used by the Director.

In response to your request for review, the Director may confirm, alter or revoke this Order and will serve you with a copy of the Director's decision or Order.

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DEEMED CONFIRMATION OF THIS ORDER

If you do not receive oral or written notice of the Director's decision on your request for review within (7) calendar days of receipt of your request, and the Director has not stayed the Order, this Order shall be deemed to be confirmed by order of the Director and deemed to be served upon you.

In the case of a deemed confirmation, you may require a hearing before the Environmental Review Tribunal (Tribunal), if, within fifteen (15) calendar days from the deemed date of service of the Director's order, you serve written notice of your appeal on the Tribunal and the Director. Your notice must state:

(a) the portion(s) of the Order in respect of which the hearing is required; and
(b) the grounds on which you intend to rely at the hearing.

Except with leave of the Tribunal, you are not entitled to appeal a portion of the Order or to rely on a ground that is not stated in the notice requiring the hearing. Unless stayed by the Tribunal, the Order remains in effect from the date of service.

Written notice requiring a hearing can be served upon:

The Secretary
Environmental Review Tribunal
655 Bay Street, 15th Floor
Toronto ON
M5G 1E5
Fax: (416) 326-5370
Email: ERTTribunalsecretary@ontario.ca

and

Director
Ministry of the Environment, Conservation and Parks
Owen Sound District Office
3rd Flr
101 17th St
Owen Sound ON N4K 0A5
Fax: (519) 371-2905
Tel:

Further information on the Tribunal and requirements for an appeal can be obtained directly from the Tribunal by:

Tel: (416) 212-6349 or 1(866) 448-2248
TTY 1-800-855-1155 via Bell Relay
Fax: (416) 326-5370 or 1(844) 213-3474
Web: www.ert.gov.on.ca

FOR YOUR INFORMATION

The following is for your information:

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above mentioned timelines.

Unless stayed, this Order is effective from the date of service. Non-compliance with the requirements of this Order constitutes an offence.

The requirements of this Order are minimum requirements only and do not relieve you from complying with the following:

(a) any applicable federal legislation,
(b) any applicable provincial legislation or requirements that are not addressed in this Order, and
(c) any applicable municipal law.

The requirements of this Order are severable. If any requirement of this Order or the application of any requirement to any circumstances is held invalid, the application of such requirement to other circumstances and the remainder of the Order are not affected.

Further orders may be issued in accordance with the legislation as circumstances require.

The procedures and other information provided above are intended as a guide. The legislation and/or regulations should be consulted for additional details and accurate reference.

Provincial Officer's Report

Order Number
5736-B4ZHSA-1

K2 Wind Ontario Inc. operating as a general partner of and on behalf of K2 Wind Ontario Limited Partnership
Suite 105 - 100 Simcoe St
Toronto, Ontario, M5H 3G2
Canada

Site
Various Locations
Ashfield-Colborne-Wawanosh, County of Huron

Observations

On January 16, 2019, a request for extension was received via email from John O'Neill, Asset Manager, Pattern Energy Group Inc. In an attached letter, also dated January 16, 2019, signed by Joseph Watchi, K2 Wind Ontario LP, an update on the progress of the tonality investigation plan was provided.

In summary, the letter stated that the tonal audibility measurement campaign commenced on November 20, 2018 and is still ongoing. The completion of the tonal audibility assessment had been delayed due to difficulties in obtaining sufficient measurement data intervals for downwind conditions towards the audit receptor locations during periods when the turbine(s) operation is at its worst-case tonal audibility observed during the E-Audit. As such the Company requested an extension of March 1, 2019 to complete the updated E-Audit and Tonality Assessments.

In view of the above, I am satisfied that the additional time provided by this Amending Order is necessary in the circumstances and is in the public interest.

This order amends Provincial Officer's Order No. 5736-B4ZHSA issued on October 5, 2018. This Amending Order forms part of Provincial Officer's Order #5736-B4ZHSA and is to be appended to that order.

Offence(s)

Suspected Violation(s)/Offence(s):	

Act - Regulation - Section,
Description
{General Offence}
1) EPA - 186 (3),
Every person who fails to comply with the terms and conditions of an environmental compliance approval, certificate of property use or renewable energy approval or of a licence or permit under this Act or who fails to comply with the terms of a report under section 29 is guilty of an offence
{}

Scott Gass
Provincial Officer
Badge Number:
Date: 2019/02/05
District Office: Owen Sound District Office

Provincial Officer's Report

Order Number
5736-B4ZHSA

K2 Wind Ontario Inc. operating as a general partner of and on behalf of K2 Wind Ontario Limited Partnership
Suite 105 - 100 Simcoe St
Toronto, Ontario, M5H 3G2
Canada

Site
K2 Wind Power Project
Ashfield-Colborne-Wawanosh Township
County of Huron

Observations

Authority to Issue Order:

I am a Provincial Officer with the Ministry. I have the authority as a Provincial Officer to issue Orders under the EPA to further the purpose of the EPA, namely, to provide for the protection and conservation of the natural environment. This Order is being issued pursuant to my authority under section and 157.1 and subsection 196(1) of the EPA.

Definitions:

"Acoustic Audit - Emission" or "E-Audit" means an investigative procedure that is compliant with the IEC Standard 61400-11 and consisting of measurements and/or acoustic modelling of noise emissions produced by wind turbine generators, assessed to determine compliance with the manufacturer's noise (acoustic) equipment specifications and emission data of the wind turbine generators, included in the Acoustic Assessment Report;

"Acoustic Audit - Immission" or "I-Audit" means an investigative procedure consisting of measurements and/or acoustic modelling of all sources of noise emissions due to the operation of the Equipment, assessed to determine compliance with the Noise Performance Limits set out in this REA.

"Acoustical Consultant" means a person currently active in the field of environmental acoustics and

noise/vibration control, who is knowledgeable about Ministry noise guidelines and procedures and has a combination of formal university education, training and experience necessary to assess noise emissions from wind facilities;

"Assessment Plan" means the document entitled "K2 Wind Power Project, Emission Testing -Tonality Assessment, Detailed Tonal Audibility Assessment Plan, REA# 3259-98EQ3G", dated August 03, 2018, prepared by Aercoustics Engineering Limited.

"Company" means K2 Wind Ontario Inc., as general partner of and on behalf of K2 Wind Ontario Limited Partnership, an Ontario limited partnership.

"Compliance Protocol" means the Ministry document entitled "Compliance Protocol for Wind Turbine Noise Guideline for Acoustic Assessment and Measurement PIBS#8540e", April 2017, as amended.

"Director" means Moshen Keyvani, Supervisor, Ministry of the Environment Conservation and Parks, Environmental Assessment and Permissions Branch, 135 St Clair Ave W, Toronto, M4V 1P5

"District Manager" means Rick Chappell, District Manager, Ministry of the Environment, Conservation and Parks, 3rd Flr, 101 17th St E, Owen Sound, ON N4K 0A5

"EAPB" means the Ministry's Environmental Assessment and Permissions Branch.

"**EAPB September 14th Letter"** means the Letter dated September 14, 2018 from EAPD to the Company: Re: Acoustic Audits for REA #3259-98EQ3G K2 Wind Facility, Ashfield-Colborne-Wawanosh Township, County of Huron Reference Number 4850-922KFZ, attached to this Order.

"EPA" means the Environment Protection Act, R.S.O. 1990, c. E. 19, as amended.

"Facility" or **"K2 Wind Power Project"** means the Class 4 wind facility approved to operate pursuant to the REA, consisting of one hundred and forty (140) wind turbine generators and two transformer stations, with a total name plate capacity of 270 megawatts (MW), located in the Township.

"**ISO 1996-2**" – means Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of sound pressure levels, Third edition, 2017-07"

"MECP" or "Ministry" means the Ontario Ministry of the Environment, Conservation and Parks.

"Noise Guidelines for Wind Farms" means the Ministry document entitled, "Noise Guidelines for Wind Farms - Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities", dated October 2008.

"O. Reg. 359/09" means Ontario Regulation 359/09 made under the EPA, 'Renewable Energy Approvals under Part V.0.1 of the EPA.

"REA" means Renewable Energy Approval No. 3259-98EQ3G issued on July 23, 2013, in accordance with Section 47.4 of the Act, including any schedules to it, as may be amended.

"Tonality" means a pronounced audible tonal quality of the sound such as a whine, screech, buzz or hum.

"Tonality Assessment" means an assessment conducted in accordance with Part D, section D3.8.3 *Tonality (Tonal Assessment)* of the Compliance Protocol

"Township" means the Township of Ashfield-Colborne-Wawanosh in the County of Huron.

"UTM" or "UTMs" means Universal Transverse Mercator coordinate system.

Description of Company:

The Company is a joint venture between Pattern Energy, Axium Infrastructure Inc., and Capital Power Corporation. The Company owns and operates the K2 Wind Power Project.

Site Description:

K2 Wind Power Project is a 270 MW wind power facility located in the Township consisting of 140 wind turbines.

Summary of Events Leading to the Order:

The Facility commenced commercial operation in June of 2015 pursuant to their REA. Conditions E and F of the REA require the Company to gather accurate information so that environmental noise impacts can be assessed to enure compliance with the EPA, O. Reg. 359/09, Noise Guidelines for Wind Farms and the REA can be verified. As per the requirements of Conditions E and F of the REA, the Company had submitted the acoustic audits; however, the Ministry's review of the submissions identified potential concerns regarding the tonal nature of turbine noise for some of the types of wind turbines used at the Facility. As such, in accordance with the Ministry's Compliance Protocol, the Company is required to complete Tonality Assessments. Tonality Assessments were not included as part of the original I-Audit submissions.

On July 6, 2018, the Ministry's EAPB sent a letter to the Company acknowledging that the Company had fulfilled the requirements of conditions E1 and E2 of the REA relating to I-Audits; however the Company had not fulfilled the requirements for an Acoustic Audit – Emission as per Condition "F" of the REA, which states:

F1. The Company shall carry out an Acoustic Audit - Emission of the acoustic emissions produced by the operation of the wind turbine generators in accordance with the following:

(1) the acoustic emission measurements shall be undertaken in accordance with the IEC Standard 61400-11;

(2) the acoustic emission measurements shall be performed by an Independent Acoustical Consultant; and

(3) the acoustic emission measurements shall be performed on one (1) of each of the six (6) types of wind turbines used in the Facility.

Specifically one (1) wind turbine generator rated at ;

2.300 megawatts generating output capacity
2.221 megawatts generating output capacity,
2.126 megawatts generating output capacity,
2.030 megawatts generating output capacity,
1.903 megawatts generating output capacity, and
1.824 megawatts generating output capacity

F2. The Company shall submit to the District Manager and the Director an Acoustic Audit Report-Emission, prepared in accordance with Section 9 of the IEC Standard 61400-11 by an Independent Acoustical Consultant, no later than eighteen (18) months after the commencement of the operation of the Facility.

In summary, the Company had retained an Acoustical Consultant to complete acoustic measurements, of six types of wind turbines used at the Facility, in accordance with Condition F of the REA. The measurements for 4 of the 6 types of the turbines measured were identified to have tonal audibility values greater than 3 dB at the measurement location. In accordance with Part D3.8.3 of the Compliance Protocol, if there is a concern regarding the tonal nature of the turbine (or wind facility) noise, including tonal audibility values greater than 3 dB, then the requirement to conduct a Tonal Assessment is triggered.

The July 6th letter from EAPD to the Company identified the E-Audits for turbines rated at 2.300 megawatts, 2.126 megawatts and 1.903 megawatts as incomplete and requested that the E-Audit assessments, for these turbine types, be updated and re-submitted by Aug 6, 2018 to include Tonality Assessments. It is noted that the test report for the wind turbine generator rated at 1.824 megawatts generating output capacity was deemed acceptable, based on a review of previous test reports conducted at a receptor which did not identify a tonality concern.

In response to the Ministry's request, on August 6, 2018, the Company submitted additional data, including an Assessment Plan to analyse tonality.

Upon review of the August 6th, 2018, submissions, EAPB notified the Company via a letter dated September 14, 2018, that the submissions did not address the tonality concerns identified in the July 6th EAPD letter, as the Company only proposed a noise investigation plan for testing. The Assessment Plan proposes to complete the Tonality Assessments during Fall 2018.

At this time, the Company is required to submit additional acoustic emission measurements to verify compliance. The Ministry has reviewed the Company's proposed Assessment Plan, dated August 3, 2018 and is satisfied with the proposed timeline for submission of the required information, provided

that the Tonality Assessments are subject to the most recent version of the ISO-1996-2 standard, and the plan, and submitted reports, include the approximate UTMs of the proposed monitoring locations.

Provincial Officer's Opinion:

I reasonably believe that the requirements specified in this Order are in the public interest and are necessary or advisable so as to prevent or reduce the risk of a discharge of a contaminant, namely sound, into the natural environment from the undertaking or the property.

Attachments:

Letter dated September 14, 2018 from EAPD to the Company: Re: Acoustic Audits for REA # 3259-98EQ3G K2 Wind Facility, Ashfield-Colborne-Wawanosh Township, County of Huron Reference Number 4850-922KFZ.

K2 Wind Power Project, Emission Testing -Tonality Assessment, Detailed Tonal Audibility Assessment Plan, REA# 3259-98EQ3G", dated August 03, 2018, prepared by Aercoustics Engineering Limited.

Offence(s)

Suspected Violation(s)/Offence(s):	
Act - Regulation - Section, **Description** **{General Offence}** 1) EPA - 47.3 (1) 1, A person shall not engage in a renewable energy project except under the authority of and in accordance with a renewable energy approval issued by the Director if engaging in the project involves engaging in any of the following activities: An activity for which, in the absence of subsection (2), subsection 9 (1) of this Act would require an environmental compliance approval {186 (1)}	

Scott Gass
Provincial Officer
Badge Number: 956
Date: 2018/10/05
District Office: Owen Sound District Office

aercoustics

Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

Tel: 416-249-3361
Fax 416-249-3613
aercoustics.com

To: John O'Neill, John.O'Neill@patternenergy.com

From: Addie Denison, addied@aercoustics.com

Copies: Payam Ashtiani, Aercoustics
Allan Munro, Aercoustics
Robin Maxwell, Pattern Energy
Mahdi Zangeneh, MOECP
Mohsen Keyvani, MOECP
Denton Miller, MOECP

Subject: K2 Wind Power Project
Emission Testing – Tonality Assessment
Detailed Tonal Audibility Assessment Plan
REA# 3259-98EQ3G

Date: August 03, 2018

Aercoustics Engineering Limited ("Aercoustics") has previously completed acoustic measurements of six (6) turbines at the K2 Wind Power Project. The purpose of the measurements was to determine the acoustic noise emission of the turbines. The measurements were carried out in accordance with the International Standard IEC 61400-11 (Edition 3.0, released 2012-11), "Wind turbine generator systems – Part 11: Acoustic noise measurement techniques". These measurements indicated that four (4) of the turbines measured had tonal audibility values greater than 3 dB at the measurement location. These turbines were T226, T271, T207 and T315.

The Ministry of the Environment, Conservation and Parks (MOECP) has indicated that the test report for T271 has been accepted on the basis that receptor-based Immission measurements previously conducted at receptor R676, in the vicinity of T271, did not indicate a tonality concern.

The MOECP has requested that a tonal audibility assessment (as per section D 3.8.3 of the NPC-350) be conducted at a receptor location most impacted by the remaining three turbines (T226, T207 and T315). Aercoustics Engineering Limited ("Aercoustics") has been retained by Pattern Energy to complete this tonal audibility assessment. K2 operates under REA #3259-98EQ3G, issued on July 23, 2013.

In order to facilitate consultation with the MOECP regarding the recommended detailed noise audit and tonal audibility assessment, Aercoustics has prepared this letter to outline the proposed measurement locations and methodology.

1 ASSESSMENT LOCATIONS

The following provides a summary of the proposed receptor locations. Detailed site plans showing the receptor location and the proposed measurement location are shown in Figures 1-3.

Receptor locations have been chosen based on the closest receptors to each subject turbine, while keeping the prevailing westerly/southwesterly wind direction in mind when possible. The following locations have been selected:

- T226: R41 – this is the closest receptor and is located in a predominant down-wind direction for the site. R40 and R39 have been noted to be vacant at this time.

- T207: R856 – this is the closest receptor to T207. Unfortunately, it is located directly south of the turbine. There are no nearby receptors located in the down-wind direction of T207, and so this location appears to be the best option. That being said, we do anticipate that achieving sufficient data with a downwind filter may be difficult at this location.

- T315: R314 – there is a receptor (R754) that is located closer to T315. R754 is located in the predominant up-wind direction however, and it is expected that it will be very difficult to obtain sufficient data at this location with a downwind filter. Aercoustics would like to propose that the noise monitor be placed at a similar distance from T315, but in the direction of R314.

2 DETAILED NOISE AUDIT METHODOLOGY

The following methodology will be applied in conducting the acoustic assessment at the locations indicated above in Section 1. The proposed methodology is based on unattended measurements and is in accordance with Part D 3.8.3 of the Compliance Protocol for Wind Turbine Noise; NPC 350, April 2017.

2.1 Acoustic Instrumentation

- One (1) sound level meter will be located at each assessment location for a total of three (3) units. Each sound level meter will be a Type 1 meter and will meet specifications outlined in section D2.1 Acoustic Instrumentation of the Part D Protocol.
- A secondary windscreen will be utilized at each measurement location. The secondary windscreens that will be used have been tested and have documented insertion loss (1/3 Octave band data).

2.2 Non-acoustic Instrumentation

- One (1) anemometer will be utilized at each assessment location for a total of three (3) anemometers. The anemometers will be located 10m above grade, as defined by Section D3.4 and will comply with performance specifications defined in Section D.2.2 of the Part D Protocol.

2.3 Measurement Procedure

- Measurement data (acoustic and anemometer) will be logged simultaneously to provide synchronous data capture.
- Measurements will be conducted only between 10pm and 5am. This is intended to provide the lowest ambient noise conditions possible and yield the highest signal to noise ratio.
- Data will be acquired for both “turbines operational” and “turbines parked” in order to satisfy the minimum data requirements outlined in Section D3.8.3 (at least five one-minute intervals for each integer wind speed) of the Part D Protocol. Data will be logged in 1 minute intervals.
- For “turbines parked” measurements, turbines in the vicinity of the measurement locations will be parked such that the predicted level is less than 30dBA (i.e. insignificant compared to overall level). The number of turbines that require parking will be verified in the acoustic model used to obtain the facility’s approval.
- Turbine SCADA data will be supplied in 1 minute intervals for the duration of the measurements. Parameters such as nacelle wind speed, active power output, nacelle yaw angle and RPM will be recorded.

2.4 Microphone Placement

- The microphone will be placed at a measurement height of 4.5m above grade, which is consistent with the receptor height modelled during the approval process.
- The microphone will be located appropriate to site specific constraints and will adhere to the following guidelines:
    - The microphone will be located away from any large reflecting surfaces (at least 5m away).
    - The microphone will be in a location such that it is not shielded from the turbine.
    - The microphone will be located away as practically as possible from deciduous trees or foliage that may impact noise measurements.

2.5 Acoustic Measurements

- Tonality analysis will be based on 1-minute narrow band spectra, ranging from 20 Hz to 3000Hz and 1Hz frequency resolution.

- Audio recordings will be taken should additional post-processing or listening be required.

2.6 Data Processing and Analysis

- Measurement data will be filtered using the following approach for both "turbines operational" and "turbines parked" data sets:
    - Measurement data with precipitation within an hour of the measurement period will be excluded from the analysis.
    - Measurements will be filtered based on wind direction. Only downwind data will be considered in the analysis. With reference to the turbine location, downwind directions are ± 45 degrees from the line of sight between the turbine and measurement location. The downwind direction will be based on the yaw angle of the turbine.
    - Additional filtering may be relied upon, if needed due to low-signal to noise ratios. Should this be required the MOECP will be consulted.
    - The presence of tones in the noise at different wind speeds shall be determined on the basis of narrowband analysis outlined in IEC 61400-11 Ed 3.0.
- In addition to the above, "turbine operational" measurements will be filtered based on the measured hub-height wind speed. Data will only be included in the analysis when the hub-height wind speed is between 10 and 13 m/s. This range has been selected because it is representative of the wind speeds at which the highest tonal audibility values were measured during the Emission testing.

3 SCHEDULE

Mobilization time is expected to be delayed because of low summer resources and high levels of vegetation noise. Pending confirmation of the plan from the MOECP, deployment of acoustic monitors is anticipated for Fall 2018.

Regarding the duration of the test, if sufficient data is not acquired within the first six weeks of monitoring, alterations to the proposed data filters may be considered, in consultation with the MOECP.

We hope this letter provides the MOECP a clear indication of our approach and methodology for the K2 detailed tonality assessment in the vicinity of turbines T226, T207 and T315.

Figure 1: Proposed Monitor Location: T226

Figure 2: Proposed Monitor Location: T207

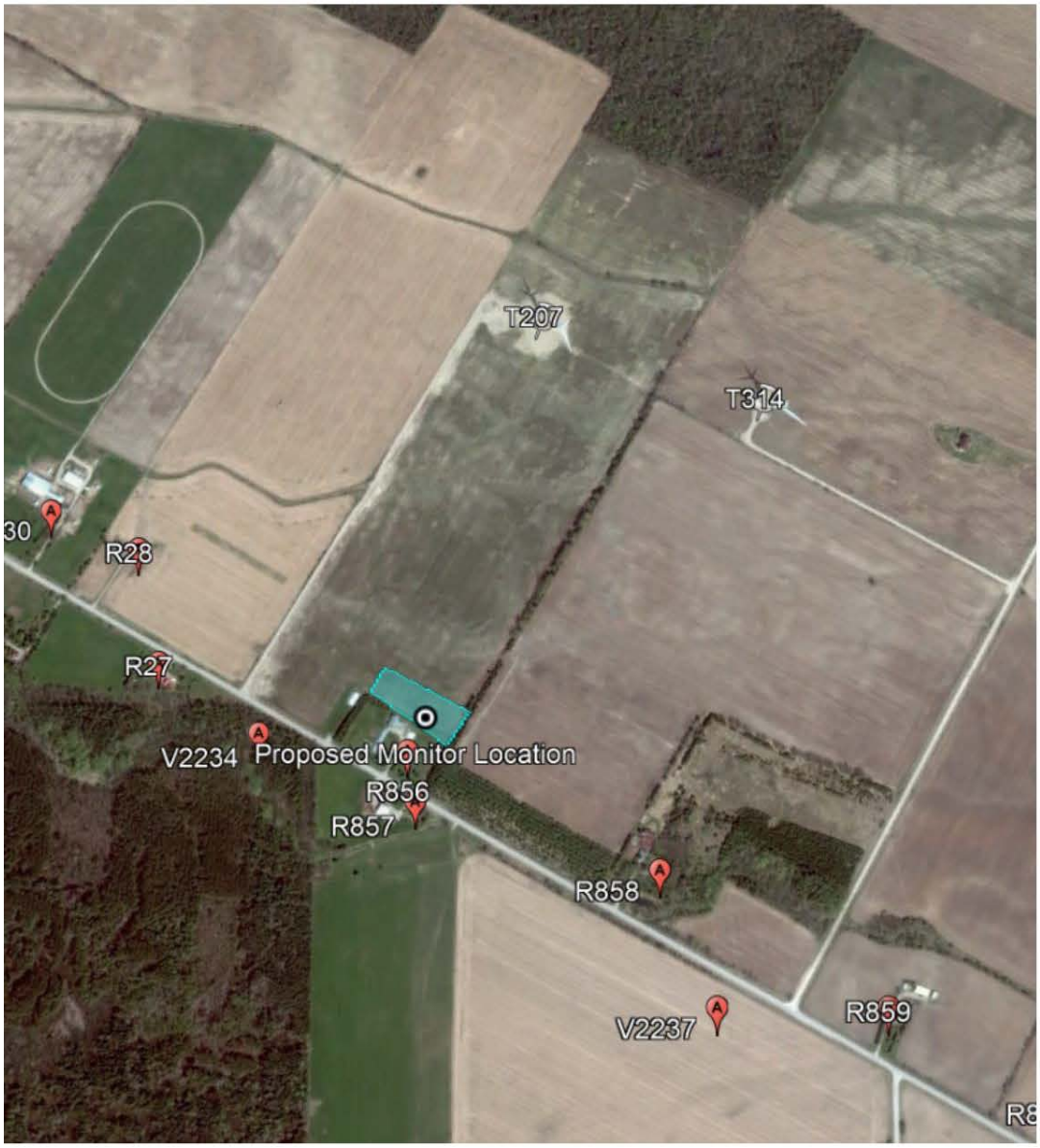

Figure: Proposed Monitor Location: T315