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ASSESSMENT REPORT - **Project: 15247.00**

Armow Wind Power Project
Tonality Assessment Report – V556

Prepared for:

SP Armow Wind Ontario LP.
2050 Derry Road West, 2nd Floor
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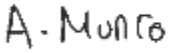
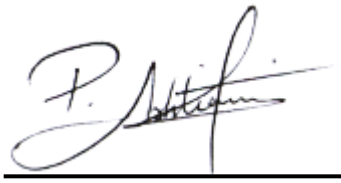
Prepared by:

Ibbtida Khan



Allan Munro, B.A.Sc., P.Eng.



Payam Ashtiani, B.A.Sc., P.Eng.

07 February 2020

Revision History

Revision Number	Description	Date
1	Tonality Investigation Noise Report	07/02/2020

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Executive Summary

The Ministry of Environment, Conservation and Parks ("MECP") has ordered (Provincial Officer's Order #2868-B8VRY4-1 dated June 19, 2019) the Armow Wind Power Project to conduct a tonal audibility assessment at receptor locations most impacted by Armow wind turbines identified in the REA as **T50**, T30, T88, T102, T75 and T95. This report is specific to Turbine T50. The tonality assessment has been conducted at the worst-case receptor for turbine T50 as agreed to by the MECP and as per section 3.b of the Armow Scope of Work document dated July 26, 2019.

Aercoustics Engineering Limited ("Aercoustics") has been retained by SP Armow Wind Ontario LP ("Armow") to complete this tonal audibility assessment at receptor location V556. The report has been prepared to facilitate submission to the MECP, in accordance with the Provincial Officer's Order #2868-B8VRY4 and Armow Scope of Work document dated July 26, 2019.

Armow operates under REA #4544-9B7MYH, issued on October 9, 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).

The tonal audibility calculation methodology followed that of ISO 1996-2:2017 (ISO/PAS 20065:2016) with modifications to adapt the method to wind turbine immission measurements. The tonal adjustment structure followed sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

No tone was present at V556 which warranted a Tonal Adjustment in any 10m wind bin. Thus, the Turbine T50 and turbines of the same type (SWT-2.3-101 2.030MW, hub 99.5) are assessed to be compliant with the acoustic requirements set out in the REA.

1 Introduction

The Ministry of Environment, Conservation and Parks ("MECP") has ordered (Provincial Officer's Order #2868-B8VRY4-1 dated June 19, 2019) the Armow Wind Power Project to conduct a tonal audibility assessment at receptor locations most impacted by Armow wind turbines identified in the REA as **T50**, T30, T88, T102, T75 and T95. This report is specific to Turbine T50 and the tonality assessment has been conducted at the worst-case receptor for turbine T50 as agreed to by the MECP and as per section 3.b of the Armow Scope of Work document dated July 26, 2019.

Aercoustics Engineering Limited ("Aercoustics") has been retained by SP Armow Wind Ontario LP ("Armow") to complete this tonal audibility assessment at receptor location V556. The report has been prepared to facilitate submission to the MECP, in accordance with the Provincial Officer's Order #2868-B8VRY4 and Armow Scope of Work document dated July 26, 2019.

Armow operates under REA #4544-9B7MYH , issued on October 9, 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).

The tonal audibility calculation methodology followed that of ISO 1996-2:2017 (ISO/PAS 20065:2016) with modifications to adapt the method to wind turbine immission measurements. The tonal adjustment structure followed sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

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 Armow 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 Generator T50 was 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
T50	Siemens SWT-2.3-101 2.030MW, hub 99.5m	15247.00.T50.RP2

Detailed measurement reports for T50 (Report ID: 15247.00.T50.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 T50 is summarised in Table 2.

Table 2 – T50 - 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 (%)
7.5	431	-4.4	-2.2	14	23	61%
8	448	-3.5	-1.3	28	28	100%
8.5	453	-1.5	0.8	34	34	100%
9	453	0.1	2.4	51	53	96%
9.5	453	1.7	3.9	64	66	97%
10	453	2.9	5.1	50	50	100%
10.5	465	5.7	7.9	59	67	88%
11	115	-4.2	-2.2	58	74	78%
	468	5.2	7.5	70	74	95%
11.5	115	-4.2	-2.2	45	57	79%
	468	6.1	8.4	49	57	86%
12	116	-3.8	-1.8	21	22	95%
	470	6.2	8.5	21	22	95%

Table 3 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 3 Summary of Relevant Tones T50

Turbine ID	Frequency Range (Hz)	Tonal Audibility (dB)	Hub Height Wind Speed Range (m/s)	Electrical Power Output Range (kW)
T50	470Hz [442Hz – 498Hz]	0.8 – 8.5	8.5 – 12	1303 - 2030

3 Tonal Assessment Details

The acoustic audit was conducted at receptor V556[1]. This location is closest to turbine T50 and has been chosen based on consultation with the MECP to determine the tonal audibility impact at the receptor location.

Monitoring at V556 spanned the following dates, summarized in Table 4.

Table 4: Monitoring Period for Each Receptor (DD/MM/YYY)

Location	Monitoring Start Date	Monitoring End Date
V556	11/06/2016	20/10/2016

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 MECP 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 A. Brunskill, D. Eaton and E.Crivella dated September 9, 2013 [3]

Table 5 provides the specific model and serial numbers for the measurement equipment used during the measurement campaign.

Table 5: Equipment Details

Location	Equipment	Make/Model	Serial Number
V556	Sound Level Meter	B&K 2250	3004725
	Microphone	B&K 4189	2888708
	Pre-Amplifier	B&K ZC 0032	20329
	Weather Anemometer	Vaisala WXT 520	K0630017

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 -10˚C

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: Armow turbines must be rotating and generating power
- Background: Armow 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 filter was applied to specifically assess operational conditions when the highest tonal audibility values were measured during the E-audit testing at T50.

Table 6: Power Filtering Summary

Location	Turbine	Power Output (kW)
V556	T50	≥ 1303

3.4 **Measurement Location**

Monitoring was conducted at the vacant lot receptor V556. V556 has a predicted impact of 39.4 dBA 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 7: Receptor Measurement Locations

	Audit Receptor ID Turbine ID	V556 T50
Receptor	UTM Coordinates (X,Y)	17T 461479mE 4889661mN
	Distance to Turbine (m)	802
	Receptor Height (m)	4.5
	Predicted Level (dBA)*	39.4
Monitor	UTM Coordinates (X,Y)	17T 461499mE 4889627mN
	Distance to Turbine (m)	798
	Monitor Height (m)	4.5
	Predicted Level (dBA)*	39.4

*Predicted Level from Aercoustics' acoustic model

Flora and Fauna

Ambient contamination from flora and fauna was present to varying degrees at the measurement location. Transient contamination (dogs barking etc.) are removed by the listening tests. Insects, birds, and noise from leaves and crops rustling were present to varying degrees in the environment surrounding all receptors; this noise is present to greater degrees at high frequencies and those frequencies were excluded to minimize contamination from insect noise.

Impact of Excluded Frequencies

Analysis of the measured sound levels for V556 were limited to 1/3rd octave band frequencies below 3150 Hz. This frequency band was excluded to minimize contamination of the acoustic measurements from steady ambient sources such as insects. The predicted impact at these frequencies is presented in Table 8.

Table 8: Predicted Impact from Facility of Excluded Frequencies

Measurement Location	Predicted Facility Immission, 3150 Hz – 10000 Hz octave bands[2]
V556	1.1 dBA

The contribution from the wind facility at these frequencies is small because high frequency sound is more efficiently absorbed by the atmosphere. The predicted facility

[2] Contribution by octave band frequency determined using CadnaA model

sound impact at from frequencies excluded from the measurement data have been added back to the Turbine-Only sound level.

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. In addition, the MECP has required that the five (5) one-minute measurements per wind speed bin are to include the entire assessment range of the turbine and is not limited to wind speed bins of 4-7 m/s.

3.6 Operational Conditions

Turbine operational data for the duration of the measurement campaign was supplied by Pattern Operation Control Centre. Measurement data at 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 T7, T8, T9, T10, T13, T14, T15, T18, T26, T27, T28, T29, T30, T31, T32, T40, T41, T42, T43, T44, T47, T49, T50, T57, T58, T60, T61, T63, T69, T82, T94, T96, T97, T102, T103, T105, T106, T107, T112, T113, T114 and T115.

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 9.

Table 9: General Weather Conditions – Range of Measured Values

	10-m AGL			
	Atmospheric Pressure [hPa]	Wind Speed [m/s]	Relative Humidity [%]	Temperature [°C]
Minimum	966	0.0	36	2
Maximum	995	16.1	92	27

4.2 Wind Direction

A Wind rose representing the recorded wind directions during the audit is 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

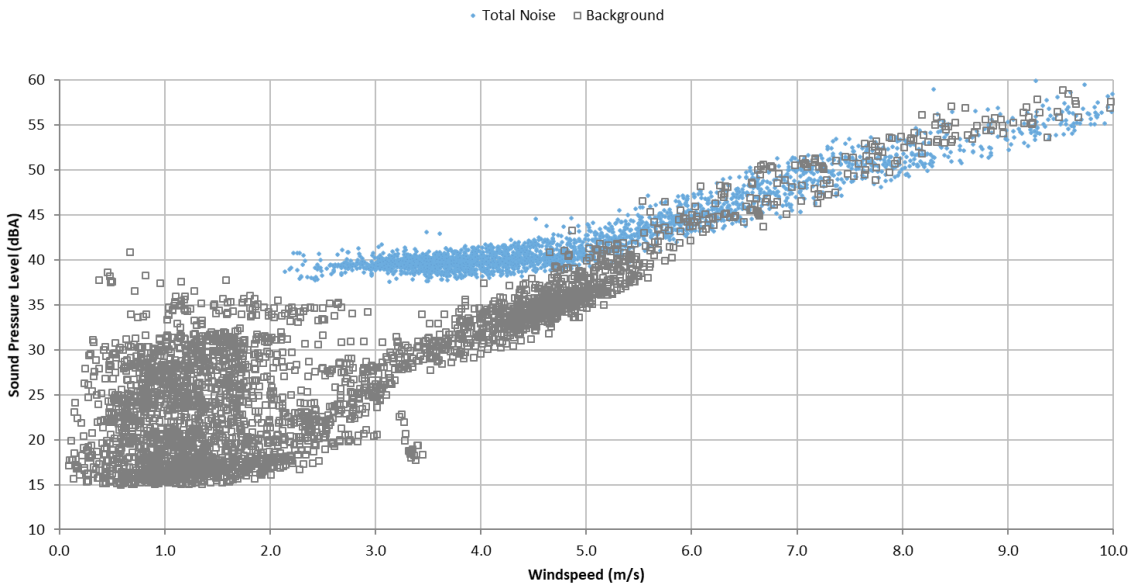
Table 10 details the sound levels measured at the receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). The Turbine ON and Turbine OFF sound level presented are filtered as per the filters detailed in Section 3.3.

Table 10: V556 Sound levels measured for Turbine ON and OFF (Downwind – T50)

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]
1	0	-	-	1198	25.9	5.4
2	29	39.2	1.0	591	27.3	5.6
3	481	39.7	0.6	222	27.5	3.9
4	838	39.9	0.8	279	33.2	1.9
5	463	41.5	1.3	400	37.0	2.1
6	334	45.1	1.5	65	44.3	2.5
7	228	49.0	1.9	58	48.8	2.1

The following figures present the scatter plots showing each valid 1-minute interval measured sound level at V556 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: V556 - Measured Sound Levels for Turbine ON and Background vs Wind Speed (Downwind – T50)



4.4 **Measured Tonality**

The tonal assessment has been completed using ISO/PAS 20065:2016 (Acoustic-Objective method for assessing the audibility of tones in noise-Engineering Method) and the tonal penalty structure taken from ISO 1996-2:2007 Annex C. Namely, Section 5.1 of the compliance protocol states:

> *If a tonal assessment … indicates a tonal audibility value that exceeds 4 dB, the Ministry will require that a tonal penalty be applied at all Receptors in accordance with the penalties described in Annex C of ISO 1996-2, Reference [2]*

The tonality analysis results of the Emission audit measurements for T50 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 to determine if a tonal adjustment would be applicable.

For a given spectra if the Tonal audibility is greater than 0dB then a tone is present. For all Spectra in which no tone is found, a tonal audibility of -10 dB is applied (as specified in Section 5.3.9 in ISO/PAS 20065:2016). The Mean Tonal Audibility values reported represent the energy average of all data points with an identified tone that falls within the same frequency of origin with the inclusion of data points with unidentified tones (i.e. -10 dB). A sample tone plot is provided in Appendix D.

4.4.1 Tonal Assessment – 10m wind speed

The presence of tones in the I-audit data binned by 10m wind speed was determined.

Tonal assessment summary table is provided in Table 11.

Table 11: Tonality Summary – V556 – 470Hz [442Hz – 498Hz]

10m Wind Speed (m/s)	Turbine ON Data points	# of Data Points with Tones	Tonal Presence	Mean Audibility, ΔL (dB)	Tonal Adjustment, K_T (dB)
1	0	0	-	-	-
2	29	0	-	-10.0	-
3	481	2	0%	-9.8	0
4	838	6	0%	-9.6	0
5	463	0	0%	-10.0	0
6	334	0	0%	-10.0	0
7	228	0	0%	-10.0	0

Relevant tones from T50 (470 Hz) were found to be present at receptor V556. No tonal adjustment was found to be applicable at receptor V556 at any 10m wind speed bin.

4.4.1 Tonal Assessment - hub-height wind speed

The presence of tones in the I-audit data as a function of hub height wind speeds was also determined. The tonal analysis covered the same hub height wind speed range as the sound power level measurement of the E-audit test for Turbine T50. The turbine electrical power filter was removed, and all spectra were sorted into half-integer hub height wind speed bins using the methodology for the E-audit (IEC 61400-11 Ed 3.0) adapted for I-audit measurements. The results of this analysis provide the mean tonal audibility over the entire assessment range of the turbine (8m/s to 12.5m/s).

Table 12 Tonality Assessment at each half-integer hub-height wind speed 470 Hz [442 to 498Hz]

Hub Height Wind Bin (m/s)	Turbine ON Data points	# of Data Points with Tones	Tonal Presence	Mean Audibility, ΔL (dB)	Turbine Power Output (kW)
7.5	1306	0	0%	-10.0	993
8	848	0	0%	-10.0	1193
8.5	1111	4	0%	-9.8	1413
9	585	4	1%	-9.7	1633
9.5	366	0	0%	-10.0	1774
10	172	0	0%	-10.0	1915
10.5	88	0	0%	-10	1962
11	108	0	0%	-10	2008
11.5	78	0	0%	-10	2018
12	50	0	0%	-10	2027

Similar to the tonal assessment binned by 10m wind speed, relevant tones from T50 (470 Hz) were found to be present at receptor V556 for some hub-height wind bins, however the tonal presence and mean audibility was relatively low compared to measurements at the E-audit location.

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.

No tone was present at V556 which warranted a Tonal Adjustment in any 10m wind bin. Thus, the Turbine T50 and turbines of the same type (SWT-2.3-101 2.030MW, hub 99.5) are assessed to be compliant with the acoustic requirements set out in the REA.

References

[1] V. Schroter, “Renewable Energy Approval #4544-9B7MYH ”, Ontario Ministry of the Environment, Toronto, ON, October 9, 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] A. Brunskill, D. Eaton and E.Crivella , “Armow Wind Farm, Ontario Noise Impact Assessment ”, GL Garrad Hassan, 9 September 2013.

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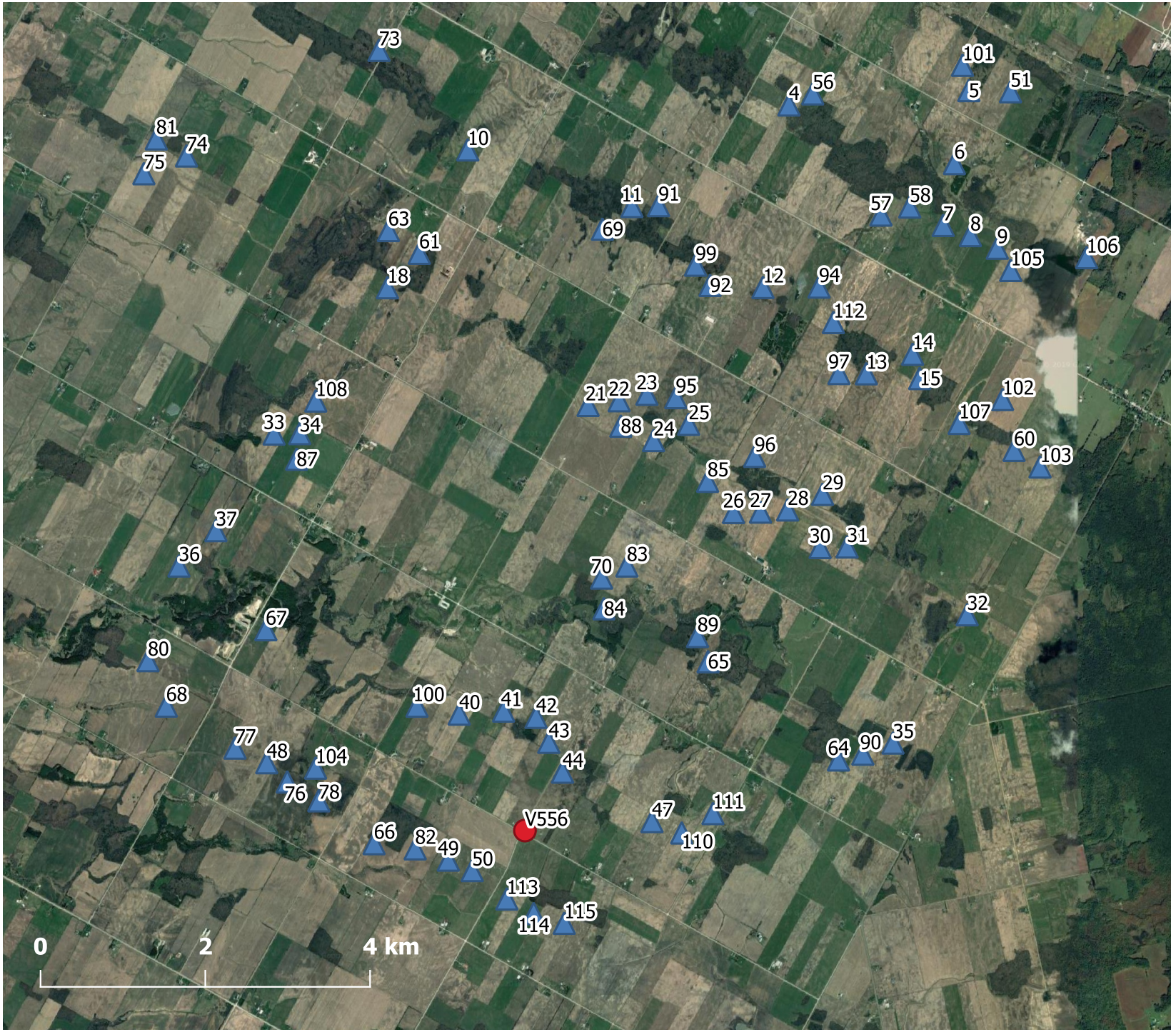
Appendix A
Location Details



Legend

- Armow Turbines
- V556 Monitor

N

Project ID:	15247.00
Drawn by:	IK
Reveiwed by:	AM
Date:	August 29, 2019
Revision:	1
Scale:	As Indicated

Armow Wind Power Project
Tonal Assessment V556

Appendix A.1

Site Plan Overview

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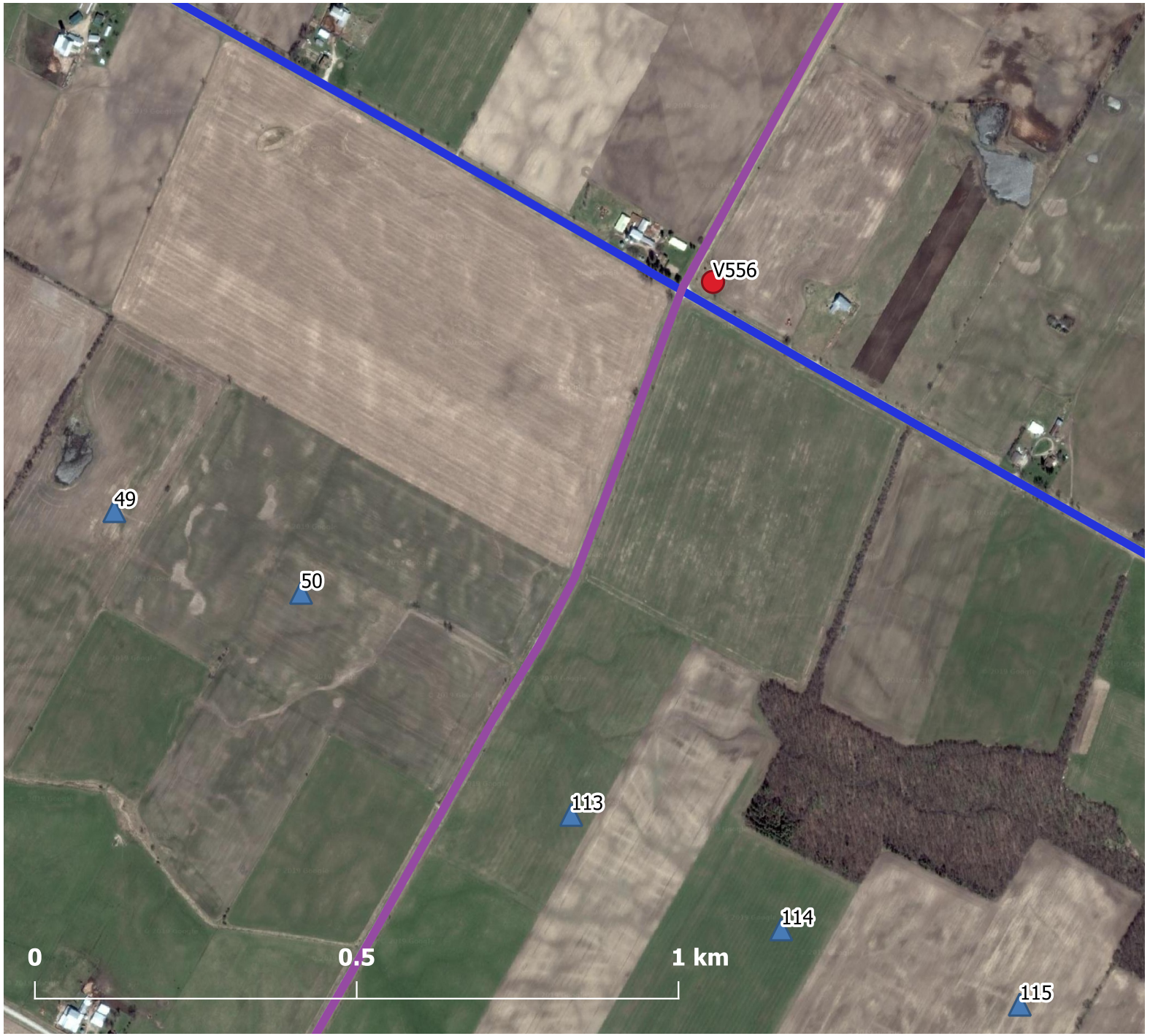

Legend

- Armow Turbines
- V556 Monitor
- Bervie Sideroad
- Concession Rd 5

N

Project ID: 15247.00
Drawn by: IK
Reveiwed by: AM
Date: August 29, 2019
Revision: 1

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment V556

Appendix A.2

Measurement Locations

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Project ID: 15247.00
Drawn by: IK
Reveiwed by: AM
Date: August 29, 2019
Revision: 1

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment V556

Appendix A.3

Site photo

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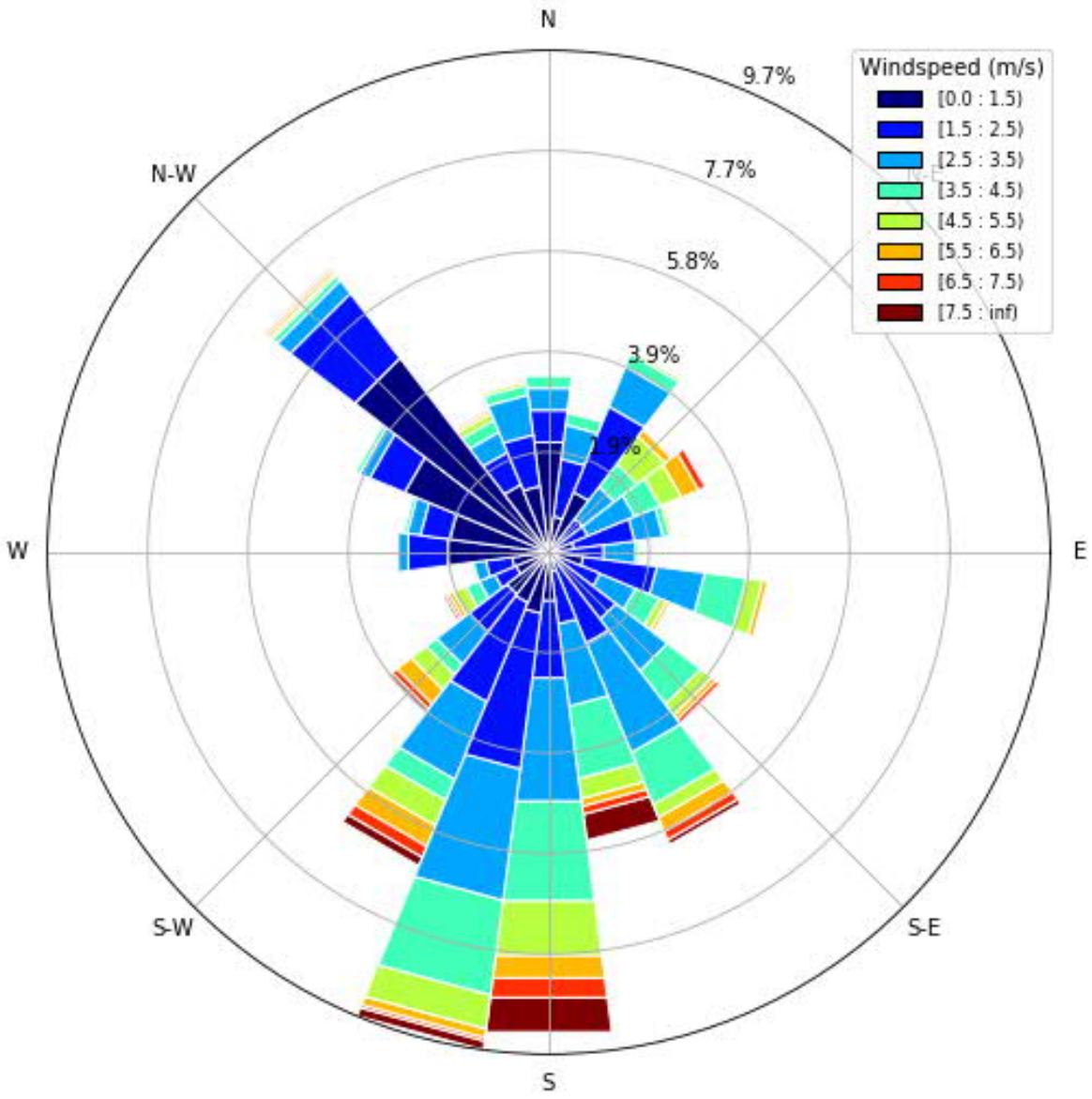
Appendix B
Wind Roses



Project ID: 15247.00
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Armow Wind Power Project
Tonal Assessment V556

Appendix B

Supplementary Wind Rose based on All Data

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Appendix E
Calibration Certificates

Calibration Certificates –

Details are disclosed in the table below regarding the calibration of the equipment used for the I-Audit campaign at monitor location V556. The associated calibration certificates are provided in this appendix.

Location	Equipment	Make/Model	Serial Number	Date Calibrated [YYYY-MM-DD]
V556	Sound Level Meter	B&K 2250	3004725	2016-01-19
	Microphone	B&K 4189	2888708	2016-01-19
	Pre-Amplifier	B&K ZC 0032	20329	2016-01-19
	Weather Anemometer	Vaisala WXT 520	K0630017	2016-02-18

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

HAND HELD ANALYZER

Manufactured by:	BRUEL & KJAER
Model No:	2250 (ID#2250-3)
Serial No:	3004725
Calibration Recall No:	26101

Submitted By:

Customer:

Company: AERCOUSTICS ENGINEERING LTD.

Address:

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. 2250 (ID#2 BRUE

Upon receipt for Calibration, the instrument was found to be:

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.

West Caldwell Calibration Laboratories' calibration control system meets the following requirements, ISO 10012-1 MIL STD 45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2008 and ISO 17025

Note: With this Certificate, Report of Calibration is included.

Calibration Date: 19-Jan-16

Certificate No: 26101 - 1

Approved by:

FC

Felix Christopher (QA Mgr.)

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

uncompromised calibration West Caldwell Calibration Laboratories, Inc.

1575 State Route 96, Victor, NY 14564, U.S.A.

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor NY 14564

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

Brüel & Kjær Hand-held Analyzer **Model No.: 2250** **Serial No.: 3004725**

Company: Aercoustics Engineering Ltd **ID No.: 2250-3**

The procedure from IEC 61672-3-2013 were used to perform the periodic test. (Test limits are from IEC 61672-1-2013)
Instrument submitted for testing has successfully completed the Class 1 periodic test of IEC 61672-3-2013 listed below.
Also meets the requirements of ANSI/ASA S1.4 - 2014 / Part 3.
Fulfils 1/1-Octave and 1/3-Octave Filter ANSI/ASA S1.11 -1-2004 and IEC61260-1 : 2014 requirements.

Absolute Acoustical Sensitivity Level, IEC 61672 - 3 (9)	Pass
Electrical Inherent Noise Level, Freq. Weig. Lin, IEC 61672-3 (10)	Pass
Determining Electrical Level for 1V at 1kHz	Pass
Frequency Response measured with Electrical Signal, Freq. Weig. A with HP filter, IEC 61672 Class 1 (12)	Pass
Frequency Response measured with Electrical Signal, Freq. Weig. C with HP filter, IEC 61672 Class 1 (12)	Pass
Frequency Response measured with Electrical Signal, Freq. Weig. Z with HP filter, IEC 61672 Class 1 (12)	Pass
Frequency Weightings at A - Weighting 1kHz, IEC 61672-3 (13)	Pass
Frequency Weightings at C - Weighting 1kHz, IEC 61672-3 (13)	Pass
Frequency Weightings at Z - Weighting 1kHz, IEC 61672-3 (13)	Pass
Linearity Range at 1kHz, IEC61672 - 3 (14)	Pass
Range Level at 1kHz, IEC61672 - 3 (15)	Pass
Time Weighting Response to Single Burst, 4kHz, 200ms, F Class 1, IEC61672 - 3 (16)	Pass
Time Weighting Response to Single Burst, 4kHz, 2ms, F Class 1, IEC61672 - 3 (16)	Pass
Time Weighting Response to Single Burst, 4kHz, 0.25ms, F Class 1, IEC61672 - 3 (16)	Pass
Time Weighting Response to Single Burst, 4kHz, 200ms, S Class 1, IEC61672 - 3 (16)	Pass
Time Weighting Response to Single Burst, 4kHz, 2ms, S Class 1, IEC61672 - 3 (16)	Pass
Peak C Level 8kHz Sine IEC 61672 - 3 Class 1 (17)	Pass
Peak C Level 500Hz Positive Pulse IEC 61672 - 3 Class 1 (17)	Pass
Peak C Level 500Hz Negative Pulse IEC 61672 - 3 Class 1 (17)	Pass
Overload Indication IEC 61672 - 3 (18)	Pass
Octave and 1/3 Octave level IEC 61260 - 5.3	Pass

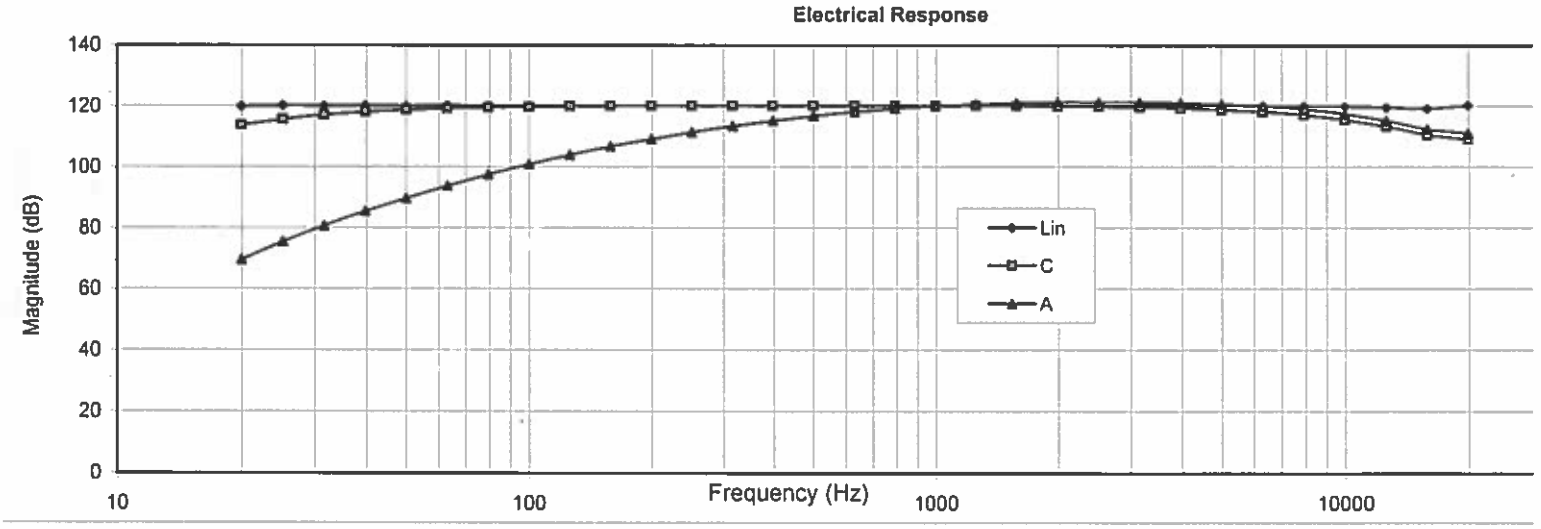
Measurements performed by: .....
Kent Zeng

Calibrated on WCCL system type 9700

Calibration results:					
	All Tests:	Pass			
	Senstivity:	Pass			After data: ...X...
	Frequency Response:	Pass	Laboratory Environment:		
	Lin Response:	Pass	Ambient Temperature:	22.0	°C
	C weighting	Pass	Ambient Humidity:	44.0	% RH
	A weighting	Pass	Ambient Pressure:	100.000	kPa
	1dB steps	Pass	Calibration Date:	19-Jan-2016	
	Linearity:	Pass	Calibration Due:	19-Jan-2017	
	Noise:	Pass	Report Number:	26101 -1	
	Random signal:	Pass	Control Number:	26101	
	Time Constant:	Pass			
	Function:	Pass			
	Filter:	Pass			

The above listed instrument meets or exceeds the tested manufacturer's specifications.
IEC 61672-1:2002 Class 1, IEC 61260:1995 w.Am.1, 1/1 and 1/3 Oct. Band Class 0 specification passed.
IEC 60804:2000 Type 1, IEC 60651:1979 w.Am.1&2 Type 1 specification passed.
IEC 61672-1:2002 Class 1 specification passed.
IEC 60804:2000 Type 1 specification passed.
This Calibration is traceable through NIST test numbers: 683/284413-14
The absolute uncertainty of calibration: See last page. Unless otherwise noted, the reported values are both "as found" and "as left" data.

The curve is the response recorded with electrical input with 50pF (1V=120dB).



The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 2250B&K**

Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures 1120

West Caldwell Calibration Laboratories Inc.

1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

Brüel & Kjær Hand-held Analyzer — Model No.: 2250 — Serial No.: 3004725
Mic. Model No.: 4189 — Serial No.: 2888708

Company: Aercoustics Engineering Ltd

Frequency Response (Reference = 94 dB @ 1000Hz)

Frequency (Hz)	Weighting Z	C	A
19.95	119.9	113.7	69.4
25.12	120.0	115.6	75.4
31.62	119.9	117.0	80.6
39.81	120.0	117.9	85.4
50.12	120.0	118.7	89.7
63.1	120.0	119.1	93.8
79.43	120.0	119.5	97.5
100	120.0	119.7	100.8
125.89	120.0	119.8	103.9
158.49	120.0	119.9	106.7
199.53	120.0	120.0	109.1
251.19	120.0	120.0	111.4
316.23	120.0	120.0	113.4
398.11	120.0	120.0	115.2
501.19	120.0	120.0	116.8
630.96	120.0	120.0	118.1

Frequency (Hz)	Weighting Z	C	A
794.33	120.0	120.0	119.2
1000	120.0	120.0	120.0
1258.93	120.0	120.0	120.6
1584.89	120.0	119.9	121.0
1995.26	120.0	119.8	121.2
2511.89	120.0	119.7	121.3
3162.28	120.0	119.5	121.2
3981.07	120.0	119.2	121.0
5011.87	120.0	118.7	120.6
6309.57	120.0	118.0	119.9
7943.28	120.0	117.0	118.9
10000	119.9	115.5	117.4
12589.25	119.6	113.3	115.2
15848.93	119.1	110.6	112.5
19952.62	120.2	109.1	111.1

Frequency Weightings at A - Weighting 1kHz, IEC 61672-3 (13)
Frequency Weightings at C - Weighting 1kHz, IEC 61672-3 (13)
Frequency Weightings at Z - Weighting 1kHz, IEC 61672-3 (13)
ANSI/ASA S1.4 - 2014 / Part 3 -13

Instruments used for calibration:			Date of Cal.	Traceability No.	Cal. Due Date
Brüel & Kjær	4134	S/N 1942286	1-Oct-2015	683/284413-14	1-Oct-2016
Brüel & Kjær	4226	S/N 1445428	10-Nov-2015	683/284413-14	10-Nov-2016
HP	34401A	S/N 36064102	1-Oct-2015	,287708	1-Oct-2016
HP	33120A	S/N 36043716	1-Oct-2015	,287708	1-Oct-2016

Cal. Date: 19-Jan-2016 — Tested by: Kent Zeng

Calibrated on WCCL system type 9700

West Caldwell Calibration Laboratories Inc.

1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

Brüel & Kjær Hand-held Analyzer — Model No.: 2250 — Serial No.: 3004725
Company: Aercoustics Engineering Ltd — ID No.: 2250-3

Level Accuracy (Reference = 120 dB @ 1000Hz)

Nom. Value [dB]	Meas. Value [dB]	Tolerance Limits [dB]	Dev. In the last 1 dB [dB]	Deviation Rel. to 94.0 dB [dB]
135.0	135.0	0.5	0.0	0.1
134.0	134.0	0.5	0.0	0.1
133.0	133.0	0.5	0.0	0.1
132.0	132.0	0.5	0.0	0.0
131.0	131.0	0.5	0.0	0.0
130.0	130.0	0.5	0.0	0.0
129.0	129.0	0.5	0.0	0.0
128.0	128.0	0.5	0.0	0.0
127.0	127.0	0.5	0.0	0.0
126.0	126.0	0.5	0.0	0.0
125.0	125.0	0.5	0.0	0.0
124.0	124.0	0.5	0.0	0.0
123.0	123.0	0.5	0.0	0.0
122.0	122.0	0.5	0.0	0.0
121.0	121.0	0.5	0.0	0.0
120.0	120.0	0.5	0.0	0.0
119.0	119.0	0.5	0.0	0.0
118.0	118.0	0.5	0.0	0.0
117.0	117.0	0.5	0.0	0.0
116.0	116.0	0.5	0.0	0.0
115.0	115.0	0.5	0.0	0.0
114.0	114.0	0.5	0.0	0.0
113.0	113.0	0.5	0.0	0.0
112.0	112.0	0.5	0.0	0.0
111.0	111.0	0.5	0.0	0.0
110.0	110.0	0.5	0.0	0.0
109.0	109.0	0.5	0.0	0.0
108.0	108.0	0.5	0.0	0.0
107.0	107.0	0.5	0.0	0.0
106.0	106.0	0.5	0.0	0.0
105.0	105.0	0.5	0.0	0.0
104.0	104.0	0.5	0.0	0.0
103.0	103.0	0.5	0.0	0.0
102.0	102.0	0.5	0.0	0.0
101.0	101.0	0.5	0.0	0.0
100.0	100.0	0.5	0.0	0.0
99.0	99.0	0.5	0.0	0.0
98.0	98.0	0.5	0.0	0.0
97.0	97.0	0.5	0.0	0.0
96.0	96.0	0.5	0.0	0.0
95.0	95.0	0.5	0.0	0.0
94.0	94.0	0.5	0.0	0.0
93.0	93.0	0.5	0.0	0.0
92.0	92.0	0.5	0.0	0.0
91.0	91.0	0.5	0.0	0.0
90.0	90.0	0.5	0.0	0.0
89.0	89.0	0.5	0.0	0.0
88.0	88.0	0.5	0.0	0.0
87.0	87.0	0.5	0.0	0.0
86.0	86.0	0.5	0.0	0.0

Nom. Value [dB]	Meas. Value [dB]	Tolerance Limits [dB]	Dev. In the last 1 dB [dB]	Deviation Rel. to 94.0 dB [dB]
85.0	85.0	0.5	0.0	0.0
84.0	84.0	0.5	0.0	0.0
83.0	83.0	0.5	0.0	0.0
82.0	82.0	0.5	0.0	0.0
81.0	81.0	0.5	0.0	0.0
80.0	80.0	0.5	0.0	0.0
79.0	79.0	0.5	0.0	0.0
78.0	78.0	0.5	0.0	0.0
77.0	77.0	0.5	0.0	0.0
76.0	76.0	0.5	0.0	0.0
75.0	75.0	0.5	0.0	0.0
74.0	74.0	0.5	0.0	0.0
73.0	73.0	0.5	0.0	0.0
72.0	72.0	0.5	0.0	0.0
71.0	71.0	0.5	0.0	0.0
70.0	70.0	0.5	0.0	0.0
69.0	69.0	0.5	0.0	0.0
68.0	68.0	0.5	0.0	0.0
67.0	67.0	0.5	0.0	0.0
66.0	66.0	0.5	0.0	0.0
65.0	65.0	0.5	0.0	0.0
64.0	64.0	0.5	0.0	0.0
63.0	63.0	0.5	0.0	0.0
62.0	62.0	0.5	0.0	0.0
61.0	61.0	0.5	0.0	0.0
60.0	60.0	0.5	0.0	0.0
59.0	59.0	0.5	0.0	0.0
58.0	58.0	0.5	0.0	0.0
57.0	57.0	0.5	0.0	0.0
56.0	56.0	0.5	0.0	0.0
55.0	55.0	0.5	0.0	0.0
54.0	54.0	0.5	0.0	0.0
53.0	53.0	0.5	0.0	0.0
52.0	52.0	0.5	0.0	0.0
51.0	51.0	0.5	0.0	0.0
50.0	50.0	0.5	0.0	0.0
49.0	49.0	0.5	0.0	0.0
48.0	48.0	0.5	0.0	0.0
47.0	47.0	0.5	0.0	0.0
46.0	46.0	0.5	0.0	0.0
45.0	45.0	0.5	0.0	0.0
44.0	44.0	0.5	0.0	0.0
43.0	43.0	0.5	0.0	0.0
42.0	42.0	0.5	0.0	0.0
41.0	41.0	0.5	0.0	0.0
40.0	40.0	0.5	0.0	0.0
39.0	39.0	0.5	0.0	0.0
38.0	38.0	0.5	0.0	0.0
37.0	37.0	0.5	0.0	0.0
36.0	36.0	0.5	0.0	0.0

Linearity Range at 1kHz, IEC61672 - 3 (14)
ANSI/ASA S1.4 - 2014 / Part 3 - 17

	Test Function	Tolerance Min	Tolerance Max	Value	Measured values	Out
,0.	**Reading with 94.0dB SPL dB** Absolute Acoustical Sensitivity Level, IEC 61672 - 3 (9) ANSI/ASA S1.4 - 2014 / Part 3. -10	93.7	94.3	94	93.9	
,0.	Determining Electrical Level for 1V at 1kHz	119.7	120.3	120	120.0	
				FSD (dB)		
,1.	**Attenuator accuracy** Linearity Range at 1kHz, IEC61672 - 3 (14) ANSI/ASA S1.4 - 2014 / Part 3 - 17	34.6	35.4	35	35.0	
		39.6	40.4	40	40.0	
		44.6	45.4	45	45.0	
		49.6	50.4	50	50.0	
		54.6	55.4	55	55.0	
		59.6	60.4	60	60.0	
		64.6	65.4	65	65.0	
		69.6	70.4	70	70.0	
		74.6	75.4	75	75.0	
		79.6	80.4	80	80.0	
		84.6	85.4	85	85.0	
		89.6	90.4	90	90.0	
		94.6	95.4	95	95.0	
		99.6	100.4	100	100.0	
		104.6	105.4	105	105.0	
		109.6	110.4	110	110.0	
		114.6	115.4	115	115.0	
		119.6	120.4	120	120.0	
		124.6	125.4	125	125.0	
		129.6	130.4	130	130.0	
		134.6	135.4	135	135.0	
,2	**Frequency Response with mic.**			(Hz)		
	A Weighting	53.3	55.9	31.5	54.8	
	Ref. 94.0 dB @ 1kHz	67.0	68.6	63	67.8	
	Frequency Weightings at A - Weighting 1kHz, IEC 61672-3 (13)	77.1	78.7	125	77.8	
	ANSI/ASA S1.4 - 2014 / Part 3 -12	84.6	86.2	250	85.3	
		90.0	91.6	500	90.7	
		93.2	94.8	1000	94.0	
		94.4	96.0	2000	95.2	
		94.2	95.8	4000	94.9	
		90.1	94.2	8000	92.4	
		83.9	92.5	12500	88.2	
		0.0	90.2	16000	85.8	
				(Hz)		
	C Weighting	89.7	92.3	31.5	91.0	
	Frequency Weightings at C - Weighting 1kHz, IEC 61672-3 (13)	92.4	94.0	63	93.2	
	ANSI/ASA S1.4 - 2014 / Part 3 -12	93.0	94.6	125	93.8	
		93.2	94.8	250	93.9	
		93.2	94.8	500	94.0	
		93.2	94.8	1000	94.0	
		93.0	94.6	2000	93.9	
		92.4	94.0	4000	93.1	
		88.2	92.3	8000	90.5	
		82.0	90.6	12500	86.3	
		0.0	88.3	16000	84.0	

	Test Function	Tolerance Min	Tolerance Max	Value	Measured values	Out
				(Hz)		
	Z Weighting	92.7	95.3	31.5	94.0	
	Frequency Weightings at Z - Weighting 1kHz, IEC 61672-3 (13)	93.2	94.8	63	93.9	
	ANSI/ASA S1.4 - 2014 / Part 3 -12	93.2	94.8	125	94.0	
		93.2	94.8	250	93.9	
		93.2	94.8	500	93.9	
		93.2	94.8	1000	94.0	
		93.2	94.8	2000	94.0	
		93.2	94.8	4000	93.9	
		91.2	95.3	8000	93.5	
		88.2	96.8	12500	92.6	
		0.0	96.8	16000	92.4	
,3	**Frequency Response with Electrical Signal**			(Hz)		
	A Weighting	67.1	71.9	20.0	69.4	
	Ref. 94.0 dB @ 1kHz	73.4	77.2	25.1	75.4	
	Frequency Response measured with Electrical Signal,	79.2	82.0	31.6	80.6	
	Freq. Weig. A with HP filter, IEC 61672 Class 1 (12)	84.0	86.8	39.8	85.4	
	ANSI/ASA S1.4 - 2014 / Part 3 -13	88.9	90.7	50.1	89.7	
		92.9	94.7	63.1	93.8	
		96.6	98.4	79.4	97.5	
		100.0	101.8	100.0	100.8	
		103.0	104.8	125.9	103.9	
		105.7	107.5	158.5	106.7	
		108.2	110.0	199.5	109.1	
		110.5	112.3	251.2	111.4	
		112.5	114.3	316.2	113.4	
		114.3	116.1	398.1	115.2	
		115.9	117.7	501.2	116.8	
		117.2	119.0	631.0	118.1	
		118.3	120.1	794.3	119.2	
		119.1	120.9	1000.0	120.0	
		119.7	121.5	1258.9	120.6	
		120.1	121.9	1584.9	121.0	
		120.3	122.1	1995.3	121.2	
		120.3	122.2	2511.9	121.3	
		120.3	122.1	3162.3	121.2	
		120.1	121.9	3981.1	121.0	
		119.6	121.9	5011.9	120.6	
		118.0	121.3	6309.6	119.9	
		116.0	120.3	7943.3	118.9	
		113.6	119.4	10000.0	117.4	
		109.8	118.6	12589.3	115.2	
		112.1	116.3	15848.9	112.5	
		0.0	113.6	19952.6	111.1	

Test Function	Tolerance Min	Tolerance Max	Value (Hz)	Measured values	Out
C Weighting	111.4	116.2	20.0	113.7	
Frequency Response measured with Electrical Signal,	113.7	117.5	25.1	115.6	
Freq. Weig. C with HP filter, IEC 61672 Class 1 (12)	115.6	118.4	31.6	117.0	
ANSI/ASA S1.4 - 2014 / Part 3 -13	116.6	119.4	39.8	117.9	
	117.8	119.6	50.1	118.7	
	118.3	120.1	63.1	119.1	
	118.6	120.4	79.4	119.5	
	118.8	120.6	100.0	119.7	
	118.9	120.7	125.9	119.8	
	119.0	120.8	158.5	119.9	
	119.1	120.9	199.5	120.0	
	119.1	120.9	251.2	120.0	
	119.1	120.9	316.2	120.0	
	119.1	120.9	398.1	120.0	
	119.1	120.9	501.2	120.0	
	119.1	120.9	631.0	120.0	
	119.1	120.9	794.3	120.0	
	119.1	120.9	1000.0	120.0	
	119.1	120.9	1258.9	120.0	
	119.0	120.8	1584.9	119.9	
	118.9	120.7	1995.3	119.8	
	118.8	120.6	2511.9	119.7	
	118.6	120.4	3162.3	119.5	
	118.3	120.1	3981.1	119.2	
	117.8	120.1	5011.9	118.7	
	116.1	119.4	6309.6	118.0	
	114.1	118.4	7943.3	117.0	
	111.7	117.5	10000.0	115.5	
	107.9	116.7	12589.3	113.3	
	110.1	114.4	15848.9	110.6	
	105.1	111.7	19952.6	109.1	

	Test Function	Tolerance Min	Tolerance Max	Value	Measured values	Out
				(Hz)		
	Z Weighting	118.6	121.4	20.0	119.9	
	Frequency Response measured with Electrical Signal,	118.6	121.4	25.1	120.0	
	Freq. Weig. Z with HP filter, IEC 61672 Class 1 (12)	118.6	121.4	31.6	119.9	
	ANSI/ASA S1.4 - 2014 / Part 3 -13	118.6	121.4	39.8	120.0	
		118.6	121.4	50.1	120.0	
		119.1	120.9	63.1	120.0	
		119.1	120.9	79.4	120.0	
		119.1	120.9	100.0	120.0	
		119.1	120.9	125.9	120.0	
		119.1	120.9	158.5	120.0	
		119.1	120.9	199.5	120.0	
		119.1	120.9	251.2	120.0	
		119.1	120.9	316.2	120.0	
		119.1	120.9	398.1	120.0	
		119.1	120.9	501.2	120.0	
		119.1	120.9	631.0	120.0	
		119.1	120.9	794.3	120.0	
		119.1	120.9	1000.0	120.0	
		119.1	120.9	1258.9	120.0	
		119.1	120.9	1584.9	120.0	
		119.1	120.9	1995.3	120.0	
		119.1	120.9	2511.9	120.0	
		119.1	120.9	3162.3	120.0	
		119.1	120.9	3981.1	120.0	
		117.1	121.4	5011.9	120.0	
		117.1	121.4	6309.6	120.0	
		117.1	121.4	7943.3	120.0	
		114.1	122.9	10000.0	119.9	
		114.1	122.9	12589.3	119.6	
		110.1	122.9	15848.9	119.1	
		110.1	122.9	19952.6	120.2	
,4	**Inherent noise level**					
	Electrical Inherent Noise Level, Freq. Weig. Lin, IEC 61672-3 (10)					
	ANSI/ASA S1.4 - 2014 / Part 3 -11					
	Z Fast	less than	27		15.64	
	Z Slow	less than	20		15.79	
	Z Impulse	less than	30		15.65	
	Z Leq	less than	20		15.87	
	Z Peak	less than	32		30.31	
	Z Max	less than	32		17	
	C Fast	less than	27		12.64	
	C Slow	less than	20		12.63	
	C Impulse	less than	30		12.37	
	C Leq	less than	20		12.6	
	C Peak	less than	32		31.84	
	C Max	less than	32		12.8	
	A Fast	less than	27		12.64	
	A Slow	less than	20		12.58	
	A Impulse	less than	30		12.53	
	A Leq	less than	20		12.57	
	A Peak	less than	32		29.03	
	A Max	less than	32		12.63	

Test Function			Tolerance Min	Tolerance Max	Value	Measured values	Out
			dB	dB			
,5	Random signal		89.6	90.4	Fast	90.3	
	90 dB Test Level		89.6	90.4	Slow	89.9	
	Overload Indication IEC 61672 - 3 (18)					140.0	
	ANSI/ASA S1.4 - 2014 / Part 3 -20						
,6	Time Constant		dB	dB			
	90 dB 2kHz Test Level		88.1	89.4	Fast	89.1	
			84.1	87.9	Slow	86.1	
,7	Functions						
ANSI/ASA S1.4 - 2014 / Part 3 -12		Z Fast	93.5	94.5	94.0	93.9	
		Z Slow	93.5	94.5	94.0	93.9	
		Z Impulse	93.5	94.5	94.0	93.9	
		Z Leq	93.5	94.5	94.0	93.9	
		Z Peak	96.0	98.0	97.0	98.0	
		Z Max	93.5	94.5	94.0	93.9	
		C Fast	93.5	94.5	94.0	93.9	
		C Slow	93.5	94.5	94.0	93.9	
		C Impulse	93.5	94.5	94.0	93.8	
		C Leq	93.5	94.5	94.0	93.9	
		C Peak	96.0	98.0	97.0	97.7	
		C Max	93.5	94.5	94.0	93.9	
		A Fast	93.5	94.5	94.0	93.9	
		A Slow	93.5	94.5	94.0	93.9	
		A Impulse	93.5	94.5	94.0	93.9	
		A Leq	93.5	94.5	94.0	93.9	
		A Peak	96.0	98.0	97.0	97.5	
		A Max	93.5	94.5	94.0	93.9	
Frequency Weightings at AFast - Weighting 1kHz, IEC 61672-3 (13)			93.6	94.4	94.0	94.0	
Frequency Weightings at CFast - Weighting 1kHz, IEC 61672-3 (13)			93.6	94.4	94.0	94.0	
Frequency Weightings at Z Fast- Weighting 1kHz, IEC 61672-3 (13)			93.6	94.4	94.0	94.0	
Time Weighting Response to Single Burst, 4kHz, 200ms, F Class 1, IEC61672 - 3 (16)			-1.5	0.5		-1.0	
Time Weighting Response to Single Burst, 4kHz, 2ms, F Class 1, IEC61672 - 3 (16)			-19.5	-17		-18.0	
Time Weighting Response to Single Burst, 4kHz, 0.25ms, F Class 1, IEC61672 - 3 (16)			-30	-26		-27.1	
Time Weighting Response to Single Burst, 4kHz, 200ms, S Class 1, IEC61672 - 3 (16)			-7.9	-6.4		-7.4	
Time Weighting Response to Single Burst, 4kHz, 2ms, S Class 1, IEC61672 - 3 (16)			-27.5	-26.5		-27.0	
ANSI/ASA S1.4 - 2014 / Part 3 - 18							
	Acoustic test at 4kHz.						
	A Weig.	A Fast	94.5	95.5	95.0	94.9	
		A Slow	94.5	95.5	95.0	94.9	
		A Impulse	94.5	95.5	95.0	94.9	
		A Leq	94.5	95.5	95.0	94.9	
		A Peak	97.0	99.0	98.0	97.7	
		A Max	94.5	95.5	95.0	94.9	

Test Function ,8 1/3 Octave filter check					
			Before		Out
Filter Hz		87.5 to 92.5	93.5 to 94.5	87.5 to 92.5	
12.5		92.2	93.9	88.0	
16		92.1	93.9	88.1	
20		92.0	94.0	88.3	
25.12		91.9	94.0	88.4	
31.62		91.8	94.0	88.7	
39.81		91.7	94.0	88.7	
50.12		91.6	94.0	88.9	
63.1		91.5	94.0	89.0	
79.43		91.4	94.0	89.1	
100		91.3	94.0	89.0	
125.89		91.4	94.0	89.3	
158.49		91.2	94.0	89.5	
199.53		91.1	94.0	89.5	
251.19		91.0	94.0	89.7	
316.23		90.9	94.0	89.9	
398.11		90.7	94.0	89.9	
501.19		90.7	94.0	90.1	
630.96		90.5	94.0	90.2	
794.33		90.4	94.0	90.3	
1000		90.3	94.0	90.2	
1258.93		90.4	94.0	90.4	
1584.89		90.2	94.0	90.6	
1995.26		90.0	94.0	90.7	
2511.89		89.9	94.0	90.8	
3162.28		89.8	94.0	91.0	
3981.07		89.6	94.0	91.0	
5011.87		89.6	94.0	91.2	
6309.57		89.4	94.0	91.3	
7943.28		89.3	94.0	91.3	
10000		89.1	93.9	91.1	
12589.25		89.0	93.6	90.8	
15848.93		88.3	93.9	91.0	
19952.62		88.2	94.3	90.4	

1/1-Octave and 1/3-Octave Filter Fulfils ANSI/ASA S1.11 -1-2004 and IEC61260-1 : 2014 specification.

1/1 Octave Filter Check					Out
Filter Hz		87.5 to 92.5	93.5 to 94.5	87.5 to 92.5	
16		90.9	94.0	89.8	
31.5		90.9	94.0	89.9	
63		90.9	94.0	90.0	
125		90.7	93.9	90.1	
250		90.6	94.0	90.2	
500		90.5	94.0	90.3	
1K		90.4	94.0	90.4	
2K		90.3	94.0	90.5	
4k		90.2	94.0	90.7	
8k		90.1	94.0	90.5	
16k		89.9	94.0	90.3	

The expanded uncertainty of calibration at 95% confidence level with a coverage factor of k=2.

Parameter	Test Instrumentation Uncertainty	DUT Uncertainty	Total DUT Uncertainty
Reading with mic. @ 1kHz:	0.09	0.1	0.16
Meter linearity:	0.008	0.1	0.12
Attenuator accuracy:	0.008	0.1	0.12
Freq. Response: 63Hz to 12.5kHz	0.15	0.1	0.21
Freq. Response: 31.5Hz & 16kHz	0.17	0.1	0.23
Electrical Freq. Resp.: 20Hz to 20kHz	0.008	0.1	0.12
Inherent noise level:	0.3	0.1	0.37
Crest Factor:	0.3	0.1	0.37
Time Constant:	0.3	0.1	0.37
Functions:	0.09	0.1	0.16
Sensitivity:	0.09	0.1	0.16
1/3 & 1/1 Filters:	0.008	0.1	0.12

Cal. Date: 19-Jan-2016 Measurements By: Kent Zeng

Calibrated on WCCL system type 9700

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE

Manufactured by:	**BRUEL & KJAER**
Model No:	**4189 (ID#2250-3)**
Serial No:	**2888708**
Calibration Recall No:	**26101**

Submitted By:

Customer:

Company: **AERCOUSTICS ENGINEERING LTD.**
Address:

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. 4189 (ID#2 BRUE

Upon receipt for Calibration, the instrument was found to be:

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.

West Caldwell Calibration Laboratories' calibration control system meets the following requirements, ISO 10012-1 MIL STD 45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2008 and ISO 17025

Note: With this Certificate, Report of Calibration is included.

Calibration Date: 19-Jan-16

Certificate No: 26101 - 2

Approved by:

FC

Felix Christopher (QA Mgr.)

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

uncompromised calibration West Caldwell Calibration Laboratories, Inc.
1575 State Route 96, Victor, NY 14564, U.S.A.

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor NY 14564

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

Brüel & Kjær Microphone **Model No.: 4189** **Serial No.: 2888708**

Company: Aercoustics Engineering Ltd **I. D. No.: 2250-3**

Calibration results:

Before & after data same: ...X...

Combined Sensitivity @ 250 Hz and pressure of 98.767 kPa

(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):

-26.84 dB re.1V/Pascal

45.51 mV/Pascal

0.84 Ko (- dB re 50 mV/Pascal)

Sensitivity: Pass

Freq. Response: Pass

All tests: Pass

Ambient Temperature:	21.4	°C
Ambient Humidity:	30.1	% RH
Ambient Pressure:	98.767	kPa
Calibration Date:	19-Jan-2016	
Re-calibration Due:	19-Jan-2017	
Report Number:	26101 -2	
Control Number:	26101	

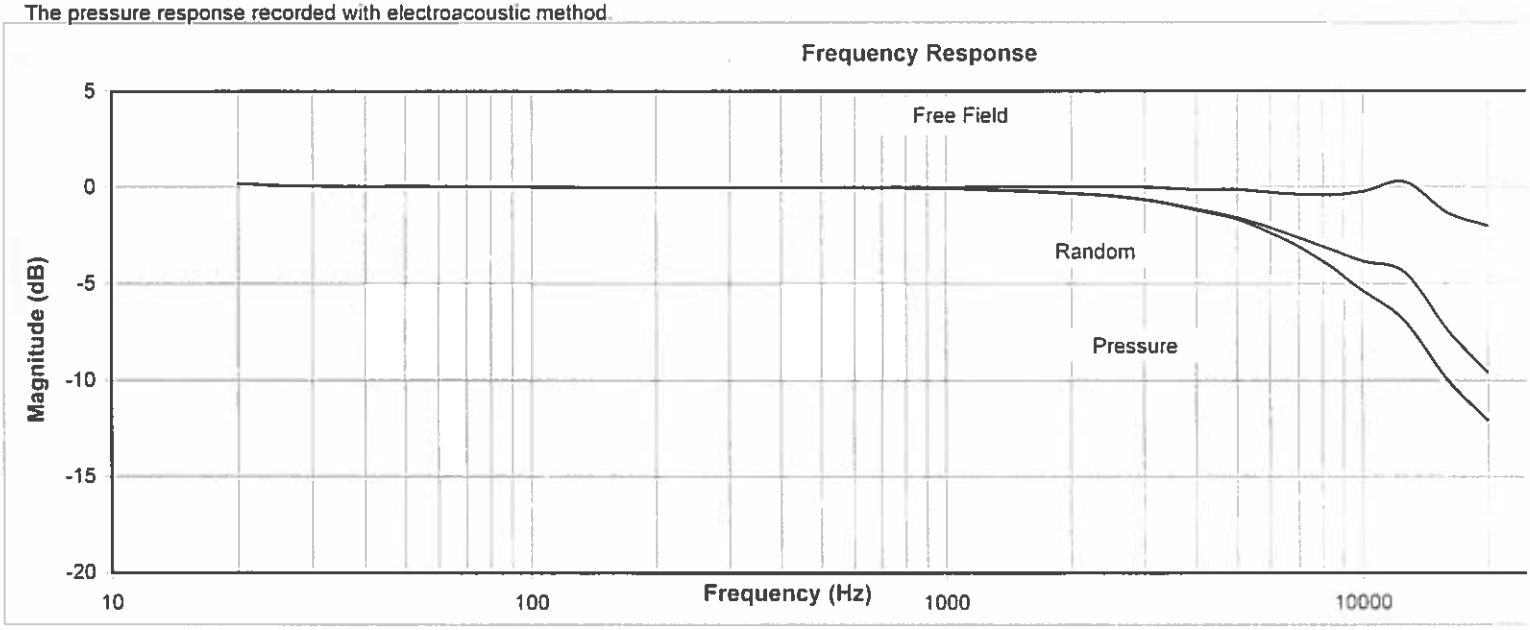
The above listed instrument meets or exceeds the tested manufacturer's specifications.

The IEC 651:1979 & 1993 Type 1 specification passed.

This Calibration is traceable through NIST test numbers: 683/284413-14

The expanded uncertainty of calibration: 0.18dB at 95% confidence level with a coverage factor of k=2.

The pressure response recorded with electroacoustic method.



The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 P4189B&K**

Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSL Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

Measurements performed by: .....
Kent Zeng

Calibrated on WCCL system type 9700

West Caldwell Calibration Laboratories Inc.

1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

Brüel & Kjær Microphone | Model No.: 4189 | Serial No.: 2888708
Company: Aercoustics Engineering Ltd | I. D. No.: 2250-3

Frequency Response (Reference = 0 dB @ 250Hz)

Frequency [Hz]	Pressure [dB]	Free Field (dB)	Random (dB)
19.95	0.20	0.20	0.20
25.12	0.10	0.10	0.10
31.62	0.09	0.09	0.09
39.81	0.06	0.06	0.06
50.12	0.08	0.08	0.08
63.10	0.06	0.06	0.06
79.43	0.05	0.05	0.05
100.00	0.04	0.04	0.04
125.89	0.02	0.02	0.02
158.49	0.00	0.00	0.00
199.53	0.01	0.01	0.01
251.19	0.00	0.00	0.00
316.23	0.00	0.00	0.00
398.11	-0.01	0.00	-0.01
501.19	-0.01	0.01	-0.01
630.96	-0.02	0.01	-0.02
794.33	-0.04	0.03	-0.04
1000.00	-0.08	0.02	-0.10
1258.93	-0.11	0.04	-0.15
1584.89	-0.18	0.04	-0.23
1995.26	-0.31	0.02	-0.31
2511.89	-0.46	0.02	-0.42
3162.28	-0.72	0.00	-0.68
3981.07	-1.19	-0.13	-1.10
5011.87	-1.68	-0.11	-1.54
6309.57	-2.58	-0.30	-2.26
7943.28	-3.77	-0.39	-3.02
10000.00	-5.34	-0.22	-3.80
12589.25	-6.91	0.28	-4.40
15848.93	-9.87	-1.28	-7.29
19952.62	-12.04	-1.99	-9.56

Freq. response: Expanded Uncertainty (dB) with coverage factor K = 2
20 to 25 Hz 0.8dB, 25 to 160 Hz 0.5dB, 160 to 2kHz 0.3dB, 2k to 10kHz 0.5dB, 10k to 20kHz 1.3dB.

Instruments used for calibration:			Date of Cal.	Traceability No.	Re-cal. Due Date
Brüel & Kjær	4226	S/N 1445428	10-Nov-2015	683/284413-14	10-Nov-2016
Brüel & Kjær	3560	S/N 2202374	10-Nov-2015	683/284413-14	10-Nov-2016
HP	33120A	S/N 36043716	1-Oct-2015	,287708	1-Oct-2016
HP	34401A	S/N 36064102	1-Oct-2015	,287708	1-Oct-2016

Cal. Date: 19-Jan-2016 **Tested by: Kent Zeng**

Calibrated on WCCL system type 9700

Rev. 7.0 Jan. 24, 2014 Doc. # 1038 P4189B&K

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: 16.US1.01908 **Date of issue:** February 18, 2016

Type: Vaisala Weather Transmitter, WXT520 **Serial number:** K0630017.0deg

Manufacturer: VAISALA Oyj, Pl 26, FIN-00421 Helsinki, Finland

Client: Aercoustics Engineering Ltd., 50 Ronson Dr, Suite 165, Toronto, ON M9W 1B3, Canada

Anemometer received: February 18, 2016 **Anemometer calibrated:** 11:48 February 18, 2016

Calibrated by: mcj **Procedure:** MEASNET, IEC 61400-12-1:2005(E) Annex F

Certificate prepared by: ejf **Approved by:** Calibration engineer, rds

Calibration equation obtained: v [m/s] = 0.98953 · f [m/s] + 0.09392

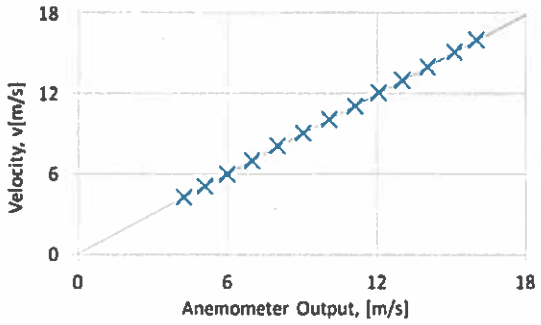
Standard uncertainty, slope: 0.00190 **Standard uncertainty, offset:** 0.21429

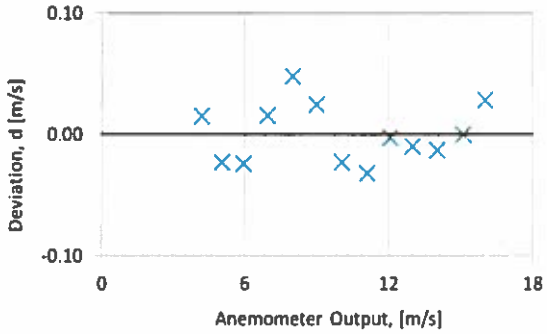
Covariance: -0.0000355 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999980

Absolute maximum deviation: 0.047 m/s at 8.060 m/s

Barometric pressure: 1020.9 hPa **Relative humidity:** 9.7%

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	11.01	24.4	27.5	4.293	4.229	0.015	0.048
4	15.52	24.4	27.5	5.098	5.081	-0.023	0.043
6	21.38	24.4	27.5	5.985	5.977	-0.024	0.041
8	29.18	24.4	27.5	6.991	6.955	0.015	0.039
10	38.79	24.4	27.5	8.060	8.003	0.047	0.040
12	48.71	24.4	27.5	9.034	9.010	0.024	0.041
13-last	59.98	24.4	27.5	10.024	10.058	-0.023	0.043
11	72.79	24.4	27.5	11.042	11.097	-0.032	0.045
9	86.28	24.4	27.5	12.023	12.058	-0.003	0.048
7	99.86	24.4	27.5	12.935	12.987	-0.010	0.051
5	116.09	24.4	27.5	13.947	14.013	-0.013	0.054
3	134.98	24.4	27.5	15.039	15.103	0.000	0.057
1-first	151.76	24.3	27.5	15.945	15.990	0.028	0.060





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord 1	Wind tunnel, blockage factor = 1.004
2254	Control cup anemometer
-	Mounting tube, D = 30 mm
TT003	Summit RT-AUI, wind tunnel
TP001	Summit RT-AUI, differential pressure box
DP004	Setra Model 239 pressure transducer
HY003	Dwyer Instruments RHP-2D20 humidity transmitter
BP002	Setra Model 278 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, & 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 2.5 x 2.5 m.

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.

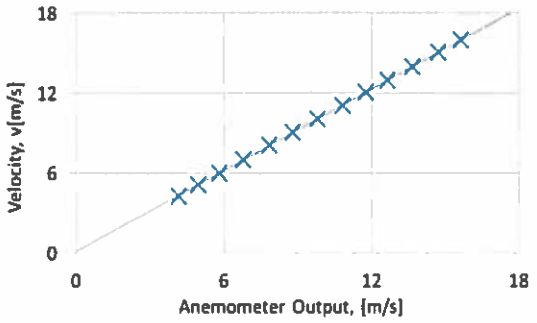
Certificate number: 16.US1.01908

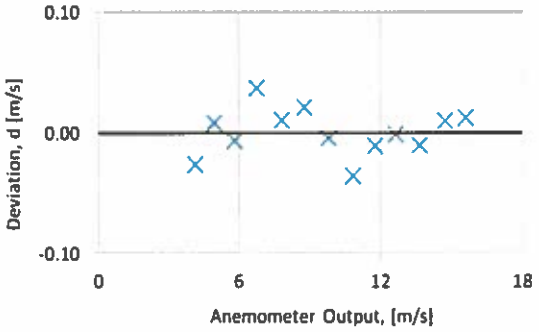
SOH Wind Engineering LLC
141 Leroy Road · Williston, VT 05495 · USA
Tel 802.316.4368 · Fax 802.735.9106 · www.sohwind.com

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

Certificate number: 16.US1.01909 **Date of issue:** February 18, 2016
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** K0630017.90deg
Manufacturer: VAISALA Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 50 Ronson Dr, Suite 165, Toronto, ON M9W 1B3, Canada
Anemometer received: February 18, 2016 **Anemometer calibrated:** 12:07 February 18, 2016
Calibrated by: mej **Procedure:** MEASNET, IEC 61400-12-1:2005(E) Annex F
Certificate prepared by: ejf **Approved by:** Calibration engineer, rds
Calibration equation obtained: v [m/s] = 1.01610 · f [m/s] + 0.08636
Standard uncertainty, slope: 0.00150 **Standard uncertainty, offset:** 0.18401
Covariance: -0.0000227 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999988
Absolute maximum deviation: 0.036 m/s at 6.993 m/s
Barometric pressure: 1020.8 hPa **Relative humidity:** 9.7%

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	10.93	24.5	27.5	4.279	4.152	-0.026	0.049
4	15.62	24.6	27.5	5.116	4.942	0.008	0.043
6	21.41	24.6	27.5	5.989	5.816	-0.007	0.041
8	29.18	24.5	27.5	6.993	6.761	0.036	0.039
10	38.75	24.5	27.5	8.058	7.835	0.010	0.040
12	48.65	24.5	27.5	9.029	8.781	0.021	0.041
13-last	59.99	24.5	27.5	10.026	9.787	-0.005	0.043
11	72.74	24.5	27.5	11.041	10.816	-0.035	0.045
9	86.24	24.5	27.5	12.022	11.758	-0.011	0.048
7	99.80	24.5	27.5	12.934	12.645	-0.001	0.051
5	116.10	24.5	27.5	13.951	13.655	-0.010	0.054
3	135.09	24.5	27.5	15.049	14.716	0.009	0.057
1-first	151.82	24.5	27.5	15.953	15.603	0.012	0.060





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord 1	Wind tunnel, blockage factor = 1.004
2254	Control cup anemometer
-	Mounting tube, D = 30 mm
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HY003	Dwyer Instruments RHP-2D20 humidity transmitter
BP002	Setra Model 278 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, & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

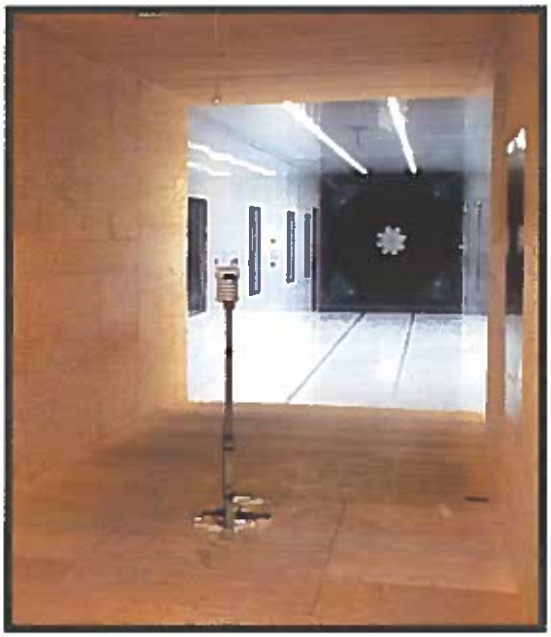


Photo of the wind tunnel setup. The cross-sectional area is 2.5 x 2.5 m.

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.

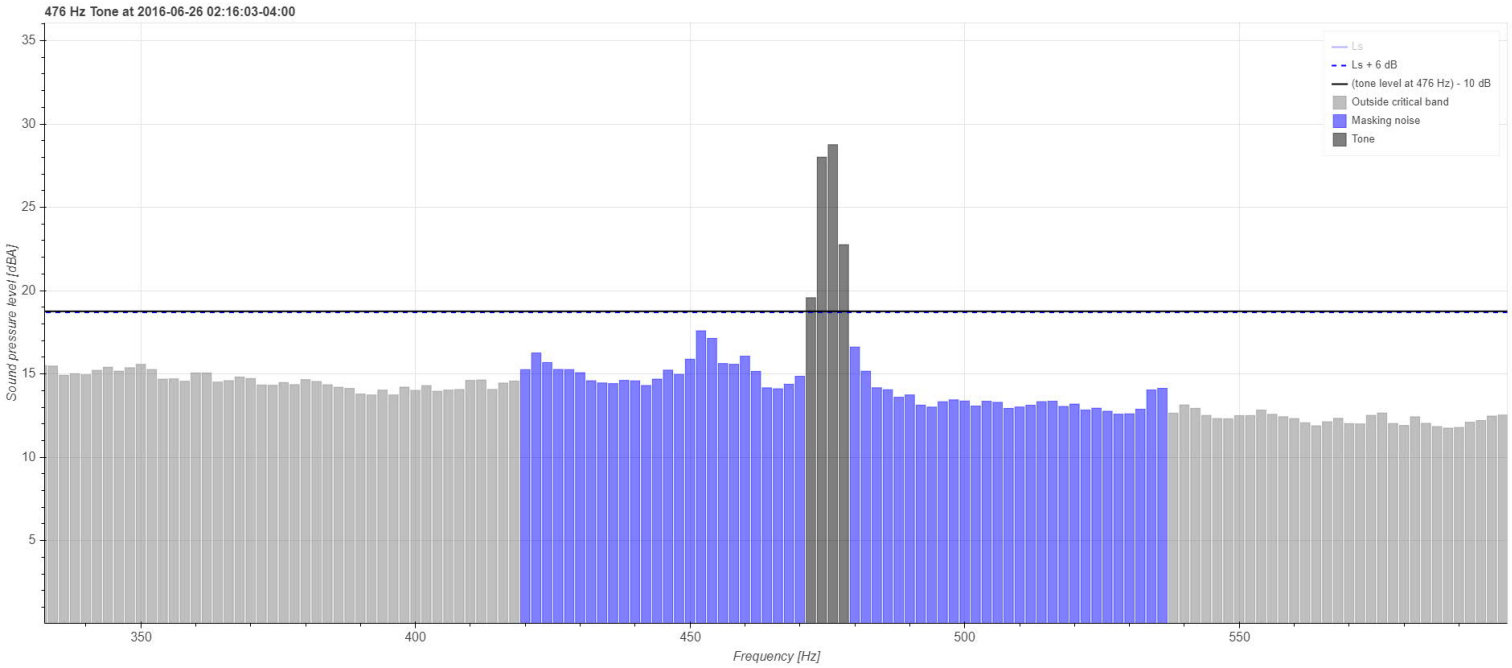
Certificate number: 16.US1.01909

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
Sample Tone Plot



Timestamp (America/Toronto)	Center Frequency (Hz)	Decisive Audibility (dB)	Level at Tone Line (dB)	Critical Bandwidth: Lower bound (Hz)	Critical Bandwidth: Upper bound (Hz)	Lc - Mean Masking Noise Level (dB)	LT - Tone Level (dB)	LG - Critical Band Masking Noise Level (dB)	Masking Index	Audibility (dB)
2019-11-09 03:38:00-05:00	526	1.1	23.1	468	588	10.2	26.8	27.9	-2.3	1.1

Project ID: 15247.00
Drawn by: IK
Reveiwed by: AM
Date: August 29, 2019
Revision: 1

Scale: As Indicated

Armow Wind Power Project
Tonal Assessment V556

Appendix B

Sample Tone Plot - V556 - Turbine ON 4m/s

aercoustics

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Appendix E
AWPP Scope of Work

SP Armow Wind Ontario LP
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Canada

July 26, 2019

BY EMAIL

Director
Ministry of the Environment, Conservation and Parks
Owen Sound District Office
101 17th St., 3rd Floor
Owen Sound, ON N4K 0A5
John.S.Ritchie@ontario.ca

Dear Mr. Ritchie:

SP Armow Wind Ontario GP Inc. ("Armow") v. Ontario (Environment, Conservation and Parks)
ERT File No. 19-051

We are writing with respect to Director's Order No. 2868-B8VRY4-1 dated June 19, 2019 (the "Order"), the Director's letter of June 27, 2019 and Armow's appeal of the Order to the Environmental Review Tribunal ("ERT"). Given the extremely complex technical nature of the Order, please find below the scope of work that Armow will conduct to comply with the Order:

1) With respect to Work Ordered Items Nos. 1, 2, 3 and 4 as set out in the Order, all work has been completed and no further action is required.

2) With respect to Work Ordered Item No. 5, such work to be conducted as set out below:

   By March 1, 2020, have the Acoustical Consultant conduct a RAM I-Audit, in accordance with The Compliance Protocol for Wind Turbine Noise published April 2017 (the "2017 Compliance Protocol") regarding equipment set-up requirements, with measurement of tonality to be undertaken in accordance with ISO 1996-2:2017 for the following:
   a) the wind turbines identified in the REA as T68 and T80; and
   b) the location of a worst-case noise receptor.

   Monitoring locations for both T68 and T80 may be moved southward if remaining within same line-of-sight for T68 and distance correction factor is used (the more conservative of: 20 log rule or CADNA prediction). Any tonal penalties will be applied in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

3) With respect to Work Ordered Item No. 6, such work to be conducted as set out below:

   By March 1, 2020, have the Acoustical Consultant complete tonality measurements in accordance with ISO 1996-2:2017 (and 2017 Compliance Protocol regarding equipment set-up requirements) for each of the six (6) wind turbines identified in the REA as T50, T30, T88, T102, T75 and T95 and in accordance with the following turbine-specific requirements:

a) T95 will be addressed through a receptor in the crosswind direction, or other receptor that is located at similar distance downwind from a turbine of the same model;
b) T50 and T102 will be addressed through separate respective receptors in the downwind direction (prior measurements conducted at receptor IDs V556 and R215 may be used to fulfil tonality assessments, provided data meets the requirement of: "At least five (5) one-minute measurements per wind speed bin over entire assessment range of the turbine and not limited to wind speed bins of 4-7 m/s as per Compliance Protocol"); and
c) T30, T88, T75 will be addressed through alternative surrogate receptors, as the closest respective receptors are in the upwind direction (taking into account the following factors: same turbine model type, extent to which permission for site access is provided/withheld, and minimization of noise source contamination).

Any tonal penalties will be applied in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

4) Completion of Work Ordered Item No. 7, as set out in the Order.

5) Completion of Work Ordered Item No. 8, as set out in the Order, by submitting a noise abatement action plan prepared in accordance with sections E5.1 and E5.5.2 of the 2017 Compliance Protocol.

This letter describes the whole scope of work that Armow proposes to complete in satisfaction of the Order. Please confirm the foregoing will allow for compliance with the Order. If such confirmation is received, Armow will proceed to withdraw its ERT appeal and implement this scope of work.

Yours truly,

SP Armow Wind Ontario LP,
by its general partner
SP Armow Wind Ontario GP Inc.

Per: _____
Name: Frank Davis
Title: Authorized Signatory

Per: _____
Name: Jae Young Ahn
Title: Authorized Signatory