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ASSESSMENT REPORT - **Project: 16227.00**

Niagara Region Wind Farm Project
Acoustic Immission Audit – Phase 2

Prepared for:

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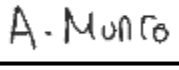

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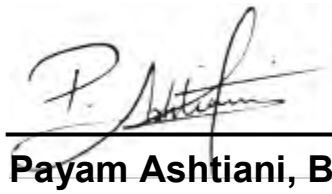

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24 May 2019

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Executive Summary

Aercoustics Engineering Limited ("Aercoustics") has been retained by 1021702 B.C. Ltd as general partner for and on behalf of FWRN L.P. to complete the acoustic immission audit outlined in the Renewable Energy Approval ("REA") for the Niagara Region Wind Farm ("NRWF"). NRWF operates under REA #4353-9HMP2R, issued on November 6, 2014.

This report details the 2nd measurement campaign of the NRWF immission audit. Monitoring near receptors O1153, V2705, O1602, O0616 and O0085 spanned the following dates:

Location	Monitoring Start Date	Monitoring End Date	Monitoring Duration (weeks)
O1153	November 5th, 2018	February 19th, 2019	15
V2705	October 26th , 2018	April 8th, 2019	25
O1602	November 29th, 2018	April 8th , 2019	19
O0616	October 29th, 2018	April 8th , 2019	25
O0085	November 5th, 2018	April 8th, 2019	22

The audit has been completed as per the methodology outlined in Parts D and E5.5 RAM-I (Revised Assessment Methodology) of the "*MECP Compliance Protocol for Wind Turbine Noise*" (Updated: April 21, 2017).

The measured turbine-only noise impact at the audit locations was compared to the Ministry of Environment Conservation and Parks ("MECP") sound level limits. The measured turbine-only levels were found to be in compliance with the applicable sound level limits at receptors O1153, V2705, O1602 and O0616 during the audit.

The measured levels were found to be non-compliant with the applicable sound level limits at receptor O0085 during the audit. It should be noted that the Phase 1 audit at this location was found to be compliant. It is Aercoustics understanding that Boralex in partnership with the turbine manufacturer Enercon has undertaken turbine inspections for physical components as well as turbine operating parameters. Further E-Audit testing is underway to investigate the source of the non-compliance with the MECP sound level limits.

1 Introduction

Aercoustics Engineering Limited ("Aercoustics") has been retained by 1021702 B.C. Ltd as general partner for and on behalf of FWRN L.P. to complete the 2nd acoustic immission audit outlined in the Renewable Energy Approval ("REA") for the Niagara Region Wind Farm ("NRWF"). NRWF operates under REA #4353-9HMP2R, issued on November 6, 2014, further modified on November 23, 2015, May 6, 2016 and May 12, 2016 [1].

The report has been prepared to facilitate submission to the MECP, in compliance with acoustic audit conditions outlined in the facility's REA (#4353-9HMP2R) section E (Wind Turbine Acoustic Audit – Immission). The audit has been completed as per the methodology outlined in Parts D and E5.5 RAM-I (Revised Assessment Methodology) of the Ontario Ministry of Environment, Conservation and Parks "*MECP Compliance Protocol for Wind Turbine Noise*" (Updated: April 21, 2017). This report outlines the measurement methodology, results, and a comparison of the turbine-only sound contribution to the MECP sound level limits.

2 Facility Description

The Niagara Region Wind Farm Project utilizes 77 Enercon turbines (Model E 101) wind turbines for power generation, each having a nameplate capacity ranging from 2.9MW and 3.0MW respectively. Each turbine has a hub height of 124 meters and a rotor diameter of 101 meters. The facility operates 24 hours per day, 7 days per week.

An overall site plan is provided in Figure A.01.

3 Audit Details

The acoustic audit was conducted at receptors O1153, V2705, O1602, O0616 and O0085[1]. Monitoring at M1153, M2705, M1602, M0616 and M0085 spanned the following dates, summarized in Table 1.

Table 1: Monitoring Period for Each Receptor

Location	Monitoring Start Date	Monitoring End Date	Monitoring Duration (weeks)
O1153	November 5th, 2018	February 19th, 2019	15
V2705	October 26th , 2018	April 8th, 2019	25
O1602	November 29th, 2018	April 8th , 2019	19
O0616	October 29th, 2018	April 8th , 2019	25
O0085	November 5th, 2018	April 8th, 2019	22

[1] Receptor IDs taken from the Noise Assessment Report by K. Ganesh and K. Mallinen, dated April 08, 2016 [3]

The following sections detail the test equipment, measurement methodology, measurement locations, and environmental conditions during the audit.

3.1 Test Equipment

The equipment, both acoustic and non-acoustic, used at each audit location for the measurement campaign is as follows.

- One (1) Type 1 sound level meter, with microphone and pre-amplifier that meet the MECP protocol specifications outlined in Part D, Section D2.1 - Acoustic Instrumentation.

- 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 programmed to sample weather data every 0.5 seconds. The anemometer was located 10m above grade, as defined by Section D3.4. Performance specifications comply with Part D, Section D.2.2 of the MECP protocol.

The following table lists the specific model and serial numbers for the equipment used during the measurement campaign. Calibration records for equipment used during the measurement campaign are provided in Appendix G.

Table 2: Equipment Details

Location	Equipment	Serial Number
M1153	NI9234 Data Acquisition Card	1C009CD
	PCB 480E09 Signal Conditioner	32814
	PCB 377B02 Microphone	174130
	PCB 426E01 Pre-Amplifier	051461
	Vaisala WXT 520	M0410642
M2705	NI9234 Data Acquisition Card	1A5E7FC
	PCB 480E09 Signal Conditioner	34423
	PCB 377B02 Microphone	167926
	PCB 426E01 Pre-Amplifier	044003
	Vaisala WXT 536	M4910194
M1602	NI9234 Data Acquisition Card	1AE459C & 1CAF718
	PCB 480E09 Signal Conditioner	33661
	PCB 377B02 Microphone	155523
	PCB 426E01 Pre-Amplifier	039195
	Vaisala WXT 536	M4910193
M0616	NI9234 Data Acquisition Card	1CAF75B
	PCB 480E09 Signal Conditioner	33370
	PCB 377B02 Microphone	156314
	PCB 426E01 Pre-Amplifier	039843
	Vaisala WXT 520	K0630016
M0085	NI9234 Data Acquisition Card	1C97512
	PCB 480E09 Signal Conditioner	33660
	PCB 377B02 Microphone	177759
	PCB 426E01 Pre-Amplifier	051463
	Vaisala WXT 520	L3020298

The sound level meter, microphone, and pre-amplifier were 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 (LA_{eq}), percentile statistical levels (L90), and 1/3 octave band levels between 20 Hz and 10,000 Hz. The microphone was placed at a measurement height of 4.5 m above grade, at least 5 metres away from any large reflecting surfaces, in direct line of sight to the nearest turbines, and as far away as practically possible from

trees or other foliage. 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 filter the data for wind gusting.

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).

A one-minute measurement interval was considered valid if:

- 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
- Either all nearby turbines were on (for Turbine ON measurements), or all nearby turbines were off (for ambient measurements). The list of turbines parked for ambient measurements is provided in Section 3.6.
- The measured LA_{eq} was no more than 10 dB greater than the L90 value
- The closest wind turbine was producing approximately 85% or more of its rated power output
- The measurement location was downwind (+/- 45 degrees from the line of sight between the turbine and measurement location) from the wind turbine during the measurement interval. The downwind direction is determined using the closest turbine's yaw angle output, also known as nacelle position.

These filters are based on the requirements outlined in Part D of the Protocol as well as the measurement equipment specifications. The intention is to exclude measurement intervals where the data reliability is reduced due to transient noise intrusions (such as vehicle pass-bys), environmental conditions, or equipment operating outside of its specifications.

Section D3.8.2 of the Protocol states that weather conditions should be similar between Background and Total Noise measurement intervals. By virtue of the minimum turbine power requirement, hub-height wind speeds are present in all Total Noise Intervals. High hub-height wind speeds were found to produce increased wind-related noise, elevating the measured noise levels. Accordingly, a hub-height windspeed filter was applied to Background data at monitoring locations to better match the environmental conditions present in the Total Noise data. Lower hub-height wind speed thresholds for Background intervals have been used to increase the available data counts. These lower thresholds

represent a conservative approach, as the Background sound level is expected to be lower during periods of low hub-height wind speed. Applying a lower hub-height wind speed threshold to the Background data therefore has the effect of over-estimating the calculated Turbine-Only sound levels.

3.3 Measurement Location

Receptors O1153, V2705, O1602, O0616, and O0085 were chosen to be representative of the worst-case impact of the facility. These locations were chosen based on the MECP selection requirements communicated in the NRWF REA. All five receptors are located in the predominant downwind direction of the facility. O1153, V2705, O1602, O0616, and O0085 have a predicted impact of 39.9 dBA, 39.7 dBA, 39.5 dBA, 39.7 dBA and 39.5 dBA respectively, as per level predicted from an "As Built" noise model based on the original CadnaA noise prediction model. The following describes the measurement locations in relation to the above listed receptors:

- M1153: Measurement equipment was placed on the open lawn to the west of O1153, 428 m to the nearest turbine (T20), on the west side of Bird Road. The predicted level based on the acoustic model at M1153 is 41.6 dBA. Monitor M1153 was erected in a location that was closer to the wind project than their representative receptor due to site specific setup limitations (trees, pond and horse enclosure). The effect of the closer measurement location is a shorter source-to-receiver distance to the closest turbines and therefore a higher sound level from the turbines at the monitor location compared to the receptor location.
- M2705: Measurement equipment was placed on the vacant lot property of V2705, 603 m to the nearest turbine (T04), on the north side of Concession Road Four. The predicted level based on the acoustic model at M2705 is 39.7 dBA.
- M1602: Measurement equipment was placed in an open field on the property of and to the west of O1602, 539 m to the closest turbine (T28), on the west side of Comfort Road. The predicted level based on the acoustic model at M1602 is 39.7 dBA.
- M0616: Measurement equipment was placed in an open field on the property of and to west of O0616, 592 m to the closest turbine (T93), on the south side of Concession Road Four. The predicted level based on the acoustic model at M0616 is 39.8 dBA.
- M0085: Measurement equipment was placed in an open field on the property of and to the west of O0085, 540 m to the closest turbine (T08), on the south side of Concession Road Three. The predicted level based on the acoustic model at M0085 is 39.7 dBA.

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 3: Receptor Measurement Locations

	Audit Receptor ID Nearest Turbine ID	O1153 T20	V2705 T04	O1602 T28	O0616 T93	O0085 T08
Receptor	UTM Coordinates (X,Y)	17T 621067mE 4749725mN	17T 627870mE 4768233mN	17T 622682mE 4769629mN	17T 618600mE 4767679mN	17T 614752mE 4765425mN
	Distance to Nearest Turbine	584m	603m	558m	617m	554m
	Predicted Level dBA*	39.9	39.7	39.5	39.7	39.5
Monitor	UTM Coordinates (X,Y)	17T 620902mE 4749669mN	17T 627870mE 4768233mN	17T 622530mE 4769635mN	17T 618528mE 4767683mE	17T 614682mE 4765434mN
	Distance to Nearest Turbine	428m	603m	539m	592m	540m
	Predicted Level dBA**	41.6	39.7	39.7	39.8	39.7

* Predicted level from Sound Level Prediction Results, [Modified Model for As-built] 77 WTGs – Stantec [3]
** Predicted level from Aercoustics' acoustic model

3.4 Sample size Reporting Requirements

As per Section D3.8 of the MECP protocol, at least 120 data points in each wind bin are required for Turbine ON measurements, and 60 data points for the ambient measurements between 4-7 m/s integer wind speeds inclusively (10m height).

The sample size requirements of 120 data points for Turbine ON and 60 data points for the ambient measurements between 4-7 m/s integer wind speeds has been satisfied for receptors O1153, O1602 and O0616.

The Revised Assessment Methodology for I-Audits (RAM-I) may allow for a lower amount of data points to be used in the analysis, provided that the quality of data remains high. RAM-I analysis was conducted as per Section 5.5 of the Protocol. This methodology is employed in cases where insufficient data is collected despite sound monitoring lasting longer than 6 weeks.

3.4.1 RAM-I Sample Size Requirements

The RAM-I assessment methodology reduces the sample size requirements, the Protocol states:

> "*The Ministry may accept a reduced number of data points for each wind speed bin with appropriate justification. […] The acceptable number of data points will be influenced by the quality of the data (standard deviation)" {Section E 5.5 (5)}*
>
> The threshold of 60 data points for Turbine ON measurements and 30 data points for Turbine OFF measurements is used in this assessment.

The range of wind bins which may be used to assess compliance is expanded to include a minimum of one of the following conditions as outlined in Section E 5.5(1):

a. "*Three (3) of the wind speed bins between 1 and 7 m/s (inclusive), or*

b. *Two (2) of the wind speed bins between 1 and 4 m/s (inclusive)"*

The RAM-I sample size requirement of 60 data points for Turbine ON and 30 data points for ambient measurements for 3 wind speed bins has been satisfied for receptor V2705 and O0085 in wind speed bins between 1 and 7m/s (inclusive).

3.5 Weather Conditions

Ambient conditions encountered over the measurement campaign were as follows:

- Ambient Humidity: 39% to 92%
- Ambient Temperature: -22˚C to 14˚C
- 10m Wind Speed: 0 m/s to 23 m/s

Historically, the predominant wind direction is from the southwest for this site. The wind direction varied over the course of the audit campaign. Wind roses have been provided in Appendix B that show the measured direction based on closest turbine yaw angle compared to 10m height wind speeds at each receptor for valid Turbine ON. The wind rose for ambient measurement intervals show the measured 10m wind speed at each receptor compared to 10m height wind direction. Wind directions shown on the wind roses indicate the direction the wind is coming from.

3.6 Operational Conditions

Turbine operational data for the duration of the measurement campaign was supplied by NRWF. 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 T4, T5, T8 T20, T27, T28, T52, T53, T56, T58, T62, T63, T66, T85, T93, T94, T96, and T99.

4 Sound Level Limits

The purpose of the sound measurements was to confirm whether the sound emitted by the wind facility is in compliance with the MECP allowable sound level limits. The MECP sound level limits for wind turbines vary with wind speed defined at a 10 m height. The details of the sound level limits are presented in Table 4 below.

Table 4: MECP Sound Level Limits for Wind Turbines

Wind speed at 10m height [m/s]	MECP Sound level limit [dBA]
≤ 4	40
5	40
6	40
7	43

As per section D6 of the MECP Protocol, if the background sound levels are greater than the applicable exclusion limits then the applicable limits are the background sound levels without extraneous noise sources.

5 Audit Results

The following tables detail the sound levels measured at all five receptors when all the nearby turbines were on (Turbine ON) and when all the nearby turbines were off (Turbine OFF). Wind bins which satisfy the RAM-I sample size requirements are highlighted in grey in Tables 5, 6, 7, 8 and 9. The Turbine ON sound level presented was filtered such that only data when the closest turbine was generating 85% power or greater and the receptor was in a downwind condition from the closest turbine was included.

Table 5: M1153 Sound levels measured for Turbine ON and OFF

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY*
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	143	28.7	3.3	-
1	3	41.8	0.1	362	28.4	3.6	*
2	40	42.5	0.5	112	28.9	2.9	*
3	180	42.6	0.7	157	32.5	3.8	40
4	160	43.1	1.0	293	36.9	3.2	40
5	356	44.0	1.2	302	39.4	3.1	40
6	649	45.9	1.8	248	43.5	2.4	40
7	520	48.6	2.4	156	46.8	2.4	42

*Insufficient amount of data points as per RAM-I protocol
**Turbine ONLY levels are given a distance correction (-1.7dB); Refer to Section 5.1 for more detail.

Table 6: M2705 Sound levels measured for Turbine ON and OFF

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	0	-	-	-
1	0	-	-	0	-	-	-
2	1	39.9	-	0	-	-	*
3	70	41.0	0.9	0	-	-	*
4	188	41.4	0.7	44	36.0	1.3	40
5	395	42.4	0.9	127	38.7	2.0	40
6	478	44.9	1.3	119	43.2	1.9	40
7	625	48.5	1.6	62	47.7	1.9	41

*Insufficient amount of data points as per RAM-I protocol

Table 7: M1602 Sound levels measured for Turbine ON and OFF

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	127	39.7	6.4	-
1	0	-	-	370	37.8	5.5	-
2	0	-	-	194	37.1	5.2	-
3	11	42.8	1.4	120	38.2	5.1	*
4	159	42.3	1.3	272	38.0	4.1	40
5	286	42.8	1.0	269	39.2	3.0	40
6	320	44.8	1.0	212	42.9	2.1	40
7	399	48.3	1.4	234	46.6	1.8	43

*Insufficient amount of data points as per RAM-I protocol
‡ Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level

Table 8 M0616 Sound levels measured for Turbine ON and OFF

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	116	29.1	3.8	*
1	9	40.9	0.5	476	31.2	4.5	*
2	73	40.5	0.8	273	32.0	4.0	40
3	138	41.0	0.9	290	32.8	3.3	40
4	146	41.8	0.8	339	36.3	2.8	40
5	260	43.5	1.0	273	40.8	2.3	40
6	204	46.1	1.2	202	44.8	1.8	40
7	222	49.4	1.1	95	48.2	1.5	43

Note: Insufficient amount of data points as per RAM-I protocol in all wind bins

Table 9: M0085 Sound levels measured for Turbine ON and OFF

Wind Speed at 10m Height (m/s)	Turbine ON			Turbine OFF			Turbine ONLY
	Number of Samples	LAeq [dBA]	Std Dev [dBA]	Number of Samples	LAeq [dBA]	Std Dev [dBA]	
0	0	-	-	114	31.6	2.2	-
1	10	42.5	1.1	370	32.5	3.0	*
2	4	42.0	0.2	290	33.8	3.3	*
3	129	42.0	0.5	386	32.7	2.4	42
4	101	42.3	0.5	410	35.5	2.7	41
5	132	43.7	1.2	514	39.3	2.8	42
6	317	46.7	1.6	331	44.3	2.7	43
7	405	49.8	1.5	118	48.0	2.1	45

*Insufficient amount of data points as per RAM-I protocol

The following figures present the scatter plots showing each valid 1-minute interval measured sound level at M1153, M2705, M1602, M0616 and M0085 when all the nearby turbines were ON (Turbine ON + Background) and when all the nearby turbines were OFF (Turbine OFF). The Turbine ON sound level presented was filtered such that only data when the closest turbine was generating 85% power or greater and the receptor was in a downwind condition from the closest turbine was included. It should be noted that the turbine ON sound level includes all sounds measured during the interval.

Figure 1: M1153 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

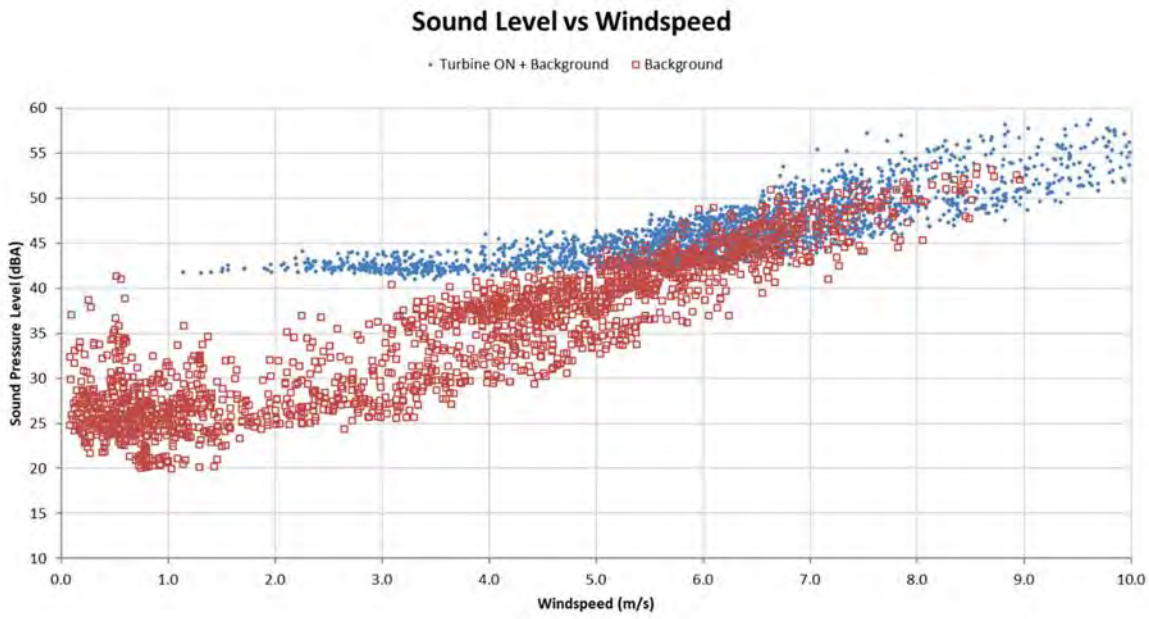


Figure 2: M2705 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

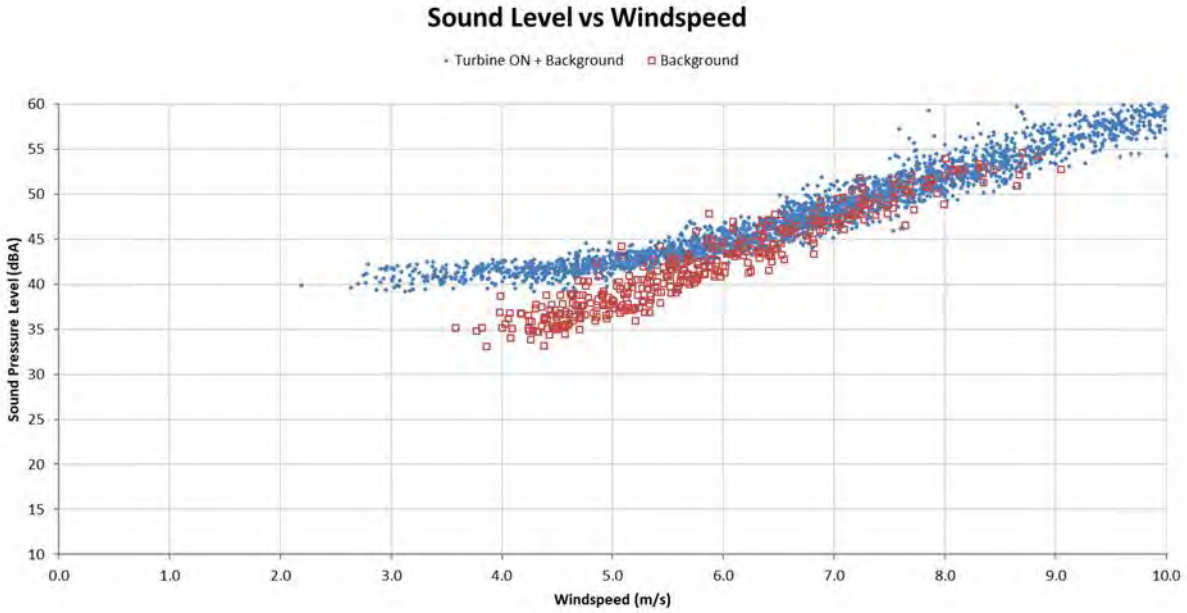


Figure 3: M1602 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

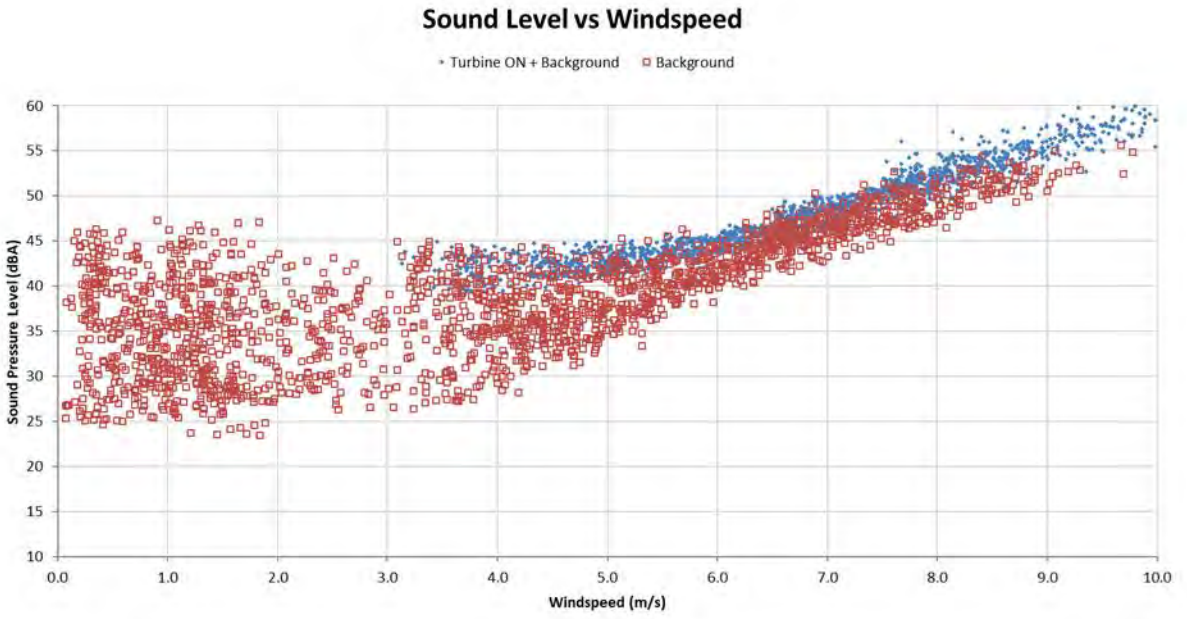


Figure 4: M0616 - Measured Sound Levels for Turbine ON and Background vs Wind Speed

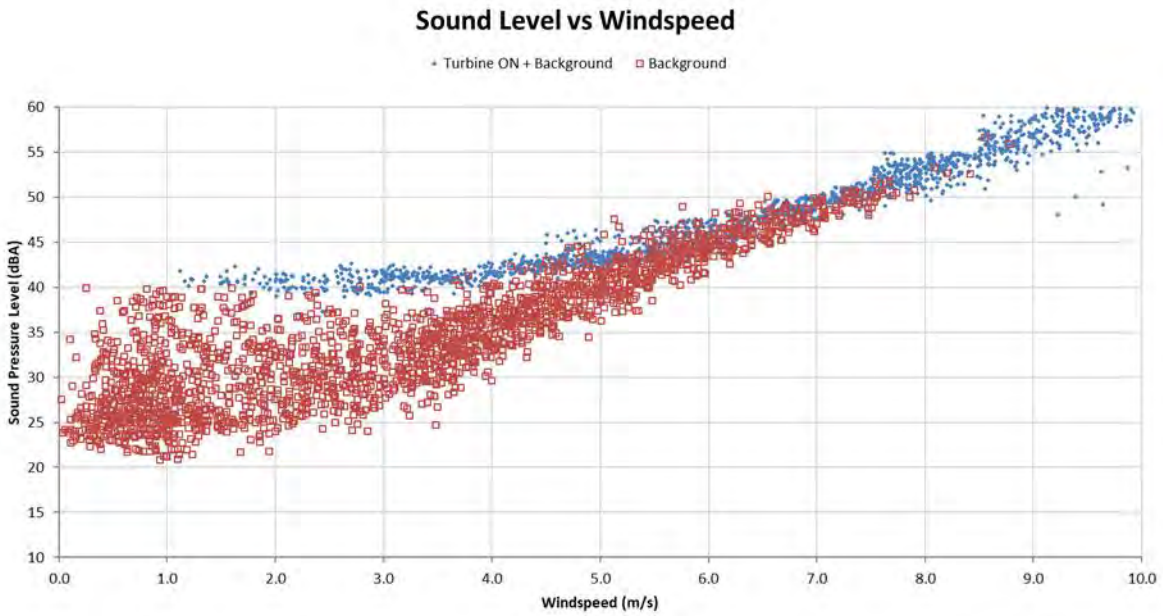
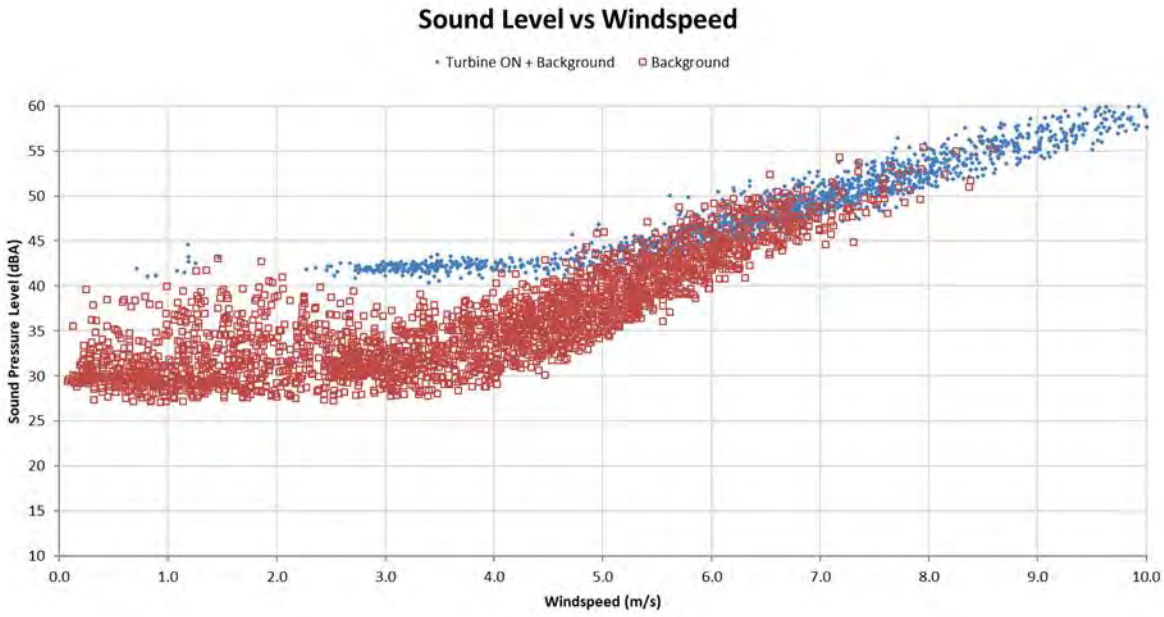


Figure 5: M0085 - Measured Sound Levels for Turbine ON and Background vs Wind Speed



6 Discussion

6.1 Overall Sound Level

The turbine-only component of the sound level was derived from a logarithmic subtraction of the ambient noise from that of the sound level measured with the turbines operating. The resulting sound level can be attributed to the turbines.

The audit at M2705, M1602, M0616 and M0085 are considered representative of the sound levels at Receptor V2705, O1602, O0616 and O0085 given the placement of the acoustic monitoring stations. Monitor M1153 was erected in a location that was significantly closer to the wind project than their representative receptor due to site specific setup limitations. The effect of the closer measurement location is a shorter source-to-receiver distance to the closest turbines and therefore a higher sound level from the turbines at the monitor location compared to the receptor location. To account for this difference in sound level, a correction has been applied based on the difference between the predicted level at the monitor location and the predicted level at the receptor location in the acoustic model. As a result, 1.7 dB was subtracted from the Turbine ONLY sound level for monitor O1153 and is presented in Table 10. See Appendix I for detailed calculation information.

Table 10 presents the Turbine ON, Turbine OFF and calculated Turbine ONLY sound pressure levels between 4-7 m/s. Wind bins which satisfy the RAM-I sample size requirements are highlighted in grey.

Table 10: Assessment Table

Measurement Location	Wind speed at 10m height [m/s]	0	1	2	3	4	5	6	7
O1153	Turbine ON LAeq [dBA]	-	42	43	43	43	44	46	49
	Turbine OFF LAeq [dBA]	29	28	29	33	37	39	44	47
	Turbine ONLY LAeq [dBA]	*	*	*	40†	40†	40†	40†	42†
V2705	Turbine ON LAeq [dBA]	-	-	40	41	41	42	45	49
	Turbine OFF LAeq [dBA]	-	-	-	-	36	39	43	48
	Turbine ONLY LAeq [dBA]	*	*	*	*	40	40	40	41‡
O1602	Turbine ON LAeq [dBA]	-	-	-	43	42	43	45	48
	Turbine OFF LAeq [dBA]	40	38	37	38	38	39	43	47
	Turbine ONLY LAeq [dBA]	*	*	*	*	40	40	40	43
O0085	Turbine ON LAeq [dBA]	-	43	42	42	42	44	47	50
	Turbine OFF LAeq [dBA]	32	33	34	33	35	39	44	48
	Turbine ONLY LAeq [dBA]	*	*	*	42	41	42	43	45
O0616	Turbine ON LAeq [dBA]	-	41	41	41	42	44	46	49
	Turbine OFF LAeq [dBA]	29	31	32	33	36	41	45	48
	Turbine ONLY LAeq [dBA]	*	*	40	40	40	40	40	43
MECP Limit		40	40	40	40	40	40	40	43

† Turbine ONLY levels are given a distance correction (-1.7dB)
‡ Higher uncertainty on calculated Turbine ONLY levels in cases where the measured ambient sound level (Turbine OFF) is within 1 dB of the measured Turbine ON level
*Insufficient amount of data points to calculate Turbine ONLY level as per RAM-I protocol

The data from Table 10 is plotted in Figures 6 to 10.

Figure 6: M1153 Turbine Levels compared to MECP Limits

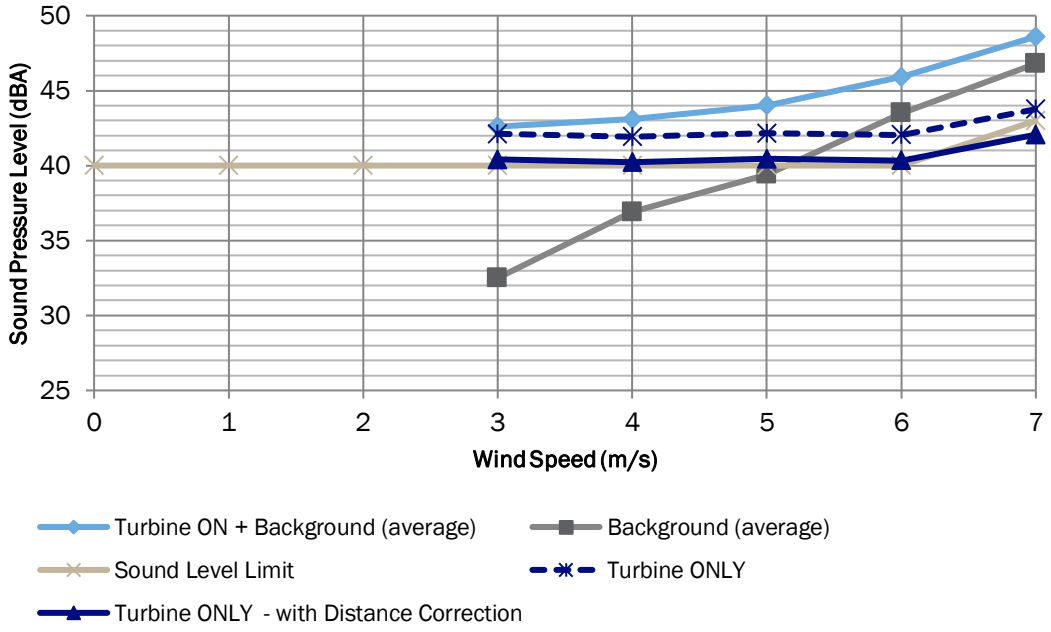


Figure 7: M2705 Turbine Levels compared to MECP Limits

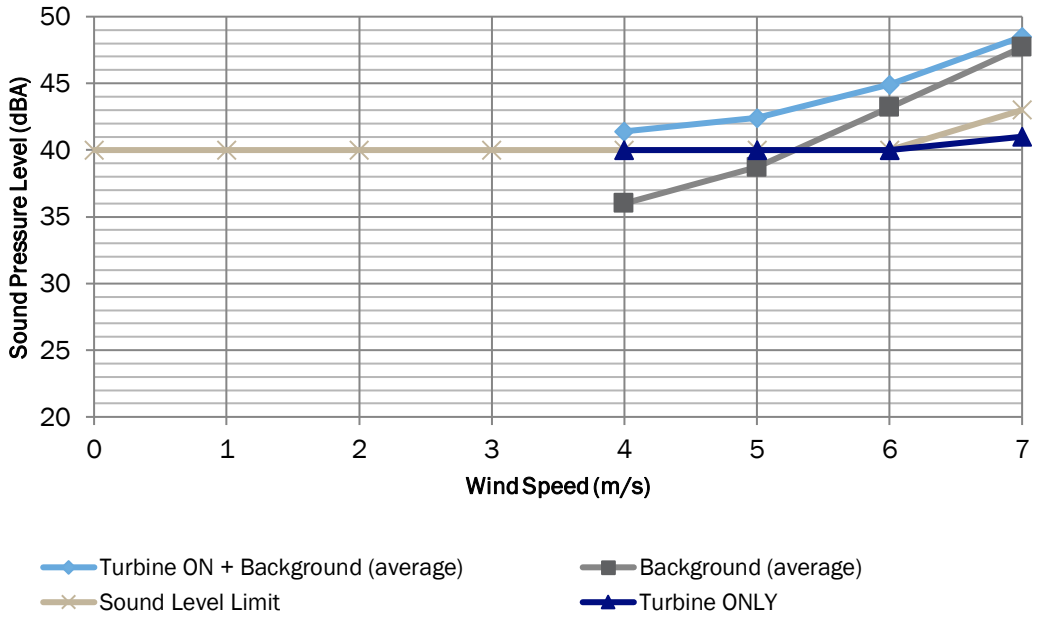


Figure 8: M1602 Turbine Levels compared to MECP Limits

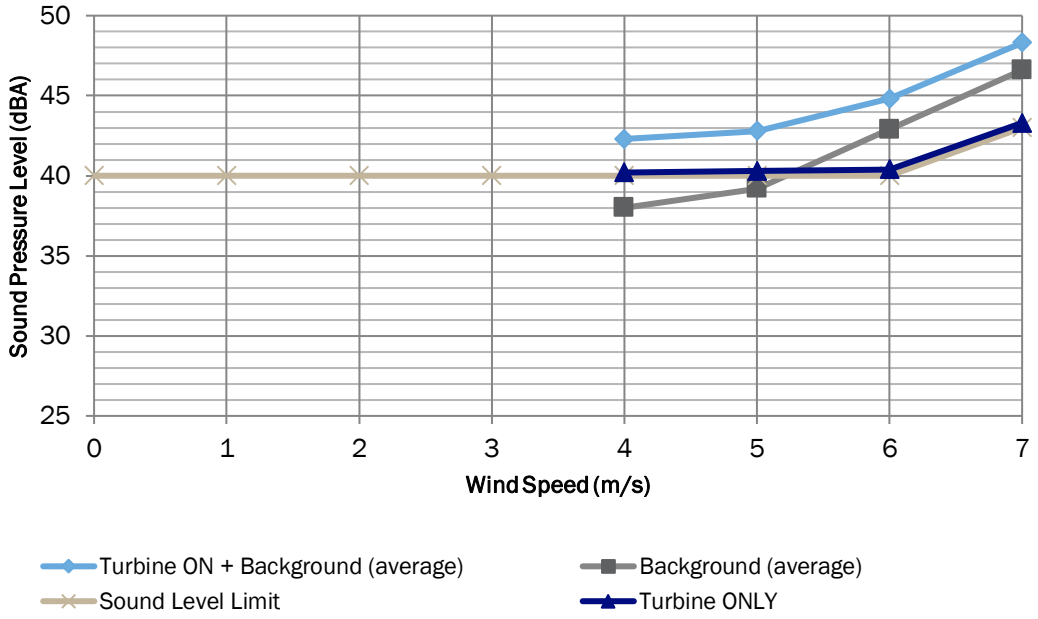


Figure 9: M0616 Turbine Levels compared to MECP Limits

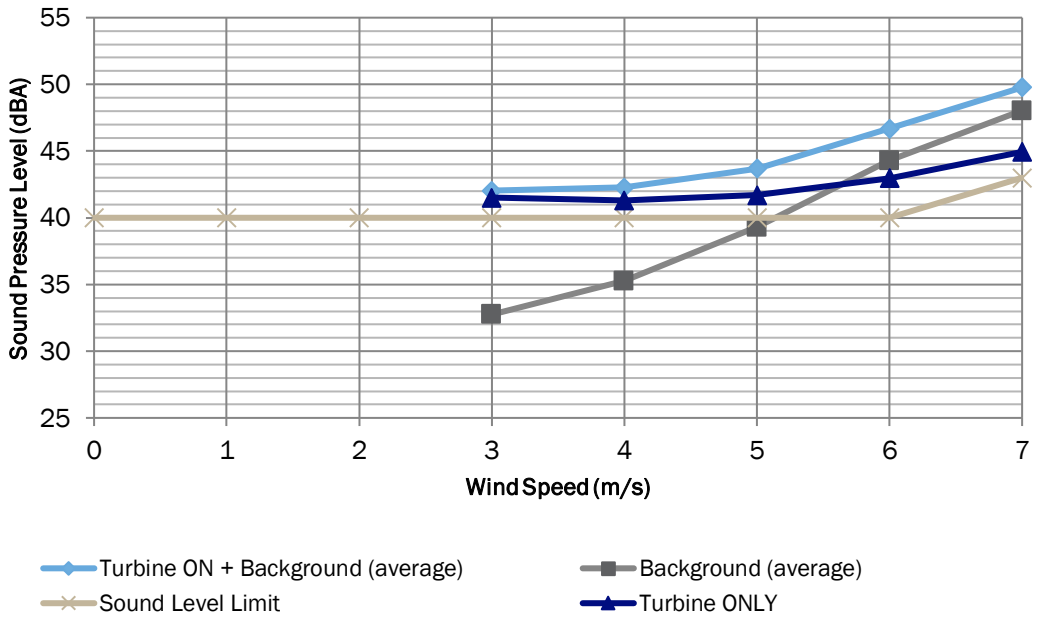
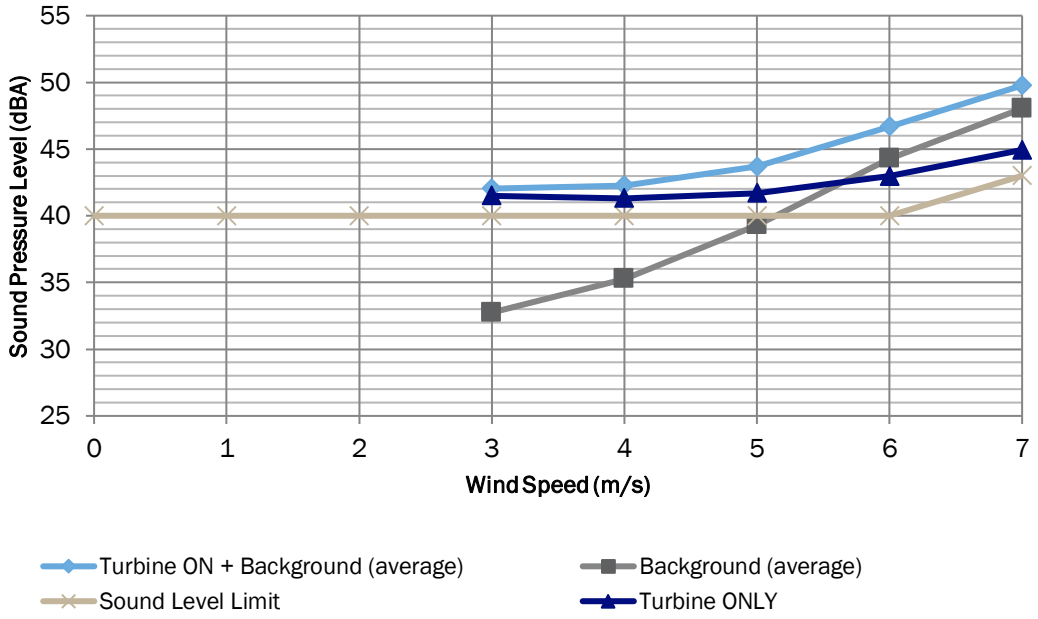


Figure 10: M0085 Turbine Levels compared to MECP Limits



6.2 Tonality

The tonality analysis results of the Emission audit measurements for turbines T35 (rated at 104.8 dBA) and T46 (rated at 102.9 dBA) were used as a basis for tones at all receptors, respectively, which were likely to have been generated by the closest turbine rather than by an external source. No tones were reportable according to the IEC 61400-11 Edition 3.0 noise emission measurements carried out on turbines T46 [4] and T35 [5].

Based on discussions with 1021702 B.C. Ltd it was determined that to be consistent with the Phase 1 audit, and Sections 3.8.3 and Section 5.1 of the Compliance protocol, the tonal assessment should been completed using IEC 61400-11 Ed. 3.0 with modifications to adapt the method to immission measurements 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]*

For the tonal assessment, narrowband data was acquired and calculated for each 1-minute interval used in the immission analysis and binned by wind speed. Each minute was analysed in order to detect any tones with tonal audibility greater than -3 dB at any of the measured frequencies. 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. The penalty structure was taken from ISO1996-2 Annex C: namely that the tonal penalty would be a positive number between 0dB and 6 dB based on the degree of tonal audibility of the worst-case tone. A tonal penalty is calculated as L_{ta} - 4 dB. i.e. a tonal audibility of 6.5 would incur a penalty of 2.5 dBA on the overall Turbine Only level.

A 116 Hz tone was observed at all receptors but was not prevalent enough nor prominent enough for a tonal penalty to be applicable. Tonal assessment summary tables are provided in Appendix D.

No tonal penalty was found to be applicable based on detailed tonal audibility analysis at audited receptors at the NRWF.

7 Assessment of Compliance

Based on the calculated turbine-only component indicated in Table 10 and Figures 6 to 9, the Niagara Region Wind Farm Project was found to be compliant with MECP limits at receptors O1153, V2705, O0616 and M1602 during the audit.

Based on the calculated turbine-only component indicated in Table 10 and Figure 10 the Niagara Region Wind Farm was found to be non-compliant with the MECP limits at receptor O0085. It should be noted that the measured sound levels of the Phase 1 audit at audit location O0085 were compliant with the MECP limits. It is Aercoustics understanding that Boralex in partnership with the turbine manufacturer Enercon has undertaken turbine inspections for physical components as well as turbine operating parameters. Further E-Audit testing is underway to investigate the source of the non-compliance with the MECP sound level limits at that location.

8 Conclusion

Aercoustics Engineering Limited has completed the Phase 2 acoustic immission audit outlined in the Renewable Energy Approval for the Niagara Region Wind Farm Project. The audit was completed as per the methodology outlined in Parts D and E of the "*MECP Compliance Protocol for Wind Turbine Noise*."

The measured levels were compared to the MECP limits, and the facility was determined to be in compliance at receptors O1153, V2705, O1602 and O0616 during the audit.

The measured levels were compared to the MECP limits, and the facility was determined to be non-compliant at receptor M0085 during the audit.

9 References

[1] V. Schroter, “Renewable Energy Approval #4353-9HMP2R”, Ontario Ministry of the Environment, Toronto, ON, November 6, 2014 and further modified on November 23, 2015, May 6, 2016 and May 12, 2016.

[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] K. Ganesh and K. Mallinen, “Niagara Region Wind Farm Noise Assessment Report – REA Amendment”, Stantec Consulting Ltd., Markham, ON, April 08, 2016.

[4] P. Ashtiani and A. Munro, “Niagara Region Wind Farm – Turbine T46 – IEC 61400-11 Edition 3.0 Measurement Report”, Aercoustics Engineering Ltd., Mississauga, ON, 03 November 2017.

[5] P. Ashtiani and A. Munro, “Niagara Region Wind Farm – Turbine T35 – IEC 61400-11 Edition 3.0 Measurement Report”, Aercoustics Engineering Ltd., Mississauga, ON, 03 November 2017.

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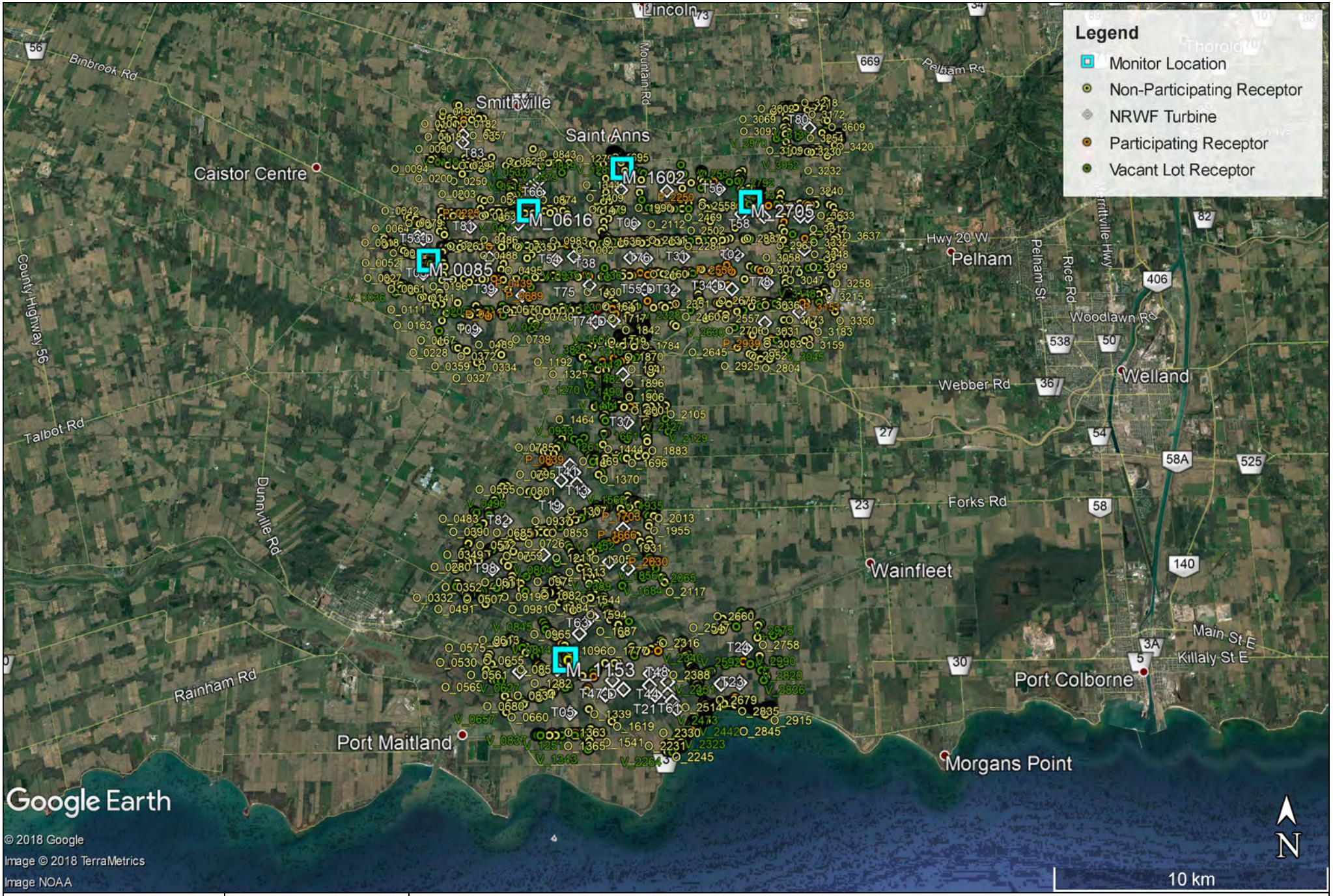
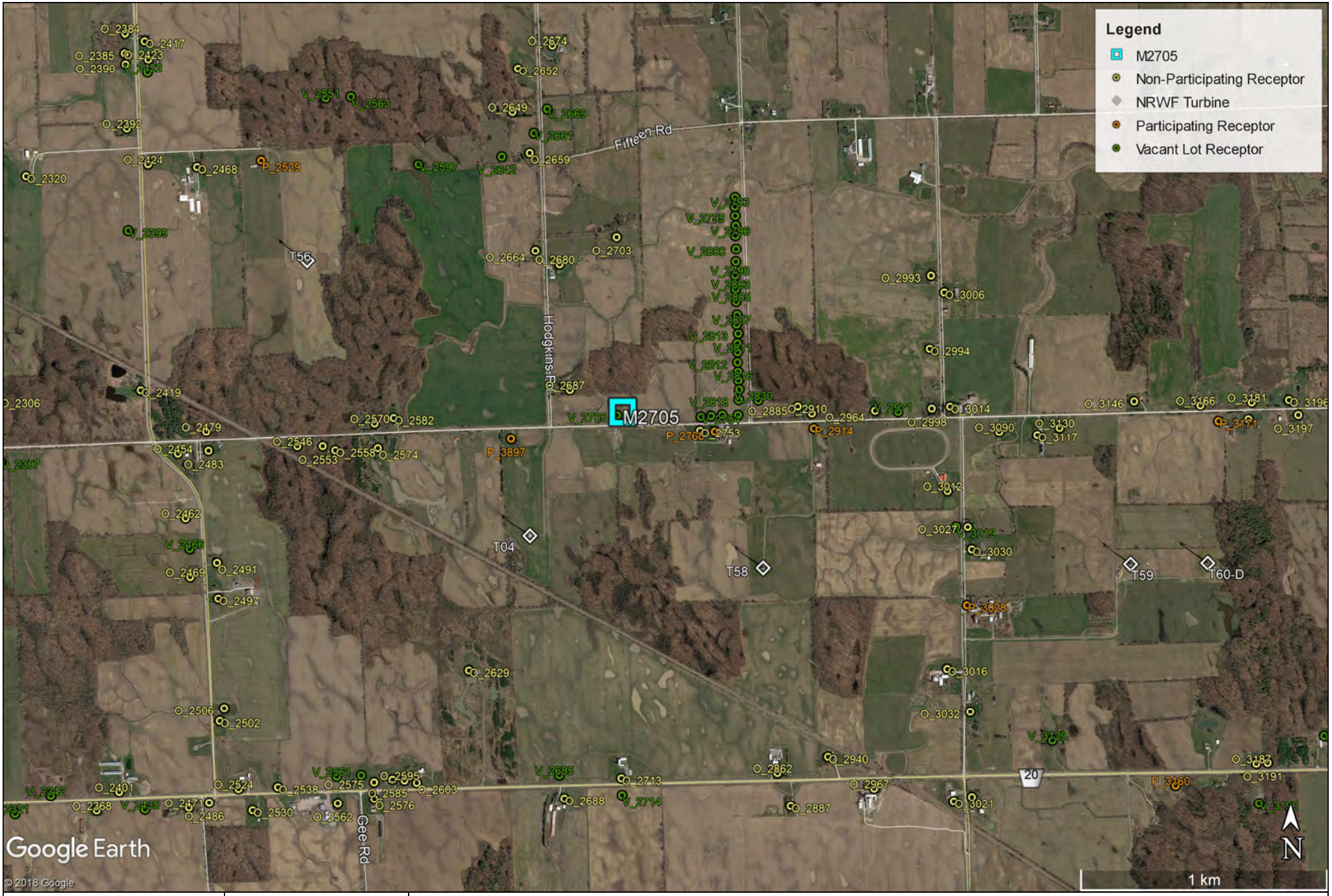
Appendix A
Location Details



aercoustics	16227.00	**Project Name**
	Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit
		Figure Title Site Plan
		Figure A.01

aercoustics	16227.00	**Project Name**
	Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit
		Figure Title M1153 - Monitor and Receptor Location Details
		Figure A.02



aercoustics	16227.00	**Project Name**
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		Figure Title M2705 - Monitor and Receptor Location Details
		Figure A.03

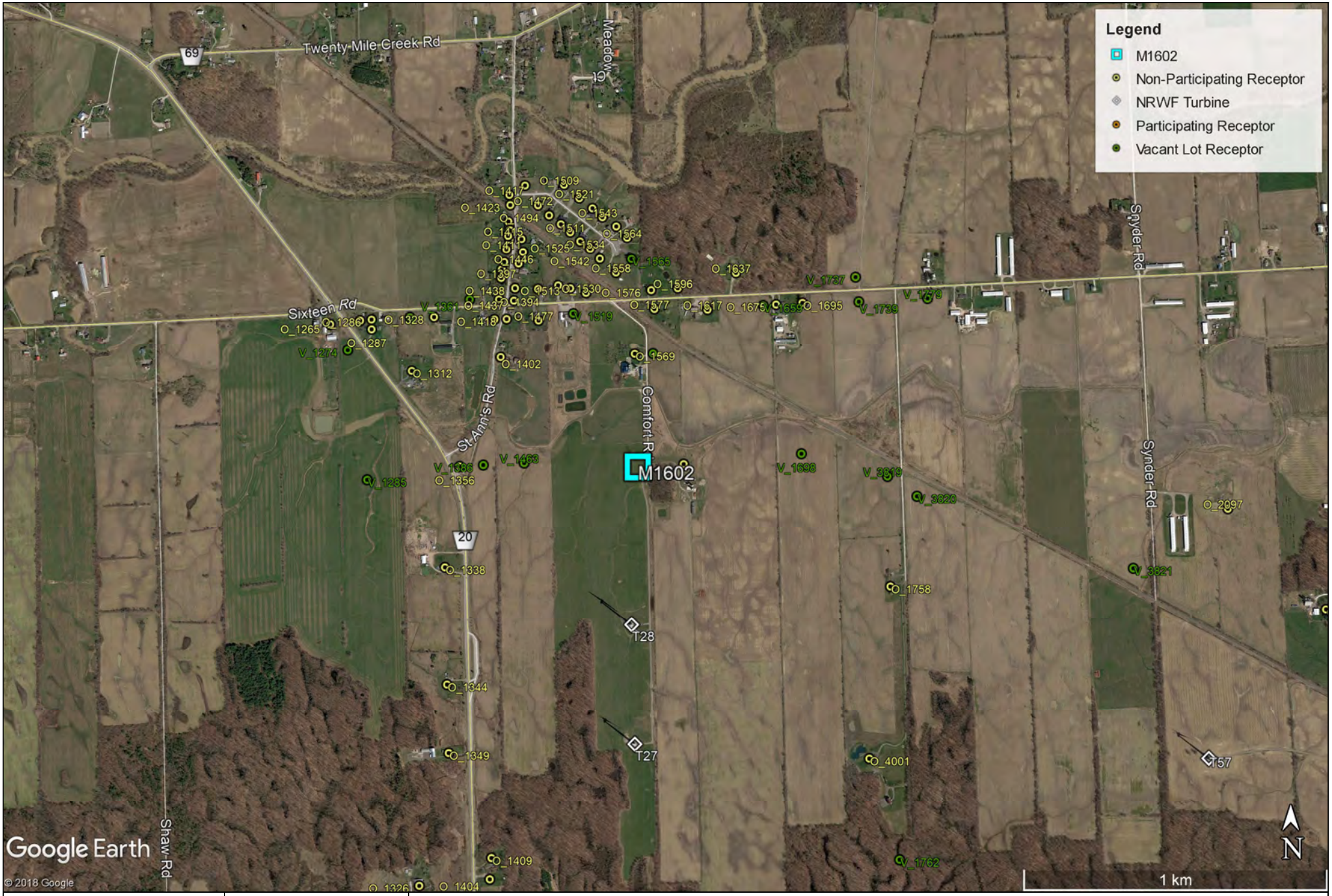

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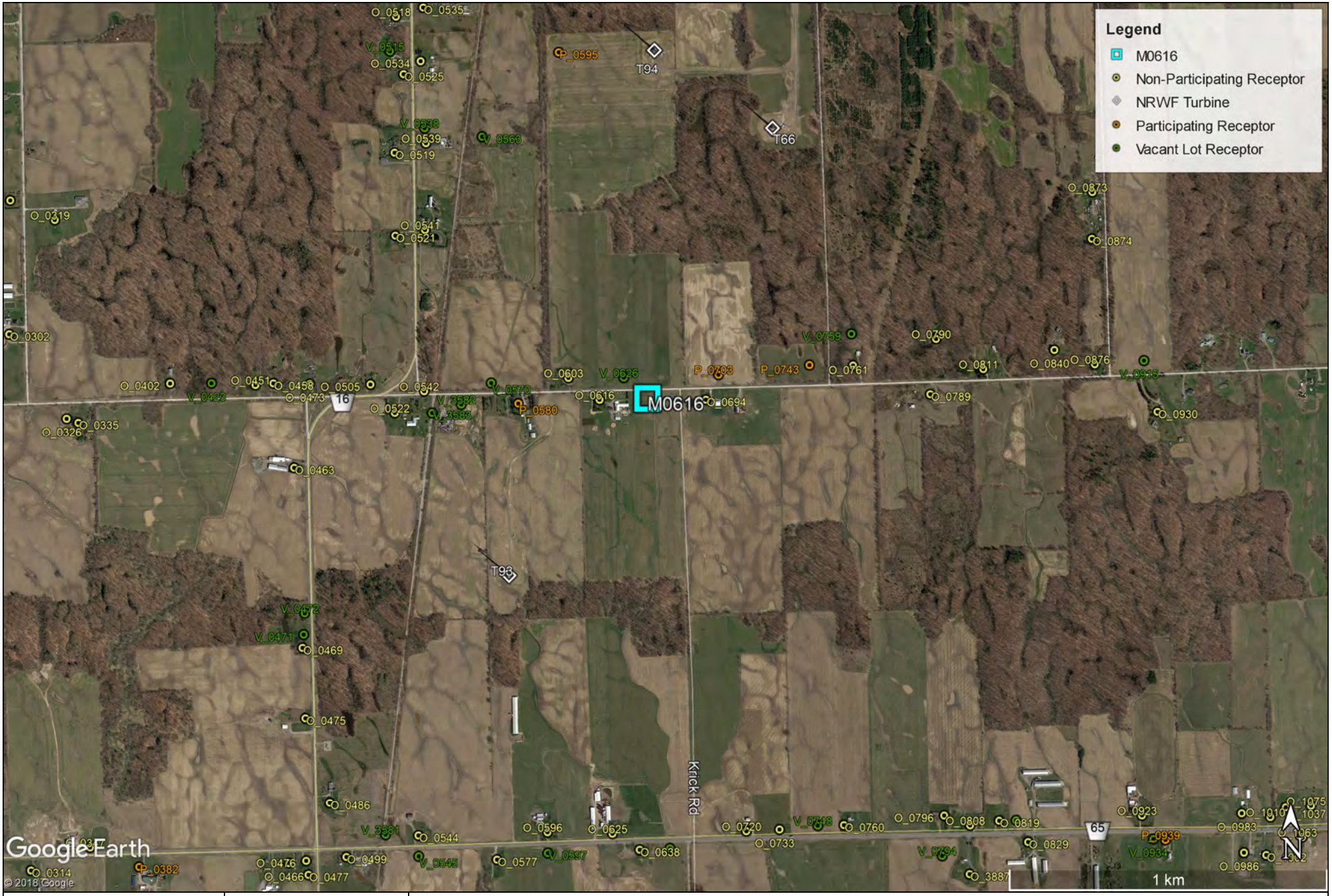
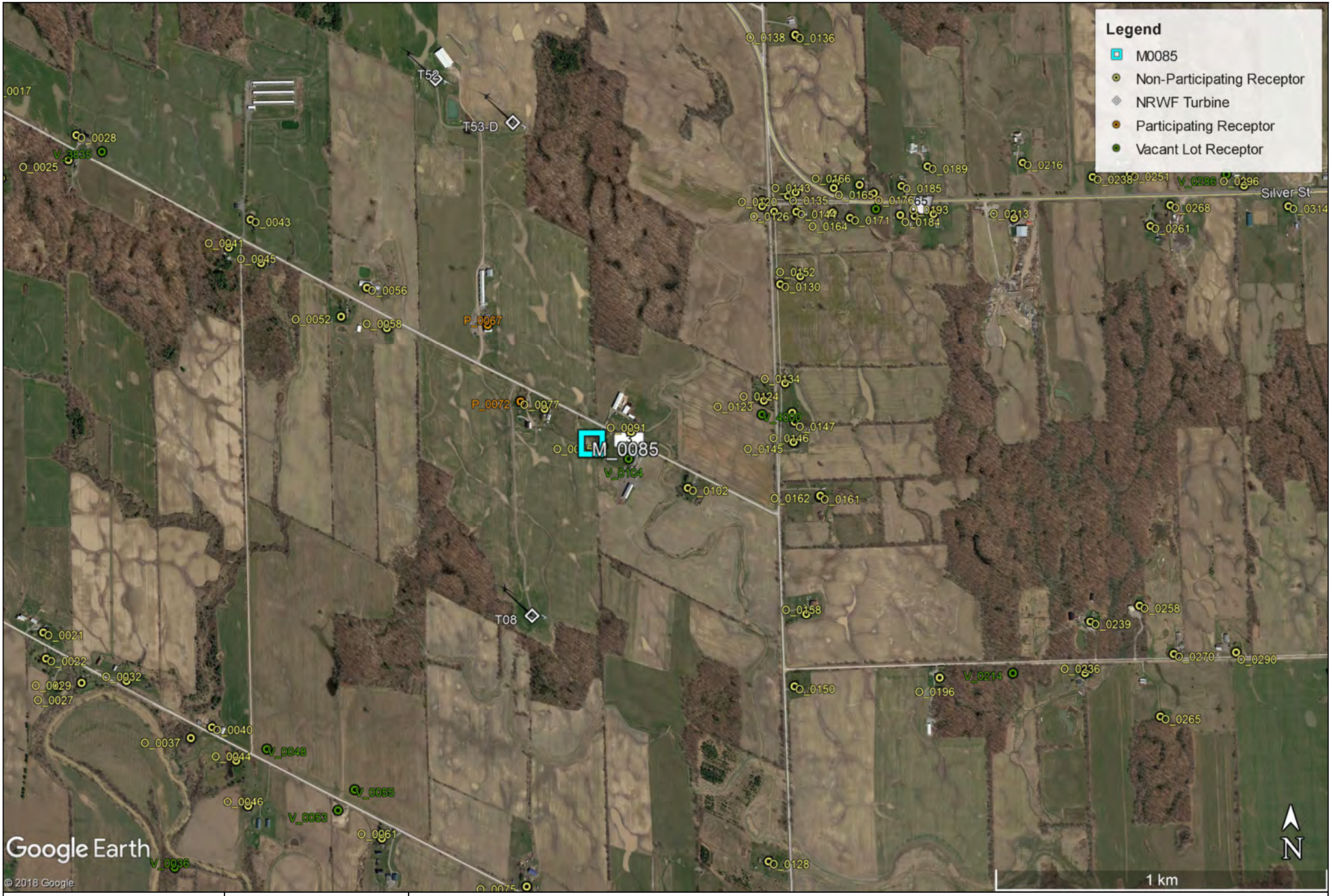
		Figure Title M1602 - Monitor and Receptor Location Details
		Figure A.04



aercoustics	16227.00 Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	**Project Name** Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit **Figure Title** M0616 - Monitor and Receptor Location Details

Figure A.05



aercoustics	16227.00 Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	**Project Name** Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit **Figure Title** M0085 - Monitor and Receptor Location Details

Figure A.06

aercoustics	16227.00 Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	**Project Name** Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit	
		Figure Title Site Photos - M1153	**Figure A.07**

aercoustics	16227.00 Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	**Project Name** Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit	
		Figure Title Site Photos - M2705	**Figure A.08**

aercoustics	16227.00	**Project Name**
	Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit
		Figure Title Site Photos - M1602
		Figure A.09

aercoustics	16227.00 Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	**Project Name** Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit	
		Figure Title Site Photos - M0616	**Figure A.10**

aercoustics	16227.00	**Project Name**
	Scale: NTS Drawn by: IK Reviewed by: AM Date: May 16, 2019 Revision: 1	Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit
		Figure Title Site Photos - M0085
		Figure A.11

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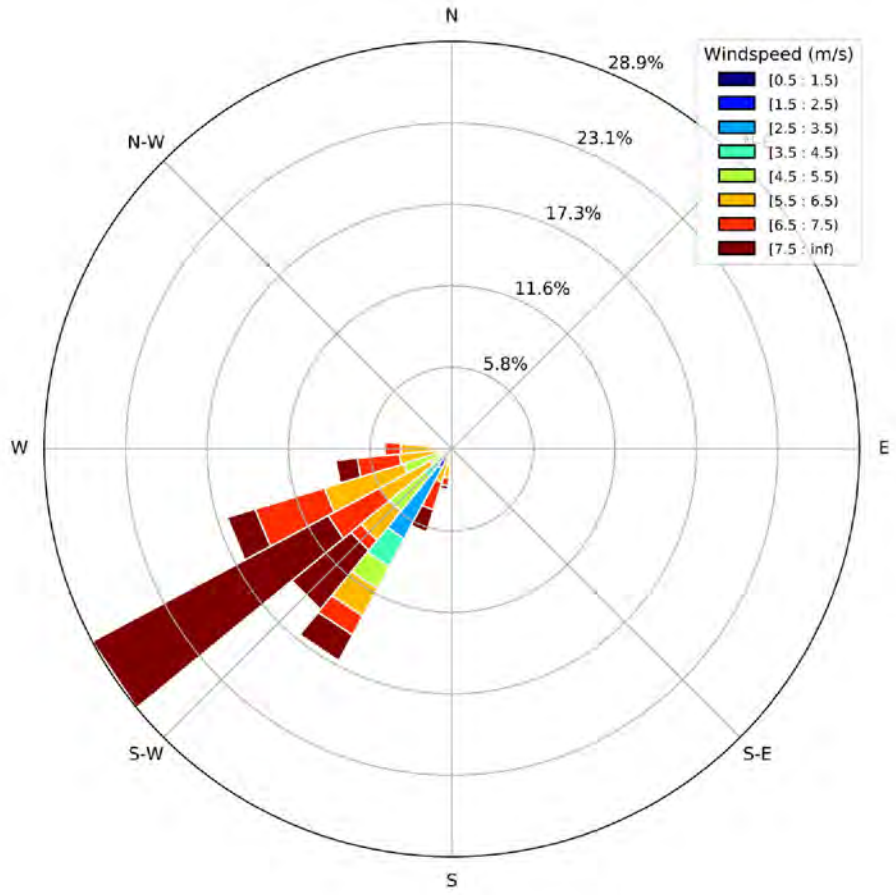
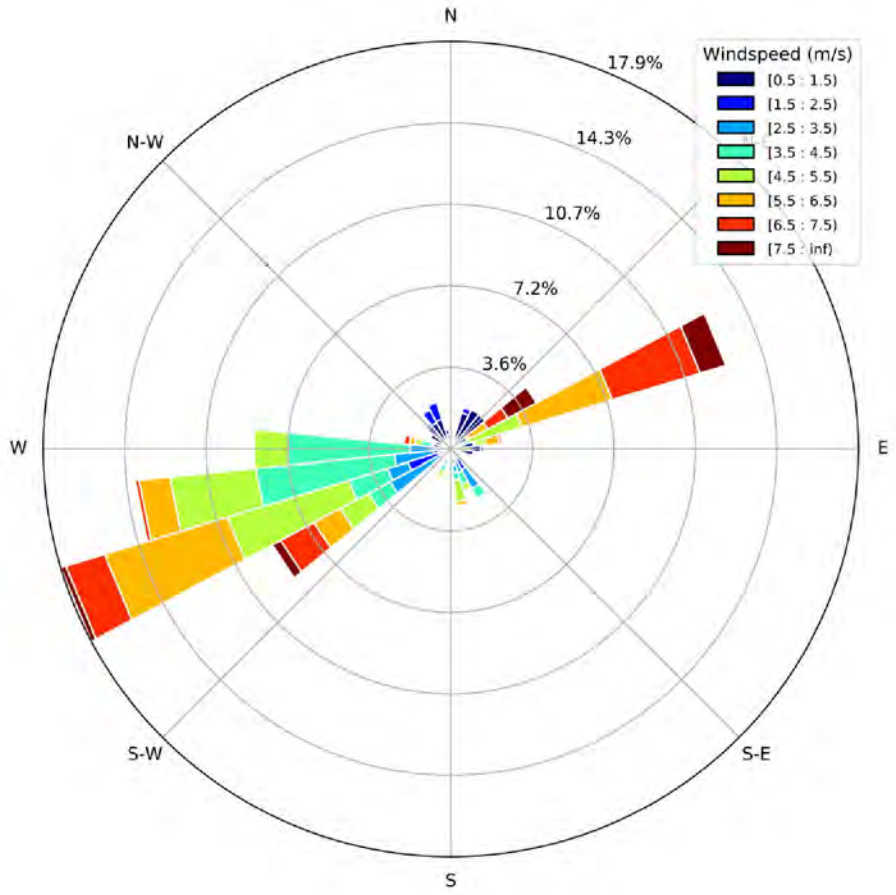
Appendix B
Wind Roses

M1153 TON	M1153 TOFF
	

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16227.00

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Drawn by: IK
Reviewed by: AM
Date: May 16, 2019
Revision: 1

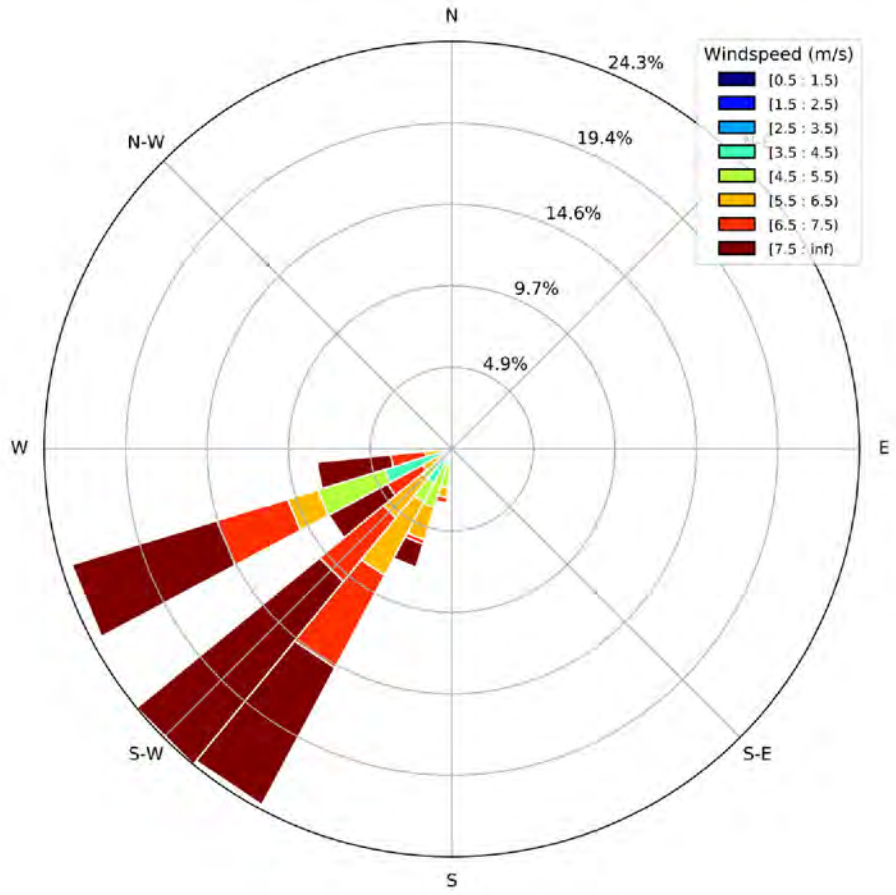
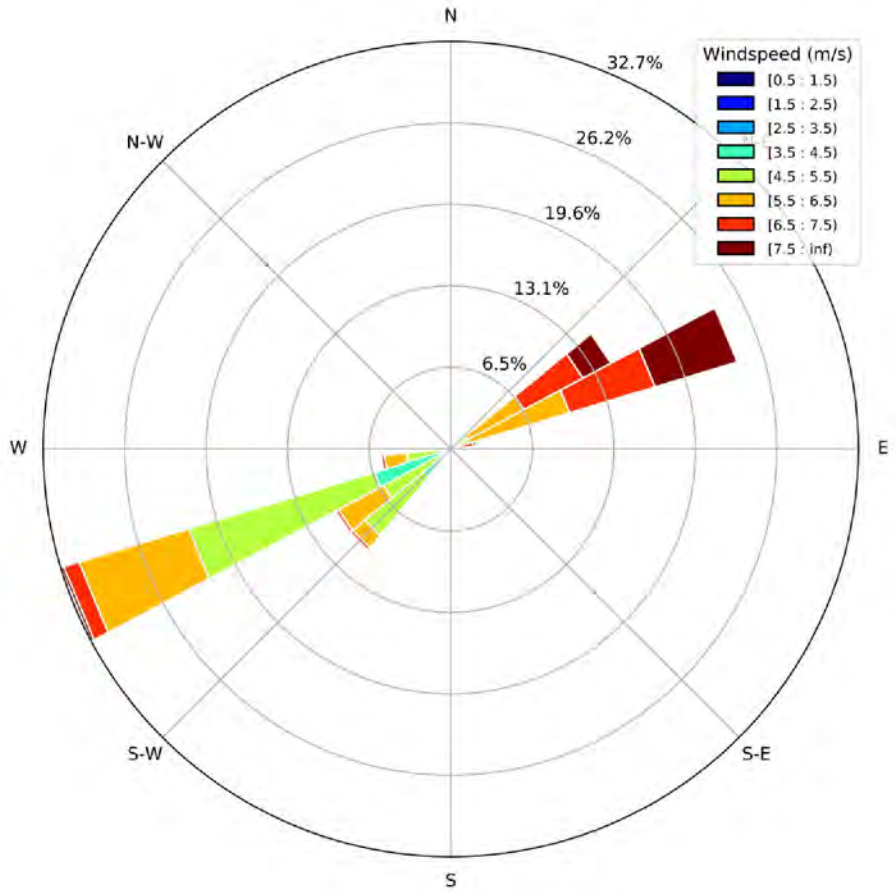
Project Name

Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit

Figure Title

Wind Roses - M1153

Figure B.01

M2705 TON	M2705 TOFF
	

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Drawn by: IK
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Date: May 16, 2019
Revision: 1

Project Name

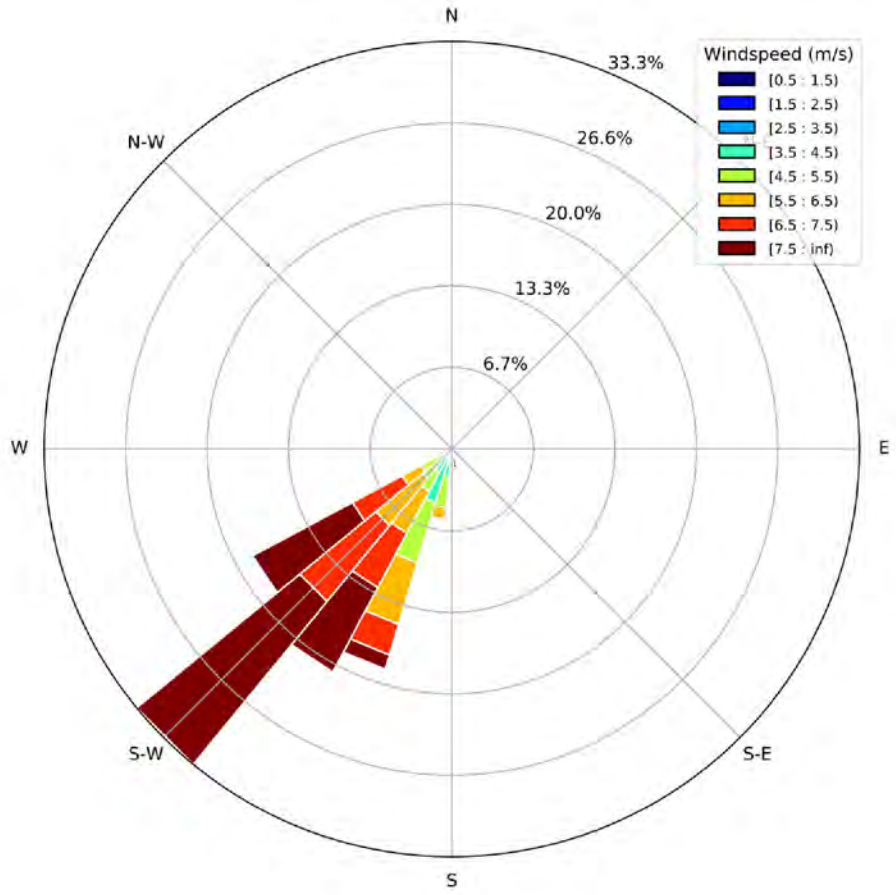
Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit

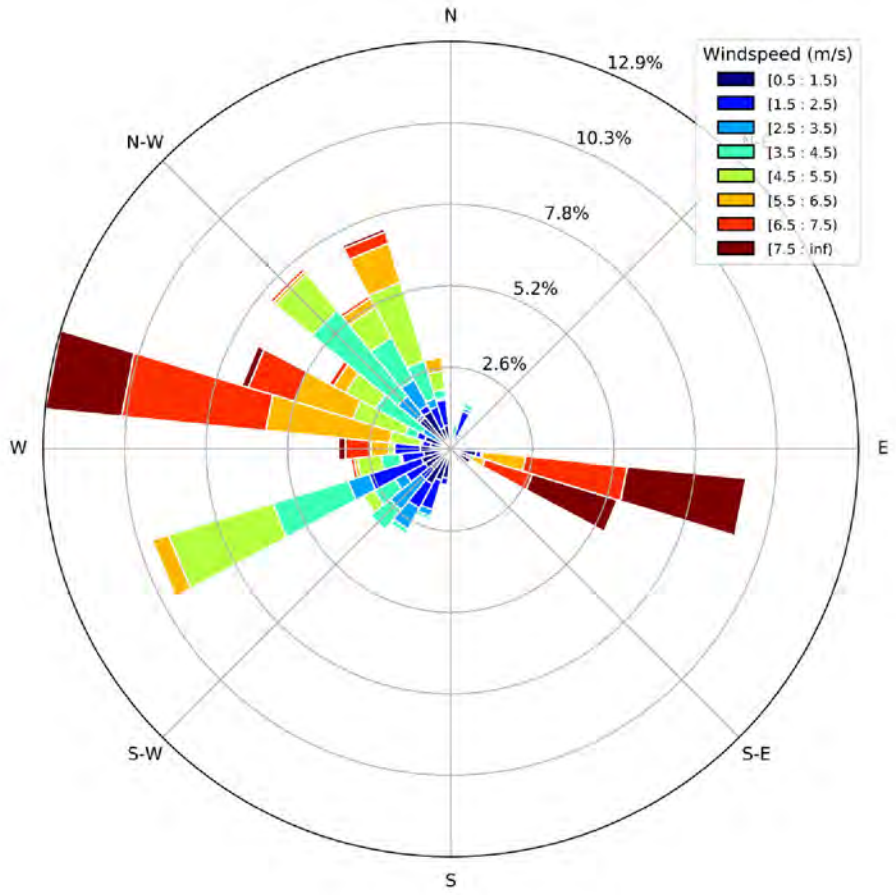
Figure Title

Wind Roses - M2705

Figure B.02

M1602 TON	M1602 TOFF





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Revision: 1

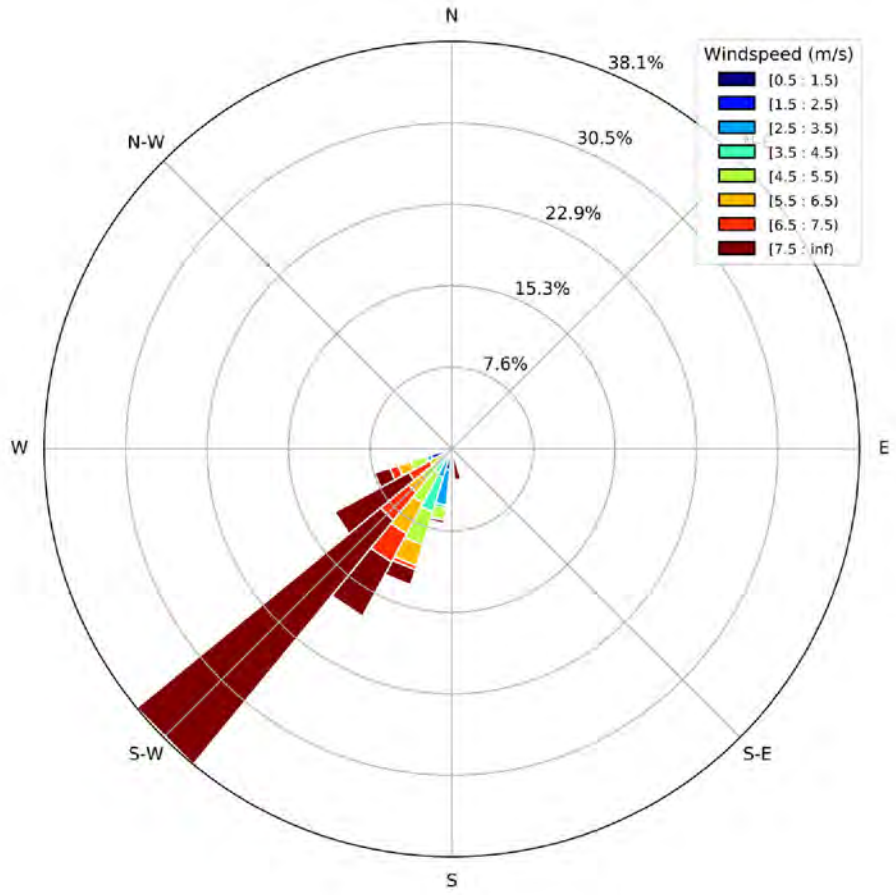
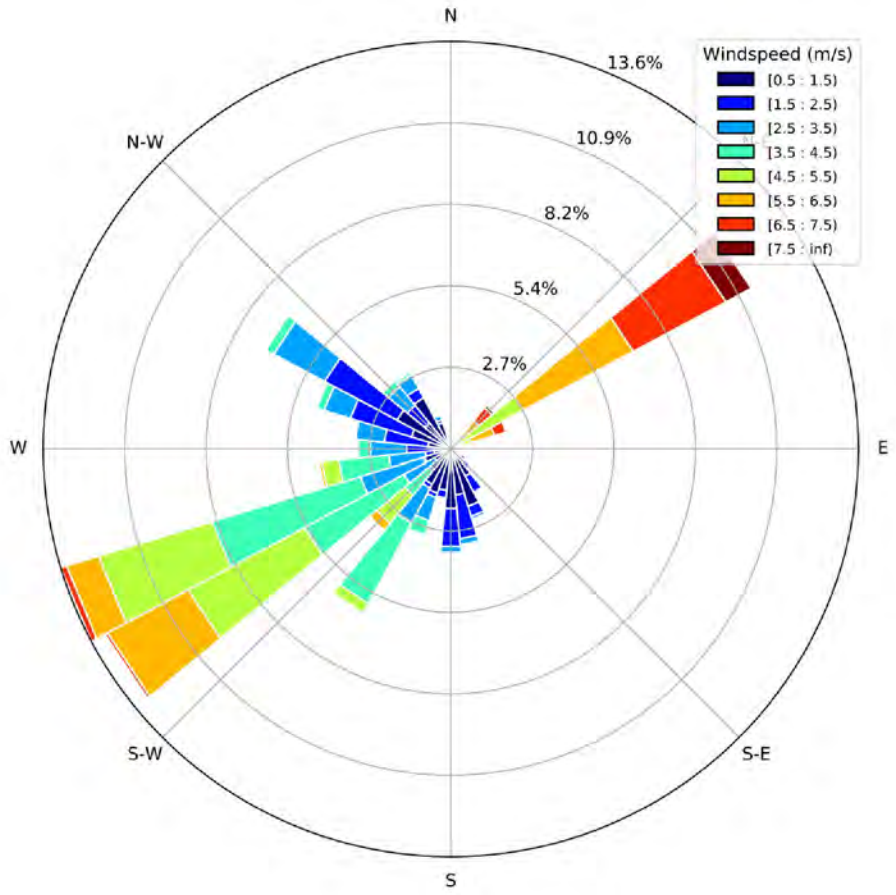
Project Name

Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit

Figure Title

Wind Roses - M1602

Figure B.03

M0616 TON	M0616 TOFF
	

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Date: May 16, 2019
Revision: 1

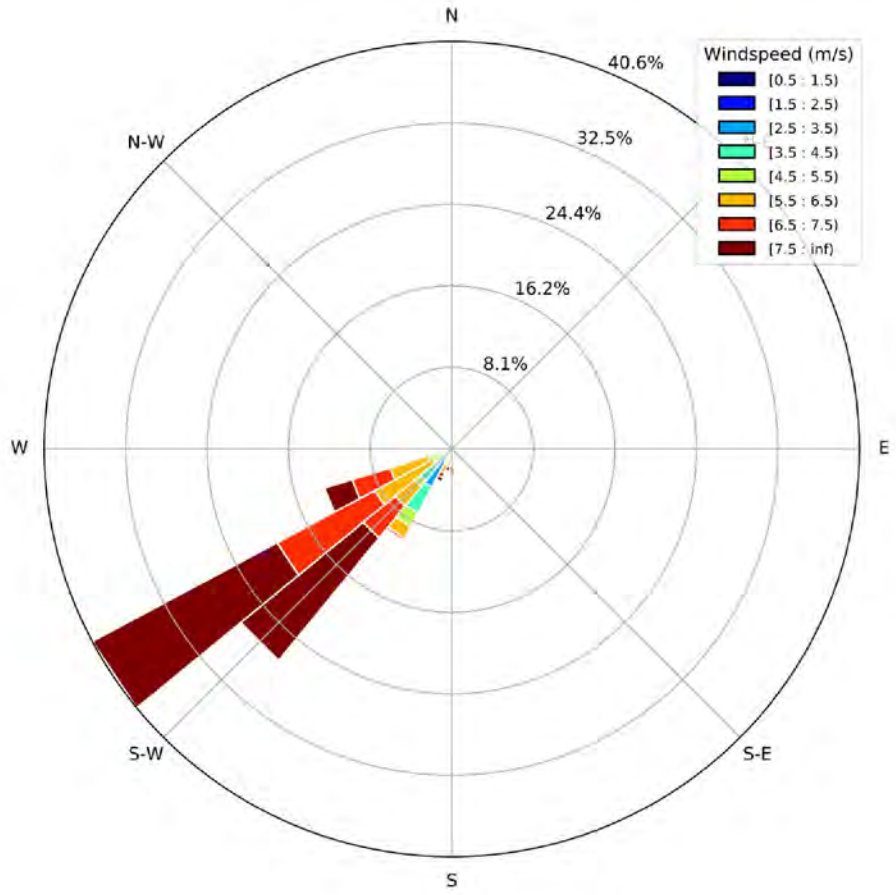
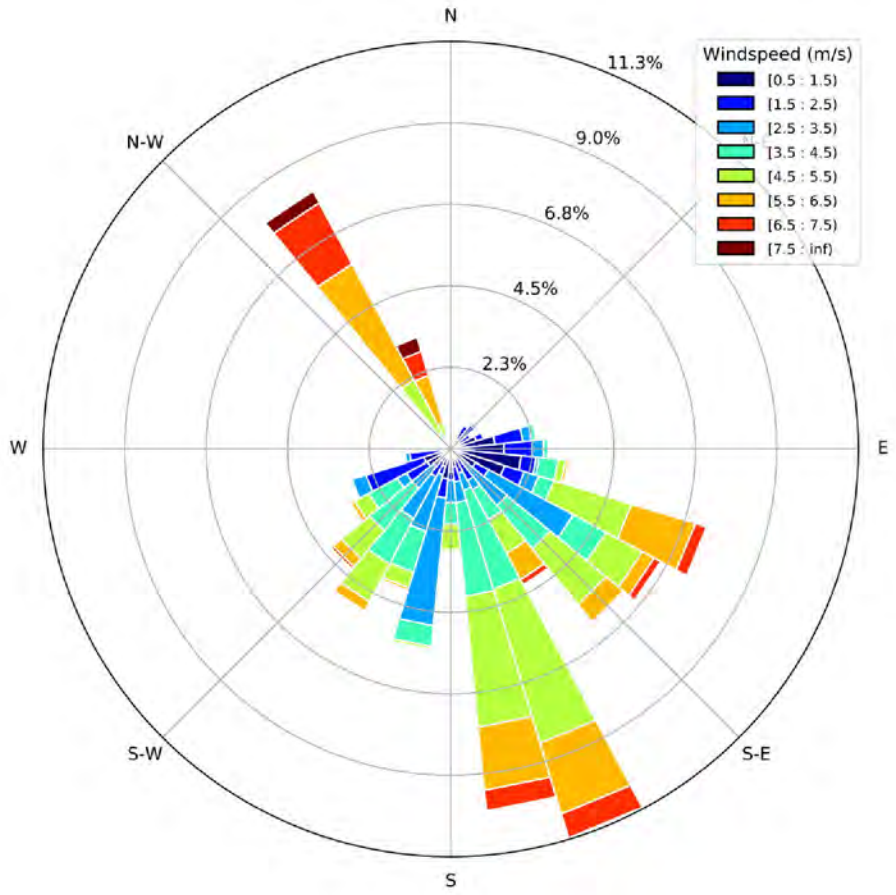
Project Name

Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit

Figure Title

Wind Roses - M0616

Figure B.04

M0085 TON	M0085 TOFF
	

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Project Name

Niagara Region Wind Farm Project - 2nd Acoustic Immission Audit

Figure Title

Wind Roses - M0085

Figure B.05

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Appendix C
Turbine Operational Statement from Operator

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Appendix D
Tonality Assessment

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 5/22/2019

M1153 91-141 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)†	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	**	**	40	**	**
1	3	3	100%	*	40	0.8	0
2	40	39	98%	*	40	2.2	0
3	180	165	92%	40	40	2.4	0
4	160	141	88%	40	40	0.8	0
5	356	227	64%	40	40	-0.4	0
6	649	226	35%	40	40	-1.1	0
7	520	73	14%	42	43	-1.9	0

* Insufficient amount of data points as per RAM-I protocol
** No data points at wind speed
† Turbine ONLY levels are given a distance correction (-1.7 dB)

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 5/22/2019

M2705 91-141 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	**	**	40	**	0
1	0	0	**	**	40	**	0
2	1	1	100%	*	40	2.5	0
3	70	48	69%	*	40	3.6	0
4	188	124	66%	40	40	2.9	0
5	395	190	48%	40	40	1.4	0
6	478	81	17%	40	40	0.6	0
7	625	40	6%	41	43	2.4	0

* Insufficient amount of data points as per RAM-I protocol
** No data points at wind speed

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 5/22/2019

M1602 91-141 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	**	**	40	**	0
1	0	0	**	**	40	**	0
2	0	0	**	**	40	**	0
3	11	11	100%	*	40	3.4	0
4	159	159	100%	40	40	3.3	0
5	286	281	98%	40	40	3.1	0
6	320	308	96%	40	40	1.5	0
7	399	312	78%	43	43	-0.1	0

* Insufficient amount of data points as per RAM-I protocol
** No data points at wind speed

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 5/22/2019

M0616 91-141 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	**	**	40	-	0
1	9	9	100%	*	40	0.5	0
2	73	73	100%	40	40	1.0	0
3	138	101	73%	40	40	-0.1	0
4	146	101	69%	40	40	-0.3	0
5	260	118	45%	40	40	-1.0	0
6	204	34	17%	40	40	-1.4	0
7	222	11	5%	43	43	-2.0	0

* Insufficient amount of data points as per RAM-I protocol
** No data points at wind speed

Appendix D - Tonality Assessment Summary

Project: Niagara Region Wind Farm Project - 1st Acoustic Immission Audit
Report ID: 16227

Created on: 5/22/2019

M0085 91-141 Hz Tonality Summary							
Wind Speed (m/s)	Data Count	Tone Count	Tonal Presence (%)	Turbine ONLY (dB)	MOECC Sound Level Limit (dB)	Average Tonal Audability (dB)	Applicable Tonal Penalty (dB)
0	0	0	**	**	40	-	0
1	10	8	80%	*	40	-0.2	0
2	4	4	100%	*	40	-0.7	0
3	129	116	90%	41	40	1.6	0
4	101	96	95%	41	40	0.7	0
5	132	95	72%	42	40	-0.2	0
6	317	158	50%	43	40	-0.6	0
7	405	127	31%	45	43	-1.6	0

* Insufficient amount of data points as per RAM-I protocol

** No data points at wind speed

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Appendix E
Turbine Status during TON and TOFF

Niagara Region – Turbine Status Matrix for TON and TOFF

Turbine ID	Monitor Locations				
	M1153	M2705	M1602	M0616	M0085
T01					
T02					
T03					
T04		1			
T05	1				
T06					
T07					
T08					1
T09					
T10					
T11					
T12					
T13					
T14					
T16					
T18					
T19					
T20	1				
T21					
T22					
T23					
T24					
T27			1		
T28			1		
T29					
T31					
T32					
T33					
T34					
T35					
T36					
T37					
T38					
T39					
T41					
T42					
T43					
T44					
T45					
T46					
T47					
T48					
T49					
T51					
T52					1
T53					1
T54					

Turbine ID	Monitor Locations				
	M1153	M2705	M1602	M0616	M0085
T55					
T56		1			
T57					
T58		1			
T59					
T60					
T61					
T62	1				
T63	1				
T65					
T66				1	
T72					
T74					
T75					
T76					
T78					
T79					
T80					
T81					
T82					
T83					
T84					
T85				1	
T88					
T89					
T91					
T93				1	
T94				1	
T95					
T96	1				
T97					
T98					
T99	1				

1 - Turbine ON/OFF
Turbines turned off such that predicted impact at monitor/receptor location is 30 dBA or less

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Appendix F
Receptor Selection Rationale

Appendix F - Receptor Selection Summary

Project: Niagara Region Wind Farm Project

Receptor ID	Description	Modelled Sound Level (dBA)	Receptor Height (m)	Distance to Closest Turbine (m)	Closest Turbine ID	Rationale
O_1097	Non-Participating Receptor	40.0	4.5	612	T75	Not in Prevailing Wind Direction
O_1344	Non-Participating Receptor	40.0	4.5	640	T28	Not in Prevailing Wind Direction
O_856	Non-Participating Receptor	40.0	4.5	556	T20	Not in Prevailing Wind Direction
V_2635	Non-Participating Vacant Lot	40.0	4.5	597	T24	Not in Prevailing Wind Direction
V_2719	Non-Participating Vacant Lot	40.0	4.5	552	T24	Not in Prevailing Wind Direction
V_563	Non-Participating Vacant Lot	40.0	4.5	601	T94	Not in Prevailing Wind Direction
O_368	Non-Participating Receptor	39.9	4.5	570	T39	Not in Prevailing Wind Direction
O_416	Non-Participating Receptor	39.9	4.5	610	T39	Not in Prevailing Wind Direction
O_1153	Non-Participating Receptor	39.9	4.5	584	T20	Selected Monitoring Location
O_1184	Non-Participating Receptor	39.9	4.5	718	T63	Not in Prevailing Wind Direction
O_1707	Non-Participating Receptor	39.9	4.5	734	T01	Not in Prevailing Wind Direction
V_2361	Non-Participating Vacant Lot	39.9	4.5	971	T43	Poor monitoring location; large tree lot to the South to block winds and corn stalks in field to cause high ambient noise
V_430	Non-Participating Vacant Lot	39.8	4.5	616	T39	Not in Prevailing Wind Direction
O_1349	Non-Participating Receptor	39.8	4.5	614	T27	Not in Prevailing Wind Direction
O_1734	Non-Participating Receptor	39.8	4.5	705	T06	Not in Prevailing Wind Direction
O_2160	Non-Participating Receptor	39.8	4.5	649	T32	Not in Prevailing Wind Direction
O_2550	Non-Participating Receptor	39.8	4.5	693	T34	Not in Prevailing Wind Direction
O_2593	Non-Participating Receptor	39.8	4.5	608	T49	Not in Prevailing Wind Direction
V_2180	Non-Participating Vacant Lot	39.8	4.5	653	T31	Not in Prevailing Wind Direction
V_3582	Non-Participating Vacant Lot	39.8	4.5	553	T93	Not in Prevailing Wind Direction
V_855	Non-Participating Vacant Lot	39.8	4.5	569	T20	Not in Prevailing Wind Direction
O_543	Non-Participating Receptor	39.7	4.5	663	T07	Not in Prevailing Wind Direction
O_1668	Non-Participating Receptor	39.7	4.5	651	T65	Not in Prevailing Wind Direction
O_1002	Non-Participating Receptor	39.7	4.5	555	T38	Not in Prevailing Wind Direction
O_1096	Non-Participating Receptor	39.7	4.5	657	T96	Not in Prevailing Wind Direction
O_1750	Non-Participating Receptor	39.7	4.5	697	T06	Not in Prevailing Wind Direction
O_1770	Non-Participating Receptor	39.7	4.5	776	T76	Not in Prevailing Wind Direction
O_2420	Non-Participating Receptor	39.7	4.5	900	T49	Not in Prevailing Wind Direction
O_2434	Non-Participating Receptor	39.7	4.5	856	T49	Not in Prevailing Wind Direction
O_2441	Non-Participating Receptor	39.7	4.5	833	T49	Not in Prevailing Wind Direction
O_2449	Non-Participating Receptor	39.7	4.5	799	T49	Not in Prevailing Wind Direction
O_2601	Non-Participating Receptor	39.7	4.5	626	T49	Not in Prevailing Wind Direction
O_2605	Non-Participating Receptor	39.7	4.5	635	T49	Not in Prevailing Wind Direction
O_2608	Non-Participating Receptor	39.7	4.5	645	T49	Not in Prevailing Wind Direction
O_2611	Non-Participating Receptor	39.7	4.5	650	T49	Not in Prevailing Wind Direction
O_2616	Non-Participating Receptor	39.7	4.5	662	T49	Not in Prevailing Wind Direction
O_2619	Non-Participating Receptor	39.7	4.5	676	T49	Not in Prevailing Wind Direction
O_2690	Non-Participating Receptor	39.7	4.5	728	T35	Permission not Granted
O_2753	Non-Participating Receptor	39.7	4.5	609	T58	Not in Prevailing Wind Direction
O_616	Non-Participating Receptor	39.7	4.5	617	T93	Selected Monitoring Location
O_986	Non-Participating Receptor	39.7	4.5	559	T38	Not in Prevailing Wind Direction
V_1122	Non-Participating Vacant Lot	39.7	4.5	628	T20	Permission not Granted
V_1995	Non-Participating Vacant Lot	39.7	4.5	705	T76	Not in Prevailing Wind Direction
V_2411	Non-Participating Vacant Lot	39.7	4.5	934	T49	Not in Prevailing Wind Direction
V_2437	Non-Participating Vacant Lot	39.7	4.5	847	T49	Not in Prevailing Wind Direction
V_2451	Non-Participating Vacant Lot	39.7	4.5	794	T49	Not in Prevailing Wind Direction
V_2705	Non-Participating Vacant Lot	39.7	4.5	603	T04	Selected Monitoring Location
O_1074	Non-Participating Receptor	39.6	4.5	632	T19	Not in Prevailing Wind Direction
O_1112	Non-Participating Receptor	39.6	4.5	673	T19	Not in Prevailing Wind Direction
O_937	Non-Participating Receptor	39.6	4.5	583	T19	Not in Prevailing Wind Direction
O_2589	Non-Participating Receptor	39.6	4.5	613	T49	Not in Prevailing Wind Direction
O_1409	Non-Participating Receptor	39.6	4.5	597	T27	Not in Prevailing Wind Direction
O_1546	Non-Participating Receptor	39.6	4.5	741	T65	Not in Prevailing Wind Direction
O_1662	Non-Participating Receptor	39.6	4.5	704	T06	Not in Prevailing Wind Direction
O_2280	Non-Participating Receptor	39.6	4.5	659	T31	Not in Prevailing Wind Direction
O_2440	Non-Participating Receptor	39.6	4.5	827	T49	Not in Prevailing Wind Direction
O_2580	Non-Participating Receptor	39.6	4.5	611	T49	Not in Prevailing Wind Direction
O_2598	Non-Participating Receptor	39.6	4.5	573	T35	Not in Prevailing Wind Direction
O_2627	Non-Participating Receptor	39.6	4.5	666	T23	Not in Prevailing Wind Direction
O_2629	Non-Participating Receptor	39.6	4.5	590	T04	Not in Prevailing Wind Direction
O_2633	Non-Participating Receptor	39.6	4.5	652	T23	Not in Prevailing Wind Direction
O_2710	Non-Participating Receptor	39.6	4.5	657	T02	Not in Prevailing Wind Direction
O_3030	Non-Participating Receptor	39.6	4.5	646	T59	Not in Prevailing Wind Direction
V_2404	Non-Participating Vacant Lot	39.6	4.5	965	T49	Not in Prevailing Wind Direction
V_3583	Non-Participating Vacant Lot	39.6	4.5	561	T93	Not in Prevailing Wind Direction
O_603	Non-Participating Receptor	39.5	4.5	643	T93	Receptor location 115m away from selected monitoring location M616
O_118	Non-Participating Receptor	39.5	4.5	636	T88	Not in Prevailing Wind Direction
O_1602	Non-Participating Receptor	39.5	4.5	558	T28	Selected Monitoring Location
O_1636	Non-Participating Receptor	39.5	4.5	724	T01	Not in Prevailing Wind Direction
O_1677	Non-Participating Receptor	39.5	4.5	700	T01	Not in Prevailing Wind Direction
O_2026	Non-Participating Receptor	39.5	4.5	759	T76	Not in Prevailing Wind Direction
O_2571	Non-Participating Receptor	39.5	4.5	618	T49	Not in Prevailing Wind Direction
O_2658	Non-Participating Receptor	39.5	4.5	603	T23	Not in Prevailing Wind Direction
O_85	Non-Participating Receptor	39.5	4.5	554	T08	Selected Monitoring Location

aercoustics

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

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

Appendix G
Calibration Certificates

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

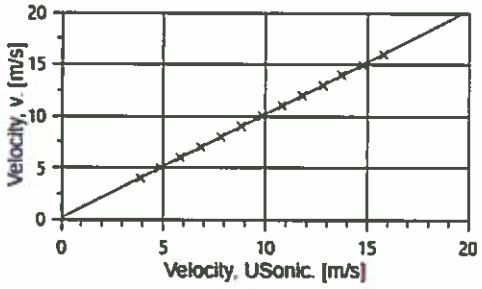
Certificate number: 17.US1.11150 **Date of issue:** December 18, 2017
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** M0410642
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

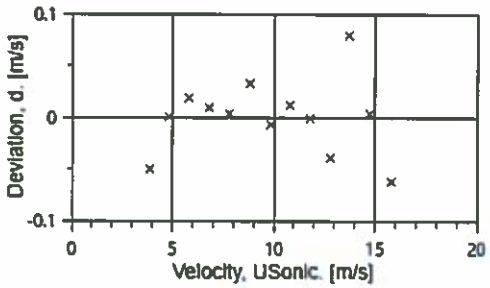
Anemometer received: December 14, 2017 **Anemometer calibrated:** December 15, 2017
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.00624 · f [m/s] + 0.12903

Standard uncertainty, slope: 0.00283 **Standard uncertainty, offset:** 0.23103
Covariance: -0.0000793 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999956
Absolute maximum deviation: 0.079 m/s at 14.014 m/s
Barometric pressure: 1004.1 hPa **Relative humidity:** 10.6%

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	9.40	21.7	25.1	3.983	3.8800	-0.050	0.024
4	14.80	21.7	25.1	4.998	4.8379	0.000	0.025
6	21.34	21.7	25.1	6.001	5.8167	0.019	0.027
8	28.99	21.8	25.1	6.994	6.8133	0.009	0.029
10	37.84	21.8	25.1	7.991	7.8100	0.004	0.032
12	48.28	21.8	25.2	9.027	8.8100	0.033	0.035
13-last	59.46	21.8	25.2	10.018	9.8345	-0.007	0.038
11	71.84	21.8	25.1	11.012	10.8033	0.012	0.041
9	85.15	21.7	25.1	11.988	11.7867	-0.001	0.044
7	99.86	21.7	25.1	12.983	12.8133	-0.039	0.047
5	116.34	21.7	25.1	14.014	13.7200	0.079	0.050
3	132.72	21.7	25.1	14.968	14.7433	0.004	0.053
1-first	151.15	21.6	25.1	15.972	15.8067	-0.062	0.056





ilac-MRA
ANAB ACCREDITED CALIBRATION LABORATORY
AC-1746
SOH Wind Engineering LLC · measnet · USA

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP004	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP001	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, 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 in the 90°output postion.

Certificate number: 17.US1.11150

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

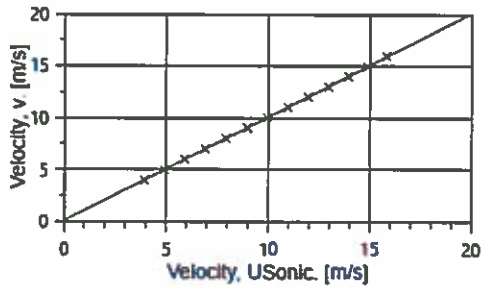
Certificate number: 17.US1.11157 **Date of issue:** December 18, 2017
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** M0410642
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

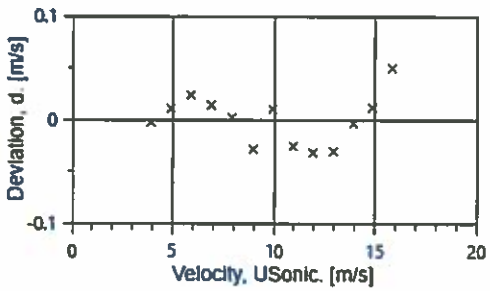
Anemometer received: December 14, 2017 **Anemometer calibrated:** December 15, 2017
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.00125 · f [m/s] + 0.05815

Standard uncertainty, slope: 0.00187 **Standard uncertainty, offset:** 0.34229
Covariance: -0.0000350 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999981
Absolute maximum deviation: 0.050 m/s at 15.968 m/s
Barometric pressure: 1004.0 hPa **Relative humidity:** 10.7%

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	9.35	21.5	25.0	3.970	3.9100	-0.003	0.024
4	14.72	21.5	25.1	4.982	4.9069	0.011	0.025
6	21.29	21.5	25.1	5.993	5.9033	0.024	0.027
8	28.95	21.5	25.1	6.988	6.9067	0.014	0.029
10	37.98	21.5	25.1	8.004	7.9333	0.002	0.032
12	48.14	21.5	25.1	9.011	8.9700	-0.029	0.035
13-last	59.47	21.5	25.1	10.016	9.9345	0.010	0.038
11	71.90	21.5	25.1	11.013	10.9667	-0.026	0.041
9	85.19	21.5	25.1	11.988	11.9467	-0.032	0.044
7	100.19	21.5	25.1	13.001	12.9567	-0.030	0.047
5	116.44	21.5	25.1	14.015	13.9433	-0.004	0.050
3	132.88	21.5	25.0	14.972	14.8833	0.012	0.053
1-first	151.18	21.4	25.0	15.968	15.8400	0.050	0.056





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP004	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP001	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, 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 in the 0°output postion.

Certificate number: 17.US1.11157

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	151681
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	32814	P. Order :	2018.02.20C
Asset # :	01083		

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 : Mar 01, 2018 By : J. Raposo

Cal. Due : Mar 01, 2019

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

Standards used : J-215 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
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	ver1.0

Calibration Report for Certificate : **151681**

Make	Model	Serial	Asset
PCB Piezotronics	480E09	32814	1083

Test	Min	Reading	Max		In/Out

Gain accuracy at 1kHz

Gain Set	Input V		V			
x1	1	0.9800	0.9998	1.0200		In
x10	0.1	0.9800	1.0002	1.0200		In
x100	0.01	0.9800	0.9993	1.0200		In

Gain Flatness

X1

I/P Hz			%			
10	1	-5.0	±0.1	5.0		In
10000	1	-5.0	±0.1	5.0		In
50000	1	-5.0	±0.1	5.0		In
100000	1	-5.0	±0.1	5.0		In

X10

I/P Hz			%			
10	0.1	-5.0	±0.1	5.0		In
10000	0.1	-5.0	±0.1	5.0		In
50000	0.1	-5.0	-0.3	5.0		In
100000	0.1	-5.0	-1.2	5.0		In

X100

I/P Hz			%			
10	0.01	-5.0	±0.1	5.0		In
10000	0.01	-5.0	-0.3	5.0		In
50000	0.01	-5.0	-1.2	5.0		In

Compliant Calibration Certificate

NATIONAL INSTRUMENTS
CALIBRATED
SN/ID 1C009CD
DATE 22-MAY-2018
DUE 22-MAY-2019
ni.com/calibration

Certificate Number:	5618239.1	**OE Number:**	21401260
Date Printed:	22-MAY-2018	**Page:**	1 of 14
Customer:	Aercoustics Engineering LTD (CA) 1004 Middlegate Road Suite 1100 MISSISSAUGA, L4Y 0G1 CANADA		
Manufacturer:	National Instruments	**Model:**	NI 9234
Serial Number:	1C009CD		
Part Number:	195551C-01L	**Description:**	MODULE ASSY,NI 9234, 4 AI CONFIGURABLE
Calibration Date:	22-MAY-2018	**Recommended Calibration Due:**	22-MAY-2019
Procedure Name:	NI 9234	**Verification Results:**	As Found: Passed As Left: Passed
Procedure Version:	3.6.1.0	**Calibration Executive Version:**	4.2.1.0
Lab Technician:	Rodolfo Maldonado	**Driver Info:**	NI-DAQmx:17.1.0
Temperature:	23.0° C	**Humidity:**	45.4% RH

The data found in this certificate must be interpreted as:

As Found The calibration data of the unit as received by National Instruments.

As Left The calibration data of the unit when returned from National Instruments.

The As Found and As Left readings are identical for units not adjusted or repaired.

This calibration conforms to ANSI/NCSL Z540.1-1994 (R2002) requirements.

The TAR (Test Accuracy Ratio) of this calibration is maintained at a ratio of 4:1 or greater, unless otherwise indicated in the measurements. A TAR determination is not possible for singled sided specification limits and therefore the absence of a value should not be interpreted as a TAR of 4:1 or greater, but rather undetermined. When provided, the expanded measurement uncertainty is calculated according to the Guide to the Expression of Uncertainty in Measurement (GUM) for a confidence level of approximately 95%. The uncertainty is calculated at time of calibration and does not include the object long-term stability and different environmental and operational conditions.

Results are reviewed to establish where any measurement results exceeded the manufacturer's specifications. Measured values greater than the Manufacturer's specification limits are marked as 'Failed', measured values within the Manufacturer's specifications are marked as 'Passed'.

This certificate applies exclusively to the item identified above and shall not be reproduced except in full, without National Instruments written authorization. Calibration certificates without signatures are not valid.

The Calibration Certificate can be viewed or downloaded online at www.ni.com/calibration/. To request a hard copy, contact NI **Customer Service at Tel:(800) 531-5066 or E-mail customer.service@NI.com**

DEKRA

ISO 9001:2008- Quality Management System (QMS) Certification
Applicable scope and other certifications can be found at ni.com/certifications

Victor Peña
Technical Manager

National Instruments Calibration Services Austin
Building A
11500 N MoPac Expwy
AUSTIN, TX 78759-3504
USA
Tel: (800) 531-5066

NATIONAL INSTRUMENTS

Calibration Notes

Type	Note
Asset	Verification and adjustment were performed.

Standards Used

Manufacturer	Model	Type	Tracking Number	Calibration Due	Notes
FLUKE	5700A/EP	Calibrator	2556	25-JUL-2018	
National Instruments	PXI-4461	Function generator	9383	25-APR-2019	
National Instruments	PXI-4071	Digital multimeter	1901	11-SEP-2018	
National Instruments	PXI-4132	SMU	9181	01-JUN-2018	

The standards used in this calibration are traceable to NIST and/or other National Measurement Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) mutual recognition agreement (MRA).

National Instruments Calibration Services Austin
Building A
11500 N MoPac Expwy
AUSTIN, TX 78759-3504
USA
Tel: (800) 531-5066

Calibration Results

As Found

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	3.99982 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	-0.00011 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-4.00003 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	4.00015 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	0.00009 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-3.99992 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	3.99994 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	-0.00005 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00004 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	4.00001 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	0.00007 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99986 V	-3.99520 V	Passed	

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USA
Tel: (800) 531-5066

As Found

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	

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Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	0.005 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	-0.005 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	0.003 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	-0.004 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	0.066 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	-0.066 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	0.036 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	-0.055 Degrees	0.490 Degrees	Passed	

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Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	53.655 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	98.748 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	66.136 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	58.554 dB	100.000 dB	Passed	

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As Found

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.091 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.070 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.067 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.073 mA	2.200 mA	Passed	

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As Found

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.884 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.884 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.885 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.887 V	24.000 V	Passed	

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As Left

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	4.00000 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	0.00001 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-3.99999 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	4.00005 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00000 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-4.00001 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	4.00004 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	0.00001 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00000 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	3.99998 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	-0.00000 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99997 V	-3.99520 V	Passed	

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Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	

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Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	0.006 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	-0.006 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	0.003 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	-0.004 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	0.066 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	-0.066 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	0.036 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	-0.055 Degrees	0.490 Degrees	Passed	

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NATIONAL INSTRUMENTS

As Left

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	53.328 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	51.629 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	56.518 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	51.255 dB	100.000 dB	Passed	

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As Left

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.070 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.070 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.067 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.073 mA	2.200 mA	Passed	

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As Left

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.875 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.885 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.886 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.888 V	24.000 V	Passed	

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NATIONAL INSTRUMENTS

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	153591
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	132192	P. Order :	2018.08.03C
Asset # :	01161		

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
Phone : 905 565 1584 Fax: 905 565 8325
http: // www.navair com
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 : **153591**

Make			Model	Serial		Asset
PCB Piezotronics			378B02	132192		01161
PCB Piezotronics			377B02	174130		

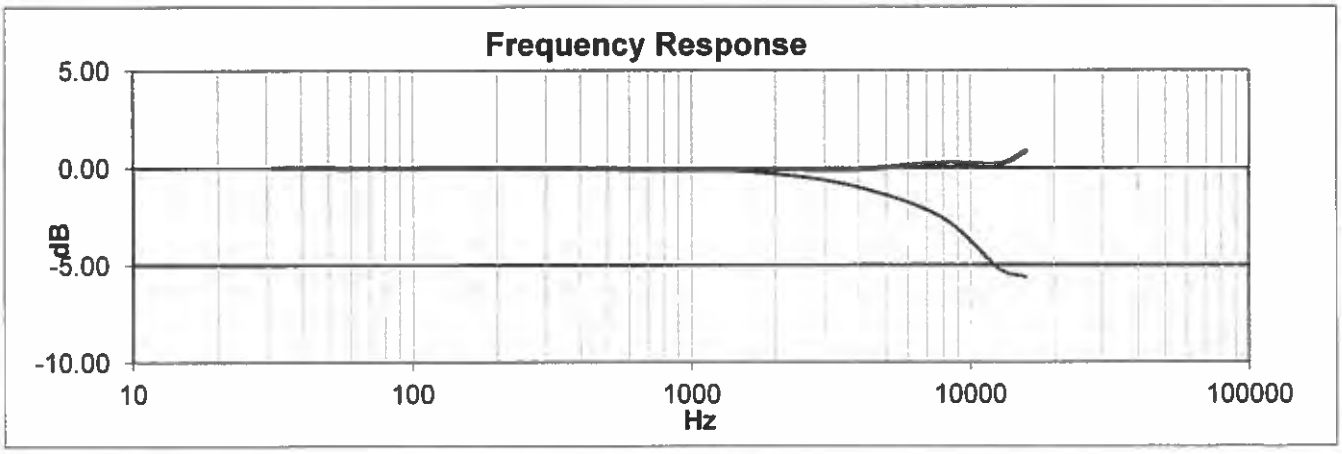
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	45.04	62.94	In
-26.02	dB re 1V/Pa	-28.02	-26.93	-24.02	In
0	dB re 50mV/Pa	-2	-0.91	2	In

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

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	0.02	0.02	
63.1	0.00	0.00	
125.9	0.00	0.00	
251.3	0.00	0.00	ref
502.5	-0.02	-0.02	
1005.1	-0.10	-0.08	
1978.7	-0.31	-0.05	
3957.5	-0.99	-0.07	
7914.9	-2.55	0.24	
12663	-5.19	0.20	
15830	-5.63	0.86	



West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE UNIT

Manufactured by:	PCB PIEZOTRONICS
Model No:	378B02
Serial No:	125630
Calibration Recall No:	28284

Submitted By:

Customer:

Company: Aerocoustics 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. 378B02 PCB PI

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

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied relates to the calibrated item listed above.
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.

Approved by: FC

Calibration Date: 19-Jan-18

Felix Christopher (QA Mgr.)

Certificate No: 28284 - 1

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
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

PCB Piezotronics Microphone Unit
Model No.: 378B02 Serial No.: 125630
Mic Model No.: 377B02 Serial No.: 167926
Preamp Model No.: 426E01 Serial No.: 044003
Company: Aerocoustics Engineering Ltd. ID No.: XXXX

Calibration results:

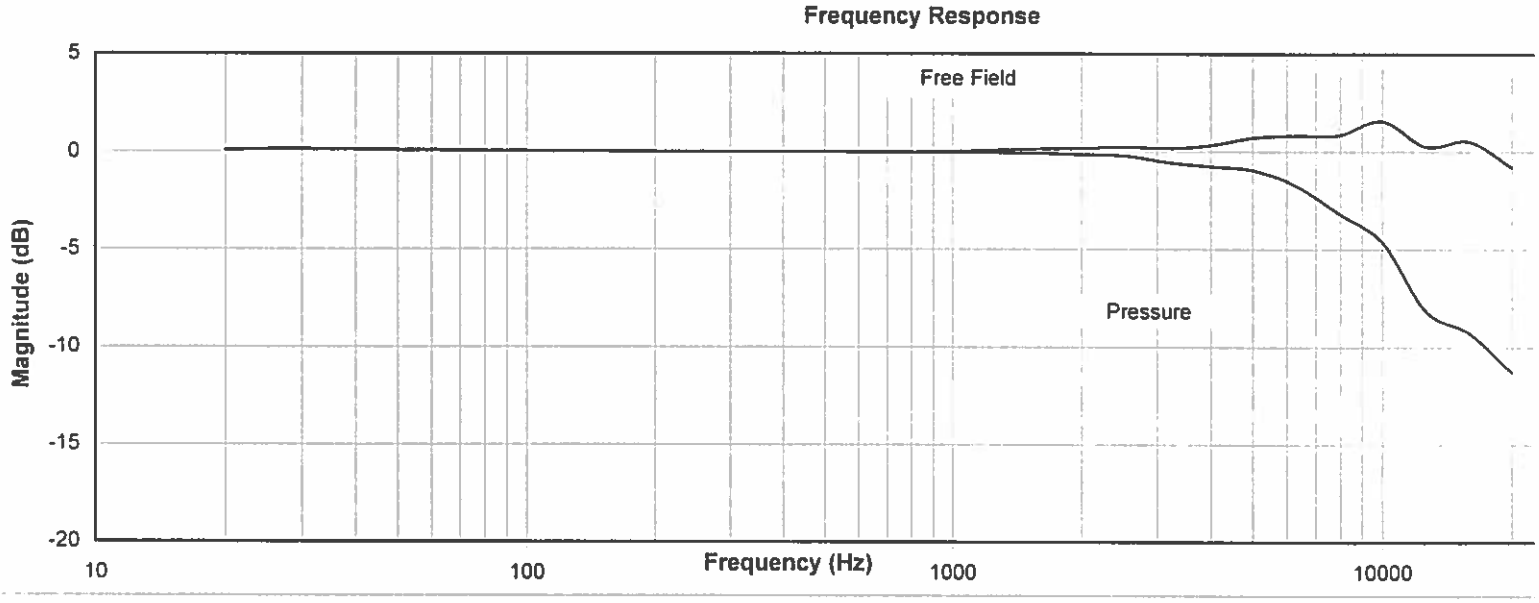
After data: ...X...

Combined Sensitivity @ 250 Hz and pressure of 99.063 kPa
(Sens. with mic. and preamp.) 0 Volts Polarization voltage (External):
-27.46 dB re.1V/Pascal
42.36 mV/Pascal
1.46 Ko (- dB re 50 mV/Pascal)
Sensitivity: Pass
Freq. Response: Pass
All tests: Pass

Ambient Temperature:	22.0	°C
Ambient Humidity:	30.1	% RH
Ambient Pressure:	99.063	kPa
Calibration Date:	19-Jan-2018	
Calibration Due:	19-Jan-2019	
Report Number:	28284 -1	
Control Number:	28284	

The above listed instrument meets or exceeds the tested manufacturer's specifications.
The IEC 651:type 1 and ANSI S1.4 1983 specification passed.
This Calibration is traceable through NIST test numbers: 683/284413-14
The expanded uncertainty of calibration: 0.12 dB 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 P378B02PCB**

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: .....
Felix Christopher

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

PCB Piezotronics Microphone Unit **Model No.: 378B02** **Serial No.: 125630**
Company: Aerocoustics Engineering Ltd. **ID No.: XXXX**

Frequency Response (Reference = 0 dB @ 250Hz)

Frequency [Hz]	Pressure [dB]	Free Field [dB]
19.95	0.11	0.11
25.12	0.14	0.14
31.62	0.14	0.14
39.81	0.12	0.12
50.12	0.11	0.11
63.10	0.09	0.09
79.43	0.06	0.06
100.00	0.05	0.05
125.89	0.03	0.03
158.49	0.03	0.03
199.53	0.01	0.01
251.19	0.00	0.00
316.23	0.00	0.00
398.11	-0.01	-0.01
501.19	-0.01	-0.01
630.96	-0.02	-0.02
794.33	-0.02	-0.02
1000.00	-0.04	0.07
1258.93	-0.06	0.10
1584.89	-0.08	0.15
1995.26	-0.14	0.19
2511.89	-0.21	0.27
3162.28	-0.54	0.18
3981.07	-0.74	0.36
5011.87	-0.94	0.74
6309.57	-1.72	0.86
7943.28	-3.13	0.87
10000.00	-4.62	1.59
12589.25	-8.14	0.29
15848.93	-9.27	0.55
19952.62	-11.27	-0.77

Freq. response: Expanded Uncertainty (dB) with coverage factor K = 2
20 to 63Hz 0.1dB, 63 to 12.5kHz 0.094dB, 12.5k to 16kHz 0.10dB, 16k to 20kHz 0.5dB.

Instruments used for calibration:			Date of Cal.	Traceability No	Re-cal. Due Date
Brüel & Kjær	4226	S/N 1445428	11-Aug-2017	683/284413-14	11-Aug-2018
Brüel & Kjær	3560	S/N 2241893	11-Aug-2017	683/284413-14	11-Aug-2018
HP	33120A	S/N 36043716	11-Aug-2017	,287708	11-Aug-2018
HP	34401A	S/N 36064102	11-Aug-2017	,287708	11-Aug-2018

Cal. Date: 19-Jan-2018 **Tested by: Felix Christopher**

Calibrated on WCCL system type 9700

Rev. 7.0 Jan. 24, 2014 Doc. # 1038 P378B02PCB

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	151680
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	34423	P. Order :	2018.02.20C
Asset # :	00980		

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 : Mar 01, 2018 By : J. Raposo

Cal. Due : Mar 01, 2019

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

Standards used : J-215 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	ver1.0

Calibration Report for Certificate : 151680

Make	Model	Serial	Asset
PCB Piezotronics	480E09	34423	980

Test	Min	Reading	Max		In/Out

Gain accuracy at 1kHz

Gain Set	Input V		V			
x1	1	0.9800	1.0000	1.0200		In
x10	0.1	0.9800	1.0003	1.0200		In
x100	0.01	0.9800	1.0001	1.0200		In

Gain Flatness

X1

I/P Hz			%			
10	1	-5.0	±0.1	5.0		In
10000	1	-5.0	±0.1	5.0		In
50000	1	-5.0	±0.1	5.0		In
100000	1	-5.0	±0.1	5.0		In

X10

I/P Hz			%			
10	0.1	-5.0	±0.1	5.0		In
10000	0.1	-5.0	±0.1	5.0		In
50000	0.1	-5.0	-0.3	5.0		In
100000	0.1	-5.0	-1.1	5.0		In

X100

I/P Hz			%			
10	0.01	-5.0	±0.1	5.0		In
10000	0.01	-5.0	-0.9	5.0		In
50000	0.01	-5.0	-4.9	5.0		In

Compliant Calibration Certificate

NATIONAL INSTRUMENTS
CALIBRATED
SN/ID 1A5E7FC
DATE 22-MAY-2018
DUE 22-MAY-2019
ni.com/calibration

Certificate Number:	5618371.1	**OE Number:**	21401260
Date Printed:	22-MAY-2018	**Page:**	1 of 14
Customer:	Aercoustics Engineering LTD (CA) 1004 Middlegate Road Suite 1100 MISSISSAUGA, L4Y 0G1 CANADA		
Manufacturer:	National Instruments	**Model:**	NI 9234
Serial Number:	1A5E7FC		
Part Number:	195551B-01L	**Description:**	MODULE ASSY,NI 9234, 4 AI CONFIGURABLE
Calibration Date:	22-MAY-2018	**Recommended Calibration Due:**	22-MAY-2019
Procedure Name:	NI 9234	**Verification Results:**	As Found: Passed As Left: Passed
Procedure Version:	3.6.1.0	**Calibration Executive Version:**	4.2.1.0
Lab Technician:	Rodolfo Maldonado	**Driver Info:**	NI-DAQmx:17.1.0
Temperature:	23.0° C	**Humidity:**	44.3% RH

The data found in this certificate must be interpreted as:

As Found The calibration data of the unit as received by National Instruments.

As Left The calibration data of the unit when returned from National Instruments.

The As Found and As Left readings are identical for units not adjusted or repaired.

This calibration conforms to ANSI/NCSL Z540.1-1994 (R2002) requirements.

The TAR (Test Accuracy Ratio) of this calibration is maintained at a ratio of 4:1 or greater, unless otherwise indicated in the measurements. A TAR determination is not possible for singled sided specification limits and therefore the absence of a value should not be interpreted as a TAR of 4:1 or greater, but rather undetermined. When provided, the expanded measurement uncertainty is calculated according to the Guide to the Expression of Uncertainty in Measurement (GUM) for a confidence level of approximately 95%. The uncertainty is calculated at time of calibration and does not include the object long-term stability and different environmental and operational conditions.

Results are reviewed to establish where any measurement results exceeded the manufacturer's specifications. Measured values greater than the Manufacturer's specification limits are marked as 'Failed', measured values within the Manufacturer's specifications are marked as 'Passed'.

This certificate applies exclusively to the item identified above and shall not be reproduced except in full, without National Instruments written authorization. Calibration certificates without signatures are not valid.

The Calibration Certificate can be viewed or downloaded online at www.ni.com/calibration/. To request a hard copy, contact NI **Customer Service at Tel:(800) 531-5066 or E-mail customer.service@NI.com**

DEKRA

ISO 9001:2008- Quality Management System (QMS) Certification
Applicable scope and other certifications can be found at ni.com/certifications

Victor Peña
Technical Manager

National Instruments Calibration Services Austin
Building A
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USA
Tel: (800) 531-5066

NATIONAL INSTRUMENTS

Calibration Notes

Type	Note
Asset	Verification and adjustment were performed.

Standards Used

Manufacturer	Model	Type	Tracking Number	Calibration Due	Notes
FLUKE	5700A/EP	Calibrator	2556	25-JUL-2018	
National Instruments	PXI-4461	Function generator	9383	25-APR-2019	
National Instruments	PXI-4071	Digital multimeter	1901	11-SEP-2018	
National Instruments	PXI-4132	SMU	9181	01-JUN-2018	

The standards used in this calibration are traceable to NIST and/or other National Measurement Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) mutual recognition agreement (MRA).

National Instruments Calibration Services Austin
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USA
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Calibration Results

As Found

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	3.99936 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	-0.00022 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-3.99978 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	3.99975 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	0.00001 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-3.99973 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	3.99969 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	-0.00002 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-3.99971 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	3.99949 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	-0.00005 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99961 V	-3.99520 V	Passed	

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USA
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As Found

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	

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As Found

Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	-0.013 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.013 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	-0.011 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	0.009 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	-0.124 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.124 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	-0.107 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	0.087 Degrees	0.490 Degrees	Passed	

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As Found

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	51.642 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	54.544 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	51.748 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	50.623 dB	100.000 dB	Passed	

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As Found

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.085 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.067 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.054 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.075 mA	2.200 mA	Passed	

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As Found

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.877 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.883 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.885 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.880 V	24.000 V	Passed	

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As Left

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	4.00000 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	0.00000 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-3.99998 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	4.00000 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	0.00000 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-3.99999 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	3.99997 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	-0.00000 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-3.99996 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	4.00000 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	0.00001 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-4.00000 V	-3.99520 V	Passed	

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As Left

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	

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Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	-0.013 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.013 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	-0.011 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	0.009 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	-0.124 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.124 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	-0.107 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	0.087 Degrees	0.490 Degrees	Passed	

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NATIONAL INSTRUMENTS

As Left

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	51.573 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	50.549 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	79.583 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	57.678 dB	100.000 dB	Passed	

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Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.075 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.067 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.054 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.075 mA	2.200 mA	Passed	

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As Left

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.882 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.885 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.887 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.880 V	24.000 V	Passed	

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Tel: (800) 531-5066

NATIONAL INSTRUMENTS

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

CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

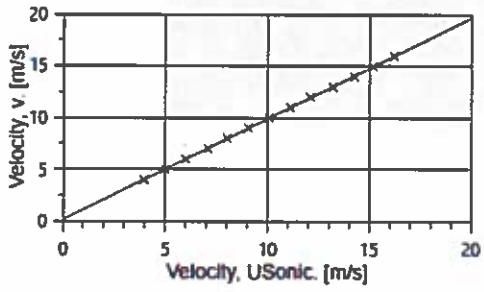
Certificate number: 18.US1.05216 **Date of issue:** October 16, 2018
Type: Vaisala Weather Transmitter, WXT536 **Serial number:** M4910194
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

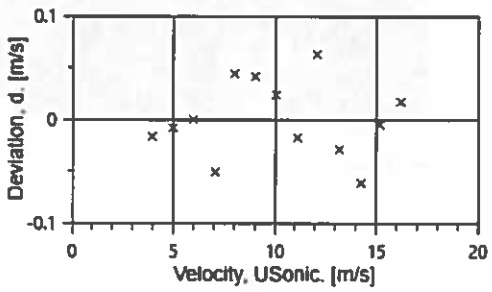
Anemometer received: October 15, 2018 **Anemometer calibrated:** October 15, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.97547 · f [m/s] + 0.12348

Standard uncertainty, slope: 0.00287 **Standard uncertainty, offset:** 0.24434
Covariance: -0.0000789 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999955
Absolute maximum deviation: 0.063 m/s at 11.973 m/s
Barometric pressure: 1002.7 hPa **Relative humidity:** 40.1%

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	9.32	20.2	27.1	3.963	3.9533	-0.017	0.020
4	14.71	20.3	27.1	4.979	4.9862	-0.008	0.023
6	21.14	20.3	27.2	5.970	5.9933	0.000	0.026
8	28.86	20.4	27.2	6.976	7.0767	-0.051	0.029
10	37.81	20.4	27.2	7.984	8.0133	0.044	0.033
12	47.82	20.4	27.2	8.980	9.0367	0.042	0.037
13-last	58.82	20.4	27.2	9.959	10.0586	0.024	0.041
11	71.14	20.4	27.2	10.953	11.1200	-0.018	0.045
9	85.00	20.3	27.2	11.973	12.0833	0.063	0.049
7	99.63	20.3	27.2	12.963	13.1917	-0.029	0.053
5	115.71	20.3	27.2	13.969	14.2567	-0.061	0.057
3	132.13	20.2	27.1	14.926	15.1800	-0.005	0.061
1-first	150.91	20.2	27.1	15.950	16.2067	0.017	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.

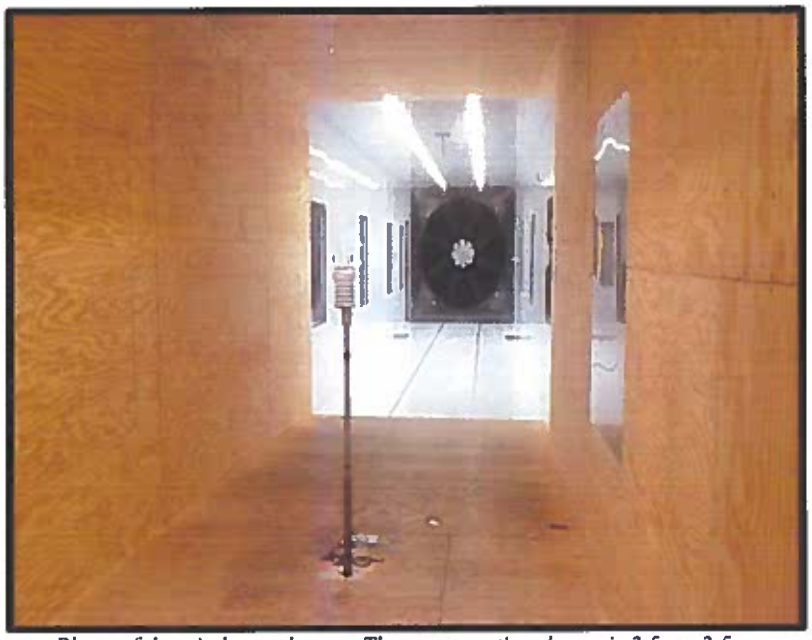


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

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.US1.05216

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

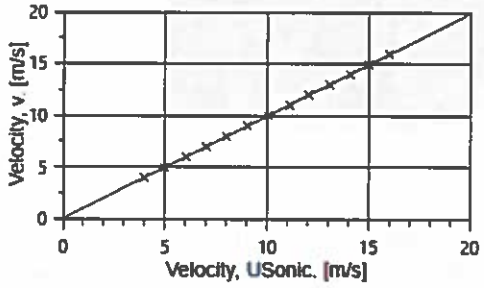
Certificate number: 18.US1.05215 **Date of issue:** October 16, 2018
Type: Vaisala Weather Transmitter, WXT536 **Serial number:** M4910194
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

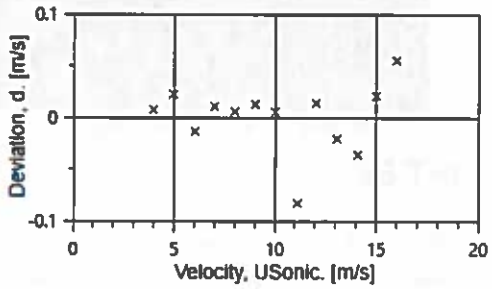
Anemometer received: October 15, 2018 **Anemometer calibrated:** October 15, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: $v\,[m/s] = 0.99274 \cdot f\,[m/s] + 0.01283$

Standard uncertainty, slope: 0.00259 **Standard uncertainty, offset:** 2.14422
Covariance: -0.0000662 $(m/s)^2/m/s$ **Coefficient of correlation:** $\rho = 0.999963$
Absolute maximum deviation: -0.083 m/s at 10.969 m/s
Barometric pressure: 1002.9 hPa **Relative humidity:** 40.4%

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	9.36	19.9	27.1	3.968	3.9767	0.007	0.020
4	14.64	20.0	27.1	4.965	4.9655	0.022	0.023
6	21.23	20.0	27.1	5.979	6.0233	-0.014	0.026
8	28.90	20.1	27.1	6.976	7.0033	0.010	0.029
10	37.66	20.1	27.1	7.964	8.0033	0.006	0.033
12	47.84	20.1	27.1	8.977	9.0167	0.013	0.037
13-last	58.96	20.1	27.1	9.966	10.0207	0.005	0.041
11	71.43	20.1	27.1	10.969	11.1200	-0.083	0.045
9	85.15	20.1	27.1	11.976	12.0367	0.014	0.049
7	99.78	20.0	27.1	12.964	13.0667	-0.021	0.053
5	115.73	20.0	27.1	13.961	14.0867	-0.036	0.057
3	132.27	19.9	27.1	14.924	15.0000	0.021	0.061
1-first	151.01	19.9	27.1	15.945	15.9933	0.055	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.

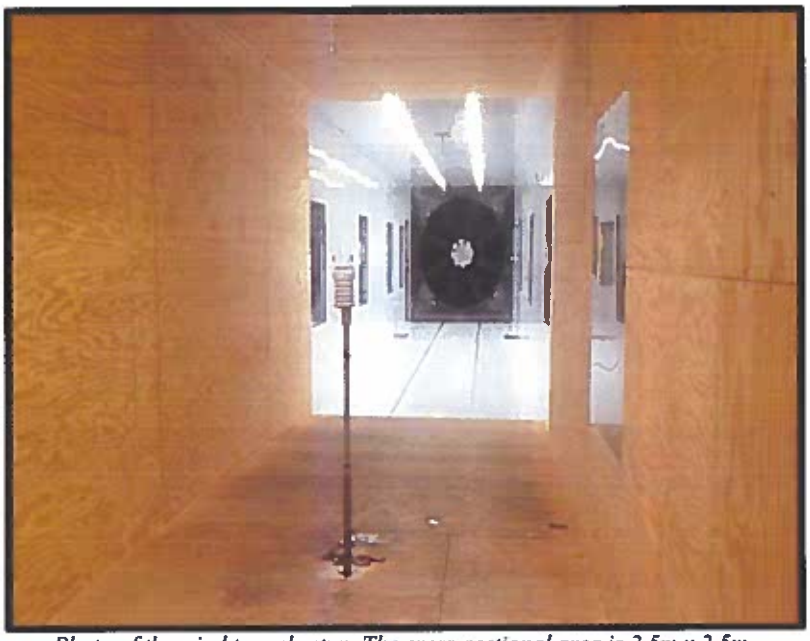


Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.

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.US1.05215

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	152968
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	00033661	P. Order :	2018.06.15C
Asset # :	00140		

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 : Jun 19, 2018 By : Petro Onasko

Cal. Due : Jun 19, 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
Phone : 905 565 1584 Fax 905 565 8325
http // www navair com
e-Mail service @ navair com

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 : **152968**

Make	Model	Serial	Asset
PCB Piezotronics	480E09	00033661	00140

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	0.100 V	0.9800	1.0005	1.0200		In
x100	0.010 V	0.9800	0.9987	1.0200		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	0.1	5.0		In
100000	1.000 V	-5.0	0.4	5.0		In

X10

I/P Hz			%			
10	0.100 V	-5.0	0.0	5.0		In
10000	0.100 V	-5.0	0.0	5.0		In
50000	0.100 V	-5.0	-0.2	5.0		In
100000	0.100 V	-5.0	-1.1	5.0		In

X100

I/P Hz			%			
10	0.010 V	-5.0	0.1	5.0		In
10000	0.010 V	-5.0	-0.2	5.0		In
50000	0.010 V	-5.0	-4.7	5.0		In

CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	152972
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	120586	P. Order :	2018.06.15C
Asset # :	00811		

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 : Jun 20, 2018 By: Petro Onasko

Cal. Due : Jun 20, 2019

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

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

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

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NT NAVAIR TECHNOLOGIES

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

Calibration Report for Certificate : **152972**

Make			Model	Serial		Asset
PCB Piezotronics			378B02	120586		00811
PCB Piezotronics			377B02	155523		00811

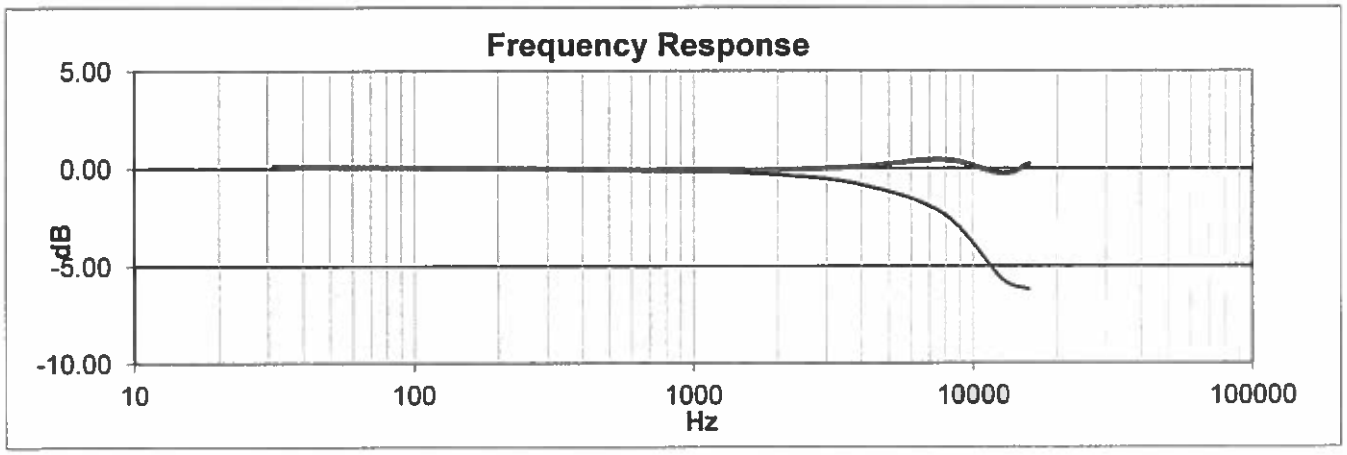
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	42.90	62.94	In
-26.02	dB re 1V/Pa	-28.02	-27.35	-24.02	In
0	dB re 50mV/Pa	-2	-1.33	2	In

Ambient Conditions:
Static Pressure 99.2 kPa
Temperature 24.2°C
Rel.Humidity 41.0%

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	0.10	0.10	
63.1	0.06	0.06	
125.9	0.03	0.03	
251.3	0.00	0.00	ref
502.5	-0.05	-0.05	
1005.1	-0.16	-0.12	
1978.7	-0.31	-0.06	
3957.5	-0.82	0.09	
7914.9	-2.36	0.43	
12663	-5.68	-0.26	
15830	-6.24	0.21	



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

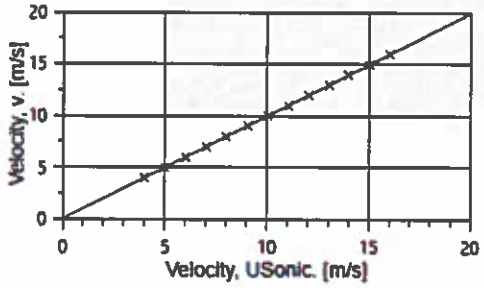
Certificate number: 18.US1.05429 **Date of issue:** October 26, 2018
Type: Vaisala Weather Transmitter, WXT536 **Serial number:** M4910193
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

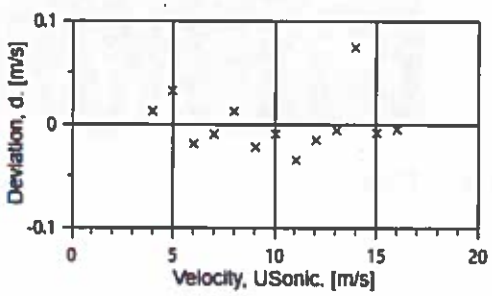
Anemometer received: October 24, 2018 **Anemometer calibrated:** October 24, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.99427 · f [m/s] + -0.00309

Standard uncertainty, slope: 0.00217 **Standard uncertainty, offset:** -7.47829
Covariance: -0.0000468 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999974
Absolute maximum deviation: 0.074 m/s at 13.961 m/s
Barometric pressure: 1005.3 hPa **Relative humidity:** 29.5%

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	9.31	22.4	28.1	3.970	3.9833	0.012	0.020
4	14.59	22.4	28.1	4.969	4.9690	0.032	0.023
6	20.99	22.4	28.1	5.960	6.0167	-0.019	0.026
8	28.65	22.5	28.1	6.964	7.0167	-0.010	0.029
10	37.48	22.5	28.1	7.965	8.0017	0.012	0.033
12	47.74	22.5	28.1	8.989	9.0667	-0.022	0.037
13-last	58.81	22.5	28.1	9.978	10.0483	-0.010	0.041
11	70.85	22.5	28.1	10.952	11.0533	-0.035	0.045
9	84.43	22.5	28.1	11.956	12.0433	-0.015	0.049
7	99.24	22.4	28.1	12.963	13.0467	-0.006	0.053
5	115.11	22.4	28.1	13.961	13.9700	0.074	0.057
3	131.52	22.4	28.1	14.923	15.0200	-0.008	0.061
1-first	149.84	22.3	28.1	15.927	16.0267	-0.005	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.US1.05429

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CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

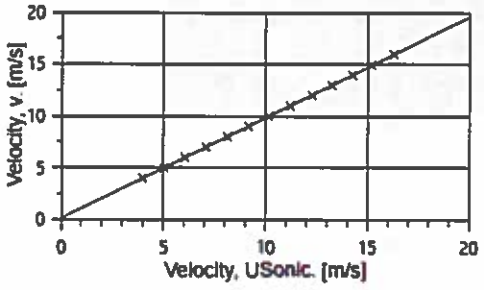
Certificate number: 18.US1.05430 **Date of issue:** October 26, 2018
Type: Vaisala Weather Transmitter, WXT536 **Serial number:** M4910193
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

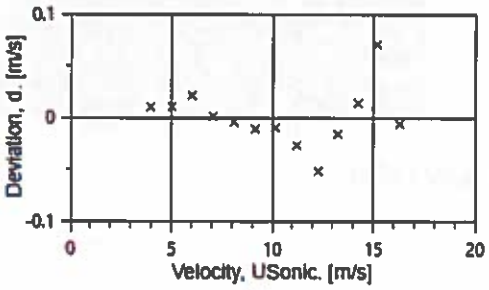
Anemometer received: October 24, 2018 **Anemometer calibrated:** October 24, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.97306 · f [m/s] + 0.08615

Standard uncertainty, slope: 0.00222 **Standard uncertainty, offset:** 0.27161
Covariance: -0.0000472 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999973
Absolute maximum deviation: 0.071 m/s at 14.937 m/s
Barometric pressure: 1005.6 hPa **Relative humidity:** 29.3%

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	9.24	22.6	28.0	3.956	3.9667	0.010	0.020
4	14.66	22.7	28.0	4.982	5.0207	0.010	0.023
6	21.10	22.7	28.0	5.978	6.0333	0.021	0.026
8	28.68	22.7	28.0	6.970	7.0733	0.001	0.029
10	37.56	22.7	28.0	7.976	8.1133	-0.005	0.033
12	47.60	22.7	28.0	8.978	9.1500	-0.011	0.037
13-last	58.55	22.7	28.0	9.958	10.1552	-0.010	0.041
11	70.93	22.7	28.0	10.961	11.2033	-0.027	0.045
9	84.77	22.7	28.0	11.983	12.2800	-0.052	0.049
7	99.15	22.7	28.0	12.960	13.2467	-0.016	0.053
5	115.08	22.6	28.0	13.963	14.2467	0.014	0.057
3	131.71	22.6	28.0	14.937	15.1900	0.071	0.061
1-first	149.90	22.5	28.1	15.934	16.2933	-0.006	0.065





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TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
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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.US1.05430

Compliant Calibration Certificate

Template Revision: Feb2018

Certificate Number:	5804565.1	**OE Number:**	21521268
Date Printed:	30-OCT-2018	**Page:**	1 of 14
Customer:	Aercoustics Engineering LTD (CA) 1004 Middlegate Road Suite 1100 MISSISSAUGA, L4Y 0G1 CANADA		
Manufacturer:	National Instruments	**Model:**	NI 9234
Serial Number:	1CAF718		
Part Number:	195551C-01L	**Description:**	MODULE ASSY,NI 9234, 4 AI CONFIGURABLE
Calibration Date:	30-OCT-2018	**Recommended Calibration Due:**	30-OCT-2019
Procedure Name:	NI 9234	**Verification Results:**	As Found: Passed As Left: Passed
Procedure Version:	3.6.1.0	**Calibration Executive Version:**	3.5.2
Lab Technician:	Rachel McKinnon	**Driver Info:**	NI-DAQmx:17.1.0
Temperature:	23.0° C	**Humidity:**	44.7% RH

NATIONAL INSTRUMENTS
CALIBRATED
SN/ID 1CAF718
DATE 30-OCT-2018
DUE 30-OCT-2019
ni.com/calibration

The data found in this certificate must be interpreted as:

As Found The calibration data of the unit as received by National Instruments.

As Left The calibration data of the unit when returned from National Instruments.

The As Found and As Left readings are identical for units not adjusted or repaired.

This calibration conforms to ANSI/NCSL Z540.1-1994 (R2002) requirements.

The TUR (Test Uncertainty Ratio) of this calibration is maintained at a ratio of 4:1 or greater, unless otherwise indicated in the measurements. A TUR determination is not possible for singled sided specification limits and therefore the absence of a value should not be interpreted as a TUR of 4:1 or greater, but rather undetermined. When provided, the expanded measurement uncertainty is calculated according to the Guide to the Expression of Uncertainty in Measurement (GUM) for a confidence level of approximately 95%. The uncertainty is calculated at time of calibration and does not include the object long-term stability and different environmental and operational conditions.

Results are reviewed to establish where any measurement results exceeded the manufacturer's specifications. Measured values greater than the Manufacturer's specification limits are marked as 'Failed', measured values within the Manufacturer's specifications are marked as 'Passed'.

This certificate applies exclusively to the item identified above and shall not be reproduced except in full, without National Instruments written authorization. Calibration certificates without signatures are not valid.

The Calibration Certificate can be viewed or downloaded online at www.ni.com/calibration/. To request a hard copy, contact NI **Customer Service at Tel:(800) 531-5066 or E-mail customer.service@NI.com**

Victor Peña
Technical Manager

National Instruments Calibration Services Austin
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Calibration Notes

Type	Note
Asset	Verification only was performed.

Standards Used

Manufacturer	Model	Type	Tracking Number	Calibration Due	Notes
Fluke	5700A/EP	Calibrator	3132	27-JAN-2019	
National Instruments	PXI-4461	Function generator	9520	20-AUG-2019	
National Instruments	PXI-4071	Digital multimeter	9837	24-AUG-2019	
National Instruments	PXI-4132	SMU	9170	03-MAY-2019	

The standards used in this calibration are traceable to NIST and/or other National Measurement Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) mutual recognition agreement (MRA).

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Calibration Results

As Found

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	4.00028 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	0.00009 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-4.00011 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	4.00011 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00009 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-4.00026 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	4.00030 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	-0.00000 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00029 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	4.00045 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	0.00023 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99998 V	-3.99520 V	Passed	

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As Found

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	

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As Found

Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	0.004 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.005 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	-0.006 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	0.006 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	0.036 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.054 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	-0.068 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	0.068 Degrees	0.490 Degrees	Passed	

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Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	51.710 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	51.020 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	51.377 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	52.208 dB	100.000 dB	Passed	

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As Found

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.073 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.078 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.075 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.066 mA	2.200 mA	Passed	

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Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.849 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.847 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.846 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.851 V	24.000 V	Passed	

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As Left

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	4.00028 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	0.00009 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-4.00011 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	4.00011 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00009 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-4.00026 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	4.00030 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	-0.00000 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00029 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	4.00045 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	0.00023 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99998 V	-3.99520 V	Passed	

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Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	

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Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	0.004 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.005 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	-0.006 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	0.006 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	0.036 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.054 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	-0.068 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	0.068 Degrees	0.490 Degrees	Passed	

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As Left

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	51.710 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	51.020 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	51.377 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	52.208 dB	100.000 dB	Passed	

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As Left

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.073 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.078 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.075 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.066 mA	2.200 mA	Passed	

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As Left

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.849 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.847 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.846 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.851 V	24.000 V	Passed	

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Compliant Calibration Certificate

Certificate Number:	5427760.1	**OE Number:**	21294535
Date Printed:	02-JAN-2018	**Page:**	1 of 14
Customer:	Aercoustics Engineering LTD (CA) 1004 Middlegate Rd No 1100 MISSISSAUGA, L4Y 1M4 CANADA		
Manufacturer:	National Instruments	**Model:**	NI 9234
Serial Number:	1AE459C		
Part Number:	195551B-01L	**Description:**	MODULE ASSY,NI 9234, 4 AI CONFIGURABLE
Calibration Date:	02-JAN-2018	**Recommended Calibration Due:**	02-JAN-2019
Procedure Name:	NI 9234	**Verification Results:**	As Found: Passed As Left: Passed
Procedure Version:	3.6.1.0	**Calibration Executive Version:**	4.1.1.0
Lab Technician:	Rachel McKinnon	**Driver Info:**	NI-DAQmx:16.1.0
Temperature:	23.0° C	**Humidity:**	39.2% RH

The data found in this certificate must be interpreted as:

As Found	The calibration data of the unit as received by National Instruments.
As Left	The calibration data of the unit when returned from National Instruments.

The As Found and As Left readings are identical for units not adjusted or repaired.

This calibration conforms to ANSI/NCSL Z540.1-1994 (R2002) requirements.

The TAR (Test Accuracy Ratio) of this calibration is maintained at a ratio of 4:1 or greater, unless otherwise indicated in the measurements. A TAR determination is not possible for singled sided specification limits and therefore the absence of a value should not be interpreted as a TAR of 4:1 or greater, but rather undetermined. When provided, the expanded measurement uncertainty is calculated according to the Guide to the Expression of Uncertainty in Measurement (GUM) for a confidence level of approximately 95%. The uncertainty is calculated at time of calibration and does not include the object long-term stability and different environmental and operational conditions.

Results are reviewed to establish where any measurement results exceeded the manufacturer's specifications. Measured values greater than the Manufacturer's specification limits are marked as 'Failed', measured values within the Manufacturer's specifications are marked as 'Passed'.

This certificate applies exclusively to the item identified above and shall not be reproduced except in full, without National Instruments written authorization. Calibration certificates without signatures are not valid.

The Calibration Certificate can be viewed or downloaded online at www.ni.com/calibration/. To request a hard copy, contact NI **Customer Service at Tel:(800) 531-5066 or E-mail customer.service@NI.com**

DEKRA

ISO 9001:2008- Quality Management System (QMS) Certification
Applicable scope and other certifications can be found at ni.com/certifications

Victor Peña
Technical Manager

NATIONAL INSTRUMENTS
CALIBRATED
SN/ID 1AE459C
DATE 02-JAN-2018
DUE 02-JAN-2019
ni.com/calibration

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Calibration Notes

Type	Note
Asset	Verification and adjustment were performed.

Standards Used

Manufacturer	Model	Type	Tracking Number	Calibration Due	Notes
FLUKE	5700A/EP	Calibrator	2556	04-FEB-2018	
National Instruments	PXI-4461	Function generator	9520	01-AUG-2018	
National Instruments	PXI-4071	Digital multimeter	8241	12-DEC-2018	
National Instruments	PXI-4132	SMU	9166	01-FEB-2018	

The standards used in this calibration are traceable to NIST and/or other National Measurement Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) mutual recognition agreement (MRA).

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NATIONAL INSTRUMENTS

Calibration Results

As Found

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	3.99983 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	-0.00018 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-4.00019 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	3.99949 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00029 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-4.00005 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	3.99976 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	-0.00001 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-3.99979 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	3.99979 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	-0.00008 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99993 V	-3.99520 V	Passed	

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NATIONAL INSTRUMENTS

As Found

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	0.001 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	-0.001 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	-0.001 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	

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As Found

Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	-0.012 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.012 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	-0.007 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	-0.008 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	-0.112 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.112 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	-0.059 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	-0.064 Degrees	0.490 Degrees	Passed	

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As Found

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	53.691 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	51.418 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	55.070 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	51.369 dB	100.000 dB	Passed	

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As Found

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.091 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.078 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.089 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.083 mA	2.200 mA	Passed	

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As Found

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.771 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.777 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.770 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.773 V	24.000 V	Passed	

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As Left

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	3.99999 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	0.00000 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-3.99999 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	4.00000 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00001 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-4.00000 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	4.00002 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	0.00000 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00001 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	4.00001 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	-0.00000 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-3.99999 V	-3.99520 V	Passed	

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As Left

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	-0.000 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	0.000 dB	0.040 dB	Passed	

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As Left

Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	-0.012 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.012 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	-0.006 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	-0.008 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	-0.112 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.112 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	-0.059 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	-0.064 Degrees	0.490 Degrees	Passed	

As Left

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	52.737 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	50.733 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	54.465 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	54.586 dB	100.000 dB	Passed	

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As Left

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.081 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.078 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.089 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.083 mA	2.200 mA	Passed	

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As Left

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.770 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.774 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.769 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.771 V	24.000 V	Passed	

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CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	153406
Model :	378B02	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Microphone System 1/2" Free Field		
Serial # :	121695	P. Order :	2018.07.18C
Asset # :	00471		

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 : Jul 25, 2018 By : Petro Onasko

Cal. Due : Jul 25, 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 : **153406**

Make			Model	Serial		Asset
PCB Piezotronics			378B02	121695		00471
PCB Piezotronics			377B02	153614		

Sensitivity at 250Hz

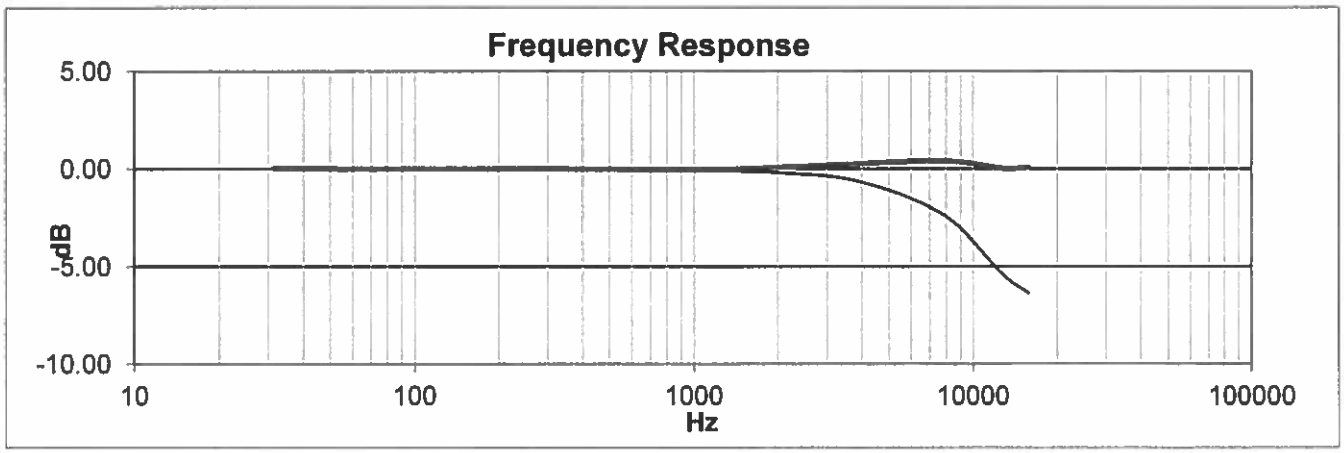
Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	49.89	62.94	In
-26.02	dB re 1V/Pa	-28.02	-26.04	-24.02	In
0	dB re 50mV/Pa	-2	-0.02	2	In

Ambient Conditions:

Static Pressure	99.1 kPa
Temperature	24.3°C
Rel.Humidity	57.0%

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	0.02	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	-0.07	-0.05	
1978.7	-0.20	0.06	
3957.5	-0.66	0.25	
7914.9	-2.39	0.40	
12663	-5.35	0.03	
15830	-6.36	0.08	



CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	153586
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	00033370	P. Order :	2018.08.03C
Asset # :	00446		

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 09, 2018 By : Petro Onasko

Cal. Due : Aug 09, 2020

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

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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 : **153586**

Make	Model	Serial	Asset
PCB Piezotronics	480E09	00033370	00446

Test	Min	Reading	Max	In/Out

Gain accuracy at 1kHz

Gain Set	Input			V			
x1	1.000 V		0.9800	0.9999	1.0200		In
x10	0.100 V		0.9800	1.0005	1.0200		In
x100	0.010 V		0.9800	0.9992	1.0200		In

Gain Flatness

X1

I/P	1.00063			%			
10 Hz	1.000 V		-5.0	-0.1	5.0		In
10 kHz	1.000 V		-5.0	0.0	5.0		In
50 kHz	1.000 V		-5.0	0.1	5.0		In
100 kHz	1.000 V		-5.0	0.2	5.0		In

X10

I/P				%			
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	-1.0	5.0		In

X100

I/P				%			
10 Hz	0.010 V		-5.0	0.1	5.0		In
10 kHz	0.010 V		-5.0	-0.2	5.0		In
50 kHz	0.010 V		-5.0	-4.6	5.0		In

Compliant Calibration Certificate

Template Revision:

NATIONAL INSTRUMENTS CALIBRATED
SN/ID 1CAF75B
DATE 05-SEP-2018
DUE 05-SEP-2019
ni.com/calibration

Certificate Number:	5741060.1	**OE Number:**	21477943
Date Printed:	05-SEP-2018	**Page:**	1 of 14
Customer:	Aercoustics Engineering LTD (CA) 1004 Middlegate Road Suite 1100 MISSISSAUGA, L4Y 0G1 CANADA		
Manufacturer:	National Instruments	**Model:**	NI 9234
Serial Number:	1CAF75B		
Part Number:	195551C-01L	**Description:**	MODULE ASSY,NI 9234, 4 AI CONFIGURABLE
Calibration Date:	05-SEP-2018	**Recommended Calibration Due:**	05-SEP-2019
Procedure Name:	NI 9234	**Verification Results:**	As Found: Passed As Left: Passed
Procedure Version:	3.6.1.0	**Calibration Executive Version:**	4.5.0.0
Lab Technician:	Justin Rees	**Driver Info:**	NI-DAQmx:17.1.0
Temperature:	23.0° C	**Humidity:**	45.5% RH

The data found in this certificate must be interpreted as:

As Found	The calibration data of the unit as received by National Instruments.
As Left	The calibration data of the unit when returned from National Instruments.

The As Found and As Left readings are identical for units not adjusted or repaired.

This calibration conforms to ANSI/NCSL Z540.1-1994 (R2002) requirements.

The TUR (Test Uncertainty Ratio) of this calibration is maintained at a ratio of 4:1 or greater, unless otherwise indicated in the measurements. A TUR determination is not possible for singled sided specification limits and therefore the absence of a value should not be interpreted as a TUR of 4:1 or greater, but rather undetermined. When provided, the expanded measurement uncertainty is calculated according to the Guide to the Expression of Uncertainty in Measurement (GUM) for a confidence level of approximately 95%. The uncertainty is calculated at time of calibration and does not include the object long-term stability and different environmental and operational conditions.

Results are reviewed to establish where any measurement results exceeded the manufacturer's specifications. Measured values greater than the Manufacturer's specification limits are marked as 'Failed', measured values within the Manufacturer's specifications are marked as 'Passed'.

The Calibration Certificate can be viewed or downloaded online at www.ni.com/calibration/. To request a hard copy, contact NI Customer Service at Tel:(800) 531-5066 or E-mail customer.service@NI.com

Victor Peña
Technical Manager

National Instruments Calibration Services Austin
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Tel: (800) 531-5066

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Calibration Notes

Type	Note
Asset	Verification only was performed.

Standards Used

Manufacturer	Model	Type	Tracking Number	Calibration Due	Notes
FLUKE	5700A	Calibrator	3020	03-OCT-2018	
National Instruments	PXI-4461	Function generator	9383	25-APR-2019	
National Instruments	PXI-4071	Digital multimeter	10513	14-MAY-2019	
National Instruments	PXI-4132	SMU	9172	23-OCT-2018	

The standards used in this calibration are traceable to NIST and/or other National Measurement Institutes (NMI's) that are signatories of the International Committee of Weights and Measures (CIPM) mutual recognition agreement (MRA).

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Calibration Results

As Found

Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	3.99990 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	0.00011 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-3.99969 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	3.99998 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00007 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-4.00010 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	4.00030 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	0.00003 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00022 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	4.00004 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	-0.00004 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-4.00011 V	-3.99520 V	Passed	

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As Found

Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.001 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	0.001 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.001 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	0.001 dB	0.040 dB	Passed	

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As Found

Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	-0.013 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.013 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	-0.011 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	-0.007 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	-0.104 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.104 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	-0.095 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	-0.055 Degrees	0.490 Degrees	Passed	

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As Found

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	75.580 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	73.473 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	75.504 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	75.161 dB	100.000 dB	Passed	

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As Found

Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.076 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.068 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.075 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.070 mA	2.200 mA	Passed	

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As Found

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.788 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.793 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.791 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.790 V	24.000 V	Passed	

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Verify Accuracy

Lower Range	Upper Range	Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
-5 V	5 V	0	4.00000 V	3.99520 V	3.99990 V	4.00480 V	Passed	
-5 V	5 V	0	0.00000 V	-0.00120 V	0.00011 V	0.00120 V	Passed	
-5 V	5 V	0	-4.00000 V	-4.00480 V	-3.99969 V	-3.99520 V	Passed	
-5 V	5 V	1	4.00000 V	3.99520 V	3.99998 V	4.00480 V	Passed	
-5 V	5 V	1	0.00000 V	-0.00120 V	-0.00007 V	0.00120 V	Passed	
-5 V	5 V	1	-4.00000 V	-4.00480 V	-4.00010 V	-3.99520 V	Passed	
-5 V	5 V	2	4.00000 V	3.99520 V	4.00030 V	4.00480 V	Passed	
-5 V	5 V	2	0.00000 V	-0.00120 V	0.00003 V	0.00120 V	Passed	
-5 V	5 V	2	-4.00000 V	-4.00480 V	-4.00022 V	-3.99520 V	Passed	
-5 V	5 V	3	4.00000 V	3.99520 V	4.00004 V	4.00480 V	Passed	
-5 V	5 V	3	0.00000 V	-0.00120 V	-0.00004 V	0.00120 V	Passed	
-5 V	5 V	3	-4.00000 V	-4.00480 V	-4.00011 V	-3.99520 V	Passed	

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NATIONAL INSTRUMENTS

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Verify Gain Matching

Max Gain Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	10240	10240	4 V	-0.040 dB	-0.001 dB	0.040 dB	Passed	
1	10240	10240	4 V	-0.040 dB	0.001 dB	0.040 dB	Passed	
2	10240	10240	4 V	-0.040 dB	0.001 dB	0.040 dB	Passed	
3	10240	10240	4 V	-0.040 dB	0.001 dB	0.040 dB	Passed	

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NATIONAL INSTRUMENTS

As Left

Verify Phase Matching

Max Phase Difference for Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	-0.085 Degrees	-0.013 Degrees	0.085 Degrees	Passed	
1	51200	16384	1000 Hz	-0.085 Degrees	0.013 Degrees	0.085 Degrees	Passed	
2	51200	16384	1000 Hz	-0.085 Degrees	-0.011 Degrees	0.085 Degrees	Passed	
3	51200	16384	1000 Hz	-0.085 Degrees	-0.007 Degrees	0.085 Degrees	Passed	
0	51200	16384	10000 Hz	-0.490 Degrees	-0.104 Degrees	0.490 Degrees	Passed	
1	51200	16384	10000 Hz	-0.490 Degrees	0.104 Degrees	0.490 Degrees	Passed	
2	51200	16384	10000 Hz	-0.490 Degrees	-0.095 Degrees	0.490 Degrees	Passed	
3	51200	16384	10000 Hz	-0.490 Degrees	-0.055 Degrees	0.490 Degrees	Passed	

As Left

Verify Common Mode Rejection Ratio

Channel	Rate	Samples per Channel	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	16384	1000 Hz	40.000 dB	75.580 dB	100.000 dB	Passed	
1	51200	16384	1000 Hz	40.000 dB	73.473 dB	100.000 dB	Passed	
2	51200	16384	1000 Hz	40.000 dB	75.504 dB	100.000 dB	Passed	
3	51200	16384	1000 Hz	40.000 dB	75.161 dB	100.000 dB	Passed	

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Verify IEPE Current

Channel	Rate	DMM Range	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	0.01 A	2.000 mA	2.000 mA	2.076 mA	2.200 mA	Passed	
1	51200	0.01 A	2.000 mA	2.000 mA	2.068 mA	2.200 mA	Passed	
2	51200	0.01 A	2.000 mA	2.000 mA	2.075 mA	2.200 mA	Passed	
3	51200	0.01 A	2.000 mA	2.000 mA	2.070 mA	2.200 mA	Passed	

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As Left

Verify IEPE Compliance Voltage

Channel	Rate	SMU Voltage Limit	Test Value	Low Limit	Reading	High Limit	Status	Notes
0	51200	24 V	2 mA	19.000 V	20.788 V	24.000 V	Passed	
1	51200	24 V	2 mA	19.000 V	20.793 V	24.000 V	Passed	
2	51200	24 V	2 mA	19.000 V	20.791 V	24.000 V	Passed	
3	51200	24 V	2 mA	19.000 V	20.790 V	24.000 V	Passed	

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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

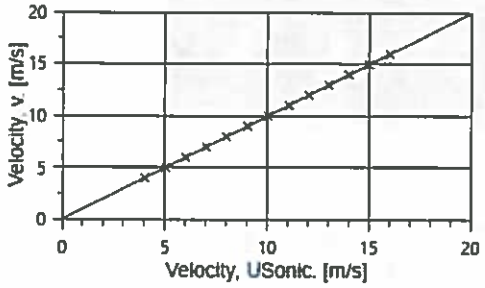
Certificate number: 18.US1.05008 **Date of issue:** September 28, 2018
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** K0630016
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

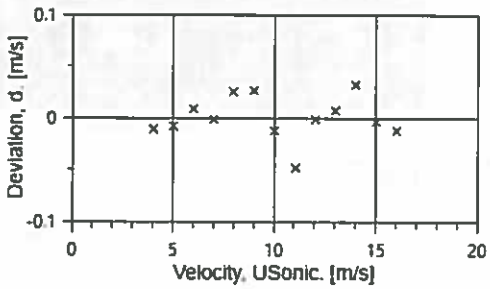
Anemometer received: September 25, 2018 **Anemometer calibrated:** September 27, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.99600 · f [m/s] + -0.01530

Standard uncertainty, slope: 0.00163 **Standard uncertainty, offset:** -1.13705
Covariance: -0.0000265 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999985
Absolute maximum deviation: -0.048 m/s at 10.969 m/s
Barometric pressure: 1006.5 hPa **Relative humidity:** 49.0%

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	9.23	25.6	26.7	3.978	4.0200	-0.011	0.020
4	14.47	25.7	26.7	4.981	5.0241	-0.008	0.023
6	20.81	25.7	26.7	5.973	6.0033	0.009	0.026
8	28.35	25.7	26.7	6.972	7.0167	-0.002	0.029
10	37.09	25.7	26.7	7.974	7.9967	0.025	0.033
12	47.19	25.7	26.7	8.995	9.0200	0.026	0.037
13-last	57.82	25.7	26.7	9.956	10.0241	-0.012	0.041
11	70.17	25.7	26.7	10.969	11.0767	-0.048	0.045
9	83.56	25.7	26.7	11.970	12.0350	-0.001	0.049
7	97.94	25.7	26.7	12.960	13.0200	0.007	0.053
5	113.70	25.7	26.7	13.964	14.0033	0.032	0.057
3	129.99	25.6	26.7	14.931	15.0100	-0.004	0.061
1-first	148.17	25.6	26.7	15.941	16.0333	-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, 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.US1.05008

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CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

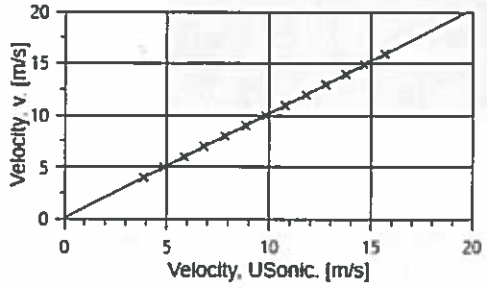
Certificate number: 18.US1.05009 **Date of issue:** September 28, 2018
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** K0630016
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

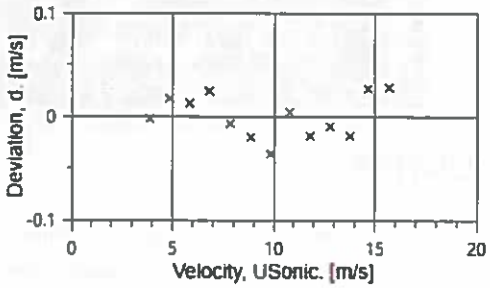
Anemometer received: September 25, 2018 **Anemometer calibrated:** September 27, 2018
Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.01021 · f [m/s] + 0.06780

Standard uncertainty, slope: 0.00161 **Standard uncertainty, offset:** 0.25078
Covariance: -0.0000258 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999986
Absolute maximum deviation: -0.036 m/s at 9.966 m/s
Barometric pressure: 1006.6 hPa **Relative humidity:** 48.7%

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	9.23	25.7	26.7	3.978	3.8733	-0.002	0.020
4	14.46	25.8	26.7	4.979	4.8448	0.017	0.023
6	20.81	25.8	26.7	5.974	5.8333	0.013	0.026
8	28.37	25.8	26.7	6.975	6.8133	0.024	0.029
10	37.11	25.8	26.7	7.977	7.8367	-0.007	0.033
12	47.15	25.7	26.7	8.991	8.8533	-0.020	0.037
13-last	57.93	25.7	26.6	9.966	9.8345	-0.036	0.041
11	70.12	25.7	26.7	10.965	10.7833	0.004	0.045
9	83.59	25.7	26.7	11.973	11.8033	-0.019	0.049
7	98.00	25.7	26.7	12.965	12.7767	-0.009	0.053
5	113.49	25.7	26.7	13.953	13.7633	-0.019	0.057
3	129.60	25.7	26.7	14.911	14.6667	0.027	0.061
1-first	148.11	25.7	26.7	15.939	15.6833	0.028	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 90°.

Certificate number: 18.US1.05009

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CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

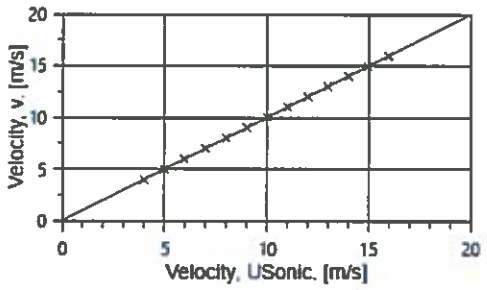
Certificate number: 17.US1.05800 **Date of issue:** July 10, 2017
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** L3020298.0°
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

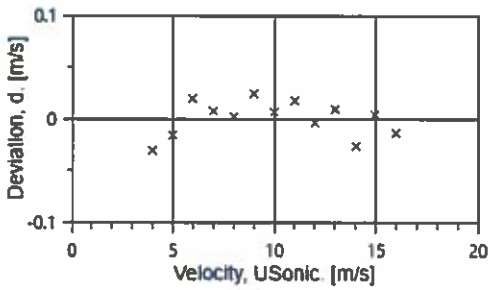
Anemometer received: July 10, 2017 **Anemometer calibrated:** July 10, 2017
Calibrated by: EJF **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.99845 · f [m/s] + 0.03088

Standard uncertainty, slope: 0.00134 **Standard uncertainty, offset:** 0.46283
Covariance: -0.0000179 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999990
Absolute maximum deviation: -0.031 m/s at 3.974 m/s
Barometric pressure: 1001.0 hPa **Relative humidity:** 46.1%

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	9.09	27.9	28.0	3.974	3.9800	-0.031	0.024
4	14.33	27.9	28.0	4.990	4.9828	-0.016	0.025
6	20.68	27.9	28.0	5.995	5.9533	0.020	0.027
8	28.29	27.9	28.0	7.011	6.9833	0.008	0.030
10	36.99	27.9	28.0	8.017	7.9967	0.002	0.032
12	47.04	27.9	28.0	9.041	9.0000	0.024	0.035
13-last	57.83	27.9	28.0	10.025	10.0034	0.007	0.038
11	70.02	27.9	28.0	11.031	11.0000	0.018	0.041
9	83.06	27.9	28.0	12.015	12.0067	-0.004	0.044
7	97.38	27.9	28.0	13.010	12.9900	0.009	0.048
5	112.72	27.9	28.0	13.998	14.0150	-0.027	0.051
3	128.84	27.9	28.0	14.965	14.9533	0.004	0.054
1-first	146.73	27.8	28.0	15.969	15.9767	-0.014	0.057





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP004	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP001	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 2,5m 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.

Certificate number: 17.US1.05800

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CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

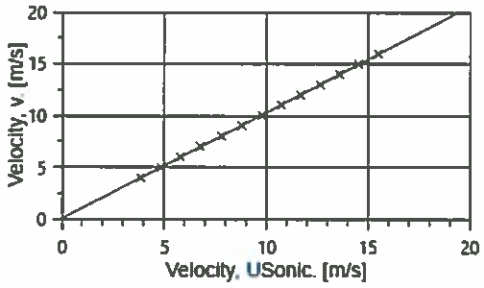
Certificate number: 17.US1.05801 **Date of issue:** July 10, 2017
Type: Vaisala Weather Transmitter, WXT520 **Serial number:** L3020298.90°
Manufacturer: Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
Client: Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

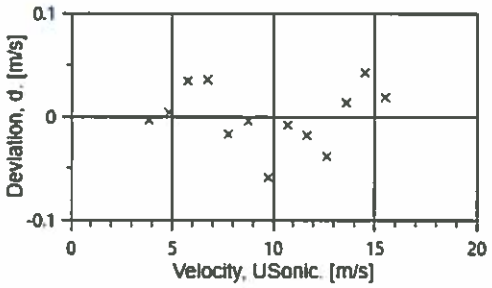
Anemometer received: July 10, 2017 **Anemometer calibrated:** July 10, 2017
Calibrated by: EJF **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 1.02647 · f [m/s] + 0.03997

Standard uncertainty, slope: 0.00229 **Standard uncertainty, offset:** 0.60999
Covariance: -0.0000537 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999971
Absolute maximum deviation: -0.059 m/s at 10.008 m/s
Barometric pressure: 1000.7 hPa **Relative humidity:** 45.3%

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	9.12	28.5	28.1	3.985	3.8467	-0.003	0.024
4	14.35	28.5	28.1	4.999	4.8276	0.004	0.025
6	20.67	28.5	28.1	6.001	5.7733	0.034	0.027
8	28.20	28.5	28.1	7.008	6.7533	0.036	0.030
10	36.89	28.5	28.1	8.016	7.7867	-0.017	0.032
12	46.93	28.4	28.1	9.041	8.7733	-0.004	0.035
13-last	57.51	28.4	28.1	10.008	9.7690	-0.059	0.038
11	69.83	28.4	28.1	11.029	10.7133	-0.008	0.041
9	82.67	28.4	28.1	12.001	11.6700	-0.018	0.044
7	96.80	28.5	28.1	12.986	12.6500	-0.039	0.047
5	112.66	28.5	28.1	14.010	13.5967	0.014	0.051
3	129.03	28.5	28.1	14.993	14.5267	0.042	0.054
1-first	146.61	28.4	28.1	15.983	15.5133	0.019	0.057





AC-1746

EQUIPMENT USED

Serial Number	Description
Njord1	Wind tunnel, blockage factor = 1.0035
2254	Control cup anemometer
-	Mounting tube, D = 19 mm
TT003	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP004	Setra Model 239, 0-1inWC, differential pressure transducer
HY002	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP001	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 2.5m 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.

Certificate number: 17.US1.05801

CERTIFICATE of CALIBRATION

Make : PCB Piezotronics

Reference # : 152970

Model : 378B02

Customer : Aercoustics Engineering Ltd
Mississauga, ON

Descr. : Microphone System 1/2" Free Field

Serial # : 132194

P. Order : 2018.06.15C

Asset # : 01163

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 : Jun 20, 2018

By : Petro Onasko

Cal. Due : Jun 20, 2019

Temperature : 23 °C ± 2 °C

Relative Humidity : 30% to 70%

Standards used : J-216 J-333 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

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

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

Calibration Report for Certificate : **152970**

Make			Model	Serial		Asset
PCB Piezotronics			378B02	132194		01163
PCB Piezotronics			377B02	177759		01163

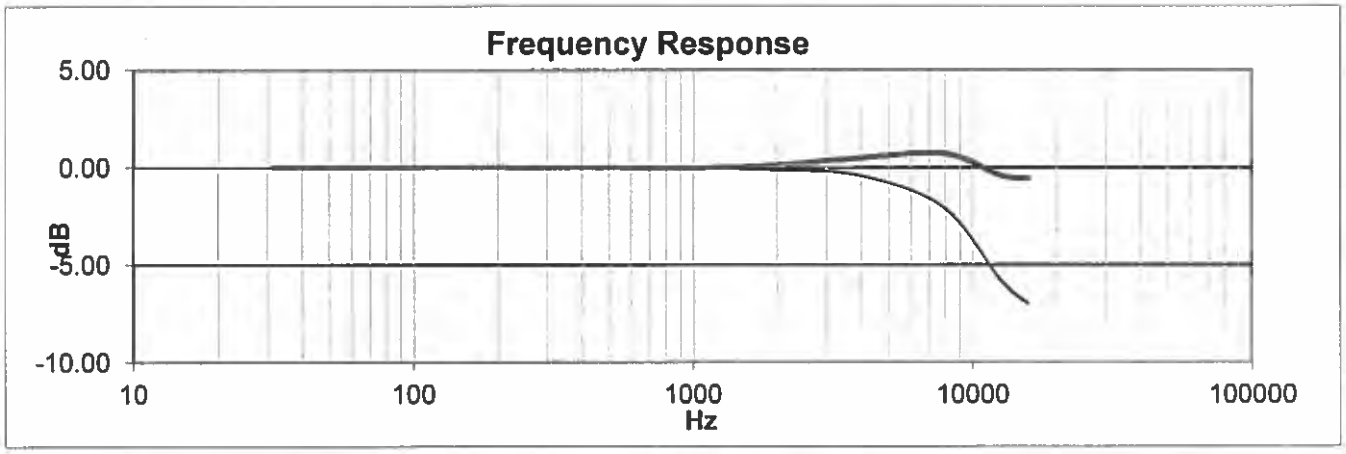
Sensitivity at 250Hz

Specs Nom	Unit	Min	Reading	Max	In/Out
50	mV/Pa	39.72	43.92	62.94	In
-26.02	dB re 1V/Pa	-28.02	-27.15	-24.02	In
0	dB re 50mV/Pa	-2	-1.13	2	In

Ambient Conditions: Static Pressure 99.2 kPa
Temperature 24.2°C
Rel.Humidity 41.0%

Frequency response

	Lower	Upper	
Freq	Pressure	Free Field	
Hz	dB	dB	
31.5	0.03	0.01	
63.1	0.01	-0.01	
125.9	0.00	0.01	
251.3	0.00	0.00	ref
502.5	-0.01	-0.01	
1005.1	-0.05	-0.03	
1978.7	-0.13	0.13	
3957.5	-0.42	0.49	
7914.9	-2.08	0.72	
12663	-5.84	-0.42	
15830	-7.01	-0.53	



CERTIFICATE of CALIBRATION

Make :	PCB Piezotronics	Reference # :	154367
Model :	480E09	Customer :	Aercoustics Engineering Ltd Mississauga, ON
Descr. :	Conditioning Amplifier		
Serial # :	33660	P. Order :	2018.10.09C
Asset # :	00154		

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 10, 2018 By : Petro Onasko

Cal. Due : Oct 10, 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
Phone : 905 565 1584 Fax: 905 565 8325
http: // www.navair.com
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 : **154367**

Make	Model	Serial	Asset
PCB Piezotronics	480E09	00033660	00154

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	0.100 V		0.9800	1.0003	1.0200		In
x100	0.010 V		0.9800	0.9992	1.0200		In

Gain Flatness

X1

I/P				%			
10 Hz	1.000 V		-5.0	-0.1	5.0		In
10 kHz	1.000 V		-5.0	0.0	5.0		In
50 kHz	1.000 V		-5.0	0.1	5.0		In
100 kHz	1.000 V		-5.0	0.2	5.0		In

X10

I/P				%			
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	-1.0	5.0		In

X100

I/P				%			
10 Hz	0.010 V		-5.0	0.0	5.0		In
10 kHz	0.010 V		-5.0	-0.1	5.0		In
50 kHz	0.010 V		-5.0	-4.6	5.0		In

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1004 Middlegate Road, Suite 1100
Mississauga, ON L4Y 0G1

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Appendix H
I-Audit Checklist

Appendix F7: I-Audit checklist

Wind Energy Project – Screening Document – Acoustic Audit Report – Immission

Information Required in the Acoustic Audit Report – Immission

Item	Description	Complete?	Comment
1	Did the Sound level Meter meet the Type 1 Sound level meter requirements according to the IEC standard 61672-1 Sound level Meters, Part 1: Specifications? Section D2.1.1	✓	
2	Was the complete sound measurement system, including any recording, data logging or computing systems calibrated immediately before and after the measurement session at one or more frequencies using an acoustic calibrator on the microphone (must not exceed ±0.5dB)? Section D2.1.3	✓	
3	Are valid calibration certificate(s) of the noise monitoring equipment and calibration traceable to a qualified laboratory? Is the validity duration of the calibration stated for each item of equipment? Section D2.3	✓	
4	Was the predictable worst case parameters such as high wind shear and wind direction toward the Receptor considered? Section D3.2	✓	
5	Is there a Wind Rose showing the wind directions at the site? Section D7 (1e)	✓	
6	Did the results cover a wind speed range of at least 4-7 m/s as outlined in section D 3.8.?	✓	
7	Was the weather report during the measurement campaign included in the report? Section D7 (1c)	✓	
8	Did the audit state there was compliance with the limits at each wind speed category? Section D6	✓	
9	Are pictures of the noise measurement setup near Point of reception provided? Section D3.3.2 & D3.4	✓	
10	Was there justification of the Receptor location choice(s) prior to commencement of the I-Audit? Section D4.1	✓	
11	Was there sufficient valid data for different wind speeds? Section D5.2 # 3	✓	
12	Was the turbine (operational) specific information during the measurement campaign in tabular form (i.e. wind speed at hub height, anemometer wind speed at 10 m height, air temperature and pressure and relative humidity) Section D3.7	✓	
13	Were all the calculated standard deviations at all relevant integer wind speeds provided? Section D7 (2d)	✓	
14	Compliance statement	✓	
15	All data included in an Excel spreadsheet	✓	
16	If deviations from standard; was justification of the deviations provided	⊘	No Deviations

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aercoustics.com

Appendix I
Distance Correction - M1153

Niagara Wind Farm
Project # 16227
M1153 - Monitor to Receptor Distance Correction

M1153		R1153	
Monitor Coordinates	17T 620902mE 4749669mN	Receptor Coordinates	17T 621067mE 4749725mN

Source ID	Partial Impact at Monitor [dBA]	Source ID	Partial Impact at Receptor [dBA]
T20	40.3	T20	37.4
T96	30.8	T96	31.9
T63	27.3	T63	28.2
T99	25.8	T62	25.6
T62	24.8	T99	24.7
T05	24.6	T05	24.4
T46	22.4	T46	23.3
T47	22.2	T47	22.8
T45	19.6	T45	20.2
T16	17.9	T16	18.6
T14	17.7	T14	18.2
T44	16.5	T44	17
T48	15.9	T48	16.5
T43	15.3	T43	15.8
T84	15.1	T22	15.4
T42	15	T84	15.4
T22	14.9	T89	15.1
T89	14.6	T42	15
T21	14.1	T21	14.6
T98	13.8	T61	13.7
T61	13.3	T98	13.6
T65	11	T65	11.3
T82	10	T19	10
T19	9.9	T49	10
T49	9.6	T82	10
T13	8.5	T13	8.6
T23	8	T23	8.4
T12	7.9	T12	8
GREPT58	7.8	T24	7.9
GREPT60	7.6	T91	7.7
GREPT61	7.6	GREPT58	7.4
T24	7.6	GREPT60	7.2
T91	7.6	GREPT61	7.2
GREPT62	7.1	T41	7
GREPT57	6.9	GREPT62	6.7
T41	6.9	MH05	6.7
GREPT59	6.6	GREPT57	6.5
MH05	6.5	T72	6.4
T72	6.3	GREPT59	6.2
MH02	6.1	MH02	6.2
RFT	5.1	MH04	5.1
MH04	4.9	RFT	5
ST2	3.8	ST2	4.1
T37	2.7	T37	2.8
MH06	2.2	MH06	2.3
WF01	1.5	WF01	1.8
WF02	1.1	WF02	1.3
WF03	0.9	WF03	1.2
MH01	0.5	MH01	0.6
MH03	0.2	MH03	0.4
		WF05	0.2
		WF04	0.1
Overall Level	41.6	Overall Level	39.9
Turbine ONLY correction		1.7dB	