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IMMISSION AUDIT REPORT – **Project: 13228.02**

# South Kent Wind Project
# R4248 – Turbine T093
Chatham-Kent, Ontario

Prepared for:

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# Revision History

| Version | Description | Author | Reviewed | Date |
|---|---|---|---|---|
| 1 | Initial Report | AED | MAD | February 28, 2020 |
| 2 | Revised to include supplementary measurement data from January 23, 2020 to February 7, 2020 to form a complete dataset for assessment. Previous submission was incomplete.<br><br>Revised measurement data intervals from 1-minute to 10-second intervals based on consultation with the MECP. | AED | AM | August 14, 2020 |

# Important Notice and Disclaimer

# Executive Summary

Aercoustics Engineering Limited ("Aercoustics") was retained by South Kent Wind LP to complete the acoustic audit requirements outlined in the Renewable Energy Approval ("REA") for South Kent Wind Project ("SKWP"). SKWP operates under REA #2871-8UKGPC, issued on June 15, 2012.

In response to Section G of the REA, emission audit ("E-Audit") tests were conducted at six (6) SKWP turbines and test reports were submitted to the Ministry of the Environment, Conservation and Parks ("MECP"). Based on these reports, the MECP requested that additional supporting immission audit ("I-Audit") tests be conducted at receptor locations close to each test turbine in order to support the completion of the E-Audit requirement.

This report presents the results of the additional I-Audit assessment for receptor R4248 near turbine T093. The E-Audit results for T093 were incomplete when evaluated under IEC 61400-11 Edition 3.0. In addition, the E-Audit results indicated that the test turbine had a tonal audibility greater than 3 dB and thus would need to be evaluated in the far field. As such, the audit at R4248 was conducted to assess compliance of the sound pressure level and tonal audibility in the far field.

The monitoring near receptor R4248 was conducted over the following period:

| Audit Receptor | Audit Start Date | Audit End Date | Monitoring Duration (weeks) |
|---|---|---|---|
| R4248 | November 3, 2019 | February 7, 2020 | 14 |

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).

Based on the results presented in this report, the assessment requirements outlined in the Compliance Protocol have been met and the cumulative sound impact calculated at R4248 complies with the MECP sound level limits at all wind bins with sufficient data for assessment.

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# 1 Introduction

Aercoustics Engineering Limited ("Aercoustics") was retained by South Kent Wind LP to complete the acoustic audit requirements outlined in the Renewable Energy Approval ("REA") for South Kent Wind Project ("SKWP"). SKWP operates under REA #2871-8UKGPC, issued on June 15, 2012.

In response to Section G of the REA, emission audit ("E-Audit") tests were conducted at six (6) SKWP turbines and test reports were submitted to the Ministry of the Environment, Conservation and Parks ("MECP"). Based on these reports, the MECP requested that additional supporting immission audit ("I-Audit") tests be conducted at receptor locations close to each test turbine in order to support the completion of the E-Audit requirement.

This report presents the results of the I-Audit assessment for receptor R4248 near turbine T093.

The audit was completed per the methodology outlined in Part D and Part E of the Compliance Protocol for Wind Turbine Noise ("Compliance Protocol" or "Protocol"), April 2017 revision. The Compliance Protocol is an Ontario MECP document used to evaluate noise from a wind turbine at nearby receptors.

# 2 Background

The most up-to-date E-Audit report submitted and reviewed by the MECP for turbine T093 is as follows:

> REPORT ID: 13228.00.T093.RP3, South Kent Wind Farm – Turbine T093, IEC 61400-11 Edition 3.0 Measurement Report 21 December 2018 – Revision 3.

The results of the E-Audit test are summarized in Table 1 below.

Table 1: E-Audit Results Summary

| Sound Power | | | Maximum Tonal Audibility | |
|---|---|---|---|---|
| REA (dBA) | Audit (dBA) | Exceeds REA plus 0.5 dB* (Y/N) | Audit (dBA) | Exceeds 3 dB** (Y/N) |
| 102 | 102.1 | N | 4.5 | Y |

* REA sound power levels plus 0.5 dB threshold specified in accordance with Section E3.1 of the Protocol.
** 3 dB threshold specified in accordance with Section D3.8.3 of the Protocol.

The E-Audit results for T093 were incomplete when evaluated under IEC 61400 11 Edition 3.0. In addition, the E-Audit results indicated that the test turbine had a tonal audibility greater than 3 dB and thus would need to be evaluated in the far field. As such, the audit at R4248 was conducted to assess compliance of the sound pressure level and tonal audibility in the far field.

In review of the report, the MECP requested that additional supporting measurements be conducted at the receptor location closest to the test turbine, in accordance with Section E.3.1.2 of the Protocol. This feedback was delivered in an email dated January 4, 2019 and further clarified in a call on January 14, 2019.

For reference, a detailed summary of the sound power and tonal audibility assessment results from the T093 E-Audit is provided in Appendix F.

# 3 Facility Description

South Kent Wind Project is a wind facility comprising 124 Siemens SWT-101 wind turbines with name plate capacities of 2.221 MW, 2.126 MW, 1.903 MW, and 1.824 MW. The total name plate capacity of the facility is 270 megawatts. Each turbine has a hub height of 99.5 metres. The facility is located in the Chatham-Kent Municipality.

The facility has two large substation transformers rated at 148 and 129 MVA. The facility is designed to operate 24 hours per day, 7 days per week.

# 4 Audit Location

The receptor selection process, measurement equipment, and details regarding the monitoring locations are provided in this section.

## 4.1 Receptor Selection

Measurement equipment was erected at receptor R4248 near the test turbine T093. The measurement location was selected as per Section E3.1.2 of the Compliance Protocol, wherein measurements are to be conducted at the point of reception with the greatest predicted noise impact from the specified test turbine (“worst-case receptor”). The frequent downwind conditions were also considered for receptors with similar predicted partial sound levels from the test turbine. The prevailing wind direction for the site is discussed in the following section. The receptor location was selected in consultation with the MECP and confirmed in a letter from the MECP dated March 29, 2019.

The receptor details for T093 are shown in Table 2 below. Predicted sound impacts at the receptor were obtained from the Noise Assessment Report for SKWP prepared by Hatch and dated May 7, 2013. A sound model using the original assessment report parameters was created by Aercoustics to calculate predicted sound levels at monitor locations.

Table 2: Receptor Selection Table

| SPL Rank | Point of Reception ID | Nearest Turbine | Test Turbine | Distance to Test Turbine (m) | Predicted Overall Sound Level (dBA) | Predicted Partial Sound Level from **test turbine** only* (dBA) | Wind Direction from Test Turbine | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | R4248 | T166** | T093 | 601 | 39.7 | 33.7 | Crosswind | Measured location |

* These values are predicted based on the manufacturer specified sound power level for each turbine, not the measured sound power levels. They are included to be indicative of the relative contribution of the turbine of interest at each location.

** The nearest turbine to R4248 is T166 (at 595 m) and not the test turbine T093. For the purposes of this I-Audit, the impact of the test turbine T093 is being evaluated and therefore receptor distance, predicted partial sound level, and wind direction from the test turbine T093 were used for receptor selection.

### 4.1.1 Historical Wind Direction

Historical wind direction information was provided by SKWP and used to support selection of suitable audit receptors. This wind direction information is provided in Figure 1, and the prevailing downwind direction for the facility was determined to be 210°.

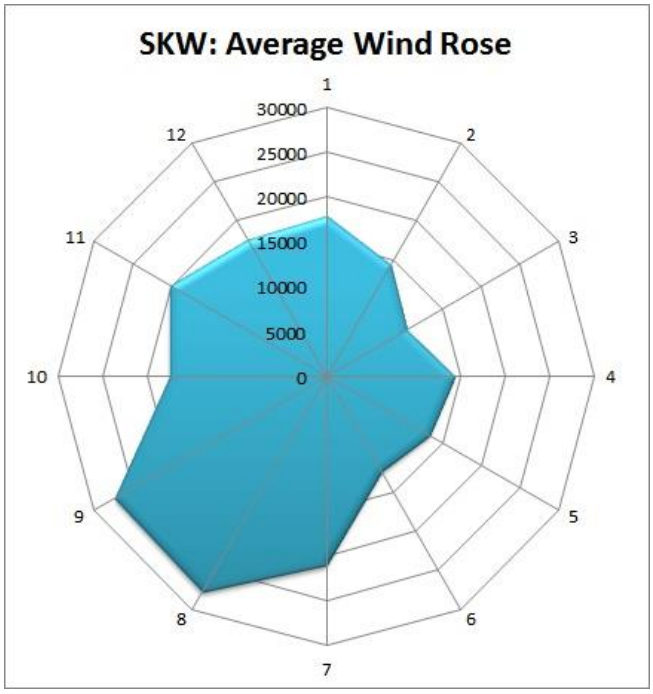


Figure 1: Historical Wind Rose used for Receptor Selection

## 4.2 Monitoring Location

The monitor was erected at approximately the same coordinates of R4248, 596 metres away from the test turbine (turbine T093). The monitor was erected at the receptor height of 4.5 metres. The ground cover between the measurement location and the nearest turbines was open field, predominantly covered with short crops and occasional trees.

Table 3 provides a summary of the receptor and monitor locations. Site photographs and plans are provided in Appendix A.

Table 3: Coordinates and Turbines to Receptor and Measurement Locations

| Audit Receptor | Measurement Duration | Location | Coordinates (UTM x,y, Zone 17T) | Distance to Test Turbine (m) | Predicted Overall Sound Level (dBA) |
|---|---|---|---|---|---|
| R4248 | Nov 3, 2019 – Feb 7, 2019 | Receptor | 425072 mE / 4693062 mN | 601 | 39.7 |
| | | Monitor | 425076 mE / 4693065 mN | 596 | 39.8 |

## 4.3 Existing Ambient Environment

The ambient acoustic environment for the SKWP site is comprised of a mixture of many different ambient sources. The contribution of noise from flora, fauna, traffic, and industry near the monitor location were considered throughout the measurement campaign.

Existing ambient noise sources were categorized as either extraneous—such as short-term events, or frequency-specific noise—or constant noise sources as part of the existing ambient sound environment. In the case of extraneous noise sources, filtering was employed to reduce or remove it, as further discussed in Section 5.3.2. For constant noise sources identified as being a part of the existing ambient sound environment, efforts were made to ensure that the noise was equally present in both *Total Noise* and *Background* periods, as further discussed in Section 5.3.3.

### 4.3.1 Flora Noise

Ambient noise from flora refers to the noise generated by wind blowing over vegetation and foliage and is typically proportional to wind speed, with higher wind speeds generating increased amounts of noise. Due to its ever-present and broadband nature, noise from flora is considered a constant noise source as part of the existing ambient environment.

The monitor was located in an empty field with no crop cover. An area of approximately 40x40 ft was cleared around the monitor prior to installation. There were no large shrubs or trees in the vicinity of the monitor.

### 4.3.2 Fauna Noise

Noise from fauna refers to noise typically arising from the activity of insects, birds, livestock, or dogs. Noise of this nature may be concentrated at high frequencies (such as crickets chirping) or limited to short-term events (such as dogs barking). Noise from fauna is considered extraneous noise.

Cricket noise was present at the monitor location and was especially prominent in the early fall months from September to November. There were no other significant sources of fauna noise identified at the monitor location.

### 4.3.3 Traffic Noise

Traffic noise may include short-term events such as individual car passbys (considered extraneous noise) or constant noise (i.e. “traffic hum”) from high-volume or frequently travelled roads and highways.

The monitor was located approximately 30 metres from Kent Bridge Road to the south-west. Due to the traffic volume and proximity to the nearest road, individual car passbys were frequent throughout the measurement campaign.

The monitor was not located near any major highways and therefore constant traffic noise was not a concern during the measurements.

### 4.3.4 Industry Noise

No significant sources of industry noise were identified in the vicinity of the monitor.

### 4.3.5 Self-Generated Noise

Self-generated noise is noise which results from wind blowing over the monitoring equipment and is a factor at high wind speeds at the measurement position. This noise was minimized by a secondary wind screen installed around the microphone in accordance with Section D2.1.4 of the Protocol. The insertion loss of the wind screen has been tested and was accounted for in the analysis.

### 4.3.6 Other Sources

No other notable ambient noise sources were identified in the vicinity of the monitor.

# 5 Audit Methodology

For the duration of the measurement campaign, acoustic and weather data were logged simultaneously at the measurement location. At the time of the initial report submission, the cumulative sound impact at R4248 could not be assessed because the amount of valid data collected up until the previous audit end date (January 22, 2020) did not meet the MECP RAM I-Audit requirements. Data collection was hindered due to the nearest receptor R4248 being located in a predominantly crosswind direction in relation to the test

turbine, T093. As a result, minimal downwind data was collected at the time of the initial report submission. In order to meet the data count requirements, the campaign was extended to include supplementary data up to and including February 7, 2020, and measurement data was analyzed in 10 second intervals (i.e. sound level measurements were based on a 10 second averaging time) as permitted by Section E5.5(7) of the Protocol and as determined in consultation with the MECP.

Analysis and filtering were conducted in accordance with Sections D5.2 and E5.5 of the Protocol, with additional filters applied as needed—following the guidance in the Protocol—to remove or reduce extraneous ambient noise (see Section 5.3.2 below) and ensure representative ambient conditions (see Section 5.3.3 below). Deviations from the Protocol are discussed in Section 5.5.

Intervals that passed the filtering criteria were sorted into integer wind bins[1] depending on the measured wind speed at 10 metres above ground level ("10m-AGL") and classified as either *Total Noise* or *Background* depending on the operation of the nearby SKWP turbines. The *Turbine-Only* sound level for each wind bin was determined by logarithmically subtracting the average *Background* levels from the *Total Noise* level in wind bins with sufficient data for assessment.

The calculation of the average measured tonal audibility was determined in accordance with IEC 61400-11 Edition 3.0, as per Section D3.8.3 of the Protocol, with modifications to adapt the method to immission measurements. Calculations were conducted based on the narrowband spectra of the intervals within the tonality assessment dataset from 20 Hz to 3000 Hz with a frequency resolution of 2 Hz. As per IEC 61400-11, a tone would have to be present in at least 20% of the samples in order to be deemed relevant and evaluated under the penalty scheme (discussed in Section 5.4.3). 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 assessment dataset was determined based on the minimum power output of the test turbine corresponding to a tonal audibility greater than 0 dB in the T093 E-Audit test results. Table 3 presents a summary of the relevant tones for this assessment as determined from the E-Audit, and includes the frequency range, tonal audibility range, and corresponding turbine operational parameters during which elevated tonal audibility levels were observed. A centre frequency of 430 Hz was selected for the tonality assessment.

[1] An integer wind bin spans 1 m/s, centred on each integer wind speed, open at the low end and closed at the high end.

Table 4: Summary of Relevant Tones from T093 E-Audit

| Turbine ID | Frequency Range (Hz) | Tonal Audibility (dB) | Hub Height Wind Speed Range (m/s) | Electrical Power Output Range (kW) |
|---|---|---|---|---|
| T093 | 418 – 442 | 0.2 – 4.5 | 9 – 12 | 1489 – 1903 |

## 5.1 Measurement Equipment

The following acoustic and non-acoustic measurement equipment was installed at the monitor location:

- One (1) Type 1 sound level meter with microphone and pre-amplifier, installed at receptor height;
- One (1) primary and one (1) secondary[2] windscreen for the microphone; and
- One (1) anemometer, installed at 10m-AGL

The measurement equipment was configured to log ten-second equivalent sound levels ($L_{eq}$) in A-weighted broadband and 1/3$^{rd}$ octave band frequencies. The microphone was installed at least 5 metres away from any large reflecting surfaces, as far away as practically possible from trees and other foliage, and in direct line of sight to the nearest SKWP turbines.

Table 5 lists the specific make, model, and serial numbers for the measurement equipment.

Table 5: Equipment Details

| Audit Receptor | Equipment | Make/Model | Serial Number | Date of Last Calibration |
|---|---|---|---|---|
| R4248 | Data Acquisition Card | NI 9234 | 1C009CD | May 7, 2019 |
| | Signal Conditioner | PCB 480E09 | 32814 | April 3, 2019 |
| | Microphone | PCB 377B02 | 153972 | August 9, 2019 |
| | Pre-Amplifier | PCB 426E01 | 38879 | August 9, 2019 |
| | Weather Anemometer | Vaisala WXT520 | L0910581 | July 11, 2019 |

The measurement chain was calibrated before, during, and after the measurement campaign using a type 4231 Brüel & Kjær acoustic calibrator. The measurement equipment was also verified by laboratory calibration per the requirements in Section D2.3 of the Protocol; calibration certificates are provided in Appendix D.

[2] The 1/3 octave band insertion loss of the secondary windscreen has been tested and has been accounted for in the data analysis.

## 5.2 Measurement Parameters

Measurement equipment was configured to run from approximately 9pm to 6am, local time. The measurement parameters acquired and used in the audit are listed in Table 6.

Table 6: Measurement Parameters Used in the Study

| Parameter Group | Measurement Parameters | Notes |
|---|---|---|
| Acoustic (microphone height) | $L_{Aeq}$ | dBA |
| | $L_{90}$ | dBA |
| | 1/3rd Octave Band | dBA (20 Hz – 10 kHz) |
| | Signal Recording | Uncompressed raw files |
| Weather (10-m height) | Wind Speed | m/s |
| | Wind Direction | 0-360˚ |
| | Temperature | ˚C |
| | Humidity | 0-100% |
| | Precipitation | mm |
| Turbine (hub height) | Wind Speed | Provided by operator |
| | Yaw Angle | Provided by operator |
| | Power Output | Provided by operator |
| | Rotational Speed | Provided by operator |

SKWP wind turbine operational information was collected during the measurement campaign using the facility SCADA system and provided to Aercoustics by South Kent Wind LP.

## 5.3 Filtering Criteria

Intervals were included or excluded from analysis depending on several filtering criteria. Some of these criteria apply to all intervals and some apply only for *Total Noise* or *Background* intervals. Measurement intervals were first passed through the *All Intervals* filters, after which they were sorted into either *Total Noise* or *Background* categories based on the operation of the nearby turbines. Intervals were included in the assessment dataset if they met all the following criteria:

*All Intervals*

- Occurred between 10pm – 5am
- Had no precipitation within one hour before or after
- Had an ambient temperature above -20˚C
- Had minimal influence from extraneous ambient noise sources

*Total Noise Intervals*

- All nearby turbines were operating
- Test turbine was generating sufficient power:
    - *For sound pressure level analysis:* Test turbine was generating at least 85% of the maximum rated power output
    - *For tonality analysis:* Test turbine was generating at least the minimum power output corresponding to the conditions where the measured tonal audibility was greater than 0 dB during the E-Audit test
- Monitor was located downwind of the test turbine

*Background Intervals*

- All nearby turbines were parked (i.e. not rotating)

### 5.3.1 Turbines in Study Area

As noted above, several filtering criteria were applied based on the operation of the nearest turbine and the turbines in the surrounding area. To verify the operation of these turbines, information from the facility SCADA was processed along with the acoustic and weather data.

The minimum number of turbines included in the study area for the receptor and verified for *Total Noise* measurements was selected based on the guidance of Section D3.8.1 of the Protocol:

> ***D3.8.1 Overall equivalent sound level – wind turbines operational***
>
> *"[…] At a minimum, all relevant turbines of the subject and adjacent wind facilities, typically within 3 km of the measurement location should be operational. In the event that an adjacent wind facility dominates the background sound levels, subsequent to approval by the Ministry, an alternative measurement location may be selected."*

The minimum number of turbines included in the study area of the receptor and verified for *Background* measurements was selected based on the guidance of Section D3.5.2 of the Protocol:

> ***D3.5.2 Acoustic measurements with wind turbines parked***
>
> *"Ambient noise measurements shall be carried out at a point of reception with all turbines in the vicinity of the point of reception parked. The prediction model will be used to determine the number of turbines that require parking in order for the predicted noise contribution of the wind facility to fall to 30 dBA or 10 dB less than the applicable criterion."*

The turbines in the study area of the receptor are listed in Table 7 below.

Table 7: Turbines Included in the Study Area

| Audit Receptor | Turbines verified for *Total Noise* Measurements | Turbines verified for *Background* Measurements |
|---|---|---|
| R4248 | T001, T002, T003, T004, T006, T093, T102, T138, T152, T166, T167 | T001, T002, T003, T004, T006, T093, T102, T138, T152, T166, T167 |

Parked turbines do not rotate or generate power. There is some idling of the blades (~2 RPM or less), but the acoustic impact of the turbines in this condition is negligible at the receptor. The turbines were confirmed to be running in their normal operating mode for the duration of the monitoring campaign. See Appendix B for a statement from the operator.

### 5.3.2 Removal of Extraneous Noise

'Extraneous noise' is defined as ambient sound sources unrelated to the operation of the wind facility. The removal or reduction of extraneous noise sources in the measurement data is important to ensure the assessment of turbine-only sound levels is as accurate and free of contamination as possible. The Protocol provides the following guidance regarding extraneous noise:

> ***C2.4.7 Extraneous noise sources[3]***
>
> *"Measurements are to be inhibited when the sound level is affected by noise from extraneous sources such as vehicle noise, dogs barking and wind gusts (i.e. other than wind turbine sound).*
>
> *"The same result can also be achieved by digitally recording the sound level time history and later editing out the extraneous events and recalculating the descriptors such as Leq. This should address measurement situations where extraneous sounds were not inhibited."*
>
> ***D3.5 Acoustic measurements***
>
> *"[…] In addition, 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."*
>
> ***D5.3 Effects of insects and fauna***
>
> *"The analysis shall identify the influence of any insects, fauna, or other extraneous but constant sources of noise and verify them through sound recordings. Noise from insects*

[3] It is acknowledged that the measurements in this report follow Part D and Part E of the Protocol and this guidance is from Part C. Nevertheless, the guidance regarding the removal of extraneous noise in Part C is applicable here as the requirement to remove contamination from the measurement dataset follows good engineering principles for noise measurements.

> *can be removed from the 1/3rd octave spectra of each measurement. It has to be shown, however, that the contribution of the wind turbine noise in those frequencies is minimal."*
>
> ***D6 Assessment of compliance***
>
> *"[…] However, if the background sound levels are greater than the applicable exclusion limits then the applicable limits are now the background sound levels without extraneous noise sources."*

Extraneous noise can be steady or transient. Steady noise can be removed via filtering or removal of specific 1/3rd octave bands affected by the contamination (as per Protocol section D5.3). Transient noise can be removed or reduced from the dataset by automatic and manual filtering techniques.

Steady noise from crickets, identified at a frequency of 3150 Hz and above and verified through listening tests, was removed from the 1/3rd octave spectra for all measurements. The contribution from the wind turbine noise in those frequencies was evaluated as further discussed in Section 6.4.1.

A combination of automatic filtering and manual removal of the data was used to exclude intervals that were contaminated with extraneous noise from car passbys and other short-term events.

#### 5.3.3 Representative Ambient Conditions

The conditions present during the *Total Noise* and *Background* periods must be from similar weather and wind shear conditions, per Protocol section D3.8.2:

> ***D3.8.2 Overall equivalent sound level – wind turbines parked***
>
> *"Ambient noise measurements should be performed with the turbines parked and conducted within the same general measurement period and with the same weather and wind shear conditions. Measurements of ambient noise obtained during other periods are not recommended and should only be used with great caution to ensure that they represent the "current" ambient noise."*

*Background* measurements were collected periodically throughout the measurement campaign to ensure the *Background* and *Total Noise* measurements were collected during similar conditions in the same seasons.

#### 5.3.4 Adjacent Wind Facilities

No additional wind facilities were present in the area adjacent the receptor location.

### 5.4 Compliance Criteria

The minimum criteria required for an assessment of compliance per the Compliance Protocol are detailed in this section.

### 5.4.1 Sample Size Requirements

Requirements per the RAM-I methodology of the Compliance Protocol (Section E5.5) are used for this audit. Per Section E5.5 of the Protocol, an assessment dataset is considered complete if at least three wind bins from 1 – 7 m/s (inclusive) or two wind bins from 1 – 4 m/s (inclusive) are complete. A wind bin is considered complete if there are at least 60 valid *Total Noise* and 30 valid *Background* intervals.

For the purposes of the tonal audibility analysis of these far field measurements, per Section D3.8.3 of the protocol, a wind bin is considered complete if there are at least five (5) intervals for *Total Noise* and *Background.*

### 5.4.2 Sound Level Limits

Sound level limits vary with 10m-AGL wind speed and by class designation. The area surrounding the South Kent Wind Project site has previously been designated as Class 3. Exclusion limits for a Class 3 area are summarized in Table 8 below.

Table 8: MECP Exclusion Limits (Class 3)

| Wind speed at 10 m height, 10m-AGL (m/s) | Sound Level Exclusion Limit (dBA) |
|---|---|
| ≤ 6 | 40 |
| 7 | 43 |

These sound level limits apply to points of reception. Given that the predicted impact at the monitoring location is greater than the predicted impact at the receptor (see Table 3, Section 4.2), results at the monitor are conservative and can be used to show compliance at the receptor.

Sections D3.5 and D6 of the Protocol also note that where the measured *Background* sound level exceeds the exclusion limits, the sound level limit for that wind bin is the *Background* sound level without extraneous noise sources. Wind bins where the measured *Background* sound level exceed the exclusion limits are noted in Table 13.

### 5.4.3 Tonal Penalty

Any applicable tonal penalties are based on the mean tonal audibility for each wind bin and are calculated according to Annex C of ISO 1996-2-2007, per Section E5.5.2 of the Protocol. The penalty scheme is summarized in Table 9 below.

Table 9: Calculation of Applicable Tonal Penalty

| Mean Audibility, ΔL | Tonal Adjustment, $K_T$ |
|---|---|
| ΔL ≤ 4 dB | 0 dB |
| 4 dB < ΔL ≤ 10 dB | ΔL-4 dB |
| 10 dB < ΔL | 6 dB |

### 5.5 Deviations

Any deviations from the methods prescribed in the Protocol are discussed in this section.

#### 5.5.1 Measurement Bandwidth

As noted in Table 6, the measurement bandwidth used is 20 – 10,000 Hz. This is a deviation from the Protocol Section D2.1.1 requirement of a 20 – 20,000 Hz frequency response. Due to the high attenuation of noise levels at high frequencies, noise at the receptor from the wind facility above 10,000 Hz will be insignificant[4].

#### 5.5.2 Measurement Intervals

Sound levels were measured in 10 second intervals (i.e. sound level measurements were based on a 10 second averaging time) as permitted by Section E5.5(7) of the Protocol. The RAM-I Audit data count requirements of 60 valid Total Noise and 30 valid Background intervals are applicable for 10 second data intervals as determined in consultation with the MECP (initially discussed in a conference call dated January 14, 2019 and further confirmed in a meeting dated January 16, 2020).

## 6 Audit Results

Sound levels and weather conditions measured throughout the course of the I-Audit campaign are summarized in the following sections.

### 6.1 Audit Duration

The length of the monitoring campaign is summarized in Table 10 below.

Table 10: Length of Monitoring Campaign

| Audit Receptor | Audit Start Date | Audit End Date | Monitoring Duration (weeks) |
|---|---|---|---|
| R4248 | November 3, 2019 | February 7, 2020 | 14 |

### 6.2 Weather Conditions

Throughout the measurement campaign, a variety of weather conditions were encountered. The range of weather conditions measured in the assessment dataset are summarized in Table 11. Note that the assessment dataset includes the *Total Noise* and *Background* data that remains after filtering.

[4] From Table 2 of ISO 9613-2, acoustic frequencies above 8 kHz experience attenuation from atmospheric absorption alone of more than 80 dB/km.

Table 11: Range of Weather Conditions in Assessment Dataset

| Audit Receptor | Atmospheric Pressure (hPa) | 10m-AGL Wind Speed (m/s) | Relative Humidity (%) | Temperature (°C) | Hub-Height Wind Speed (m/s) |
|---|---|---|---|---|---|
| R4248 | 967 – 1012 | 0.1 – 10.5 | 53 – 88 | -9 – 9 | 2.0 – 15.1 |

During the audit period, the predominant wind direction was measured to be from the south-west. A wind rose detailing the measured wind directions observed during the entire measurement campaign is provided in Figure 2. Note that wind directions shown on the wind rose indicate the direction the wind is coming from. The purple shaded region represents the downwind condition from the test turbine at the monitor location.

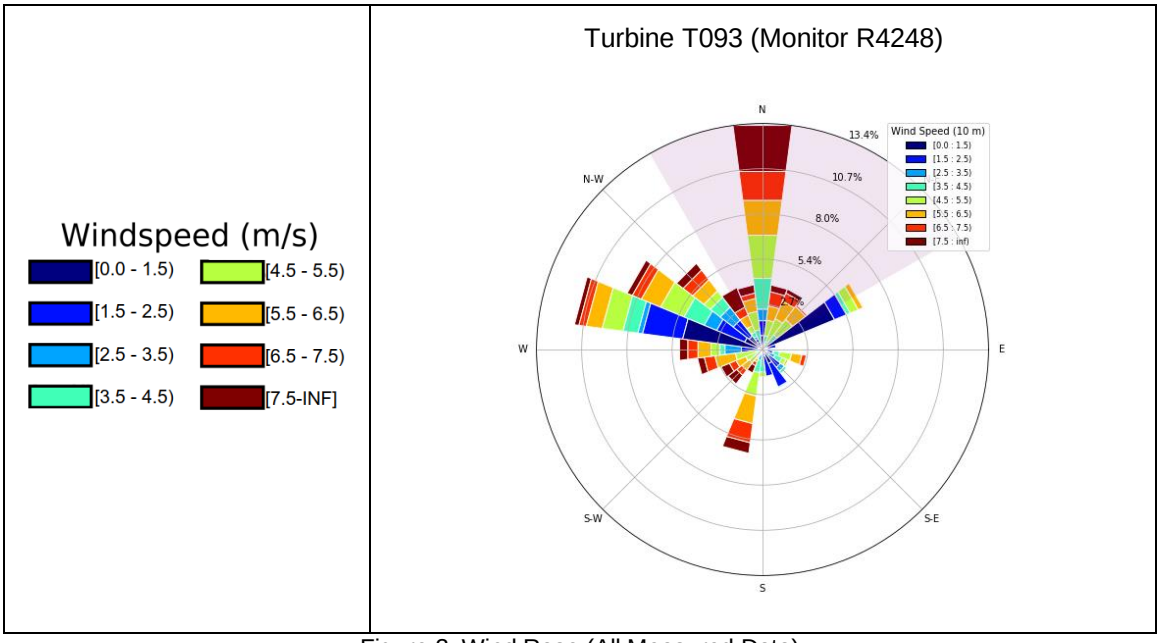


Figure 2: Wind Rose (All Measured Data)

From Figure 2, the distribution of wind directions observed during the measurement campaign is similar to those expected based on the historical wind rose provided in Section 4.1.1. Wind roses for the assessment dataset are included in Appendix C.

### 6.3 Data Excluded due to Filtering Criteria

A range of power output and wind conditions were measured over the course of the audit campaign. Table 12 provides the amount of time during the measurements (between 9pm and 6am) where the two main filtering conditions (high turbine power and downwind conditions) were met, i.e. the percentage of time during the measurement campaign that a receptor experienced the maximum noise impact from the South Kent Wind Project facility.

Table 12: Prevalence of Suitable Turbine Conditions During Measurements

| Audit Receptor | Test Turbine | Prevalence of Downwind | Prevalence of High Output (>85% power) | Prevalence of Downwind and High Output |
|---|---|---|---|---|
| R4248 | T093 | 25% | 15% | 3% |

These conditions represent the minimum requirements for valid *Total Noise* intervals. The additional filters discussed in Section 5.3 further reduced the assessment dataset.

### 6.4 Measured Sound Levels

Average measured sound levels by wind bin for *Total Noise* and *Background* periods are presented in Table 13 below. As noted in Section 5.3, the sound pressure level assessment dataset was filtered based on a minimum power threshold of 85% of the maximum turbine power output.

Table 13: Average Measured Sound Levels, RAM-I Analysis

| Audit Receptor | Period | Measurement Parameter | Wind Bin (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| R4248 | Total Noise | Number of Samples | 0 | 0 | 0 | 4 | 53 | 254 | 202 |
| | | Average $L_{Aeq}$ (dBA) | - | - | - | - | 42 | 43 | 46 |
| | | Standard Deviation (dB) | - | - | - | - | 0.8 | 1.1 | 1.5 |
| | Background | Number of Samples | 379 | 131 | 22 | 70 | 144 | 109 | 61 |
| | | Average $L_{Aeq}$ (dBA) | 28 | 30 | - | 34 | 36 | 41† | 44† |
| | | Standard Deviation (dB) | 2.7 | 3.1 | - | 1.2 | 1.7 | 2.0 | 1.7 |

- Sound level not reported in wind bin if significantly fewer data points were collected than the minimum sample size outlined in Section 5.4.1.

† Measured *Background* sound level is higher than the MECP exclusion limit in the wind bin.

It should be noted that the sound levels presented here are rounded to the nearest integer; all calculations and analysis are conducted using the un-rounded sound levels.

Measurement data points from Table 13 are also plotted in Figure 3 below.

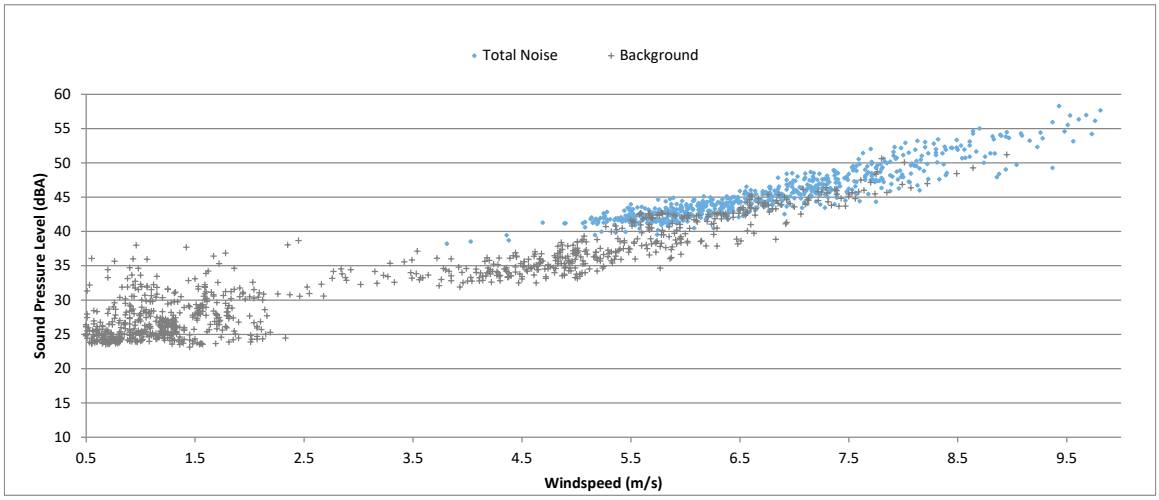


Figure 3: Average Measured Total Noise and Background Sound Levels
Monitor Near R4248

### 6.4.1 Tonal Adjustment

Tonal audibility results for R4248 in the far field of T093 are presented in Table 14 below. As noted in Section 5.3, the tonal assessment dataset was filtered based on a minimum power threshold of 1489 kW.

Table 14: Tonality Assessment Table

| Centre Frequency | Tonality Parameter | Wind Bin (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 430 Hz | Data Points in Wind Bin | 0 | 0 | 0 | 4 | 102 | 396 | 319 |
| | Data Points with Detected Tone | 0 | 0 | 0 | 1 | 27 | 58 | 58 |
| | Tonal Presence | 0 | 0 | 0 | 25% | 26% | 15% | 18% |
| | Mean Tonal Audibility, ΔL (dB) | - | - | - | - | -5.5 | -5.5 | -4.3 |
| | Tonal Adjustment, $K_T$ (dB) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

- Sound level not reported in wind bin if minimum sample size (5) not met.

As shown in Table 14, the tonal audibilities in all bins were found to be below the 4 dB threshold for tonal penalties. As a result, no tonal penalty is applicable in any wind bin.

### 6.4.2 Other Adjustments

As noted in Section 5.3.2, the 1/3$^{rd}$ octave band frequencies of 3150 Hz and above were removed from the assessment dataset due to contamination from cricket noise. The contribution from the wind facility at these excluded frequencies was determined at the monitor location by calculating the partial noise impact from the facility in the excluded frequency range. The impact from the facility at 3150 Hz and above was determined to be 10.0 dBA at the monitor, which is considered negligible.

### 6.5 Turbine-Only Sound Levels

The average measured sound levels by wind bin for *Total Noise* and *Background* periods are presented in Table 15.

Table 15: Calculated Turbine-Only Sound Levels, RAM-I Analysis

| Audit Receptor | Measurement Period | Wind Bin (m/s) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| R4248 | Total Noise (dBA) | - | - | - | - | 42 | 43 | 46 |
| | Background (dBA) | 28 | 30 | - | 34 | 36 | 41† | 44† |
| | Signal to Noise (dBA) | - | - | - | - | 5.3 | 2.2 | 2.0 |
| | Turbine-Only (dBA) [monitor location] | - | - | - | - | 40 | 39* | 42* |
| | Tonal Adjustment | - | - | - | - | 0 | 0 | 0 |

- Sound level not reported in wind bin if significantly fewer data points were collected than the minimum sample size outlined in Section 5.4.1.

† Measured background sound level is higher than the MECP exclusion limit in the wind bin.

* Signal-to-noise level less than 3 dB. Increased uncertainty in determination of Turbine-Only Sound Impact.

As discussed in Section 6.3, less than 3% of the measurement data met the turbine operational power and wind direction requirements due to infrequent downwind conditions at the receptor location. As a result, limited data was collected throughout the campaign, with only 53 *Total Noise* data points collected in the 5 m/s wind bin. Based on feedback from the MECP in an email dated January 24, 2020 and in accordance with Section E5.5.5 of the Protocol, the Ministry would consider accepting fewer data points provided the standard deviation requirements in Section D5.2.3 of the Protocol are satisfied. As per Section D5.2.3, the objective value for the standard deviation of the sound level in each wind bin is 2 dB. As shown in Table 13 above, the *Total Noise* measurement data in the 5 m/s wind bin meets this requirement, with a standard deviation of 0.8. In addition, as shown in Table 15 above, there was a high signal-to-noise ratio of 5.3 between the measured *Total Noise* and *Background* levels at 5 m/s, indicating low uncertainty in the determination of the Turbine-Only sound impact at the monitor. Based on the standard deviation and signal-to-noise ratio, the data quality is satisfactory to assess compliance at 5 m/s with the reduced data count.

Also shown in Table 17 above, the signal to noise ratio was below 3 dB in the 6 m/s and 7 m/s wind bins. As a result, there is an increased uncertainty in the determination of the Turbine-Only sound impact at the monitor for these wind bins. However, the standard deviations of the *Total Noise* data at all wind bins is below 2 dB, which indicates that the signal has low variation in the measured level.

# 7 Assessment of Compliance

This section provides the results of the measurements and calculations as they pertain to the determination of compliance of the facility in accordance with the criteria listed in Section 5.4 of this report.

### 7.1 Assessment Table

Table 16 compares the final Turbine-Only sound levels for each wind bin at the Receptor location to the applicable exclusion limits and background sound levels. Final Turbine-Only sound levels at the Point of Reception are calculated by taking the Turbine-Only sound level at the measurement location and applying any applicable adjustments as indicated in Table 15.

Table 16: Assessment Table

| Audit Receptor | Wind speed at 10m-AGL (m/s) | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| **R4248** | Turbine-Only Sound Level (dBA) | - | - | - | - | 40 | 39* | 42* |
| | *Background Sound Level (dBA)* | *28* | *30* | *-* | *34* | *36* | *41†* | *44†* |
| MECP Exclusion Limit (dBA) | | 40 | 40 | 40 | 40 | 40 | 40 | 43 |
| Compliance? (Y/N) | | - | - | - | - | Yes | Yes | Yes |

- Sound level not reported in wind bin if significantly fewer data points were collected than the minimum sample size outlined in Section 5.4.1.

† Measured background sound level is higher than the MECP exclusion limit in the wind bin.

* Signal-to-noise level less than 3 dB. Increased uncertainty in determination of Turbine-Only Sound Impact.

### 7.2 Statement of Compliance

Based on the Receptor Turbine-Only sound levels presented in Table 16, sound immission levels at the audited receptor are in compliance with the applicable sound level limits.

# 8 Conclusion

Aercoustics was retained by South Kent Wind LP to complete an additional supporting I-Audit at the worst-case receptor of turbine T093, in response to the E-Audit test submitted December 21, 2018 and reviewed by the MECP.

The additional I-Audit measurements were conducted in accordance with the MECP Compliance Protocol for Wind Turbine Noise from November 3, 2019 to February 7, 2020 at receptor R4248 near T093.

Based on the results presented in this report, the assessment requirements outlined in the Compliance Protocol have been met and the cumulative sound impact calculated at R4248 complies with the MECP sound level limits at all wind bins with sufficient data for assessment.

# Appendix A
Site Details


## Legend

- Ontario HWY 401
- Campaign Monitor
- Spring 2015 Campaign Monitor
- Receptor Locations
- South Kent Turbines

Third Party Turbines

- Talbot
- Chatam
- Front Line
- Port Alma
- Bisnett Line
- Raleigh
- Erieau Blenheim

N

| | |
|---|---|
| **Project ID:** | 13228.02 |
| **Drawn by:** | AA |
| **Reveiwed by:** | AD |
| **Date:** | February 12, 2020 |
| **Revision:** | 1 |
| **Scale:** | As Indicated |

South Kent Wind Project
Immission Audit Report
R4248 - T093

# Appendix A.1

Site Plan Overview

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## Legend

- Campaign Receptor
- Campaign Monitor
- South Kent Turbines
- Kent Bridge Road

N

| | |
|---|---|
| **Project ID:** | 13228.02 |
| **Drawn by:** | AA |
| **Reveiwed by:** | AD |
| **Date:** | November 29, 2019 |
| **Revision:** | 1 |
| **Scale:** | As Indicated |

South Kent Wind Project
Immission Audit Report
R4248 - T093

# Appendix A.2

Monitor and Receptor Location

aercoustics

| | |
|---|---|
| **Project ID:** | 13228.02 |
| **Drawn by:** | AA |
| **Reveiwed by:** | AD |
| **Date:** | November 29, 2019 |
| **Revision:** | 1 |
| **Scale:** | As Indicated |

South Kent Wind Project
Immission Audit Report
R4248 - T093

# Appendix A.3

Monitor to T093

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# Appendix B
Statement from the Operator

**SP South Kent Wind LP**
2050 Derry Road West
2nd Floor
Mississauga, ON L5N 0B9
www.southkentwind.com

August 14, 2020

Director, Environmental Approvals Access and Service
Integration Branch Ministry of Environment
2 St. St Clair Avenue West, Floor 12A
Toronto ON M4V 1L5

Subject: South Kent Wind Project (REA #2871-8UKGPC) Receptor Emission Audit 2019-2020

Dear Director

Please accept this letter as confirmation that all turbines tested during the acoustics measurement campaign conducted by Aercoustics Engineering Limited from November 3, 2019 to February 7, 2020 were operating normally for the duration of the campaign, with the exception of specific time periods during which the turbines were placed in remote owner stop to facilitate ambient noise measurements.

The turbines placed in remote owner stop for ambient measurements were different depending on the receptor targeted, and were as follows:

- R4248: T001, T002, T003, T004, T006, T093, T102, T138, T152, T166, T167

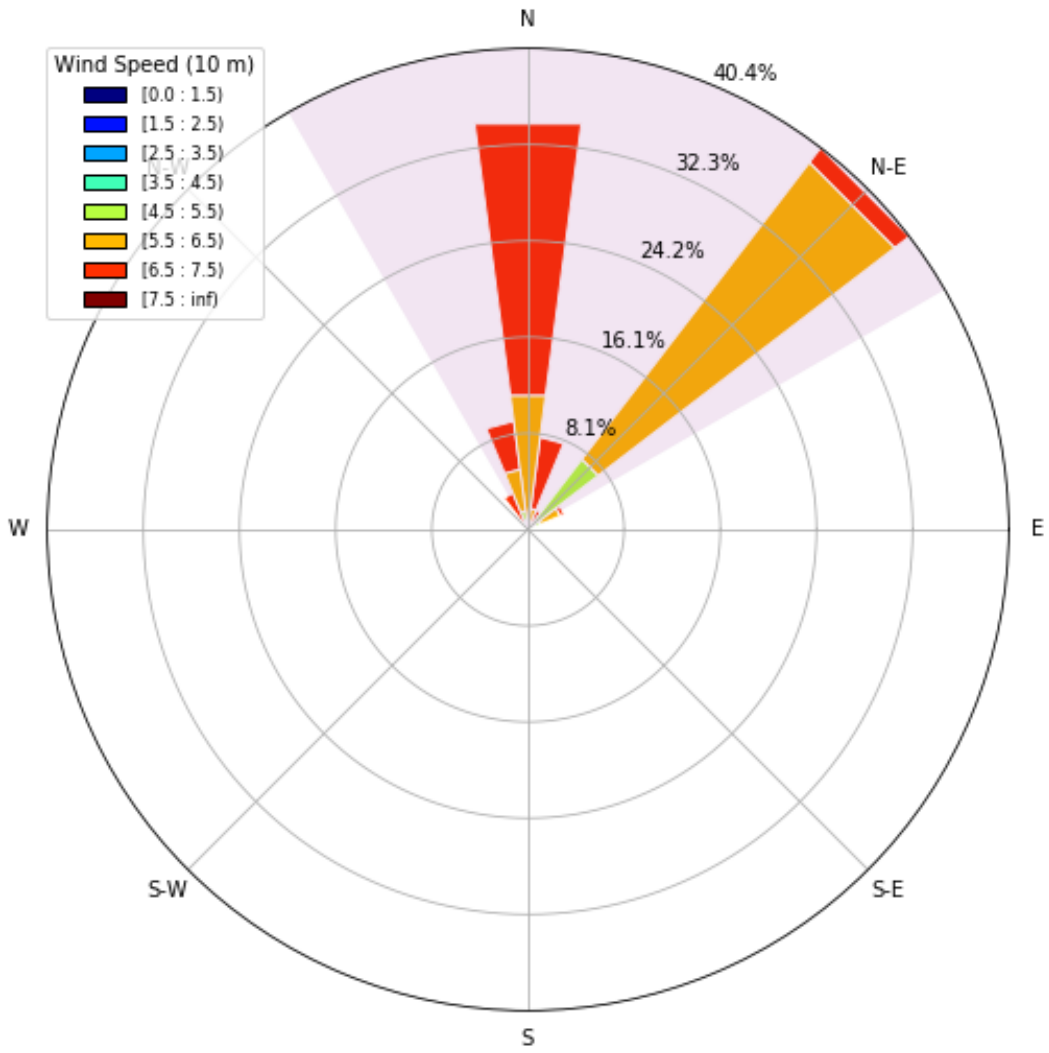
The turbines verified for operational measurements were different depending on the receptor targeted, and were as follows:

- R4248: T001, T002, T003, T004, T006, T093, T102, T138, T152, T166, T167

Sincerely,

Kevin Aikenhead
Facility Manager
South Kent Wind
C: 519-350-9373

# Appendix C
Wind Roses




## Legend

**Turbine Downwind Direction**

| | |
|---|---|
| **Project ID:** | 13228.02 |
| **Drawn by:** | AA |
| **Reveiwed by:** | AD |
| **Date:** | August 11, 2020 |
| **Revision:** | 1 |
| **Scale:** | As Indicated |

South Kent Wind Project
Immission Audit Report
R4248 - T093

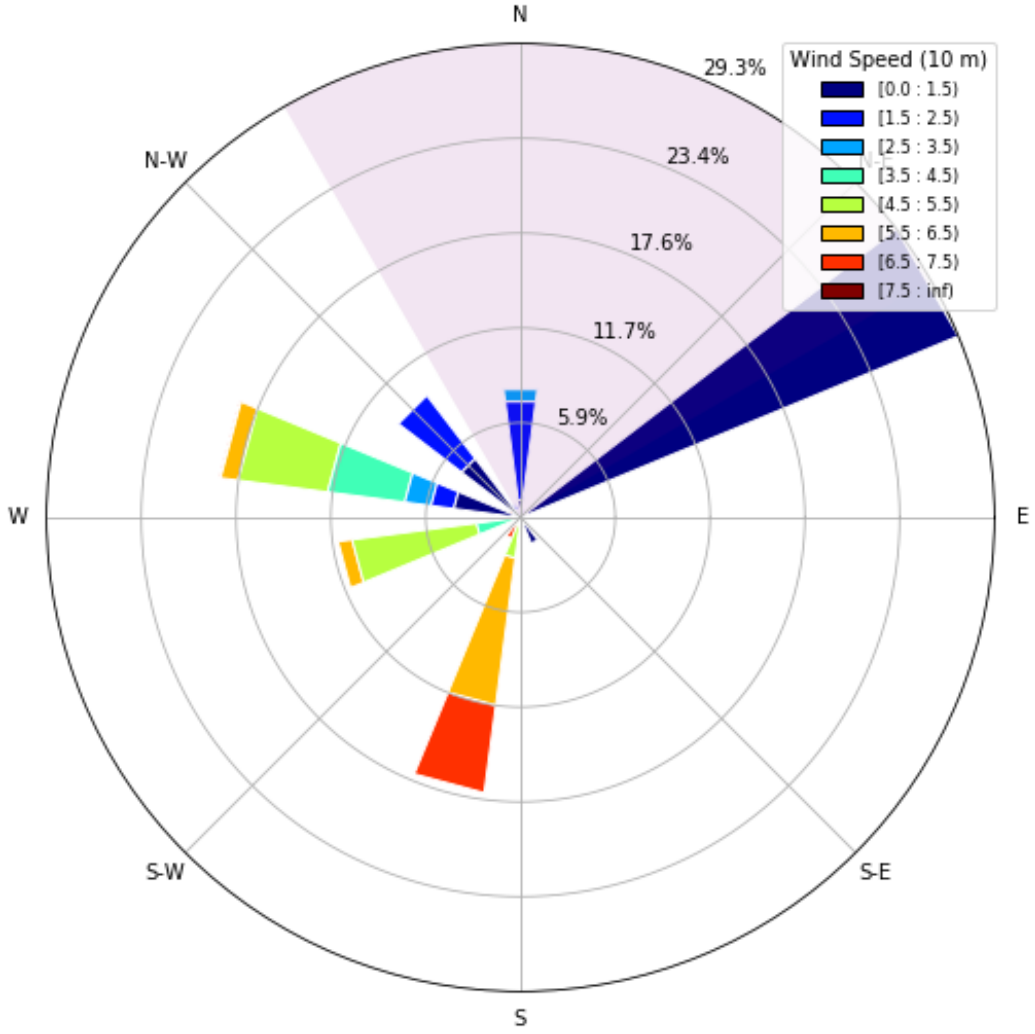
# Appendix C.1

Supplementary Wind Rose based on Assessment Data Total Noise

aercoustics

## Legend

**Turbine Downwind Direction**




| | |
|---|---|
| **Project ID:** | 13228.02 |
| **Drawn by:** | AA |
| **Reveiwed by:** | AD |
| **Date:** | August 11, 2020 |
| **Revision:** | 1 |
| **Scale:** | As Indicated |

South Kent Wind Project
Immission Audit Report
R4248 - T093

# Appendix C.2

Supplementary Wind Rose based on Assessment Data Background Noise

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# Appendix D
Calibration Certificates

## CALIBRATION CERTIFICATES

Details are disclosed in the table below regarding the calibration of the equipment used for the Immission Audit at monitor location R4248. The associated calibration certificates are provided in this appendix.

| Audit Receptor | Equipment | Make/Model | Serial Number | Date of Last Calibration |
|---|---|---|---|---|
| R4248 | Data Acquisition Card | NI 9234 | 1C009CD | May 7, 2019 |
| | Signal Conditioner | PCB 480E09 | 32814 | April 3, 2019 |
| | Microphone | PCB 377B02 | 153972 | August 9, 2019 |
| | Pre-Amplifier | PCB 426E01 | 38879 | August 9, 2019 |
| | Weather Anemometer | Vaisala WXT520 | L0910581 | July 11, 2019 |

# *CERTIFICATE of CALIBRATION*

| | | | |
|---|---|---|---|
| Make : | PCB Piezotronics | Reference # : | 158299 |
| Model : | 378B02 | Customer : | Aercoustics Engineering Ltd<br>Mississauga, ON |
| Descr. : | Microphone System 1/2" Free Field | | |
| Serial # : | 120183 | P. Order : | 2019.08.07C |
| Asset # : | 00155 | | |

Cal. status : Received in spec's, no adjustment made.
Preamp System with Mic 377B02 s/n 153972

*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 Quality System system complies with the requirements of ISO-9001-2015 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, 2019 By : Petro Onasko

Cal. Due : Aug 09, 2021

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

Standards used : J-216 J-324 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 : 800-668-7440 Fax: 905 565 8325 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: 378B02 | Approved by: JR | Feb-16 | Ver 1.0 |
|---|---|---|---|

Calibration Report for Certificate : 158299

| Make | | | Model | Serial | Asset | | |
|---|---|---|---|---|---|---|---|
| PCB Piezotronics | | | 378B02 | 120183 | 00155 | | |
| PCB Piezotronics | | | 426E01 | 038879 | 00155 | | |
| PCB Piezotronics | | | 377B02 | 153972 | 00155 | | |

Sensitivity at 250 Hz

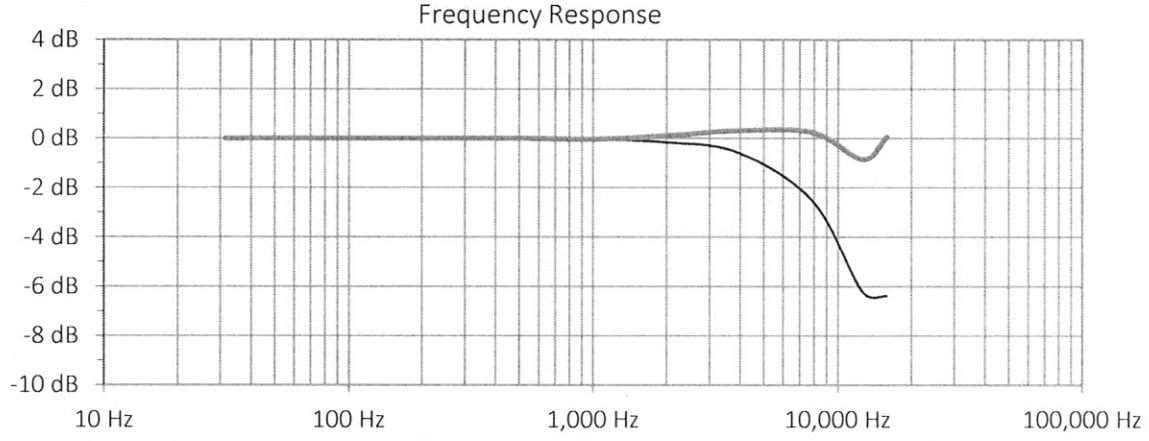
| Specs Nom | Unit | | Min | Reading | Max | | In/Out |
|---|---|---|---|---|---|---|---|
| 50 | mV/Pa | | 39.72 | 52.62 | 62.94 | | In |
| -26.02 | dB re 1V/Pa | | -28.02 | -25.58 | -24.02 | | In |
| 0 | dB re 50mV/Pa | | -2 | 0.44 | 2 | | In |

Ambient Conditions:

| | |
|---|---|
| Static Pressure | 98.7 kPa |
| Temperature | 24.8°C |
| Rel.Humidity | 44.0% |

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 | -0.01 | -0.01 | |
| 1005.1 | -0.06 | -0.04 | |
| 1978.7 | -0.15 | 0.10 | |
| 3957.5 | -0.59 | 0.31 | |
| 7914.9 | -2.56 | 0.23 | |
| 12663 | -6.24 | -0.85 | |
| 15830 | -6.39 | 0.05 | |



# West Caldwell Calibration Laboratories Inc.

# Certificate of Calibration

for

ICP SENSOR SIGNAL CONDITIONER

| | |
|---|---|
| Manufactured by: | PCB PIEZOTRONICS |
| Model No: | 480E09 |
| Serial No: | 32814 |
| Calibration Recall No: | 29794 |

Submitted By:

Customer:

Company: Aercoustics Engineering LTD.
Address:

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

West Caldwell Calibration Laboratories Procedure No. 480E09 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 requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2015 and ISO 17025.

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

Calibration Date: 03-Apr-19

Certificate No: 29794 -1

Approved by:

James Zhu

Quality Manager
ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01



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

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

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

# REPORT OF CALIBRATION

for

**PCB Piezotronics ICP Signal Conditioner** **Model No.: 480E09** **Serial No.: 32814**
**Company: Aercoustics Engineering LTD.** **ID No.: XXXX**

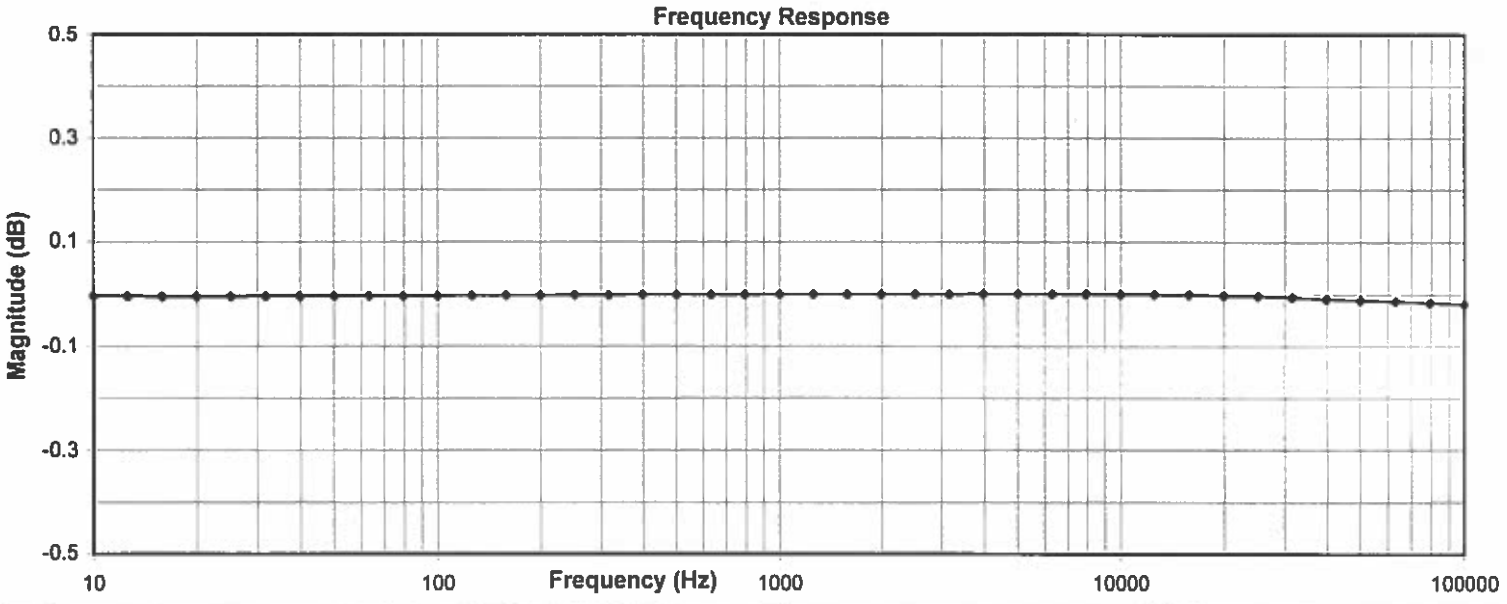
Calibration results:

| | |
|---|---|
| **Before & after data same:** | ...X... |
| **DC Current and voltage:** | **Pass** |
| **Gain:** | **Pass** |
| **Noise:** | **Pass** |
| **Distortion:** | **Pass** |
| **Freq. Response:** | **Pass** |
| **All tests:** | **Pass** |

| Laboratory Environment: | | |
|---|---|---|
| Ambient Temperature: | 20.1 | °C |
| Ambient Humidity: | 36.1 | % RH |
| Ambient Pressure: | 99.080 | kPa |
| Calibration Date: | 3-Apr-2019 | |
| Calibration Due: | 3-Apr-2020 | |
| Report Number: | 29794 -1 | |
| Control Number: | 29794 | |

**The above listed instrument meets or exceeds the tested manufacturer's specifications.**
This Calibration is traceable through NIST test numbers: ,1010733
The absolute uncertainty of calibration: See last page. Unless otherwise noted, the reported values are both "as found" and "as left" data.

The curve is the response recorded with accelerometer simulated 100mV input @ X1 Position.




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 480E09PCB**
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 9001:2015, ISO 17025

Measurements performed by: MS
**Matthew Smith**

**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 ICP Signal Conditioner** **Model No.: 480E09** **Serial No.: 32814**
**Company: Aercoustics Engineering LTD.**

**Frequency Response ( Reference = 0 dB @ 1000Hz ) + - 0.2dB**

| Freq. (Hz) | Response [dB] | Freq. (Hz) | Response [dB] | Freq. (Hz) | Response [dB] |
|---|---|---|---|---|---|
| 10.00 | 0.00 | 316.23 | 0.00 | 10000.00 | 0.00 |
| 12.59 | 0.00 | 398.11 | 0.00 | 12589.25 | 0.00 |
| 15.85 | 0.00 | 501.19 | 0.00 | 15848.93 | 0.00 |
| 19.95 | 0.00 | 630.96 | 0.00 | 19952.62 | 0.00 |
| 25.12 | 0.00 | 794.33 | 0.00 | 25118.84 | 0.00 |
| 31.62 | 0.00 | 1000.00 | 0.00 | 31622.72 | -0.01 |
| 39.81 | 0.00 | 1258.93 | 0.00 | 39810.61 | -0.01 |
| 50.12 | 0.00 | 1584.89 | 0.00 | 50118.55 | -0.01 |
| 63.10 | 0.00 | 1995.26 | 0.00 | 63095.47 | -0.01 |
| 79.43 | 0.00 | 2511.89 | 0.00 | 79432.43 | -0.02 |
| 100.00 | 0.00 | 3162.28 | 0.00 | 99999.42 | -0.02 |
| 125.89 | 0.00 | 3981.07 | 0.00 | | |
| 158.49 | 0.00 | 5011.87 | 0.00 | | |
| 199.53 | 0.00 | 6309.57 | 0.00 | | |
| 251.19 | 0.00 | 7943.28 | 0.00 | | |

| Test | Function | | Tolerance Min | Tolerance Max | Measured values Data | Measured values Out |
|---|---|---|---|---|---|---|
| 1.0 | Current | | 1.8 | 4.2 | 2.93 | |
| | Voltage | | 15 | 30 | 26.58 | |
| 2.0 | Gain accuracy (dB) | X 1 | -0.2 | 0.2 | -0.03 | |
| | | X 10 | -0.2 | 0.2 | -0.03 | |
| | | X 100 | -0.2 | 0.2 | -0.03 | |
| 3.0 | Frequency response | See above | | | Pass | |
| 4.0 | Noise (uV) 2 to 22.4kHz | | | | Pass | |
| 5.0 | Distortion | | | | Pass | |

| Instruments used for calibration: | | | Date of Cal. | Traceability No. | Cal. Due Date |
|---|---|---|---|---|---|
| HP | 33120A | S/N SG400116 | 19-Jul-2018 | ,1010733 | 19-Jul-2019 |
| Brüel & Kjær | 2636 | S/N 1487493 | 17-Jul-2018 | 683/290345-18 | 17-Jul-2019 |
| HP | 34401A | S/N US361025 | 19-Jul-2018 | ,1010733 | 19-Jul-2019 |

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

| Parameter | Test Instrumentation Uncertainty | DUT Uncertainty | Total DUT Uncertainty |
|---|---|---|---|
| Electrical Frequency Response(10 Hz to 20 kHz): | 0.024 | 0.1 | 0.124 |
| Electrical Frequency Response(10 kHz to 50 kHz): | 0.04 | 0.1 | 0.14 |
| Electrical Frequency Response(50 kHz to 100 kHz): | 0.06 | 0.1 | 0.16 |
| Random Noise Measure (100 Hz to 10 kHz): | 0.3 | 0.1 | 0.40 |
| DC Voltage Measure (10 V to 100 V): | 0.20 % | | |
| DC Current Measure (0.1 A to 1 A): | 0.039 % | | |
| AC Voltage Measure (1 V)(40 Hz to 1 kHz): | 0.011 % | | |
| AC Voltage Measure (1 V)(1 kHz to 20 kHz): | 0.022 % | | |

Cal. Date: 3-Apr-2019 Tested by: Matthew Smith

Calibrated on WCCL system type 9700

# Compliant Calibration Certificate

Template Revision: Feb2018

| | | | |
|---|---|---|---|
| **Certificate Number:** | 6017443.1 | **OE Number:** | 21666323 |
| **Date Printed:** | 07-MAY-2019 | **Page:** | 1 of 14 |
| **Customer:** | Aercoustics Engineering LTD (CA)<br>1004 Middlegate Road<br>Suite 1100<br>ONTARIO MISSISSAUGA, L4Y 0G1<br>CANADA | | |
| **Manufacturer:** | National Instruments | **Model:** | NI 9234 |
| **Serial Number:** | 1C009CD | | |
| **Part Number:** | 195551C-01L | **Description:** | MODULE ASSY,NI 9234, 4 AI CONFIGURABLE |
| **Calibration Date:** | 07-MAY-2019 | **Recommended Calibration Due:** | 07-MAY-2020 |
| **Procedure Name:** | NI 9234 | **Verification Results:** | As Found: Passed<br>As Left: Passed |
| **Procedure Version:** | 3.6.1.0 | **Calibration Executive Version:** | 4.6.2.0 |
| **Lab Technician:** | Rachel McKinnon | **Driver Info:** | NI-DAQmx:17.6.0 |
| **Temperature:** | 23.0° C | **Humidity:** | 42.5% RH |

NATIONAL INSTRUMENTS
CALIBRATED
SN/ID 1C009CD
DATE 07-MAY-2019
DUE 07-MAY-2020
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'.



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**

**Ted Talley**
**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 | 5720A | Calibrator | 9379 | 09-JUL-2019 | |
| National Instruments | PXI-4461 | Function generator | 9520 | 20-AUG-2019 | |
| National Instruments | PXI-4071 | Digital multimeter | 9083 | 25-JUN-2019 | |
| National Instruments | PXI-4132 | SMU | 9170 | 06-MAY-2020 | |

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 | 3.99979 V | 4.00480 V | Passed | |
| -5 V | 5 V | 0 | 0.00000 V | -0.00120 V | -0.00003 V | 0.00120 V | Passed | |
| -5 V | 5 V | 0 | -4.00000 V | -4.00480 V | -3.99987 V | -3.99520 V | Passed | |
| -5 V | 5 V | 1 | 4.00000 V | 3.99520 V | 3.99988 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 | -3.99986 V | -3.99520 V | Passed | |
| -5 V | 5 V | 2 | 4.00000 V | 3.99520 V | 3.99987 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 | -3.99981 V | -3.99520 V | Passed | |
| -5 V | 5 V | 3 | 4.00000 V | 3.99520 V | 3.99980 V | 4.00480 V | Passed | |
| -5 V | 5 V | 3 | 0.00000 V | -0.00120 V | -0.00002 V | 0.00120 V | Passed | |
| -5 V | 5 V | 3 | -4.00000 V | -4.00480 V | -3.99984 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 | -0.000 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 | 0.005 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 | -0.056 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 | 76.144 dB | 100.000 dB | Passed | |
| 1 | 51200 | 16384 | 1000 Hz | 40.000 dB | 74.217 dB | 100.000 dB | Passed | |
| 2 | 51200 | 16384 | 1000 Hz | 40.000 dB | 75.057 dB | 100.000 dB | Passed | |
| 3 | 51200 | 16384 | 1000 Hz | 40.000 dB | 75.459 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 | 2.080 mA | 2.200 mA | Passed | |
| 1 | 51200 | 0.01 A | 2.000 mA | 2.000 mA | 2.069 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 | 20.883 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 | 20.886 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 | -0.00001 V | 0.00120 V | Passed | |
| -5 V | 5 V | 0 | -4.00000 V | -4.00480 V | -4.00000 V | -3.99520 V | Passed | |
| -5 V | 5 V | 1 | 4.00000 V | 3.99520 V | 4.00003 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 | -3.99998 V | -3.99520 V | Passed | |
| -5 V | 5 V | 2 | 4.00000 V | 3.99520 V | 4.00000 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 | -3.99999 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 | -0.00000 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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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 | -0.056 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 | 78.036 dB | 100.000 dB | Passed | |
| 1 | 51200 | 16384 | 1000 Hz | 40.000 dB | 75.809 dB | 100.000 dB | Passed | |
| 2 | 51200 | 16384 | 1000 Hz | 40.000 dB | 78.247 dB | 100.000 dB | Passed | |
| 3 | 51200 | 16384 | 1000 Hz | 40.000 dB | 77.294 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 | 2.070 mA | 2.200 mA | Passed | |
| 1 | 51200 | 0.01 A | 2.000 mA | 2.000 mA | 2.069 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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**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 | 20.881 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 | 20.886 V | 24.000 V | Passed | |

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NATIONAL INSTRUMENTS

**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

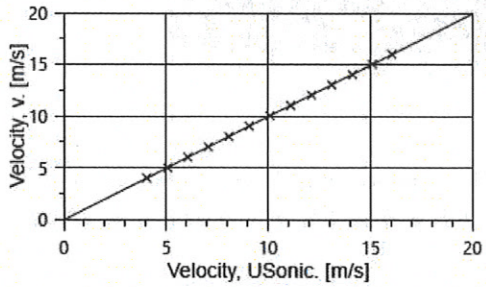
**Certificate number:** 19.US2.06160 **Date of issue:** July 08, 2019
**Type:** Vaisala Weather Transmitter, WXT520 **Serial number:** L0910581
**Manufacturer:** Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
**Client:** Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

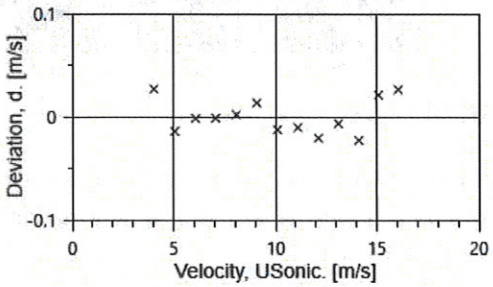
**Anemometer received:** July 11, 2019 **Anemometer calibrated:** July 08, 2019
**Calibrated by:** MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
**Certificate prepared by:** EJF **Approved by:** Calibration engineer, EJF

**Calibration equation obtained:** $v$ [m/s] = 0.99859 · U [m/s] + -0.05112

**Standard uncertainty, slope:** 0.00132 **Standard uncertainty, offset:** -0.27724
**Covariance:** -0.0000175 (m/s)²/m/s **Coefficient of correlation:** ρ = 0.999990
**Absolute maximum deviation:** 0.027 m/s at 4.010 m/s
**Barometric pressure:** 1004.1 hPa **Relative humidity:** 47.3%

| Succession | Velocity pressure, q. [Pa] | Temperature in wind tunnel [°C] | d.p. box [°C] | Wind velocity, $v$. [m/s] | Anemometer Output, U. [m/s] | Deviation, d. [m/s] | Uncertainty $u_c$ (k=2) [m/s] |
|---|---|---|---|---|---|---|---|
| 2 | 9.38 | 25.1 | 27.2 | 4.010 | 4.0400 | 0.027 | 0.023 |
| 4 | 14.58 | 25.1 | 27.2 | 5.000 | 5.0724 | -0.014 | 0.026 |
| 6 | 21.10 | 25.1 | 27.2 | 6.015 | 6.0767 | -0.002 | 0.030 |
| 8 | 28.66 | 25.1 | 27.2 | 7.011 | 7.0733 | -0.001 | 0.034 |
| 10 | 37.49 | 25.1 | 27.2 | 8.018 | 8.0783 | 0.002 | 0.038 |
| 12 | 47.61 | 25.1 | 27.2 | 9.036 | 9.0867 | 0.013 | 0.043 |
| 13-last | 58.65 | 25.1 | 27.2 | 10.029 | 10.1069 | -0.013 | 0.047 |
| 11 | 71.02 | 25.1 | 27.2 | 11.036 | 11.1133 | -0.010 | 0.051 |
| 9 | 84.53 | 25.1 | 27.2 | 12.041 | 12.1300 | -0.021 | 0.056 |
| 7 | 99.09 | 25.1 | 27.2 | 13.037 | 13.1133 | -0.007 | 0.060 |
| 5 | 114.81 | 25.1 | 27.2 | 14.033 | 14.1267 | -0.023 | 0.064 |
| 3 | 131.98 | 25.1 | 27.2 | 15.045 | 15.0967 | 0.021 | 0.069 |
| 1-first | 149.54 | 25.0 | 27.2 | 16.013 | 16.0600 | 0.026 | 0.073 |




AC-1746

## EQUIPMENT USED

| Serial Number | Description |
|---|---|
| Njord2 | Wind tunnel, blockage factor = 1.0035 |
| 13924 | 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. |
| DP008 | Setra Model 239, 0-1inWC, differential pressure transducer |
| HY002 | Dwyer RHP-2D20, 0-10V Output, humidity transmitter |
| BP003 | Setra M278, 0-5VDC Output, barometer |
| PL3 | Pitot tube |
| XB001 | Computer Board. 16 bit A/D data acquisition board |
| Njord2-PC | PC dedicated to data acquisition |

The accuracies of all measurements were traceable to the SI through NIST or CIPM recognized NMI's.

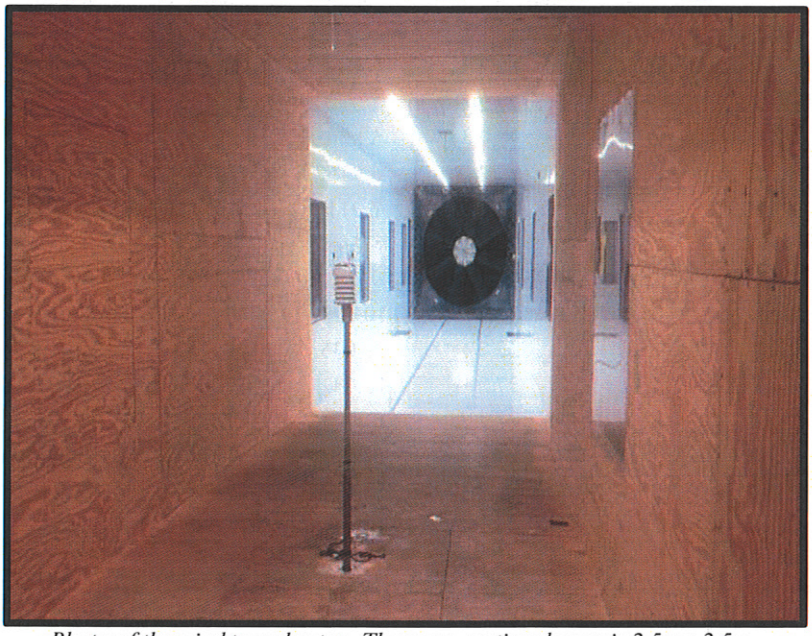


*Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.*

## 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 positioned at the 0° orientation during calibration.

**Certificate number:** 19.US2.06160

**SOH Wind Engineering LLC**
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# CERTIFICATE FOR CALIBRATION OF SONIC ANEMOMETER

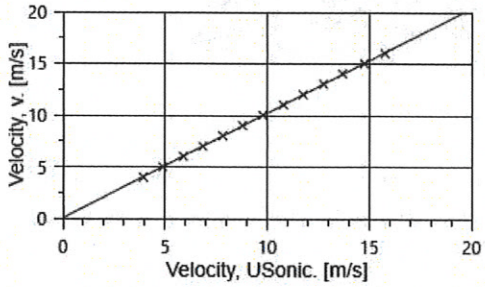
**Certificate number:** 19.US2.06159 **Date of issue:** July 08, 2019
**Type:** Vaisala Weather Transmitter, WXT520 **Serial number:** L0910581
**Manufacturer:** Vaisala, Oyj, Pl 26, FIN-00421 Helsinki, Finland
**Client:** Aercoustics Engineering Ltd., 1004 Middlegate RD, Suite 1100, S.Tower, Mississauga, ON L4Y 1M4, Canada

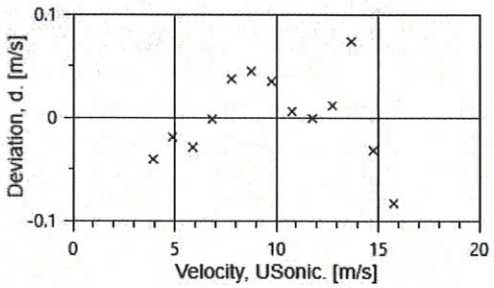
**Anemometer received:** July 11, 2019 **Anemometer calibrated:** July 08, 2019
**Calibrated by:** MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F
**Certificate prepared by:** EJF **Approved by:** Calibration engineer, EJF

**Calibration equation obtained:** $v$ [m/s] = 1.01811 · U [m/s] + 0.04684

**Standard uncertainty, slope:** 0.00323 **Standard uncertainty, offset:** 0.73496
**Covariance:** -0.0001059 (m/s)²/m/s **Coefficient of correlation:** $\rho = 0.999943$
**Absolute maximum deviation:** -0.083 m/s at 16.023 m/s
**Barometric pressure:** 1004.3 hPa **Relative humidity:** 47.9%

| Succession | Velocity pressure, q. [Pa] | Temperature in wind tunnel [°C] | d.p. box [°C] | Wind velocity, $v$. [m/s] | Anemometer Output, U. [m/s] | Deviation, d. [m/s] | Uncertainty $u_c$ (k=2) [m/s] |
|---|---|---|---|---|---|---|---|
| 2 | 9.36 | 24.9 | 27.4 | 4.004 | 3.9267 | -0.041 | 0.023 |
| 4 | 14.63 | 25.0 | 27.4 | 5.006 | 4.8897 | -0.019 | 0.026 |
| 6 | 21.13 | 25.0 | 27.4 | 6.018 | 5.8933 | -0.029 | 0.030 |
| 8 | 28.67 | 25.0 | 27.3 | 7.009 | 6.8400 | -0.002 | 0.034 |
| 10 | 37.68 | 25.0 | 27.3 | 8.035 | 7.8100 | 0.037 | 0.039 |
| 12 | 47.58 | 25.0 | 27.3 | 9.030 | 8.7800 | 0.045 | 0.043 |
| 13-last | 58.71 | 25.0 | 27.3 | 10.031 | 9.7724 | 0.035 | 0.047 |
| 11 | 71.09 | 25.0 | 27.3 | 11.038 | 10.7900 | 0.006 | 0.051 |
| 9 | 84.47 | 25.0 | 27.3 | 12.032 | 11.7733 | -0.001 | 0.056 |
| 7 | 99.40 | 25.0 | 27.3 | 13.053 | 12.7633 | 0.011 | 0.060 |
| 5 | 115.31 | 24.9 | 27.4 | 14.058 | 13.6900 | 0.074 | 0.064 |
| 3 | 131.95 | 24.9 | 27.4 | 15.039 | 14.7567 | -0.032 | 0.069 |
| 1-first | 149.80 | 24.8 | 27.5 | 16.023 | 15.7733 | -0.083 | 0.073 |




AC-1746

## EQUIPMENT USED

| Serial Number | Description |
|---|---|
| Njord2 | Wind tunnel, blockage factor = 1.0035 |
| 13924 | 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. |
| DP008 | Setra Model 239, 0-1inWC, differential pressure transducer |
| HY002 | Dwyer RHP-2D20, 0-10V Output, humidity transmitter |
| BP003 | Setra M278, 0-5VDC Output, barometer |
| PL3 | Pitot tube |
| XB001 | Computer Board. 16 bit A/D data acquisition board |
| Njord2-PC | PC dedicated to data acquisition |

The accuracies of all measurements were traceable to the SI through NIST or CIPM recognized NMI's.

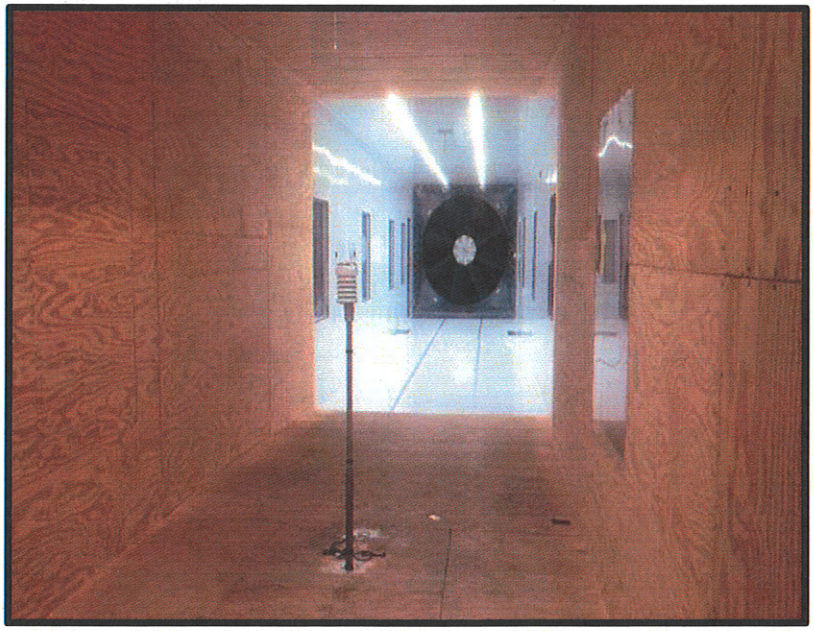


*Photo of the wind tunnel setup. The cross-sectional area is 2.5m x 2.5m.*

## 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 positioned at the 90° orientation during calibration.

**Certificate number:** 19.US2.06159

# Appendix E
MECP I-Audit Checklist

**MECP 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 | ✓* | Sufficient valid data in relevant wind bins as required for tonal audibility assessment; insufficient valid data for sound pressure level assessment |
| 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 | ✓ | |

# Appendix F
E-Audit Report Summary

# E-AUDIT REPORT SUMMARY

This section provides a summary of the results from the following E-Audit report:

> REPORT ID: 13228.00.T093.RP3, South Kent Wind Farm – Turbine T093, IEC 61400-11 Edition 3.0 Measurement Report 21 December 2018 – Revision 3.

### Sound Power Level of Turbine

The calculated apparent sound power level at hub height is summarized in Table 1. Corresponding sound power levels for 10 m height wind speeds are provided in Table 2.

Table 1 – $L_{WA,\,K}$ at each integer wind speed

| Wind Speed (m/s) | Apparent $L_{WA}$, (dBA) | Uncertainty (dB) |
|---|---|---|
| 7.5 | 101.1 | 0.9 |
| 8 | 101.4 | 0.7 |
| 8.5 | 101.5 | 0.7 |
| 9 | 101.7 | 0.7 |
| 9.5 | 101.6 | 0.8 |
| 10 | 101.8 | 0.8 |
| 10.5 | 102.1 | 0.8 |
| 11 | 101.8 | 0.8 |
| 11.5 | 102.0 | 0.8 |
| 12 | 101.8 | 0.9 |

Table 2 – $L_{WA\ 10m,\,K}$ at each integer wind speed

| Wind Speed (m/s) | Apparent $L_{WA}$, (dBA) | Uncertainty (dB) |
|---|---|---|
| 5 | 100.7 | 1.1 |
| 6 | 101.5 | 0.7 |
| 7 | 101.8 | 0.8 |
| 8 | 101.9 | 0.9 |
| 9 | 101.5* | 1.0 |

### Tonality Analysis

The tonality analysis for the turbine is summarized in Table 3. All $\Delta L_{tn}$ and $\Delta L_a$ values reported represent the energy average of all data points with an identified tone that fall within the same frequency of origin.

Table 3 – Tonality Assessment Summary

| Wind Speed (m/s) | Frequency (Hz) | Tonality, $\Delta L_{tn}$ (dB) | Tonal audibility, $\Delta L_a$ (dB) | FFT's with tones | Total # of FFT's | Presence (%) |
|---|---|---|---|---|---|---|
| 8.5 | 420 | -3.2 | -1.0 | 8 | 8 | 100% |
| 9 | 423 | -2.1 | 0.2 | 27 | 28 | 96% |
| 9.5 | 423 | -1.6 | 0.6 | 31 | 32 | 97% |
| 10 | 418 | -0.4 | 1.8 | 17 | 40 | 43% |
| 10.5 | 438 | 0.8 | 3.0 | 26 | 26 | 100% |
| 11 | 442 | 1.0 | 3.2 | 27 | 45 | 60% |
| 11.5 | 437 | 0.0 | 2.2 | 37 | 40 | 93% |
| 12 | 434 | 2.3 | 4.5 | 34 | 50 | 68% |

## Closure

Measurements and analyses per IEC 61400-11:2012 (Edition 3.0) were performed on turbine T093 of the South Kent Wind Farm, located in the municipality of Chatham-Kent. The test turbine was found to have a maximum apparent sound power level of 102.1 dBA and a maximum tonal audibility of 4.5 dB.

## End of Report