

REPORT ID: 14331.00.T44.RP3

Bornish Wind Energy Centre – Turbine T44 IEC 61400-11 Edition 3.0 Measurement Report


Prepared for:

Bornish Wind LP
32185 Kerwood Road
Parkhill, ON
N0M2K0

Prepared by:

A. Munro

Allan Munro, B.A.Sc.



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

27 November 2018 – Revision #3



Revision History

Revision Number	Description	Date
1	Issued Edition 2.1 test report	06/02/2015
2	Issued Edition 3.0 test report	20/11/2017
3	Updates to Section 2.2, 3.2.1, 4.2, 4.3.2, Table 2. Added Table B.01, Appendix F.02,F.03 and F.04	27/11/2018

This report in its entirety, including appendices contains 108 pages.

Statement Qualifications and Limitations

This report was prepared by Aercoustics Engineering Limited in accordance with International Standard IEC 61400-11 (Edition 3.0, released 2012-11), “Wind turbine generator systems – Part 11: Acoustic noise measurement techniques”. This report is specific only to the Wind Turbine identified in this report.

Aercoustics Engineering Limited shall not be responsible for any events or circumstances that may have occurred since the date on which the Wind Turbine was tested and/or this report was prepared, or for any inaccuracies contained in information that was provided to Aercoustics Engineering Limited. Further, Aercoustics Engineering Limited agrees that this report represents test data analysed as per the above described standard for the specific Wind Turbine described in this report, but Aercoustics Engineering Limited makes no other representations with respect to this report or any part thereof.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Aercoustics Engineering Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Any use of this report is subject to this Statement of Qualifications and Limitations. Any damages arising from improper use of this report or parts thereof shall be borne by the party making such use.

This Statement of Qualifications and Limitations is attached to and forms part of this report.

Table of Contents

Revision History	2
Statement Qualifications and Limitations	2
List of Appendices	6
1 Introduction	8
2 Wind Turbine Information	8
2.1 Wind turbine equipment specific information.....	8
2.2 Wind Turbine Location.....	9
3 Measurement Details	10
3.1 Measurement Equipment.....	10
3.1.1 Acoustic Measurement Equipment.....	10
3.1.2 Meteorological Equipment.....	10
3.2 Measurement Setup.....	10
3.2.1 Microphone Placement.....	10
3.2.2 Double Windscreen Setup.....	11
3.3 Measurement Schedule.....	11
3.4 Meteorological Conditions.....	11
3.5 Turbine operational information.....	11
4 Measurement Results	12
4.1 Deviations from IEC-61400-11 Edition 3.0.....	12
4.2 Special Notes & Considerations.....	12
4.3 Analysis Details.....	12
4.3.1 Double Windscreen Adjustment.....	12
4.3.2 Wind Speed Correction.....	12
4.4 Type B uncertainties.....	13
4.5 Sound Pressure Level Measurements.....	13
4.6 Sound Power Level of Turbine.....	14
4.7 Tonality Analysis.....	14
5 Closure	15
6 References	15

List of Figures

Figure A.01 – Site plan.....	Appendix A
Figure A.02 – Site photos	Appendix A
Figure B.01 – Power Curve.....	Appendix B
Figure B.02 – Rotor RPM vs. Wind Speed.....	Appendix B
Figure C.01 – Plot of overall measurement data pairs at Position 1 (Turbine ON &Background).....	Appendix C
Figure C.02 – Plot of measured total noise vs electrical power output.....	Appendix C
Figure C.03 - Plot of power curve relative to nacelle anemometer and 10m anemometer.....	Appendix C
Figure C.04 - Plot of rotor RPM vs. electrical power output.....	Appendix C
Figure C.05 – Plot of sound pressure spectrum in 1/3 Octave at 8 m/s.....	Appendix C
Figure C.06 – Plot of sound pressure spectrum in 1/3 Octave at 8.5 m/s.....	Appendix C
Figure C.07 – Plot of sound pressure spectrum in 1/3 Octave at 9 m/s.....	Appendix C
Figure C.08 – Plot of sound pressure spectrum in 1/3 Octave at 9.5 m/s.....	Appendix C
Figure C.09 – Plot of sound pressure spectrum in 1/3 Octave at 10 m/s.....	Appendix C
Figure C.10 – Plot of sound pressure spectrum in 1/3 Octave at 10.5 m/s.....	Appendix C
Figure C.11 – Plot of sound pressure spectrum in 1/3 Octave at 11 m/s.....	Appendix C
Figure C.12 – Plot of sound pressure spectrum in 1/3 Octave at 11.5 m/s.....	Appendix C
Figure C.13 – Plot of sound pressure spectrum in 1/3 Octave at 12 m/s.....	Appendix C
Figure C.14 – Plot of sound pressure spectrum in 1/3 Octave at 12.5 m/s.....	Appendix C
Figure C.15 – Plot of sound pressure spectrum in 1/3 Octave at 13 m/s.....	Appendix C
Figure D.01 – Plot of narrow band spectra – Turbine ON vs. Background at 8 m/s.....	Appendix D
Figure D.02 – Plot of narrow band spectra – Turbine ON vs. Background at 8.5 m/s...Appendix D	Appendix D
Figure D.03 – Plot of narrow band spectra – Turbine ON vs. Background at 9 m/s.....Appendix D	Appendix D
Figure D.04 – Plot of narrow band spectra – Turbine ON vs. Background at 9.5 m/s...Appendix D	Appendix D
Figure D.05 – Plot of narrow band spectra – Turbine ON vs. Background at 10 m/s.....Appendix D	Appendix D
Figure D.06 – Plot of narrow band spectra – Turbine ON vs. Background at 10.5 m/s...Appendix D	Appendix D
Figure D.07 – Plot of narrow band spectra – Turbine ON vs. Background at 11 m/s...Appendix D	Appendix D
Figure D.08 – Plot of narrow band spectra – Turbine ON vs. Background at 11.5 m/s...Appendix D	Appendix D
Figure D.09 – Plot of narrow band spectra – Turbine ON vs. Background at 12 m/s...Appendix D	Appendix D
Figure D.10 – Plot of narrow band spectra – Turbine ON vs. Background at 12.5 m/s...Appendix D	Appendix D
Figure D.11 – Plot of narrow band spectra – Turbine ON vs. Background at 13 m/s...Appendix D	Appendix D

List of Tables

Table 1 - Wind Turbine Details	8
Table 2 - Operating Details.....	8
Table 3 - Rotor Details.....	9
Table 4 - Gearbox Details.....	9
Table 5 - Generator Details	9
Table 6 - Acoustic Measurement Equipment.....	10
Table 7 – Meteorological Measurement Equipment.....	10
Table 8 - Measurement Schedule Summary	11
Table 9 - Summary of Type B uncertainties	13
Table 10 - Summary of Sound Pressure Level Measurements.....	13
Table 11 - LWA _{10m, K} at each integer wind speed	14
Table 12 - Tonality Assessment Summary.....	15
Table B.01 – Allowed range of power curve and required wind speeds.....	Appendix C
Table C.01 – Detailed apparent sound power level data at hub height.....	Appendix C
Table C.02 – Detailed apparent sound power level data at 10m height.....	Appendix C
Table C.03 – Type B measurement uncertainty summary.....	Appendix C
Table C.04 – Detailed measurement uncertainty at hub height.....	Appendix C
Table D.01 – Tonality Assessment Table – 7 m/s.....	Appendix D
Table D.02 – Tonality Assessment Table – 7.5 m/s.....	Appendix D
Table D.03 – Tonality Assessment Table – 8 m/s.....	Appendix D
Table D.04 – Tonality Assessment Table – 8.5 m/s.....	Appendix D
Table D.05 – Tonality Assessment Table – 9 m/s.....	Appendix D
Table D.06 – Tonality Assessment Table – 9.5 m/s.....	Appendix D
Table D.07 – Tonality Assessment Table – 10 m/s.....	Appendix D
Table D.08 – Tonality Assessment Table – 10.5 m/s.....	Appendix D
Table D.09 – Tonality Assessment Table – 11 m/s.....	Appendix D
Table E.01 – Measurement data –Turbine ON.....	Appendix E
Table E.02 – Measurement data – Background.....	Appendix E

List of Appendices

Appendix A – Site Details

- Figure A.01 – Site plan
- Figure A.02 – Site photos

Appendix B – Turbine Information

- Figure B.01 – Power curve
- Figure B.02 – Rotor RPM vs. wind speed
- Table B.01 – Allowed range of power curve and required wind speeds

Appendix C – Apparent Sound Power Level

- Figure C.01 – Plot of overall measurement data pairs at Position 1 (Turbine ON & Background)
- Figure C.02 – Plot of measured total noise vs electrical power output
- Figure C.03 - Plot of measured wind speeds (nacelle and 10m) vs derived wind speed
- Figure C.04 - Plot of rotor RPM vs. electrical power output
- Figure C.05 – Plot of sound pressure spectrum in 1/3 Octave at 7 m/s
- Figure C.06 – Plot of sound pressure spectrum in 1/3 Octave at 7.5 m/s
- Figure C.07 – Plot of sound pressure spectrum in 1/3 Octave at 8 m/s
- Figure C.08 – Plot of sound pressure spectrum in 1/3 Octave at 8.5 m/s
- Figure C.09 – Plot of sound pressure spectrum in 1/3 Octave at 9 m/s
- Figure C.10 – Plot of sound pressure spectrum in 1/3 Octave at 9.5 m/s
- Figure C.11 – Plot of sound pressure spectrum in 1/3 Octave at 10 m/s
- Figure C.12 – Plot of sound pressure spectrum in 1/3 Octave at 10.5 m/s
- Figure C.13 – Plot of sound pressure spectrum in 1/3 Octave at 11 m/s
- Table C.01 – Detailed apparent sound power level data at hub height
- Table C.02 – Detailed apparent sound power level data at 10m height
- Table C.03 – Type B measurement uncertainty summary
- Table C.04 – Detailed measurement uncertainty at hub height

Appendix D – Tonality Assessment

- Figure D.01 – Plot of narrow band spectra – Turbine ON vs. Background at 7 m/s
- Figure D.02 – Plot of narrow band spectra – Turbine ON vs. Background at 7.5 m/s
- Figure D.03 – Plot of narrow band spectra – Turbine ON vs. Background at 8 m/s
- Figure D.04 – Plot of narrow band spectra – Turbine ON vs. Background at 8.5 m/s
- Figure D.05 – Plot of narrow band spectra – Turbine ON vs. Background at 9 m/s
- Figure D.06 – Plot of narrow band spectra – Turbine ON vs. Background at 9.5 m/s
- Figure D.07 – Plot of narrow band spectra – Turbine ON vs. Background at 10 m/s
- Figure D.08 – Plot of narrow band spectra – Turbine ON vs. Background at 10.5 m/s
- Figure D.09 – Plot of narrow band spectra – Turbine ON vs. Background at 11 m/s
- Table D.01 – Tonal Assessment Table – 7 m/s
- Table D.02 – Tonal Assessment Table – 7.5 m/s
- Table D.03 – Tonal Assessment Table – 8 m/s
- Table D.04 – Tonal Assessment Table – 8.5 m/s
- Table D.05 – Tonal Assessment Table – 9 m/s
- Table D.06 – Tonal Assessment Table – 9.5 m/s
- Table D.07 – Tonal Assessment Table – 10 m/s
- Table D.08 – Tonal Assessment Table – 10.5 m/s

Table D.09 – Tonal Assessment Table – 11 m/s

Appendix E – Measurement Data

Table E.01 – Measurement data –Turbine ON

Table E.02 – Measurement data – Background

Appendix F – Supplementary Information for the Regulators

Appendix F.01 - Note N6.023.17

Appendix F.02 – Calibration Certificates

Appendix F.03 – E-Audit Checklist

Appendix F.04 – Summary of Measurement Results

1 Introduction

Aercoustics Engineering Limited (Aercoustics) was retained by Bornish Wind LP (“Bornish”) to conduct an acoustic measurement of turbine T44 at the Bornish Wind Energy Centre. The purpose of the measurement was to provide verification of the maximum noise emission of the turbine. The measurement was carried out in accordance with International Standard IEC 61400-11 (Edition 3.0, released 2012-11), “Wind turbine generator systems – Part 11: Acoustic noise measurement techniques”. This report is specific only to Turbine T44.

2 Wind Turbine Information

2.1 Wind turbine equipment specific information

Wind turbine specific equipment information for turbine T44 was provided by Bornish Wind LP and is summarized in Tables 1 – 5.

Table 1 - Wind Turbine Details

Wind Turbine Details	
Manufacturer	General Electric
Model Number	1.6-100
Turbine ID	WBN-044 (Bornish -44)

Table 2 - Operating Details

Operating Details	
Vertical or Horizontal axis wind turbine	HAWT
Upwind or downwind rotor	Upwind
Hub height	80m
Horizontal distance from rotor centre to tower axis	4100mm
Diameter of rotor	100m
Tower type (lattice or tube)	Tube
Passive stall, active stall, or pitch controlled turbine	Pitch Controlled
Constant or variable speed	Variable
Power curve	See Figure B.01
Rotational speed at each integer standardised wind speed	See Figure B.02
Rated power output	1.62 MW
Control software version	V.04.07.02C

Table 3 - Rotor Details

Rotor Details	
Rotor control devices	Electric Motor
Presence of vortex generators, stall strips, serrated trailing edges	Yes
Blade type	GE 48.7 Glass- TPI
Serial number	S/N: 40295 GE ID # D21907-101-04032-W860 S/N: 30265 GE ID # D21907-101-03834-W860 S/N: 50259 GE ID # D21907-101-03833-W860
Number of blades	3

Table 4 - Gearbox Details

Gearbox Details	
Manufacturer	Rexroth
Model number	GPV457-1PALL60 Hz
Serial number	980807-102-00684-W924

Table 5 - Generator Details

Generator Details	
Manufacturer	GE
Model number	IP54 TFFOAN GE ID Tag# 1-6-HEAD-32525-P
Serial number	G07663-105-03495-W930

2.2 Wind Turbine Location

Turbine T44 is located in the municipality of North Middlesex, approximately 890m East of Centre Road, and 530m North of Elm Tree Drive. The area surrounding T44 is flat and consists primarily of farmland. The UTM coordinates of Turbine T44 are Zone 17T 445507m E 4770915m N.

A general layout of the area in which the turbine is located is provided in the site plan (Figure A.01).

3 Measurement Details

3.1 Measurement Equipment

3.1.1 Acoustic Measurement Equipment

A summary of acoustic equipment utilized by Aercoustics for the measurement of turbine T44 is summarized in Table 6.

Table 6 - Acoustic Measurement Equipment

Equipment	Manufacturer Name & Model	Serial Number
Acoustic Data acquisition system	LMS SCADA Mobile	22143211
Microphone	B&K 4189	2622170
Pre-amplifier	B&K 2671	2614901
Acoustic calibrator	B&K 4231	2513182

Calibration of the measurement setup was carried out before and after Aercoustics set of measurements.

3.1.2 Meteorological Equipment

Wind speed for Turbine ON was derived from the power curve (as per procedures outlined in IEC 61400-11). Wind direction for turbine ON measurements was utilized from the yaw position from turbine T44. Data for background measurements was obtained from a 10m high anemometer, which was placed as per guidelines outlined in IEC-61400-11 Edition 3.0.

The meteorological equipment is summarized in Table 7

Table 7 – Meteorological Measurement Equipment

Equipment	Manufacturer Name & Model	Serial Number
Anemometer	VAISALA WXT520	K2420011
Serial to Analog Converter	NOKEVAL 7470	A159784

3.2 Measurement Setup

3.2.1 Microphone Placement

The measurement microphone was setup 130m from the base of the turbine in 'Position 1', (i.e. downwind of the turbine, as per IEC 61400-11) at an elevation of 0m relative to the base of T44. The slant distance (R_1) from microphone location to rotor centre includes the distance from rotor center (hub) to tower axis ($R_1 = 156.1\text{m}$). The microphone was placed in the centre of a circular, acoustically reflective board.

During the measurement period only data points for which the microphone was within 15 degrees of downwind from the turbine were used. The microphone position relative to

downwind of the turbine was monitoring via the yaw angle output provided from the turbine system (discussed further in Section 3.5). During placement of the microphone the turbine was parked and the reference yaw angle for that measurement logged.

When measurements of T44 were taken, the surrounding land was cleared farmland. There were no nearby reflecting surfaces (houses, barns etc.); as such the influence from reflecting surfaces was considered to be negligible.

Photos of the measurement setup are provided in Figure A.02, Appendix A.

3.2.2 Double Windscreen Setup

A double windscreen setup was not utilized.

3.3 Measurement Schedule

Table 8 provides a summary of the test date and times. Data was logged in 10 second intervals for post-processing (as per the measurement standard).

Table 8 - Measurement Schedule Summary

Date	Test Type	Start Time	Finish time
October 28, 2014	Turbine ON	3:41pm	4:06pm
	Background	4:46pm	5:21pm
October 29, 2014	Turbine ON	10:06am	10:37am
	Background	10:47am	11:23am
	Turbine ON	12:01 pm	12:56pm
	Turbine ON	1:12pm	1:39pm

3.4 Meteorological Conditions

Detailed meteorological data relevant to the measurement is provided in Appendix E.

As previously mentioned, wind speed for Turbine ON was derived from T44's power curve (as per the standard), while wind direction was provided by T44's yaw position. Background data was obtained from an anemometer located 10m above ground level near T44.

Temperature and pressure readings during the measurement period were provided by the 10m anemometer, located near turbine T44 for the duration of Aercoustics measurements.

3.5 Turbine operational information

Output data from the turbine (Power, yaw, RPM, pitch angle, and nacelle wind speed) were obtained as analog output signals that were simultaneously acquired with the acoustic and anemometer measurement data using Aercoustics data acquisition system.

4 Measurement Results

4.1 Deviations from IEC-61400-11 Edition 3.0

Originally, the test contract required measurements in accordance to edition 2.1 of the standard (61400-11) which requires the anemometer to be placed upwind of the turbine. This test report is a reprocessing of the originally acquired data and as such during the test, the anemometer position was erected in an upwind (Ed 2.1), rather than crosswind (Ed 3.0) position relative to the test turbine.

The acoustic signal to noise ratio for the noise levels is $>7.4\text{dB}$ for all wind bins, and $>10\text{dBA}$ for 8m/s and above. Figure C.01 shows the clear separation between Turbine ON and background sound levels. Based on the high signal to noise ratio, and the flat relationship between background sound and measured wind speed, this deviation is considered to be negligible to the assessment of the maximum sound power of this turbine for this test. This method is in accordance with recommendations made by the convenor of the IEC 61400-11 working group and detailed in Note N6.023.17 and is provided in Appendix F.

4.2 Special Notes & Considerations

Bornish Turbine T45 was parked for the duration of the test.

4.3 Analysis Details

The following section outlines analysis of the measurement data acquired for T44. The data presented is exclusive of transient events such as vehicle traffic, wildlife, air traffic etc. The site has been assessed to have a roughness length of 0.05m , representative of farmland with some vegetation.

4.3.1 Double Windscreen Adjustment

As previously mentioned, no double wind screen was used, as such the measurement data did not require adjustment.

4.3.2 Wind Speed Correction

The wind speed for each measurement data point for Turbine ON was derived through the power curve (as per Section 8.2.1.1 of IEC-61400-11). For data points during Turbine ON that were outside the allowed range of the power curve, the wind speed was derived from the nacelle anemometer wind speed (as specified in Section 8.2.1.2 of IEC-61400-11).

Background wind speed was derived utilizing data acquired with the 10m anemometer and normalizing the wind speed (as per Section 8.2.2 of IEC-61400-11).

Table 9 - Calculated nacelle anemometer (k_nac) and 10m (k_Z) wind speed k-factor

k_nac	k_Z
1.06	1.28

4.4 Type B uncertainties

Type B uncertainties were obtained through interpretation of information provided in Annex C of IEC-61400-11, and instrument uncertainties obtained from the calibration certificate. A summary of Type B uncertainties is provided in Table 10, while detailed information (including data in 1/3 octave) is provided in Appendix C.

Table 10 - Summary of Type B uncertainties

Component	Typical (dB)	Used (dB)
Calibration	0.2	0.2
Board	0.3	0.3
Distance & direction	0.1	0.1
Air absorption	0	0
Weather conditions	0.5	0.5
Wind speed measured	0.7	0.7
Wind speed derived	0.2	0.2
Wind speed from power curve	0.2	0.2

4.5 Sound Pressure Level Measurements

Sound pressure level measurements are summarized in Table 11. Detailed 1/3 Octave band spectrum data, respective uncertainties, and analysis plots are provided in Appendix C. A copy of the measurement data used for analysis is provided in Appendix E and includes meteorological and turbine operational data.

Table 11 - Summary of Sound Pressure Level Measurements

Wind Speed (m/s)	Turbine ON		Background		Turbine ON, Background adjusted L _{eq} , (dBA)
	L _{eq} , (dBA)	# of data pts	L _{eq} , (dBA)	# of data pts	
7	49.7	56	42.3	22	48.8
7.5	51.0	54	41.8	29	50.5
8	52.5	49	39.1	19	52.3
8.5	53.6	50	41.7	28	53.4
9	54.2	39	42.6	20	53.9
9.5	54.8	72	41.2	28	54.6
10	54.7	51	42.9	15	54.4
10.5	54.7	32	43.1	16	54.4
11	54.7	27	42.9	12	54.4

4.6 Sound Power Level of Turbine

The calculated sound power level of the turbine T44 (as per IEC 61400-11) is summarized in Table 11 (hub height) and Table 13 (10m height). Detailed 1/3 Octave band spectrum data and respective uncertainties are provided in Appendix C.

Table 12 - $L_{WA, K}$ at each integer wind speed

Wind Speed (m/s)	Apparent L_{WA} , (dBA)	Uncertainty (dB)
7	97.7	0.9
7.5	99.3	0.8
8	101.2	0.7
8.5	102.2	0.8
9	102.8	0.7
9.5	103.5	0.7
10	103.3	0.8
10.5	103.3	0.8
11	103.3	0.8

Table 13 - $L_{WA 10m, K}$ at each integer wind speed

Wind Speed (m/s)	Apparent L_{WA} , (dBA)	Uncertainty (dB)
5	97.7	0.8
6	101.7	0.8
7	103.4	0.8
8	103.4	0.8

4.7 Tonality Analysis

The tonality analysis for Turbine T44 is summarized in Table 14, while plots of narrow band spectra at each wind speed are provided in Appendix D. The ΔL_{tn} and ΔL_a values reported represent the energy average of all data points with an identified tone that falls within the same frequency origin (as specified in Section 9.5.8 in IEC-61400-11).

The narrow band spectra provided in the plots represents an energy average of all data points in the given wind speed bin for both Turbine ON and Background.

Table 14 - Tonality Assessment Summary

Wind Speed (m/s)	Frequency (Hz)	Tonality, ΔL_{tn} (dB)	Tonal audibility, ΔL_a (dB)	FFT's with tones	Total # of FFT's	Presence (%)
7	117	-3.1	-1.1	13	56	23%
7.5	122	-5.0	-3.0	29	54	54%
8.5	597	0.5	2.9	40	50	80%
9	134	-4.0	-2.0	34	39	87%
9	599	-0.2	2.2	21	39	54%
9.5	137	-0.5	1.5	69	72	96%
9.5	629	2.1	4.6	62	72	86%
10	137	0.7	2.7	51	51	100%
10	628	1.2	3.6	48	51	94%
10.5	137	0.7	2.8	32	32	100%
10.5	629	1.3	3.7	30	32	94%
10.5	1258	-5.9	-2.9	24	32	75%
11	137	0.4	2.5	27	27	100%
11	624	1.1	3.5	27	27	100%
11	1249	-5.7	-2.7	25	27	93%

5 Closure

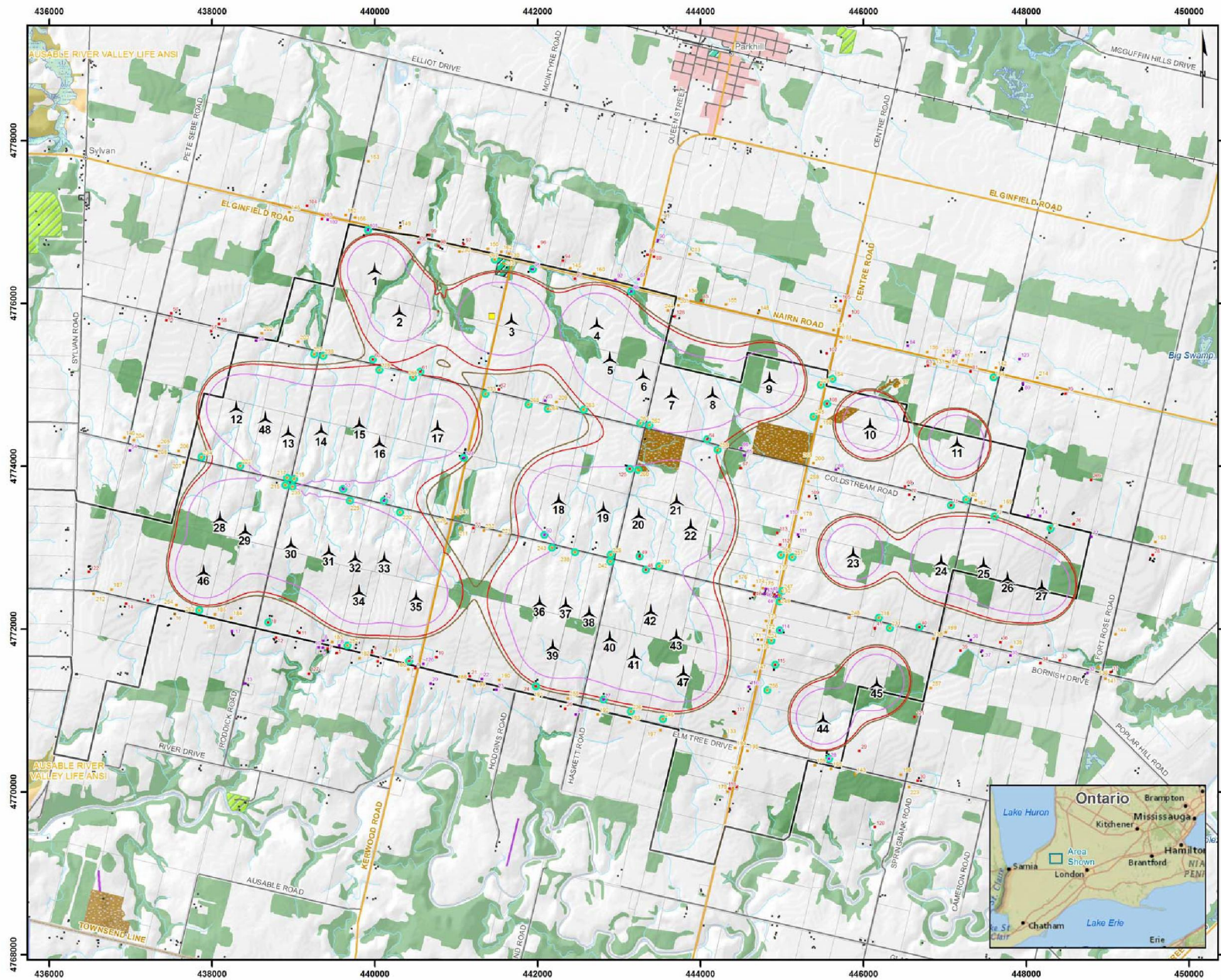
Measurements and analysis were carried on Turbine T44 of the Bornish Wind Energy Centre, located in the municipality of Middlesex as per International IEC 61400-11 (Edition 3.0, released 2012-11), “Wind turbine generator systems – Part 11: Acoustic noise measurement techniques”.

Should you have any questions or comments please do not hesitate to contact the authors of this report.

6 References

1. International Standard IEC 61400-11 (Edition 3.0, released 2012-11), “Wind turbine generator systems – Part 11: Acoustic noise measurement techniques”.

Appendix A Site Details



Legend

Project Components	Other Components
Wind Turbine (48)	1-Storey Receptor
Substation	2-Storeys Receptor
Participating Receptor	3-Storeys Receptor
Project Area	Vacant Lot Receptor
	Other Building
Predicted Sound Level	Railway
40 dB(A) at 1.5 m agl	Arterial / Collector
40 dB(A) at 4.5 m agl	Local Road / Street
40 dB(A) at 7.5 m agl	Permanent Watercourse
	Intermittent Watercourse
	Residential Area
	Runway
	Recreational Area
	Park / Sports Field
	Campground
	Cemetery
	ANSI - Life Science
	Pit or Quarry
	Waterbody
	Wetland
	Wooded Area
	Lot Line
	Municipal Boundary
	County Boundary



NEXtera ENERGY

Bornish Wind Energy Centre

**48 TURBINE LAYOUT WITH
SIMULATED SOUND ISOCONTOUR LEVELS
(WIND SPEED OF 6 m/s)**

GL
GL Garrard Hassan

1008-001-00043-001-003
April 12, 2013

Projection: UTM Zone 17, NAD83
Sources: Ontario Base Mapping, Ontario Road Network,
Land Information Ontario, Geobase, CanVec, Industry Canada.
© Every symbol has a name. All rights reserved. All rights reserved.
© Her Majesty the Queen in Right of Canada, Ontario Minister of Natural Resources. All rights reserved.



14331.00.T44.RP3
Scale: NTS
Drawn by: AM
Reviewed by: PA
Date: Nov28, 2018
Revision: 1

Project Name
Bornish Wind Farm - Turbine T44 - IEC 61400-11 Edition 3.0

Figure Title
Site plan



Figure A.01



14331.00.T44.RP3

Scale: NTS
Drawn by: AM
Reviewed by: PA
Date: Nov28, 2018
Revision: 1

Project Name

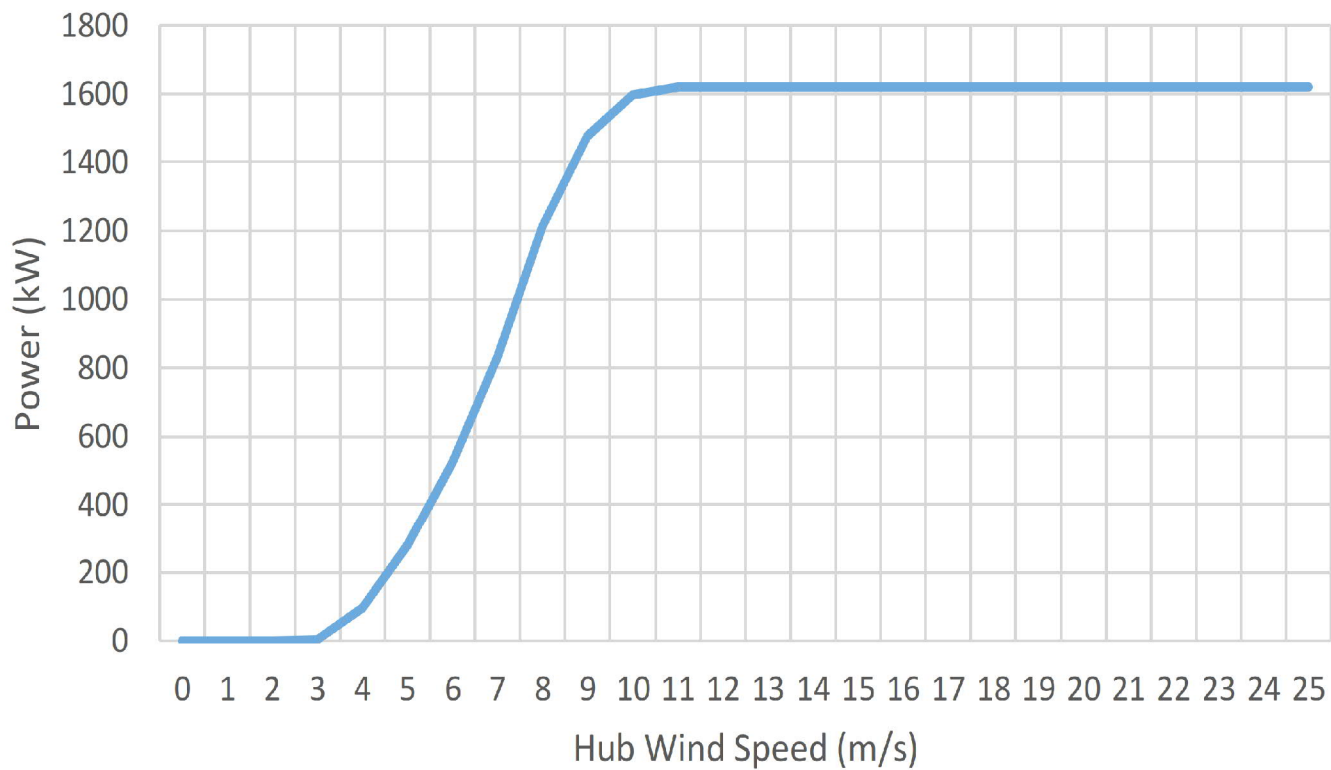
Bornish Wind Farm - Turbine T44 - IEC 61400-11 Edition 3.0

Figure Title

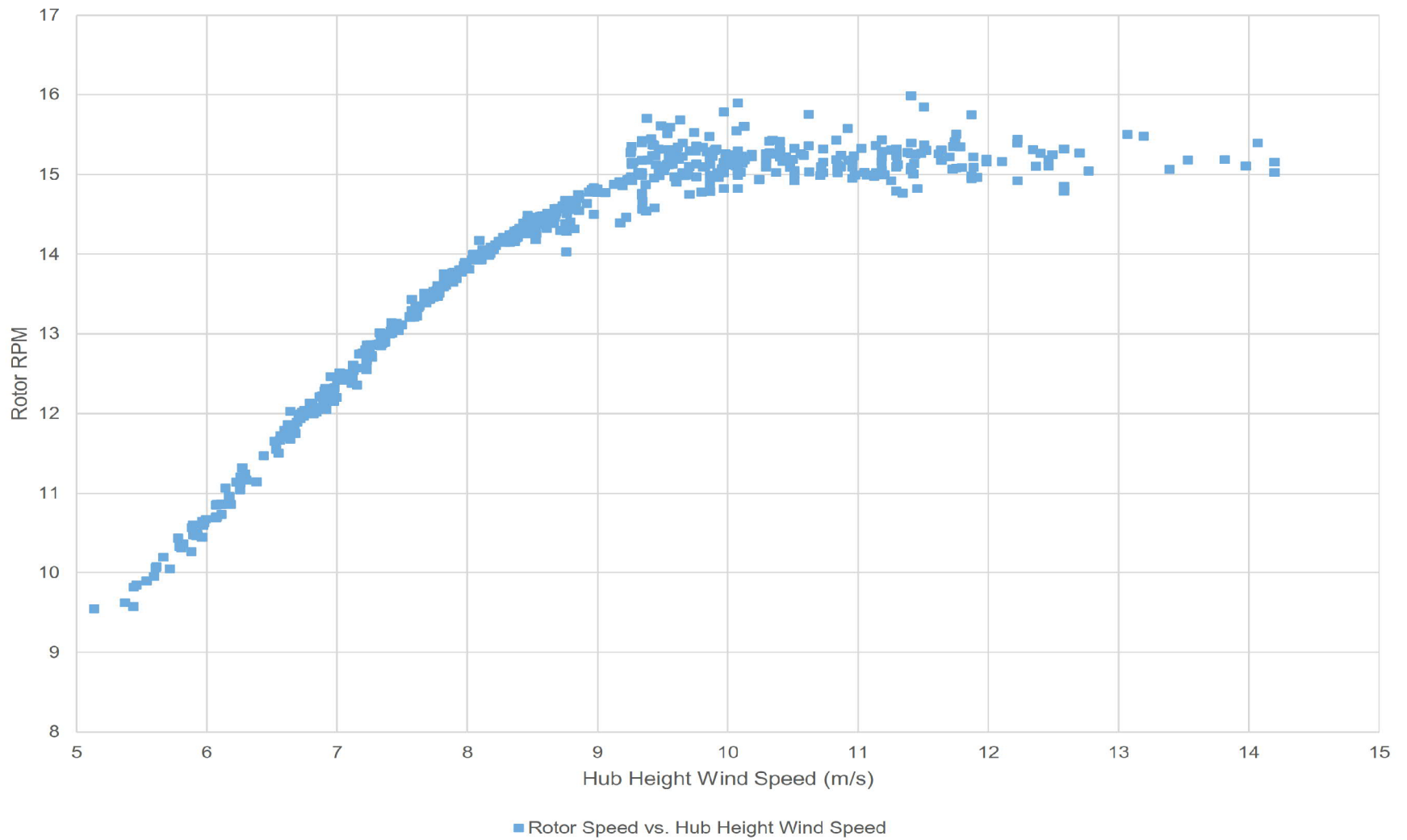
Site photos

Figure A.02

Appendix B Turbine Information

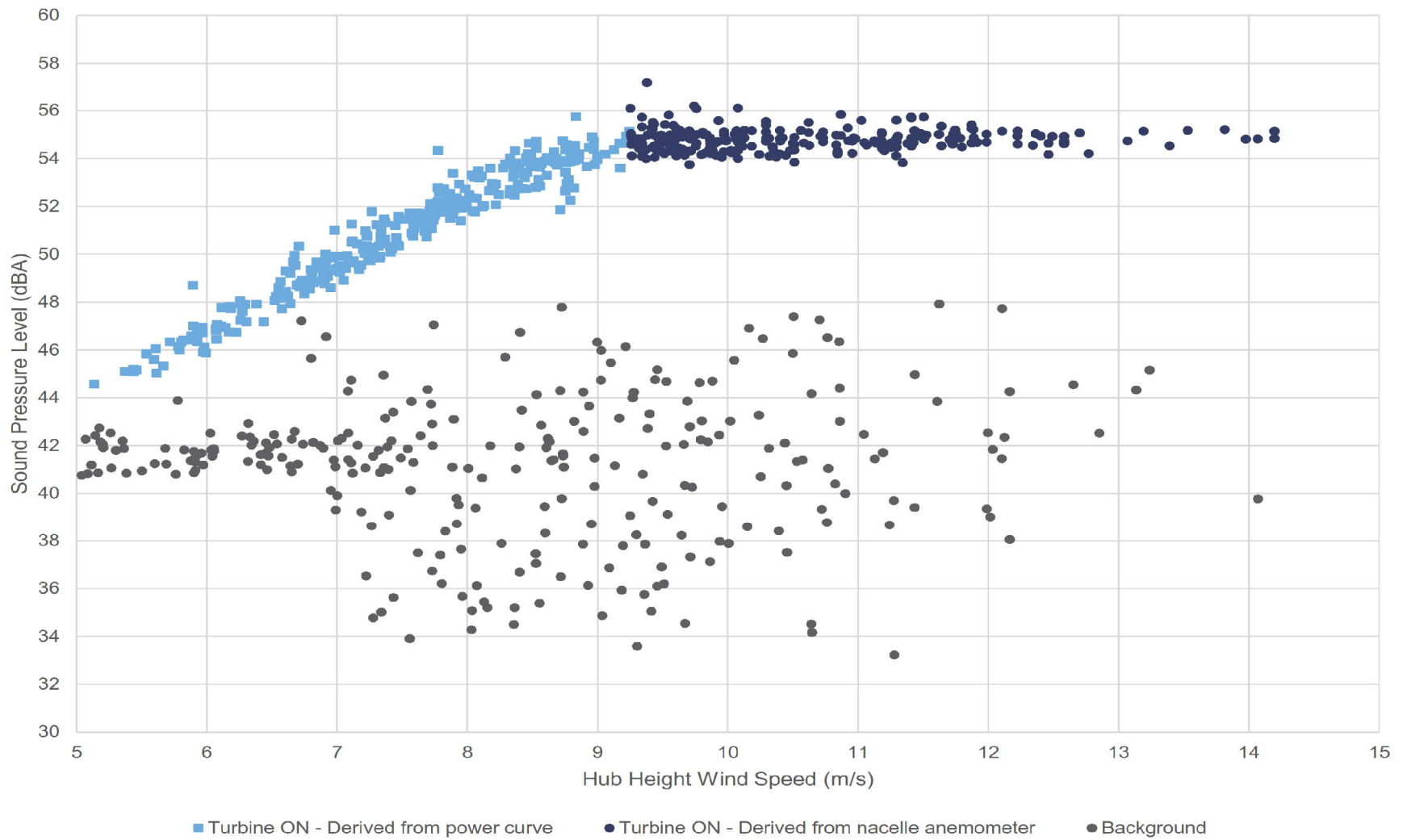


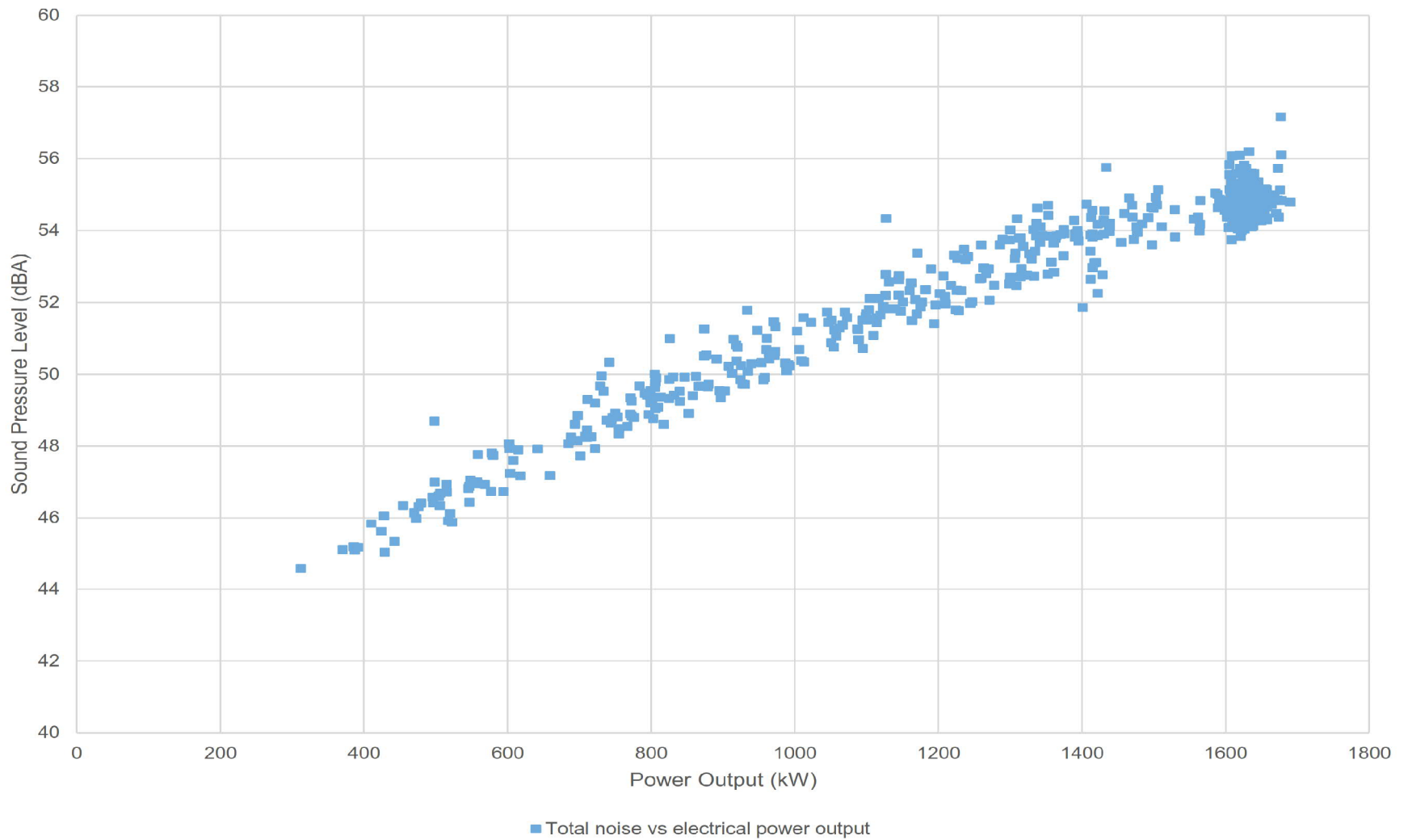
Power Curve	
Hub Wind Speed (m/s)	Power [kW]
0	0
1	0
2	0
3	0
4	4
5	97
6	279
7	524
8	832
9	1213
10	1477
11	1596
12	1620
13	1620
14	1620
15	1620
16	1620
17	1620
18	1620
19	1620
20	1620
21	1620
22	1620
23	1620
24	1620
25	1620

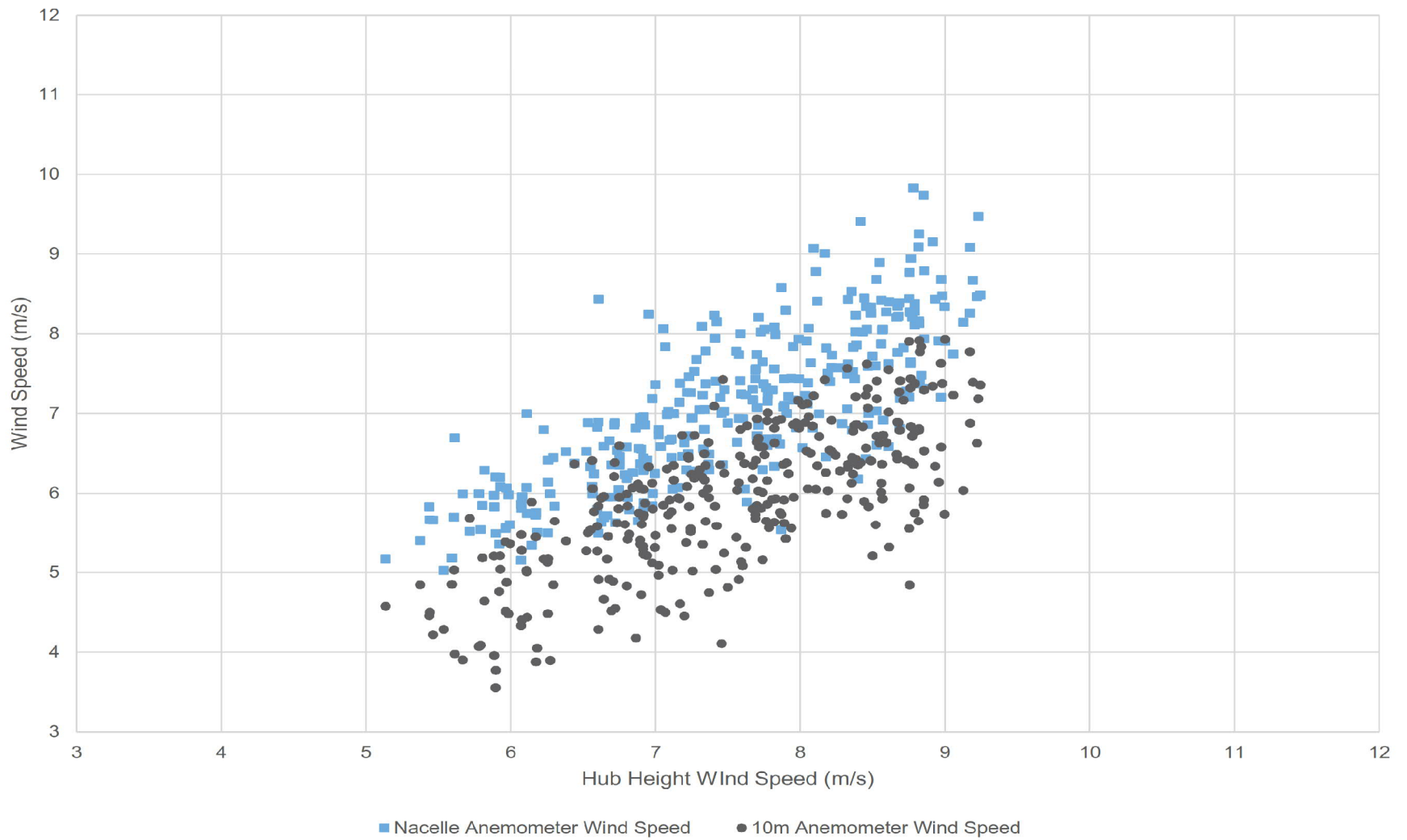


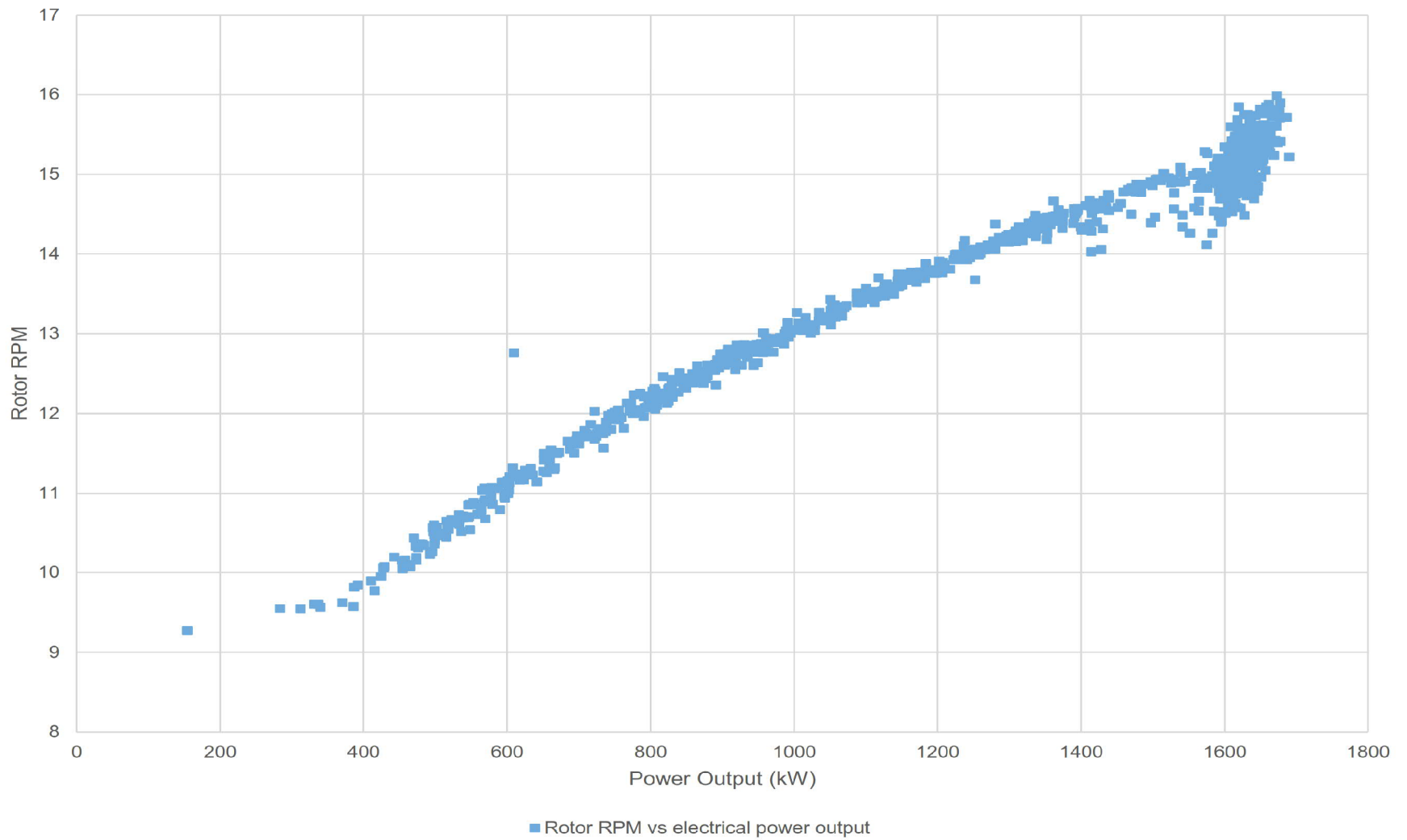
Appendix C

Apparent Sound Power Level

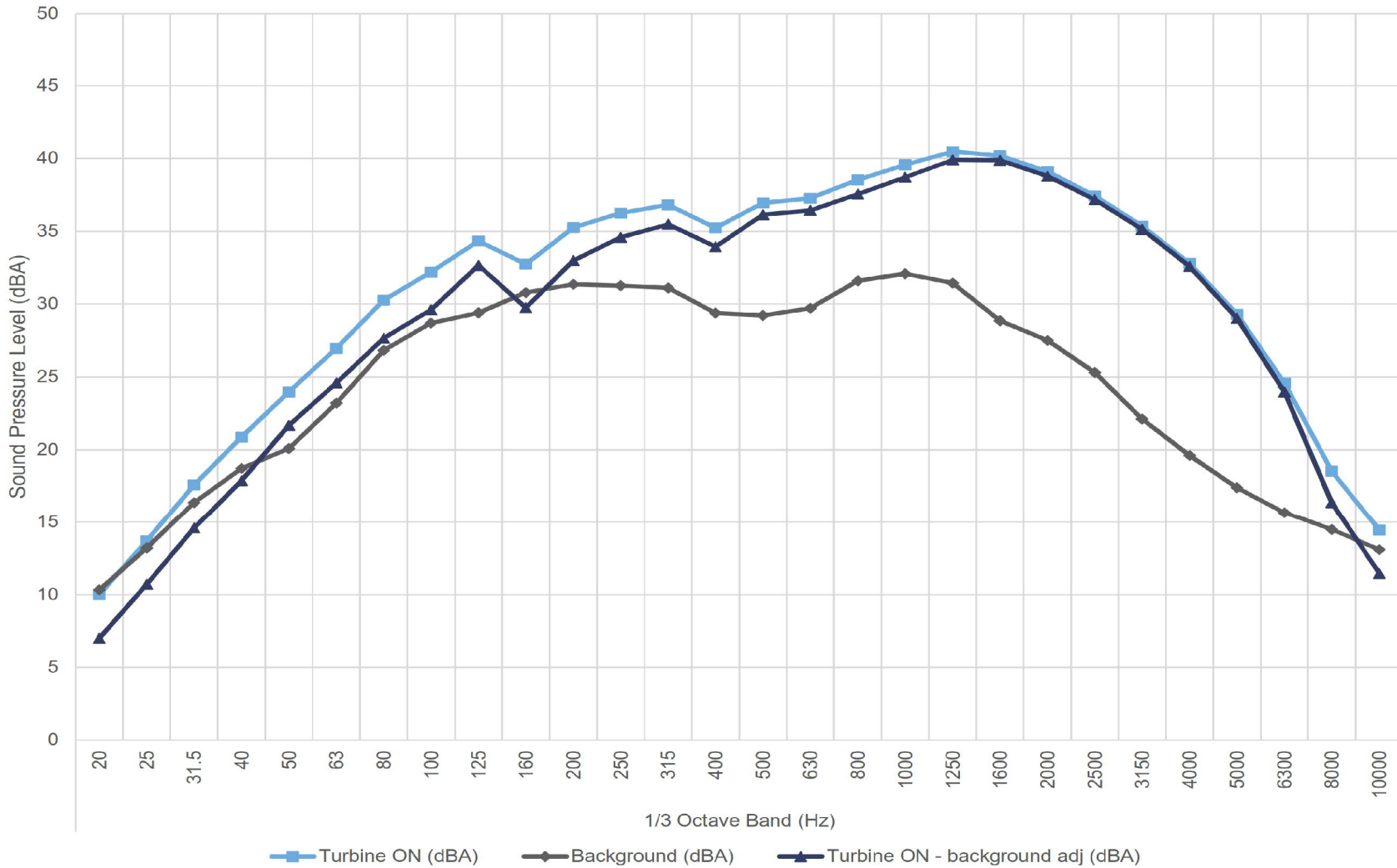








7.0 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

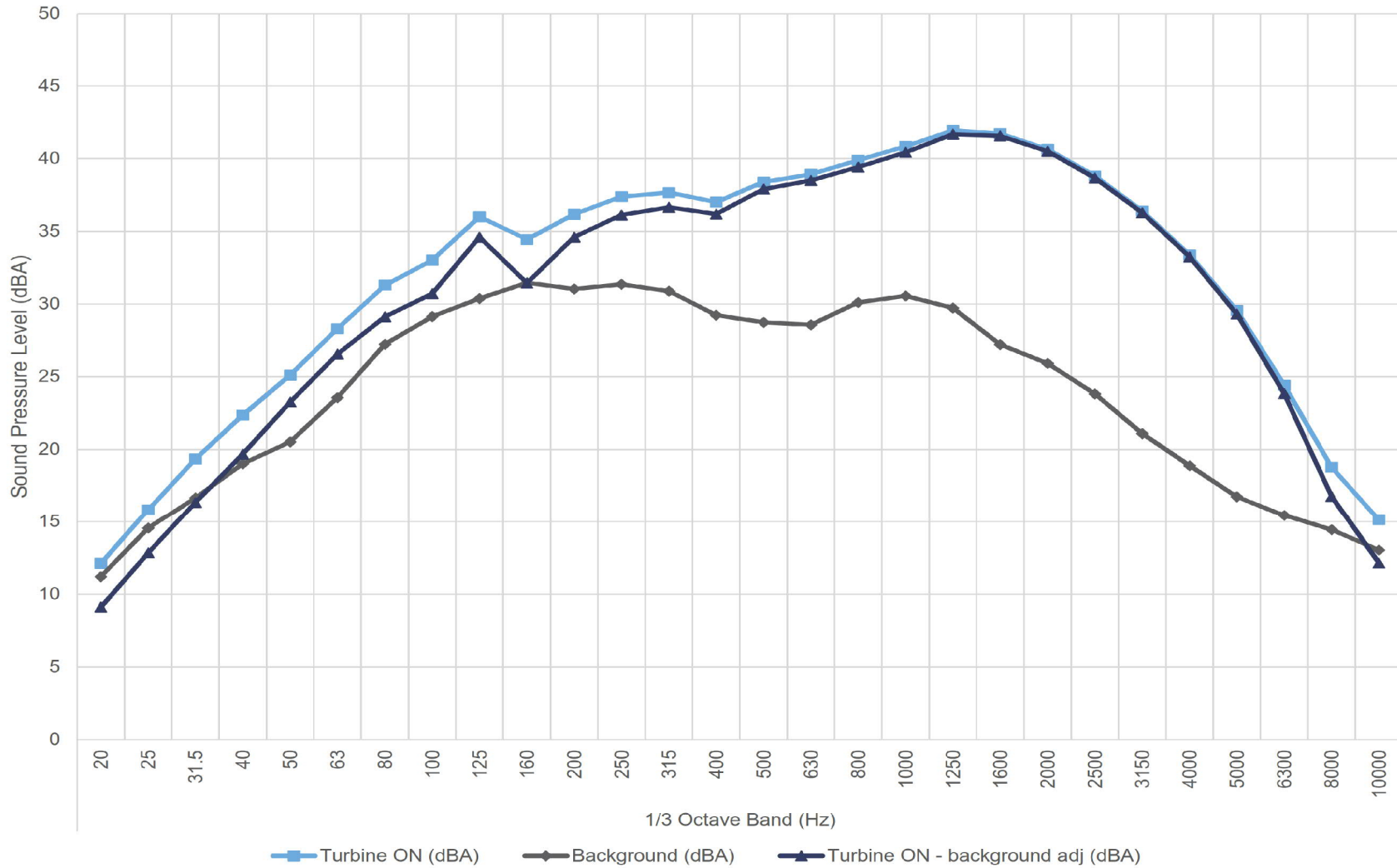
Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 7 m/s

Figure C.05

7.5 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

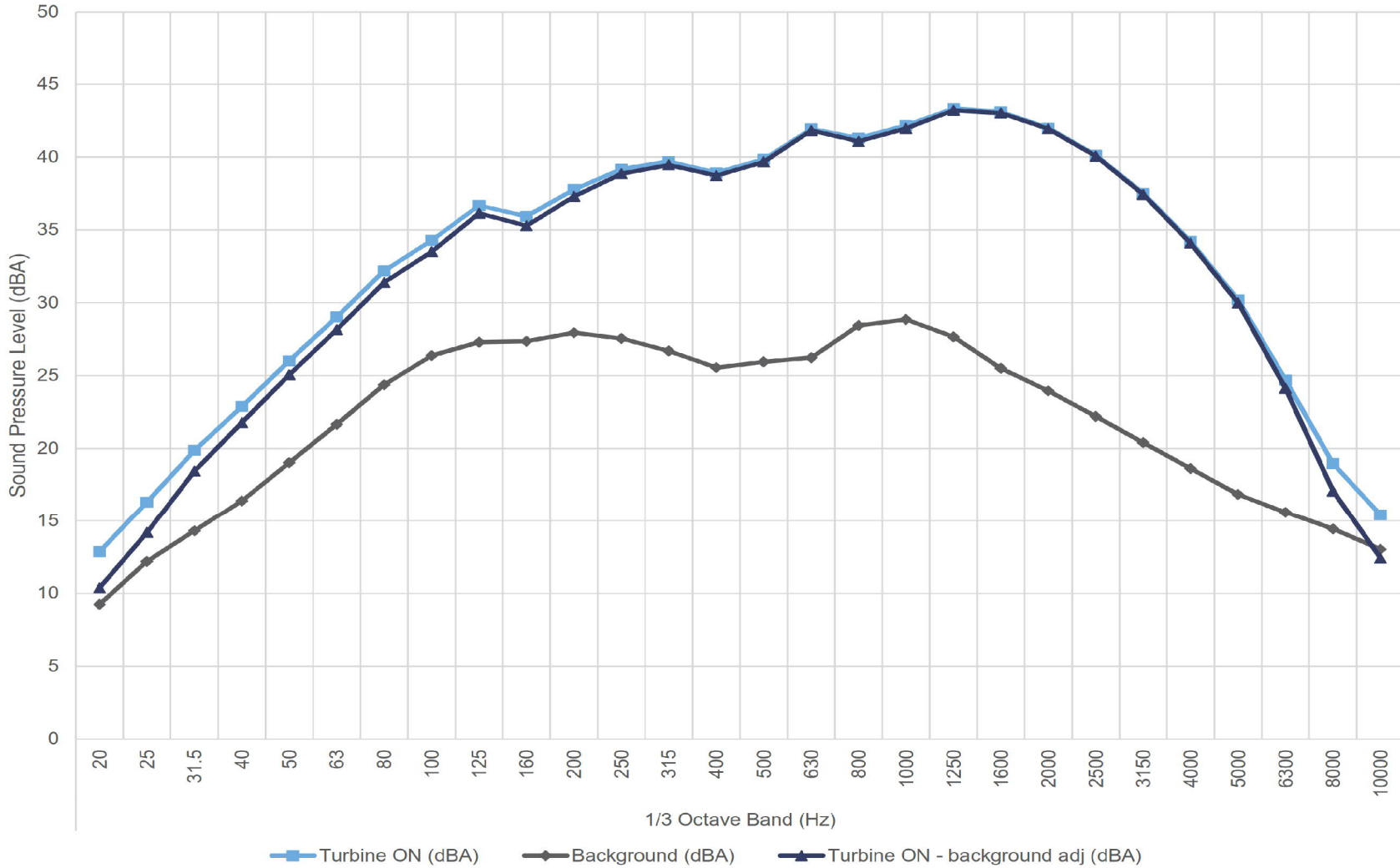
Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 7.5 m/s

Figure C.06

8.0 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

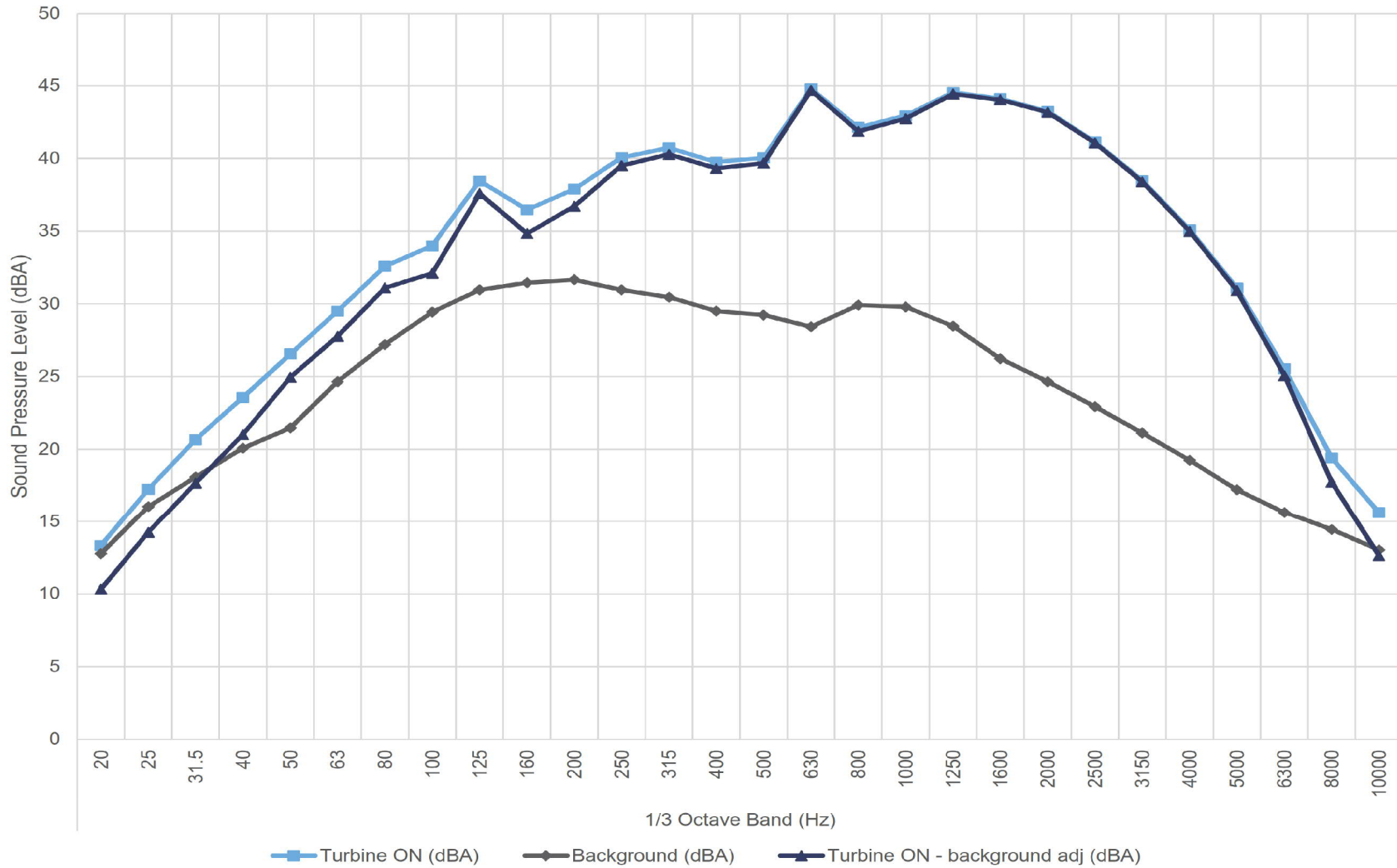
Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 8 m/s

Figure C.07

8.5 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

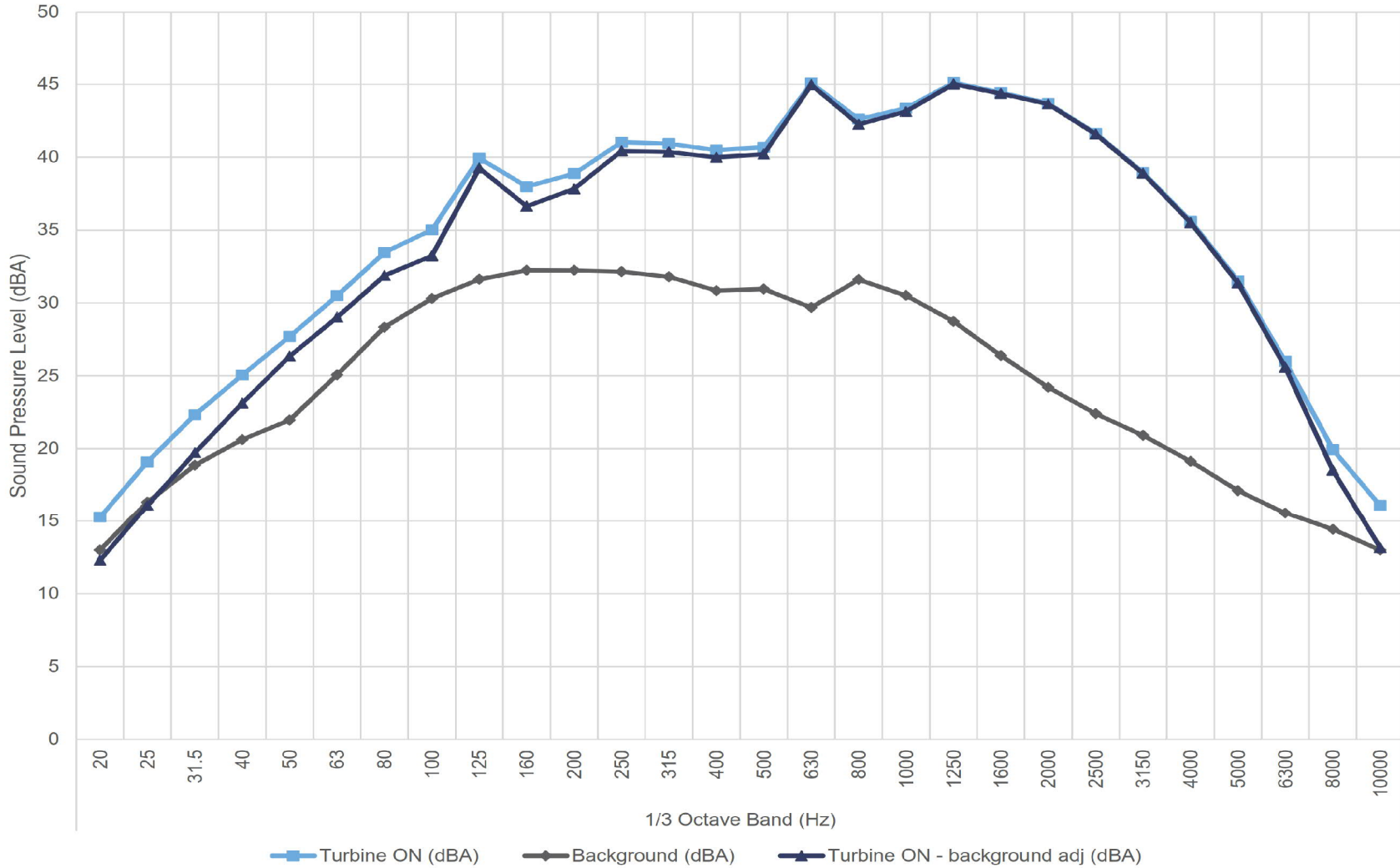
Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 8.5 m/s

Figure C.08

9.0 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

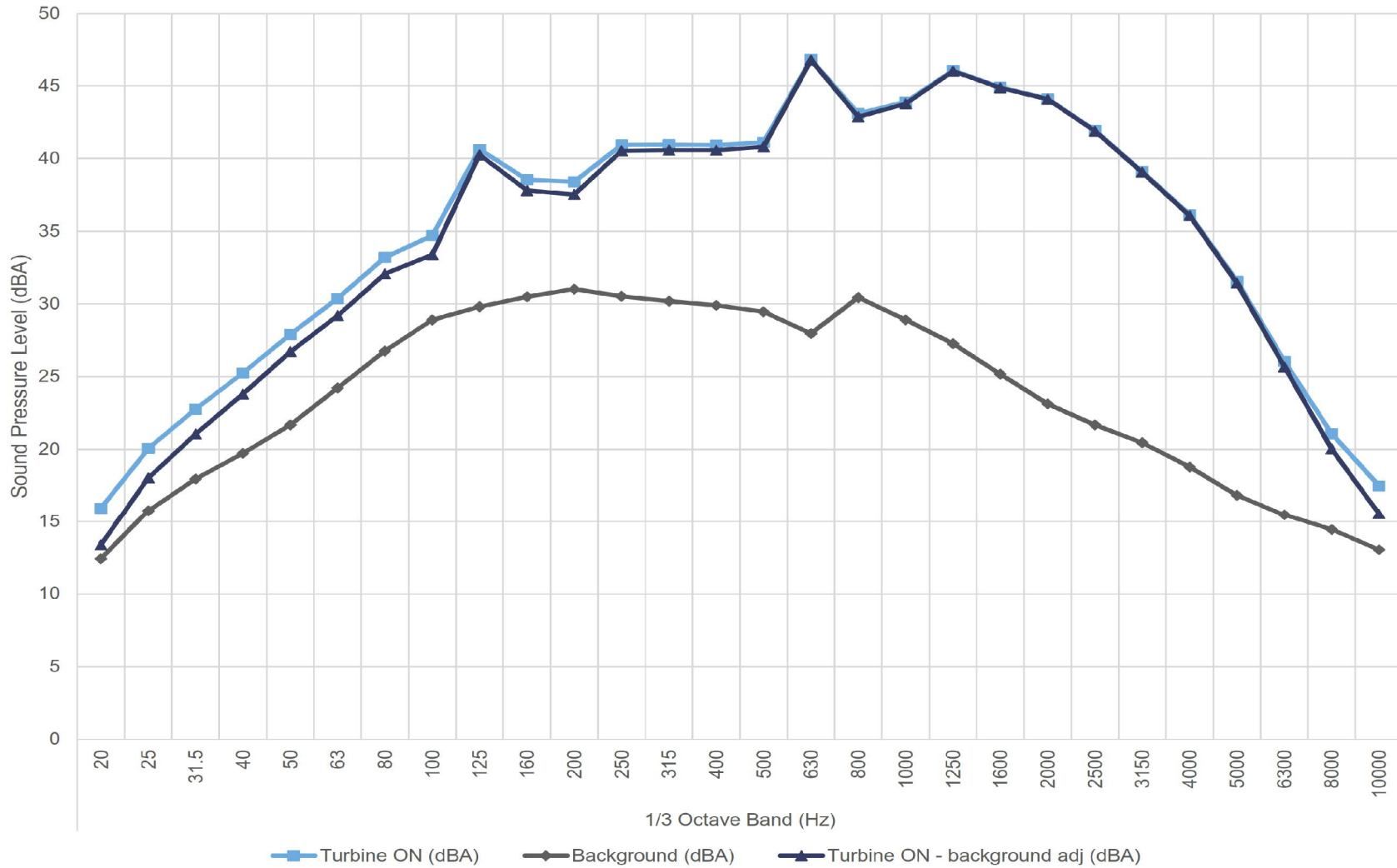
Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 9 m/s

Figure C.09

9.5 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

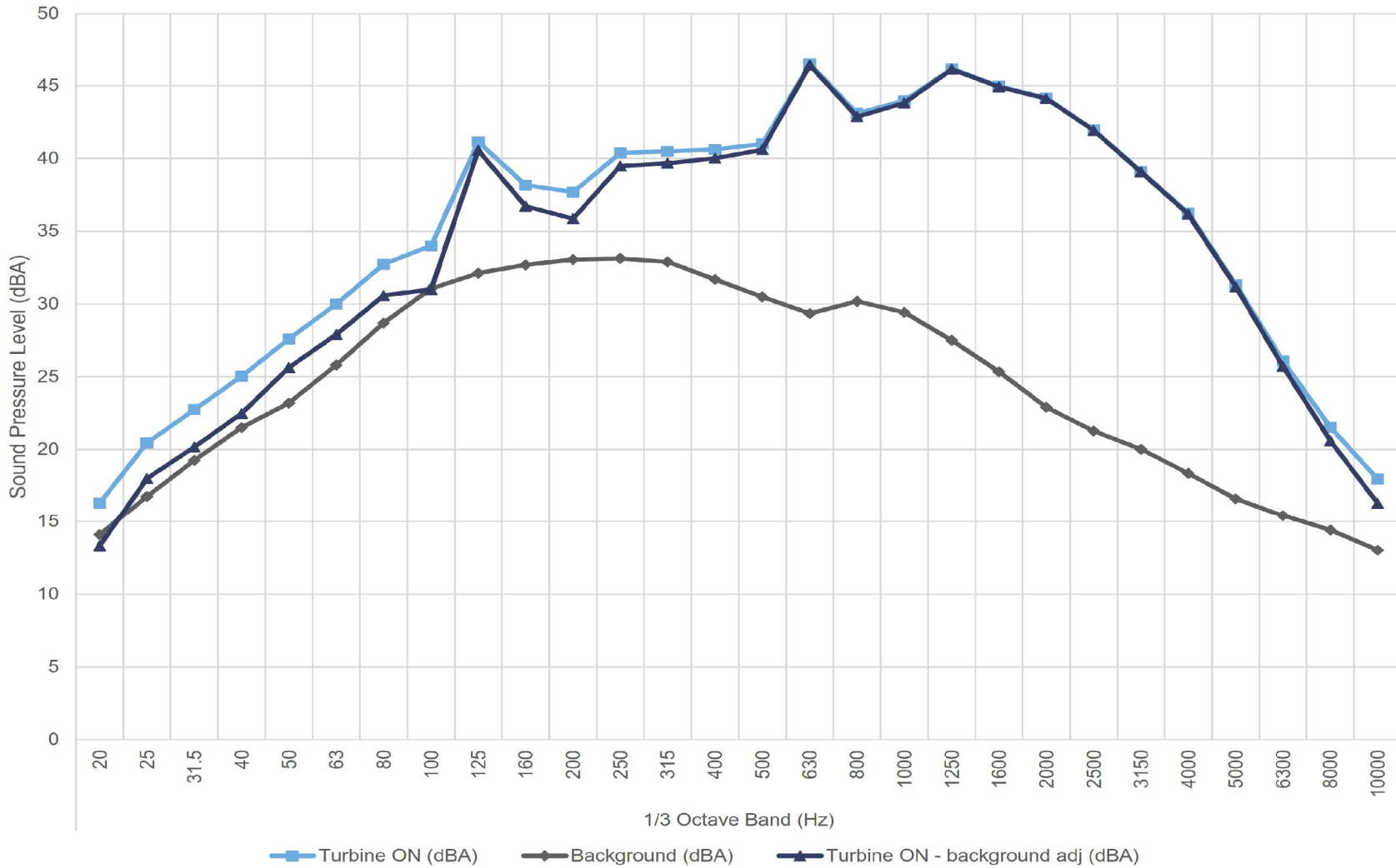
Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 9.5 m/s

Figure C.10

10.0 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

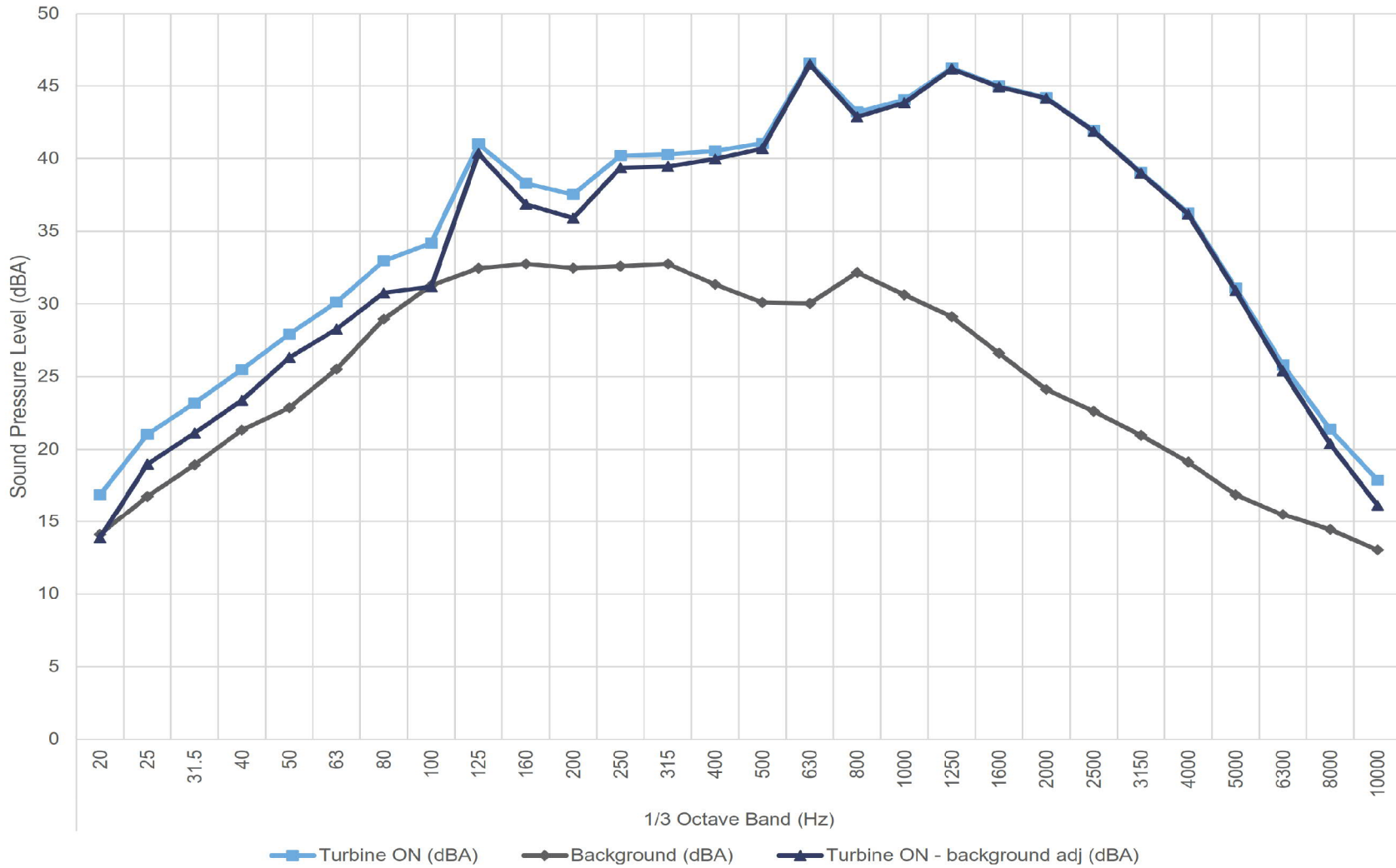
Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 10 m/s

Figure C.11

10.5 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

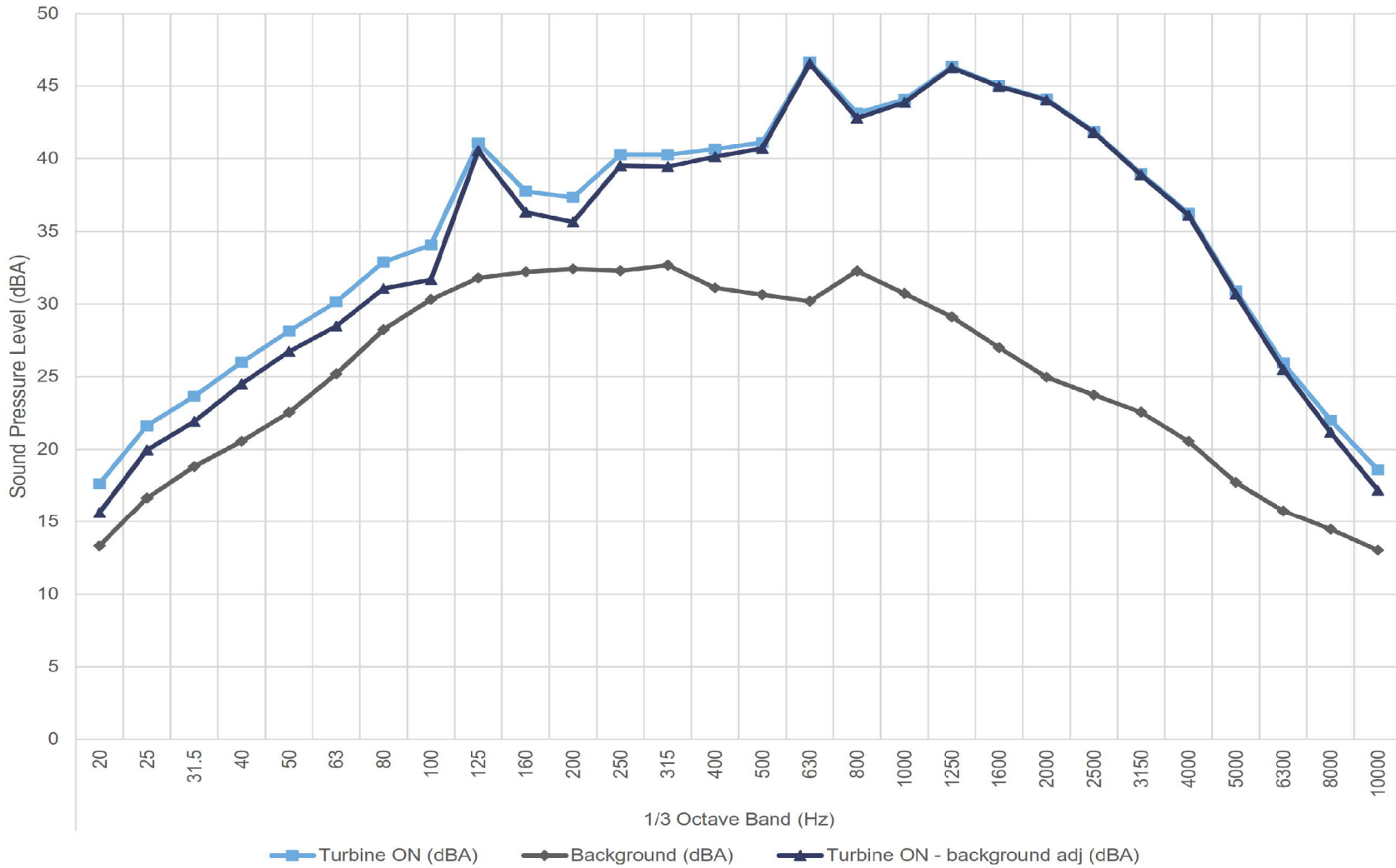
Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 10.5 m/s

Figure C.12

11.0 m/s - Hub Height



14331.00.T44.RP3

Scale: NTS
 Drawn by: AM
 Reviewed by: PA
 Date: Nov 1, 2017
 Revision: 1

Project Name

Bornish Wind Energy Centre - Turbine T44 - IEC61400-11 Edition 3.0

Figure Title

Plot of sound pressure spectrum in 1/3 Octave at 11 m/s

Figure C.13

Table C.01 Detailed apparent sound power level data at hub height

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement

Report ID: 14331.00.T44.RP3

1/3 Octave values marked with brackets [] denote less than 3 dB difference between Turbine ON and Background

Overall levels marked with an asterisk * denote 3 to 6 dB difference between Turbine ON and Background, while Overall values with less than 3 dB difference between Turbine ON and Background are not reported

Wind Bin (m/s)	Parameter	1/3 Octave Band (Hz)																		Overall											
		20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000		
11.0	Turbine ON (dBA)	17.6	21.6	23.6	26.0	28.1	30.1	32.9	34.1	41.1	37.7	37.3	40.3	40.3	40.6	41.1	46.6	43.1	44.0	46.3	45.0	44.1	41.9	39.0	36.2	30.9	25.9	22.0	18.6	54.7	
	Background (dBA)	13.3	16.6	18.8	20.6	22.5	25.2	28.2	30.3	31.8	32.2	32.4	32.3	32.7	31.1	30.6	30.2	32.3	30.7	29.1	27.0	25.0	23.7	22.6	20.5	17.7	15.7	14.5	13.0	42.9	
	Turbine ON - background adj (dBA)	15.6	20.0	21.9	24.5	26.7	28.5	31.1	31.7	40.5	36.3	35.6	39.5	39.4	40.1	40.7	46.5	42.8	43.8	46.2	44.9	44.0	41.8	38.9	36.1	30.7	25.5	21.2	17.2	54.4	
	Signal to noise (dB)	4.3	5.0	4.8	5.4	5.6	5.0	4.7	3.7	9.3	5.5	4.9	8.0	7.6	9.5	10.5	16.4	10.9	13.3	17.2	18.0	19.1	18.1	16.4	15.7	13.2	10.2	7.6	5.6	11.8	
	Uncertainty (dB)	2.0	1.8	1.5	1.3	1.2	1.3	1.4	1.7	1.0	1.2	1.2	0.9	0.9	0.8	0.8	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	1.0	2.1	0.8
	PWL (dBA)	64.5	68.8	70.8	73.4	75.6	77.3	79.9	80.5	89.4	85.2	84.5	88.4	88.3	89.0	89.5	95.4	91.6	92.7	95.1	93.8	92.9	90.6	87.7	85.0	79.5	74.3	70.0	66.0	103.3	

Table C.02 Detailed apparent sound power level data at 10m height

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 1
 Created on: 11/1/2017

1/3 Octave values marked with brackets [] denote less than 3 dB difference between Turbine ON and Background

Overall levels marked with an asterisk * denote 3 to 6 dB difference between Turbine ON and Background, while Overall values with less than 3 dB difference between Turbine ON and Background are not reported

Wind Bin (m/s)	Parameter	1/3 Octave Band (Hz)																		Overall										
		20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
5.0	Turbine ON (dBA)	10.5	14.1	17.9	21.1	24.0	27.0	30.2	32.2	34.5	32.9	35.3	36.1	36.5	35.3	36.9	37.3	38.7	39.5	40.5	40.2	39.1	37.4	35.3	32.6	29.0	24.2	18.4	14.5	49.6
	Background (dBA)	9.7	13.2	15.8	18.2	19.5	22.6	26.6	28.2	28.8	30.0	30.6	30.6	30.7	28.8	29.0	29.5	31.4	32.0	31.5	28.9	27.8	25.5	22.2	19.6	17.2	15.6	14.5	13.1	42.0
	Turbine ON - background adj (dBA)	[7.5]	[11.1]	[14.9]	[18.1]	22.1	25.0	27.7	30.0	33.2	[29.9]	33.5	34.6	35.2	34.3	36.1	36.5	37.8	38.7	39.9	39.9	38.8	37.1	35.0	32.4	28.7	23.6	16.1	[11.5]	48.8
	Signal to noise (dB)	0.8	0.9	2.1	2.9	4.5	4.4	3.6	4.0	5.7	2.9	4.7	5.5	5.8	6.6	7.9	7.8	7.3	7.5	9.0	11.3	11.3	11.9	13.1	13.0	11.8	8.6	3.9	1.4	7.7
	Uncertainty (dB)	2.4	2.4	1.9	1.8	1.3	1.3	1.5	1.4	1.1	1.8	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.8	0.8	0.8	0.8	0.9	1.4	3.1	0.8
	PWL (dBA)	[56.3]	[60]	[63.7]	[66.9]	71.0	73.9	76.6	78.8	82.1	[78.7]	82.4	83.5	84.1	83.1	85.0	85.4	86.6	87.5	88.8	88.7	87.6	86.0	83.9	81.2	77.6	72.4	65.0	[60.4]	97.7
6.0	Turbine ON (dBA)	13.5	17.3	20.7	23.6	26.5	29.5	32.6	34.3	38.1	36.6	38.0	39.8	40.2	39.5	40.0	43.6	41.8	42.6	44.1	43.7	42.7	40.7	38.1	34.8	30.7	25.2	19.2	15.6	53.2
	Background (dBA)	12.4	15.5	17.8	19.7	21.3	24.3	27.2	29.4	30.9	31.5	31.5	31.2	30.6	29.6	29.5	28.5	30.0	29.8	28.3	26.1	24.4	22.6	20.9	19.1	17.1	15.6	14.4	13.0	41.7
	Turbine ON - background adj (dBA)	[10.5]	[14.3]	[17.7]	21.3	25.0	27.9	31.1	32.6	37.2	35.0	36.9	39.2	39.7	39.0	39.6	43.5	41.5	42.4	44.0	43.6	42.7	40.7	38.0	34.6	30.5	24.7	17.5	[12.6]	52.9
	Signal to noise (dB)	1.1	1.8	2.9	3.9	5.2	5.2	5.4	4.9	7.2	5.1	6.5	8.6	9.6	9.8	10.5	15.1	11.8	12.8	15.7	17.6	18.4	18.1	17.2	15.7	13.6	9.6	4.8	2.5	11.5
	Uncertainty (dB)	2.4	2.4	1.9	1.5	1.2	1.2	1.2	1.0	1.2	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	1.2	3.1	0.8
	PWL (dBA)	[59.4]	[63.2]	[66.6]	70.2	73.8	76.8	80.0	81.5	86.1	83.8	85.8	88.0	88.5	87.8	88.5	92.4	90.3	91.3	92.8	92.4	91.5	89.5	86.9	83.5	79.4	73.6	66.3	[61.4]	101.7
7.0	Turbine ON (dBA)	16.2	20.3	22.9	25.3	27.9	30.3	33.1	34.5	40.8	38.4	38.2	40.7	40.8	40.8	41.1	46.6	43.1	43.9	46.1	44.9	44.1	41.9	39.1	36.2	31.5	26.1	21.2	17.6	54.8
	Background (dBA)	13.2	16.3	18.6	20.7	22.3	24.9	27.8	30.0	31.0	31.6	31.9	31.7	31.4	30.6	29.8	28.6	30.6	29.5	27.8	25.6	23.4	21.8	20.4	18.7	16.8	15.5	14.4	13.0	42.0
	Turbine ON - background adj (dBA)	13.3	18.2	20.9	23.4	26.5	28.8	31.6	32.6	40.4	37.4	37.0	40.1	40.2	40.3	40.7	46.5	42.9	43.8	46.0	44.9	44.1	41.9	39.1	36.1	31.3	25.7	20.2	15.8	54.5
	Signal to noise (dB)	3.1	4.1	4.3	4.6	5.6	5.4	5.3	4.5	9.9	6.8	6.3	9.0	9.4	10.2	11.3	18.0	12.5	14.5	18.3	19.3	20.7	20.1	18.7	17.4	14.7	10.6	6.8	4.6	12.7
	Uncertainty (dB)	2.4	1.9	1.4	1.3	1.2	1.2	1.2	1.4	0.9	1.0	1.0	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	1.0	2.3	0.8
	PWL (dBA)	62.1	67.0	69.7	72.3	75.3	77.7	80.4	81.4	89.2	86.2	85.8	89.0	89.1	89.2	89.6	95.4	91.7	92.6	94.9	93.7	93.0	90.8	87.9	85.0	80.2	74.5	69.0	64.6	103.4
8.0	Turbine ON (dBA)	17.6	21.6	23.7	26.0	28.3	30.3	32.9	34.1	40.9	37.9	37.4	40.3	40.4	40.7	41.1	46.7	43.2	44.1	46.3	45.1	44.2	42.0	39.0	36.2	31.0	26.1	22.2	18.7	54.8
	Background (dBA)	13.8	17.0	19.1	21.1	22.8	25.3	28.6	30.8	32.2	32.6	32.7	32.5	32.9	31.4	30.6	30.4	32.4	30.8	29.3	26.9	24.7	23.4	22.0	20.0	17.4	15.6	14.5	13.0	43.1
	Turbine ON - background adj (dBA)	15.2	19.7	21.8	24.3	26.9	28.6	30.9	31.4	40.3	36.4	35.5	39.5	39.6	40.2	40.7	46.6	42.8	43.9	46.2	45.0	44.1	41.9	38.9	36.1	30.8	25.7	21.4	17.4	54.5
	Signal to noise (dB)	3.8	4.6	4.6	4.9	5.5	5.0	4.3	3.3	8.7	5.3	4.6	7.8	7.5	9.3	10.5	16.3	10.8	13.3	17.1	18.2	19.5	18.6	17.0	16.2	13.6	10.5	7.7	5.7	11.7
	Uncertainty (dB)	2.1	1.8	1.5	1.4	1.2	1.3	1.4	1.8	1.0	1.2	1.2	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	1.0	2.0	0.8
	PWL (dBA)	64.1	68.6	70.7	73.2	75.8	77.5	79.8	80.3	89.1	85.3	84.4	88.4	88.4	89.0	89.6	95.5	91.7	92.8	95.1	93.9	93.0	90.8	87.8	84.9	79.7	74.6	70.2	66.2	103.4

Table C.03 Type B measurement uncertainty summary

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 1
 Created on: 11/1/2017

Overall Equipment Uncertainties		
	Typical values	Used values
Calibration	0.2 dB	0.2 dB
Board	0.3 dB	0.3 dB
Distance	0.1 dB	0.1 dB
Air absorption	0 dB	0 dB
Weather	0.5 dB	0.5 dB

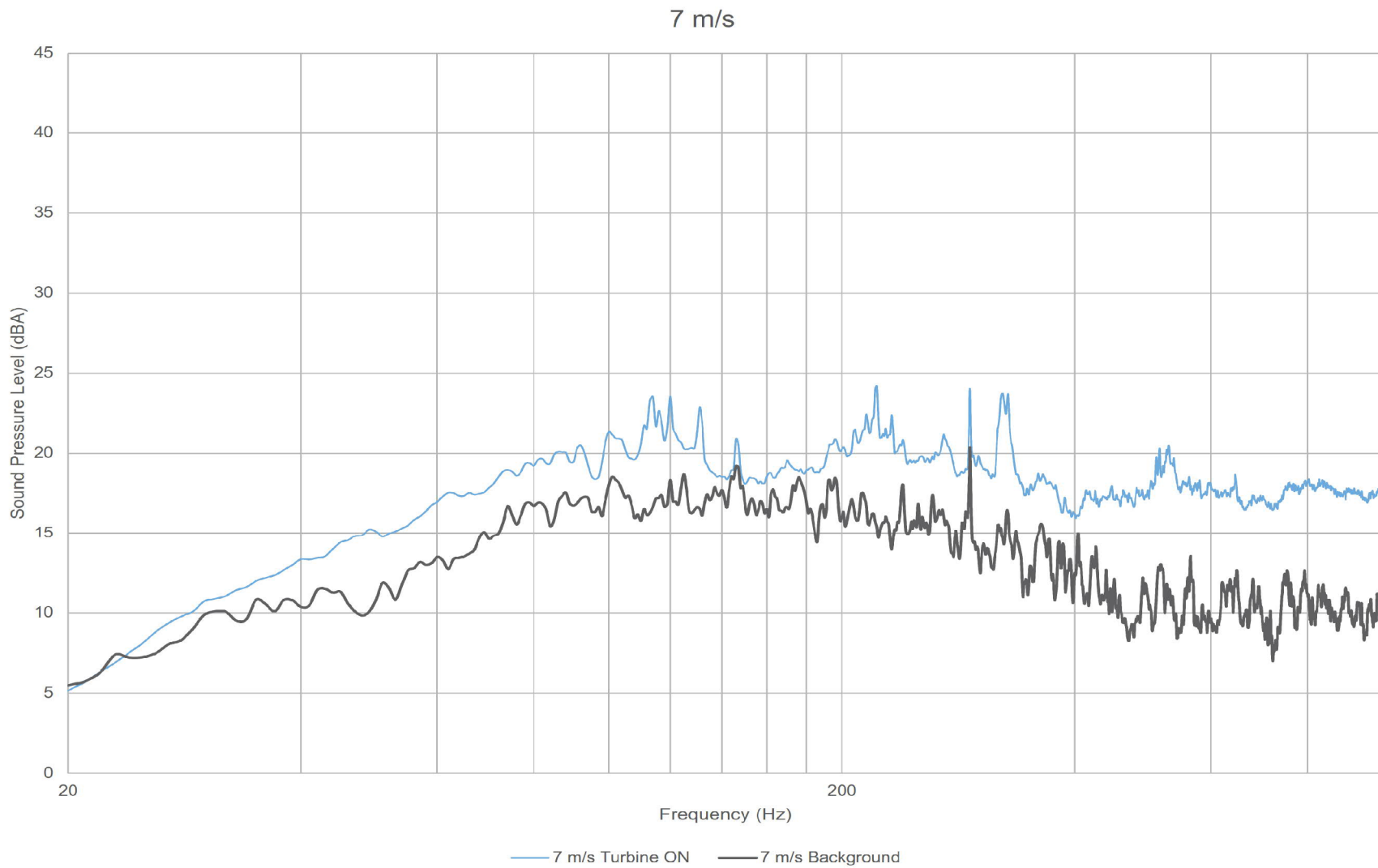
1/3 Octave Band Uncertainties		
Frequency (Hz)	Microphone Uncertainty	Overall (including overall equipment Uncertainties)
20	0.8 dB	1 dB
25	0.8 dB	1 dB
31.5	0.5 dB	0.8 dB
40	0.5 dB	0.8 dB
50	0.5 dB	0.8 dB
63	0.5 dB	0.8 dB
80	0.5 dB	0.8 dB
100	0.5 dB	0.8 dB
125	0.5 dB	0.8 dB
160	0.5 dB	0.8 dB
200	0.3 dB	0.7 dB
250	0.3 dB	0.7 dB
315	0.3 dB	0.7 dB
400	0.3 dB	0.7 dB
500	0.3 dB	0.7 dB
630	0.3 dB	0.7 dB
800	0.3 dB	0.7 dB
1000	0.3 dB	0.7 dB
1250	0.3 dB	0.7 dB
1600	0.3 dB	0.7 dB
2000	0.3 dB	0.7 dB
2500	0.5 dB	0.8 dB
3150	0.5 dB	0.8 dB
4000	0.5 dB	0.8 dB
5000	0.5 dB	0.8 dB
6300	0.5 dB	0.8 dB
8000	0.5 dB	0.8 dB
10000	1.3 dB	1.4 dB

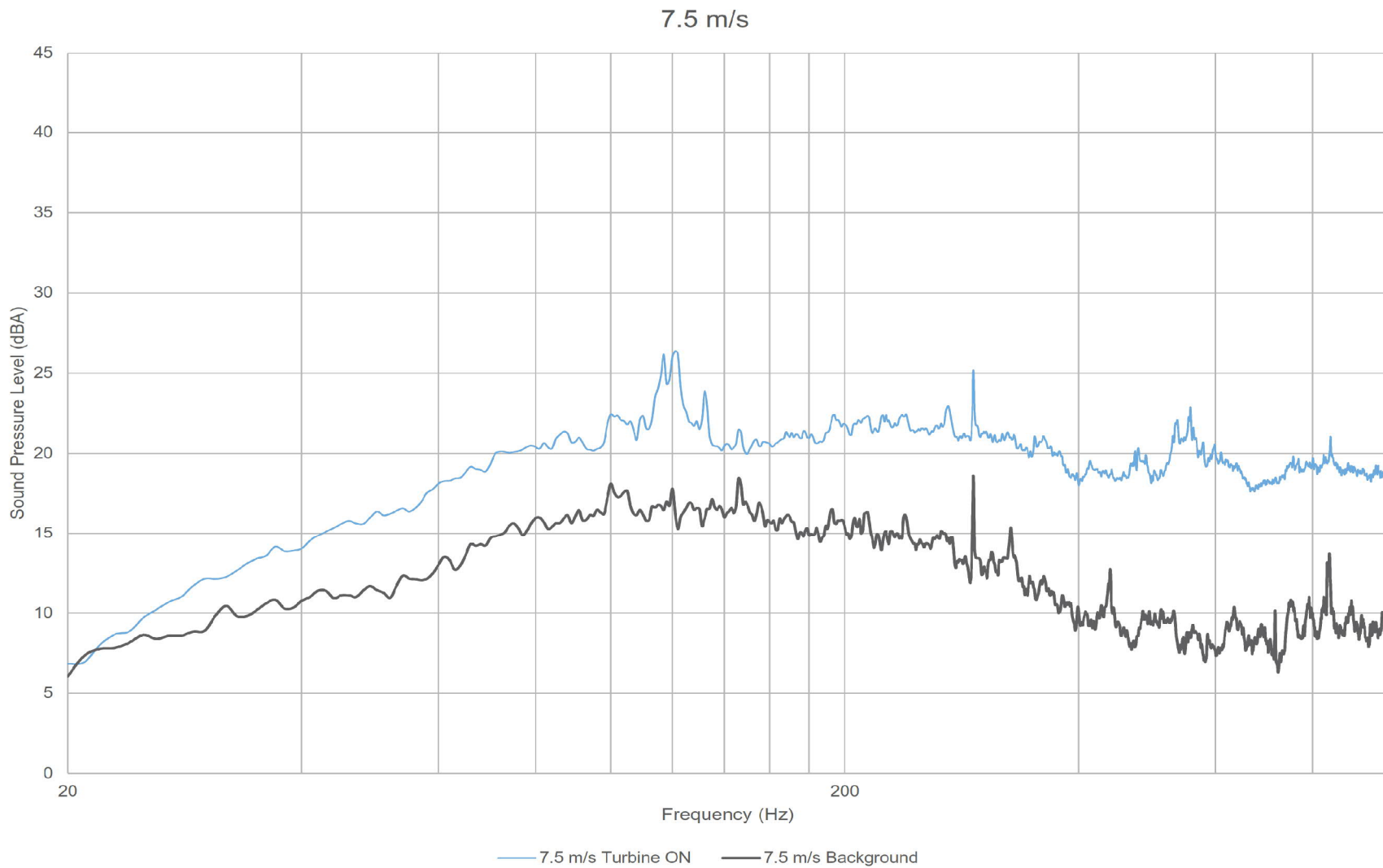
Table C.04 Detailed measurement uncertainty at hub height

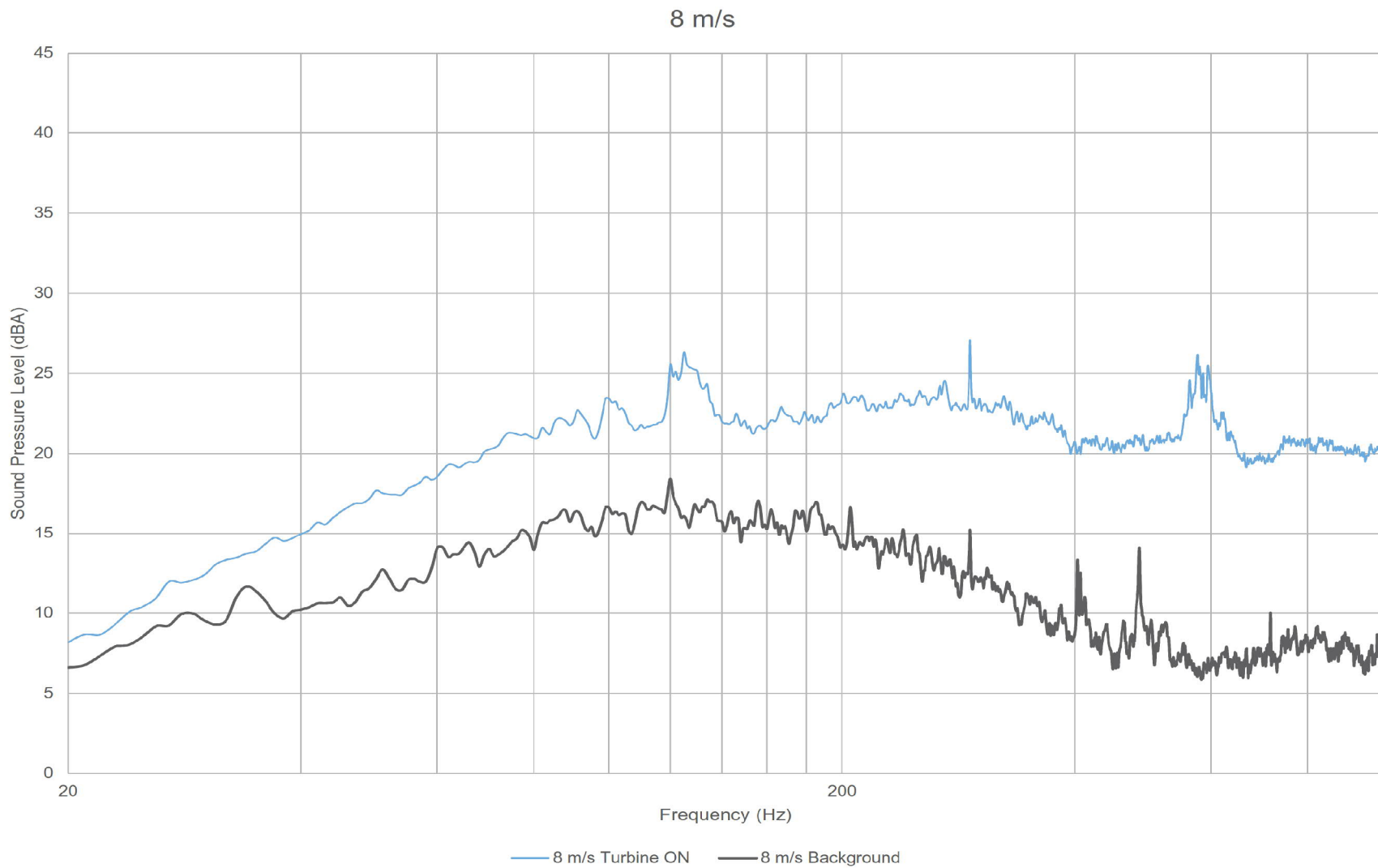
Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

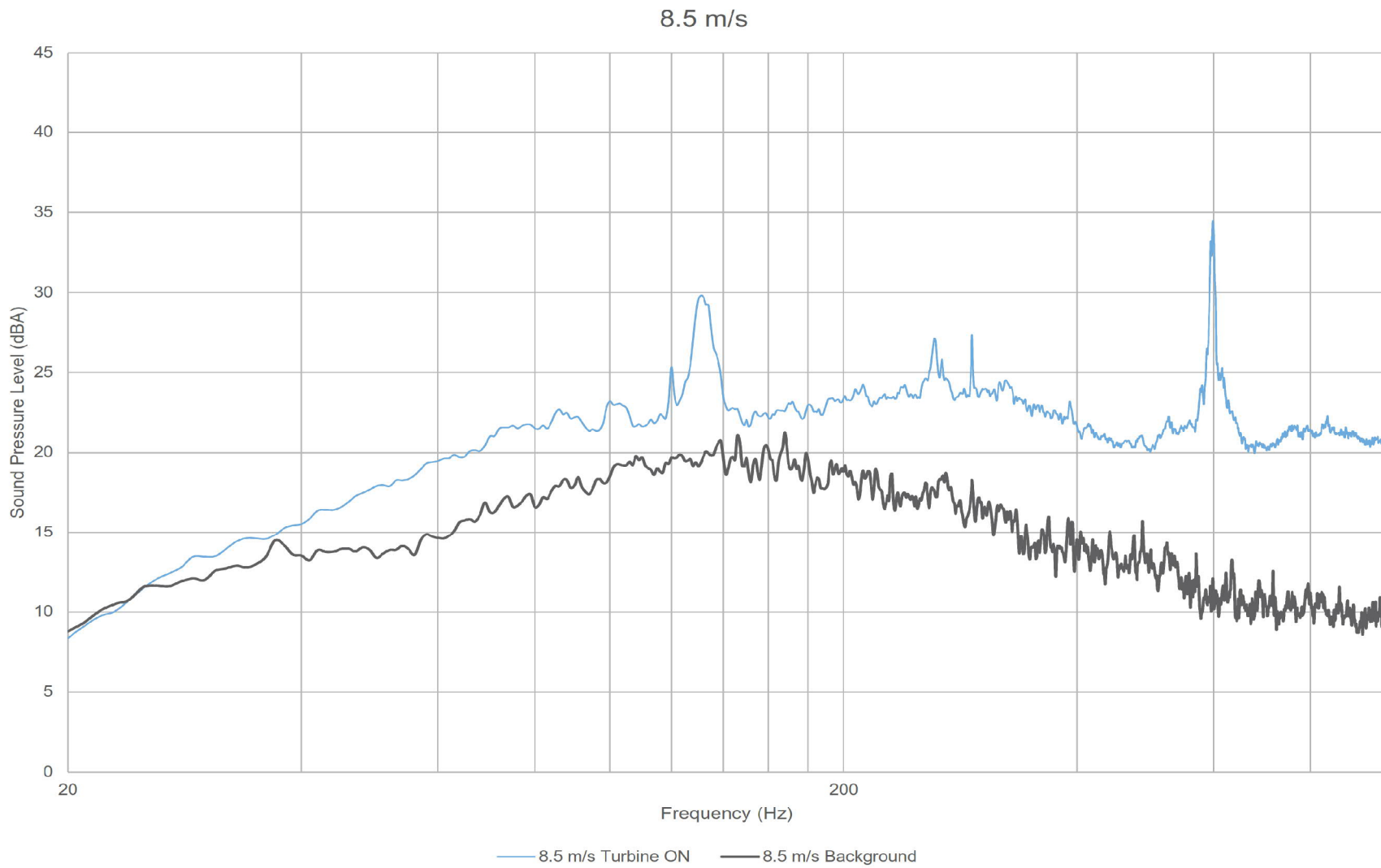
Wind Bin (m/s)	Parameter	Average Wind Speed (m/s)	# of data points	Parameter	1/3 Octave Band (Hz)																	Overall													
					20	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800		1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000		
10.5	Turbine ON	10.46	32	Average (dBA)	16.8	21.0	23.2	25.5	27.9	30.1	33.0	34.2	41.0	38.3	37.5	40.2	40.3	40.5	41.0	46.6	43.2	44.0	46.2	45.0	44.2	41.9	39.0	36.3	31.1	25.8	21.3	17.9	54.7		
				Uncertainty A (dB)	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.4
				Uncertainty B (dB)	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	1.4
				Combined Uncertainty (dB)	1.1	1.1	0.9	0.9	0.9	0.8	0.8	0.8	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	1.5
Background	10.50	16	Average (dBA)	14.1	16.8	18.9	21.3	22.9	25.5	29.0	31.3	32.5	32.7	32.5	32.6	32.7	31.3	30.1	30.0	32.2	30.6	29.1	26.6	24.1	22.6	21.0	19.1	16.9	15.5	14.4	13.0	43.1			
			Uncertainty A (dB)	1.2	1.1	1.0	0.9	0.9	0.9	1.1	1.2	1.3	1.3	1.5	1.7	1.7	1.5	1.4	1.5	1.1	0.9	0.8	0.6	0.5	0.6	0.5	0.6	0.5	0.2	0.1	0.0	0.0			
			Uncertainty B (dB)	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	1.4		
			Combined Uncertainty (dB)	1.6	1.5	1.3	1.2	1.2	1.2	1.4	1.5	1.5	1.5	1.6	1.8	1.8	1.6	1.6	1.6	1.3	1.2	1.0	0.9	0.9	1.0	0.9	0.8	0.8	0.8	0.8	0.8	1.4			
11.0	Turbine ON	10.99	27	Average (dBA)	17.6	21.6	23.7	26.0	28.1	30.1	32.9	34.1	41.1	37.7	37.3	40.3	40.3	40.6	41.1	46.6	43.1	44.0	46.3	45.0	44.1	41.9	39.0	36.2	30.9	25.9	22.0	18.6	54.7		
				Uncertainty A (dB)	0.6	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	
				Uncertainty B (dB)	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	1.4	
				Combined Uncertainty (dB)	1.2	1.1	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	1.5
Background	10.93	12	Average (dBA)	13.1	16.4	18.6	20.2	22.4	25.2	28.1	30.2	31.6	32.0	32.2	32.2	32.6	30.9	30.6	30.2	32.3	30.7	29.0	27.0	25.0	23.8	22.6	20.6	17.7	15.8	14.5	13.0	42.8			
			Uncertainty A (dB)	1.2	1.3	1.3	1.0	1.0	0.9	1.1	1.1	1.1	1.0	1.1	1.1	1.2	1.3	1.2	1.0	1.6	1.3	1.1	1.0	0.9	0.9	0.9	0.8	0.5	0.2	0.0	0.0				
			Uncertainty B (dB)	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	1.4			
			Combined Uncertainty (dB)	1.6	1.7	1.5	1.3	1.3	1.2	1.4	1.3	1.4	1.3	1.3	1.3	1.4	1.5	1.4	1.2	1.8	1.4	1.3	1.2	1.1	1.2	1.2	1.1	0.9	0.8	0.8	0.8	1.4			

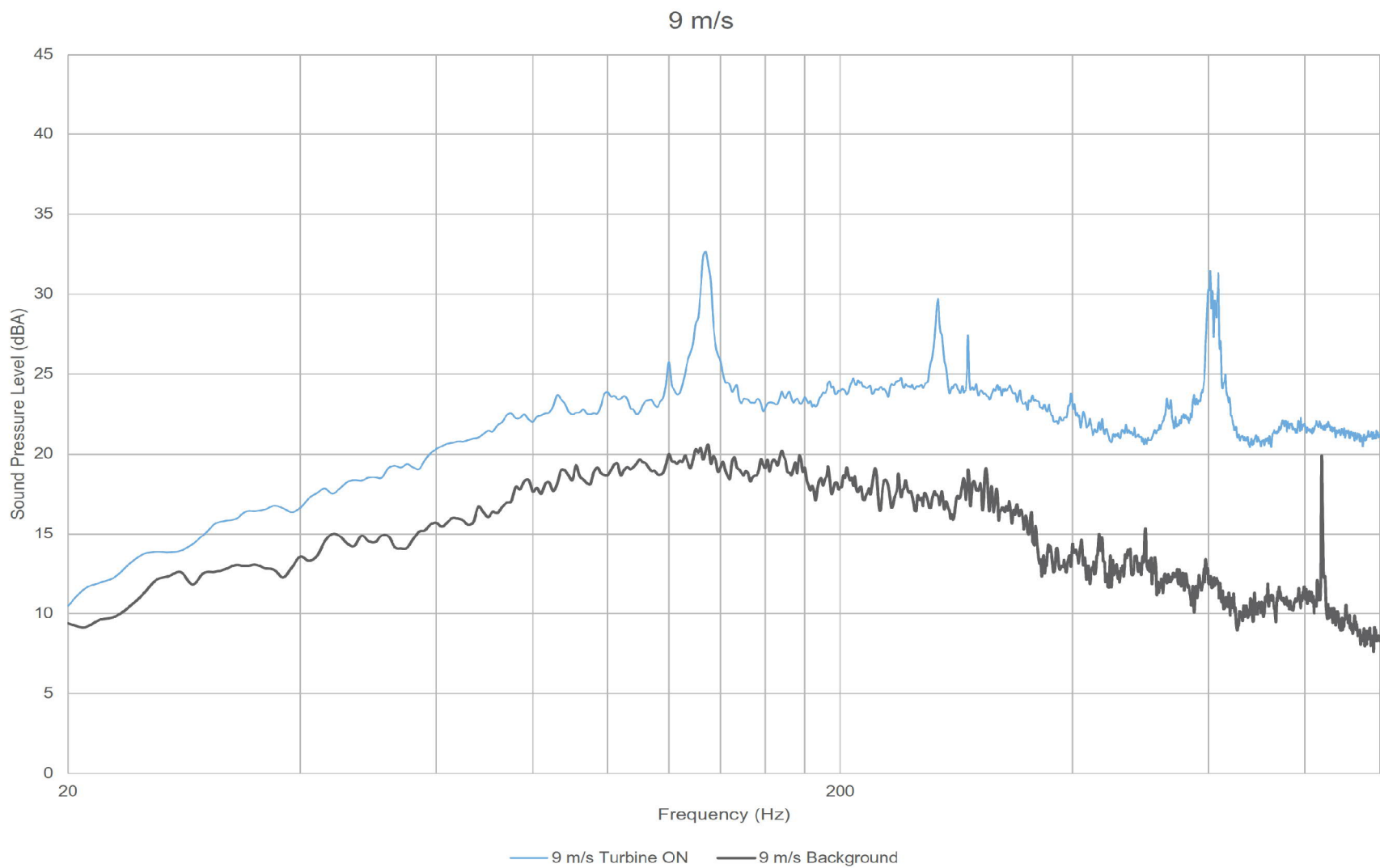
Appendix D Tonality Assessment

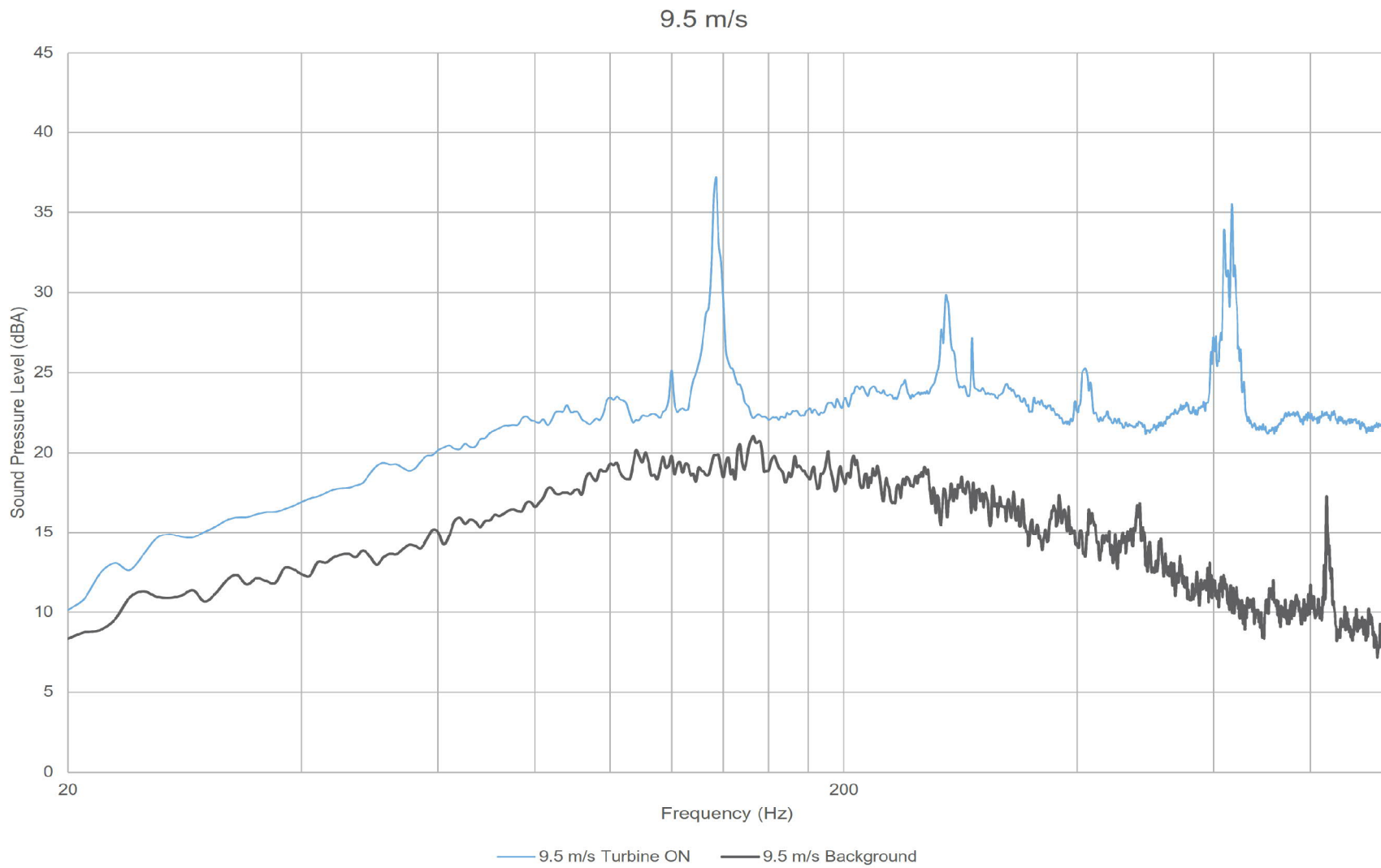


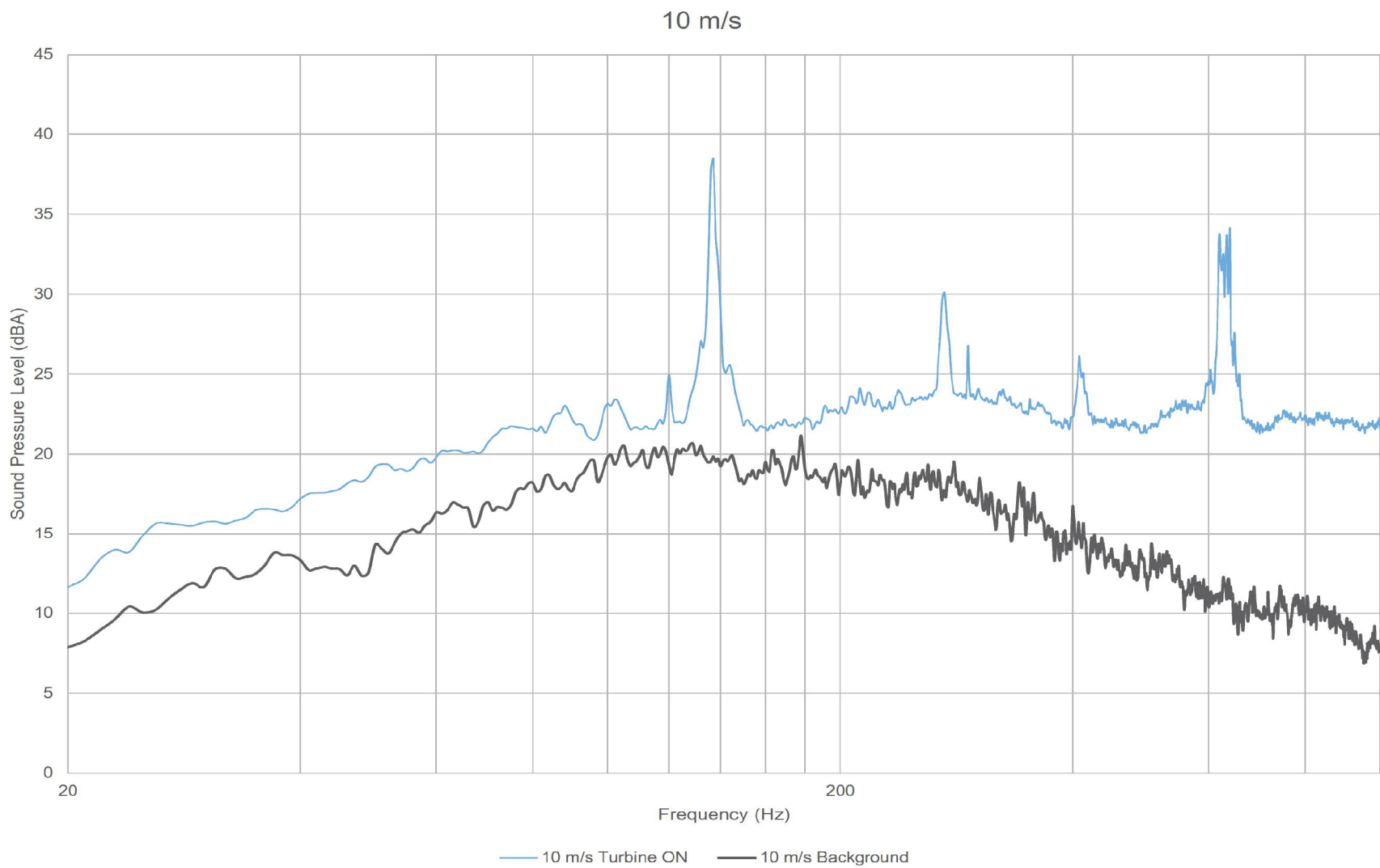


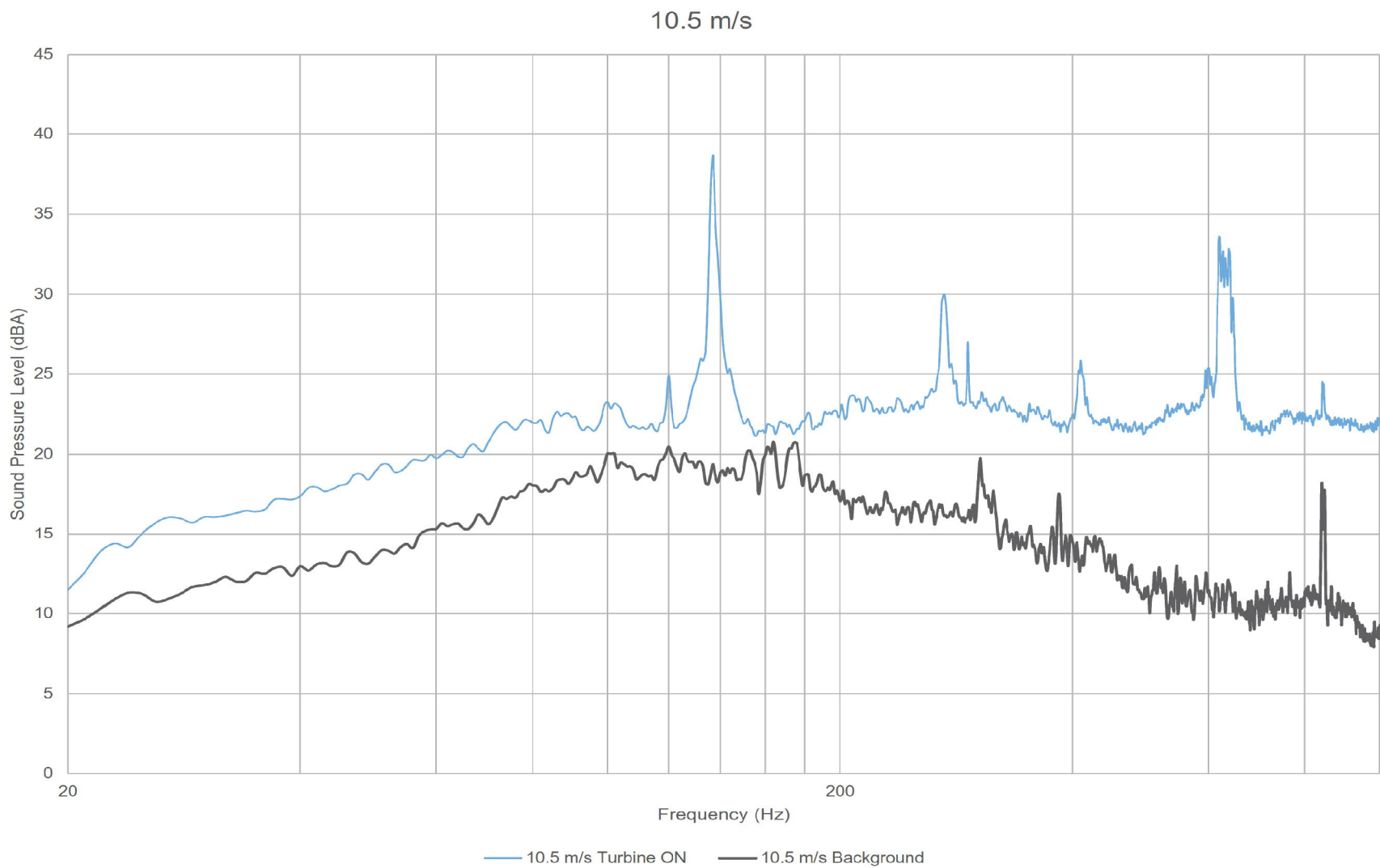












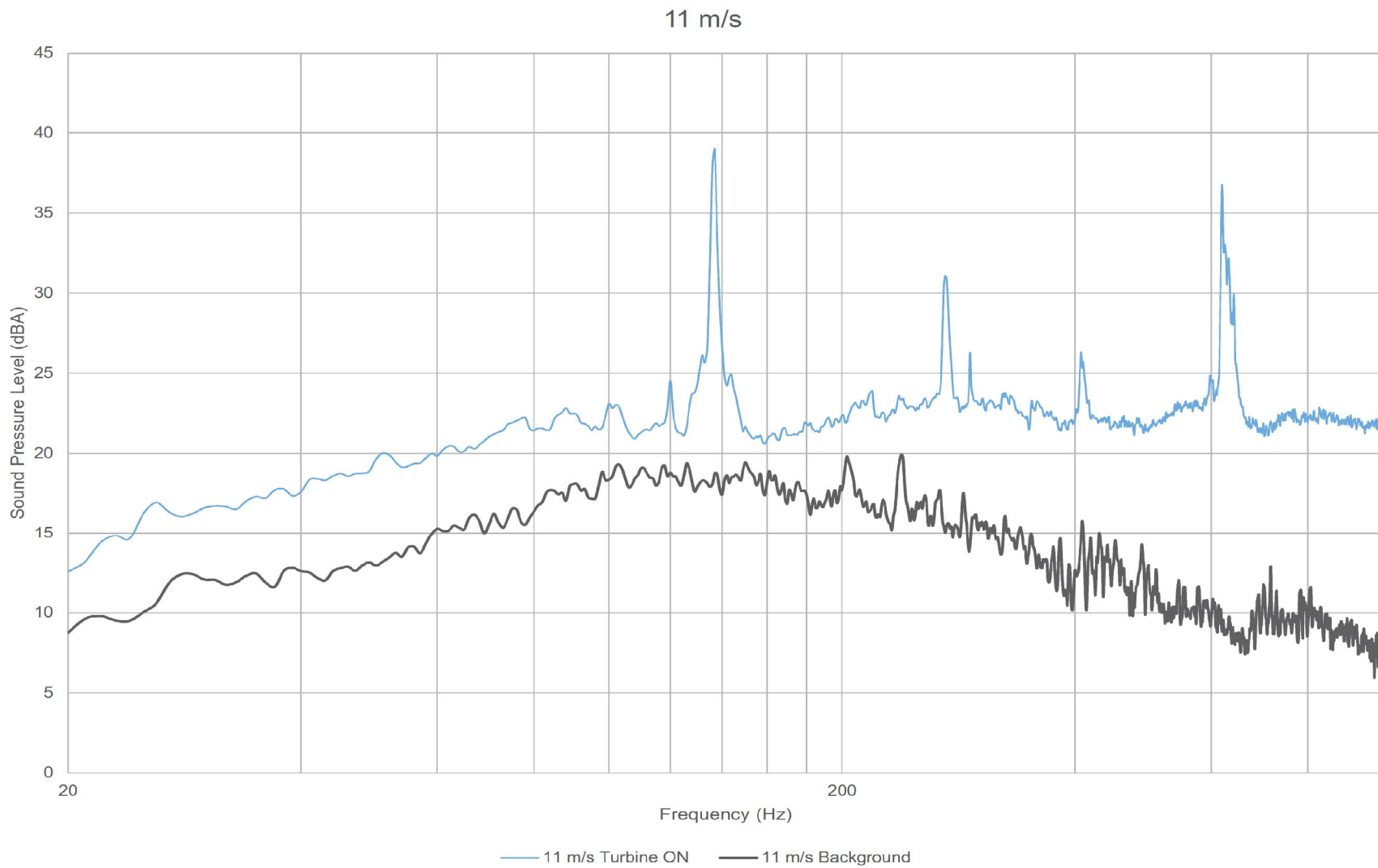


Table D.01 Tonality Assessment Table - 7 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP2

Page 1 of 1
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
24	99			18.0	36.2	26.0	-10.2	-2.0	-8.2
21	101			18.0	36.2	24.2	-12.0	-2.0	-10.0
17	108			17.5	35.8	28.7	-7.1	-2.0	-5.1
16	113			19.4	37.7	38.9	1.2	-2.0	3.2
22	113			18.7	37.0	26.2	-10.8	-2.0	-8.8
15	114			20.2	38.5	40.2	1.7	-2.0	3.7
14	117			19.6	37.9	34.3	-3.6	-2.0	-1.6
564	120			18.5	36.8	27.9	-8.9	-2.0	-6.9
565	120			19.4	37.7	25.6	-12.1	-2.0	-10.1
185	122			19.9	38.2	32.3	-5.9	-2.0	-3.9
10	130			19.1	37.4	33.5	-4.0	-2.0	-2.0
610	131			21.3	39.6	41.8	2.1	-2.0	4.1
9	133			19.1	37.4	31.4	-6.0	-2.0	-4.0
Average	117						-3.1	-2.0	-1.1

Table D.02 Tonality Assessment Table - 7.5 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 1
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
611	117			20.7	38.9	45.0	6.1	-2.0	8.1
697	119			20.6	38.8	27.0	-11.9	-2.0	-9.9
650	120			20.5	38.8	29.8	-9.1	-2.0	-7.1
40	120			18.2	36.5	25.1	-11.4	-2.0	-9.4
653	120			20.3	38.6	26.8	-11.8	-2.0	-9.8
39	120			19.1	37.4	25.5	-11.9	-2.0	-9.9
665	120			20.0	38.2	26.6	-11.7	-2.0	-9.7
656	120			20.2	38.5	26.6	-12.0	-2.0	-9.9
693	121			20.3	38.6	30.7	-7.9	-2.0	-5.9
621	121			20.4	38.7	26.9	-11.8	-2.0	-9.8
646	121			20.3	38.6	32.1	-6.4	-2.0	-4.4
594	121			19.8	38.0	28.1	-9.9	-2.0	-7.9
533	121			20.1	38.4	32.1	-6.3	-2.0	-4.3
38	121			20.3	38.6	31.3	-7.4	-2.0	-5.3
657	121			20.7	39.0	31.2	-7.8	-2.0	-5.7
692	121			20.6	38.9	30.1	-8.8	-2.0	-6.8
529	121			20.2	38.5	30.8	-7.7	-2.0	-5.7
566	121			20.5	38.8	30.9	-7.9	-2.0	-5.9
655	122			21.1	39.4	32.0	-7.4	-2.0	-5.4
541	122			20.6	38.9	30.8	-8.1	-2.0	-6.1
654	122			21.1	39.4	31.3	-8.1	-2.0	-6.0
493	122			20.5	38.8	28.3	-10.5	-2.0	-8.5
649	122			20.3	38.6	33.5	-5.1	-2.0	-3.1
709	122			20.4	38.7	30.9	-7.8	-2.0	-5.8
758	122			20.5	38.8	33.9	-4.9	-2.0	-2.9
757	122			20.2	38.5	33.1	-5.4	-2.0	-3.4
682	122			20.1	38.4	30.1	-8.3	-2.0	-6.3
609	132			21.9	40.2	40.4	0.3	-2.0	2.3
8	135			19.7	38.0	28.0	-10.1	-2.0	-8.1
Average	122						-5.0	-2.0	-3.0

Table D.03 Tonality Assessment Table - 8 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
Report ID: 14331.00.T44.RP3

Page 1 of 1
Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
No Reportable Tones									

Table D.04 Tonality Assessment Table - 8.5 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 1
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
257	571			21.3	40.4	33.0	-7.5	-2.4	-5.1
686	588			21.7	40.9	39.9	-1.0	-2.4	1.3
346	594			22.0	41.2	43.4	2.2	-2.4	4.6
174	594			22.2	41.3	34.3	-7.1	-2.4	-4.7
633	595			22.2	41.4	39.3	-2.1	-2.4	0.3
527	595			22.7	41.9	41.4	-0.5	-2.4	1.9
343	595			21.7	40.9	44.8	3.9	-2.4	6.3
340	595			22.2	41.3	41.6	0.2	-2.4	2.6
341	595			22.1	41.3	47.3	6.1	-2.4	8.5
344	595			21.7	40.9	41.2	0.3	-2.4	2.7
644	595			21.9	41.1	37.1	-4.0	-2.4	-1.6
592	595			22.5	41.7	33.7	-8.0	-2.4	-5.6
572	596			23.2	42.3	38.3	-4.1	-2.4	-1.7
483	596			21.8	41.0	37.6	-3.5	-2.4	-1.0
579	596			22.4	41.6	44.5	2.8	-2.4	5.3
559	596			23.2	42.3	39.7	-2.6	-2.4	-0.2
940	596			22.3	41.5	31.5	-9.9	-2.4	-7.5
375	598			21.6	40.8	40.7	-0.1	-2.4	2.3
365	598			22.1	41.3	42.1	0.8	-2.4	3.2
589	599			22.5	41.7	44.4	2.8	-2.4	5.2
685	599			22.2	41.3	42.1	0.7	-2.4	3.1
376	599			21.7	40.9	41.6	0.7	-2.4	3.1
551	599			22.1	41.3	40.2	-1.1	-2.4	1.4
487	599			22.0	41.2	42.8	1.6	-2.4	4.0
345	599			22.0	41.2	46.5	5.3	-2.4	7.7
906	599			23.3	42.5	41.9	-0.6	-2.4	1.8
347	600			22.6	41.8	45.5	3.8	-2.4	6.2
576	600			22.6	41.8	41.1	-0.7	-2.4	1.8
939	600			22.2	41.4	42.5	1.1	-2.4	3.5
574	600			22.4	41.6	39.4	-2.2	-2.4	0.2
481	600			22.1	41.3	39.9	-1.4	-2.4	1.0
543	600			23.8	42.9	40.3	-2.6	-2.4	-0.2
380	600			22.2	41.3	42.1	0.7	-2.4	3.1
558	601			22.5	41.7	44.9	3.2	-2.4	5.6
377	601			22.3	41.5	40.5	-1.0	-2.4	1.5
600	601			22.8	42.0	43.5	1.5	-2.4	3.9
245	601			22.6	41.8	38.7	-3.1	-2.4	-0.7
573	601			22.3	41.5	43.2	1.6	-2.4	4.1
258	601			22.3	41.5	37.4	-4.2	-2.4	-1.7
374	601			22.5	41.7	40.0	-1.7	-2.4	0.7
Average	597						0.5	-2.4	2.9

Table D.05 Tonality Assessment Table - 9 m/s

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 2
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
480	130			22.1	40.4	34.2	-6.2	-2.0	-4.2
583	131			23.2	41.5	35.8	-5.7	-2.0	-3.7
248	132			23.4	41.6	31.3	-10.3	-2.0	-8.3
578	132			22.4	40.7	37.7	-3.0	-2.0	-1.0
591	133			23.2	41.5	38.2	-3.3	-2.0	-1.3
582	133			22.6	40.9	38.5	-2.4	-2.0	-0.4
588	133			22.3	40.6	37.6	-3.0	-2.0	-0.9
590	133			23.2	41.5	38.9	-2.6	-2.0	-0.6
342	133			22.1	40.4	36.8	-3.6	-2.0	-1.6
577	133			22.4	40.7	39.2	-1.5	-2.0	0.6
907	133			24.0	42.3	35.3	-7.0	-2.0	-5.0
632	133			21.8	40.1	37.0	-3.0	-2.0	-1.0
623	134			23.7	42.0	36.1	-5.9	-2.0	-3.9
212	134			23.6	41.9	36.8	-5.2	-2.0	-3.2
550	134			22.5	40.8	40.1	-0.7	-2.0	1.3
587	134			22.9	41.2	35.4	-5.8	-2.0	-3.8
624	134			23.0	41.2	36.1	-5.2	-2.0	-3.2
349	134			22.4	40.7	36.5	-4.2	-2.0	-2.2
228	134			26.7	45.0	38.8	-6.2	-2.0	-4.2
586	134			24.0	42.3	35.7	-6.7	-2.0	-4.6
244	134			24.6	42.9	39.2	-3.7	-2.0	-1.7
926	134			24.9	43.2	37.0	-6.2	-2.0	-4.2
348	134			22.3	40.6	36.1	-4.6	-2.0	-2.5
905	135			24.0	42.3	35.2	-7.1	-2.0	-5.1
627	135			23.9	42.2	33.9	-8.4	-2.0	-6.4
544	135			23.3	41.6	39.6	-2.0	-2.0	0.0
690	135			22.4	40.7	35.3	-5.4	-2.0	-3.4
571	135			22.4	40.7	40.1	-0.6	-2.0	1.4
570	135			23.2	41.5	37.4	-4.1	-2.0	-2.1
372	136			23.0	41.3	37.2	-4.1	-2.0	-2.1
190	136			26.1	44.4	39.9	-4.5	-2.0	-2.5
379	136			23.7	42.0	40.1	-1.8	-2.0	0.2
634	136			23.0	41.3	37.5	-3.7	-2.0	-1.7
178	138			23.7	42.0	36.4	-5.6	-2.0	-3.5
	134						-4.0	-2.0	-2.0

Table D.05 Tonality Assessment Table - 9 m/s

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 2 of 2
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
261	569			21.7	40.8	31.2	-9.5	-2.4	-7.2
324	574			25.5	44.6	39.6	-5.0	-2.4	-2.6
264	582			22.7	41.8	32.5	-9.4	-2.4	-7.0
248	587			22.3	41.5	35.6	-5.9	-2.4	-3.5
907	597			23.1	42.3	41.8	-0.5	-2.4	1.9
583	598			22.6	41.8	42.4	0.5	-2.4	3.0
480	599			22.2	41.4	43.0	1.6	-2.4	4.0
624	599			23.2	42.4	43.1	0.7	-2.4	3.1
588	601			22.7	41.9	42.7	0.8	-2.4	3.2
632	601			23.0	42.2	43.5	1.3	-2.4	3.8
634	602			23.1	42.3	42.3	0.0	-2.4	2.4
591	603			22.7	41.9	41.8	-0.1	-2.4	2.3
582	603			22.7	41.9	44.0	2.2	-2.4	4.6
926	604			23.3	42.5	41.5	-0.9	-2.4	1.5
578	605			22.8	42.0	44.0	2.1	-2.4	4.5
577	607			23.0	42.2	44.3	2.2	-2.4	4.6
590	608			22.6	41.9	39.5	-2.4	-2.4	0.0
342	611			22.2	41.4	43.0	1.6	-2.4	4.0
349	611			22.4	41.6	42.2	0.6	-2.4	3.0
550	612			22.9	42.1	37.6	-4.5	-2.4	-2.0
348	612			22.5	41.7	41.7	0.0	-2.4	2.4
Average	599						-0.2	-2.4	2.2

Table D.06 Tonality Assessment Table - 9.5 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 3
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
777	130			23.8	42.1	34.5	-7.6	-2.0	-5.5
445	132			22.4	40.7	36.0	-4.7	-2.0	-2.7
422	132			23.5	41.8	35.2	-6.6	-2.0	-4.6
454	133			22.1	40.3	35.6	-4.7	-2.0	-2.7
412	133			22.7	41.0	40.0	-1.0	-2.0	1.1
455	133			22.5	40.8	38.9	-1.9	-2.0	0.1
197	134			23.4	41.7	37.9	-3.8	-2.0	-1.8
983	135			21.8	40.1	38.2	-2.0	-2.0	0.1
408	136			21.7	40.0	38.5	-1.5	-2.0	0.5
476	136			21.4	39.7	41.1	1.5	-2.0	3.5
813	136			23.4	41.7	44.2	2.5	-2.0	4.5
1072	136			22.0	40.3	38.0	-2.2	-2.0	-0.2
378	136			24.1	42.4	41.3	-1.1	-2.0	0.9
920	136			23.3	41.6	39.7	-1.9	-2.0	0.1
1028	136			21.3	39.6	37.3	-2.3	-2.0	-0.3
1061	136			21.6	39.9	42.9	3.0	-2.0	5.0
899	136			22.1	40.4	39.0	-1.4	-2.0	0.6
941	136			23.3	41.6	36.7	-4.9	-2.0	-2.8
1073	136			21.5	39.8	38.8	-0.9	-2.0	1.1
477	136			21.7	40.0	36.9	-3.1	-2.0	-1.1
350	136			23.2	41.5	38.1	-3.4	-2.0	-1.4
825	136			23.2	41.5	39.8	-1.7	-2.0	0.3
885	136			20.9	39.2	45.0	5.7	-2.0	7.8
870	136			21.3	39.6	37.0	-2.6	-2.0	-0.6
864	137			22.9	41.2	36.2	-4.9	-2.0	-2.9
406	137			21.9	40.2	43.5	3.3	-2.0	5.3
474	137			21.7	40.0	37.1	-2.9	-2.0	-0.9
962	137			22.0	40.3	43.0	2.7	-2.0	4.7
857	137			22.7	41.0	44.1	3.1	-2.0	5.1
628	137			23.7	42.0	42.5	0.5	-2.0	2.5
397	137			22.0	40.3	41.0	0.7	-2.0	2.8
457	137			23.6	41.9	40.3	-1.6	-2.0	0.4
909	137			24.2	42.5	40.5	-2.0	-2.0	0.0
889	137			21.6	39.9	40.6	0.7	-2.0	2.7
464	137			21.8	40.1	40.4	0.2	-2.0	2.2
790	137			22.1	40.4	43.8	3.4	-2.0	5.4
1059	137			22.1	40.4	40.8	0.4	-2.0	2.4
439	137			22.3	40.6	38.6	-2.0	-2.0	0.1
546	137			22.5	40.8	42.7	1.9	-2.0	3.9
969	137			24.1	42.4	40.0	-2.4	-2.0	-0.4
389	137			23.3	41.6	39.5	-2.1	-2.0	-0.1
952	137			21.6	39.9	43.2	3.3	-2.0	5.4
1075	137			21.0	39.3	41.8	2.6	-2.0	4.6
456	137			23.0	41.3	42.8	1.5	-2.0	3.5
469	137			21.3	39.6	40.1	0.5	-2.0	2.5
639	137			22.2	40.5	40.2	-0.4	-2.0	1.6
441	137			21.4	39.7	43.3	3.6	-2.0	5.6
423	137			23.9	42.2	33.6	-8.6	-2.0	-6.6
785	137			24.9	43.2	37.2	-6.0	-2.0	-3.9
856	137			22.6	40.9	44.6	3.7	-2.0	5.7
1017	137			22.7	41.0	40.2	-0.8	-2.0	1.2
354	138			22.3	40.6	36.6	-4.0	-2.0	-2.0
868	139			21.0	39.3	39.7	0.4	-2.0	2.4
1076	139			22.5	40.8	39.9	-0.9	-2.0	1.1
895	139			23.6	41.9	37.2	-4.7	-2.0	-2.7
352	139			22.9	41.2	33.9	-7.4	-2.0	-5.4
466	139			22.4	40.7	37.0	-3.7	-2.0	-1.7
460	139			22.4	40.7	36.1	-4.6	-2.0	-2.6
468	139			21.3	39.6	40.4	0.9	-2.0	2.9
834	139			21.9	40.2	37.6	-2.6	-2.0	-0.6
308	139			26.9	45.2	33.5	-11.7	-2.0	-9.7
467	139			21.4	39.7	39.9	0.2	-2.0	2.2
461	139			23.0	41.3	39.7	-1.6	-2.0	0.4
1002	139			22.4	40.7	39.6	-1.2	-2.0	0.9
846	139			23.3	41.6	39.6	-2.0	-2.0	0.0
426	139			22.2	40.5	33.7	-6.8	-2.0	-4.8
243	140			23.9	42.2	33.9	-8.3	-2.0	-6.3

Table D.06 Tonality Assessment Table - 9.5 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement

Report ID: 14331.00.T44.RP3

Page 2 of 3

Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
312	140			24.6	42.9	37.9	-5.0	-2.0	-3.0
636	141			21.6	39.9	33.2	-6.6	-2.0	-4.6
Average	137						-0.5	-2.0	1.5

Table D.06 Tonality Assessment Table - 9.5 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 3 of 3
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
983	616			23.6	42.8	45.6	2.8	-2.4	5.2
439	617			23.7	42.9	46.2	3.3	-2.4	5.7
464	617			23.3	42.5	43.7	1.2	-2.4	3.6
477	618			23.4	42.6	43.2	0.6	-2.4	3.1
1073	618			23.8	43.0	43.5	0.5	-2.4	2.9
378	619			23.3	42.6	43.4	0.9	-2.4	3.3
408	619			23.2	42.4	47.8	5.3	-2.4	7.8
1072	619			23.3	42.6	44.4	1.8	-2.4	4.2
870	619			23.2	42.5	46.4	3.9	-2.4	6.4
899	619			23.3	42.5	45.5	3.0	-2.4	5.4
920	619			23.2	42.5	44.9	2.5	-2.4	4.9
1028	620			23.4	42.7	44.0	1.3	-2.4	3.8
889	620			22.6	41.8	43.8	1.9	-2.4	4.4
350	620			22.9	42.2	45.3	3.2	-2.4	5.6
456	620			23.3	42.6	40.7	-1.8	-2.4	0.6
292	621			24.4	43.6	35.3	-8.3	-2.4	-5.9
813	622			23.3	42.6	44.0	1.4	-2.4	3.9
476	622			23.5	42.7	39.5	-3.3	-2.4	-0.8
885	623			23.9	43.1	44.6	1.5	-2.4	3.9
1061	624			23.7	43.0	43.9	0.9	-2.4	3.4
628	625			23.7	43.0	43.5	0.5	-2.4	3.0
941	625			23.5	42.7	41.1	-1.6	-2.4	0.8
441	625			23.7	42.9	40.2	-2.7	-2.4	-0.2
962	626			23.2	42.5	40.7	-1.7	-2.4	0.7
856	626			24.6	43.9	42.3	-1.6	-2.4	0.9
857	626			23.6	42.8	42.6	-0.2	-2.4	2.2
406	626			23.3	42.6	41.4	-1.2	-2.4	1.2
952	627			23.5	42.7	40.9	-1.8	-2.4	0.6
969	627			24.3	43.6	42.6	-1.0	-2.4	1.4
639	627			23.6	42.9	43.2	0.3	-2.4	2.8
1059	628			23.7	43.0	42.3	-0.7	-2.4	1.7
397	628			23.4	42.7	43.0	0.3	-2.4	2.8
825	629			23.9	43.2	41.4	-1.8	-2.4	0.7
785	631			23.2	42.5	44.5	2.0	-2.4	4.5
790	631			23.6	42.9	42.7	-0.1	-2.4	2.3
469	632			23.2	42.5	45.5	3.0	-2.4	5.5
1002	632			23.7	43.0	45.2	2.2	-2.4	4.7
354	632			22.8	42.1	46.7	4.6	-2.4	7.0
895	633			23.5	42.8	47.4	4.5	-2.4	7.0
846	633			23.6	42.9	48.5	5.6	-2.4	8.1
457	633			23.4	42.7	46.3	3.6	-2.4	6.1
243	633			22.9	42.2	41.9	-0.3	-2.4	2.1
834	633			23.1	42.4	45.7	3.3	-2.4	5.8
468	633			23.5	42.8	45.9	3.1	-2.4	5.6
909	634			23.5	42.8	45.4	2.6	-2.4	5.1
308	634			23.0	42.3	42.9	0.6	-2.4	3.1
461	634			23.7	43.0	45.2	2.3	-2.4	4.7
389	634			23.3	42.6	47.2	4.6	-2.4	7.0
1076	634			23.9	43.2	48.4	5.3	-2.4	7.7
195	635			24.5	43.8	41.3	-2.5	-2.4	-0.1
868	635			23.8	43.1	45.8	2.7	-2.4	5.1
467	637			23.7	43.0	46.9	3.9	-2.4	6.3
312	638			22.8	42.1	45.7	3.6	-2.5	6.1
466	638			23.4	42.7	44.0	1.3	-2.5	3.8
546	638			23.2	42.5	47.6	5.1	-2.5	7.5
352	640			23.2	42.5	47.7	5.2	-2.5	7.6
1017	640			23.4	42.6	45.2	2.6	-2.5	5.1
864	641			24.3	43.6	41.7	-2.0	-2.5	0.5
636	643			23.8	43.1	46.2	3.1	-2.5	5.5
423	644			23.5	42.8	45.5	2.7	-2.5	5.1
426	646			23.7	43.0	46.8	3.8	-2.5	6.3
460	650			23.2	42.6	47.2	4.6	-2.5	7.1
Average	629						2.1	-2.4	4.6

Table D.07 Tonality Assessment Table - 10 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 2
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
192	130			23.6	41.9	34.5	-7.4	-2.0	-5.3
202	132			27.7	46.0	38.6	-7.4	-2.0	-5.4
305	134			23.5	41.8	34.0	-7.8	-2.0	-5.8
850	134			23.3	41.6	37.8	-3.8	-2.0	-1.8
959	135			21.1	39.4	37.2	-2.2	-2.0	-0.2
216	135			24.9	43.2	38.1	-5.2	-2.0	-3.2
999	135			21.5	39.8	38.1	-1.7	-2.0	0.4
986	136			21.6	39.9	43.0	3.1	-2.0	5.2
322	136			25.0	43.3	37.4	-5.8	-2.0	-3.8
992	136			21.2	39.5	43.5	4.0	-2.0	6.1
1071	136			22.6	40.9	42.1	1.2	-2.0	3.2
472	136			20.6	38.9	40.7	1.8	-2.0	3.8
985	136			21.0	39.3	43.7	4.4	-2.0	6.4
1067	136			22.2	40.5	41.5	1.0	-2.0	3.1
1011	136			20.2	38.5	41.8	3.4	-2.0	5.4
1070	136			21.0	39.3	44.4	5.1	-2.0	7.1
838	136			20.8	39.1	43.4	4.2	-2.0	6.3
811	136			21.5	39.8	41.4	1.5	-2.0	3.6
891	136			22.6	40.9	39.4	-1.5	-2.0	0.5
584	137			23.3	41.6	40.7	-0.9	-2.0	1.1
793	137			23.3	41.6	41.8	0.3	-2.0	2.3
440	137			21.6	39.9	40.5	0.6	-2.0	2.6
955	137			20.7	39.0	41.9	2.8	-2.0	4.9
351	137			23.4	41.7	36.9	-4.8	-2.0	-2.8
849	137			23.0	41.3	44.3	3.0	-2.0	5.0
402	137			21.7	40.0	41.6	1.6	-2.0	3.6
922	137			23.7	42.0	42.3	0.2	-2.0	2.3
1063	137			21.1	39.4	41.6	2.2	-2.0	4.2
883	137			21.2	39.5	42.9	3.4	-2.0	5.4
1027	137			21.1	39.4	40.0	0.6	-2.0	2.6
791	137			24.0	42.3	44.6	2.3	-2.0	4.3
1054	137			21.1	39.4	39.4	0.0	-2.0	2.0
839	137			21.8	40.1	39.9	-0.2	-2.0	1.8
1053	137			21.6	39.9	39.7	-0.2	-2.0	1.8
879	137			22.3	40.6	43.2	2.6	-2.0	4.6
875	137			22.2	40.5	41.5	1.0	-2.0	3.0
1040	137			22.2	40.5	38.7	-1.8	-2.0	0.2
1009	137			21.0	39.3	45.2	5.9	-2.0	7.9
585	137			23.4	41.7	39.6	-2.1	-2.0	-0.1
635	137			23.5	41.8	37.4	-4.4	-2.0	-2.4
1014	137			22.9	41.2	38.1	-3.1	-2.0	-1.1
898	137			22.2	40.5	39.8	-0.7	-2.0	1.3
979	138			20.6	38.9	37.6	-1.3	-2.0	0.7
465	139			22.4	40.7	40.2	-0.6	-2.0	1.4
956	139			21.6	39.9	38.8	-1.1	-2.0	0.9
970	139			24.2	42.5	38.5	-4.0	-2.0	-2.0
827	139			22.6	40.9	39.0	-1.9	-2.0	0.1
316	139			24.0	42.3	38.9	-3.4	-2.0	-1.4
470	139			22.4	40.7	40.0	-0.7	-2.0	1.4
399	139			21.5	39.8	40.1	0.2	-2.0	2.3
852	139			23.4	41.7	40.4	-1.3	-2.0	0.7
Average	137						0.7	-2.0	2.7

Table D.07 Tonality Assessment Table - 10 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 2 of 2
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
999	617			23.1	42.4	43.4	1.0	-2.4	3.5
811	617			23.8	43.0	44.0	1.0	-2.4	3.4
216	619			23.1	42.4	40.2	-2.2	-2.4	0.3
959	619			23.4	42.7	42.8	0.2	-2.4	2.6
891	619			23.4	42.6	45.8	3.1	-2.4	5.6
849	619			23.3	42.6	44.8	2.2	-2.4	4.6
1053	620			24.2	43.5	45.6	2.2	-2.4	4.6
1067	620			24.0	43.3	45.0	1.8	-2.4	4.2
1040	620			23.7	43.0	42.7	-0.3	-2.4	2.1
986	620			23.6	42.8	42.9	0.1	-2.4	2.5
472	621			23.9	43.1	40.9	-2.2	-2.4	0.2
985	621			23.7	42.9	39.0	-3.9	-2.4	-1.5
1011	621			24.1	43.3	42.5	-0.8	-2.4	1.6
992	621			23.5	42.8	42.8	0.0	-2.4	2.5
1071	621			23.9	43.1	43.2	0.1	-2.4	2.6
1070	622			23.9	43.2	42.7	-0.4	-2.4	2.0
322	622			23.2	42.4	40.3	-2.1	-2.4	0.3
838	622			22.9	42.1	42.2	0.0	-2.4	2.5
793	623			23.4	42.6	44.1	1.5	-2.4	3.9
305	623			22.5	41.8	42.7	1.0	-2.4	3.4
1009	624			24.4	43.6	40.5	-3.1	-2.4	-0.7
791	625			23.8	43.1	41.0	-2.0	-2.4	0.4
402	626			23.5	42.8	40.9	-1.9	-2.4	0.5
1063	626			23.5	42.8	42.8	0.1	-2.4	2.5
883	626			24.1	43.4	42.9	-0.5	-2.4	1.9
1014	626			23.8	43.1	41.7	-1.3	-2.4	1.1
1027	627			24.0	43.3	43.6	0.4	-2.4	2.8
584	627			23.9	43.2	41.1	-2.1	-2.4	0.3
585	627			23.6	42.9	40.7	-2.2	-2.4	0.2
955	627			23.3	42.6	41.3	-1.3	-2.4	1.1
979	631			23.9	43.2	44.3	1.1	-2.4	3.5
875	631			23.2	42.4	41.6	-0.8	-2.4	1.6
879	633			23.4	42.6	44.6	2.0	-2.4	4.4
898	633			23.5	42.7	44.9	2.2	-2.4	4.6
839	633			23.8	43.1	45.4	2.3	-2.4	4.8
316	634			23.2	42.5	43.1	0.6	-2.4	3.0
1054	634			24.1	43.4	46.3	2.9	-2.4	5.3
440	634			24.1	43.3	45.2	1.8	-2.4	4.3
399	634			23.5	42.8	44.9	2.1	-2.4	4.5
827	637			23.4	42.7	45.2	2.5	-2.4	5.0
470	637			23.0	42.3	45.2	3.0	-2.4	5.4
465	638			23.4	42.7	46.8	4.1	-2.5	6.6
956	639			24.2	43.5	47.7	4.2	-2.5	6.7
852	639			24.3	43.5	48.7	5.2	-2.5	7.6
351	639			22.9	42.2	45.5	3.2	-2.5	5.7
922	644			22.9	42.2	44.6	2.4	-2.5	4.8
970	648			24.0	43.3	47.4	4.1	-2.5	6.5
635	649			24.2	43.5	45.3	1.8	-2.5	4.2
Average	628						1.2	-2.4	3.6

Table D.08 Tonality Assessment Table - 10.5 m/s

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 3
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
175	132			23.0	41.3	32.3	-9.0	-2.0	-7.0
918	134			23.4	41.7	33.8	-7.8	-2.0	-5.8
318	135			25.7	44.0	35.4	-8.7	-2.0	-6.6
313	135			24.7	43.0	31.6	-11.4	-2.0	-9.3
1049	135			21.8	40.1	36.4	-3.7	-2.0	-1.7
1057	136			23.1	41.3	34.8	-6.6	-2.0	-4.6
1060	136			21.7	40.0	40.8	0.8	-2.0	2.8
807	136			23.1	41.4	39.0	-2.4	-2.0	-0.4
855	136			22.9	41.2	40.5	-0.7	-2.0	1.3
994	136			20.8	39.1	43.8	4.7	-2.0	6.8
1035	136			21.2	39.5	39.0	-0.5	-2.0	1.5
978	136			21.5	39.8	42.5	2.8	-2.0	4.8
951	137			21.5	39.8	43.8	4.0	-2.0	6.0
981	137			20.8	39.1	44.8	5.7	-2.0	7.7
844	137			24.3	42.6	38.0	-4.6	-2.0	-2.6
880	137			21.3	39.5	42.8	3.3	-2.0	5.3
976	137			20.9	39.2	46.4	7.2	-2.0	9.2
315	137			23.0	41.3	33.9	-7.4	-2.0	-5.4
1020	137			23.1	41.4	39.3	-2.0	-2.0	0.0
858	137			22.4	40.7	42.6	1.8	-2.0	3.9
1084	137			21.7	40.0	44.5	4.5	-2.0	6.5
1047	137			21.6	39.9	41.4	1.6	-2.0	3.6
877	137			22.4	40.7	39.8	-0.9	-2.0	1.2
1077	137			22.1	40.4	41.4	0.9	-2.0	2.9
321	138			21.3	39.6	37.7	-2.0	-2.0	0.0
980	138			21.1	39.4	38.9	-0.4	-2.0	1.6
320	138			25.3	43.6	38.2	-5.4	-2.0	-3.4
638	139			21.6	39.9	37.5	-2.4	-2.0	-0.4
867	139			21.5	39.8	41.8	1.9	-2.0	4.0
878	139			22.5	40.8	41.1	0.3	-2.0	2.3
788	141			22.6	40.9	37.2	-3.7	-2.0	-1.7
948	141			22.1	40.4	36.5	-3.9	-2.0	-1.9
Average	137						0.7	-2.0	2.8

Table D.08 Tonality Assessment Table - 10.5 m/s

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 2 of 3
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
313	616			22.7	41.9	40.0	-1.9	-2.4	0.5
1049	618			23.8	43.0	44.1	1.1	-2.4	3.5
318	619			22.8	42.0	39.1	-3.0	-2.4	-0.5
1057	619			23.3	42.6	45.5	2.9	-2.4	5.3
1035	620			24.2	43.5	42.8	-0.7	-2.4	1.7
807	620			23.1	42.4	46.2	3.8	-2.4	6.2
1060	621			23.8	43.1	45.3	2.2	-2.4	4.6
880	622			23.2	42.4	42.4	0.0	-2.4	2.4
994	624			23.9	43.1	42.9	-0.2	-2.4	2.2
981	625			23.6	42.9	43.0	0.1	-2.4	2.6
315	626			22.5	41.8	38.0	-3.7	-2.4	-1.3
976	626			23.4	42.6	43.4	0.8	-2.4	3.3
1084	626			24.1	43.3	42.8	-0.6	-2.4	1.9
951	626			23.2	42.5	40.8	-1.7	-2.4	0.8
1047	627			23.9	43.1	43.4	0.3	-2.4	2.7
858	627			23.7	43.0	40.8	-2.2	-2.4	0.2
1020	631			23.3	42.6	44.7	2.2	-2.4	4.6
321	631			22.6	41.9	39.8	-2.1	-2.4	0.4
320	631			23.5	42.8	39.8	-2.9	-2.4	-0.5
980	631			24.3	43.6	44.6	1.0	-2.4	3.4
978	632			23.7	43.0	43.0	0.0	-2.4	2.4
877	632			23.2	42.5	44.2	1.7	-2.4	4.2
1077	634			23.9	43.2	46.1	3.0	-2.4	5.4
878	637			23.2	42.5	45.1	2.6	-2.4	5.0
844	637			23.5	42.8	45.9	3.1	-2.4	5.5
867	638			23.8	43.1	46.0	2.9	-2.5	5.4
855	639			24.1	43.3	47.1	3.8	-2.5	6.2
638	639			23.9	43.2	46.8	3.6	-2.5	6.1
948	644			23.7	43.0	45.6	2.6	-2.5	5.1
788	645			23.9	43.2	47.4	4.2	-2.5	6.6
Average	629						1.3	-2.4	3.7

Table D.08 Tonality Assessment Table - 10.5 m/s

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 3 of 3
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
807	1240			22.3	43.3	35.2	-8.1	-3.0	-5.1
1060	1242			23.0	44.0	40.1	-3.9	-3.0	-0.9
978	1244			23.5	44.6	37.9	-6.6	-3.0	-3.6
951	1245			22.7	43.7	38.7	-5.1	-3.0	-2.0
880	1246			22.5	43.6	35.2	-8.4	-3.0	-5.4
1057	1246			22.6	43.7	35.9	-7.8	-3.0	-4.8
1035	1247			22.9	44.0	40.0	-4.0	-3.0	-0.9
1084	1248			23.2	44.3	40.4	-3.8	-3.0	-0.8
994	1250			23.6	44.7	37.7	-7.0	-3.0	-3.9
981	1252			23.1	44.2	38.5	-5.8	-3.0	-2.7
976	1253			22.9	44.0	41.2	-2.8	-3.0	0.2
1047	1254			23.0	44.0	39.7	-4.3	-3.0	-1.3
877	1255			23.0	44.1	33.5	-10.6	-3.0	-7.5
1077	1256			23.5	44.6	39.6	-4.9	-3.0	-1.9
858	1257			23.3	44.4	35.5	-8.9	-3.0	-5.9
980	1258			23.4	44.5	38.1	-6.4	-3.0	-3.4
315	1262			21.9	43.0	28.3	-14.7	-3.0	-11.7
321	1262			22.1	43.2	38.0	-5.2	-3.0	-2.1
320	1264			22.0	43.1	38.5	-4.7	-3.0	-1.6
867	1275			23.9	45.1	40.8	-4.3	-3.1	-1.2
844	1275			22.8	43.9	32.7	-11.2	-3.1	-8.2
878	1275			23.6	44.8	40.3	-4.5	-3.1	-1.4
788	1288			23.5	44.7	34.7	-10.0	-3.1	-6.9
948	1289			22.7	43.9	37.9	-6.0	-3.1	-3.0
Average	1258						-5.9	-3.0	-2.9

Table D.09 Tonality Assessment Table - 11 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 1 of 3
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
874	136			22.1	40.4	38.6	-1.8	-2.0	0.2
1041	136			21.4	39.7	38.8	-0.8	-2.0	1.2
869	136			21.5	39.8	40.8	1.0	-2.0	3.0
984	136			20.5	38.8	42.5	3.7	-2.0	5.7
1030	136			20.8	39.1	33.5	-5.6	-2.0	-3.6
1037	136			22.7	40.9	39.1	-1.8	-2.0	0.2
821	136			23.2	41.5	40.2	-1.3	-2.0	0.7
1056	136			21.1	39.4	36.1	-3.3	-2.0	-1.3
1012	136			21.9	40.2	40.0	-0.2	-2.0	1.8
947	137			22.8	41.1	40.6	-0.5	-2.0	1.5
1064	137			22.4	40.7	44.2	3.5	-2.0	5.5
1062	137			23.3	41.6	42.8	1.2	-2.0	3.2
805	137			21.9	40.2	42.9	2.7	-2.0	4.7
1023	137			22.6	40.8	40.6	-0.2	-2.0	1.8
795	137			23.5	41.8	39.4	-2.4	-2.0	-0.4
1004	137			21.9	40.2	40.3	0.1	-2.0	2.2
848	137			22.8	41.1	44.4	3.3	-2.0	5.4
1043	137			21.5	39.8	42.2	2.3	-2.0	4.4
1003	137			21.9	40.2	42.8	2.7	-2.0	4.7
1026	137			20.3	38.6	38.4	-0.2	-2.0	1.8
1082	137			22.0	40.3	41.5	1.2	-2.0	3.3
815	137			23.2	41.5	38.2	-3.4	-2.0	-1.3
1039	137			22.0	40.3	40.7	0.4	-2.0	2.4
1021	137			22.1	40.3	43.7	3.3	-2.0	5.3
319	138			23.8	42.1	38.3	-3.8	-2.0	-1.8
799	139			23.0	41.3	36.7	-4.7	-2.0	-2.7
1006	139			23.1	41.4	37.2	-4.3	-2.0	-2.2
Average	137						0.4	-2.0	2.5

Table D.09 Tonality Assessment Table - 11 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 2 of 3
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
1004	618			23.2	42.5	41.6	-0.8	-2.4	1.6
821	618			23.6	42.8	43.4	0.6	-2.4	3.0
1012	618			24.3	43.5	43.6	0.1	-2.4	2.5
815	619			23.7	42.9	45.6	2.7	-2.4	5.1
1030	620			23.5	42.7	45.1	2.4	-2.4	4.8
1056	620			23.1	42.3	45.4	3.0	-2.4	5.5
874	620			23.6	42.8	45.7	2.9	-2.4	5.3
1023	620			23.7	42.9	44.2	1.2	-2.4	3.7
947	620			23.2	42.4	44.7	2.2	-2.4	4.7
869	621			23.3	42.6	43.8	1.3	-2.4	3.7
1041	621			23.6	42.8	42.3	-0.6	-2.4	1.9
1037	622			24.1	43.3	41.8	-1.5	-2.4	0.9
848	622			23.1	42.4	43.8	1.4	-2.4	3.9
984	622			23.9	43.2	41.8	-1.4	-2.4	1.1
1064	624			24.1	43.4	41.2	-2.2	-2.4	0.2
805	625			23.4	42.7	43.3	0.6	-2.4	3.1
1039	625			24.0	43.2	41.3	-1.9	-2.4	0.6
1043	625			24.0	43.2	40.4	-2.8	-2.4	-0.4
1003	626			23.3	42.6	40.7	-1.9	-2.4	0.6
1026	627			24.0	43.2	42.5	-0.8	-2.4	1.7
1082	627			23.7	43.0	44.2	1.2	-2.4	3.6
1021	627			24.0	43.3	44.0	0.7	-2.4	3.2
795	630			23.0	42.3	44.6	2.3	-2.4	4.7
799	632			24.0	43.3	45.3	2.0	-2.4	4.4
319	634			23.6	42.9	40.9	-2.0	-2.4	0.4
1062	634			23.8	43.1	46.2	3.2	-2.4	5.6
1006	642			24.1	43.4	48.3	4.9	-2.5	7.4
Average	624						1.1	-2.4	3.5

Table D.09 Tonality Assessment Table - 11 m/s

Project: Bornish Wind Energy Centre- Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 3 of 3
 Created on: 11/1/2017

Measurement #	Centre frequency (Hz)	Energy average of all masking lines (dB)	Background (dB)	Background adjusted criterion level (dB)	Masking level (dB)	Tone level (dB)	Determination of tonality (dB)	Frequency dependent audibility criterion (dB)	Tonal Audibility (dB)
1012	1233			23.3	44.3	39.0	-5.3	-3.0	-2.3
874	1240			22.7	43.7	35.9	-7.8	-3.0	-4.8
1056	1240			22.1	43.2	36.2	-7.0	-3.0	-4.0
1030	1241			22.2	43.3	36.9	-6.4	-3.0	-3.4
869	1241			22.9	43.9	30.8	-13.1	-3.0	-10.1
795	1243			22.8	43.9	30.0	-13.9	-3.0	-10.9
1041	1244			22.5	43.6	38.3	-5.3	-3.0	-2.2
1023	1244			23.1	44.2	39.1	-5.1	-3.0	-2.1
984	1245			22.6	43.7	40.6	-3.0	-3.0	0.0
1037	1245			23.0	44.1	39.5	-4.6	-3.0	-1.5
848	1246			22.8	43.8	38.5	-5.3	-3.0	-2.3
1064	1247			22.9	43.9	41.5	-2.5	-3.0	0.6
1003	1248			22.6	43.6	36.6	-7.1	-3.0	-4.0
947	1248			23.2	44.3	38.1	-6.1	-3.0	-3.1
1026	1248			23.1	44.2	35.8	-8.4	-3.0	-5.4
805	1249			23.3	44.4	35.8	-8.6	-3.0	-5.6
1039	1249			22.7	43.8	39.8	-4.0	-3.0	-0.9
1043	1250			22.9	44.0	39.4	-4.6	-3.0	-1.5
1004	1250			22.2	43.3	35.3	-8.0	-3.0	-5.0
1021	1253			23.4	44.5	39.5	-5.0	-3.0	-1.9
1082	1255			23.2	44.3	38.4	-5.9	-3.0	-2.8
799	1264			24.0	45.1	36.2	-8.9	-3.0	-5.9
319	1267			22.4	43.5	40.0	-3.5	-3.0	-0.5
1062	1269			23.6	44.7	42.3	-2.3	-3.0	0.7
1006	1271			23.9	45.0	33.8	-11.3	-3.0	-8.2
Average	1249						-5.7	-3.0	-2.7

Appendix E Measurement Data

Table E.01 Measurement data - Turbine ON

Project: Bornish Wind Energy Centre - Turbine T44 - IEC 61400-11 Measurement
 Report ID: 14331.00.T44.RP3

Page 7 of 7
 Created on: 11/1/2017

***Blank data denotes values that were omitted in the analysis due to an extraneous event during recording

Data Point #	Standardized Wind Speed	LIneq	Turbine Power Output (kW)	Reference Yaw Angle (°)	Yaw Angle (°)	Pitch Angle (°)	Rotor RPM	Nacelle Anemometer Wind Speed (m/s)	10m Anemometer Wind Speed (m/s)	Air Temperature (°C)	Pressure (kPa)	Relative Humidity (%)
1057	10.5	54.6	1655	334.0	337.5	7.7	15.2	9.9	9.6	9	98.5	59
1058	11.4	54.5	1632	334.0	337.5	8.9	15.3	10.7	9.3	9	98.5	59
1059	9.5	54.7	1621	334.0	337.5	7.6	15.2	9.0	8.2	9	98.5	59
1060	10.7	54.8	1622	334.0	337.5	8.0	15.0	10.1	7.7	9	98.5	59
1061	9.3	54.8	1628	334.0	337.5	5.9	15.2	8.7	8.8	9	98.5	61
1062	11.0	55.6	1640	334.0	337.5	8.1	15.3	10.4	8.1	9	98.5	61
1063	10.0	54.3	1628	334.0	337.5	7.7	15.2	9.4	7.4	9	98.5	61
1064	10.9	55.0	1617	334.0	337.5	6.7	15.1	10.2	7.7	9	98.5	61
1065	11.3	55.6	1637	334.0	337.5	8.9	15.3	10.6	8.7	9	98.5	61
1066			1615	334.0	337.5	8.8	15.1	7.9	7.9	9	98.5	61
1067	10.0	54.7	1639	334.0	337.5	7.2	15.1	9.4	9.1	9	98.5	61
1068			1634	334.0	337.5	9.0	15.2	8.6	8.6	9	98.5	61
1069	11.4	54.8	1632	334.0	337.5	8.3	15.1	10.7	9.4	9	98.5	61
1070	10.1	54.9	1607	334.0	337.5	8.0	15.0	9.5	8.8	9	98.5	61
1071	10.1	54.7	1628	334.0	337.5	6.7	15.0	9.5	7.9	9	98.5	61
1072	9.5	54.2	1635	334.0	337.5	7.2	15.0	8.9	9.3	9	98.5	61
1073	9.7	54.4	1625	334.0	337.5	5.2	15.0	9.1	10.0	9	98.5	60
1074			1614	334.0	337.5	4.9	14.9	8.6	10.1	9	98.5	60
1075	9.7	54.3	1656	334.0	337.5	5.1	15.3	9.1	9.4	9	98.5	60
1076	9.3	55.7	1629	334.0	337.5	7.1	15.4	8.8	8.7	9	98.5	60
1077	10.3	55.1	1613	334.0	337.5	6.2	15.3	9.7	8.9	9	98.5	60
1078			1606	334.0	337.5	7.0	15.1	8.3	9.2	9	98.5	60
1079			1623	334.0	337.5	5.8	14.9	6.2	8.3	9	98.5	60
1080			1612	334.0	337.5	4.0	15.0	6.6	8.7	9	98.5	60
1081			1642	334.0	337.5	5.3	15.2	7.7	8.6	9	98.5	60
1082	10.8	55.0	1655	334.0	337.5	5.6	15.4	10.2	7.1	9	98.5	60
1083			1625	334.0	337.5	6.2	15.2	7.9	7.1	9	98.5	60
1084	10.7	55.1	1624	334.0	337.5	5.7	15.1	10.1	6.1	9	98.5	60
1085			1609	334.0	337.5	6.5	15.2	8.7	8.3	9	98.5	62
1086			1625	334.0	337.5	6.6	15.1	8.2	8.4	9	98.5	62
1087			1631	334.0	337.5	5.7	15.2	10.9	6.4	9	98.5	62
1088			1618	334.0	337.5	6.2	15.1	10.1	7.8	9	98.5	62
1089			100	334.0	5.0	5.0	0.0	0.0	0.0	-35	60.0	0
1090			100	334.0	5.0	5.0	0.0	0.0	0.0	-35	60.0	0
1091			100	334.0	5.0	5.0	0.0	0.0	0.0	-35	60.0	0
1092			100	334.0	5.0	5.0	0.0	0.0	0.0	-35	60.0	0
1093			100	334.0	5.0	5.0	0.0	0.0	0.0	-35	60.0	0
1094			100	334.0	5.0	5.0	0.0	0.0	0.0	-35	60.0	0
1095			100	334.0	5.0	5.0	0.0	0.0	0.0	-35	60.0	0
1096			100	334.0	5.0	5.0	0.0	0.0	0.0	-35	60.0	0

***Blank data denotes values that were omitted in the analysis due to an extraneous event during recording

Data Point #	Standardized Wind Speed	LIneq	Turbine Power Output (kW)	Reference Yaw Angle (°)	Yaw Angle (°)	Pitch Angle (°)	Rotor RPM	Nacelle Anemometer Wind Speed (m/s)	10m Anemometer Wind Speed (m/s)	Air Temperature (°C)	Pressure (kPa)	Relative Humidity (%)
1145												
1146												
1147												
1148												
1149												
1150												
1151												
1152												
1153												
1154												
1155												
1156												
1157												
1158												
1159												
1160												
1161												
1162												
1163												
1164												
1165												
1166												
1167												
1168												
1169												
1170												
1171												
1172												
1173												
1174												
1175												
1176												
1177												
1178												
1179												
1180												
1181												
1182												
1183												
1184												

Appendix F Supplementary Information for the Regulator

Appendix F.01

Note on anemometer position with IEC 61400-11 Ed 2.1 and Ed 3.0

Note N6.040.17

Note on anemometer position with IEC 61400-11 editions 2.1 and 3.0

Project number: 35.6539.01

Project manager: Bo Søndergaard

Author: Bo Søndergaard

Date: 7/11/2017

Controlled by: -

To : Aercoustics Engineering Limited
Att.: Payam Ashtiani

From : Bo Søndergaard

1. Purpose

In the capacity of convenor for Maintenance Team 11, the workgroup in charge of IEC 61400-11, since 2006, I have been asked to provide background information, and comment on the consequences of changing the anemometer position when going from edition 2.1 to edition 3, and the recommended method for using measurements based on edition 2.1 for an analysis with edition 3.

2. Comment

There are several differences between IEC 61400-11 standard edition 2.1 (November 2006) and edition 3.0 (November 2012). In particular, the general data treatment procedures for noise levels, and the tonality assessment were changed to keep up with the changes in wind turbine design at the time.

However, since edition 1.0 (1998), very few changes have been made to the IEC 61400-11 standard with respect to the measurement setup. In edition 1.0 the prescribed position of the anemometer was upwind (2 to 4 rotor diameters) as it was allowed to use the anemometer for determination of the standardized wind speed with the wind turbine running. At that time the distances were smaller and this setup is maintained in Annex F on small wind turbines in edition 3. Editions 2.0 and 2.1, still allowed such use of the anemometer

In Germany, modified versions of IEC 61400-11 edition 2 were introduced by the FGW. In revision 15 (from 2004), using the power for determination of the standardized wind speed was mandatory. In revision 16 (from 2005), it was stated that the position of the anemometer can deviate from the requirements in IEC 61400-11 edition 2, without specifying position requirements. Germany has had a strong influence on the development of the IEC 61400-11 standard through the experience from several measuring companies and German authorities. The decision to allow alternative positions for the anemometer is very representative of the situation. It is difficult to set up general requirements for the position of the anemometer that works at all sites. As such, it makes sense to allow for an expert

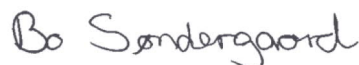
judgement on the anemometer position in a given situation. In the Danish regulations, it is stated that the anemometer has to be close to the wind turbine in a position where neither the wind turbine nor objects in the terrain is expected to influence the wind speed measurements.

The German and Danish considerations on the position of the anemometer is based on the fact that the dominating background noise at the microphone position can be more or less dependent on wind speed; and can be generated by vegetation upwind, downwind or to the side of the wind turbine. This is often reflected in background noise with a weak dependence on wind speed.

Maintenance Team 11, responsible for revising IEC 61400-11, discussed this issue and there was a strong support from the measurement institutes for using the nacelle anemometer for background noise measurements. In most cases, this would give a reasonable correlation between wind speed and background noise. The nacelle anemometer is not influenced by terrain and represents, to a reasonable degree, the wind in the surroundings. However, the manufacturers argued that the nacelle anemometer might not be a part of future designs and could not be guaranteed. There was a general agreement that it was difficult to decide on an optimum position, but in most cases, downwind and to the side would make sense, resulting in Figure 5 of edition 3.0. The position of the anemometer is not considered an important issue and the wording is "guidance" and "acceptable" and not a stronger wording like "shall". This is a deliberate decision by the Maintenance Team 11 to ensure flexibility when other choices make more sense.

The recommended method when using measurements made according to IEC 61400-11 edition 2.1 for analysis with IEC 61400-11 edition 3.0 is to use the nacelle anemometer for the background noise. This will work well in most cases. Alternatively, to use the measured wind speed at 10 m height if there is no strong influence from the background noise (e.g. when signal to noise ratio is better than 6 dB).

SWECO Danmark A/S



Bo Søndergaard

Acoustica

Appendix F.02 Calibration Certificates

ISO 17025

CALIBRATION CERTIFICATE

Region: AMERICAS
Account: Aercoustics, Canada

Instrument: LMS Scadas
Manufacturer: LMS Instruments BV
Type: SCR202
Serial number(s): 22143211

Calibration method: Two calibrated external standards (DC voltage and frequency) are used to calibrate the internal LMS Scadas references: time/frequency accuracy of the internal system clock and amplitude accuracy of the internal signal sources. All input channels are calibrated against the internal references.

Ambient conditions: The calibrations have been carried out in a controlled environment, at an ambient temperature of 22.3°C and a relative humidity of 57%.

Calibration date: 26 August 2014

Results: The calibration results, together with their associated uncertainties, are included in this calibration certificate.
Calibration results within specification.

Uncertainty: The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k = 2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.
The standard uncertainty of measurement has been determined in accordance with publication EA-4/02

Traceability: The measurements have been executed using methods for which the traceability to international standards has been demonstrated towards the Raad voor Accreditatie.

Breda, 28 August 2014

Calibration performed by:



P. Tetteroo

Certificate approved by:



P. Korse

The Raad voor Accreditatie is one of the signatories of the Multilateral Agreement of the European Cooperation for Accreditation (EA) for the mutual recognition of calibration certificates

Reproduction of the complete certificate is allowed. Parts of the certificate may only be reproduced with written approval of the calibration laboratory

This certificate is issued provided that neither LMS Instruments nor the Raad voor Accreditatie assumes any liability

Certificate number: **22143211-20140826-0**

Page: 1 of 15



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 ANEMOMETER

Certificate number: 14.US1.04688

Date of issue: July 1, 2014

Type: Vaisala Weather Transmitter, WXT520

Serial number: K2420011

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

Client: Aercoustics Engineering Ltd., 50 Ronson Dr, Suite 165, Toronto, ON M9W IB3, Canada

Anemometer received: June 26, 2014

Anemometer calibrated: July 1, 2014

Calibrated by: mej

Calibration procedure: IEC 61400-12-1:2005(E) Annex F

Certificate prepared by: ejf

Approved by: Calibration engineer, rds

Calibration equation obtained: $v [m/s] = 1.05788 \cdot f [m/s] + -0.04497$

Standard uncertainty, slope: 0.00184

Standard uncertainty, offset: -0.43799

Covariance: -0.0000375 (m/s)²/m/s

Coefficient of correlation: $\rho = 0.999981$

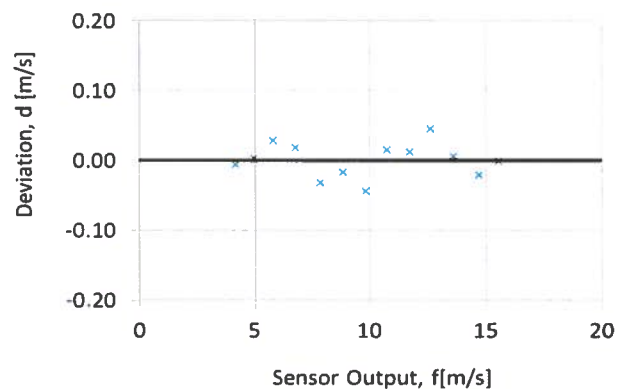
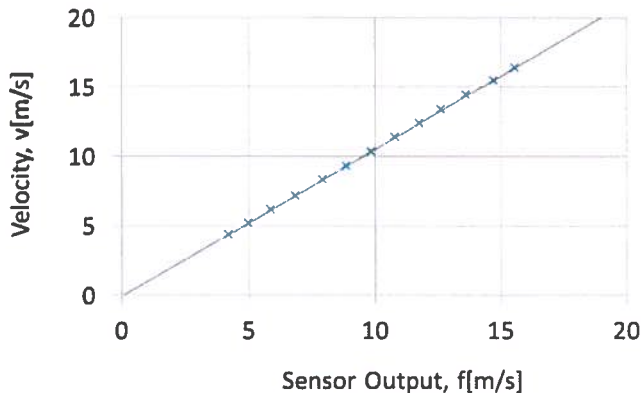
Absolute maximum deviation: 0.044 m/s at 13.329 m/s

Barometric pressure: 992.4 hPa

Relative humidity: 53.5%

Sensor Orientation: 90°

Succession	Velocity pressure, q, [Pa]	Temperature in wind tunnel [°C]	Temperature in d.p. box [°C]	Wind velocity, v, [m/s]	Sensor Output, f, [m/s]	Deviation, d, [m/s]	Uncertainty $u_c (k=2)$ [m/s]
2	10.15	28.9	26.2	4.377	4.1862	-0.006	0.047
4	14.49	29.0	26.2	5.229	4.9828	0.003	0.040
6	20.18	29.0	26.2	6.173	5.8517	0.027	0.034
8	27.34	29.0	26.2	7.184	6.8172	0.017	0.030
10	36.48	29.0	26.2	8.299	7.9172	-0.032	0.027
12	46.02	29.0	26.2	9.320	8.8690	-0.017	0.025
13-last	56.53	29.0	26.2	10.330	9.8483	-0.044	0.023
11	68.33	29.0	26.2	11.358	10.7655	0.014	0.023
9	81.17	29.0	26.2	12.380	11.7345	0.011	0.022
7	94.08	29.0	26.2	13.329	12.6000	0.044	0.022
5	109.30	29.0	26.2	14.366	13.6172	0.005	0.022
3	126.98	29.0	26.2	15.484	14.7000	-0.021	0.023
1-first	142.83	28.8	26.2	16.420	15.5655	-0.002	0.023



EQUIPMENT USED

Serial Number	Description
Njord 1	Wind tunnel, blockage factor = 1.003
2254	Control cup anemometer
-	Mounting tube, D = 26.7 mm
TT001	Summit RT-AUI, wind tunnel
TT002	Summit RT-AUI, differential pressure box
DP005	Setra Model 239 pressure transducer
HY001	Dwyer Instruments RHP-2D20 humidity transmitter
BP001	Setra Model 278 barometer
PL3	Pitot tube
XB001	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: TRANSCAT, Atlantic Scale, & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

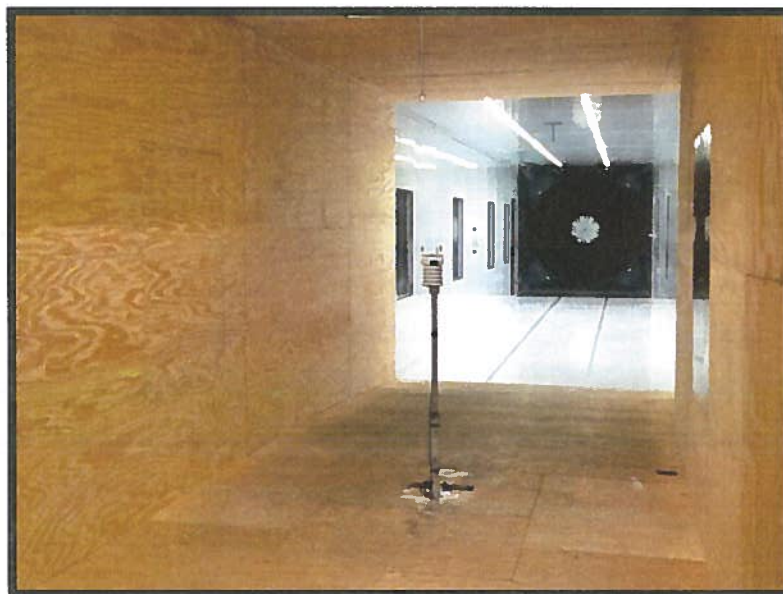


Photo of the wind tunnel setup. The cross-sectional area is 2.5 x 2.5 m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level ($k=2$) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.DC.016 for further details.

Certificate number: 14.US1.04688



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 ANEMOMETER

Certificate number: 14.US1.04687

Date of issue: July 1, 2014

Type: Vaisala Weather Transmitter, WXT520

Serial number: K2420011

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

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

Anemometer received: June 26, 2014

Anemometer calibrated: July 1, 2014

Calibrated by: mej

Calibration procedure: IEC 61400-12-1:2005(E) Annex F

Certificate prepared by: ejf

Approved by: Calibration engineer, rds

Calibration equation obtained: $v \text{ [m/s]} = 1.05657 \cdot f \text{ [m/s]} + -0.02907$

Standard uncertainty, slope: 0.00162

Standard uncertainty, offset: -0.59400

Covariance: -0.0000288 (m/s)²/m/s

Coefficient of correlation: $\rho = 0.999986$

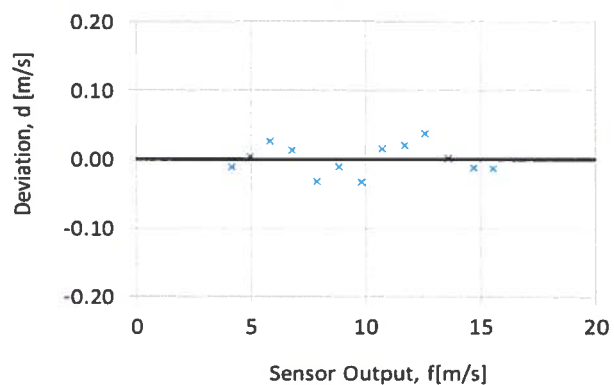
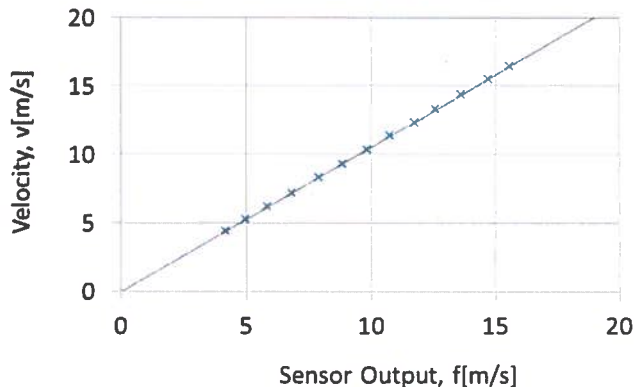
Absolute maximum deviation: 0.036 m/s at 13.320 m/s

Barometric pressure: 993.2 hPa

Relative humidity: 53.6%

Sensor Orientation: 0°

Succession	Velocity	Temperature in		Wind	Sensor	Deviation, d.	Uncertainty u_c (k=2)
	pressure, q.	wind tunnel	d.p. box	velocity, v.	Output, f.		
	[Pa]	[°C]	[°C]	[m/s]	[m/s]	[m/s]	[m/s]
2	10.19	28.8	26.1	4.383	4.1862	-0.011	0.047
4	14.56	28.9	26.1	5.239	4.9828	0.004	0.040
6	20.26	28.9	26.1	6.179	5.8517	0.025	0.034
8	27.40	28.9	26.1	7.186	6.8172	0.012	0.030
10	36.57	28.9	26.1	8.304	7.9172	-0.032	0.027
12	46.17	28.9	26.1	9.331	8.8690	-0.011	0.025
13-last	56.74	28.9	26.1	10.344	9.8483	-0.033	0.023
11	68.44	28.9	26.1	11.360	10.7655	0.015	0.023
9	81.39	28.9	26.1	12.389	11.7345	0.019	0.022
7	94.10	28.9	26.1	13.320	12.6000	0.036	0.022
5	109.37	28.9	26.1	14.360	13.6172	0.001	0.022
3	127.26	28.8	26.1	15.490	14.7000	-0.012	0.023
1-first	142.75	28.7	26.1	16.404	15.5655	-0.013	0.023



EQUIPMENT USED

Serial Number	Description
Njord 1	Wind tunnel, blockage factor = 1.003
2254	Control cup anemometer
-	Mounting tube, D = 26.7 mm
TT001	Summit RT-AUI, wind tunnel
TT002	Summit RT-AUI, differential pressure box
DP005	Setra Model 239 pressure transducer
HY001	Dwyer Instruments RHP-2D20 humidity transmitter
BP001	Setra Model 278 barometer
PL3	Pitot tube
XB001	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: TRANSCAT, Atlantic Scale, & Furness Controls. A real-time analysis module within the data acquisition software detects pulse frequency.

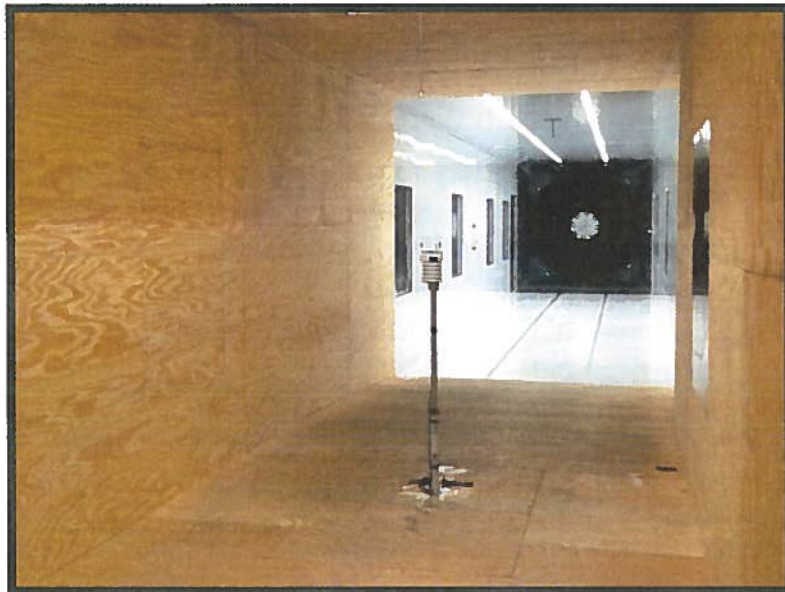


Photo of the wind tunnel setup. The cross-sectional area is 2.5 x 2.5 m.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level ($k=2$) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the IEC 61400-12-1:2005 procedure. See Document US.DC.016 for further details.

Certificate number: 14.US1.04687

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

MICROPHONE UNIT

Manufactured by: **BRUEL & KJAER**
Model No: **4189-A-021**
Serial No: **2622170**
Calibration Recall No: **24274**

Submitted By:

Customer:
Company: **AERCOUSTICS ENGINEERING**
Address:

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

West Caldwell Calibration Laboratories Procedure No. **4189-A-021 BRUE**

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

Within () see attached Report of Calibration.

the tolerance of the indicated specification.

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

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

Approved by:

Calibration Date: **16-Jun-14**

Certificate No: **24274 - 3**

QA Doc. #1051 Rev. 2.0 10/1/01

Certificate Page 1 of 1

FC
Felix Christopher (QA Mgr.)
ISO/IEC 17025:2005

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



Calibration Lab. Cert. # 1533.01

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



Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for
Brüel & Kjær Microphone Unit Model No.: 4189-A-021
Mic. Model: 4189
Preamp. Model No.: 2671
Company : Aercoustics Engineering

Serial No.: 2622170
Serial No.: 2625197
Serial No.: 2614901
I. D. No.: XXXX

Calibration results:	Before data:	After data:
Combined Sensitivity @ 250 Hz and pressure of 99.622 kPa	Before & after data same: ...✓...	
(Sensitivity with microphone and preamplifier.)	Ambient Temperature: 21 °C	Ambient Humidity: 51.8 % RH
-26.67 dB re.1V/Pascal	Ambient Pressure: 99.62 kPa	Calibration Date: 16-Jun-2014
46.39 mV/Pascal	Re-calibration Due: 16-Jun-2015	Report Number: 24274 -3
0.67 Ko (- dB re 50 mV/Pascal)	Control Number: 24274	
Sensitivity: Pass		
Freq. Response: Pass		
All tests: Pass		
Combined Sensitivity @ 1000 Hz	-26.74 dB re.1V/Pascal or	46.03 mV/Pascal

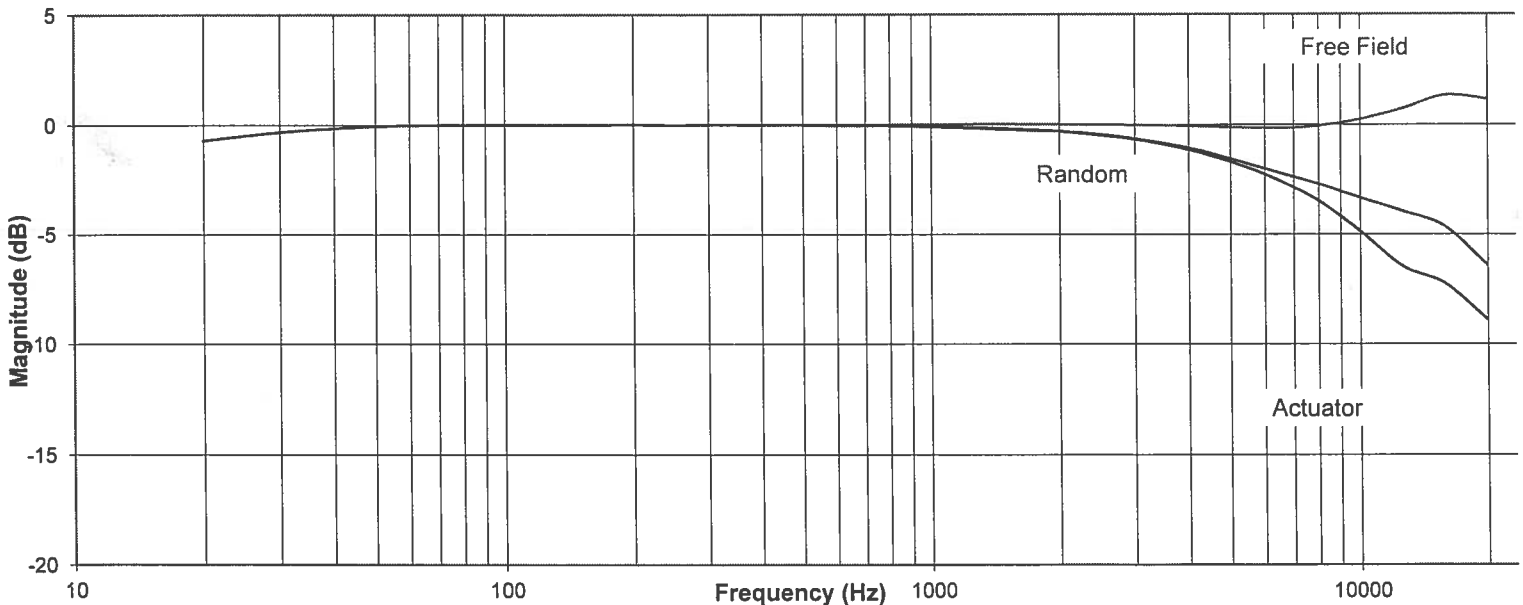
The above listed instrument meets or exceeds the tested manufacturer's specifications.

This Calibration is traceable through NIST test numbers: 683/281764-12

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

The lower curve is the pressure response recorded with electrostatic actuator.

Frequency Response



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 4189A021B&K

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

intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSS Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

Measurements performed by:

Felix Christopher

Calibrated on WCCL system type 9700

This document shall not be reproduced, except in full, without the written approval from West Caldwell Cal. Labs. Inc.

Rev. 7.0 Jan. 24, 2014 Doc. # 1038 4189A021B&K

West Caldwell Calibration Laboratories Inc.

1575 State Route 96, Victor NY 14564

Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

Brüel & Kjær Microphone Unit Model No.: 4189-A-021

Serial No.: 2622170

I. D. No.: XXXX

Company : Aercoustics Engineering

Frequency Response (Reference = 0 dB @ 250Hz)

Frequency [Hz]	Actuator [dB]	Random (dB)	Free Field (dB)	Frequency [Hz]	Actuator [dB]	Random (dB)	Free Field (dB)
19.95	-0.70	-0.70	-0.70	631.0	-0.03	-0.03	0.00
25.12	-0.47	-0.47	-0.47	794.3	-0.04	-0.04	0.02
31.62	-0.28	-0.28	-0.28	1000.0	-0.07	-0.09	0.03
39.81	-0.15	-0.15	-0.15	1258.9	-0.11	-0.15	0.03
50.12	-0.05	-0.05	-0.05	1584.9	-0.19	-0.24	0.03
63.10	0.00	0.00	0.00	1995.3	-0.30	-0.30	0.03
79.43	0.01	0.01	0.01	2511.9	-0.47	-0.44	0.00
100.00	0.01	0.01	0.01	3162.3	-0.73	-0.70	-0.02
125.89	0.00	0.00	0.00	3981.1	-1.13	-1.04	-0.07
158.49	0.01	0.01	0.01	5011.9	-1.69	-1.55	-0.12
199.53	0.02	0.02	0.02	6309.6	-2.45	-2.13	-0.17
251.19	0.00	0.00	0.00	7943.3	-3.44	-2.69	-0.06
316.23	0.02	0.02	0.02	10000.0	-4.87	-3.34	0.25
398.11	-0.01	-0.01	0.00	12589.3	-6.46	-3.95	0.73
501.19	-0.01	-0.01	0.01	15848.9	-7.24	-4.66	1.35
				19952.6	-8.88	-6.40	1.17

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

Instruments used for calibration:	Date of Cal.	Traceability No.	Re-cal. Due Date
Brüel & Kjær 4134 S/N 1942286	2-Oct-2013	683/281764-12	3-Oct-2014
HP 34401A S/N 36064102	8-Oct-2013	,287708	8-Oct-2014
HP 34401A S/N 36102471	8-Oct-2013	,287708	8-Oct-2014
HP 33120A S/N 36043716	8-Oct-2013	,287708	8-Oct-2014
Brüel & Kjær 2636 S/N 1324082	3-Oct-2013	683/281764-12	3-Oct-2014
Brüel & Kjær 2669 S/N 1835082	3-Oct-2013	683/281764-12	3-Oct-2014
Brüel & Kjær 4228 S/N 1742061	2-Oct-2013	683/281764-12	3-Oct-2014

Cal. Date: 16-Jun-2014

Tested by: Felix Christopher

Calibrated on WCCL system type 9700

This document shall not be reproduced except in full without the written approval from West Caldwell Cal. Labs. Inc.

Rev. 7.0 Jan. 24, 2014 Doc. # 1038 4189A021B&K

West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

ACOUSTICAL CALIBRATOR

Manufactured by: BRUEL & KJAER
Model No: 4231
Serial No: 2513182
Calibration Recall No: 24213

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. 4231 BRUE

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

Within (X) see attached Report of Calibration.

the tolerance of the indicated specification.

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

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

Approved by:

Calibration Date: 05-Jun-14

FC

Certificate No: 24213 - 1

Felix Christopher (QA Mgr.)
ISO/IEC 17025:2005

QA Doc. #1051 Rev. 2.0 10/1/01

Certificate Page 1 of 1

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

**West Caldwell
Calibration
Laboratories, Inc.**



Calibration Lab. Cert. # 1533.01



REPORT OF CALIBRATION

Brüel & Kjær Acoustical Calibrator

for
Model No.: 4231

Serial No.: 2513182

Company : Aercoustics Engineering, Ltd.

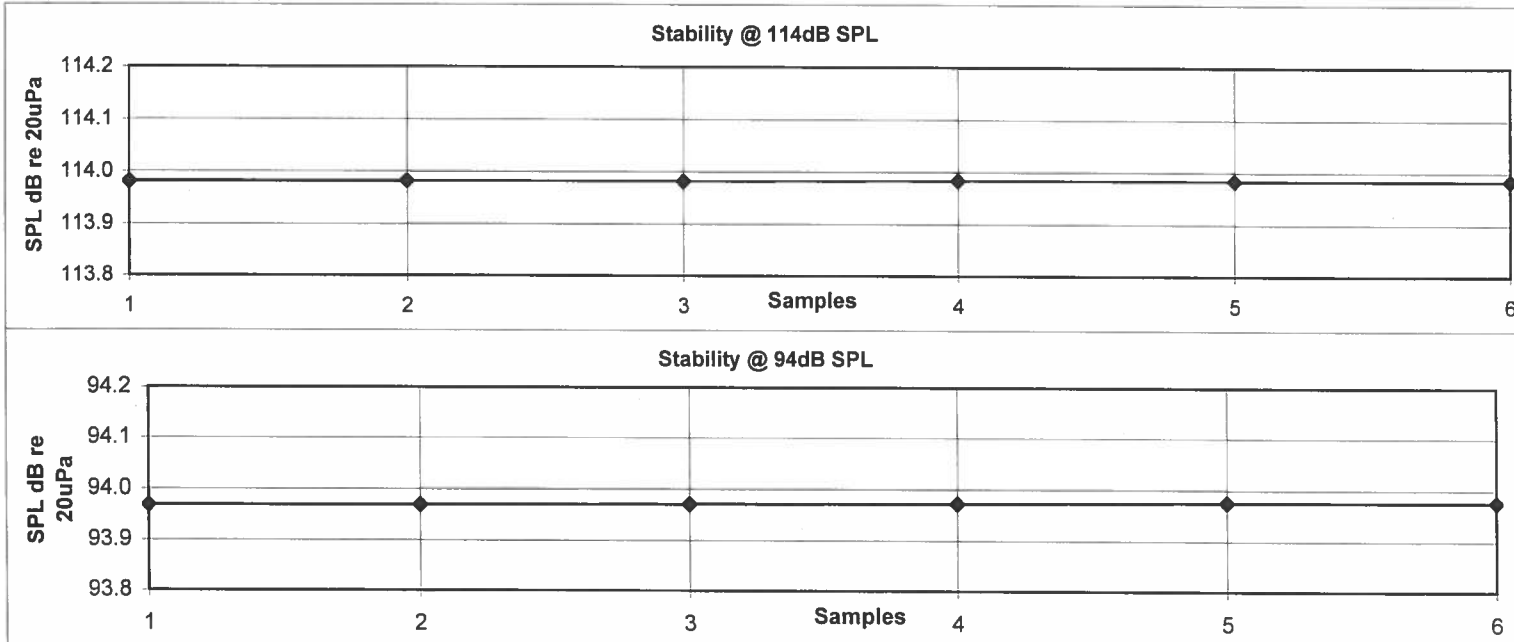
I. D. No: XXXX

Calibration results: Sound Pressure Level at 1000.0 Hz and pressure of 1013 hPa (mbar) was 114.0 dB re 20µPa (Calibrator tested with ½" adaptor UC 0210) IEC 1094-4 Type WS 2 P Microphone was used for measurement.	Before data: After data: Before & after data same: <input checked="" type="checkbox"/>																		
<table border="0"> <tr> <td></td> <td style="text-align: center;">114dB</td> <td style="text-align: center;">94dB</td> </tr> <tr> <td>Sound Pressure Level:</td> <td style="text-align: center;">Pass</td> <td style="text-align: center;">Pass</td> </tr> <tr> <td>Frequency:</td> <td style="text-align: center;">Pass</td> <td style="text-align: center;">Pass</td> </tr> <tr> <td>Distortion:</td> <td style="text-align: center;">Pass</td> <td style="text-align: center;">Pass</td> </tr> <tr> <td>Stability:</td> <td style="text-align: center;">Pass</td> <td style="text-align: center;">Pass</td> </tr> <tr> <td>All tested parameters:</td> <td style="text-align: center;">Pass</td> <td style="text-align: center;">Pass</td> </tr> </table>		114dB	94dB	Sound Pressure Level:	Pass	Pass	Frequency:	Pass	Pass	Distortion:	Pass	Pass	Stability:	Pass	Pass	All tested parameters:	Pass	Pass	Laboratory Environment: Ambient Temperature: 21.9 °C Ambient Humidity: 43.5 % RH Ambient Pressure: 98.563 kPa Calibration Date: 5-Jun-2014 Re-calibration Due: 5-Jun-2015 Report Number: 24213 -1 Control Number: 24213
	114dB	94dB																	
Sound Pressure Level:	Pass	Pass																	
Frequency:	Pass	Pass																	
Distortion:	Pass	Pass																	
Stability:	Pass	Pass																	
All tested parameters:	Pass	Pass																	

The above listed instrument meets or exceeds the tested manufacturer's specifications
 The IEC 942:1988 Class 1 specifications, passed.
 The ANSI S1.4-1984 specifications, passed.

This Calibration is traceable through NIST test numbers: 822/275722-13
 The expanded uncertainty of calibration: 0.09dB at 95% confidence level with a coverage factor of k=2.

Graph represents six samples of Sound Pressure Level measured at 5sec. interval.



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 4231B&K**
 Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NC SL Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

Cal. Date: 5-Jun-2014

Measurements performed by:

Calibrated on WCCL system type 9700

Stephen Johnson

This document shall not be reproduced, except in full, without the written approval from West Caldwell Cal. Labs. Inc.

Rev. 7.0 Jan. 24, 2014 Doc. # 1038 4231B&K

West Caldwell Calibration Laboratories Inc.

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

Calibration Data Record

Brüel & Kjær Acoustical Calibrator

for
Model No.: 4231

Serial No.: 2513182

Company : Aercoustics Engineering, Ltd.

All tested parameters: Pass

Measured Sound Pressure Level (Six samples measured at 5 sec. interval)

Sample	1	113.98 dB re 20µPa	93.97 dB re 20µPa
	2	113.98	93.97
	3	113.98	93.97
	4	113.98	93.97
	5	113.98	93.98
	6	113.98	93.98
	Average	114.0 Spec. 114dB ± 0.2dB	94.0 Spec. 94dB ± 0.2dB

Frequency measured (Three samples at 30 sec. Interval)

Sample	1	999.98 Hz	999.97 Hz
	2	999.98	999.97
	3	999.98	999.98
	Average	999.98	999.97 Spec. 1000Hz ±0.1%

The Frequency expanded uncertainty of calibration:45µHz/Hz at 95% confidence level with a coverage factor of k=2.

Distortion measured	-50.1 dB	-46.6 dB	Spec. ≤-40dB
----------------------------	----------	----------	--------------

Instruments used for calibration:	Date of Cal.	Traceability No.	Re-cal. Due Date
Brüel & Kjær 4231 S/N 2308998	31-Jul-2013	822/275722-13	31-Jul-2014
Brüel & Kjær 4134 S/N 173494	13-May-2014	822/275722-14	13-May-2015
Brüel & Kjær 2669 S/N 1835084	8-Nov-2013	683/281764-13	8-Nov-2014
Hewlett Packard 34401A S/N 3146A223	29-Jul-2013	,205342	29-Jul-2014
Brüel & Kjær 2636 S/N 1107902	29-Jul-2013	822/275722-13	29-Jul-2014
Hewlett Packard 33120A S/N 36045845	24-Jul-2013	,205342	24-Jul-2014

Cal. Date: 5-Jun-2014

Tested by: Stephen Johnson

Calibrated on WCCL system type 9700

This document shall not be reproduced, except in full, without the written approval from West Caldwell Cal. Labs. Inc.

Rev. 7.0 Jan. 24, 2014 Doc. # 1038 4231B&K

CERTIFICATE OF CALIBRATION

Customer: AEROCOUSTICS ENGINEERING LTD
50 RONSON DRIVE
SUITE 165
TORONTO, ON M9W 1B3

Customer Nbr: 9-322110-000
PO Nbr: C022414
Date Received: February 24, 2014

Cert/SO Nbr: 33-8Z881-1-1
Manufacturer: Nokeval
Model Nbr: 7470

Date Completed: March 11, 2014
Due Date: March 11, 2015

Description: Serial to Analog Converter
Serial Nbr: A159784
ID Nbr: NONE
Unit Barcode: 901B0150195

Calibrated To: Manufacturer Specification
Calibration Proc: 1-AC58014-0
Item Received: In Tolerance
Item Returned: In Tolerance

Transcat Calibration Laboratories have been audited and found in compliance with ISO/IEC 17025:2005. Accredited calibrations performed within the Lab's Scope of Accreditation are indicated by the presence of the Accrediting Body's Logo and Certificate Number on this Certificate of Calibration. Any measurements on an accredited calibration not covered by that Lab's Scope are listed in the notes section of the certificate. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

Transcat calibrations, as applicable, are performed in compliance with the requirements of ISO 9001:2008, ISO TS16949, ANSI/NCSL Z540-1994, and ISO 10012-1992. When specified contractually, the requirements of 10CFR21, 10CFR50 App. B and NQA-1 are also covered.

Traceability includes no less than: An unbroken chain of comparison, realization of SI units, measurement uncertainty, documentation, competence, periodic recalibration, and measurement assurance. Transcat documents the traceability of measurements to the SI units through the National Institute of Standards and Technology (NIST) or the National Research Council of Canada (NRC), or other recognized national measurement institutes (NMI's) or international standard bodies, or to measurable conditions created in our laboratory, or accepted fundamental and/or natural physical constants, ratio type of calibration, or by comparison to consensus standards. The specific path of traceability for the reported measurement results is maintained at the Transcat facility and is available there for review.

Complete records of work performed are maintained by Transcat and are available for inspection. Laboratory standards used in the performance of this calibration are shown on the Supplemental Report.

The results in this report relate only to the item calibrated or tested, and the determination of in or out of tolerance is specific to the model/serial no. referenced above based on the tolerances shown on the supplemental report; these tolerances are either the original equipment manufacturer's (OEM's) warranted specifications or the client's requested specifications.

The applied uncertainty is the uncertainty of the calibration process. The Test Uncertainty Ratio (TUR) is calculated as per NCSL International RP-9, section 8.2. All calibrations have been performed using processes having a TUR of 4:1 or better (3:1 for mass calibrations), unless otherwise noted on the Supplemental Report. Uncertainties have been estimated at a 95 percent confidence level (k=2). Calibration at a 4:1 TUR (or greater) provides reasonable confidence that the instrument is within the stated tolerances. For measuring instruments, in order to consider the contribution to the uncertainty from reproducibility of the unit under test (UUT), add 0.6 of the UUT's least significant digit to the reported uncertainty. For mass calibrations, conventional mass referenced to 8.0 g/cm³.

Any number of factors can cause a unit to drift out of tolerance at any time following its calibration. Limitations on the uses of this instrument are detailed in the OEM's operating instructions.

Notes:

Calibrated At:

4043 Carling Avenue
Ottawa, ON K2K 2A4
By: Shabeba Bucknor

Facility Responsible:

4043 Carling Avenue
Ottawa, ON K2K 2A4
613-591-8140



Digitally Signed By Keith Powell

Date: March 11, 2014

Keith Powell
Lab Manager

Digitally Signed On March 11, 2014

Revision 0

This certificate may not be reproduced except in full, without the written approval of Transcat. Additional information, if applicable, may be included on separate report(s).

SUPPLEMENTAL REPORT FOR 33-8Z881-1-1

CALIBRATION LAB DATA AS FOUND / AS LEFT

Service Order Nbr: 33-8Z881-1-1
 Description: Serial to Analog Converter
 Serial: A159784
 Customer: AEROCOUSTICS ENGINEERING LTD
 Calibrated: March 11, 2014
 Date Due: March 11, 2015
 Service Type: R9

Mfg: Nokeval
 Model: 7470
 PO Nbr: C022414
 ID Nbr: NONE
 Calibration Proc: 1-AC58014-0

Description	Setpoints	Accuracy	Low Limit	High Limit	As Found / As Left	Q O T	Uncertainty (k=2; #)	TUR
DC Current % Source - 4-20mA Ch #1								
4 - 20mA	0%	±(0.1% Span)	3.984	4.016	3.996 mA		1.6e-004 mA	100.0 : 1
	25%	±(0.1% Span)	7.984	8.016	7.995 mA		2.7e-004 mA	59.3 : 1
	50%	±(0.1% Span)	11.984	12.016	12.000 mA		1.1e-003 mA	14.5 : 1
	75%	±(0.1% Span)	15.984	16.016	16.000 mA		1.3e-003 mA	12.3 : 1
	100%	±(0.1% Span)	19.984	20.016	19.998 mA		1.4e-003 mA	11.4 : 1
DC Current % Source - 4-20mA Ch #2								
4 - 20mA	0%	±(0.1% Span)	3.984	4.016	3.995 mA		1.6e-004 mA	100.0 : 1
	25%	±(0.1% Span)	7.984	8.016	7.999 mA		2.7e-004 mA	59.3 : 1
	50%	±(0.1% Span)	11.984	12.016	11.997 mA		1.1e-003 mA	14.5 : 1
	75%	±(0.1% Span)	15.984	16.016	16.001 mA		1.3e-003 mA	12.3 : 1

The reported uncertainty is the uncertainty of the calibration process. For measuring instruments, add 0.6 of the least significant digit to the reported uncertainty to obtain the measurement uncertainty of the unit under test at the specific test point.
 Reported resolution of the UUT does not represent calibration uncertainty or accuracy of the UUT

SUPPLEMENTAL REPORT FOR 33-8Z881-1-1

CALIBRATION LAB DATA AS FOUND / AS LEFT

Description	Setpoints	Accuracy	Low Limit	High Limit	As Found / As Left	$\frac{Q}{T}$	Uncertainty (k=2; ±)	TUR
DC Current % Source - 4-20mA Ch #3								
4 - 20mA	0%	±(0.1% Span)	3.984	4.016	3.995 mA		1.6e-004 mA	100.0 : 1
	25%	±(0.1% Span)	7.984	8.016	7.995 mA		2.7e-004 mA	59.3 : 1
	50%	±(0.1% Span)	11.984	12.016	11.996 mA		1.1e-003 mA	14.5 : 1
	75%	±(0.1% Span)	15.984	16.016	16.002 mA		1.3e-003 mA	12.3 : 1
	100%	±(0.1% Span)	19.984	20.016	20.002 mA		1.4e-003 mA	11.4 : 1
DC Current % Source - 4-20mA Ch #4								
4 - 20mA	0%	±(0.1% Span)	3.984	4.016	3.997 mA		1.6e-004 mA	100.0 : 1
	25%	±(0.1% Span)	7.984	8.016	7.995 mA		2.7e-004 mA	59.3 : 1
	50%	±(0.1% Span)	11.984	12.016	11.999 mA		1.1e-003 mA	14.5 : 1
	75%	±(0.1% Span)	15.984	16.016	15.998 mA		1.3e-003 mA	12.3 : 1
	100%	±(0.1% Span)	19.984	20.016	20.002 mA		1.4e-003 mA	11.4 : 1
DC Current % Source - 0-20mA Ch #1								
0 - 20mA	0%	±(0.1% Span)	-0.020	0.020	0.000 mA		9.2e-007 mA	100.0 : 1
	25%	±(0.1% Span)	4.980	5.020	4.997 mA		1.9e-004 mA	100.0 : 1
	50%	±(0.1% Span)	9.980	10.020	9.998 mA		3.2e-004 mA	62.5 : 1
	75%	±(0.1% Span)	14.980	15.020	14.998 mA		1.2e-003 mA	16.7 : 1
	100%	±(0.1% Span)	19.980	20.020	19.998 mA		1.4e-003 mA	14.3 : 1

The reported uncertainty is the uncertainty of the calibration process. For measuring instruments, add 0.6 of the least significant digit to the reported uncertainty to obtain the measurement uncertainty of the unit under test at the specific test point. Reported resolution of the UUT does not represent calibration uncertainty or accuracy of the UUT.

SUPPLEMENTAL REPORT FOR 33-8Z881-1-1

CALIBRATION LAB DATA AS FOUND / AS LEFT

Description	Setpoints	Accuracy	Low Limit	High Limit	As Found / As Left	$\frac{Q}{T}$	Uncertainty (k=2; ±)	TUR
DC Current % Source - 0-20mA Ch #2								
0 - 20mA	0%	±(0.1% Span)	-0.020	0.020	0.000 mA		9.2e-007 mA	100.0 : 1
	25%	±(0.1% Span)	4.980	5.020	4.996 mA		1.9e-004 mA	100.0 : 1
	50%	±(0.1% Span)	9.980	10.020	10.000 mA		3.2e-004 mA	62.5 : 1
	75%	±(0.1% Span)	14.980	15.020	15.000 mA		1.2e-003 mA	16.7 : 1
	100%	±(0.1% Span)	19.980	20.020	19.999 mA		1.4e-003 mA	14.3 : 1
DC Current % Source - 0-20mA Ch #3								
0 - 20mA	0%	±(0.1% Span)	-0.020	0.020	0.000 mA		9.2e-007 mA	100.0 : 1
	25%	±(0.1% Span)	4.980	5.020	4.995 mA		1.9e-004 mA	100.0 : 1
	50%	±(0.1% Span)	9.980	10.020	9.995 mA		3.2e-004 mA	62.5 : 1
	75%	±(0.1% Span)	14.980	15.020	14.997 mA		1.2e-003 mA	16.7 : 1
	100%	±(0.1% Span)	19.980	20.020	20.002 mA		1.4e-003 mA	14.3 : 1
DC Current % Source - 0-20mA Ch #4								
0 - 20mA	0%	±(0.1% Span)	-0.020	0.020	0.000 mA		9.2e-007 mA	100.0 : 1
	25%	±(0.1% Span)	4.980	5.020	4.992 mA		1.9e-004 mA	100.0 : 1
	50%	±(0.1% Span)	9.980	10.020	9.997 mA		3.2e-004 mA	62.5 : 1
	75%	±(0.1% Span)	14.980	15.020	14.996 mA		1.2e-003 mA	16.7 : 1
	100%	±(0.1% Span)	19.980	20.020	20.002 mA		1.4e-003 mA	14.3 : 1
DC Voltage % Source - 0-5V Ch#1								

The reported uncertainty is the uncertainty of the calibration process. For measuring instruments, add 0.6 of the least significant digit to the reported uncertainty to obtain the measurement uncertainty of the unit under test at the specific test point. Reported resolution of the UUT does not represent calibration uncertainty or accuracy of the UUT.

SUPPLEMENTAL REPORT FOR 33-8Z881-1-1

CALIBRATION LAB DATA AS FOUND / AS LEFT

Description	Setpoints	Accuracy	Low Limit	High Limit	As Found / As Left	$\frac{Q}{T}$	Uncertainty (k=2; ±)	TUR
0 -5V	0%	±(0.1% Span)	-0.0050	0.0050	0.0004 V		5.0e-007 V	100.0 : 1
	20%	±(0.1% Span)	0.9950	1.0050	1.0006 V		5.5e-006 V	100.0 : 1
	40%	±(0.1% Span)	1.9950	2.0050	1.9990 V		1.1e-005 V	100.0 : 1
	60%	±(0.1% Span)	2.9950	3.0050	2.9969 V		1.6e-005 V	100.0 : 1
	80%	±(0.1% Span)	3.9950	4.0050	3.9981 V		2.1e-005 V	100.0 : 1
	100%	±(0.1% Span)	4.9950	5.0050	4.9970 V		2.6e-005 V	100.0 : 1
DC Voltage % Source - 0-5V Ch#2								
0 -5V	0%	±(0.1% Span)	-0.0050	0.0050	0.0016 V		5.0e-007 V	100.0 : 1
	20%	±(0.1% Span)	0.9950	1.0050	0.9993 V		5.5e-006 V	100.0 : 1
	40%	±(0.1% Span)	1.9950	2.0050	1.9998 V		1.1e-005 V	100.0 : 1
	60%	±(0.1% Span)	2.9950	3.0050	2.9979 V		1.6e-005 V	100.0 : 1
	80%	±(0.1% Span)	3.9950	4.0050	3.9963 V		2.1e-005 V	100.0 : 1
	100%	±(0.1% Span)	4.9950	5.0050	4.9974 V		2.6e-005 V	100.0 : 1
DC Voltage % Source - 0-5V Ch#3								
0 -5V	0%	±(0.1% Span)	-0.0050	0.0050	0.0004 V		5.0e-007 V	100.0 : 1
	20%	±(0.1% Span)	0.9950	1.0050	0.9988 V		5.5e-006 V	100.0 : 1
	40%	±(0.1% Span)	1.9950	2.0050	1.9980 V		1.1e-005 V	100.0 : 1
	60%	±(0.1% Span)	2.9950	3.0050	2.9968 V		1.6e-005 V	100.0 : 1
	80%	±(0.1% Span)	3.9950	4.0050	3.9989 V		2.1e-005 V	100.0 : 1
	100%	±(0.1% Span)	4.9950	5.0050	4.9974 V		2.6e-005 V	100.0 : 1

The reported uncertainty is the uncertainty of the calibration process. For measuring instruments, add 0.6 of the least significant digit to the reported uncertainty to obtain the measurement uncertainty of the unit under test at the specific test point. Reported resolution of the UUT does not represent calibration uncertainty or accuracy of the UUT.

SUPPLEMENTAL REPORT FOR 33-8Z881-1-1

CALIBRATION LAB DATA AS FOUND / AS LEFT

Description	Setpoints	Accuracy	Low Limit	High Limit	As Found / As Left	$\frac{O}{I}$	Uncertainty (k=2; ±)	TUR
DC Voltage % Source - 0-5V Ch#4								
0-5V	0%	±(0.1% Span)	-0.0050	0.0050	0.0002 V		5.0e-007 V	100.0 : 1
	20%	±(0.1% Span)	0.9950	1.0050	1.0000 V		5.5e-006 V	100.0 : 1
	40%	±(0.1% Span)	1.9950	2.0050	1.9981 V		1.1e-005 V	100.0 : 1
	60%	±(0.1% Span)	2.9950	3.0050	2.9985 V		1.6e-005 V	100.0 : 1
	80%	±(0.1% Span)	3.9950	4.0050	3.9967 V		2.1e-005 V	100.0 : 1
	100%	±(0.1% Span)	4.9950	5.0050	4.9975 V		2.6e-005 V	100.0 : 1
DC Voltage % Source - 0-10V Ch#1								
0-10V	0%	±(0.1% Span)	-0.010	0.010	0.001 V		5.0e-007 V	100.0 : 1
	20%	±(0.1% Span)	1.990	2.010	2.000 V		1.1e-005 V	100.0 : 1
	40%	±(0.1% Span)	3.990	4.010	4.000 V		2.1e-005 V	100.0 : 1
	60%	±(0.1% Span)	5.990	6.010	6.000 V		3.1e-005 V	100.0 : 1
	80%	±(0.1% Span)	7.990	8.010	7.997 V		4.1e-005 V	100.0 : 1
	100%	±(0.1% Span)	9.990	10.010	9.997 V		5.2e-005 V	100.0 : 1
DC Voltage % Source - 0-10V Ch#2								
0-10V	0%	±(0.1% Span)	-0.010	0.010	0.002 V		5.0e-007 V	100.0 : 1
	20%	±(0.1% Span)	1.990	2.010	2.001 V		1.1e-005 V	100.0 : 1
	40%	±(0.1% Span)	3.990	4.010	3.998 V		2.1e-005 V	100.0 : 1

The reported uncertainty is the uncertainty of the calibration process. For measuring instruments, add 0.6 of the least significant digit to the reported uncertainty to obtain the measurement uncertainty of the unit under test at the specific test point. Reported resolution of the UUT does not represent calibration uncertainty or accuracy of the UUT.

SUPPLEMENTAL REPORT FOR 33-8Z881-1-1

CALIBRATION LAB DATA AS FOUND / AS LEFT

Description	Setpoints	Accuracy	Low Limit	High Limit	As Found / As Left	$\frac{Q}{T}$	Uncertainty (k=2; ±)	TUR
DC Voltage % Source - 0-10V Ch#3								
0 - 10V	60%	±(0.1% Span)	5.990	6.010	5.998 V		3.1e-005 V	100.0 : 1
	80%	±(0.1% Span)	7.990	8.010	7.998 V		4.1e-005 V	100.0 : 1
	100%	±(0.1% Span)	9.990	10.010	9.998 V		5.2e-005 V	100.0 : 1
DC Voltage % Source - 0-10V Ch#4								
0 - 10V	0%	±(0.1% Span)	-0.010	0.010	0.001 V		5.0e-007 V	100.0 : 1
	20%	±(0.1% Span)	1.990	2.010	1.999 V		1.1e-005 V	100.0 : 1
	40%	±(0.1% Span)	3.990	4.010	4.001 V		2.1e-005 V	100.0 : 1
	60%	±(0.1% Span)	5.990	6.010	6.000 V		3.1e-005 V	100.0 : 1
	80%	±(0.1% Span)	7.990	8.010	7.999 V		4.1e-005 V	100.0 : 1
	100%	±(0.1% Span)	9.990	10.010	9.998 V		5.2e-005 V	100.0 : 1
DC Voltage % Source - 0-10V Ch#4								
0 - 10V	0%	±(0.1% Span)	-0.010	0.010	0.001 V		5.0e-007 V	100.0 : 1
	20%	±(0.1% Span)	1.990	2.010	1.999 V		1.1e-005 V	100.0 : 1
	40%	±(0.1% Span)	3.990	4.010	3.998 V		2.1e-005 V	100.0 : 1
	60%	±(0.1% Span)	5.990	6.010	6.000 V		3.1e-005 V	100.0 : 1
	80%	±(0.1% Span)	7.990	8.010	8.000 V		4.1e-005 V	100.0 : 1
	100%	±(0.1% Span)	9.990	10.010	9.999 V		5.2e-005 V	100.0 : 1

The reported uncertainty is the uncertainty of the calibration process. For measuring instruments, add 0.6 of the least significant digit to the reported uncertainty to obtain the measurement uncertainty of the unit under test at the specific test point.

Reported resolution of the UUT does not represent calibration uncertainty or accuracy of the UUT.

SUPPLEMENTAL REPORT FOR 33-8Z881-1-1

CALIBRATION LAB DATA AS FOUND / AS LEFT

Description	Setpoints	Accuracy	Low Limit	High Limit	As Found / As Left	$\frac{O}{I}$	Uncertainty (k=2; ±)	TUR
-------------	-----------	----------	-----------	------------	--------------------	---------------	----------------------	-----

As Found and As Left Data recorded on March 11, 2014

Temperature: 69.8°F / 21.0°C Relative Humidity: 48%

Temp/RH Asset: N0457

Asset: N0118

Manufacturer: Agilent/HP

Model: 3458A Opt 002

Description: Multimeter, 8.5 Digit

Cal Date: June 25, 2013

Due Date: June 30, 2014

Traceability Numbers: 5-&N0118-10-6

The reported uncertainty is the uncertainty of the calibration process. For measuring instruments, add 0.6 of the least significant digit to the reported uncertainty to obtain the measurement uncertainty of the unit under test at the specific test point. Reported resolution of the UUT does not represent calibration uncertainty or accuracy of the UUT.

Appendix F.03 E-Audit Checklist

Appendix F.03 - (2017 Compliance Protocol AF5): E-Audit checklist

Wind Energy Project – Screening Document – Acoustic Audit Report – Emission IEC61400-11 Standard
Information Required in the Acoustic Audit Report – Immission

Item #	Description	Complete?	Comment
1	Characterization of the wind turbine Items 1 to 26; IEC61400-11:2013, Section 10.2	✓	
2	Physical environment Items 27 to 33; IEC61400-11:2013, Section 10.3, Physical Environment	✓	
3	Measurement instrumentation Items 34 to 39; IEC61400-11:2013, Section 10.4, Instrumentation	✓	
4	Acoustic data Items 40 to 52; IEC61400-11:2013, Section 10.5, Acoustic Data	✓	
5	Non-acoustic data Items 50 to 53, and 56; IEC61400-11:2003 Section 10.6, Non-Acoustic Data Items 59 and 60; NPC-233, Section 12.3, Acoustic Audit – Acoustical Data, bullet point number 8, All necessary and supporting calculations	✓	
6	Uncertainty the apparent sound power level at integer wind speeds one-third octave band spectrum of the noise at the reference position at each integer wind speed the Tonality of the sound emissions of the wind turbine measured at the reference position	✓	
7	Additional information Item 60; NPC-233, Section 10, Report Format, bullet point number 4, Conclusions and Recommendations Item 61; NPC-233, Section 12.3, Acoustic Audit – Acoustical Data, bullet point number 8, All necessary and supporting calculations Item 62; NPC-233, Section 12.3, Acoustic Audit – Acoustical Data, bullet point number 3, Details of measurement procedure	✓	All data Excel sheet to be provided separately
8	Items 68 to 72; IEC61400-11:2013, Section 10.5, Acoustic Data	⊗	Items 68 to 72 acoustic data as per IEC 61400-11 standard are optional; low frequency noise, infrasound, impulsivity, amplitude modulation not reported
9	Non-acoustic data Items 73 to 74 are from IEC61400-11:2013, Section 10.6, Non-Acoustic Data	⊗	Items 73 to 74 non-acoustic data as per IEC 64100-11 standard are optional; turbulence intensity during acoustic mееasurements not reported

Appendix F.04

Summary of Measurement Results

Summary of Measurement Results

1.1 Overall Sound Power Levels

From Table 12 of IEC test report 14431.00.T44.RP3:

Table 1 Overall A-weighted Sound Power Levels compared to REA Maximum Sound Power Level

Wind Speed (m/s)	Apparent L _{WA} , (dBA)	Maximum Sound Power Level (dBA)* REA # 2494-94QQ97
7	97.7	103.5
7.5	99.3	103.5
8	101.2	103.5
8.5	102.2	103.5
9	102.8	103.5
9.5	103.5	103.5
10	103.3	103.5
10.5	103.3	103.5
11	103.3	103.5

*Includes +0.5 dB, per Section E3.1 of the MECPP Compliance Protocol for Wind Turbine Noise

1.2 Octave Band Sound Power Levels

Table 2 Sound Power Levels (overall A-weighted levels and octave bands for each wind speed)

Wind Speed (m/s)	Octave Band (Hz), dBA								
	31.5	63	125	250	500	1000	2000	4000	8000
7	68.9	78.9	84.6	88.1	89.3	92.5	92.4	86.6	73.7
7.5	70.8	80.6	86.2	89.5	91.3	94.2	94.0	87.4	73.7
8	72.8	82.6	88.7	92.3	93.9	95.8	95.5	88.4	74.0
8.5	72.1	82.3	89.0	92.7	95.6	96.8	96.6	89.4	74.9
9	74.2	83.3	90.7	93.3	96.0	97.3	97.0	89.9	75.4
9.5	75.2	83.5	91.6	93.4	97.4	98.0	97.4	90.1	75.9
10	74.2	82.1	91.3	92.3	97.0	98.1	97.5	90.2	76.1
10.5	75.2	82.5	91.2	92.1	97.0	98.1	97.5	90.1	75.8
11	76.2	82.7	91.2	92.2	97.1	98.2	97.4	90.0	76.2

Table 3: [Table B2] Maximum Sound Power Level Spectrum (dBA) of the 1.62 MW Wind Turbine Generators

1-48	Octave Band (Hz), dBA								
	31.5	63	125	250	500	1000	2000	4000	8000
Sound Power Level	-	84	91.7	95.5	97.0	97.8	95.1	87.9	69.1

1.3 Tonal Audibility Values

From Table 14 of IEC test report 14331.00.T44.RP3:

Wind Speed (m/s)	Frequency (Hz)	Tonal audibility, ΔL_a (dB)	Tonal Audibility from AAR* (dB)
7	117	-1.1	2
7.5	122	-3.0	2
8.5	597	2.9	2
9	134	-2.0	2
9	599	2.2	2
9.5	137	1.5	2
9.5	629	4.6	2
10	137	2.7	2
10	628	3.6	2
10.5	137	2.8	2
10.5	629	3.7	2
10.5	1258	-2.9	2
11	137	2.5	2
11	624	3.5	2
11	1249	-2.7	2

*Garrad Hassan – Noise Impact Assessment Report (April 15, 2018)

1.4 Statement of Compliance

Based on the results in Table 12 of the IEC 61400-11 test report to which this statement is attached, the maximum apparent overall sound power level of the test turbine complies with the overall sound power level in REA # 2494-94QQ97 and Section E3.1 of the MECP Compliance Protocol for Wind Turbine Noise.

The measured apparent octave band sound power levels do not satisfy the REA maximum permitted octave band sound power levels noted in Schedule B2 Table B2 in REA # 2494-94QQ97. However, it should be noted that the maximum apparent overall sound power level of the test turbine does satisfy the REA Maximum sound power level.

Based on the results in Table 14 of the IEC 61400-11 to which this statement is attached, the maximum tonal audibility of the test turbine exceeds the maximum tonal audibility of 2 dB as indicated in the statement from the manufacturer in Appendix E of the Acoustic Assessment Report dated March 19, 2013.

Due to the exceedance noted above the Protocol requires additional actions as detailed in Section E3.1.1 or E3.1.2 to demonstrate compliance.

End of Report
