MM92, 1880 kW, 93626 / T4

Results of acoustic noise measurements according to IEC 61400-11 Edition 3.0

Gunn's Hill LP

Report No.: GLGH-4286 16 14199 293-A-0007-A
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Customer:	Gunn's Hill LP, 19 Bold Street, Unit 2B, Hamilton, ON L8P 1T3, Canada	
Contact person:	Rochelle Rumney	
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DNV GL - Energy
Renewables Measurements
GL Garrad Hassan
Deutschland GmbH
Sommerdeich 14b
25709 Kaiser-Wilhelm-Koog
Germany
Tel: +49 4856 901 0
HR B 636 ME

Task and objective:
Noise emission measurement according to IEC 61400-11 Edition 3.0 on a wind turbine of type Senvion MM92 near Gunns Hill in Canada.

Prepared by:	Verified by:	Approved by:
Dr. rer. Nat. Ivan Asin Cruz (Project engineer)	Dipl.-Ing. (FH) Jörg Dedert (Deputy Head of Section Acoustics)	Dipl.-Ing. (FH) Jörg Dedert (Deputy Head of Section Acoustics)

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Table of contents

1 EXECUTIVE SUMMARY

This report describes methods and results of a noise emission measurement according to IEC 61400-11 Edition 3.0 on a wind turbine generator system Senvion MM92 with serial number 93626 and internal park id. T4 near Gunns Hill in Canada.

2 INTRODUCTION

The order from Gunn's Hill LP required GL Garrad Hassan Canada Inc. which is part of the Energy Renewables Advisory of DNV GL to carry out acoustic noise measurements on the wind turbine generator system (WTGS or 'turbine') Senvion MM92 of hub height 100 m with serial number 93626 and internal park id. T4 near Gunn's Hill in Canada. GL Garrad Hassan Deutschland GmbH (GH-D) was subcontracted by GL Garrad Hassan Canada Inc. to perform the mesaurement. From this turbine the sound power level and frequency spectra, emitted at different wind speeds, have been determined.

The results given in this report only relate to the specific turbine, weather conditions and measurement site. The results mentioned in this report can only be transferred to other turbines of the same model and technical construction with consideration of the uncertainty in the results, due to manufacturing tolerances and variation in meteorological and geographical conditions where the turbines might be installed.

3 METHODS

3.1 Measurement procedure

The measurements of the acoustical emissions are performed in accordance with the legacy GH-D management system procedure /2/. This test procedure is an integral part of the management system of DNV GL.

All measurements and analysis described in this report were done in accordance with /2/ in combination with IEC 61400-11 Ed. 3.0 Wind Turbines, Part 11: Acoustic Noise Measurement Techniques, 2012-11-07 /1/.

According to /1/ the sound power level has to be analysed for wind speeds from 0.8 to 1.3 times the wind speed at 85 % of maximum power rounded to the bin centres.

Note: A calculated power curve for the turbine was provided by the customer for purposes of converting the measured turbine power output into the standardised wind speed. This power curve is given in the annex.

3.2 Measurement object

Table 3-1 shows the characteristics of the measured WTGS. The remaining characteristics can be found in the manufacturer's certificate in the annex.

Table 3-1 Characteristics of the measured WTGS

Parameter	Value
Manufacturer	Senvion
Type	Senvion MM92
Mode	1880 kW
Rated Power	2050 kW
Site	Gunns Hill
Turbine serial no.	93626
Wind park internal id.	T4
Hub-height above ground	100 m
Rotor diameter	92.5 m
Distance middle of tower to middle of blade flange	3.15 m
Gearbox type	Eickhoff, EBN1378 C13
Generator type	Siemens, JFRA-560SR-06A
Rotor blades	Power Blades, RE45.2
Power control (pitch/stall)	Pitch

3.3 Course of measurements

The total measurement period lasted from 2017-11-16 11:43 h until 2017-11-16 20:41 h. During turbine operation the measured wind speed at hub height ranged from 6.9 to 16.9 m/s. The real electrical power output of the turbine ranged between 617 and 1959 kW. During the measurement only the WTG with wind park id T5 was shut down. Additional WTGS in the wind park are located at distances of 1000 m or larger and therefore have a negligible influence on the measurement results.

The sound pressure level was measured with a microphone on an acoustically hard board and fed into a sound level meter which then calculated A-weighted equivalent 1-second average values which were then acquired by the measurement system. Non-acoustic data were acquired by the measurement system with a sampling rate of 1 Hz. Time periods with intermittent background noise of a significant nature, e.g. passing cars, planes flying over, rain etc., were marked accordingly during the measurements and are omitted in the later evaluation. If there were random and reoccurring disturbances which could not be marked during the measurement, a later state correction by means of a comparison with the audio-recording was done.

The wind turbine generator system is sited in farmland. The surface is covered by grass/plants, therefore a typical roughness length of 0.05 m is assumed in the following. The microphone position was chosen to minimise the effect of buildings, trees or bushes in the surrounding area of the wind turbine generator system, which might have had an influence on the measurement results. The conditions comply with free field behaviour over a reflecting plane.

During the noise measurements the meteorological conditions given in Table 3-2 prevailed.w

Table 3-2 Prevailing meteorological conditions during the measurements

Parameter	Value
Barometric pressure at 2 m height above ground [hPa]	973 - 982
Air temperature at 2 m height above ground [°C]	0 - 5
Prevailing wind direction	WSW
Range of wind direction [°]	212 - 282
Weather conditions	Dry and sunny

3.4 Measuring equipment

The used measuring equipment is listed in the annex. The equipment is tested regularly according to the management system support function /3/ which includes the requirements of the /1/ to ensure a high degree of measurement accuracy as well as data security. The complete acoustic measurement system was checked before and after the measurement using an acoustic calibrator.

3.5 Position of microphone

The microphone was placed according to /1/. The distance from the turbine to the reference measuring point, R_0 = 144.0 m, was chosen taking local circumstances into account. The height of the microphone with respect to the bottom of the turbine foundation was h_A = 0.0 m.

3.6 Position of met mast

To gain results of free wind at the turbine position the met mast was located at the marked area in Figure 1. The aim is to measure the wind speed and wind direction in free-wind conditions by means of an anemometer and wind vane mounted on a 10 m met mast. The wind speed measured at the met mast is used for background noise measurements.

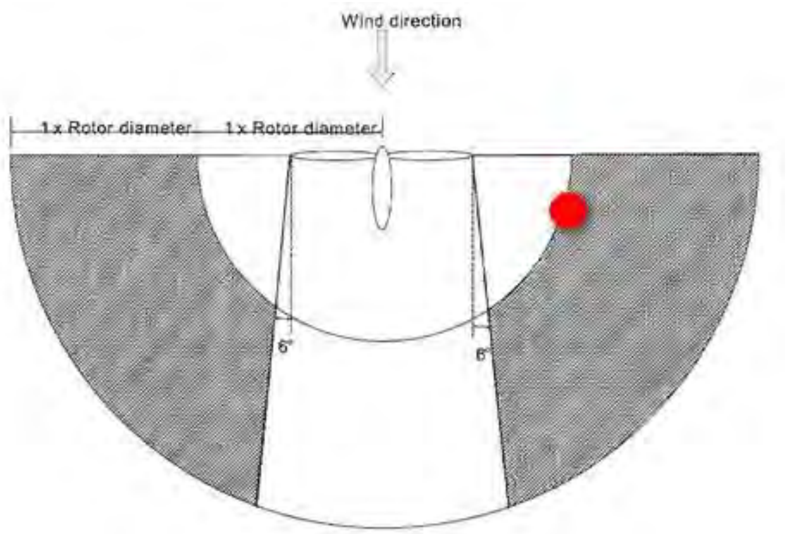


Figure 1: Position of the met mast

4 MEASUREMENT RESULTS

4.1 Determination of noise directivity

As no significant noise directivity was ascertained the reference noise measurement position was chosen to be directly downwind of the turbine. This position ensured that the worst-case sound propagation conditions were taken into account.

4.2 Sound pressure level

The microphone converts the sound pressure into a continuous analogue signal which is then fed to a sound level meter. The resulting dB value (L_{Aeq}) together with the status, the wind speed (WS) at a height of 10 m ($V_{z,m}$) and the measured power output (P_m) of the turbine, all recorded by the measurement system, is plotted against time in a graph given in the annex 9.8.

Here it can be seen at which points in time the turbine is in operation and shut down and provides an overview of the background noise in relation to the operating noise over the whole period of the measurement.

Non-normal background noises occurring in the measurement period, e.g. from aircraft or traffic, were marked during data acquisition to enable their easy omission in the evaluation to follow.

The state signal is used to differentiate between periods when the turbine is in operation and when it is stopped.

Following states have been used for evaluation in this report:

State 0: marks the data to be omitted in the evaluation,

State 0.5: depicts a stopped turbine,

State 1: depicts a turbine in operation.

Remark Nr. 1: This measurement was performed using a secondary wind shield. The attenuation effect of this wind shield was corrected by use of the measured coefficients for the secondary wind shield of type EWS-12A-01 which are shown in the annex.

In order to determine the wind speed at hub height during noise measurement of the turbine the allowed range of the power curve is taken into account based of the following equation:

$$(P_{k+1} - P_{tol}) - (P_k + P_{tol}) > 0 \quad (1)$$

where

k is the wind speed bin number of the power curve;

P_k is the power curve value at wind speed bin k;

P_{k+1} is the power curve value above wind speed bin k;

P_{tol} is the tolerance on the power reading, in this case it is 1 % of the maximum power.

All data points which exceed or are below these limitations are determined with the nacelle anemometer and the wind speed from the power curve using the following relation:

$$V_{\mathrm{nac,n}} = \kappa_{nac} \cdot V_{\mathrm{nac,m}} \quad (2)$$

where

$V_{\mathrm{nac,n}}$ is the normalised wind speed from the nacelle anemometer, corrected to hub height;

$V_{\mathrm{nac,m}}$ is the wind speed measured with the nacelle anemometer.

Outside the allowed range of the power curve the normalised WS at hub height is $V_{H,n} = V_{nac,n}$.

For this measurement κ_{nac} is determined to be $\kappa_{\mathrm{nac}} = 1.05$.

For background noise measurements the wind speed is measured at hub height, corrected to a height of 10 m and furthermore multiplied by another κ_Z factor to calculate the normalised wind speed.

$$V_{\mathrm{B,n}} = \kappa_{\mathrm{Z}} \cdot V_{\mathrm{Z,m}} \quad (3)$$

where

$V_{Z,m}$ is the wind speed measured with an anemometer at height Z of at least 10 m;

$V_{B,n}$ is the normalised wind speed at hub height.

During background noise measurements: $V_{H,n} = V_{B,n}$.

For this measurement κ_Z is determined to be $\kappa_Z = 1.51$.

Besides the equivalent noise level, a 1/3-octave spectrum with centre frequencies between 20 Hz and 10 kHz is calculated from the recorded WAV files and later on is used for the evaluation of the equivalent noise level $L_{Aeq,o,j}$.

$$L_{\mathrm{Aeq,o,j}} = 10 \cdot \log \sum_{i=1}^{28} 10^{\left(\frac{L_{\mathrm{Aeq,i,j}}}{10}\right)} \tag{4}$$

$$\Delta_j = L_{\mathrm{Aeq,j}} - L_{\mathrm{Aeq,o,j}} \tag{5}$$

The difference Δ_j between the noise level and the sum of the 1/3-octave band spectrum is added to each individual band $L_{\mathrm{Aeq,n,i,j}}$ in the 1/3-octave band spectrum for each measurement period j.

$$L_{\mathrm{Aeq,n,i,j}} = L_{\mathrm{Aeq,i,j}} + \Delta_j \tag{6}$$

4.3 Sound power level

In accordance to /1/ the corrected sound pressure level for the 1/3-octave band i is the energetic difference between the total noise level and the background noise level expressed as:

$$L_{\mathrm{V,c,i,k}} = 10 \cdot \log\left(10^{0.1 \cdot L_{\mathrm{V,T,i,k}}} - 10^{0.1 \cdot L_{\mathrm{V,B,i,k}}}\right) \tag{7}$$

The corresponding sound power level $L_{WA,i,k}$ is calculated from the background corrected sound pressure level for the same 1/3-octave band as follows:

$$L_{\mathrm{WA,i,k}} = L_{\mathrm{V,c,i,k}} - 6 + 10 \cdot \lg\left(\frac{4 \cdot \pi \cdot R_1^2}{S_0}\right) \tag{8}$$

where 6 dB is the correction due to the doubled sound pressure sensed by the microphone caused by the coherent interference at the acoustically hard board.

$10 \cdot \lg\left(\frac{4 \cdot \pi \cdot R_1^2}{S_0}\right)$ corresponds to the ratio in dB of the surface area of a sphere having the radius R_1 to the reference surface area of S_0

where
$S_0 = 1\ m^2$

$$R_1 = \sqrt{(R_0 + d)^2 + (H - h_A)^2} \tag{9}$$

The total sound power level $L_{WA,k}$ of the turbine in dB in wind speed bin k is derived by energy summing all the 1/3-octave band sound power levels:

$$L_{\mathrm{WA,k}} = 10 \cdot \log \sum_{i=1}^{28} 10^{\left(\frac{L_{\mathrm{WA,i,k}}}{10}\right)} \qquad (10)$$

The difference between the sum of the 1/3-octave bands of the total noise and the sum of the 1/3-octave band of the background noise has to be at least 3 dB. Otherwise the result shall not be reported. If the difference is larger than 3 dB and smaller than 6 dB the result shall be marked with an asterisk.

The following results are given in the annex:

- A plot of $L_{T,c,I,k}$ and $L_{v,B,I,k}$ against wind speed;
- A plot of L_{Aeq} against power;
- A plot of rotor speed against power;
- A plot of met mast wind speed against wind speed from power curve;
- A plot of nacelle wind speed against wind speed from power curve;
- A time plot of the measurement.

For the Senvion MM92 in the present configuration the apparent sound power levels are given in Table 6-1.

4.4 Tonal and frequency analysis

In accordance with the international standard /1/ a tonal analysis is carried out. The frequency spectrum of the noise measured on the acoustically hard board is determined on the basis of a narrow band analysis. This analysis is performed after the measurements using the recorded audio signal.

The results of the tonal analysis of the Senvion MM92 according to /1/ are given in Table 6-1.

4.5 One-third octave analysis

The A-weighted sound spectra at all the wind speed bins are given in the annex.

4.6 Uncertainties

4.6.1 Type B uncertainties

For these measurements all the type B measurement uncertainty components as specified in the international standard /1/ are given in Table 4-1. For all of the type B uncertainties mentioned here, a rectangular distribution of possible values is assumed for simplicity with a range described as "±a". The standard deviation for such a distribution is

$$U = \frac{a}{\sqrt{3}} \qquad (11)$$

Table 4-1 Type B measurement uncertainty components

Parameter	Value
Calibration, U_{B1}	0.2 dB
Instruments, U_{B2}	Taken from calibration certificates
Board, U_{B3}	0.3 dB
Wind screen insertion loss, U_{B4}	Depending on the frequency
Distance and direction of microphone, U_{B5}	0.1 dB
Air absorption, U_{B6}	Usually no uncertainty assumption
Weather, U_{B7}	0.5 dB
Wind speed (measured), U_{B8} [1)]	0.7 m/s
Wind speed (derived), U_{B8} [2)]	0.2 m/s
Wind speed from power curve, U_{B9}	0.2 m/s

1) through nacelle anemometer or met mast
2) through power curve

4.6.2 Uncertainty on the wind speed

Before calculating the sound power level uncertainty the uncertainty on the average wind speed per bin needs to be considered. Specifications are given in the international standard /1/.

The values per bin shall be averaged arithmetically as:

$$\overline{V}_k = \frac{1}{N} \cdot \sum_{j=1}^{N} V_{j,k} \tag{12}$$

where

N is the number of measurements in wind speed bin k;

$V_{j,k}$ is the average value of the wind speed at measurement period j in wind speed bin k.

The type A uncertainty on the average wind speed in the k-th bin is calculated as:

$$s_{V,\mathrm{k}} = \sqrt{\frac{\sum_{j=1}^{N} \left(V_{\mathrm{j,k}} - \overline{V}_k\right)^2}{N \cdot (N-1)}} \tag{13}$$

where

$V_{j,k}$ is the average value of the wind speed at measurement period j;

$\overline{V}_k$ is the average wind speed in the wind-speed bin k.

The type B uncertainty on the wind speed u_{V_j} for each measurement period j is calculated as:

$$u_{V_\mathrm{j}} = \sqrt{\sum_{q=8}^{9} u_{V_{j,q}}^2} \tag{14}$$

where

$u_{V_{j,q}}$ is the type B uncertainty due to the source q on the average wind speed for each measurement period j.

Information about the sources are given in Table 4-1.

The type B uncertainty $u_{V,\mathrm{k}}$ on the average wind speed bin k is calculated as:

$$u_{V,\mathrm{k}} = \sqrt{\frac{1}{N} \cdot \sum_{j=1}^{N} u_{V_j}^2} \tag{15}$$

The combined uncertainty $u_{com,V,k}$ can be expressed as:

$$u_{com,V,k} = \sqrt{s_{V,k}^2 + u_{V,k}^2} \tag{16}$$

4.6.3 Uncertainty on the average sound spectra

For each 1/3-octave band i the average sound pressure level is energetically averaged as:

$$\overline{L_{i,k}} = 10 \cdot \log\left[\frac{1}{N} \cdot \sum_{j=1}^{N} 10^{\left(\frac{L_{\mathrm{i,j,k}}}{10}\right)}\right] \tag{17}$$

where

N is the number of measurements in the wind speed bin k;

$L_{i,j,k}$ is the und pressure level of the 1/3-octave band i in the measurement period j and in wind speed bin k.

The type A uncertainty on the uncertainty on the sound pressure level measured in the wind-speed bin k is calculated as:

$$s_{\mathrm{L_{i,k}}} = \sqrt{\frac{\sum_{j=1}^{N}\left(L_{\mathrm{i,j,k}} - \bar{L}_{i,k}\right)^2}{N \cdot (N-1)}} \tag{18}$$

where

$\bar{L}_{i,k}$ is the average sound pressure spectrum in the wind speed bin k

The type B uncertainty on the energy averaged sound pressure level of the i-th 1/3-octave band for each measurement period j is calculated as:

$$u_{L_{i,j}} = \sqrt{\sum_{q=1}^{7} u_{L_{i,j,q}}^2} \tag{19}$$

where

$u_{L_{i,j,q}}$ is the type B uncertainty from source q on the average sound pressure level of the 1/3-octave band for each measurement period j.

The type B uncertainty on the average sound pressure level of the 1/3-octave band i in wind speed bin k is calculated as:

$$u_{L_{i,k}} = \sqrt{\frac{1}{N} \cdot \sum_{j=1}^{N} u_{L_{i,j,k}}^2} = u_{L_{i,j,k}} \tag{20}$$

The combined uncertainty can be expressed as:

$$u_{com,L_{i,k}} = \sqrt{s_{L_{i,k}}^2 + u_{L_{i,k}}^2} \tag{21}$$

4.6.4 Uncertainty on the noise levels at bin centres

The sound pressure level for both total noise and background noise at bin centre is calculated at each 1/3- octave band i and at every bin centre of the wind speed k. Using linear interpolation the estimated sound pressure level at wind speed v is given as:

$$L_{\mathrm{V}}(t) = (1-t) \cdot \bar{L}_k + t \cdot \bar{L}_{k+1} \tag{22}$$

Where $\bar{V}_k \leq V < \bar{V}_{k+1}$

The t value at a certain wind speed v is given as:

$$t = \frac{(V - \bar{V}_k)}{(\bar{V}_{k+1} - \bar{V}_k)} \tag{23}$$

To fulfil an entire statistical evaluation according to the /1/ a corresponding covariance is calculated as:

$$\mathrm{cov}_{L_{V,i,k}} = \frac{1}{N-1} \cdot \sum_{j=1}^{N} (V_{j,k} - \bar{V}_k) \cdot (L_{i,j,k} - \bar{L}_{i,k}) \tag{24}$$

The corresponding covariance is used to calculate the uncertainty on the sound pressure level at the wind-speed bin centre v by using:

$$u_{L_{\mathrm{V}}}(t) = \sqrt{u_L^2(t) - \frac{\mathrm{cov}_{LV}^2(t)}{u_V^2(t)}} \tag{25}$$

where

$$u_L^2(t) = (1-t)^2 \cdot u_{com,L,k}^2 + t^2 \cdot u_{com,L,k+1}^2$$

$$u_v^2(t) = (1-t)^2 \cdot u_{com,V,k}^2 + t^2 \cdot u_{com,V,k+1}^2$$

$$\mathrm{cov}_{LV}(t) = (1-t)^2 \cdot \frac{\mathrm{cov}_{LV,k}}{N_k} + t^2 \cdot \frac{\mathrm{cov}_{LV,k+1}}{N_{k+1}}$$

N_k is the number of measurements in the wind speed bin k.

4.6.5 Uncertainty on the total noise level

If the difference between the total noise level and the background level is higher than 3 dB in the same 1/3- octave band i, the standard deviation of the background-corrected sound-pressure-levels is calculated as follows:

$$u_{\mathrm{c,i,k}} = \frac{\sqrt{(u_{L_{\mathrm{V}},\mathrm{T,i}} \cdot 10^{0.1 \cdot L_{\mathrm{V,T,i}}})^2 + (u_{L_{\mathrm{V}},\mathrm{B,i}} \cdot 10^{0.1 \cdot L_{\mathrm{v,B,i}}})^2}}{10^{0.1 \cdot L_{\mathrm{V,T,i}}} - 10^{0.1 \cdot L_{\mathrm{V,B,i}}}} \tag{26}$$

If the difference between the total noise level and the background level is less than 3 dB in the same 1/3- octave band i, a 3 dB correction is applied and the result is marked with brackets [ ]. The corresponding uncertainty is then calculated, as if the background noise level is 3 dB smaller than the total noise level $L_{V,B,i} = L_{V,T,i} - 3$ dB:

$$u_{c,i,k} = \frac{\sqrt{(u_{L_{V,T,i}} \cdot 10^{0.1 \cdot L_{V,T,i}})^2 + (u_{L_{V,B,i}} \cdot 10^{0.1 \cdot L_{V,T,i} - 3})^2}}{10^{0.1 \cdot L_{V,T,i}} - 10^{0.1 \cdot (L_{V,T,i} - 3)}} \tag{27}$$

4.6.6 Sound power level

The result of the sound power level measurement is subject to uncertainties which are due to the environment, meteorological conditions and the measurement system as calculated is the previous chapters.

There is the assumption all 1/3-octave bands are correlated. Therefore the uncertainty of the sound power level can be expressed as:

$$u_{L_{WA,k}} = \frac{\sum_{i=1}^{28} \left(u_{c,i,k} \cdot 10^{(0.1 \cdot L_{WA,i,k})} \right)}{\sum_{i=1}^{28} 10^{(0.1 \cdot L_{WA,i,k})}} \tag{28}$$

The result of $u_{L_{WA,k}}$ will be shown in the annex.

4.6.7 Uncertainty on the tonality analysis

The uncertainty in the tonality is given in the annex for all the given tones.

5 DEVIATIONS

There are following deviations to the standard:

- The power signal was not measured according to the standard /1/. This signal was taken from the controller of the turbine as provided by the manufacturer.
- The manufacturer did not provide a pitch-angle signal during the measurements.

6 CONCLUSIONS

As ordered by Gunn's Hill LP GL, Garrad Hassan Deutschland GmbH took measurements of the acoustic noise emissions on the WTGS Senvion MM92 with a hub height of 100 m.

All measurements and analysis of the sound power level and tonality described in this report based on the international standard /1/. The analysis of the sound power level was carried out using the standardised wind speed which was derived from the calculated power curve provided by the customer (see annex).

The result of this measurement is given in Table 6-1. For detailed results please refer to the annex.

For the measured turbine in 1880 kW the relevant wind range according to /1/ is between 7.8 m/s and 12.6 m/s.

Table 6-1 Summary of results at hub height

WS at hub height [m/s]	SPL $L_{WA,k}$ [dB]	Combined uncertainty in the SPL $U_{C,L,WA,k}$ [dB]	Measured rotor speed [min^{-1}]	Tonal audibility $\Delta L_{a,k}$ [dB]	Frequency of the most prevalent tone [Hz]	Relevant tone?
8.0	100.6	1.0	14.0	-4.94	149	No
8.5	101.1	1.0	14.2	-5.36	75	No
9.0	101.5	1.0	14.2	-2.55	75	No
9.5	101.7	1.0	14.2	5.69	145	No
10.0	101.8	1.0	14.2	-1.91	131	No
10.5	101.8	1.4	14.2	-3.51	141	No
11.0	101.9	1.5	14.2	-3.70	272	No
11.5	101.9	1.9	14.2	8.44	148	No
12.0	102.4	1.9	14.2	-0.32	270	No
12.5	102.3	1.9	14.2	-5.88	151	No

Table 6-2 Summary of results at 10 m height

WS at 10 m height [m/s]	SPL $L_{WA,10m,k}$ [dB]	Combined uncertainty in the SPL $U_{C,L,WA,10m,k}$ [dB]
5	99.1	2.2
6	101.1	1.0
7	101.8	1.1
8	102.1	1.9
9	102.4	1.8

The results of the measurement confirm that the Senvion MM92 turbine with serial number 93626 and park internal id. T4 does not exceed the value of the maximum sound power level, including the 0.5 dB tolerance, shown in the Compliance Protocol of the Ministry of the Environment and Climate Change of Ontario (MOECC 2017). The measured maximum sound power level is 102.4 dB.

The tonality analysis has been performed in accordance to /1/. No relevant tone has been found.

It is assured that this report has been drawn up impartially and with best knowledge and conscience.

7 REFERENCES

/1/ IEC 61400-11 Ed. 3.0 Wind Turbines,
Part 11: Acoustic Noise Measurement Techniques
2012-11-07

/2/ ISI-RA-MEA-4601
Noise emission measurements on wind turbines – one third octave level method
2017-03-01
This document is part of the management system of the GL Garrad Hassan Deutschland GmbH. It is possible to view this document at GH-D.

/3/ ISI-RA-MEA-2501
Calibration Programs
2017-05-12
This document is part of the quality management documentation of the GL Garrad Hassan Deutschland GmbH. It is possible to view this document at GH-D.

8 LIST OF ABBREVIATIONS

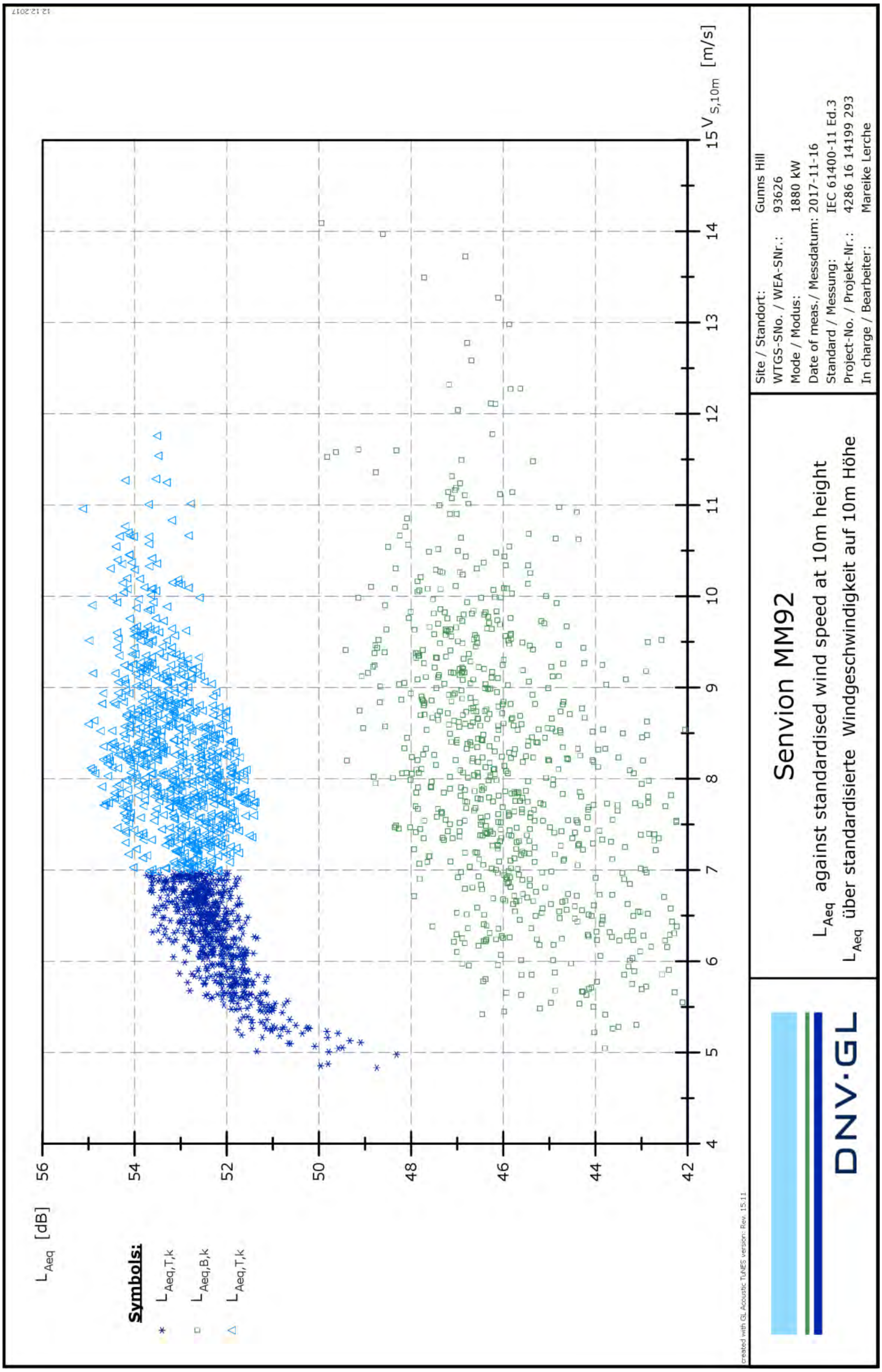
Abbreviation	Description	Unit
d	distance from rotor centre to tower axis	[m]
D	rotor diameter	[m]
H	height of rotor centre above local ground near the wind turbine	[m]
L_A or L_C	A or C-weighted sound pressure level	[dB]
L_{Aeq}	equivalent continuous A-weighted sound pressure level	[dB]
$L_{pn,j,k}$	sound pressure level of masking noise within a critical band in the 'j th' spectrum at the 'k th' wind speed bin	[dB]
$L_{pn,avg,j,k}$	average of analysis bandwidth sound pressure levels of masking noise in the 'j th' spectra at the 'k th' wind speed bin	[dB]
$L_{pt,j,k}$	sound pressure level of the tone or tones in the 'j th' spectra at the 'k th' wind speed bin	[dB]
$L_{WA,k}$	apparent sound power level, where k is a wind speed centre value	[dB]
log	logarithm to base 10	
P_m	measured electric power	[kW]
P_n	normalised electric power	[kW]
P_k	power curve value at wind bin k	[kW]
P_{tol}	tolerance of the power reading	[kW]
R_0	reference distance	[m]
R_1	slant distance from rotor centre to actual measurement position	[m]
S_0	reference area, S_0 = 1 m^2	[m]
SPL	sound power level	[dB]
T_C	air temperature	[°C]
T_K	absolute air temperature	[K]
u_A	Uncertainty components of Type A	[dB]
u_B	Uncertainty components of Type B	[dB]
$V_{H,n}$	normalised wind speed at hub height H	[m/s]
$V_{P,n}$	normalised wind speed derived from power curve	[m/s]
V_z	wind speed at height z	[m/s]
$V_{nac,m}$	measured wind speed from nacelle anemometer	[m/s]
$V_{nac,n}$	normalised wind speed from nacelle anemometer	[m/s]
f	frequency of the tone	[Hz]
f_c	centre frequency of critical band	[Hz]
p	atmospheric pressure	[kPa]
z_0	roughness length	[m]
z_{0ref}	reference roughness length, 0.05 m	[m]
z	anemometer height	[m]
κ	Ratio between normalised wind speed and measured wind speed	[-]
$\Delta L_{tn,j,k}$	tonality of the 'j th' spectrum at 'k th' wind speed	[dB]
Φ	inclination angle	[°]
$V_{Z,m}$	is the measured wind speed with an anemometer at height Z of at least 10 m	[m/s]
$V_{B,n}$	is the normalised wind speed at hub height	[m/s]

Description of the subscripts and indexes of the formulas

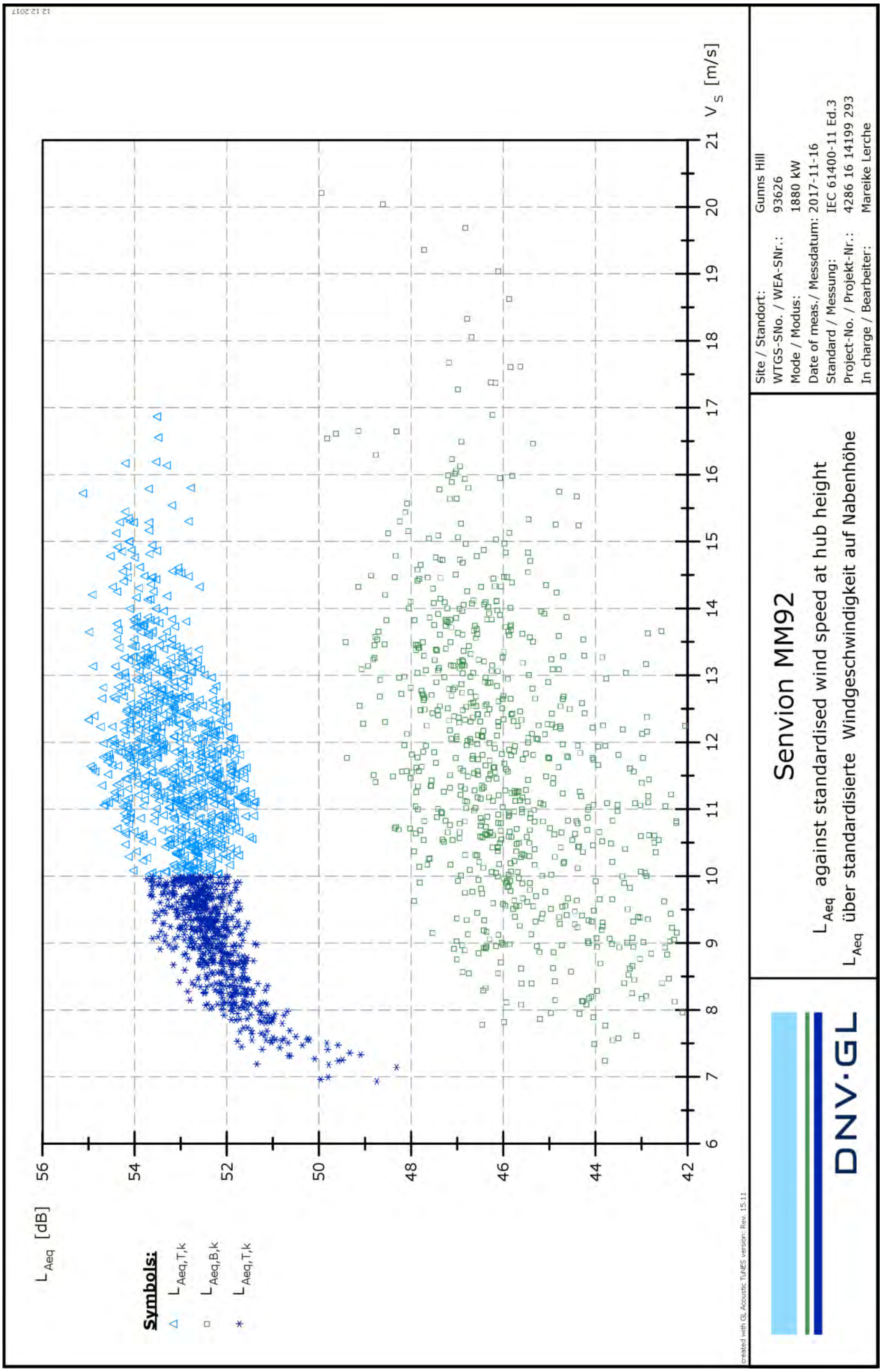
i	1/3 octave band number (e.g. i = 1 for 20 Hz centre frequency, i = 2 for 25 Hz centre frequency, ... , i = 28 for 10 kHz centre frequency)
j	10 s measurement period number (each bin should have the minimum of 10 points per bin therefore j = 1 to 10 or greater)
k	wind speed bin (i.e. k = 6 m/s bin, k = 6,5 m/s bin, k = 7 m/s bin, etc.)
V	bin centre value; of measured 1/3 octave spectrum
n	normalized spectrum
N	number of measurements in wind speed k
T	total noise
B	background noise
C	background corrected total noise

9 APPENDIX

9.1 L_{Aeq} vs. wind speed at 10 m height



9.2 L_{Aeq} vs. wind speed at hub height



9.3 Summary of analysis input and results

Parameters of evaluation / Auswerteparameter:

H = 100 m	d = 3.15 m	h_A = 0.0 m	$P_{85\%}$ = 1.598 MW	$V_{(85\%)}$ * 0.8 = 7.8 m/s	$state_{total\ noise}$ = 1.0
D = 92.5 m	z_0 = 0.05 m	R_0 = 144 m	$V_{(85\%)}$ = 9.7 m/s	$V_{(85\%)}$ * 1.3 = 12.6 m/s	$state_{background\ noise}$ = 0.5

Measurement conditions / Messbedingungen:

Temperature / Temperatur = min. 0.5°C, max. 5.1°C

Air pressure / Luftdruck = min. 973.0 hPa, max. 981.0 hPa

Range of the wind direction / Windrichtungsbereich = 212.1° - 281.8°

Results / Ergebnisse:

k_{nac} = 1.05

k_z = 1.51

Remark: Table 1 shows results for a calculated hub height of H_{calc} = 100 m

$V_{z,k}$ [m/s]	$L_{V,T,k}$ [dB]	$L_{V,B,k}$ [dB]	$L_{V,C,k}$ [dB]	$L_{WA,k}$ [dB]	$U_{C,LWA,k}$ [dB]	operation noise [no.]	background noise [no.]
5.0	50.4	44.4	49.1	**99.1**	2.2	58	9
6.0	52.0	44.8	51.1	**101.1**	1.0	334	90
7.0	52.7	45.7	51.8	**101.8**	1.1	414	160
8.0	53.1	46.1	52.1	**102.1**	1.9	359	189
9.0	53.4	46.7	52.4	**102.4**	1.8	200	162

Table 1: results L = f (V_Z) / Tabelle 1: Ergebnisse L = f (V_Z), z = 10 m

$V_{H,k}$ [m/s]	$L_{V,T,k}$ [dB]	$L_{V,B,k}$ [dB]	$L_{V,C,k}$ [dB]	$L_{WA,k}$ [dB]	$U_{C,LWA,k}$ [dB]	operation noise [no.]	background noise [no.]
8.0	51.6	44.5	50.6	**100.6**	1.0	75	19
8.5	52.0	44.9	51.1	**101.1**	1.0	106	22
9.0	52.4	45.1	51.5	**101.5**	1.0	147	46
9.5	52.6	45.1	51.8	**101.7**	1.0	189	47
10.0	52.8	45.7	51.8	**101.8**	1.0	144	47
10.5	52.8	46.0	51.8	**101.8**	1.4	101	72
11.0	52.9	45.7	51.9	**101.9**	1.5	125	71
11.5	53.0	46.5	51.9	**101.9**	1.9	124	63
12.0	53.3	46.0	52.4	**102.4**	1.9	120	64
12.5	53.3	46.6	52.3	**102.3**	1.9	94	66

Table 2: results L = f (V_H) / Tabelle 2: Ergebnisse L = f (V_H)

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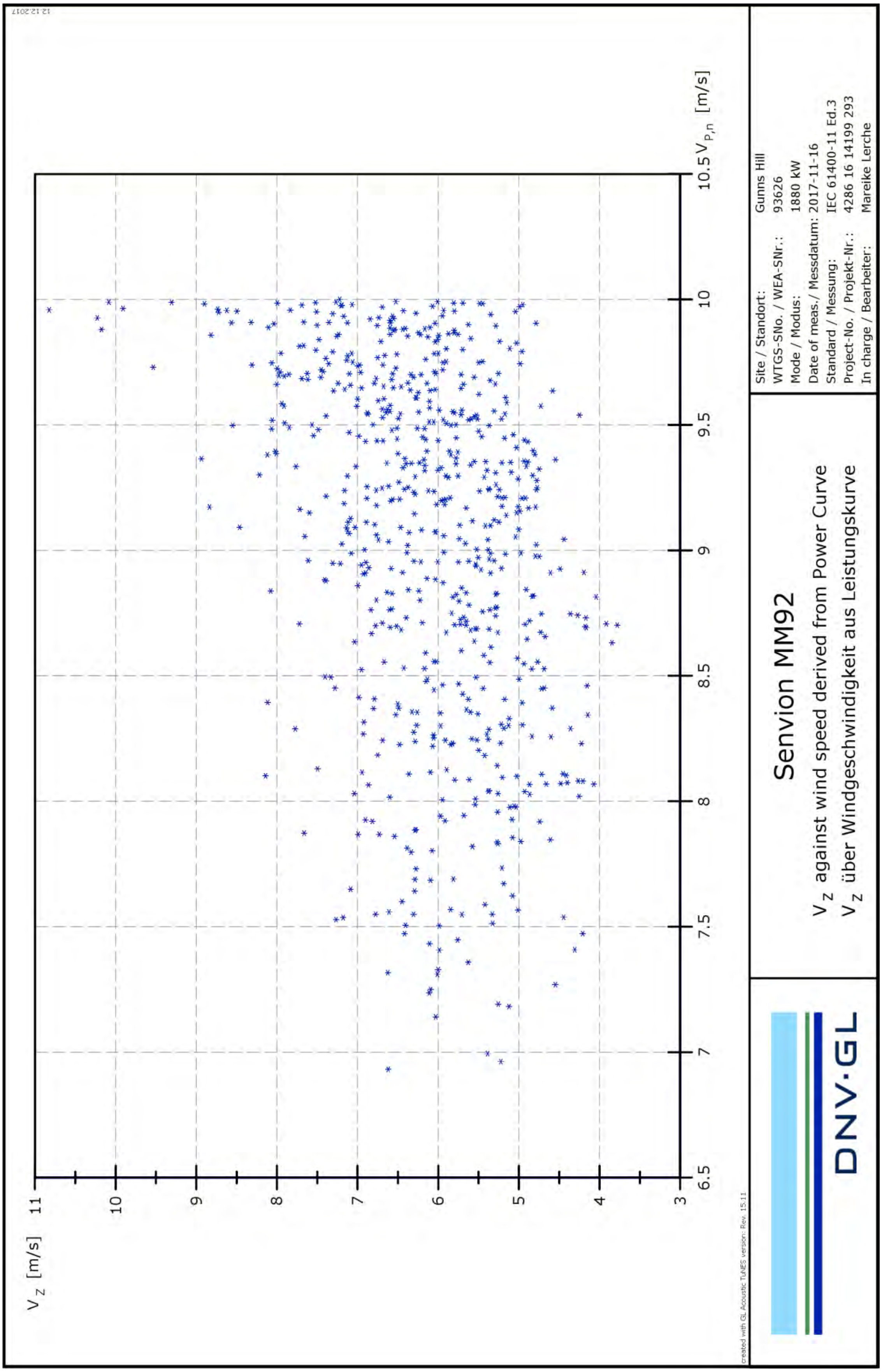
Senvion MM92

Results

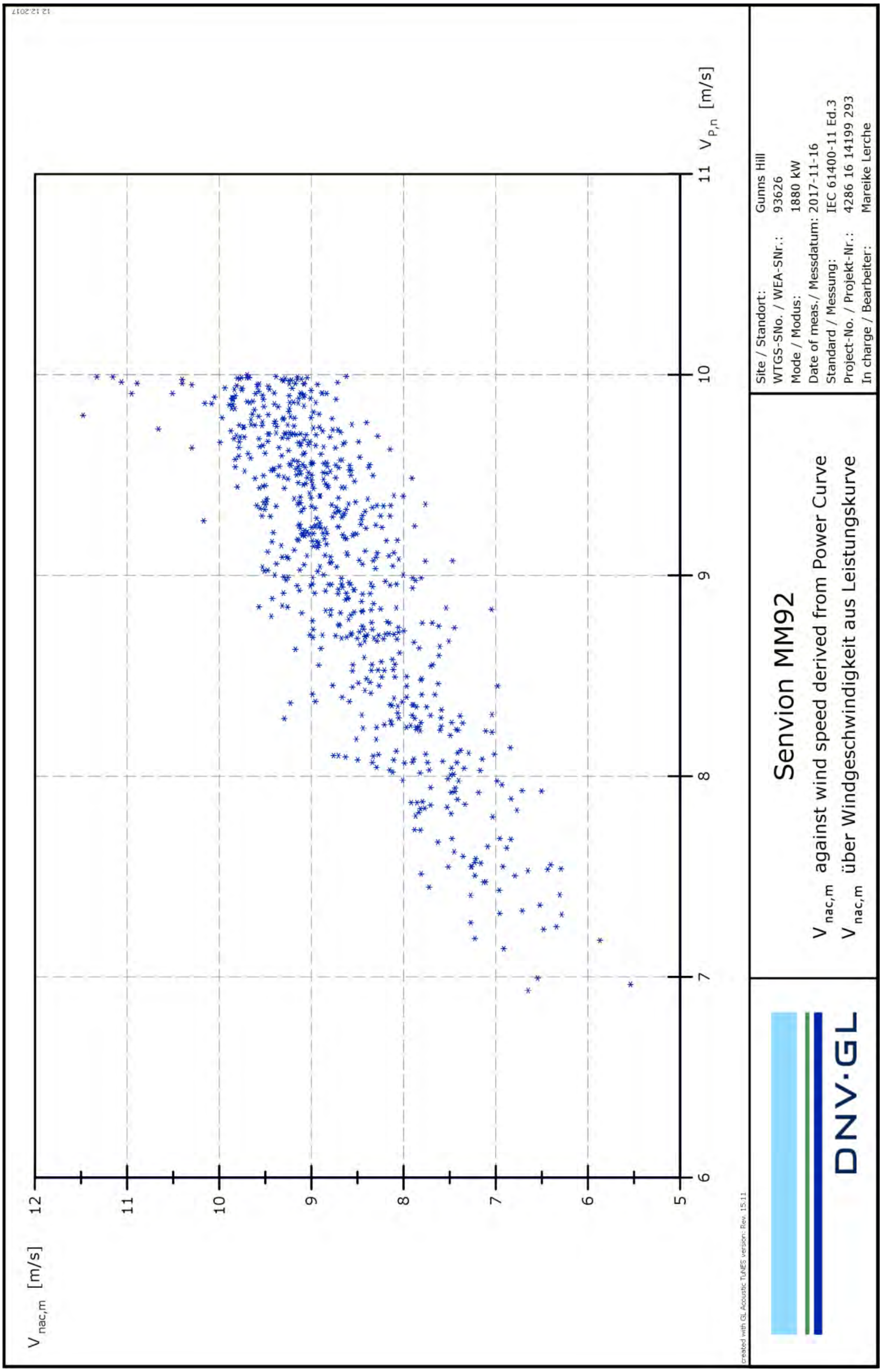
Ergebnisse

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

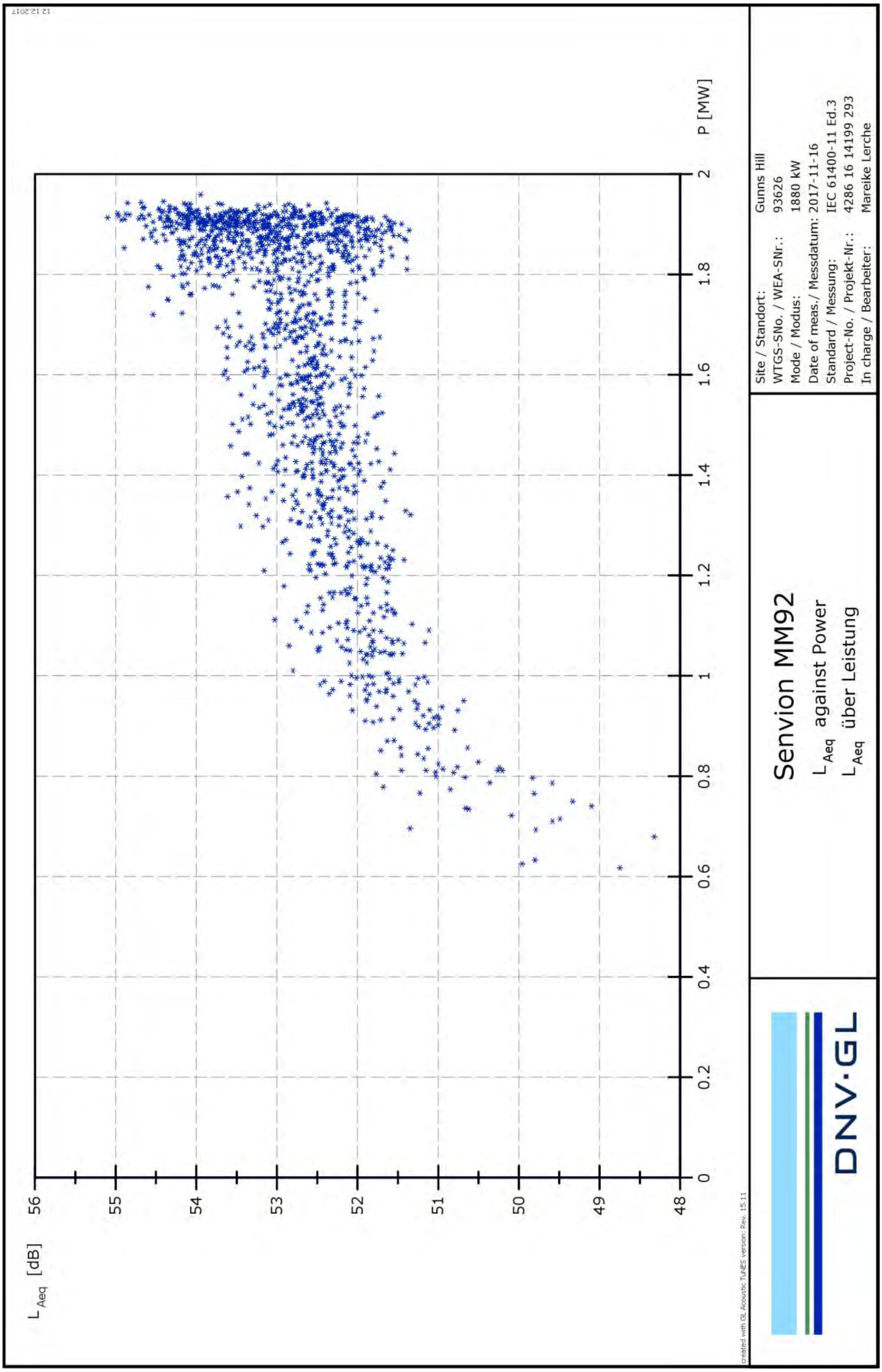
9.4 Measured wind speed from met mast vs. wind speed from power curve



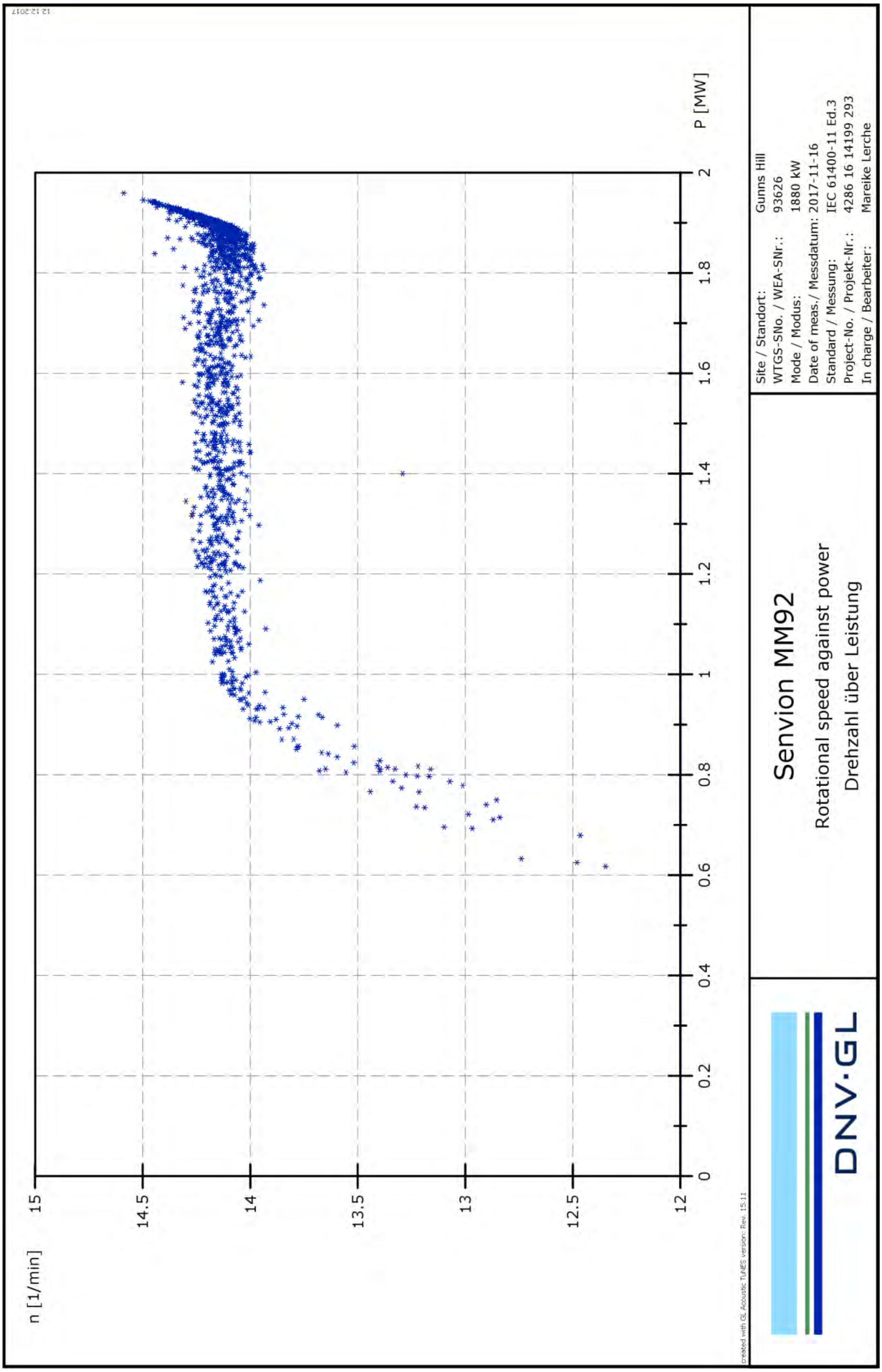
9.5 Measured wind speed from nacelle anemometer vs. wind speed from power curve



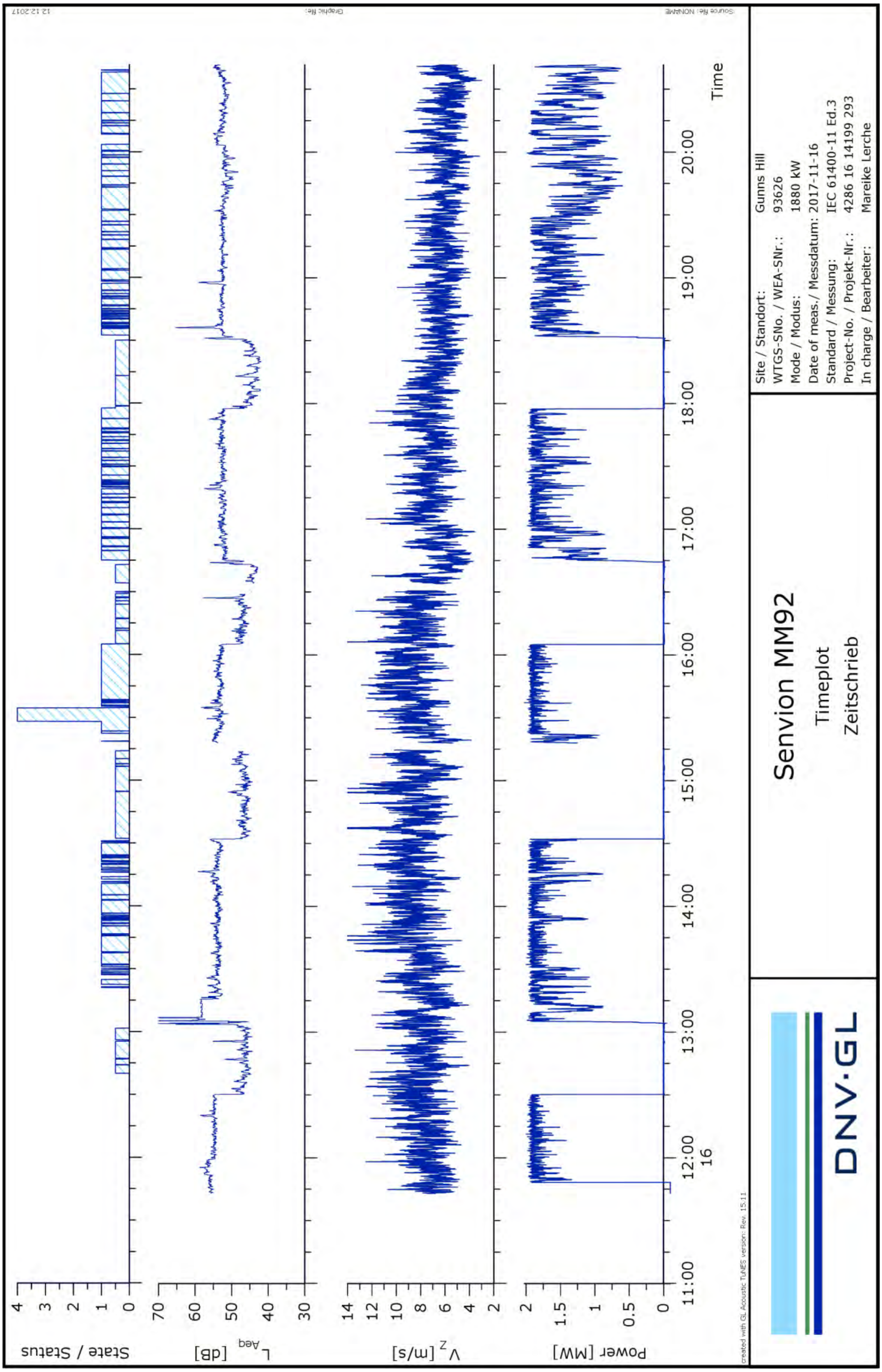
9.6 L_{Aeq} vs. active power



9.7 Rotor speed vs. active power



9.8 Time plot of measurement



9.10 Third-octave sound power spectra at a WS of 8.0 m/s at hub height

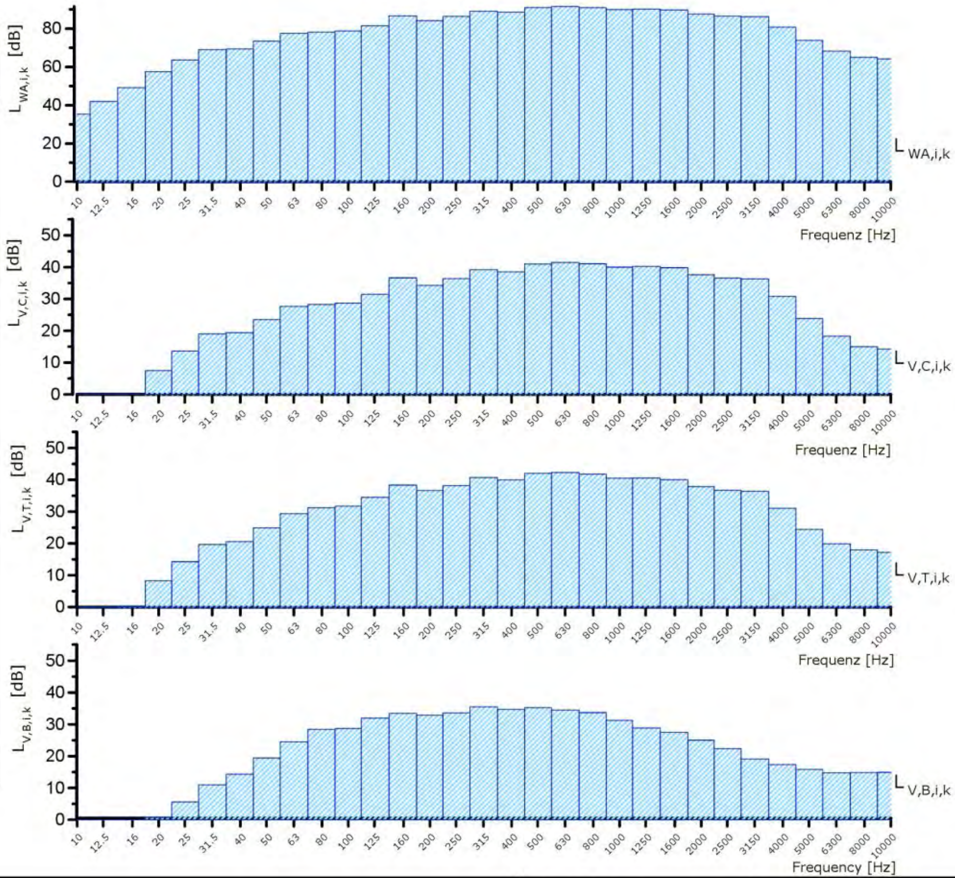
Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 100.6 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.00 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 8 m/s

12.12.2017

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	35.4	-14.6	-13.8	-21.2	2.5	-
12.5	41.9	-8.1	-7.2	-14.6	2.1	-
16	49.3	-0.7	0.3	-6.3	2.2	58.2
20	57.5	7.5	8.3	0.8	1.7	-
25	63.6	13.6	14.3	5.6	1.3	-
31.5	69.0	19.1	19.7	11.0	1.3	72.8
40	69.4	19.4	20.6	14.4	1.8	-
50	73.5	23.5	24.9	19.5	1.8	-
63	77.6	27.6	29.3	24.5	2.1	81.6
80	78.2	[28.2]	31.2	28.4	3.0	-
100	78.7	[28.7]	31.7	28.7	2.5	-
125	81.5	[31.5]	34.5	32.0	2.6	88.3
160	86.6	36.6	38.3	33.4	1.4	-
200	84.3	34.3	36.6	32.9	2.0	-
250	86.4	36.4	38.2	33.6	1.7	91.8
315	89.1	39.1	40.7	35.5	1.4	-
400	88.5	38.5	40.0	34.6	1.4	-
500	91.0	41.0	42.0	35.2	1.0	95.3
630	91.5	41.5	42.3	34.5	0.8	-
800	91.0	41.0	41.8	33.7	0.7	-
1000	90.0	40.0	40.5	31.2	0.7	95.2
1250	90.2	40.2	40.5	28.8	0.6	-
1600	89.8	39.8	40.0	27.4	0.7	-
2000	87.6	37.6	37.9	25.0	0.7	93.0
2500	86.5	36.5	36.7	22.4	0.7	-
3150	86.3	36.3	36.4	19.1	1.1	-
4000	80.9	30.9	31.0	17.4	1.0	87.6
5000	73.8	23.8	24.5	15.8	0.9	-
6300	68.3	18.3	19.9	14.8	2.1	-
8000	65.0	15.0	17.9	14.8	4.3	71.0
10000	64.3	[14.3]	17.3	15.0	6.5	-
Σ	**100.6**	**50.6**	**51.6**	**44.5**		



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Bin 8 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

9.11 Third-octave sound power spectra at a WS of 8.5 m/s at hub height

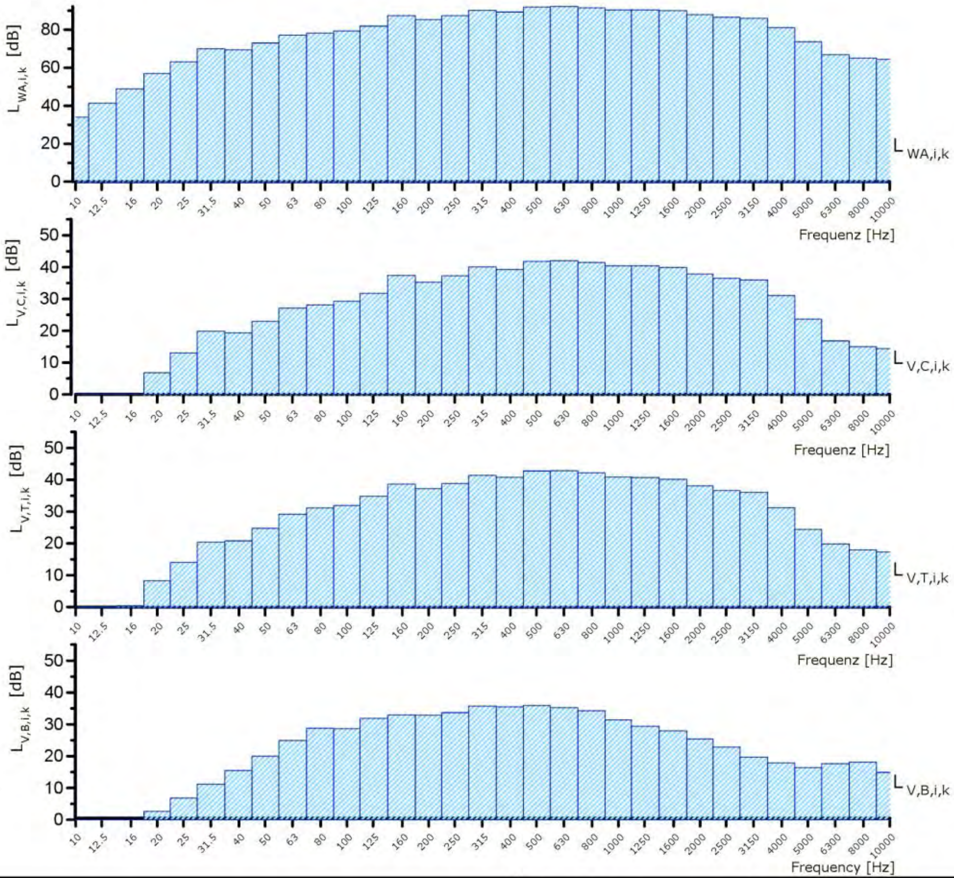
12.12.2017

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.1 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.02 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 8.5 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	33.8	-16.2	-13.5	-17.0	5.2	-
12.5	41.3	-8.7	-7.0	-11.7	3.3	-
16	48.8	-1.2	0.4	-4.7	2.7	57.6
20	56.9	6.9	8.3	2.7	2.1	-
25	63.1	13.1	14.0	6.9	1.4	-
31.5	69.9	19.9	20.4	11.2	1.1	73.1
40	69.3	19.3	20.8	15.5	2.0	-
50	73.0	23.0	24.8	20.0	2.2	-
63	77.1	27.1	29.2	25.0	2.2	81.4
80	78.2	[28.2]	31.2	28.8	2.9	-
100	79.3	29.3	32.0	28.6	2.2	-
125	81.8	[31.8]	34.8	31.9	2.3	88.9
160	87.3	37.3	38.7	32.9	1.2	-
200	85.2	35.2	37.2	32.9	1.7	-
250	87.3	37.3	38.9	33.7	1.6	92.7
315	90.0	40.0	41.4	35.7	1.4	-
400	89.2	39.2	40.8	35.5	1.5	-
500	91.8	41.8	42.8	35.9	1.0	96.0
630	92.1	42.1	42.9	35.2	0.9	-
800	91.4	41.4	42.2	34.3	0.8	-
1000	90.4	40.4	40.9	31.4	0.7	95.5
1250	90.4	40.4	40.7	29.4	0.6	-
1600	89.9	39.9	40.2	28.0	0.7	-
2000	87.8	37.8	38.1	25.4	0.7	93.1
2500	86.5	36.5	36.7	22.9	0.7	-
3150	86.0	36.0	36.1	19.6	1.1	-
4000	81.0	31.0	31.3	17.9	1.1	87.4
5000	73.7	23.7	24.4	16.4	1.1	-
6300	66.8	[16.8]	19.8	17.6	4.5	-
8000	65.0	[15.0]	18.0	18.1	5.6	70.3
10000	64.3	[14.3]	17.3	14.9	6.8	-
Σ	**101.1**	**51.1**	**52.0**	**44.9**		



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Bin 8.5 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

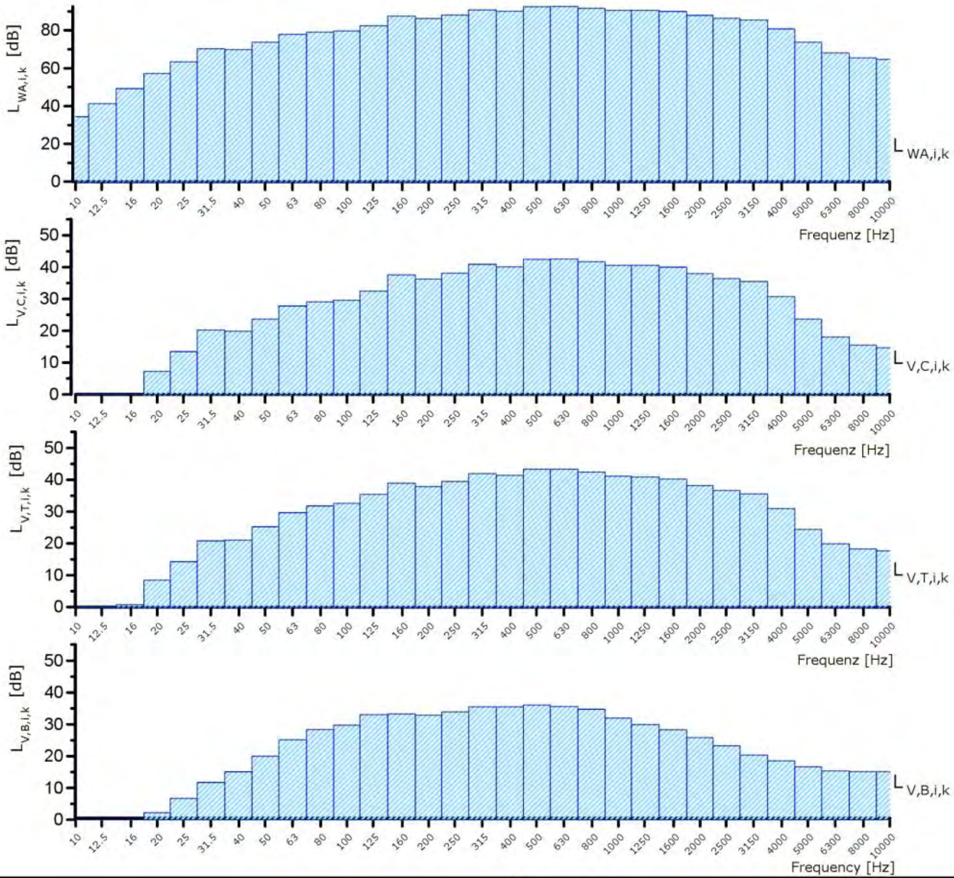
9.12 Third-octave sound power spectra at a WS of 9.0 m/s at hub height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.5 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.02 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 9 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	34.4	-15.6	-13.6	-17.8	3.3	-
12.5	41.2	-8.8	-6.9	-11.4	3.0	-
16	49.3	-0.7	0.7	-4.6	2.5	58.0
20	57.3	7.3	8.5	2.3	1.9	-
25	63.4	13.4	14.3	6.8	1.4	-
31.5	70.3	20.3	20.8	11.8	1.2	73.5
40	69.8	19.8	21.1	15.1	2.0	-
50	73.7	23.7	25.2	20.0	2.0	-
63	77.8	27.8	29.7	25.2	2.2	82.2
80	79.1	29.1	31.8	28.4	2.9	-
100	79.6	[29.6]	32.6	29.7	3.1	-
125	82.4	[32.4]	35.4	33.0	3.3	89.2
160	87.5	37.5	38.9	33.2	1.4	-
200	86.2	36.2	37.9	32.9	1.7	-
250	88.1	38.1	39.5	33.9	1.5	93.6
315	90.8	40.8	42.0	35.5	1.2	-
400	90.1	40.1	41.4	35.5	1.3	-
500	92.4	42.4	43.3	36.0	0.9	96.6
630	92.5	42.5	43.3	35.6	0.8	-
800	91.7	41.7	42.5	34.7	0.8	-
1000	90.5	40.6	41.1	31.9	0.7	95.7
1250	90.5	40.5	40.9	29.9	0.6	-
1600	90.0	40.0	40.3	28.3	0.7	-
2000	87.9	37.9	38.2	25.8	0.7	93.1
2500	86.4	36.4	36.6	23.3	0.9	-
3150	85.4	35.4	35.6	20.3	1.0	-
4000	80.7	30.7	30.9	18.5	1.1	86.9
5000	73.7	23.7	24.5	16.6	1.1	-
6300	68.0	18.0	19.9	15.4	2.5	-
8000	65.5	15.5	18.3	15.2	4.6	71.1
10000	64.7	[14.7]	17.7	15.2	6.8	-
Σ	101.5	51.5	52.4	45.1		



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Bin 9 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

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9.13 Third-octave sound power spectra at a WS of 9.5 m/s at hub height

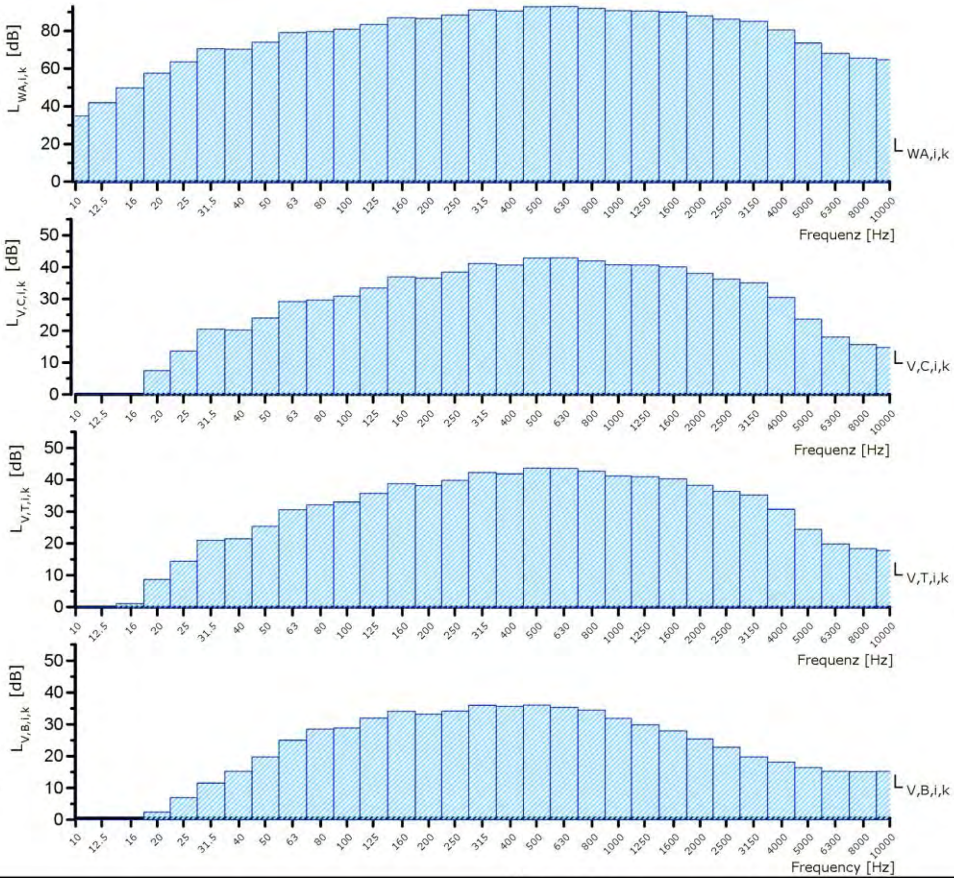
Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.7 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.00 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 9.5 m/s

12.12.2017

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	34.8	-15.1	-13.3	-17.8	3.2	-
12.5	42.0	-8.0	-6.4	-11.5	2.6	-
16	49.8	-0.2	1.1	-4.7	2.2	58.3
20	57.5	7.5	8.7	2.4	1.8	-
25	63.6	13.6	14.5	7.0	1.4	-
31.5	70.5	20.5	21.0	11.6	1.1	73.8
40	70.2	20.3	21.4	15.3	1.8	-
50	74.0	24.0	25.4	19.8	1.6	-
63	79.2	29.2	30.6	25.0	1.9	83.0
80	79.6	29.6	32.1	28.5	2.6	-
100	80.9	30.9	33.0	28.8	1.9	-
125	83.4	33.4	35.7	31.9	2.0	89.2
160	87.0	37.0	38.8	34.1	2.0	-
200	86.6	36.6	38.2	33.2	1.4	-
250	88.4	38.4	39.8	34.2	1.4	93.9
315	91.2	41.2	42.3	36.0	1.1	-
400	90.6	40.6	41.8	35.7	1.3	-
500	92.8	42.8	43.7	36.1	0.9	97.0
630	92.9	42.9	43.6	35.3	0.8	-
800	92.0	42.0	42.7	34.5	0.8	-
1000	90.7	40.7	41.2	31.9	0.7	95.9
1250	90.6	40.6	41.0	29.8	0.7	-
1600	90.0	40.0	40.3	28.0	0.7	-
2000	88.0	38.0	38.2	25.4	0.7	93.1
2500	86.2	36.2	36.4	22.8	0.8	-
3150	85.1	35.1	35.2	19.8	1.0	-
4000	80.5	30.5	30.8	18.2	1.1	86.6
5000	73.7	23.7	24.4	16.4	1.1	-
6300	68.0	18.0	19.9	15.3	2.6	-
8000	65.6	15.6	18.4	15.1	4.6	71.1
10000	64.8	[14.8]	17.8	15.3	6.9	-
Σ	**101.7**	**51.8**	**52.6**	**45.1**		



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DNV·GL

Bin 9.5 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

9.14 Third-octave sound power spectra at a WS of 10.0 m/s at hub height

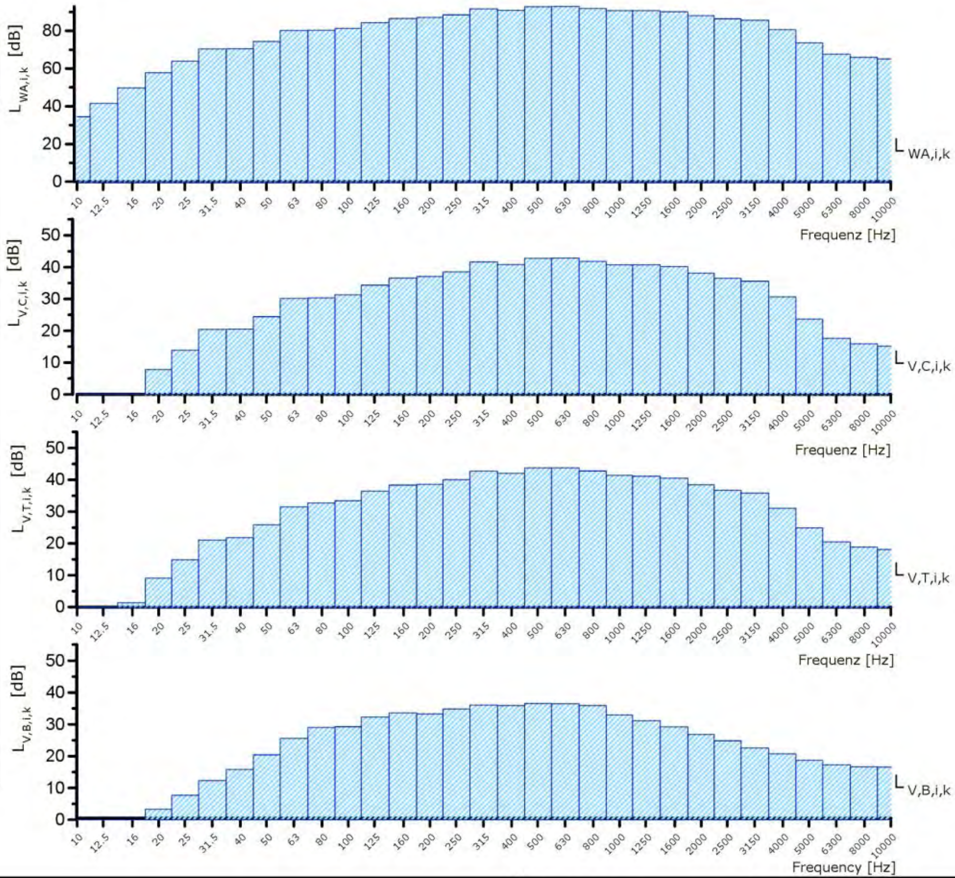
12.12.2017

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.8 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.04 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 10 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	34.4	[-15.6]	-12.6	-14.7	5.8	-
12.5	41.6	-8.4	-5.8	-9.3	4.2	-
16	49.7	-0.3	1.5	-3.4	2.7	58.5
20	57.8	7.8	9.1	3.3	1.9	-
25	63.9	13.9	14.8	7.7	1.5	-
31.5	70.4	20.4	21.1	12.3	1.2	73.9
40	70.5	20.5	21.8	15.8	1.6	-
50	74.4	24.4	25.9	20.4	1.6	-
63	80.1	30.1	31.4	25.6	1.7	83.8
80	80.3	30.3	32.7	29.0	2.5	-
100	81.3	31.3	33.4	29.3	1.9	-
125	84.3	34.3	36.4	32.3	2.3	89.3
160	86.6	36.6	38.3	33.6	1.5	-
200	87.0	37.0	38.6	33.3	1.4	-
250	88.5	38.5	40.1	34.8	1.5	94.2
315	91.6	41.6	42.6	36.0	1.2	-
400	90.8	40.8	42.0	35.9	1.2	-
500	92.8	42.8	43.7	36.6	0.9	97.0
630	92.8	42.8	43.7	36.5	0.9	-
800	91.8	41.8	42.8	35.9	0.9	-
1000	90.7	40.7	41.4	32.9	0.8	95.9
1250	90.7	40.7	41.2	31.1	0.7	-
1600	90.1	40.2	40.5	29.2	0.7	-
2000	88.1	38.1	38.4	26.8	0.7	93.3
2500	86.4	36.4	36.7	24.8	1.0	-
3150	85.6	35.6	35.8	22.5	1.3	-
4000	80.6	30.6	31.0	20.7	1.2	87.0
5000	73.7	23.7	24.9	18.7	1.7	-
6300	67.7	17.7	20.5	17.3	4.2	-
8000	65.9	[15.9]	18.9	16.7	5.3	71.1
10000	65.2	[15.2]	18.2	16.5	6.9	-
Σ	**101.8**	**51.8**	**52.8**	**45.7**		



created with GL Acoustic TuNES version: Rev. 15.11

DNV·GL

Bin 10 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

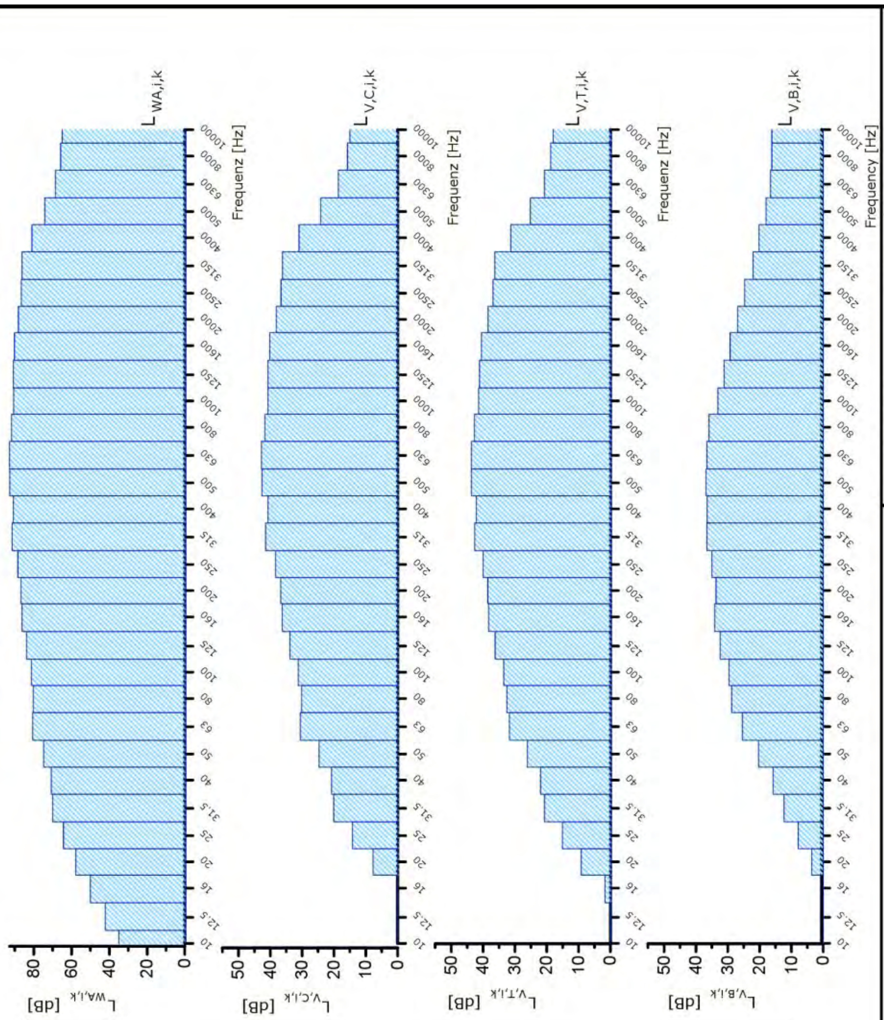
9.15 Third-octave sound power spectra at a WS of 10.5 m/s at hub height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.8 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.38 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 10.5 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	35.0	-15.0	-12.1	-15.3	5.5	-
12.5	42.1	-7.9	-5.4	-9.0	4.2	-
16	50.1	0.1	1.8	-3.2	2.7	58.5
20	57.7	7.8	9.2	3.6	2.0	-
25	64.2	14.2	15.1	7.9	1.5	-
31.5	70.1	20.1	20.7	12.3	1.4	73.9
40	70.8	20.8	22.0	15.8	1.8	-
50	74.7	24.7	26.0	20.3	1.8	-
63	80.6	30.6	31.7	25.4	1.8	83.9
80	80.2	30.2	32.6	28.8	2.4	-
100	81.3	31.3	33.5	29.6	2.3	-
125	83.9	33.9	36.2	32.3	2.4	89.0
160	86.2	36.2	38.3	34.0	1.9	-
200	86.7	36.7	38.5	33.7	1.9	-
250	88.4	38.4	40.0	35.0	2.0	94.1
315	91.4	41.4	42.6	36.5	1.8	-
400	90.7	40.7	42.1	36.5	2.1	-
500	92.6	42.6	43.6	36.8	1.3	96.9
630	92.7	42.7	43.7	36.5	1.2	-
800	91.7	41.7	42.7	35.8	1.1	-
1000	90.7	40.7	41.4	33.1	0.9	95.8
1250	90.7	40.7	41.2	31.2	0.8	-
1600	90.1	40.1	40.5	29.2	0.8	-
2000	88.1	38.1	38.4	26.9	0.8	93.3
2500	86.6	36.6	36.9	24.7	1.2	-
3150	86.1	36.1	36.3	22.1	1.6	-
4000	81.0	31.0	31.3	20.2	1.4	87.5
5000	74.2	24.2	25.1	18.0	1.6	-
6300	68.6	18.6	20.7	16.6	3.5	-
8000	65.8	[15.8]	18.8	16.2	5.4	71.5
10000	65.0	[15.0]	18.0	16.2	7.2	-
Σ	101.8	51.8	52.8	46.0		



created with GL Acoustic TuNES version: Rev. 15.11

Bin 10.5 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

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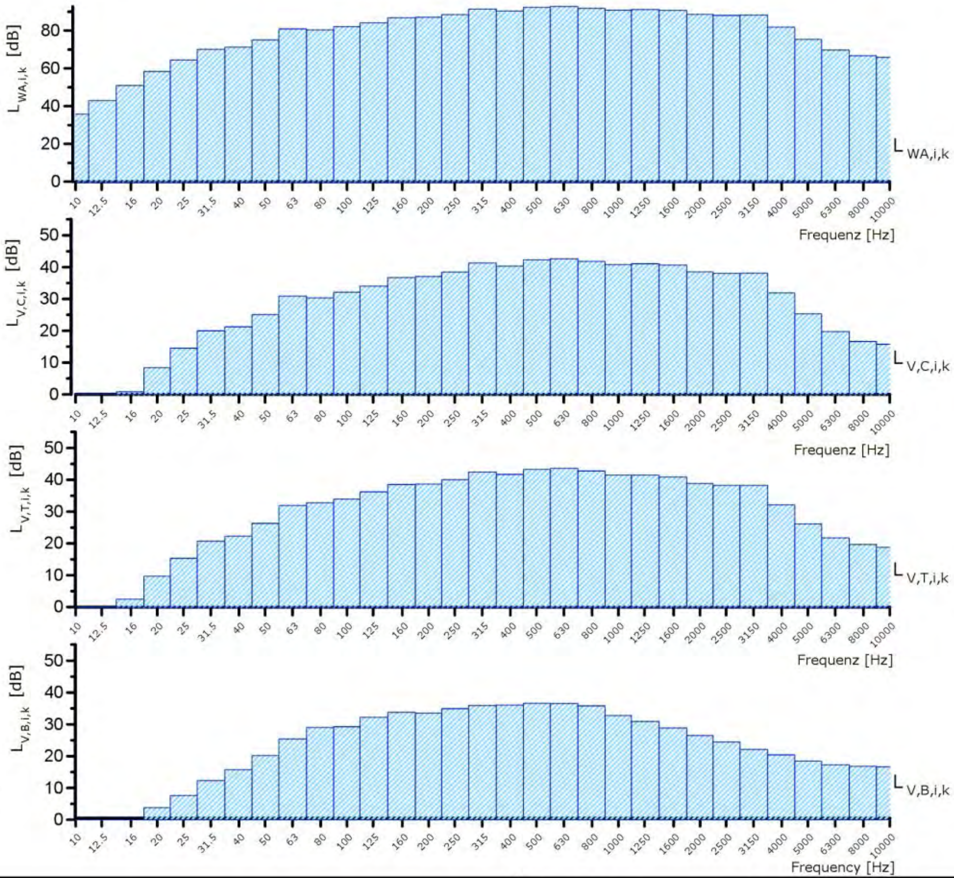
9.16 Third-octave sound power spectra at a WS of 11.0 m/s at hub height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.9 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.54 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 11 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	35.8	-14.2	-11.3	-14.4	5.8	-
12.5	42.9	-7.1	-4.8	-8.7	4.2	-
16	50.9	0.9	2.5	-2.7	3.0	59.2
20	58.4	8.4	9.7	3.8	2.2	-
25	64.5	14.5	15.3	7.7	1.4	-
31.5	70.0	20.0	20.7	12.3	1.3	74.2
40	71.2	21.2	22.3	15.8	1.7	-
50	75.1	25.1	26.3	20.2	1.7	-
63	80.9	30.9	32.0	25.4	1.5	84.2
80	80.4	30.4	32.7	29.0	2.5	-
100	82.1	32.1	33.9	29.3	2.2	-
125	84.0	34.0	36.2	32.2	2.1	89.5
160	86.7	36.7	38.5	33.7	1.9	-
200	87.1	37.1	38.6	33.5	2.2	-
250	88.5	38.5	40.0	34.9	2.5	94.1
315	91.3	41.3	42.4	35.9	1.9	-
400	90.3	40.3	41.7	36.1	2.2	-
500	92.2	42.2	43.3	36.6	1.7	96.6
630	92.6	42.6	43.6	36.5	1.5	-
800	91.7	41.7	42.7	35.8	1.2	-
1000	90.8	40.8	41.5	32.8	1.0	96.0
1250	91.0	41.0	41.4	30.9	0.8	-
1600	90.6	40.6	40.9	28.9	0.9	-
2000	88.5	38.5	38.8	26.5	0.9	94.0
2500	88.0	38.0	38.2	24.5	1.7	-
3150	88.1	38.1	38.2	22.1	2.2	-
4000	81.9	31.9	32.2	20.4	1.4	89.2
5000	75.3	25.3	26.1	18.5	1.7	-
6300	69.7	19.7	21.7	17.3	3.2	-
8000	66.6	[16.6]	19.6	16.8	5.5	72.5
10000	65.8	[15.8]	18.8	16.6	7.2	-
Σ	**101.9**	**51.9**	**52.9**	**45.7**		



12.12.2017

created with GL Acoustic TuNES version: Rev. 15.11

DNV·GL

Bin 11 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

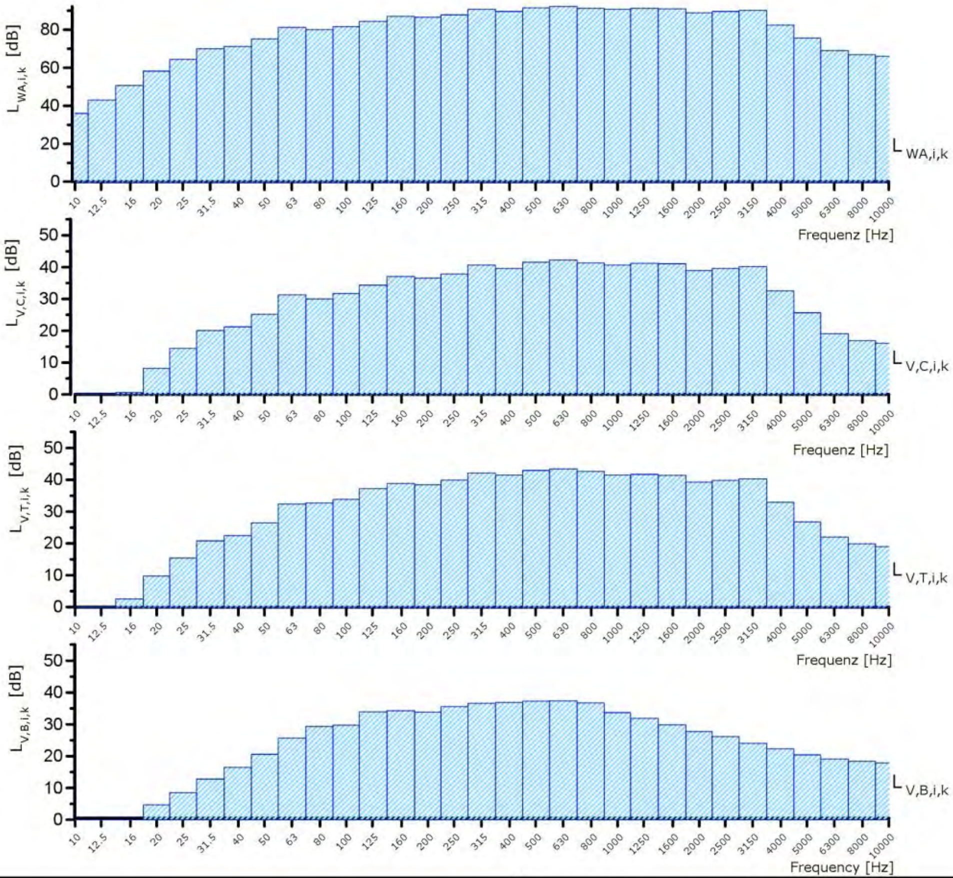
9.17 Third-octave sound power spectra at a WS of 11.5 m/s at hub height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.9 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.93 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 11.5 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	36.0	[-14.0]	-11.0	-13.7	6.4	-
12.5	43.0	-7.0	-4.4	-7.8	5.0	-
16	50.6	0.6	2.6	-1.8	3.3	59.0
20	58.2	8.2	9.8	4.7	2.3	-
25	64.4	14.4	15.4	8.6	1.6	-
31.5	70.1	20.1	20.8	12.8	1.3	74.2
40	71.3	21.3	22.5	16.5	1.8	-
50	75.2	25.2	26.5	20.6	1.7	-
63	81.3	31.3	32.3	25.7	1.5	84.3
80	80.0	30.0	32.7	29.3	2.5	-
100	81.7	31.7	33.9	29.8	2.3	-
125	84.4	34.4	37.2	33.9	4.1	89.7
160	87.0	37.0	38.9	34.2	2.3	-
200	86.5	36.6	38.4	33.8	2.4	-
250	87.8	37.8	39.9	35.6	3.0	93.5
315	90.7	40.7	42.1	36.6	2.4	-
400	89.6	39.6	41.5	36.8	2.9	-
500	91.5	41.5	42.9	37.3	2.2	96.0
630	92.2	42.2	43.4	37.3	1.9	-
800	91.3	41.3	42.6	36.7	1.7	-
1000	90.7	40.7	41.5	33.7	1.2	95.9
1250	91.2	41.2	41.7	31.9	0.9	-
1600	91.1	41.1	41.4	29.9	1.0	-
2000	88.9	38.9	39.2	27.7	0.9	94.7
2500	89.6	39.6	39.8	26.2	2.1	-
3150	90.2	40.2	40.3	24.0	2.6	-
4000	82.5	32.5	32.9	22.3	1.6	91.0
5000	75.7	25.7	26.8	20.4	2.0	-
6300	69.1	19.1	22.1	19.1	5.2	-
8000	66.9	[16.9]	19.9	18.4	6.4	72.3
10000	66.1	[16.1]	19.1	17.9	7.9	-
Σ	**101.9**	**51.9**	**53.0**	**46.5**		



12.12.2017

created with GL Acoustic TuNES version: Rev. 15.11

DNV·GL

Bin 11.5 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

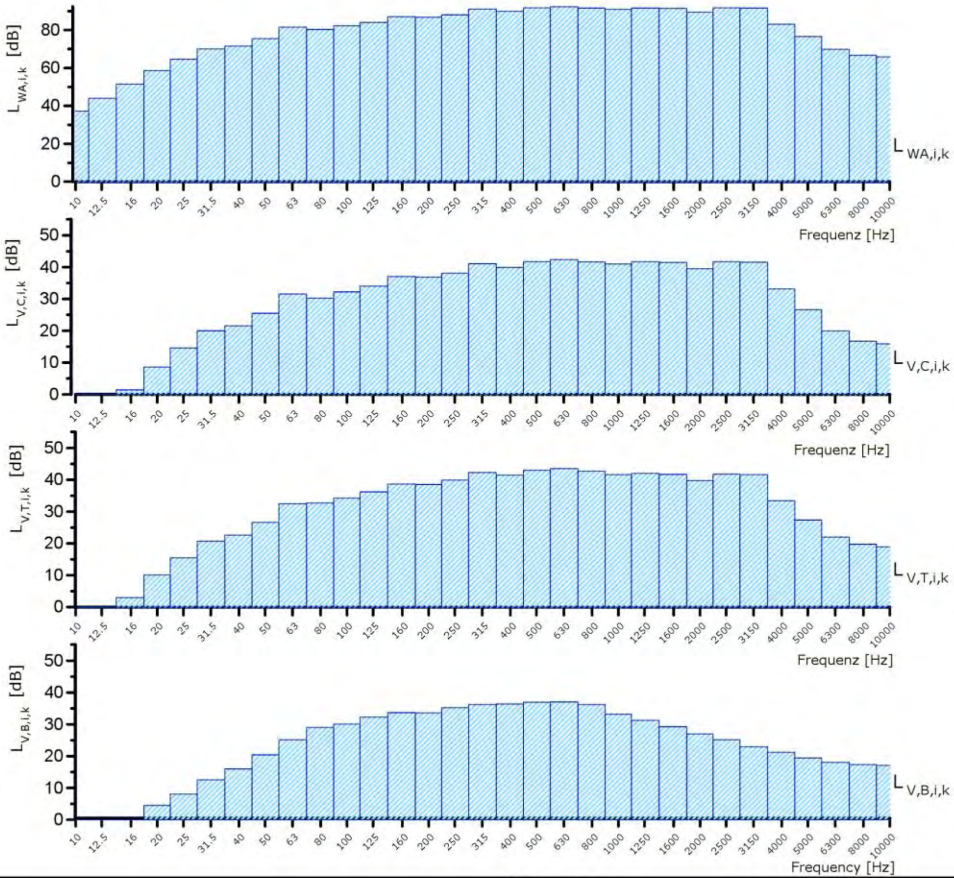
9.18 Third-octave sound power spectra at a WS of 12.0 m/s at hub height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 102.4 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.92 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 12 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	37.3	-12.7	-10.3	-13.9	5.0	-
12.5	44.1	-5.9	-4.0	-8.3	3.7	-
16	51.5	1.5	3.0	-2.2	2.7	59.5
20	58.7	8.7	10.1	4.5	2.2	-
25	64.6	14.6	15.5	8.1	1.5	-
31.5	70.0	20.0	20.7	12.6	1.4	74.4
40	71.6	21.6	22.6	16.0	1.7	-
50	75.5	25.5	26.7	20.4	1.7	-
63	81.6	31.6	32.5	25.2	1.4	84.6
80	80.3	30.3	32.7	29.0	2.4	-
100	82.2	32.2	34.3	30.1	2.8	-
125	84.0	34.0	36.2	32.3	2.3	89.7
160	87.0	37.1	38.7	33.7	2.0	-
200	86.8	36.8	38.5	33.6	2.5	-
250	88.1	38.1	39.9	35.2	2.8	93.8
315	91.1	41.1	42.3	36.2	2.6	-
400	89.9	39.9	41.5	36.3	2.7	-
500	91.7	41.7	43.0	36.9	2.2	96.2
630	92.4	42.4	43.5	37.0	2.0	-
800	91.6	41.6	42.7	36.2	1.7	-
1000	91.0	41.0	41.6	33.2	1.2	96.2
1250	91.7	41.7	42.0	31.2	0.8	-
1600	91.5	41.5	41.7	29.3	0.9	-
2000	89.5	39.5	39.7	27.0	1.0	95.8
2500	91.7	41.7	41.8	25.1	2.4	-
3150	91.6	41.6	41.6	22.9	2.7	-
4000	83.1	33.1	33.4	21.2	1.5	92.3
5000	76.6	26.6	27.4	19.4	1.4	-
6300	69.9	19.9	22.1	18.0	3.3	-
8000	66.8	[16.8]	19.8	17.4	5.7	72.7
10000	65.9	[15.9]	18.9	17.1	7.4	-
Σ	**102.4**	**52.4**	**53.3**	**46.0**		



created with GL Acoustic TuNES version: Rev. 15.11

12.12.2017

DNV·GL

Bin 12 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

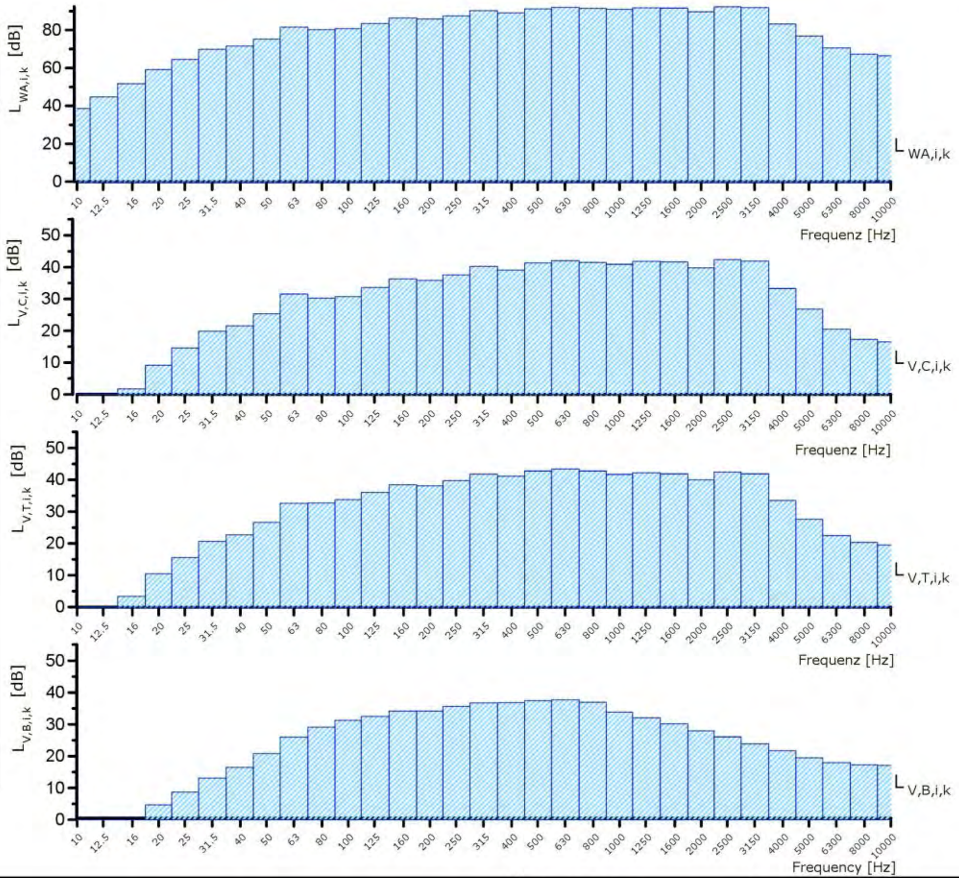
9.19 Third-octave sound power spectra at a WS of 12.5 m/s at hub height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 102.3 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.86 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 12.5 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	38.7	-11.3	-9.3	-13.7	4.4	-
12.5	44.8	-5.2	-3.3	-7.8	3.9	-
16	51.7	1.7	3.4	-1.6	3.0	60.1
20	59.2	9.2	10.5	4.7	2.2	-
25	64.6	14.6	15.6	8.8	1.7	-
31.5	69.9	19.9	20.7	13.2	1.3	74.3
40	71.6	21.6	22.7	16.5	1.9	-
50	75.3	25.3	26.6	20.8	1.7	-
63	81.5	31.5	32.6	26.0	1.5	84.5
80	80.2	30.2	32.7	29.1	2.6	-
100	80.7	[30.7]	33.7	31.2	3.1	-
125	83.6	33.6	36.0	32.4	2.1	88.9
160	86.3	36.3	38.4	34.1	1.8	-
200	85.8	35.8	38.1	34.2	2.4	-
250	87.5	37.5	39.7	35.7	2.8	93.0
315	90.2	40.2	41.8	36.7	2.3	-
400	89.1	39.1	41.1	36.8	2.8	-
500	91.2	41.3	42.8	37.4	2.3	95.7
630	92.1	42.1	43.4	37.7	2.2	-
800	91.4	41.4	42.7	36.9	1.8	-
1000	90.9	40.9	41.7	33.8	1.3	96.1
1250	91.8	41.8	42.2	32.0	0.8	-
1600	91.6	41.6	41.9	30.2	0.9	-
2000	89.7	39.7	40.0	27.9	1.0	96.1
2500	92.4	42.4	42.5	26.1	2.2	-
3150	91.8	41.8	41.9	23.8	2.5	-
4000	83.2	33.2	33.5	21.7	1.3	92.5
5000	76.8	26.8	27.6	19.5	1.4	-
6300	70.5	20.5	22.4	18.0	3.3	-
8000	67.3	[17.3]	20.3	17.3	6.0	73.2
10000	66.5	[16.5]	19.5	17.0	7.8	-
Σ	102.3	52.3	53.3	46.6		



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12.12.2017

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Bin 12.5 Senvion MM92

One third octave analysis at hub height

Terzanalyse auf Nabenhöhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

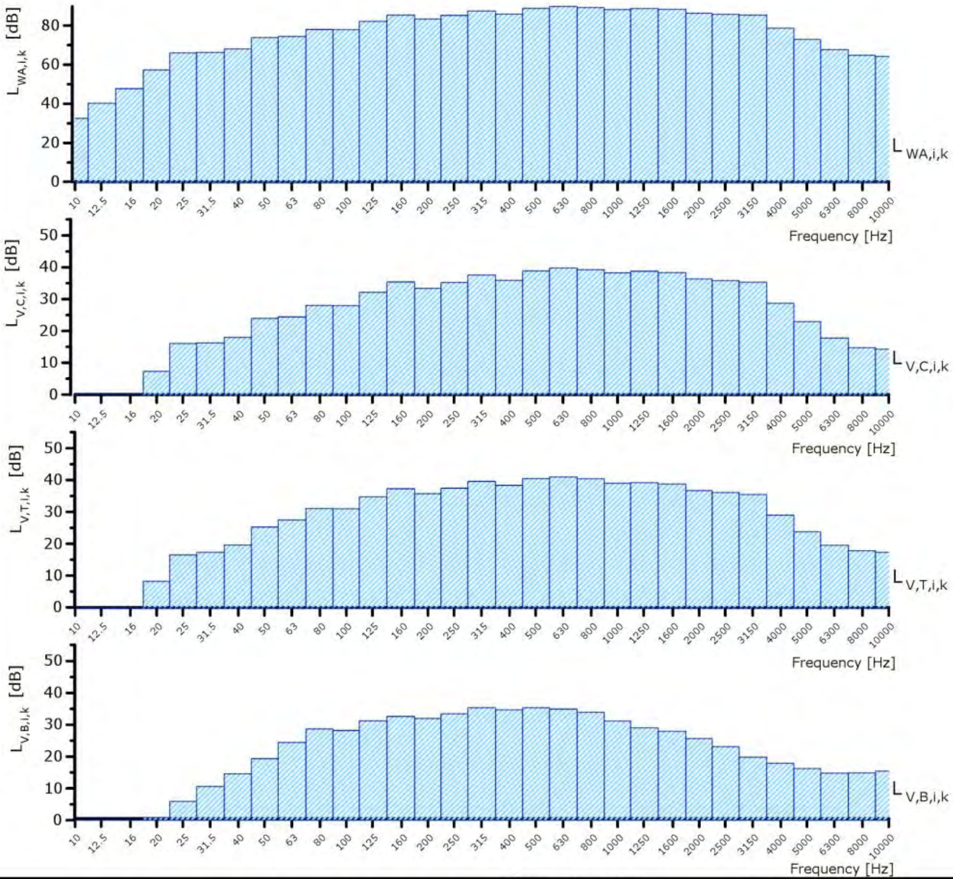
9.20 Third-octave sound power spectra at a WS of 5 m/s at 10 m height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 99.1 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 2.19 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 5 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	32.5	-17.5	-15.2	-18.9	5.3	-
12.5	40.3	-9.7	-8.3	-13.9	3.4	-
16	47.8	-2.2	-0.7	-5.8	3.6	57.9
20	57.3	7.3	8.2	0.9	2.3	-
25	66.1	16.1	16.5	5.9	2.5	-
31.5	66.2	16.2	17.3	10.6	3.7	71.6
40	68.0	18.0	19.6	14.6	2.9	-
50	73.9	23.9	25.2	19.4	2.2	-
63	74.4	24.5	27.5	24.4	4.1	80.7
80	78.1	[28.1]	31.1	28.7	4.9	-
100	78.0	[28.0]	31.0	28.2	3.5	-
125	82.1	32.2	34.7	31.2	3.2	87.6
160	85.4	35.4	37.2	32.6	3.3	-
200	83.4	33.4	35.7	31.9	3.0	-
250	85.2	35.2	37.4	33.4	3.3	90.5
315	87.6	37.6	39.6	35.3	3.0	-
400	85.9	35.9	38.3	34.7	3.1	-
500	88.8	38.8	40.4	35.3	2.2	93.2
630	89.7	39.7	41.0	34.9	1.8	-
800	89.3	39.3	40.4	33.9	1.8	-
1000	88.2	38.2	39.0	31.1	1.7	93.5
1250	88.8	38.8	39.2	29.0	1.6	-
1600	88.4	38.4	38.7	28.0	1.7	-
2000	86.3	36.3	36.7	25.7	1.6	91.7
2500	85.8	35.8	36.0	23.1	1.6	-
3150	85.4	35.4	35.5	19.8	2.2	-
4000	78.7	28.7	29.0	17.9	2.3	86.4
5000	73.0	23.0	23.8	16.2	1.9	-
6300	67.8	17.8	19.6	14.8	3.9	-
8000	64.8	[14.8]	17.8	14.9	7.2	70.7
10000	64.3	[14.3]	17.3	15.4	10.0	-
Σ	**99.1**	**49.1**	**50.4**	**44.4**		



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12.12.2017

Bin 5 Senvion MM92

One third octave analysis at 10 m height

Terzanalyse auf 10 m Höhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

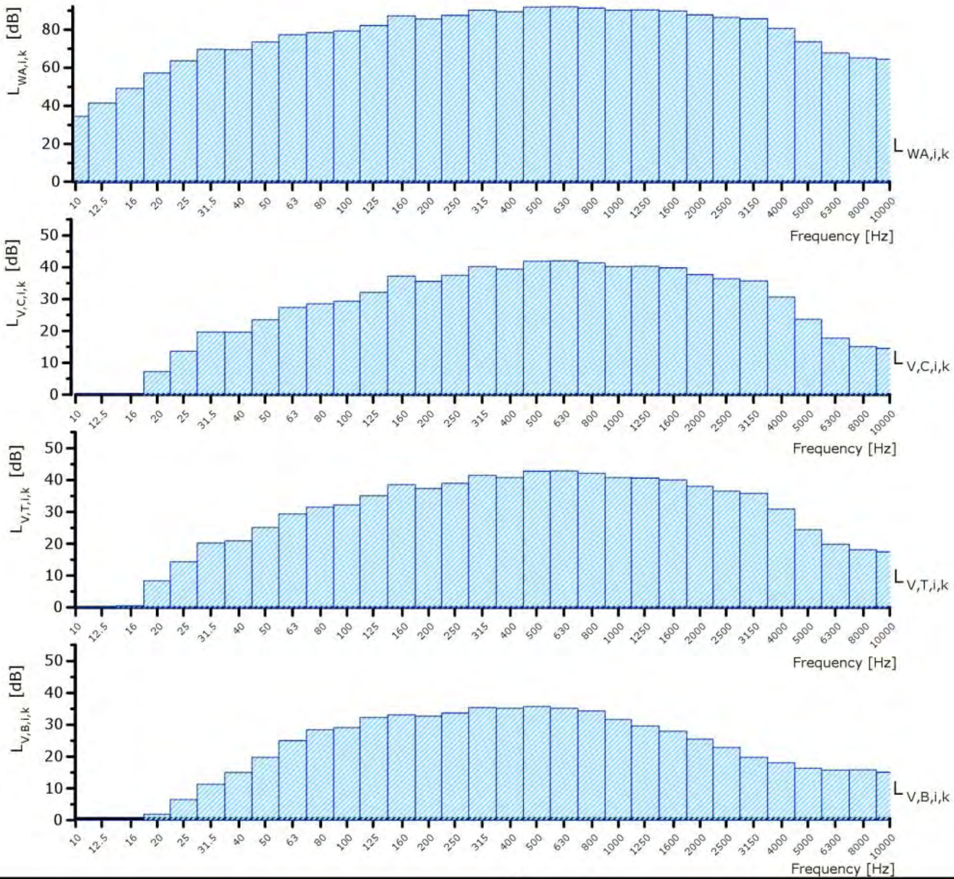
9.21 Third-octave sound power spectra at a WS of 6 m/s at 10 m height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.1 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.03 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 6 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	34.5	-15.5	-13.7	-18.3	3.1	-
12.5	41.4	-8.6	-7.0	-12.3	2.6	-
16	49.1	-0.9	0.5	-5.1	2.3	58.0
20	57.3	7.3	8.4	1.9	1.8	-
25	63.6	13.6	14.4	6.5	1.3	-
31.5	69.7	19.7	20.3	11.3	1.2	73.2
40	69.6	19.6	20.9	15.0	1.9	-
50	73.5	23.6	25.1	19.8	1.9	-
63	77.4	27.4	29.4	25.0	2.1	81.7
80	78.5	28.5	31.5	28.4	2.9	-
100	79.3	29.3	32.2	29.1	2.6	-
125	82.1	[32.1]	35.1	32.3	2.8	88.9
160	87.2	37.2	38.6	33.1	1.3	-
200	85.5	35.5	37.4	32.7	1.7	-
250	87.5	37.5	39.0	33.7	1.6	92.9
315	90.2	40.2	41.5	35.4	1.3	-
400	89.4	39.4	40.8	35.1	1.4	-
500	91.8	41.8	42.8	35.7	1.0	96.0
630	92.1	42.1	42.9	35.2	0.9	-
800	91.3	41.3	42.1	34.4	0.8	-
1000	90.2	40.2	40.8	31.7	0.7	95.4
1250	90.3	40.3	40.7	29.6	0.6	-
1600	89.8	39.8	40.1	28.0	0.7	-
2000	87.7	37.7	38.0	25.5	0.7	93.0
2500	86.4	36.4	36.6	22.9	0.8	-
3150	85.7	35.7	35.8	19.8	1.1	-
4000	80.7	30.7	30.9	18.0	1.1	87.1
5000	73.7	23.7	24.4	16.3	1.0	-
6300	67.7	17.7	19.8	15.8	2.7	-
8000	65.1	[15.1]	18.1	15.9	4.7	70.8
10000	64.5	[14.5]	17.5	15.1	6.4	-
Σ	**101.1**	**51.1**	**52.0**	**44.8**		



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12.12.2017

Bin 6 Senvion MM92

One third octave analysis at 10 m height

Terzanalyse auf 10 m Höhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

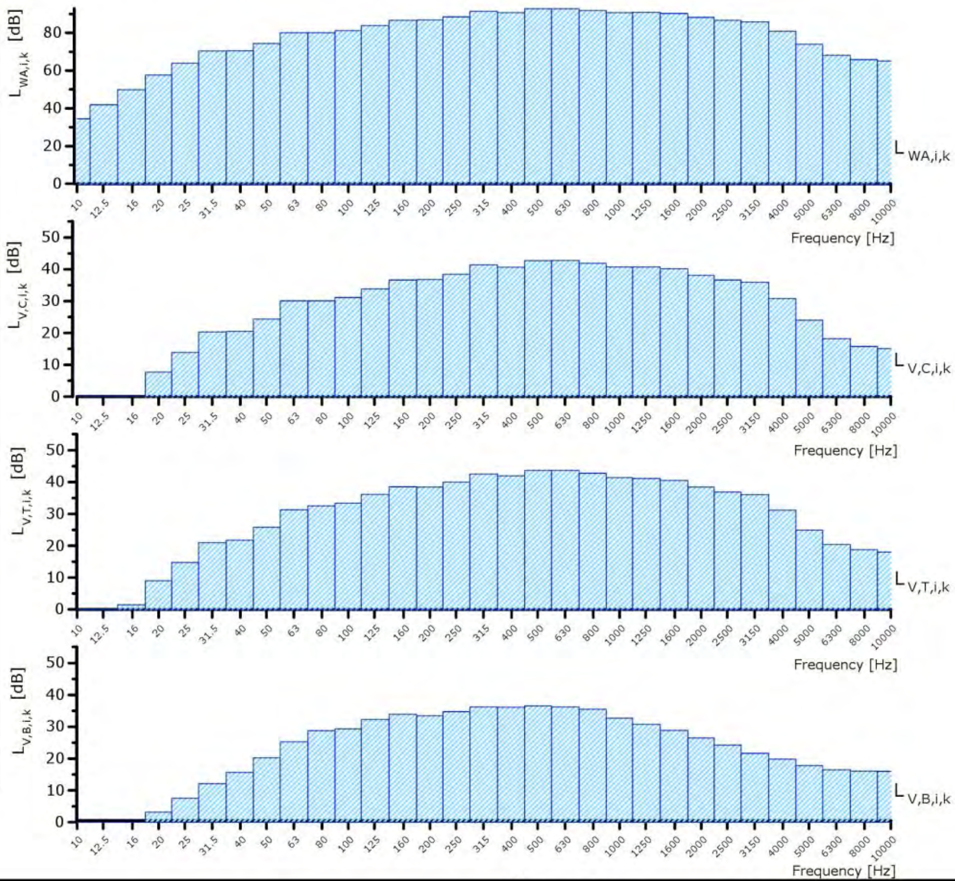
9.22 Third-octave sound power spectra at a WS of 7 m/s at 10 m height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 101.8 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.10 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 7 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	34.5	-15.5	-12.6	-15.7	5.2	-
12.5	41.9	-8.1	-5.8	-9.7	3.7	-
16	49.9	-0.1	1.5	-3.6	2.5	58.5
20	57.7	7.7	9.0	3.2	1.9	-
25	63.9	13.9	14.8	7.6	1.5	-
31.5	70.4	20.4	21.0	12.1	1.2	73.9
40	70.5	20.5	21.7	15.6	1.7	-
50	74.4	24.4	25.8	20.2	1.7	-
63	80.0	30.0	31.3	25.3	1.8	83.6
80	80.1	30.1	32.5	28.8	2.4	-
100	81.1	31.1	33.3	29.3	2.0	-
125	83.9	33.9	36.1	32.3	2.2	89.2
160	86.7	36.7	38.5	33.9	1.8	-
200	86.8	36.8	38.4	33.5	1.5	-
250	88.4	38.4	39.9	34.7	1.6	94.0
315	91.3	41.3	42.5	36.2	1.3	-
400	90.6	40.6	41.9	36.1	1.5	-
500	92.7	42.7	43.6	36.5	1.0	96.9
630	92.8	42.8	43.7	36.2	0.9	-
800	91.8	41.8	42.7	35.5	0.9	-
1000	90.7	40.7	41.4	32.7	0.8	95.9
1250	90.7	40.7	41.1	30.8	0.7	-
1600	90.2	40.2	40.5	28.9	0.7	-
2000	88.1	38.1	38.4	26.5	0.7	93.3
2500	86.6	36.7	36.9	24.3	0.9	-
3150	85.9	35.9	36.0	21.6	1.3	-
4000	80.8	30.8	31.1	19.8	1.2	87.2
5000	74.0	24.0	24.9	17.8	1.4	-
6300	68.2	18.2	20.4	16.5	3.2	-
8000	65.8	[15.8]	18.8	16.0	5.1	71.3
10000	65.1	[15.1]	18.1	16.0	6.8	-
Σ	**101.8**	**51.8**	**52.7**	**45.7**		



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DNV·GL

Bin 7 Senvion MM92

One third octave analysis at 10 m height

Terzanalyse auf 10 m Höhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

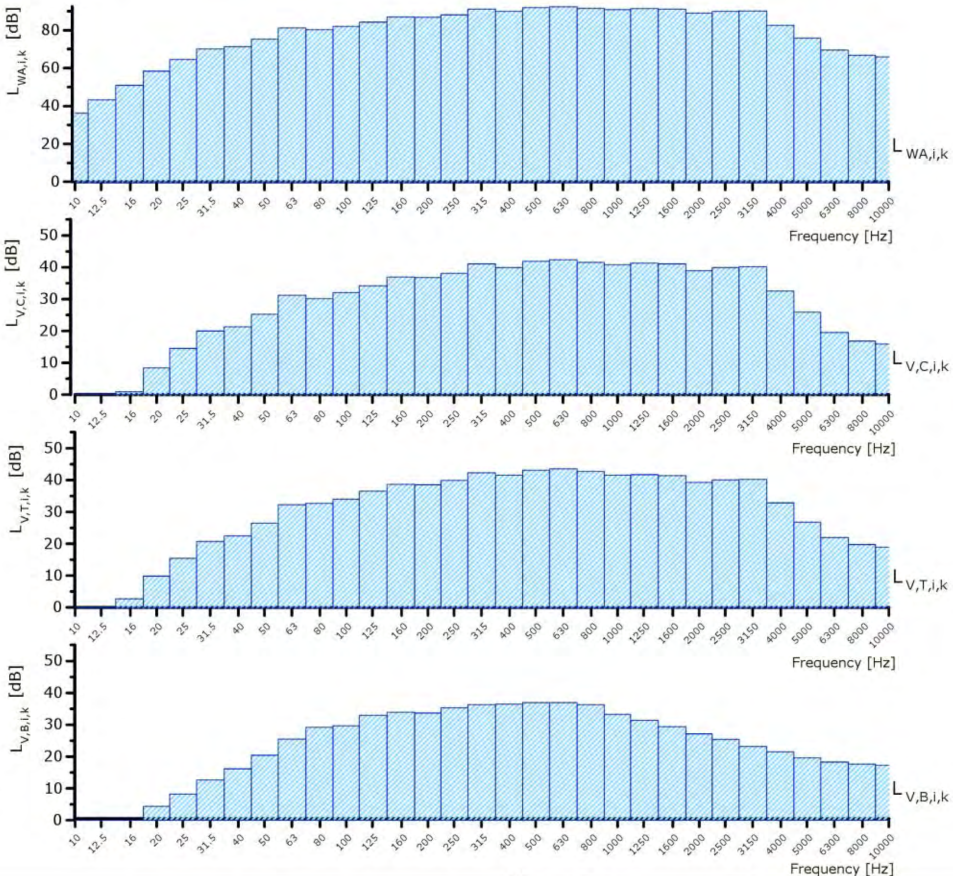
9.23 Third-octave sound power spectra at a WS of 8 m/s at 10 m height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 102.1 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.93 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 8 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	36.2	-13.8	-10.8	-13.9	6.3	-
12.5	43.2	-6.8	-4.4	-8.2	4.5	-
16	51.0	1.0	2.7	-2.1	3.1	59.2
20	58.4	8.4	9.8	4.4	2.3	-
25	64.5	14.5	15.4	8.2	1.6	-
31.5	70.0	20.0	20.7	12.6	1.4	74.2
40	71.3	21.3	22.5	16.1	1.8	-
50	75.2	25.2	26.5	20.4	1.8	-
63	81.2	31.2	32.3	25.5	1.6	84.3
80	80.2	30.2	32.7	29.2	2.6	-
100	82.0	32.0	34.0	29.7	2.5	-
125	84.1	34.1	36.6	32.9	3.0	89.6
160	86.9	36.9	38.7	33.9	2.2	-
200	86.8	36.8	38.5	33.6	2.5	-
250	88.1	38.1	39.9	35.3	2.9	93.8
315	91.0	41.0	42.3	36.3	2.4	-
400	89.9	39.9	41.5	36.5	2.7	-
500	91.8	41.8	43.1	37.0	2.1	96.3
630	92.4	42.4	43.5	37.0	1.9	-
800	91.6	41.6	42.7	36.3	1.6	-
1000	90.8	40.8	41.5	33.2	1.2	96.0
1250	91.3	41.3	41.7	31.4	0.9	-
1600	91.1	41.1	41.3	29.4	1.0	-
2000	89.0	39.0	39.2	27.1	1.0	94.8
2500	89.9	39.9	40.1	25.4	2.5	-
3150	90.1	40.1	40.2	23.2	2.9	-
4000	82.5	32.5	32.8	21.5	1.6	91.0
5000	75.9	25.9	26.8	19.6	1.9	-
6300	69.5	19.5	22.0	18.3	4.0	-
8000	66.8	[16.8]	19.8	17.6	6.1	72.5
10000	65.9	[15.9]	18.9	17.3	7.8	-
Σ	**102.1**	**52.1**	**53.1**	**46.1**		



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Bin 8 Senvion MM92

One third octave analysis at 10 m height

Terzanalyse auf 10 m Höhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

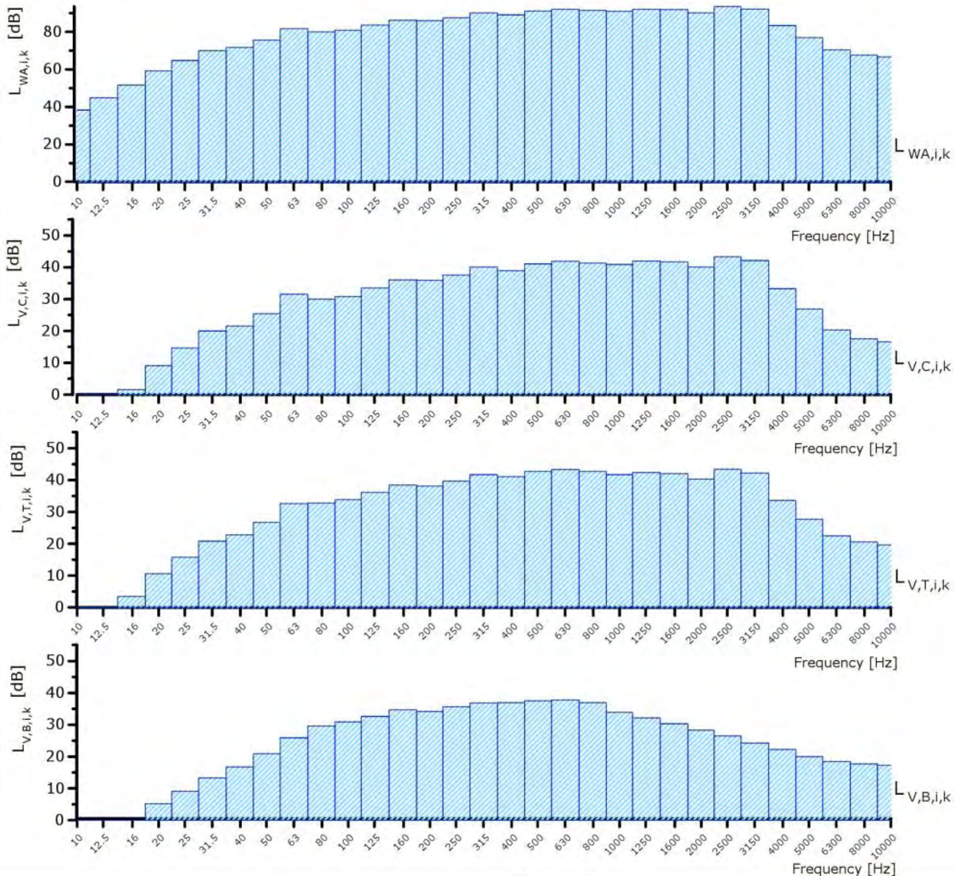
9.24 Third-octave sound power spectra at a WS of 9 m/s at 10 m height

Reference sound power / Referenz - Schallleistung $L_{WA,k}$ = 102.4 dB

Standard deviation / Standardabweichung $u_{WA,k}$ = 1.80 dB

Reference wind speed at / Referenzwindgeschwindigkeit WS_{BIN} = 9 m/s

f [Hz]	$L_{WA,i,k}$ [dB]	$L_{V,C,i,k}$ [dB]	$L_{V,T,i,k}$ [dB]	$L_{V,B,i,k}$ [dB]	$u_{,c,i,k}$ [dB]	Octave $L_{WA,i,k}$ [dB]
10	38.3	-11.7	-9.3	-13.1	5.0	-
12.5	44.8	-5.2	-3.0	-7.1	4.4	-
16	51.6	1.6	3.5	-1.1	3.2	60.0
20	59.1	9.1	10.6	5.2	2.3	-
25	64.7	14.7	15.7	9.1	1.7	-
31.5	70.0	20.0	20.8	13.3	1.3	74.4
40	71.6	21.6	22.8	16.7	1.8	-
50	75.4	25.4	26.8	20.9	1.6	-
63	81.6	31.6	32.6	25.9	1.3	84.5
80	80.0	30.0	32.8	29.6	2.9	-
100	80.8	[30.8]	33.8	30.9	3.1	-
125	83.5	33.5	36.1	32.6	2.2	88.8
160	86.1	36.1	38.4	34.7	2.0	-
200	85.9	35.9	38.1	34.2	2.2	-
250	87.5	37.5	39.7	35.6	2.5	92.9
315	90.1	40.1	41.7	36.8	2.1	-
400	88.9	38.9	41.1	37.0	2.6	-
500	91.1	41.1	42.7	37.5	2.2	95.6
630	91.9	41.9	43.3	37.8	2.0	-
800	91.3	41.3	42.7	37.0	1.7	-
1000	90.9	40.9	41.7	34.0	1.2	96.2
1250	92.0	42.0	42.4	32.1	0.8	-
1600	91.7	41.7	42.0	30.4	0.8	-
2000	90.1	40.1	40.3	28.3	1.0	96.7
2500	93.4	43.4	43.5	26.5	2.3	-
3150	92.1	42.1	42.2	24.3	2.4	-
4000	83.2	33.3	33.6	22.2	1.2	92.7
5000	76.9	26.9	27.7	20.0	1.4	-
6300	70.3	20.3	22.5	18.4	3.4	-
8000	67.6	[17.6]	20.6	17.7	5.9	73.2
10000	66.6	[16.6]	19.6	17.3	7.4	-
Σ	102.4	52.4	53.4	46.7		



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12.12.2017

Bin 9 Senvion MM92

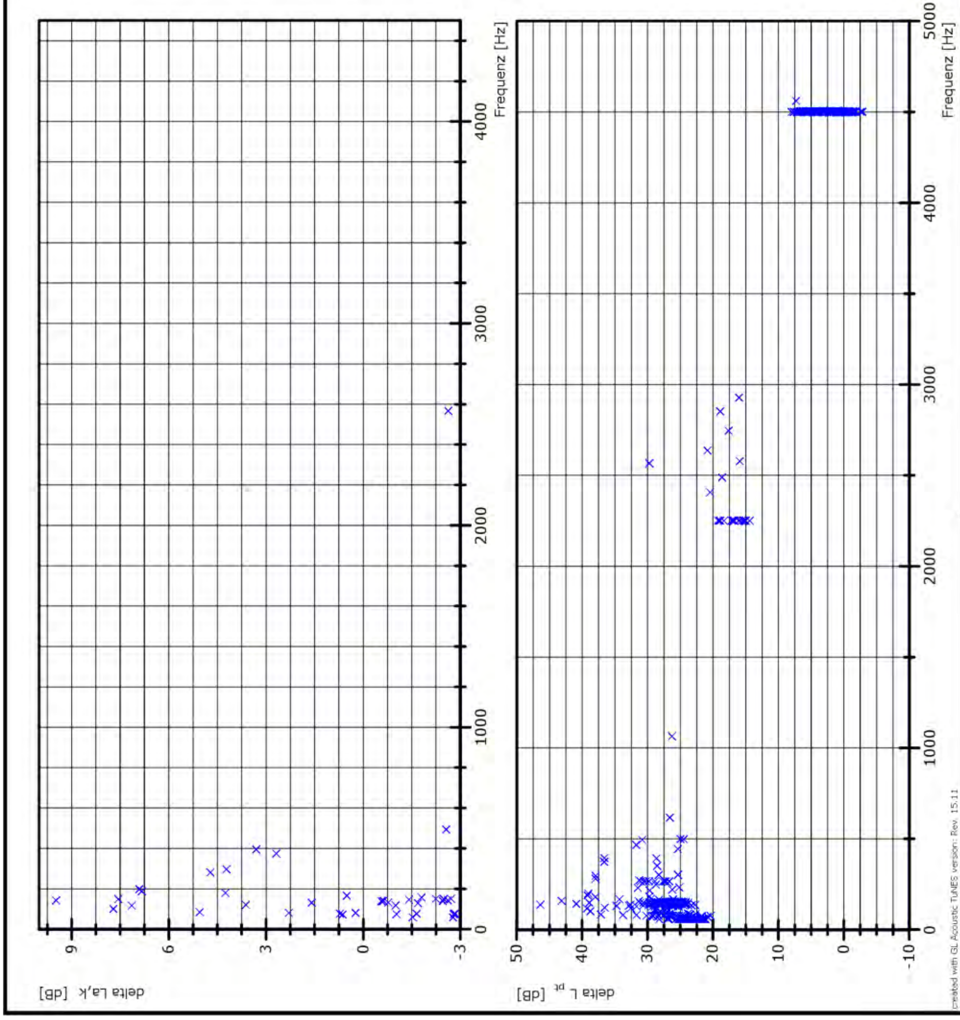
One third octave analysis at 10 m height

Terzanalyse auf 10 m Höhe

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

9.25 Tonality analysis overview – all frequencies

WS [m/s]	tone f_T [Hz]	n all	n ident	delta $L_{a,k}$ [dB]	WS-BIN complete	tonal audibility
8	149	75	38	***-4.94***	Yes	No
8.5	75	106	3	***-5.36***	Yes	No
9	75	147	3	***-2.55***	Yes	No
9.5	145	189	3	***5.69***	Yes	No
10	131	144	5	***-1.91***	Yes	No
10.5	141	101	3	***-3.51***	Yes	No
11	272	125	1	***-3.70***	Yes	No
11.5	148	124	5	***8.44***	Yes	No
12	270	120	4	***-0.32***	Yes	No
12.5	151	94	4	***-5.88***	Yes	No



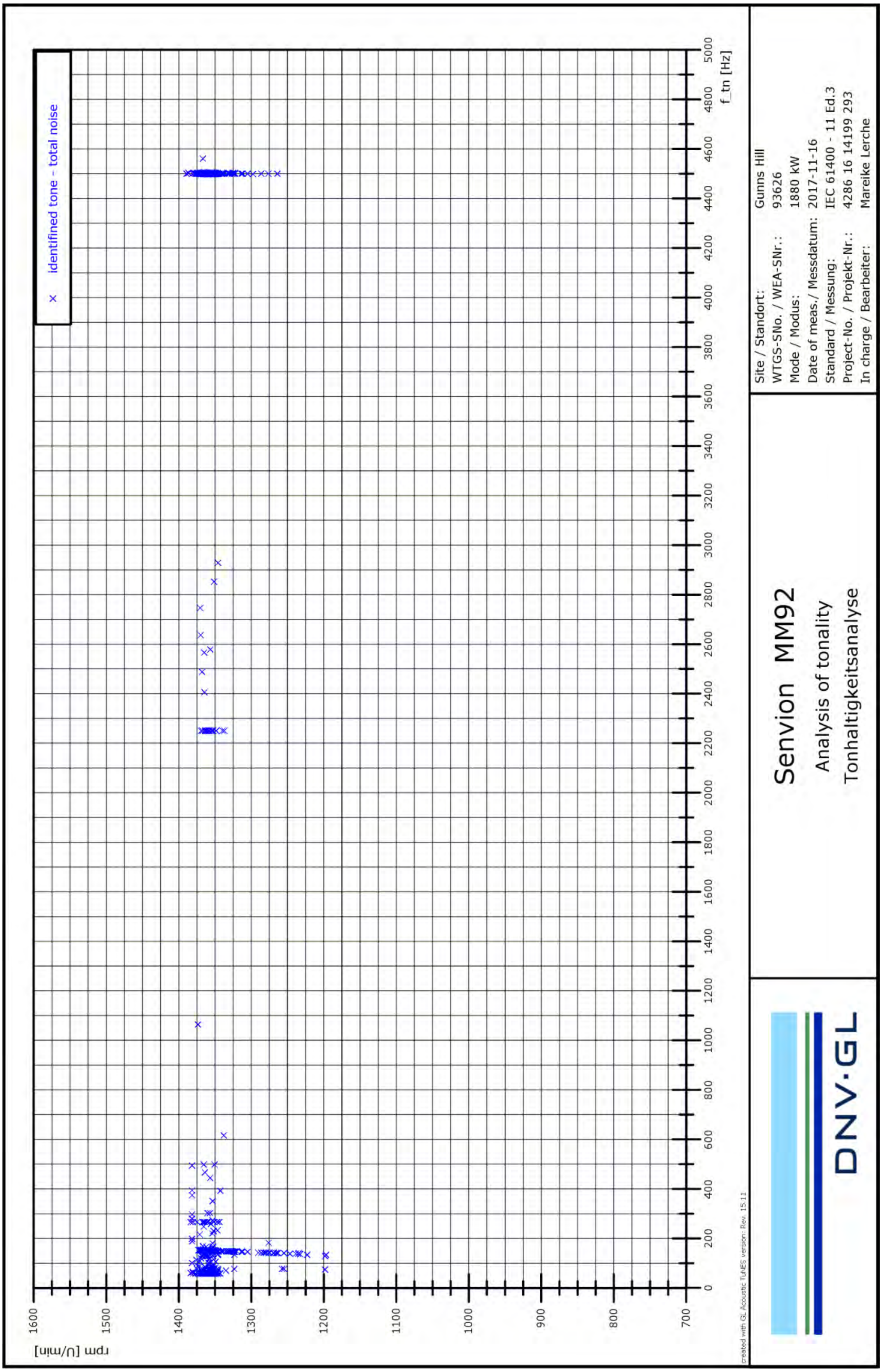
Senvion MM92

Analysis of tonality

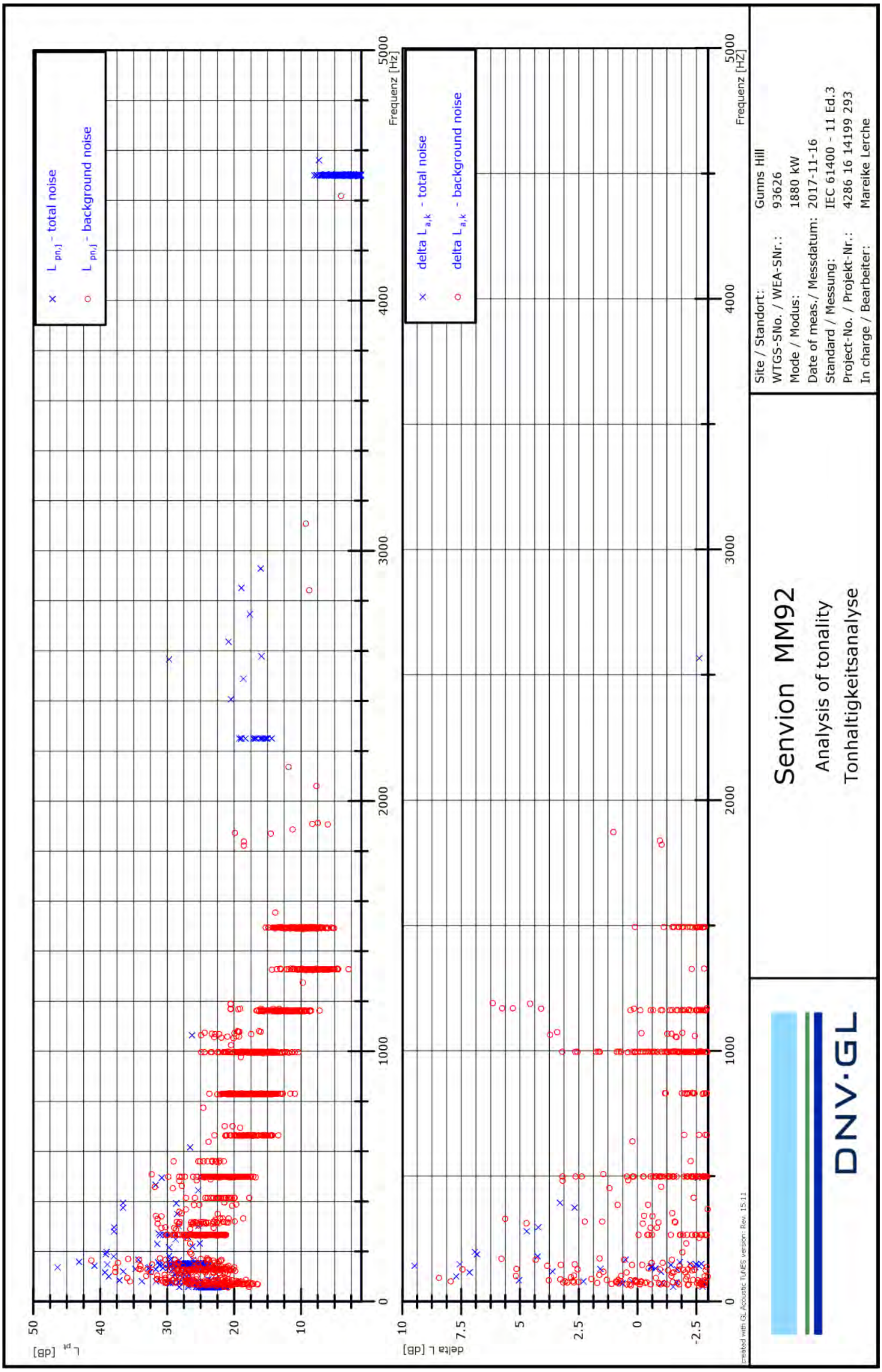
Tonhaltigkeitsanalyse

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400 - 11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

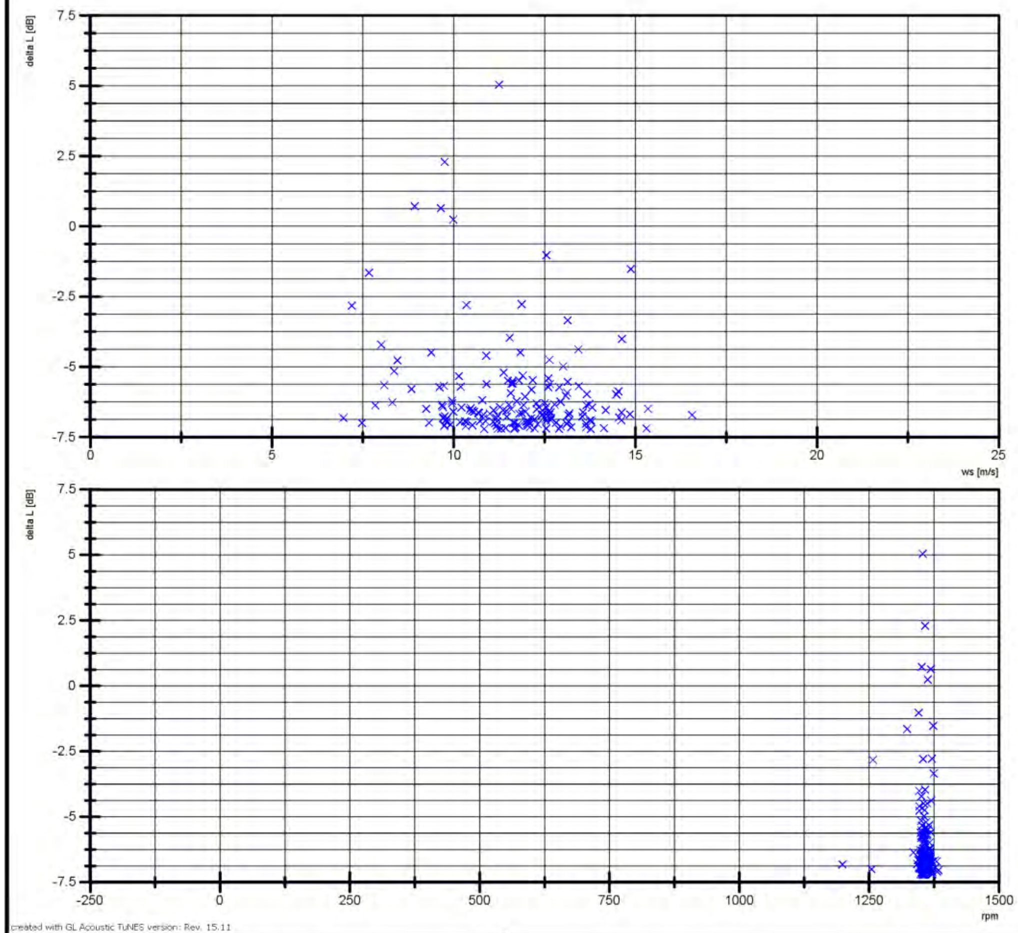
9.26 Tonality analysis - rpm vs. frequency for the identified tones in the total noise



9.27 Tonality analysis - $\Delta L_{pn,j}$ and $\Delta L_{a,k}$ vs. frequency



9.28 Tonality analysis - wind bin overview (page 1)



WS [m/s]	tone f_T [Hz]	n all	n ident	delta $L_{a,k}$ [dB]	WS-BIN complete	tonal audibility
8	74	75	3	-5.32	Yes	No
8.5	75	106	3	-5.36	Yes	No
9	75	147	3	-2.55	Yes	No
9.5	63	189	12	-5.08	Yes	No
10	67	144	13	-3.94	Yes	No
10.5	62	101	12	-6.26	Yes	No
11	59	125	18	-4.15	Yes	No
11.5	60	124	23	-6.30	Yes	No
12	59	120	22	-6.16	Yes	No
12.5	59	94	24	-5.99	Yes	No

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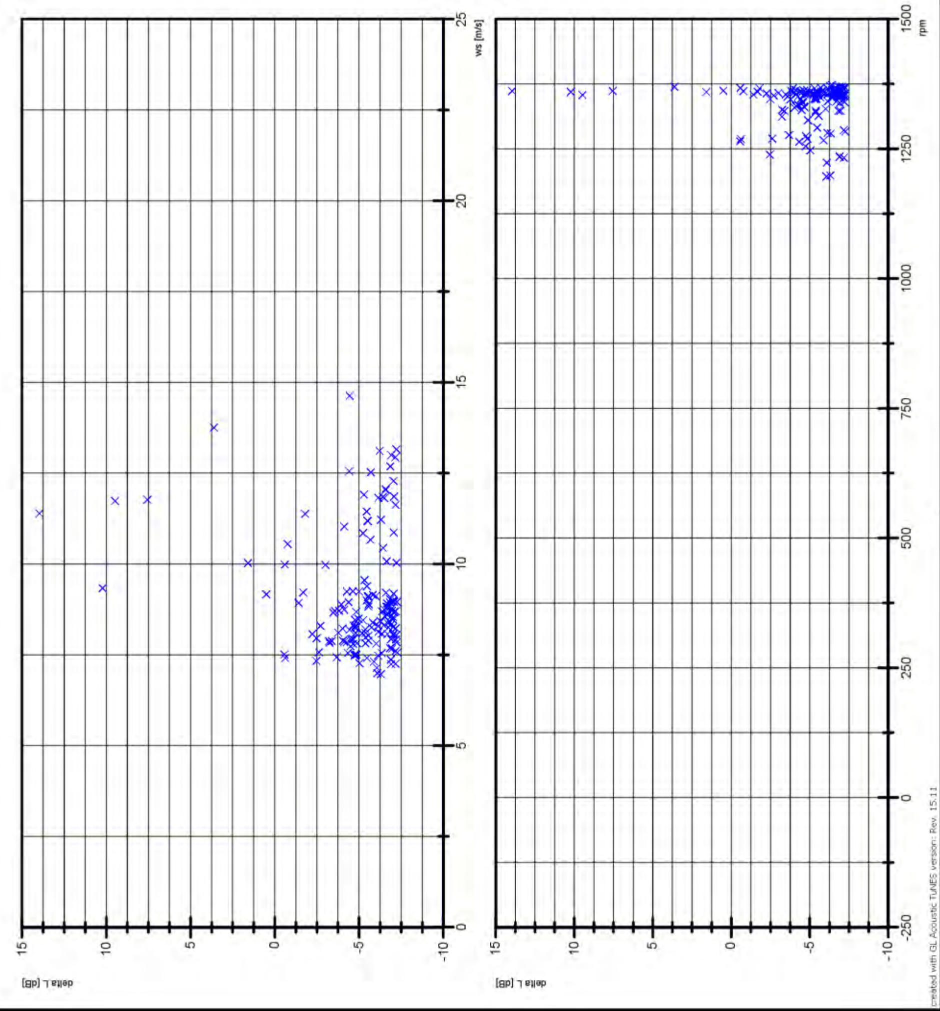
Senvion MM92

Analysis of tonality

analysis of tonality / Tonhaltigkeitsanalyse

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400 - 11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

WS [m/s]	tone f_T [Hz]	n all	n ident	delta $L_{a,k}$ [dB]	WS-BIN complete	tonal audibility
8	149	75	38	-4.94	Yes	No
8.5	150	106	32	-5.66	Yes	No
9	151	147	27	-4.92	Yes	No
9.5	145	189	3	5.69	Yes	No
10	131	144	5	-1.91	Yes	No
10.5	141	101	3	-3.51	Yes	No
11	143	125	6	-5.53	Yes	No
11.5	148	124	5	8.44	Yes	No
12	151	120	8	-0.39	Yes	No
12.5	151	94	4	-5.88	Yes	No



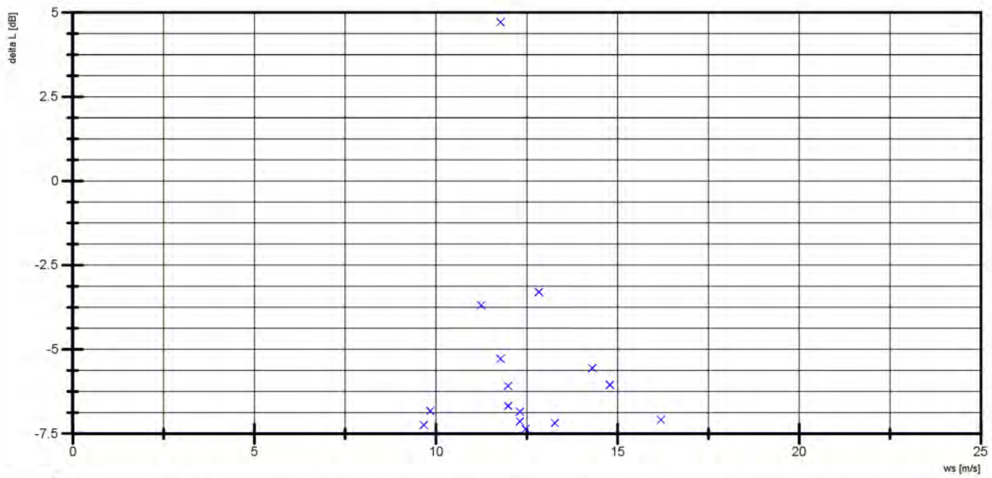
Senvion MM92

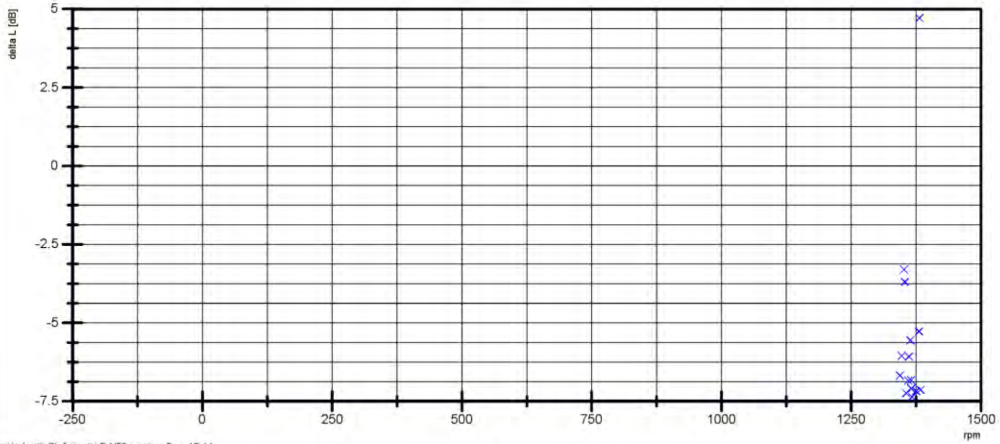
Analysis of tonality

analysis of tonality / Tonhaltigkeitsanalyse

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400 - 11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

9.30 Tonality analysis - wind bin overview (page 3)





WS [m/s]	tone f_T [Hz]	n all	n ident	delta $L_{a,k}$ [dB]	WS-BIN complete	tonal audibility
8		75	0		Yes	No
8.5		106	0		Yes	No
9		147	0		Yes	No
9.5	258	189	1	-7.24	Yes	No
10	248	144	1	-6.83	Yes	No
10.5		101	0		Yes	No
11	272	125	1	-3.70	Yes	No
11.5		124	0		Yes	No
12	270	120	4	-0.32	Yes	No
12.5	266	94	3	-7.11	Yes	No

DNV·GL

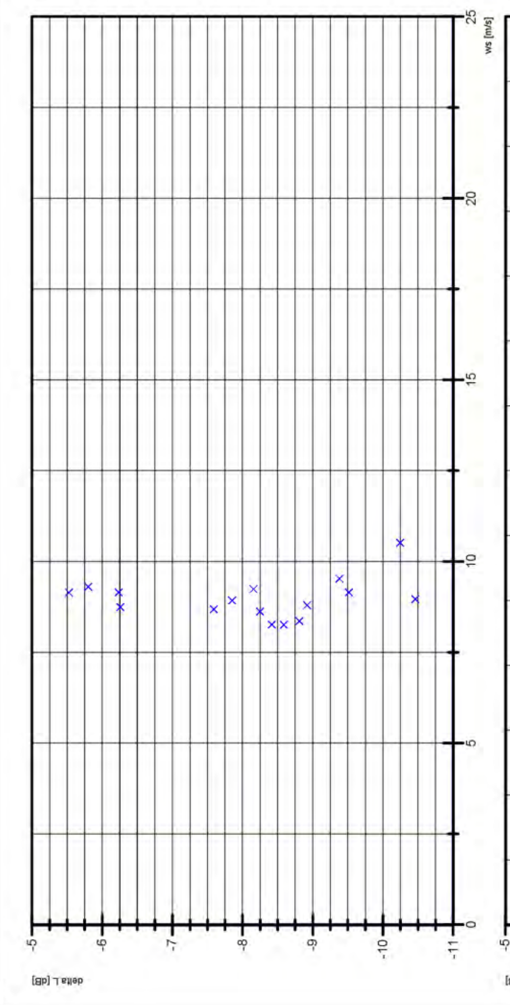
Senvion MM92

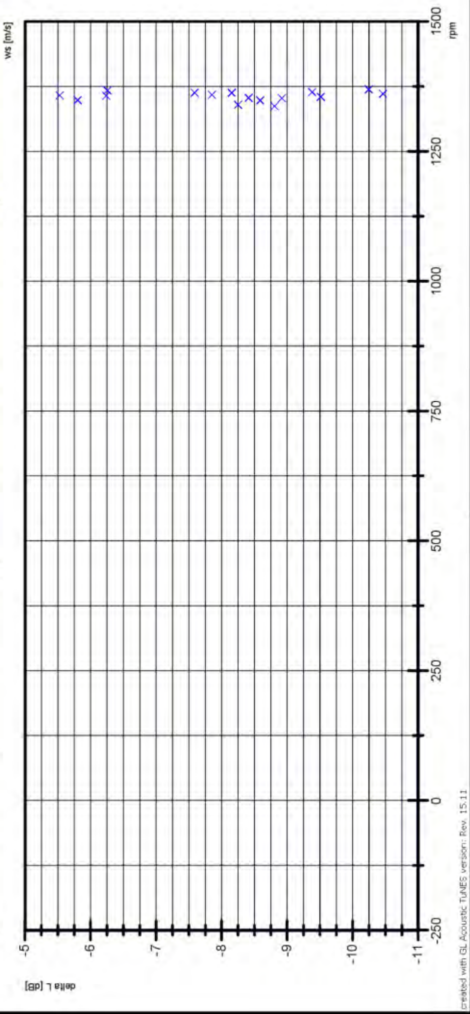
Analysis of tonality

analysis of tonality / Tonhaltigkeitsanalyse

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400 - 11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

9.31 Tonality analysis - wind bin overview (page 4)





WS [m/s]	tone f_T [Hz]	n all	n ident	delta $L_{a,k}$ [dB]	WS-BIN complete	tonal audibility
8		75	0		Yes	No
8.5	2250	106	6	-7.89	Yes	No
9	2250	147	7	-7.79	Yes	No
9.5	2250	189	2	-7.23	Yes	No
10		144	0		Yes	No
10.5	2250	101	1	-10.25	Yes	No
11		125	0		Yes	No
11.5		124	0		Yes	No
12		120	0		Yes	No
12.5		94	0		Yes	No

Senvion MM92

Analysis of tonality

analysis of tonality / Tonhaltigkeitsanalyse

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400 - 11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

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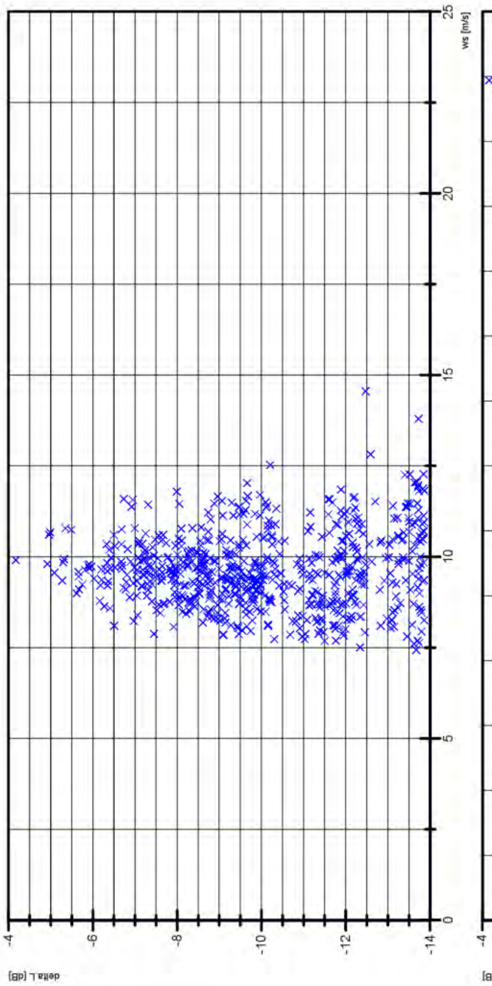
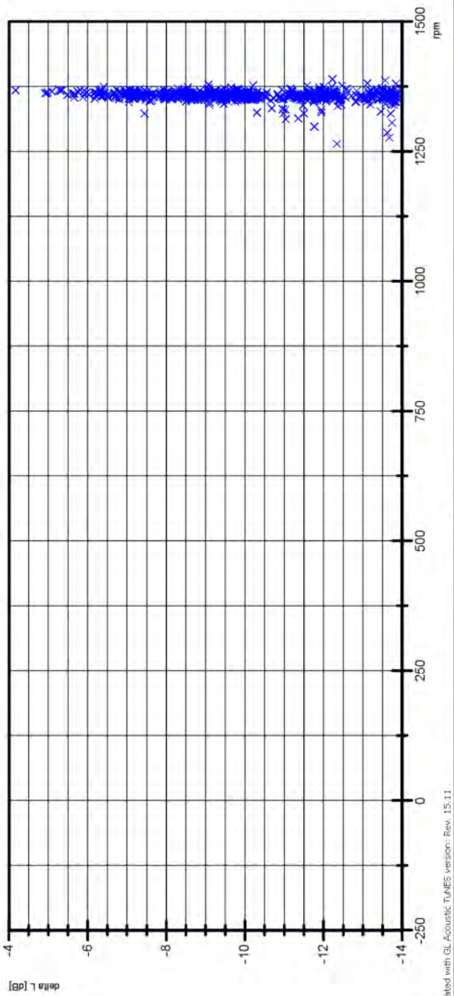
9.32 Tonality analysis - wind bin overview (page 5)

WS [m/s]	tone f_T [Hz]	n all	n ident	delta $L_{a,k}$ [dB]	WS-BIN complete	tonal audibility
8	4500	75	47	-10.36	Yes	No
8.5	4500	106	82	-10.00	Yes	No
9	4501	147	113	-9.14	Yes	No
9.5	4501	189	156	-8.79	Yes	No
10	4501	144	106	-8.92	Yes	No
10.5	4500	101	74	-9.39	Yes	No
11	4501	125	43	-10.43	Yes	No
11.5	4500	124	36	-10.20	Yes	No
12	4500	120	11	-12.13	Yes	No
12.5	4501	94	3	-12.19	Yes	No





created with GL Acoustic TuNES version: Rev. 15.11

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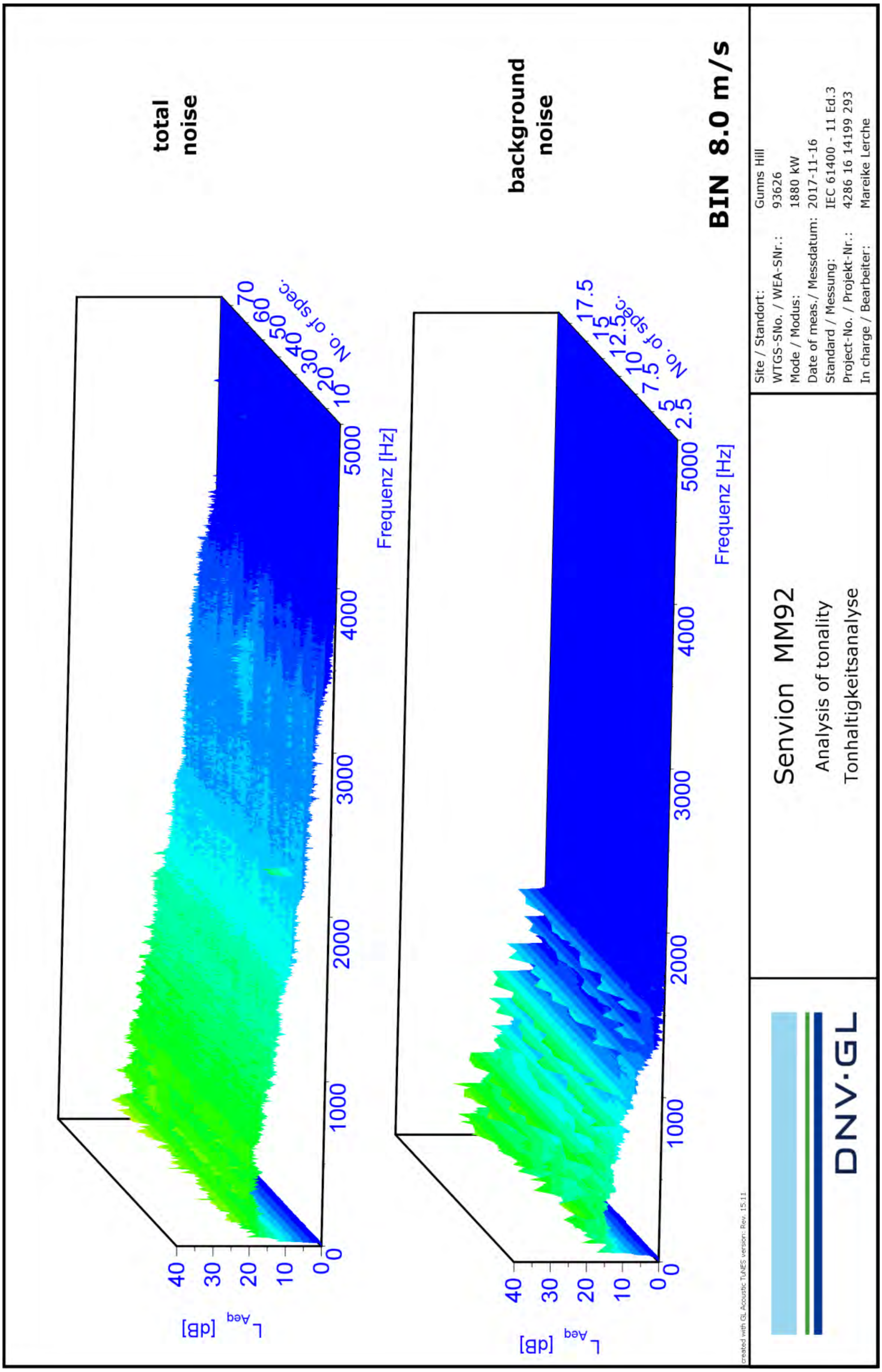
Senvion MM92

Analysis of tonality

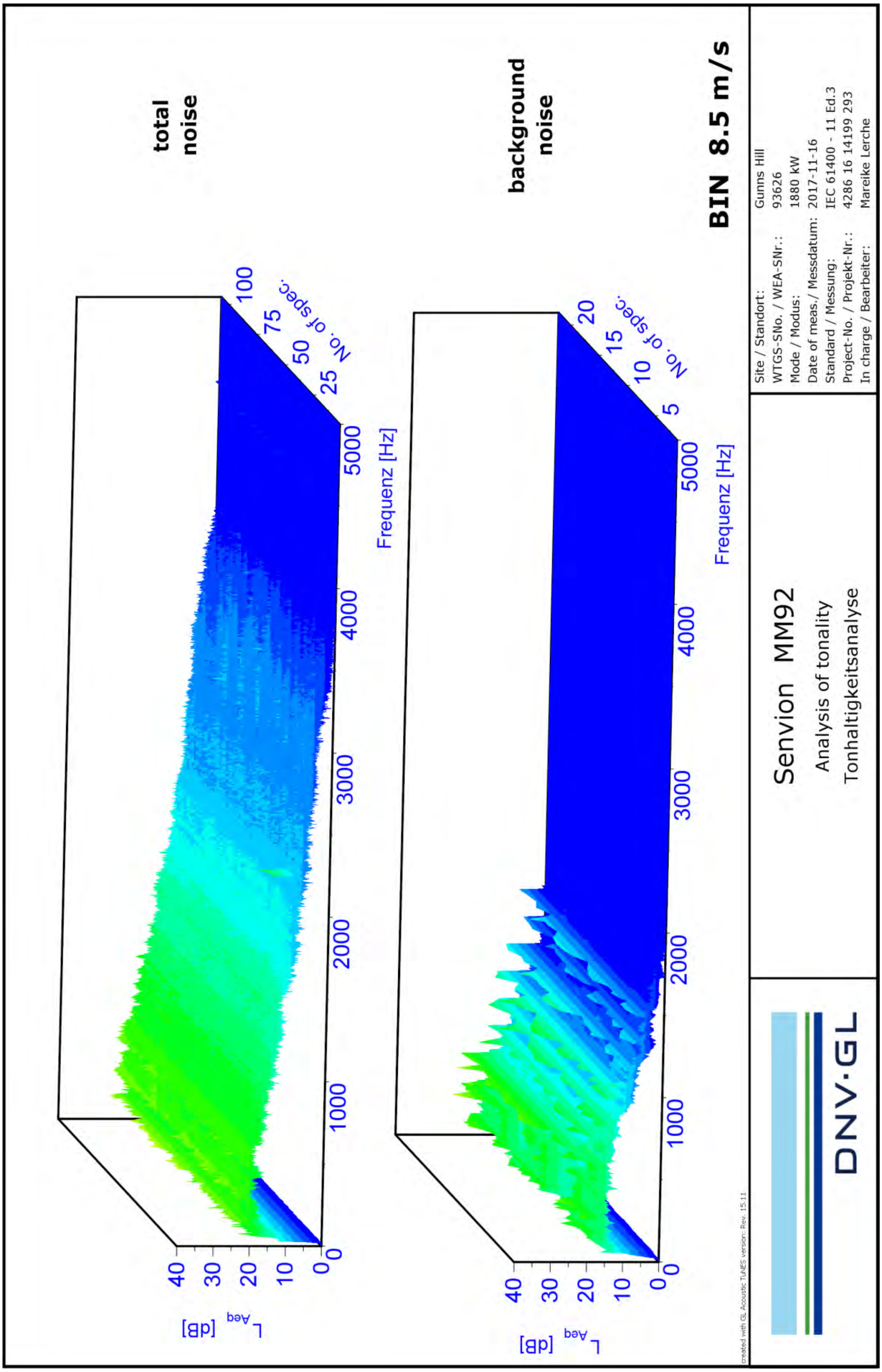
analysis of tonality / Tonhaltigkeitsanalyse

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400 - 11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

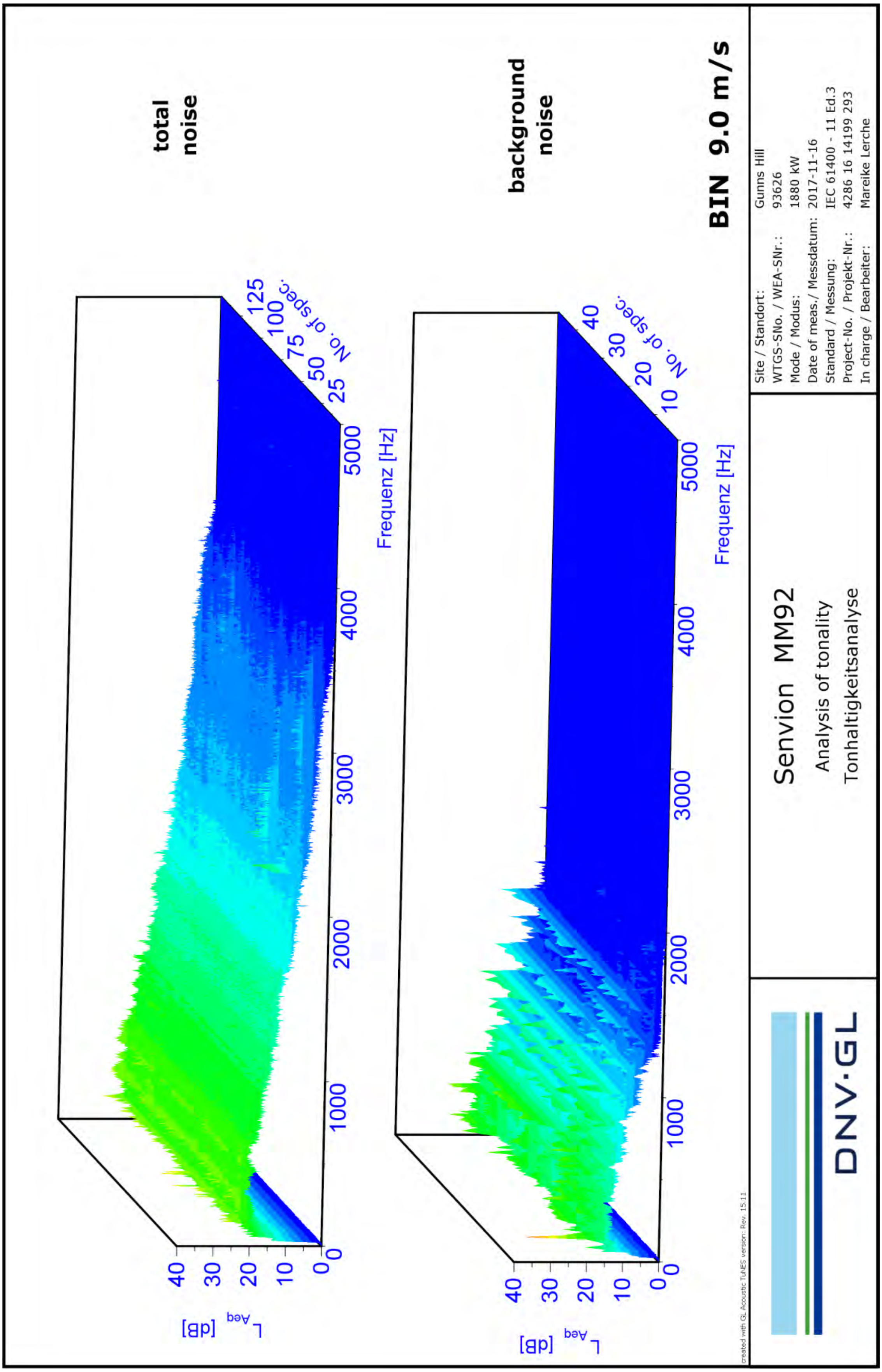
9.33 Frequency spectra of total and background noise at a WS of 8.0 m/s at hub height



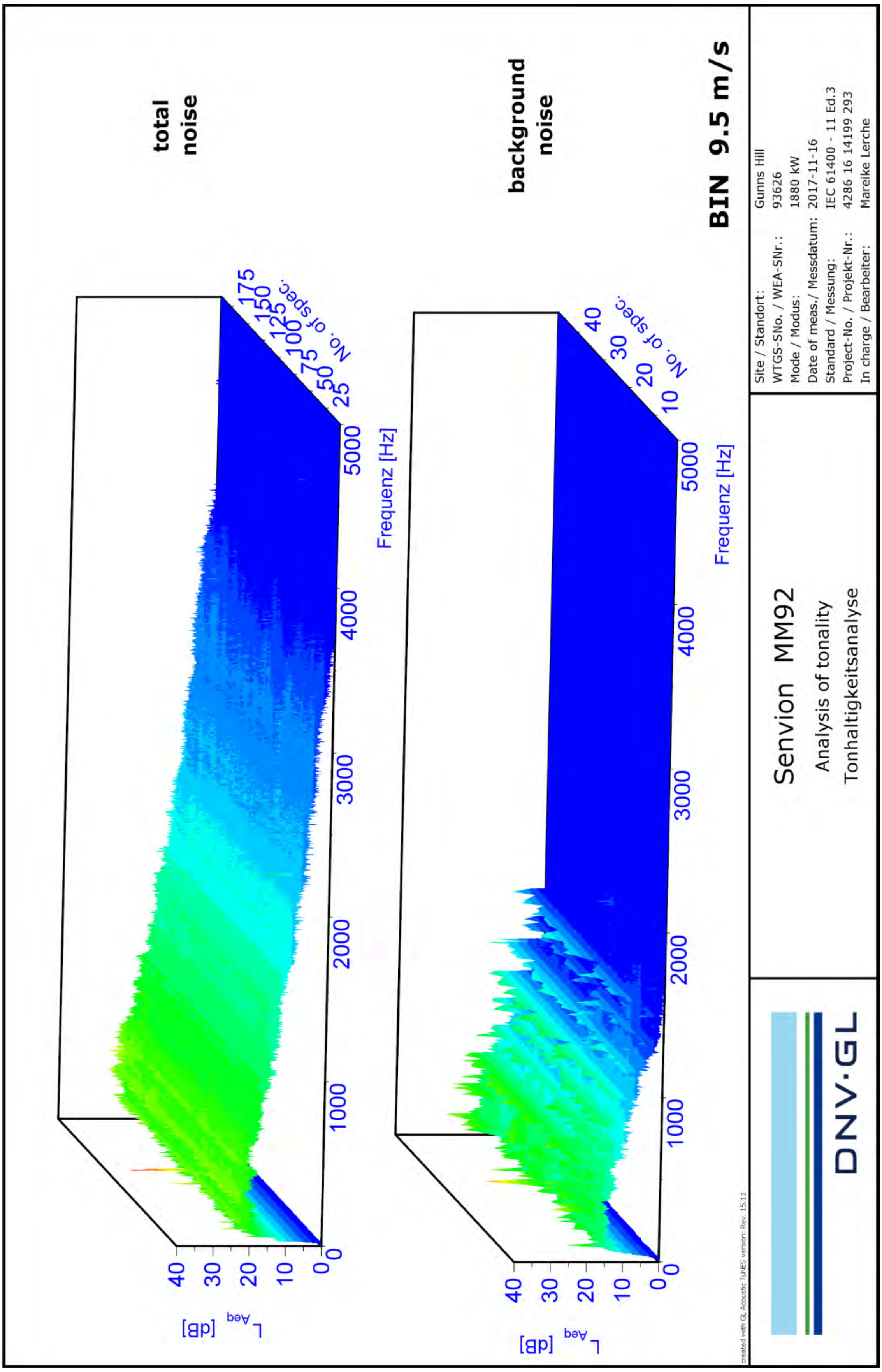
9.34 Frequency spectra of total and background noise at a WS of 8.5 m/s at hub height



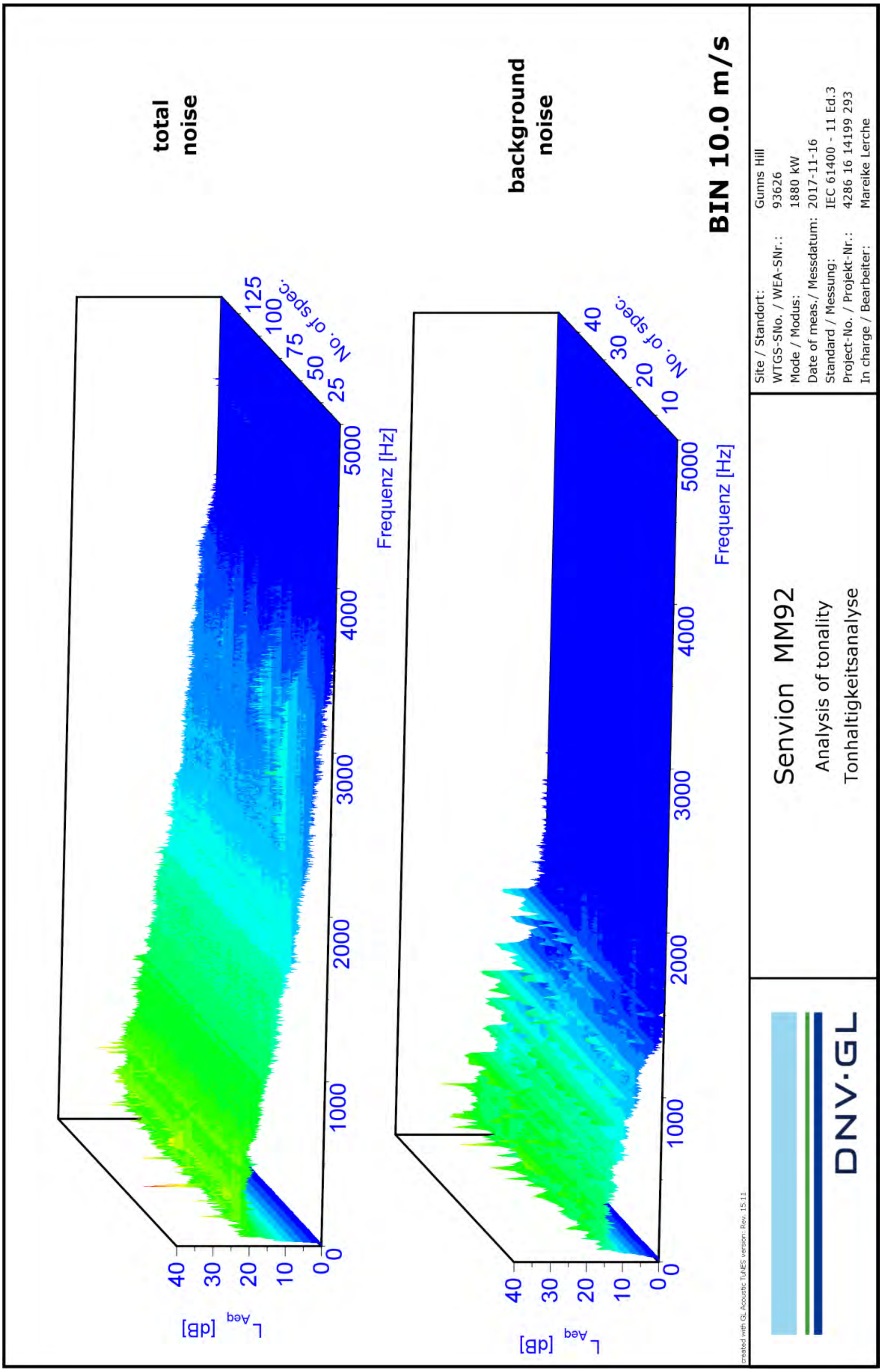
9.35 Frequency spectra of total and background noise at a WS of 9.0 m/s at hub height



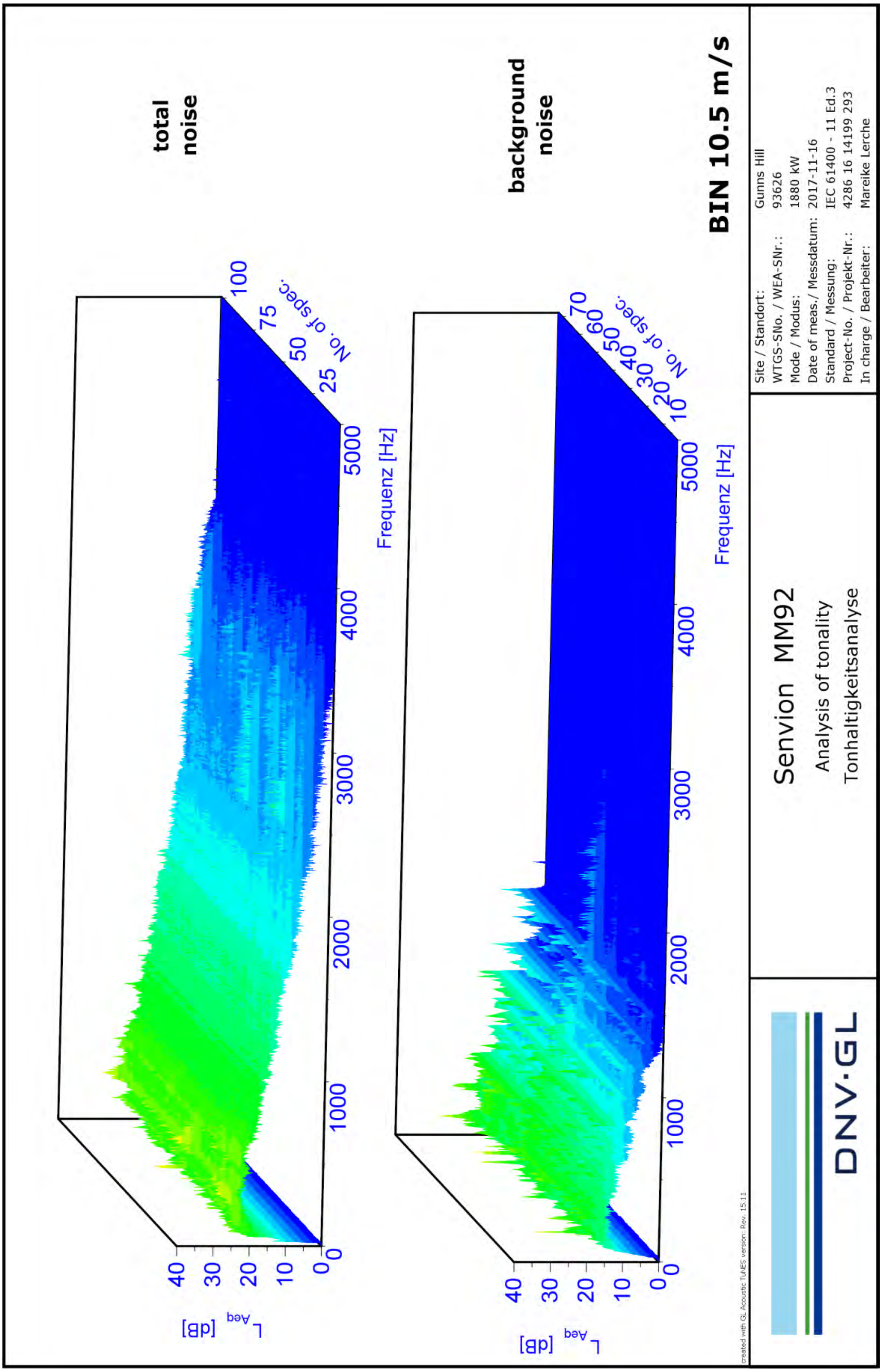
9.36 Frequency spectra of total and background noise at a WS of 9.5 m/s at hub height



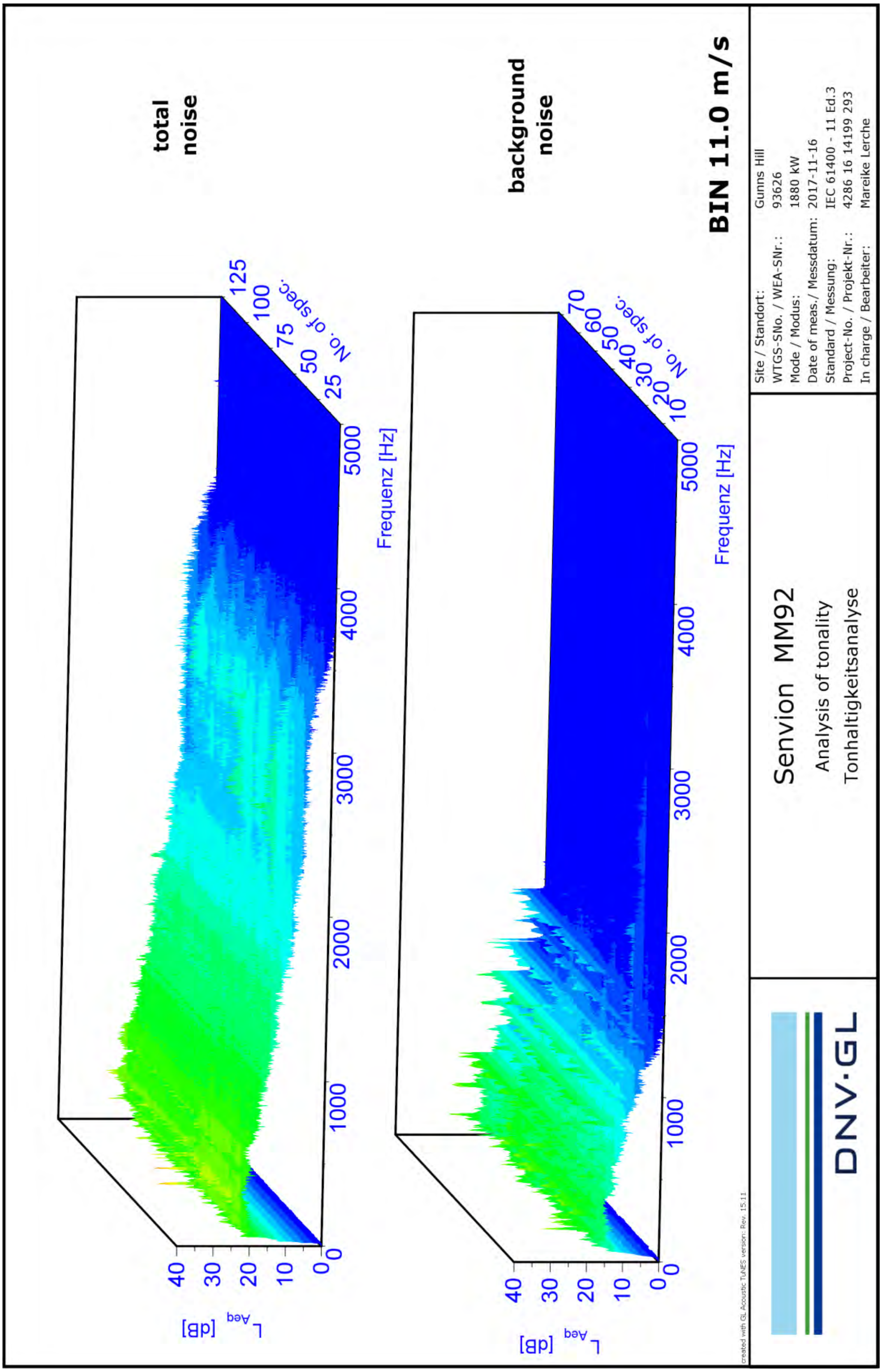
9.37 Frequency spectra of total and background noise at a WS of 10.0 m/s at hub height



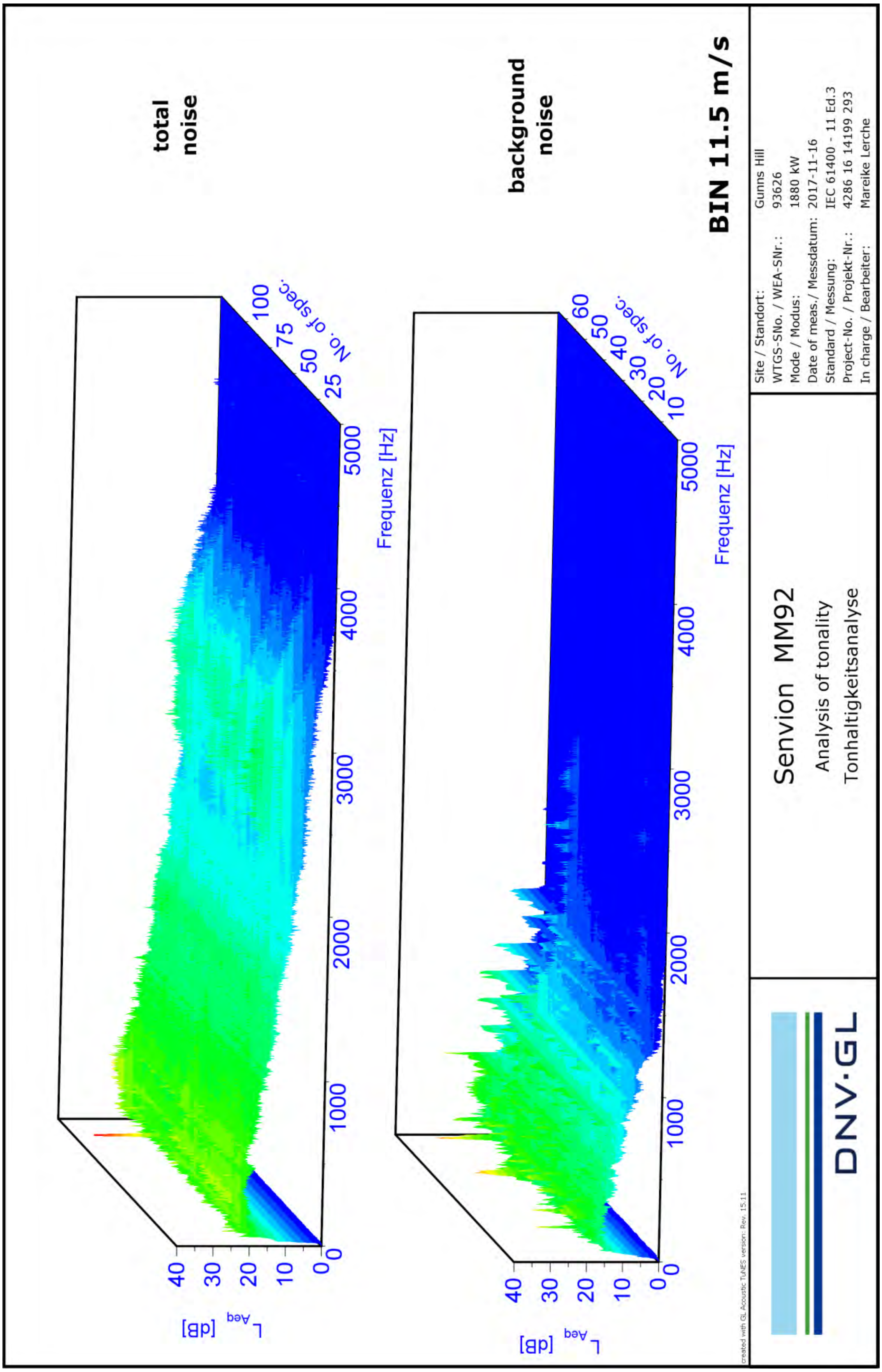
9.38 Frequency spectra of total and background noise at a WS of 10.5 m/s at hub height



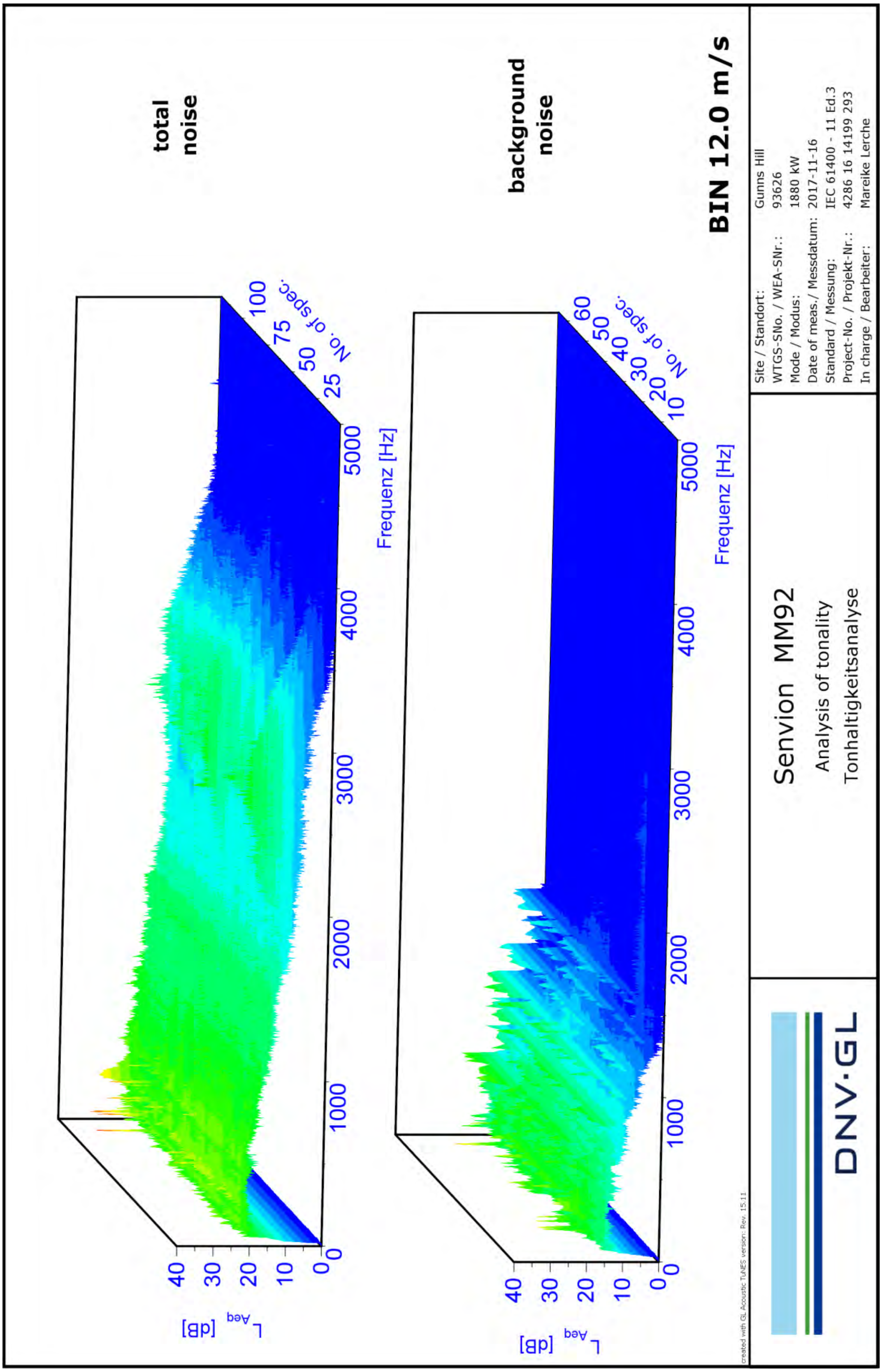
9.39 Frequency spectra of total and background noise at a WS of 11.0 m/s at hub height



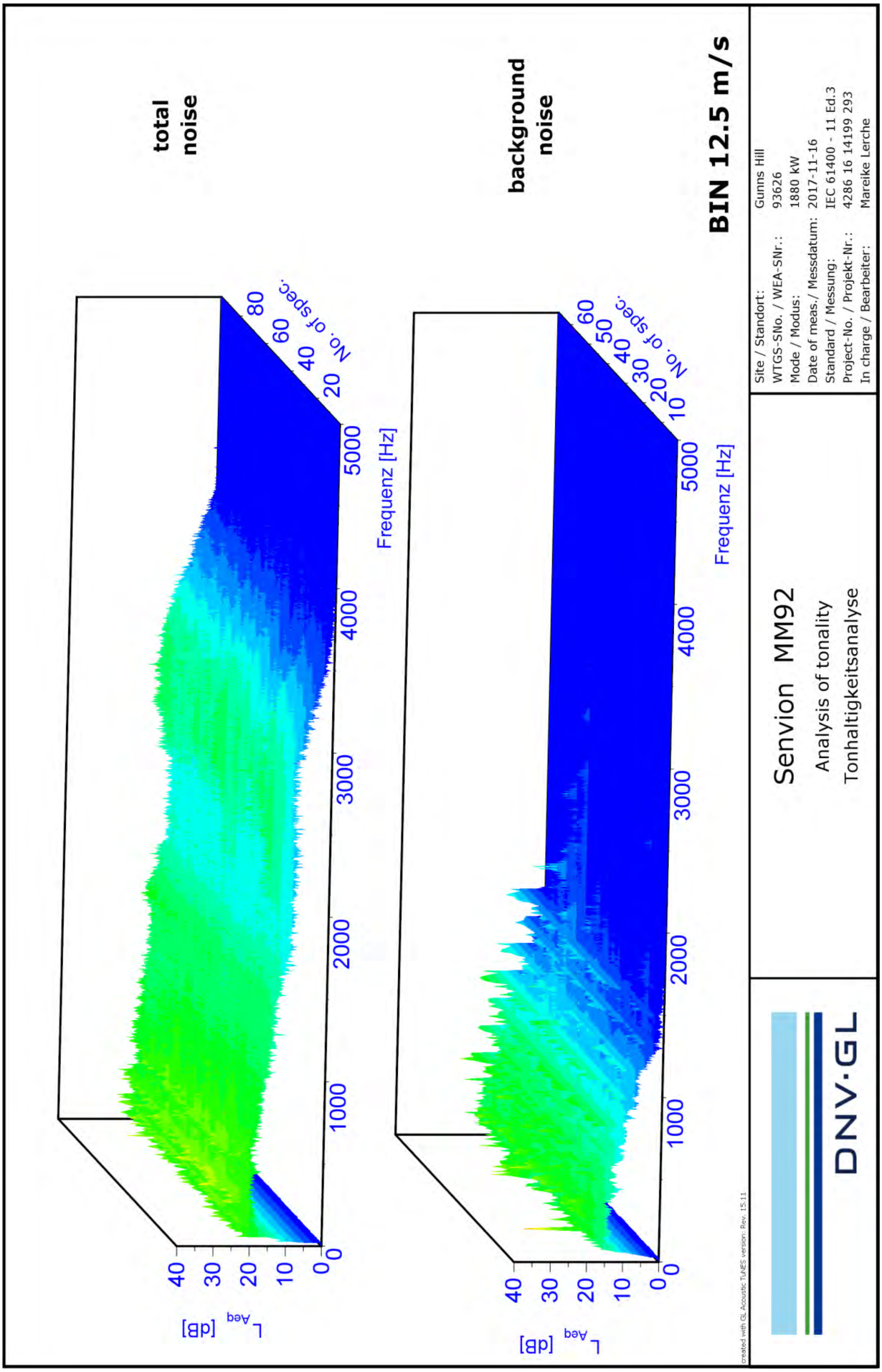
9.40 Frequency spectra of total and background noise at a WS of 11.5 m/s at hub height



9.41 Frequency spectra of total and background noise at a WS of 12.0 m/s at hub height



9.42 Frequency spectra of total and background noise at a WS of 12.5 m/s at hub height



9.43 Power curve used for the analysis (page 1)

Power Curve & Sound Power Level 102.0 dB(A) [MM92/60Hz/CCV]
Guaranteed electrical power curve and guaranteed sound power level

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3 Guaranteed electrical power curve and guaranteed sound power level

3.1 Guaranteed electrical power curve

Values related to an air density of 1.225 kg/m³

Wind speed v [m/s]	Power P [kW]	Thrust coefficient c_T [-]	Power coefficient c_P [-]
3.0	20	0.98	0.180
4.0	94	0.84	0.357
5.0	205	0.81	0.398
6.0	391	0.80	0.440
7.0	634	0.80	0.449
8.0	957	0.79	0.454
9.0	1332	0.72	0.444
10.0	1710	0.66	0.416
11.0	1880	0.49	0.343
12.0	1880	0.36	0.264
13.0	1880	0.27	0.208
14.0	1880	0.22	0.166
15.0	1880	0.18	0.135
16.0	1880	0.15	0.112
17.0	1880	0.12	0.093
18.0	1880	0.10	0.078
19.0	1880	0.09	0.067
20.0	1880	0.08	0.057
21.0	1880	0.07	0.049
22.0	1880	0.06	0.043
23.0	1880	0.05	0.038
24.0	1880	0.05	0.033

The electrical power is guaranteed for pure active power set points.

The electrical power is guaranteed on the low-voltage side of the transformer.

SD-2.12-WT.PO.01-C-D-EN

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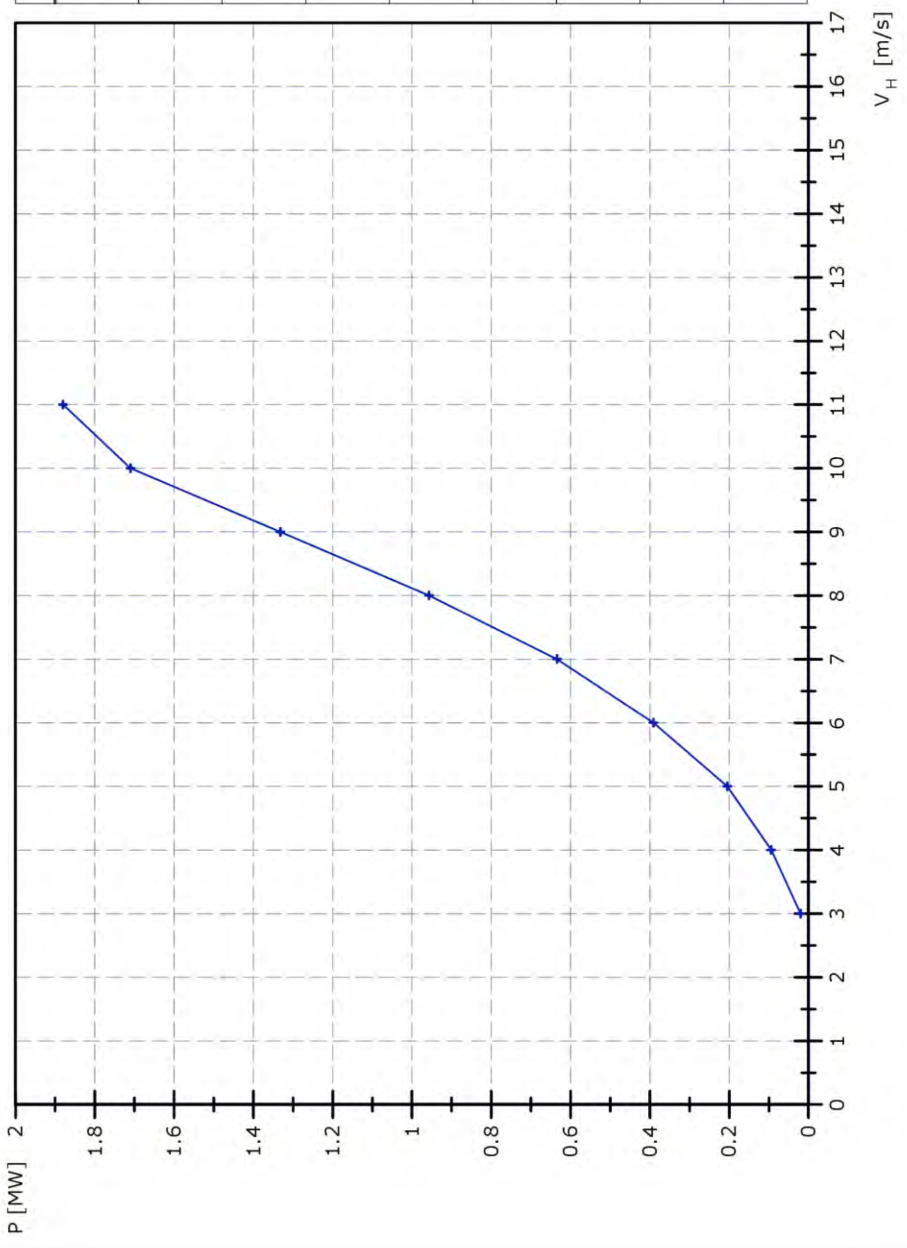
9.44 Power curve used for the analysis (page 2)

Source file: NONAME

Graphic file:

12.12.2017



V_H [m/s]	P [MW]
3	0.020
4	0.094
5	0.205
6	0.391
7	0.634
8	0.957
9	1.332
10	1.710
11	1.880

created with GL Acoustic TuNES version: Rev. 15.11

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Senvion MM92

Power curve

Leistungskurve

Site / Standort:	Gunns Hill
WTGS-SNo. / WEA-SNr.:	93626
Mode / Modus:	1880 kW
Date of meas./ Messdatum:	2017-11-16
Standard / Messung:	IEC 61400-11 Ed.3
Project-No. / Projekt-Nr.:	4286 16 14199 293
In charge / Bearbeiter:	Mareike Lerche

9.45 Manufacturer's certificate (page 1)

SENVION

Senvion Canada Inc.
1100 René-Lévesque Blvd. West, Suite 1910
Montreal, Quebec, H3B 4N4
Canada
quebec@senvion.com
www.senvion.com

Herstellerbescheinigung, Kurzfassung für akustische Nachmessungen

Manufacturer's certificate, short version for control measurements of acoustic noise

1. Allgemeine Informationen – General information		
Anlagenhersteller – turbine manufacturer:		Senvion GmbH
Spezifische Anlagenbezeichnung – specific turbine type name:		MM92
Seriennummer der vermessenden WEA – serial number of tested WT:		93626
Standort der vermessenden WEA – location of tested WT:		Gunn's Hill
Koordinaten des Standortes – coordinates of turbine location:		43.06972135115 / -80.686389040076
Rotorachse – rotor axis:	horizontal – horizontal ☒	vertikal – vertical ☐
Nennleistung – rated power:		2050 kW
Leistungsregelung – power control:	pitch ☒	stall ☐
Nabenhöhe über Grund – hub height above ground:		100 m
Nabenhöhe über Fundamentflansch – hub height above top of foundation flange:		98 m
Nennwindgeschwindigkeit – rated wind speed:		12,5 m/s
Ein- / Abschaltwindgeschwindigkeit – cut-in / cut-out wind speed:		3,0 m/s – 24,0 m/s
2. Rotor - Rotor		
Durchmesser – rotor diameter:		92,5 m
Anzahl der Blätter – number of blades:		3
Nabenart – kind of hub:	pendelnd – teetered ☐	starr – rigid ☒
Anordnung zum Turm – position relative to tower:		Luvseitig / upwind
Drehzahlbereich/Drehzahlstufen – rotor speed range/stages of rotor speed:		7,5 – 15,0 rpm
Rotorblatteinstellwinkel – rotor blade pitch setting:		variabel (0 – 91°)
Konuswinkel – cone angel:		3,5°
Achsneigung – tilt angle:		5°
Horizontaler Abstand zwischen Rotormittelpunkt und Turmmittellinie – horizontal distance between centre of rotor and tower centre line:		3150 mm
3. Rotorblatt – Rotor blade		
Hersteller – manufacturer:		Power Blades
Typenbezeichnung – type:		RE45.2
Seriennummer der Rotorblätter – serial number of rotor blades:		061 – 065 – 067
Zusatzkomponenten (z.B. strips, Vortex-Gen., Turbulatoren) – additional components (e.g. stall strips, vortex gen., trip strips):		
4. Getriebe – Gearbox		
Hersteller – manufacturer:		Eickhoff
Typenbezeichnung – type:		EBN1378 C13
Seriennummer des Getriebes – serial number of gear box:		30630
Ausführung – design:		Planeten-/Stirnradgetriebe Planetary/spur gearbox
Übersetzungsverhältnis – gear ratio:		1:96

9.46 Manufacturer's certificate (page 2)

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5. Generator – Generator	
Hersteller – manufacturer:	Siemens
Typenbezeichnung – type:	JFRA-560SR-06A
Seriennummer des Generators – serial number of generator:	6022689
Anzahl der Generatoren – number of generators:	1
Art des Generators (z.B. synchron, asynchr.) – kind of generator (e.g. synchronous, asynchr.):	doppeltgespeist, asynchrony Asynchronous double - fed
Nennleistung(en) – rated power values(s):	2080 kW
Drehzahlbereich/Drehzahlstufen – rotor speed range/stages of rotor speed:	720 – 1400 rpm
6. Turm – Tower	
Ausführung – design:	konisch – conical
Material – material:	Stahl
Durchmesser Turmfuß – foot of the tower diameter	4,3 m
7. Betriebsführung / Regelung – Control system	
Art der Leistungsregelung – kind of power control:	Pitch
Antrieb der Leistungsregelung – actuation of power control:	Elektrisch
Hersteller der Betriebsführung / Regelung – manufacturer of control system:	Bachmann
Typenbezeichnung der Betriebsführung / Regelung – control system type:	MC 210CC
Bezeichnung der verwendeten Steuerungskurve – designation of used control setup:	Standard
Bezeichnung / Messbericht der verwendeten Leistungskurve – designation of power curve report:	Standard

Datum, Stempel und Unterschrift des Herstellers
Date, manufacturer's stamp and signature

SENVION CANADA INC.
1100, boul. René-Lévesque O. #1910
Montréal, Québec
H3B 4N4

13-Dec-2017

Der Hersteller der Windenergieanlage bestätigt, dass die WEA, deren Schallemission, Leistungskurve und elektrische Eigenschaften in den Prüfberichten abgebildet sind, die o.g. Eigenschaften aufweist. – The manufacturer of the wind turbine (WT) confirms that the WT whose noise level, performance curve and power quality is measured and depicted in the test reports, shows the characteristics given above.

9.47 Measuring equipment

Beschreibung *description*	Fabrikat *supplier*	Typ *Type*	WT Nr./Ser.Nr. *WT stock number/ serial number*	letzte Kalibrierung *last calibration*	nächste Kalibrierung *next calibration*	letzte Eichung *last verification*	nächste Eichung *next verification*
Schallpegelmesser *sound level meter*	Brüel & Kjær	2238	WT300119506 (2540948)	Jul. 17	Jul. 19		
Mikrofon *microphone*	Brüel & Kjær	4188	zu WT300119506 (2760470)	gemeinsame Kalibration *common calibration*	gemeinsame Kalibration *common calibration*	gemeinsame Eichung *common verification*	gemeinsame Eichung *common verification*
Vorverstärker *preamp.*	Brüel & Kjær	ZC 0030	zu WT300119506 (-)				
Mikrofonkabel *microphone cable*	Brüel & Kjær	AO 0560	zu WT300119506 (-)				
Akustischer Kalibrator *acoustic calibrator*	Brüel & Kjær	4231	WT 300119306 (2507176)	Feb. 17	Feb. 19		

Primärwindschirm *primary wind shield*	Brüel & Kjær	UA 0237	-				
Sekundärwindschirm *secondary wind shield*	DNVGL	EWS 12A-01	GLGH-428606-336000021				

Anemometer *anemometer*	Thies Clima	4.3519.00.000	WT010062308 (1208487)	Jul. 17	Jul. 19		
Windrichtungsgeber *wind direction sensor*	Thies Clima	4.3129.00.012	WT020020208 (1208517)				
Temperaturgeber *temperature sensors*	Heraeus	PT100	428604-112000046	Okt. 14	Okt. 16		
Luftdruckgeber *pressure sensors*	Wilmers Messtechnik	0619	428612-111000049	Apr. 15	Apr. 17		
Feuchtesensor *humidity sensor*							
Niederschlagssensor *rain sensor*							

WEA Box	DNVGL		GLGH-428613-611000017	Okt. 15	Okt. 17		

Laser-Entfernungsmesser *laser distance meter*							

Erfassungsrechner *data acquisition computer*	HP	nc2400	GLGH-428612-411000095 (CNF6412953)				

Erfassungs- und Auswertesoftware *data acquisition and analytical software*	GfS Aachen Microsoft DATALOG GmbH	DIAdem 15.0 Office 365 ProPlus Dasy-Lab 10.0					

9.48 Calibration certificate of noise level meter (page 1)

Scantek, Inc.
CALIBRATION LABORATORY

ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC MRA signatory)

NVLAP®
CALIBRATION
NVLAP Lab Code: 200625-0

Calibration Certificate No.38943

Instrument:	**Sound Level Meter**
Model:	**2238**
Manufacturer:	**Brüel and Kjær**
Serial number:	**2540948**
Tested with:	**Microphone 4188 s/n 2760470** **Preamplifier ZC0030 s/n 3677**
Type (class):	**1**
ID number:	**WT 300119506**
Customer:	**GL Garrad Hassan Canada, Inc.**
Tel/Fax:	**514-716-4070 /**

Date Calibrated: **7/7/2017** *Cal Due:* **7/7/2018**

Status:	**Received**	**Sent**
In tolerance:	**X**	**X**
Out of tolerance:		
See comments:		

Contains non-accredited tests: __ **Yes** _X_ **No**

Calibration service: __ **Basic** _X_ **Standard**

Address: **4100 rue Molson Suite 100, Montreal, QC, H1Y 3N1, Canada**

Tested in accordance with the following procedures and standards:
Calibration of Sound Level Meters, Scantek Inc., Rev. 6/26/2015
SLM & Dosimeters – Acoustical Tests, Scantek Inc., Rev. 7/6/2011

Instrumentation used for calibration: Nor-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31061	Jul 27, 2016	Scantek, Inc./ NVLAP	Jul 27, 2017
DS-360-SRS	Function Generator	88077	Sep 15, 2016	ACR Env./ A2LA	Sep 15, 2018
34401A-Agilent Technologies	Digital Voltmeter	MY47011118	Sep 15, 2016	ACR Env./ A2LA	Sep 15, 2017
HM30-Thommen	Meteo Station	1040170/39633	Nov 1, 2016	ACR Env./ A2LA	Nov 1, 2017
PC Program 1019 Norsonic	Calibration software	v.6.1T	Validated Nov 2014	Scantek, Inc.	-
1251-Norsonic	Calibrator	30878	Nov 10, 2016	Scantek, Inc./ NVLAP	Nov 10, 2017

Instrumentation and test results are traceable to SI (International System of Units) through standards maintained by NIST (USA) and NPL (UK).

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
21.8	99.52	58.2

Calibrated by:	Jeremy Gotwalt	**Authorized signatory:**	Steven E. Marshall
Signature	*[signature]*	Signature	*[signature]*
Date	7/7/17	Date	7/10/2017

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.
This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.
Document stored Z:\Calibration Lab\SLM 2017\BNK2238_2540948_WT 300119506_M1.doc

Page 1 of 2

Scanned by CamScanner

Results summary: Device complies with following clauses of mentioned specifications:

CLAUSES [1] FROM IEC/ANSI STANDARDS REFERENCED IN PROCEDURES:	RESULT[2,3]	EXPANDED UNCERTAINTY (coverage factor 2) [dB]
SELF-GENERATED NOISE - IEC 61672-3 ED.2 CLAUSE 11	Passed	0.3
FREQUENCY WEIGHTINGS: A NETWORK - IEC 61672-3 ED.2.0 CLAUSE 13	Passed	0.2
FREQUENCY WEIGHTINGS: C NETWORK - IEC 61672-3 ED.2.0 CLAUSE 13	Passed	0.2
FREQUENCY WEIGHTINGS: Z NETWORK - IEC 61672-3 ED.2.0 CLAUSE 13 (ACTUALLY LIN NETWORK)	Passed	0.2
FREQUENCY AND TIME WEIGHTINGS AT 1 KHZ IEC 61672-3 ED.2.0 CLAUSE 14	Passed	0.2
LEVEL LINEARITY ON THE REFERENCE LEVEL RANGE - IEC 61672-3 ED.2 CLAUSE 16	Passed	0.25
LEVEL LINEARITY INCLUDING THE LEVEL RANGE CONTROL - IEC 61672-3 ED.2.0 CLAUSE 17	Passed	0.25
TONEBURST RESPONSE - IEC 61672-3 ED.2.0 CLAUSE 18	Passed	0.3
PEAK C SOUND LEVEL - IEC 61672-3 ED.2.0 CLAUSE 19	Passed	0.35
OVERLOAD INDICATION - IEC 61672-3 ED.2.0 CLAUSE 20	Passed	0.25
HIGH LEVEL STABILITY TEST - IEC 61672-3 ED.2.0 CLAUSE 21	Passed	0.1
LONG TERM STABILITY TEST - IEC 61672-3 ED.2.0 CLAUSE 15	Passed	0.1
COMBINED ELECTRICAL AND ACOUSTICAL TEST - IEC 61672-3 ED.2.0 CLAUSE 13	Passed	See test report

1 The results of this calibration apply only to the instrument type with serial number identified in this report.

2 Parameters are certified at actual environmental conditions.

3 The tests marked with (*) are not covered by the current NVLAP accreditation.

Comments: The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organization responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2, to demonstrate that the model of sound level meter fully conforms to the requirements in the IEC 61672-2, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1.

Note: The instrument was tested for the parameters listed in the table above, using the test methods described in the listed standards. All tests were performed around the reference conditions. The test results were compared with the manufacturer's or with the standard's specifications, whichever are larger.
Compliance with any standard cannot be claimed based solely on the periodic tests.

Tests made with the following attachments to the instrument:

Microphone:	Brüel & Kjær 4188 s/n 2760470 for acoustical test
Preamplifier:	Brüel & Kjær ZC0030 s/n 3677 for all tests
Other:	line adaptor ADP005 (18pF) for electrical tests. Microphone cable B&K AO 0560-D-100 used for all tests.
Accompanying acoustical calibrator:	none
Windscreen:	none

Measured Data: in Test Report # 38943 of 7+1 pages.

Place of Calibration: Scantek, Inc.
6430 Dobbin Road, Suite C
Columbia, MD 21045 USA

Ph/Fax: 410-290-7726/ -9167
callab@scantekinc.com

Calibration Certificates or Test Reports shall not be reproduced, except in full, without written approval of the laboratory.
This Calibration Certificate or Test Reports shall not be used to claim product certification, approval or endorsement by NVLAP, NIST, or any agency of the federal government.

Document stored Z:\Calibration Lab\SLM 2017\BNK2238_2540948_WT 300119506_M1.doc

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9.50 Calibration certificate of microphone (page 1)

Scantek, Inc.
CALIBRATION LABORATORY
ISO 17025: 2005, ANSI/NCSL Z540:1994 Part 1
ACCREDITED by NVLAP (an ILAC MRA signatory)

NVLAP®
CALIBRATION
NVLAP Lab Code: 200625-0

Calibration Certificate No.38944

Instrument: **Microphone**
Model: **4188**
Manufacturer: **Brüel & Kjær**
Serial number: **2760470**
Composed of:

Date Calibrated: **7/7/2017** *Cal Due:* **7/7/2018**

Status:	Received	Sent
In tolerance:	X	X
Out of tolerance:		
See comments:		

Contains non-accredited tests: __Yes _X_ No

Customer: **GL Garrad Hassan Canada, Inc.**
Tel/Fax: **514-716-4070/**
Address: **4100 rue Molson Suite 100 Montreal, QC, H1Y 3N1, Canada**

Tested in accordance with the following procedures and standards:
Calibration of Measurement Microphones, Scantek, Inc., Rev. 2/25/2015

Instrumentation used for calibration: N-1504 Norsonic Test System:

Instrument - Manufacturer	Description	S/N	Cal. Date	Traceability evidence Cal. Lab / Accreditation	Cal. Due
483B-Norsonic	SME Cal Unit	31061	Jul 27, 2016	Scantek, Inc./ NVLAP	Jul 27, 2017
DS-360-SRS	Function Generator	88077	Sep 15, 2016	ACR Env./ A2LA	Sep 15, 2018
34401A-Agilent Technologies	Digital Voltmeter	MY47011118	Sep 15, 2016	ACR Env./ A2LA	Sep 15, 2017
HM30-Thommen	Meteo Station	1040170/39633	Nov 1, 2016	ACR Env./ A2LA	Nov 1, 2017
PC Program 1017 Norsonic	Calibration software	v.6.1T	Validated Nov 2014	Scantek, Inc.	-
1253-Norsonic	Calibrator	28326	Nov 10, 2016	Scantek, Inc./ NVLAP	Nov 10, 2017
1203-Norsonic	Preamplifier	92268	Oct 17, 2016	Scantek, Inc./ NVLAP	Oct 17, 2017
4180-Brüel&Kjær	Microphone	2246115	Oct 26, 2015	NPL-UK / UKAS	Oct 26, 2017

Instrumentation and test results are traceable to SI - BIPM through standards maintained by NPL (UK) and NIST (USA)

Calibrated by:	Jeremy Gotwalt	**Authorized signatory:**	Steven E. Marshall
Signature	[signature]	Signature	[signature]
Date	7/7/17	Date	7/10/2017

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9.51 Calibration certificate of microphone (page 2)

Results summary: Device was tested and complies with following clauses of mentioned specifications:

CLAUSES / METHODS[1] FROM PROCEDURES		MET[2,3]	NOT MET	NOT TESTED	MEASUREMENT EXPANDED UNCERTAINTY (coverage factor 2)
Open circuit sensitivity (insert voltage method, 250 Hz)		X			See below
Frequency response	Actuator response	X			63 – 200Hz: 0.3 dB 200 – 8000 Hz: 0.2 dB 8 – 10 kHz: 0.5 dB 10 – 20 kHz: 0.7 dB 20 – 50 kHz: 0.9 dB 50 – 100 kHz: 1.2 dB
	FF/Diffuse field responses	X			63 – 200Hz: 0.3 dB 200 – 4000 Hz: 0.2 dB 4 – 10 kHz: 0.6 dB 10 – 20 kHz: 0.9 dB 20 – 50 kHz: 2.2 dB 50 – 100 kHz: 4.4 dB
	Scantek, Inc. acoustical method			X	31.5 – 125 Hz: 0.16 dB 250, 1000 Hz: 0.12 dB 2 – 8 kHz: 0.8 dB 12.5 – 16 kHz: 2.4 dB

1 The results of this calibration apply only to the instrument type with serial number identified in this report.
2 Results are normalized to the reference conditions.
3 The tests marked with (*) are not covered by the current NVLAP accreditation.

Note: The free field/diffuse field characteristics were calculated based on the measured actuator response and adjustment coefficients as provided by the manufacturer. The uncertainties reported for these characteristics may include assumed uncertainty components for the adjustment coefficients.

Comments:	The instrument was tested and met all specifications found in the referenced procedures.

Environmental conditions:

Temperature (°C)	Barometric pressure (kPa)	Relative Humidity (%)
21.8 ± 1.0	99.52 ± 0.020	58.2 ± 2.0

Main measured parameters:

Tone frequency (Hz)	Measured[4]/Acceptable Open circuit sensitivity (dB re 1V/Pa)	Sensitivity (mV/Pa)
250	-29.87 ± 0.12/ -30.0 ±2.0	32.11

4 The reported expanded uncertainty is calculated with a coverage factor k=2.00

Tests made with following attachments to instrument and auxiliary devices:

Protection grid mounted for sensitivity measurements
Actuator type: G.R.A.S. RA0014

Measured Data: Found on Microphone Test Report # 38944 of one page.

Place of Calibration: Scantek, Inc.
6430 Dobbin Road, Suite C
Columbia, MD 21045 USA
Ph/Fax: 410-290-7726/ -9167
callab@scantekinc.com

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9.52 Calibration certificate of calibrator (page 1)

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden

Kalibriersysteme · Spezialausrüstungen · DAkkS Laboratorium · Umweltsimulation

akkreditiert durch die / *accredited by the*

Deutsche Akkreditierungsstelle GmbH

als Kalibrierlaboratorium im / *as calibration laboratory in the*

Deutschen Kalibrierdienst DKD

DAkkS Deutsche Akkreditierungsstelle D-K-15183-01-00

Kalibrierschein
Calibration Certificate

Kalibrierzeichen
Calibration mark

0610
D-K-15183-01-00
2017-02

Gegenstand *Object*	**Schallpegelkalibrator**
Hersteller *Manufacturer*	**Brüel & Kjaer**
Typ *Type*	**4231**
Fabrikat/Serien-Nr. *Serial number*	**2507176** **300119306**
Auftraggeber *Customer*	**GL Garrad Hassan Deutschland GmbH** **DE-25709 Kaiser-Wilhelm-Koog**
Auftragsnummer *Order No.*	**170241**
Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate*	**2**
Datum der Kalibrierung *Date of calibration*	**13.02.2017**

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multi-lateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung sowohl der Deutschen Akkreditierungsstelle GmbH als auch des ausstellenden Kalibrierlaboratoriums. Kalibrierscheine ohne Unterschrift haben keine Gültigkeit.
This calibration certificate may not be reproduced other than in full except with the permission of both the Deutsche Akkreditierungsstelle GmbH and the issuing laboratory. Calibration certificates without signature are not valid.

Datum *Date*	Stellv. Leiter des Kalibrierlaboratoriums *Deputy head of the calibration laboratory*	Bearbeiter *Person in charge*
13.02.2017	Mario Gutbier	H.-G. Uszakiewicz

DK17-0610/2

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

9.53 Calibration certificate of calibrator (page 2)

Seite 2 zum Kalibrierschein vom 13.02.2017
Page of calibration certificate dated

0610
D-K-15183-01-00
2017-02

1. Kalibriergegenstand

Gegenstand:	Hersteller:	Typ:	Serien-Nr:
Schallpegelkalibrator	**Brüel & Kjaer**	**4231**	**2507176**

2. Kalibrierverfahren

Die Kalibrierung erfolgte durch Vergleich der Anzeige des erzeugten Schalldruckpegels des Kalibriergegenstandes mit der eines auf das nationale Normal rückgeführten akustischen Kalibrators an einer Normalmesseinrichtung.

3. Umgebungsbedingungen

Umgebungstemperatur des Prüflings:	**(21,4 ± 1) °C**
Relative Luftfeuchte:	**(35 ± 5) %**
Statischer Luftdruck:	**(1005,1 ± 1) hPa**

4. Messunsicherheit

Die relativen Messunsicherheiten für die ausgewiesenen Werte betragen:

- bei Ermittlung des Schalldruckpegels	**0,1 dB**
- bei Ermittlung der Schallfrequenz	**0,1 Hz**
- bei Ermittlung des Klirrfaktors	**0,2 %**

Angegeben ist die erweiterte Messunsicherheit, die sich aus der Standardmessunsicherheit durch Multiplikation mit dem Erweiterungsfaktor k = 2 ergibt. Sie wurde gemäß DAkkS-DKD-3 ermittelt. Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95 % im zugeordneten Werteintervall.

5. Bestandteile der Normalmesseinrichtung

	Hersteller	Typ	Serien-Nr.
Vergleichsnormal	Brüel & Kjaer	4231	2501479
Messmikrofonkapsel	Brüel & Kjaer	4192	2802765 with GRID
Mikrofonvorverstärker	Microtech Gefell	MV203	0173
Kalibriersystem	SPEKTRA	CS18 AK 2	200717

6. Ergebnisse

6.1 Schalldruckpegel, Frequenz, Klirrfaktor

Schalldruckpegel:	Sollwert	94,00 dB	114,00 dB
	Messwert	**94,03 dB**	**114,03 dB**
	Abweichung	0,03 dB	0,03 dB
	Pegelschwankung	< 0,01 dB	< 0,01 dB
Schallfrequenz:	Sollwert	1000,0 Hz	1000,0 Hz
	Messwert	**1000,0 Hz**	**1000,0 Hz**
	Abweichung	0,00 %	0,00 %
Klirrfaktor:	**Messwert**	**0,3 %**	**0,4 %**
Bezugsschalldruck:		20 µPa	

DK17-0610/2

SPEKTRA Schwingungstechnik und Akustik GmbH Dresden
Heidelberger Str. 12, DE-01189 Dresden - Tel. (0351) 4 00 24 31

9.54 Test report of noise level meter calibration (page 1)

Summary of Test Report No.:38943

Brüel and Kjær Type: 2238 Serial no: 2540948_WT 300119506

Customer:	**GL Garrad Hassan Canada, Inc.**
Address:	**4100 rue Molson Suite 100, Montreal, QC, H1Y 3N1, Canada**
Contact Person:	**Sergio Roldan**
Phone No.:	**514-716-4070**

Instrument software version: 1.2.0

Microphone:	Brüel & Kjær	Type: 4188	Serial no: 2760470	Sens:-29.87dB
Preamplifier	Brüel & Kjær	Type: ZC0030	Serial no: 3677	
Microphone cable	Brüel & Kjær	Type: AO-0560-D-100		

Measurement Results:

Indication at the calibration check frequency - IEC61672-3 Ed.2 Clause 10	Passed
Self-generated noise - IEC 61672-3 Ed.2 Clause 11	Passed
Frequency weightings: A Network - IEC 61672-3 Ed.2.0 Clause 13	Passed
Frequency weightings: C Network - IEC 61672-3 Ed.2.0 Clause 13	Passed
Frequency weightings: Z Network - IEC 61672-3 Ed.2.0 Clause 13 (Actually Lin network)	Passed
Frequency and time weightings at 1 kHz IEC 61672-3 Ed.2.0 Clause 14	Passed
Level linearity on the reference level range - IEC 61672-3 Ed.2 Clause 16	Passed
Level linearity including the level range control - IEC 61672-3 Ed.2.0 Clause 17	Passed
Toneburst response - IEC 61672-3 Ed.2.0 Clause 18	Passed
Peak C sound level - IEC 61672-3 Ed.2.0 Clause 19	Passed
Overload indication - IEC 61672-3 Ed.2.0 Clause 20	Passed
High level stability test - IEC 61672-3 Ed.2.0 Clause 21	Passed
Long term stability test - IEC 61672-3 Ed.2.0 Clause 15	Passed
Combined electrical and acoustical test - IEC 61672-3 Ed.2.0 Clause 13	Passed

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
99.39	22.3	57.5

Date of calibration: 7/7/2017
Date of issue: 7/7/2017
Supervisor: Steven E. Marshall
Measurements performed by:

Jeremy Gotwalt

Software version: 6.1 T

Scantek, Inc.
6430 Dobbin Rd., Suite C, Columbia, MD 21045
Ph: 410-290-7726 eMail: callab@scantekinc.com

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9.55 Test report of noise level meter calibration (page 2)

Test Report No.:38943

Manufacturer:	Brüel and Kjær
Instrument type:	2238
Serial no:	2540948_WT 300119506
Customer:	GL Garrad Hassan Canada, Inc.
Department:	
Order No:	
Contact Person:	Sergio Roldan
Address:	4100 rue Molson Suite 100, Montreal, QC, H1Y 3N1, Canad

Environmental conditions:

Pressure:	99.39
Temperature:	22.3
Relative humidity:	57.5

Supervisor	Steven E. Marshall
Engineer	Jeremy Gotwalt
Date:	7/7/2017

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9.56 Test report of noise level meter calibration (page 3)

Measurement Results:

Indication at the calibration check frequency - IEC61672-3 Ed.2 Clause 10

Reference Calibrator: WSC4 - NOR1251-30878
Reference calibrator level: 114.00
Before calibration:
  Environmental corrections: 0.00
  Other corrections: -0.11
  Notional level: 113.89
Reference calibrator level before calibration: 113.8
After calibration:
  Environmental corrections: 0.00
  Other corrections: -0.11
  Notional level: 113.89
Reference calibrator level after calibration: 113.9
Associated Calibrator: - -
Associated calibrator level: Not calibrated
Test Passed

Self-generated noise - IEC 61672-3 Ed.2 Clause 11

Network	Level (dB)	Max (dB)	Uncert. (dB)	Result	Comment
A	11.1	18.0	0.3	P	Equivalent capacity
C	12.8	19.0	0.3	P	Equivalent capacity
Z (Lin)	17.5	24.0	0.3	P	Equivalent capacity

Test Passed

Frequency weightings: A Network - IEC 61672-3 Ed.2.0 Clause 13

Freq (Hz)	Ref. (dB)	Meas. (dB)	Tol. (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result
63.1	85.0	85.2	1.0	-1.0	0.2	0.2	P
125.9	85.0	85.1	1.0	-1.0	0.2	0.1	P
251.2	85.0	85.0	1.0	-1.0	0.2	0.0	P
501.2	85.0	85.0	1.0	-1.0	0.2	0.0	P
1000.0	85.0	84.9	0.7	-0.7	0.2	-0.1	P
1995.3	85.0	84.6	1.0	-1.0	0.2	-0.4	P
3981.1	85.0	84.8	1.0	-1.0	0.2	-0.2	P
7943.3	85.0	85.5	1.5	-2.5	0.2	0.5	P
15848.9	85.0	85.8	2.5	-16.0	0.2	0.8	P

Test Passed

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9.57 Test report of noise level meter calibration (page 4)

Frequency weightings: C Network - IEC 61672-3 Ed.2.0 Clause 13

Freq (Hz)	Ref. Level (dB)	Meas. Value (dB)	Tol. (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result
63.1	85.0	85.2	1.0	-1.0	0.2	0.2	P
125.9	85.0	85.2	1.0	-1.0	0.2	0.2	P
251.2	85.0	85.1	1.0	-1.0	0.2	0.1	P
501.2	85.0	85.1	1.0	-1.0	0.2	0.1	P
1000.0	85.0	84.9	0.7	-0.7	0.2	-0.1	P
1995.3	85.0	84.6	1.0	-1.0	0.2	-0.4	P
3981.1	85.0	84.7	1.0	-1.0	0.2	-0.3	P
7943.3	85.0	85.4	1.5	-2.5	0.2	0.4	P
15848.9	85.0	85.7	2.5	-16.0	0.2	0.7	P

Test Passed

Frequency weightings: Z Network - IEC 61672-3 Ed.2.0 Clause 13 (Actually Lin network)

Freq (Hz)	Ref. Level (dB)	Meas. Value (dB)	Tol. (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result
63.1	85.0	85.2	1.0	-1.0	0.2	0.2	P
125.9	85.0	85.2	1.0	-1.0	0.2	0.2	P
251.2	85.0	85.2	1.0	-1.0	0.2	0.2	P
501.2	85.0	85.1	1.0	-1.0	0.2	0.1	P
1000.0	85.0	85.0	0.7	-0.7	0.2	0.0	P
1995.3	85.0	84.6	1.0	-1.0	0.2	-0.4	P
3981.1	85.0	84.9	1.0	-1.0	0.2	-0.1	P
7943.3	85.0	85.7	1.5	-2.5	0.2	0.7	P
15848.9	85.0	85.7	2.5	-16.0	0.2	0.7	P

Test Passed

Frequency and time weightings at 1 kHz IEC 61672-3 Ed.2.0 Clause 14

Weightings Time	Netw	Ref. (dB)	Measured (dB)	Tol. (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result
Fast	A	94.0	94.0	0.1	-0.1	0.2	0.0	P
Fast	C	94.0	94.0	0.1	-0.1	0.2	0.0	P
Slow	A	94.0	94.1	0.1	-0.1	0.2	0.1	P
Leq	A	94.0	94.1	0.1	-0.1	0.2	0.1	P
SEL	A	104.0	104.1	0.1	-0.1	0.2	0.1	P

Test Passed

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9.58 Test report of noise level meter calibration (page 4)

Level linearity on the reference level range - IEC 61672-3 Ed.2 Clause 16

Full scale setting: 130dB

The following measurements are SPL measurements

Ref. (dB)	Measured (dB)	Tol. (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result
Measured at 31.5 Hz						
84.0	84.0	0.8	-0.8	0.25	0.0	P
86.6	86.6	0.8	-0.8	0.25	0.0	P
84.0	84.1	0.8	-0.8	0.25	0.1	P
79.0	79.2	0.8	-0.8	0.25	0.2	P
74.0	74.1	0.8	-0.8	0.25	0.1	P
69.0	69.3	0.8	-0.8	0.25	0.3	P
64.0	64.2	0.8	-0.8	0.25	0.2	P
59.0	58.9	0.8	-0.8	0.25	-0.1	P
54.0	54.3	0.8	-0.8	0.25	0.3	P
53.0	53.1	0.8	-0.8	0.25	0.1	P
52.0	52.2	0.8	-0.8	0.25	0.2	P
51.0	51.1	0.8	-0.8	0.25	0.1	P
50.0	50.2	0.8	-0.8	0.25	0.2	P
Measured at 1 kHz						
94.0	94.0	0.8	-0.8	0.25	0.0	P
99.0	99.0	0.8	-0.8	0.25	0.0	P
104.0	104.0	0.8	-0.8	0.25	0.0	P
109.0	109.0	0.8	-0.8	0.25	0.0	P
114.0	114.0	0.8	-0.8	0.25	0.0	P
119.0	119.0	0.8	-0.8	0.25	0.0	P
124.0	123.9	0.8	-0.8	0.25	-0.1	P
126.0	125.9	0.8	-0.8	0.25	-0.1	P
94.0	94.0	0.8	-0.8	0.25	0.0	P
89.0	89.0	0.8	-0.8	0.25	0.0	P
84.0	84.0	0.8	-0.8	0.25	0.0	P
79.0	79.0	0.8	-0.8	0.25	0.0	P
74.0	74.1	0.8	-0.8	0.25	0.1	P
69.0	69.1	0.8	-0.8	0.25	0.1	P
64.0	64.3	0.8	-0.8	0.25	0.3	P
59.0	59.1	0.8	-0.8	0.25	0.1	P
54.0	54.2	0.8	-0.8	0.25	0.2	P
53.0	53.1	0.8	-0.8	0.25	0.1	P
52.0	52.1	0.8	-0.8	0.25	0.1	P
51.0	51.1	0.8	-0.8	0.25	0.1	P
50.0	50.1	0.8	-0.8	0.25	0.1	P
Measured at 8 kHz						
94.0	94.0	0.8	-0.8	0.25	0.0	P
99.0	99.0	0.8	-0.8	0.25	0.0	P
104.0	104.0	0.8	-0.8	0.25	0.0	P
109.0	109.0	0.8	-0.8	0.25	0.0	P
114.0	114.0	0.8	-0.8	0.25	0.0	P
119.0	119.0	0.8	-0.8	0.25	0.0	P
124.9	124.8	0.8	-0.8	0.25	-0.1	P
94.0	94.0	0.8	-0.8	0.25	0.0	P
89.0	89.0	0.8	-0.8	0.25	0.0	P
84.0	84.0	0.8	-0.8	0.25	0.0	P
79.0	79.0	0.8	-0.8	0.25	0.0	P
74.0	74.0	0.8	-0.8	0.25	0.0	P
69.0	69.1	0.8	-0.8	0.25	0.1	P
64.0	64.1	0.8	-0.8	0.25	0.1	P
59.0	59.1	0.8	-0.8	0.25	0.1	P
54.0	54.1	0.8	-0.8	0.25	0.1	P

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Level linearity on the reference level range - IEC 61672-3 Ed.2 Clause 16

Ref. (dB)	Measured (dB)	Tol. (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result
53.0	53.2	0.8	-0.8	0.25	0.2	P
52.0	52.2	0.8	-0.8	0.25	0.2	P
51.0	51.2	0.8	-0.8	0.25	0.2	P
50.0	50.2	0.8	-0.8	0.25	0.2	P

Test Passed

Level linearity including the level range control - IEC 61672-3 Ed.2.0 Clause 17

Full Scale (dB)	Ref. Value (dB)	Measured Value (dB)	Tol. Value (dB)	Uncert. (dB)	Dev. (dB)	Result
Measured at 1 kHz						
The following measurements are SPL measurements						
Measuring the reference level on the available ranges.						
140	94.0	94.0	0.8	0.25	0.0	P
130	94.0	94.0	0.8	0.25	0.0	P
120	94.0	94.0	0.8	0.25	0.0	P
110	94.0	94.0	0.8	0.25	0.0	P
100	94.0	93.9	0.8	0.25	-0.1	P
Measuring 5 dB below full scale on all available ranges.						
140	135.0	134.9	0.8	0.25	-0.1	P
130	125.0	124.9	0.8	0.25	-0.1	P
120	115.0	114.9	0.8	0.25	-0.1	P
110	105.0	104.9	0.8	0.25	-0.1	P
100	95.0	94.9	0.8	0.25	-0.1	P
90	85.0	84.9	0.8	0.25	-0.1	P
80	75.0	74.9	0.8	0.25	-0.1	P

Test Passed

Toneburst response - IEC 61672-3 Ed.2.0 Clause 18

Burst type	Ref. (dB)	Measured (dB)	Tol. (dB)	Tol. (dB)	Uncert. (dB)	Dev. (dB)	Result
Fast 200 mSec	127.0	126.9	0.5	-0.5	0.3	-0.1	P
Fast 2.0 mSec	110.0	109.7	1.0	-1.5	0.3	-0.3	P
Fast 0.25 mSec	101.0	99.9	1.0	-3.0	0.3	-1.1	P
Slow 200 mSec	120.6	120.5	0.5	-0.5	0.3	-0.1	P
Slow 2.0 mSec	101.0	100.6	1.0	-3.0	0.3	-0.4	P
SEL 200 mSec	121.0	120.9	0.5	-0.5	0.3	-0.1	P
SEL 2.0 mSec	101.0	101.1	1.0	-1.5	0.3	0.1	P
SEL 0.25 mSec	92.0	91.5	1.0	-3.0	0.3	-0.5	P

Test Passed

3rüel and Kjær Type 2238 SNo.: 2540948_WT 300119506 Certificate No.:38943 Page 5
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Peak C sound level - IEC 61672-3 Ed.2.0 Clause 19

Pulse Type	Pulse Freq. (Hz)	Ref. RMS (dB)	Ref. Peak (dB)	Measured Value (dB)	Tol. (+/-dB)	Uncert. (dB)	Dev. (dB)	Result
1 cycle	8k	129.0	132.4	132.8	2.0	0.35	0.4	P
Pos 1/2 cycle	500	132.0	134.4	134.7	1.0	0.35	0.3	P
Neg 1/2 cycle	500	132.0	134.4	134.7	1.0	0.35	0.3	P

Test Passed

Overload indication - IEC 61672-3 Ed.2.0 Clause 20

	Measured (dB)	Tol. (+/-dB)	Uncert. (dB)	Result
Level difference of positive and negative pulses:	0.4	1.5	0.25	P
Positive 1/2 cycle 4 kHz. Overload occurred at:	141.6			
Negative 1/2 cycle 4 kHz. Overload occurred at:	141.2			

Test Passed

High level stability test - IEC 61672-3 Ed.2.0 Clause 21

Test signal: Sine wave at 1 kHz

Initial level (dB)	Final level (dB)	Diff. (dB)	Tol. value (dB)	Uncert. (dB)	Result
139.1	139.0	-0.1	0.1	0.1	P

Test Passed

Long term stability test - IEC 61672-3 Ed.2.0 Clause 15

Test signal: Sine wave at 1 kHz

Time inteval (mm:SS)	StartLevel (dB)	StopLevel (dB)	Difference (dB)	Tolerence (dB)	Result
25:57	94.0	94.0	0.0	0.1	P

Test Passed

Combined electrical and acoustical test - IEC 61672-3 Ed.2.0 Clause 13

A-Weighted results: Free field

Frequency	SLM Val (dB)	SLM U (dB)	Microphone Val (dB)	Microphone U (dB)	Case Refl. Val (dB)	Case Refl. U (dB)	Wind Screen Val (dB)	Wind Screen U (dB)	Uncert (dB)	Tol (dB)	Result (dB)	
63 Hz	0.2	0.2	0.0	0.0					0.2	+-1.0	0.2	P
125 Hz	0.1	0.2	0.1	0.0					0.2	+-1.0	0.2	P
250 Hz	0.0	0.2	0.0	0.0					0.2	+-1.0	0.0	P
500 Hz	0.0	0.2	0.0	0.0					0.2	+-1.0	0.0	P
1 kHz	-0.1	0.2	0.0	0.1					0.2	+-0.7	-0.1	P

Brüel and Kjær Type 2238 SNo.: 2540948_WT 300119506 Certificate No.:38943 Page 6
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Combined electrical and acoustical test - IEC 61672-3 Ed.2.0 Clause 13

2 kHz	-0.4	0.2	0.0	0.0					0.2	+-1.0	-0.4	P
4 kHz	-0.2	0.2	0.2	0.2					0.3	+-1.0	0.0	P
8 kHz	0.5	0.2	0.5	0.2					0.3	+1.5/-2.5	1.0	P
16 kHz	0.8	0.2	-1.5	0.4					0.5	+2.5/-16.0	-0.7	P

C-Weighted results: Free field

Frequency	SLM		Microphone		Case Refl.		Wind Screen		Uncert	Tol	Result	
	Val	U	Val	U	Val	U	Val	U				
	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	
63 Hz	0.2	0.2	0.0	0.0					0.2	+-1.0	0.2	P
125 Hz	0.2	0.2	0.1	0.0					0.2	+-1.0	0.3	P
250 Hz	0.1	0.2	0.0	0.0					0.2	+-1.0	0.1	P
500 Hz	0.1	0.2	0.0	0.0					0.2	+-1.0	0.1	P
1 kHz	-0.1	0.2	0.0	0.1					0.2	+-0.7	-0.1	P
2 kHz	-0.4	0.2	0.0	0.0					0.2	+-1.0	-0.4	P
4 kHz	-0.3	0.2	0.2	0.2					0.3	+-1.0	-0.1	P
8 kHz	0.4	0.2	0.5	0.2					0.3	+1.5/-2.5	0.9	P
16 kHz	0.7	0.2	-1.5	0.4					0.5	+2.5/-16.0	-0.8	P

Z-Weighted results: Free field

Frequency	SLM		Microphone		Case Refl.		Wind Screen		Uncert	Tol	Result	
	Val	U	Val	U	Val	U	Val	U				
	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	
63 Hz	0.2	0.2	0.0	0.0					0.2	+-1.0	0.2	P
125 Hz	0.2	0.2	0.1	0.0					0.2	+-1.0	0.3	P
250 Hz	0.2	0.2	0.0	0.0					0.2	+-1.0	0.2	P
500 Hz	0.1	0.2	0.0	0.0					0.2	+-1.0	0.1	P
1 kHz	0.0	0.2	0.0	0.1					0.2	+-0.7	0.0	P
2 kHz	-0.4	0.2	0.0	0.0					0.2	+-1.0	-0.4	P
4 kHz	-0.1	0.2	0.2	0.2					0.3	+-1.0	0.1	P
8 kHz	0.7	0.2	0.5	0.2					0.3	+1.5/-2.5	1.2	P
16 kHz	0.7	0.2	-1.5	0.4					0.5	+2.5/-16.0	-0.8	P

The actual frequency response of Brüel & Kjær / 4188 2760470 has been used for the calculations.

Test Passed

The overall frequency response of the sound level meter and microphone response has shown to conform with the requirements in IEC 61672-3 for a class 1 sound level meter.

JDG

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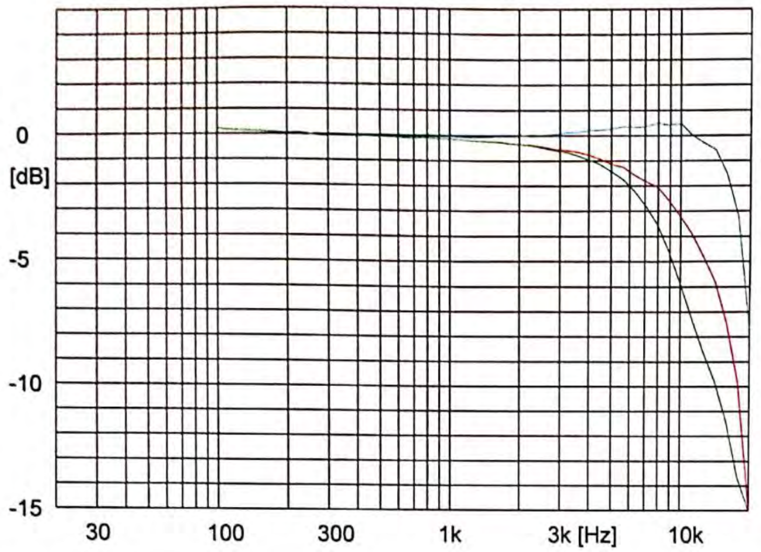
9.62 Test report of noise level meter calibration (page 9)

Microphone Test Report No.:38944



Brüel & Kjær
Type: 4188

Serial no: 2760470

Sensitivity: 32.11 mV/Pa
-29.87 ±0.12 dB re. 1 V/Pa

Date: 7/7/2017

Signature:

Measurement conditions:

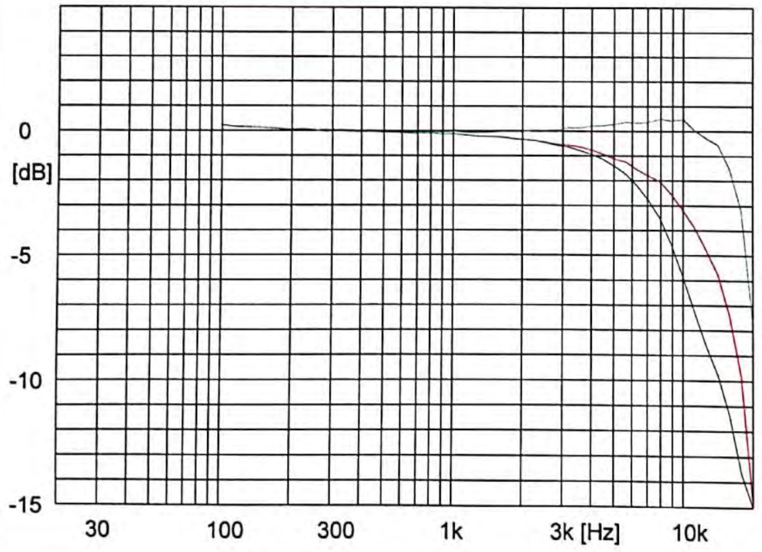
Polarisation voltage:	0.0 V
Pressure:	99.52 ±0.02 kPa
Temperature:	21.8 ±1.0 °C
Relative humidity:	58.2 ±2.0 %RH

Results are normalized to the reference conditions.

Free field response
Diffuse field response
Actuator response

Scantek, Inc.
6430 Dobbin Rd., Suite C, Columbia, MD 21045
Ph: 410-290-7726 eMail: callab@scantekinc.com

Microphone Test Report No.:38944



Brüel & Kjær
Type: 4188

Serial no: 2760470

Sensitivity: 32.11 mV/Pa
-29.87 ±0.12 dB re. 1 V/Pa

Date: 7/7/2017

Signature:

Measurement conditions:

Polarisation voltage:	0.0 V
Pressure:	99.52 ±0.02 kPa
Temperature:	21.8 ±1.0 °C
Relative humidity:	58.2 ±2.0 %RH

Results are normalized to the reference conditions.

Free field response
Diffuse field response
Actuator response

Scantek, Inc.
6430 Dobbin Rd., Suite C, Columbia, MD 21045
Ph: 410-290-7726 eMail: callab@scantekinc.com

Comment:
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9.63 Calibration certificate of anemometer (page 1)

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 CUP ANEMOMETER

Certificate number: 17.US2.07737 **Date of issue:** July 11, 2017

Type: Thies Compact 4.3519.00.000 **Serial number:** 1208487

Manufacturer: Thies Clima, ADOLF THIES GmbH & Co.KG, Hauptstrasse 76, 37083 Göttingen, Germany

Client: GL Garrad Hassan Canada Inc., 1400 Ravello Drive, Katy, TX 77449

Anemometer received: July 11, 2017 **Anemometer calibrated:** July 11, 2017

Calibrated by: MEJ **Procedure:** MEASNET, IEC 61400-12-1:2017 Annex F

Certificate prepared by: EJF **Approved by:** Calibration engineer, EJF

Calibration equation obtained: v [m/s] = 0.07800 · f [Hz] + 0.46257

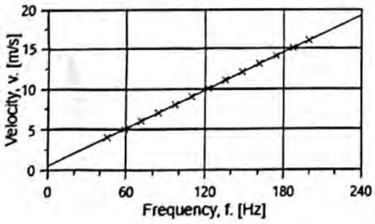
Standard uncertainty, slope: 0.00151 **Standard uncertainty, offset:** 0.03351

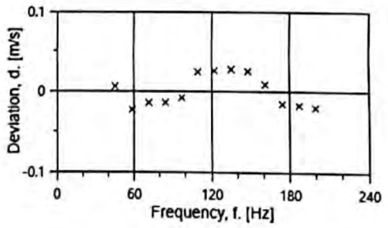
Covariance: -0.0000017 (m/s)²/Hz **Coefficient of correlation:** ρ = 0.999987

Absolute maximum deviation: 0.027 m/s at 11.049 m/s

Barometric pressure: 998.8 hPa **Relative humidity:** 48.8%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in d.p. box [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	9.18	28.1	28.0	4.001	45.2876	0.006	0.024
4	14.41	28.2	28.0	5.013	58.6398	-0.023	0.025
6	20.77	28.2	28.0	6.018	71.4047	-0.014	0.027
8	28.32	28.2	28.1	7.027	84.3394	-0.014	0.030
10	36.92	28.2	28.1	8.024	97.0491	-0.008	0.033
12	46.79	28.2	28.1	9.033	109.5712	0.024	0.036
13-last	57.65	28.2	28.1	10.027	122.2947	0.025	0.039
11	70.00	28.2	28.1	11.049	135.3807	0.027	0.042
9	83.19	28.2	28.1	12.045	148.1802	0.024	0.045
7	97.66	28.2	28.1	13.052	161.2935	0.008	0.048
5	113.15	28.1	28.0	14.050	174.3914	-0.016	0.051
3	129.80	28.1	28.0	15.047	187.2057	-0.018	0.054
1-first	146.98	28.0	28.0	16.010	199.5866	-0.020	0.057





AC-1746

Page 1 of 2

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9.64 Calibration certificate of anemometer (page 2)

EQUIPMENT USED

Serial Number	Description
Njord2	Wind tunnel, blockage factor = 1.003
13924	Control cup anemometer
-	Mounting tube, D = 33.5 mm
TT002	Summit Electronics, 1XPT100, 0-10V Output, wind tunnel temp.
TP001	PR Electronics 5102, 0-10V Output, differential pressure box temp.
DP008	Setra Model 239, 0-1inWC, differential pressure transducer
HY003	Dwyer RHP-2D20, 0-10V Output, humidity transmitter
BP002	Setra M278, 0-5VDC Output, barometer
PL3	Pitot tube
XB001	Computer Board. 16 bit A/D data acquisition board
66GSPS1	PC dedicated to data acquisition

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

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

UNCERTAINTIES

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

COMMENTS

(none)

Certificate number: 17.US2.07737

All calibrations are done in the "As Left" condition unless otherwise noted.
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9.65 Calibration certificate of secondary wind screen (page 1)

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

PTB

Prüfbericht

Test Report

Gegenstand: *Object:*	Sekundärer Windschirm
Hersteller: *Manufacturer:*	DNV-GL
Typ: *Type:*	EWS-12A
Gerätenummer: *Serial No.:*	01
Auftraggeber: *Applicant:*	GL Garrad Hassan Deutschland GmbH Sommerdeich 14b 25709 Kaiser-Wilhelm-Koog
Anzahl der Seiten: *Number of pages:*	9
Geschäftszeichen: *Reference No.:*	PTB-1.63-4070049
Prüfzeichen: *Test mark:*	16149 PTB 14
Datum der Prüfung: *Date of test:*	03.06.2014 bis 11.06.2014

Im Auftrag *On behalf of PTB*	Braunschweig, 2014-06-18	Im Auftrag *On behalf of PTB*
Dr.-Ing. Ingolf Bork	Siegel *Seal*	Dr. Christoph Kling

393 03A j

PHYSIKALISCH-TECHNISCHE BUNDESANSTALT 65

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9.66 Calibration certificate of secondary wind screen (page 2)

Physikalisch-Technische Bundesanstalt

Seite 2 zum Prüfbericht vom 2014-06-18, Prüfzeichen: 16149 PTB 14
Page 2 of the Test Report dated 2014-06-18, test mark: 16149 PTB 14

Prüfgegenstand

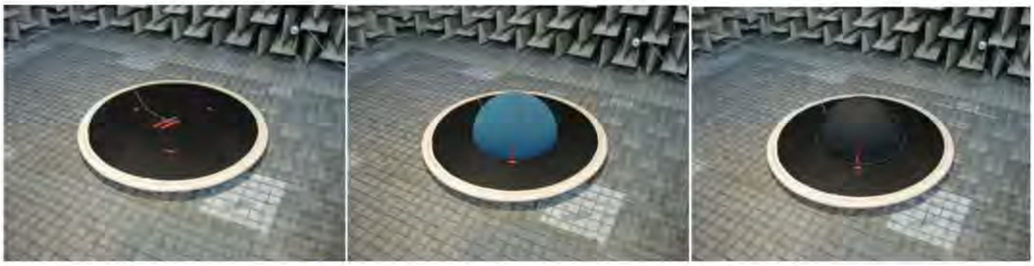
Geprüft wurde ein sekundärer Windschirm vom Typ EWS-12A mit der Seriennummer 01. Der Prüfgegenstand selbst ist nicht mit Typbezeichnung und Seriennummer beschriftet. Er besteht aus offenporigem, blauem Schaumstoff und hat die Form einer Halbkugelschale mit einem Durchmesser von ca. 52 cm. Das Exemplar ist ausgeblichen und macht einen etwas älteren Eindruck.

Der Windschirm wurde zusätzlich mit der optionalen Wetterschutzhaube geprüft. Die Haube ist ebenfalls nicht beschriftet. Die Wetterschutzhaube besteht aus schwarzem Stoff in Halbkugelform mit einem wulstig ausgeprägten Rand und wird dem Schaumstoffschirm übergestülpt.

Beide Schirmkombinationen wurden für die Vermessung auf der mitgelieferten Grundplatte aufgebaut. Die Platte ist ebenfalls nicht beschriftet. Bei der Platte handelt es sich um eine Holzplatte mit ca. 1,11 m Durchmesser und abgerundeten Kanten.

Zur Identifizierung kann auch Abbildung 1 herangezogen werden.

Abbildung 1: Grundplatte mit Mikrofon (links), aufgesetzter Windschirm EWS-12A-01 (Mitte), zusätzlich mit übergestülpter Wetterschutzhaube (rechts). Die roten Markierungen sind nicht Teil des Prüfgegenstandes.



Physikalisch-Technische Bundesanstalt

Seite 3 zum Prüfbericht vom 2014-06-18, Prüfzeichen: 16149 PTB 14
Page 3 of the Test Report dated 2014-06-18, test mark: 16149 PTB 14

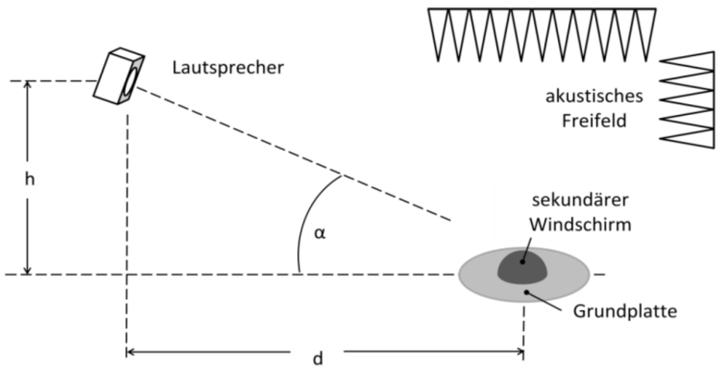
Prüfverfahren

Geprüft wurde nach DIN EN 61400-11 (VDE 0127-11):2013-09 Anhang E.

In einem ausreichend großen Freifeldraum wurde über einen Lautsprecher, der in einer Höhe h = 4,00 m angebracht war, rosa Rauschen eingespielt. Der sekundäre Windschirm wurde körperschall-isoliert in drei Abständen d = (4,80 m, 6,00 m, 7,20 m) von der Quelle aufgestellt und in jedem Ab-stand mit drei Wiederholungen vermessen. Dabei wurde der Schirm jeweils um ca. 120° gedreht um geometrische Unregelmäßigkeiten auszumitteln. Die verschiedenen Messabstände d entsprechen verschiedenen Schalleinfallswinkeln α = (29°, 34°, 40°). Abbildung 2 zeigt den grundlegenden Aufbau.

Abweichend von der Norm wurde in Absprache mit dem Auftraggeber ohne den halben primären Windschirm gemessen. Dieser konnte aufgrund der Schirmkonstruktion nicht wie vorgesehen auf dem Mikrofon angebracht werden. Das Mikrofon (Kapsel mit Vorverstärker) war auf der kreisförmigen Grundplatte plan etwa 4 cm außerhalb der Mitte fixiert und wies stets in Richtung der Schallquelle. In Absprache wurde die vom Hersteller vorgesehene Klemmvorrichtung zur Befestigung des Mikrofons auf der Platte nicht benutzt. Der Windschirm wurde mittig auf der Unterplatte aufgestellt.

Abbildung 2: Skizze des Aufbaus im Freifeldraum



Vermessen wurden der akustische Hintergrund, der Aufbau ohne Schirm, der Aufbau mit Schirm und der Aufbau mit Schirm und Wetterschutzhaube. Ausgewertet wurde der unbewertete äquivalente Dauerschallpegel LZeq in Terzen von 20 Hz bis 20 kHz über eine Mittelungszeit von 3 min. Um mögli-che Schwankungen des Lautsprecherpegels zu kompensieren, wurde der LZeq in Terzen mit einem zweiten Mikrofon an einer festen Kontrollposition abseits des Aufbaus aufgenommen und am Schirm-mikrofon korrigiert.

Die Messkette bestand aus einem kalibrierten 2-Kanal-Schallpegelmessgerät Norsonic Typ 840 und zwei Messmikrofonen B&K Typ 4133 auf Vorverstärkern B&K Typ 2669.

Nach Korrektur der gemessenen Pegel am Schirmmikrofon um die Schwankung des Lautsprecherpe-gels wurde aus den Terzspektren der neun Einzelmessungen (drei Messabstände x drei Wiederho-lungen) der Mittelwert und die Standardabweichung der Einfügungsdämpfung in dB bestimmt:

Einfügungsdämpfung = korrigierter Pegel ohne Schirm – korrigierter Pegel mit Schirm

Eine Dämpfungswirkung des Schirmes führt somit zu einem positiven Wert der Einfügungsdämpfung, eine Verstärkungswirkung zu einem negativen Wert.

Physikalisch-Technische Bundesanstalt

Seite 4 zum Prüfbericht vom 2014-06-18, Prüfzeichen: 16149 PTB 14
Page 4 of the Test Report dated 2014-06-18, test mark: 16149 PTB 14

Ergebnisse

Die Ergebnisse beziehen sich nur auf den geprüften Gegenstand.

Nach Norm werden die einzeln gemessenen Einfügungsdämpfungen des Schirms über alle Messabstände und Wiederholungen gemittelt. Die angegebene Einfügungsdämpfung repräsentiert damit einen Mittelwert über einen Einfallswinkelbereich von etwa 29° bis 40°. Aufgrund von Interferenzen im Schirmaufbau ist die Unsicherheit dieser Größe recht hoch (siehe Tabelle 3). Hier sind zusätzlich die (nur über je drei Wiederholungen gemittelten) Einzelergebnisse der drei Messabstände angegeben, die Informationen über Interferenzen im Schirmaufbau beinhalten.

Die Umgebungsbedingungen während der Messungen waren wie folgt:

Lufttemperatur: 23,7°C ± 1°C

Relative Luftfeuchte: 46 % ± 15 %

Luftdruck: 100,2 kPa ± 3 kPa

Der Signal-Rausch-Abstand war an beiden Mikrofonen in jeder Einzelmessung in allen angegebenen Terzbändern größer als der in der Norm geforderte Mindestwert von 3 dB:

Frequenzband um 20 Hz:	Signal-Rausch-Abstand > 3 dB
Frequenzbänder um 25 Hz bis 63 Hz:	Signal-Rausch-Abstand > 15 dB
Frequenzbänder um 80 Hz bis 5 kHz:	Signal-Rausch-Abstand > 60 dB
Frequenzbänder um 6,3 kHz bis 16 kHz:	Signal-Rausch-Abstand > 15 dB
Frequenzband um 20 kHz:	Signal-Rausch-Abstand > 3 dB

Die ermittelten Einfügungsdämpfungen des sekundären Windschirms sind tabellarisch in den Tabellen 1 bis 2 und grafisch in den Abbildungen 3 bis 4 angegeben.

Hinweis: Die in den Tabellen 1 bis 2 und Abbildungen 3 bis 4 nach Norm angegebenen Standardunsicherheiten der Einfügungsdämpfungen beruhen ausschließlich auf der Mittelung über 3 bzw. 9 Einzelmessungen und sind **nicht** die zugehörigen Messunsicherheiten. Letztere sind in Tabelle 3 aufgelistet.

9.69 Calibration certificate of secondary wind screen (page 5)

Physikalisch-Technische Bundesanstalt

Seite 5 zum Prüfbericht vom 2014-06-18, Prüfzeichen: 16149 PTB 14
Page 5 of the Test Report dated 2014-06-18, test mark: 16149 PTB 14

Tabelle 1: Einfügungsdämpfung des Sekundären Windschirms EWS-12A-01 ohne optionale Wetterschutzhaube als Mittelwert und Standardabweichung aus 3 (fester Abstand) bzw. 9 (gesamt) Einzelmessungen.

	Abstand 4,80 m		Abstand 6,00 m		Abstand 7,20 m		gesamt	
	Mittelwert	StAbw	Mittelwert	StAbw	Mittelwert	StAbw	Mittelwert	StAbw
Frequenz in Hz	Einfügungsdämpfung in dB (re 1)							
20	-0,13	0,15	0,10	0,00	-0,03	0,15	-0,02	0,15
25	-0,07	0,06	0,00	0,00	-0,03	0,06	-0,03	0,05
31,5	0,00	0,00	0,03	0,12	0,03	0,06	0,02	0,07
40	0,00	0,00	0,00	0,10	0,00	0,00	0,00	0,05
50	0,00	0,00	0,00	0,10	0,00	0,00	0,00	0,05
63	0,00	0,00	-0,03	0,06	0,00	0,00	-0,01	0,03
80	0,00	0,00	0,00	0,10	0,00	0,00	0,00	0,05
100	0,00	0,00	0,00	0,00	-0,07	0,06	-0,02	0,04
125	0,00	0,00	-0,03	0,06	0,00	0,00	-0,01	0,03
160	0,00	0,00	-0,03	0,06	0,00	0,00	-0,01	0,03
200	-0,10	0,00	-0,07	0,06	0,00	0,00	-0,06	0,05
250	-0,10	0,00	0,00	0,00	0,00	0,00	-0,03	0,05
315	0,00	0,00	-0,07	0,06	0,00	0,00	-0,02	0,04
400	-0,07	0,06	-0,13	0,06	0,00	0,00	-0,07	0,07
500	0,10	0,00	0,17	0,15	0,20	0,00	0,16	0,09
630	0,37	0,06	0,40	0,00	0,33	0,06	0,37	0,05
800	0,40	0,00	0,40	0,00	0,33	0,06	0,38	0,04
1000	0,00	0,00	0,00	0,00	0,03	0,06	0,01	0,03
1250	0,23	0,06	0,30	0,00	0,33	0,06	0,29	0,06
1600	0,20	0,10	0,20	0,00	0,23	0,06	0,21	0,06
2000	0,27	0,06	0,37	0,06	0,43	0,06	0,36	0,09
2500	0,30	0,00	0,37	0,06	0,43	0,06	0,37	0,07
3150	0,23	0,06	0,37	0,06	0,33	0,06	0,31	0,08
4000	0,40	0,00	0,37	0,06	0,37	0,06	0,38	0,04
5000	0,43	0,06	0,43	0,06	0,37	0,06	0,41	0,06
6300	0,43	0,06	0,53	0,12	0,50	0,00	0,49	0,08
8000	0,60	0,00	0,63	0,12	0,67	0,12	0,63	0,09
10000	0,63	0,06	0,83	0,12	0,73	0,06	0,73	0,11
12500	0,67	0,06	0,87	0,12	0,93	0,06	0,82	0,14
16000	0,80	0,00	0,83	0,21	1,13	0,35	0,92	0,26
20000	0,30	0,00	0,67	0,32	0,87	0,06	0,61	0,30

9.70 Calibration certificate of secondary wind screen (page 6)

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Tabelle 2: Einfügungsdämpfung des Sekundären Windschirms EWS-12A-01 mit optionaler Wetterschutzhaube als Mittelwert und Standardabweichung aus 3 (fester Abstand) bzw. 9 (gesamt) Einzelmessungen.

	Abstand 4,80 m		Abstand 6,00 m		Abstand 7,20 m		gesamt	
	Mittelwert	StAbw	Mittelwert	StAbw	Mittelwert	StAbw	Mittelwert	StAbw
Frequenz in Hz	Einfügungsdämpfung in dB (re 1)							
20	0,00	0,20	0,07	0,21	0,13	0,06	0,07	0,16
25	0,03	0,06	0,00	0,00	0,07	0,12	0,03	0,07
31,5	0,00	0,00	0,10	0,10	0,03	0,06	0,04	0,07
40	0,00	0,00	0,07	0,06	0,00	0,00	0,02	0,04
50	0,00	0,00	0,07	0,06	0,00	0,00	0,02	0,04
63	0,07	0,06	0,07	0,06	0,00	0,00	0,04	0,05
80	0,00	0,00	0,03	0,06	-0,03	0,06	0,00	0,05
100	0,00	0,00	0,00	0,00	-0,07	0,06	-0,02	0,04
125	0,00	0,00	0,03	0,06	-0,10	0,00	-0,02	0,07
160	0,00	0,00	-0,03	0,06	-0,03	0,06	-0,02	0,04
200	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
250	-0,10	0,00	0,00	0,00	0,00	0,00	-0,03	0,05
315	0,10	0,00	-0,03	0,06	0,07	0,06	0,04	0,07
400	0,13	0,06	0,10	0,00	0,10	0,00	0,11	0,03
500	0,50	0,00	0,53	0,06	0,43	0,06	0,49	0,06
630	0,80	0,00	0,80	0,00	0,60	0,17	0,73	0,13
800	0,53	0,06	0,60	0,00	0,30	0,20	0,48	0,17
1000	0,10	0,00	0,10	0,00	0,13	0,06	0,11	0,03
1250	1,00	0,00	0,87	0,06	0,60	0,17	0,82	0,20
1600	0,57	0,12	0,50	0,00	0,30	0,10	0,46	0,14
2000	1,23	0,06	1,00	0,10	0,63	0,23	0,96	0,29
2500	1,03	0,06	1,23	0,06	0,77	0,29	1,01	0,25
3150	0,53	0,06	1,37	0,06	1,20	0,36	1,03	0,42
4000	0,57	0,06	1,37	0,12	1,53	0,32	1,16	0,48
5000	0,40	0,00	1,13	0,23	1,67	0,21	1,07	0,57
6300	0,30	0,17	0,40	0,00	0,90	0,10	0,53	0,30
8000	1,43	0,40	0,20	0,26	0,17	0,29	0,60	0,69
10000	2,13	0,64	0,93	0,06	-0,33	0,21	0,91	1,12
12500	0,50	0,35	3,33	0,42	0,17	0,47	1,33	1,55
16000	1,50	0,69	2,37	0,32	1,57	0,81	1,81	0,70
20000	-0,23	0,06	0,07	0,42	2,07	0,50	0,63	1,13

9.71 Calibration certificate of secondary wind screen (page 7)

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Abbildung 3: Einfügungsdämpfung des Sekundären Windschirms EWS-12A-01 ohne optionale Wetterschutzhaube (Mittelwert und Standardabweichung aus 9 Einzelmessungen).

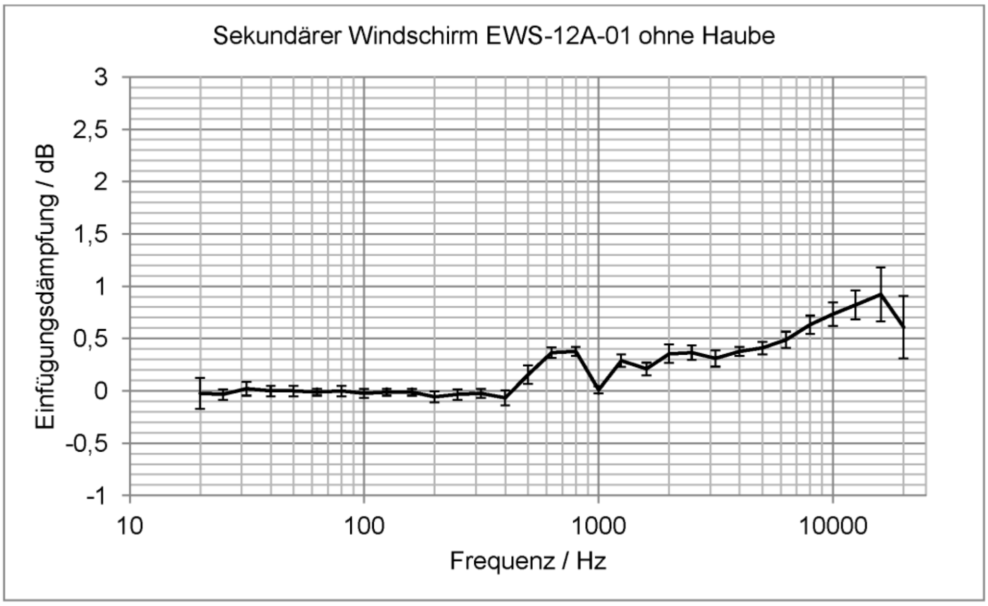
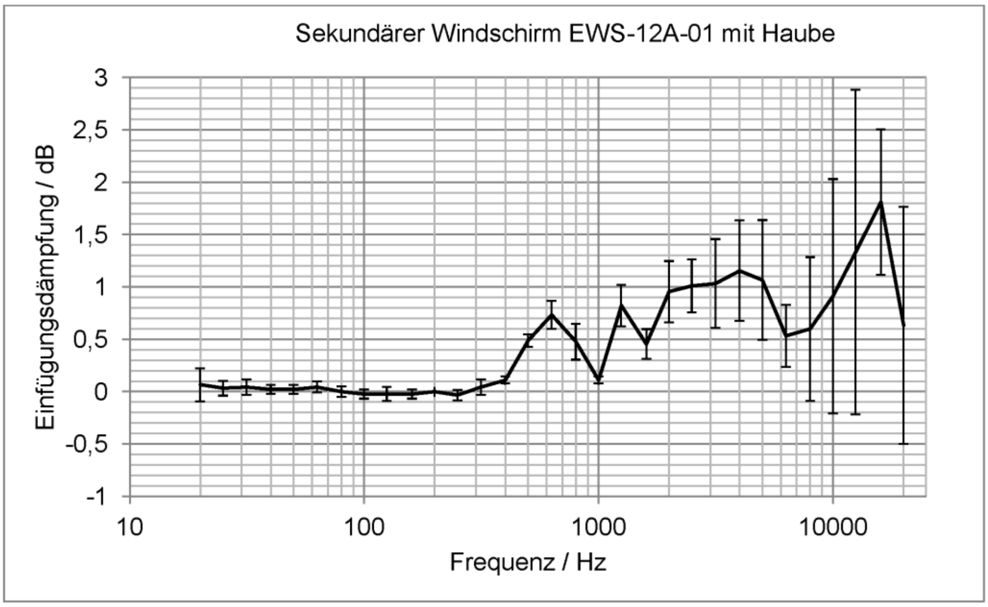


Abbildung 4: Einfügungsdämpfung des Sekundären Windschirms EWS-12A-01 mit optionaler Wetterschutzhaube (Mittelwert und Standardabweichung aus 9 Einzelmessungen).



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Messunsicherheit

Tabelle 3 zeigt die erweiterten Messunsicherheiten für einen Erweiterungsfaktor von 2, entsprechend einem Vertrauensniveau von ungefähr 95 %. Sie wurde berechnet und wird angegeben nach den Leitlinien im "GUM - Guide to the expression of uncertainty in measurement" (Leitfaden zur Angabe der Unsicherheit beim Messen).

Die Messunsicherheit wird über eine Grundunsicherheit hinaus maßgeblich beeinflusst durch schlechteren Signal-Rausch-Abstand der gemessenen Schalldruckpegel in den äußeren Terzbändern und - bei Mittelung über einen Bereich von Messabständen bzw. Einfallswinkeln – bei höheren Frequenzen durch verschiedenartig ausgeprägte Interferenzen im Schirmaufbau.

Tabelle 3: Messunsicherheit u (Deckungsintervall 95%) der angegebenen Einfügungsdämpfungen für die Schirmaufbauten mit und ohne Wetterschutzhaube, jeweils für die Angaben bei festem Messabstand (einzeln) und für die Mittelung über alle Abstände (gesamt).

	ohne Haube		mit Haube	
Messabstand	einzeln	gesamt	einzeln	gesamt
Frequenz in Hz	u(Einfügungsdämpfung, 95%) in dB (re 1)			
20	0,9	0,9	0,9	0,9
25	0,4	0,4	0,4	0,4
31,5	0,4	0,4	0,4	0,4
40	0,4	0,4	0,4	0,4
50	0,4	0,4	0,4	0,4
63	0,4	0,4	0,4	0,4
80	0,4	0,4	0,4	0,4
100	0,4	0,4	0,4	0,4
125	0,4	0,4	0,4	0,4
160	0,4	0,4	0,4	0,4
200	0,4	0,4	0,4	0,4
250	0,4	0,4	0,4	0,4
315	0,4	0,4	0,4	0,4
400	0,4	0,4	0,4	0,4
500	0,4	0,4	0,4	0,4
630	0,4	0,4	0,4	0,4
800	0,4	0,4	0,4	0,4
1000	0,4	0,4	0,4	0,4
1250	0,4	0,4	0,4	0,5
1600	0,4	0,4	0,4	0,4
2000	0,4	0,4	0,4	0,5
2500	0,4	0,4	0,4	0,5
3150	0,4	0,4	0,4	0,7
4000	0,4	0,4	0,4	0,9
5000	0,4	0,4	0,4	1,0
6300	0,4	0,4	0,4	0,6
8000	0,4	0,4	0,5	1,0
10000	0,4	0,4	0,5	1,6
12500	0,4	0,4	0,6	2,1
16000	0,4	0,5	0,8	1,1
20000	1,3	1,3	1,3	2,0

9.73 Calibration certificate of secondary wind screen (page 9)

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Die Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig und Berlin ist das nationale Metrologieinstitut und die technische Oberbehörde der Bundesrepublik Deutschland für das Messwesen. Die PTB gehört zum Geschäftsbereich des Bundesministeriums für Wirtschaft und Energie. Sie erfüllt die Anforderungen an Kalibrier- und Prüflaboratorien auf der Grundlage der DIN EN ISO/IEC 17025.

Zentrale Aufgabe der PTB ist es, die gesetzlichen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI) darzustellen, zu bewahren und weiterzugeben. Die PTB steht damit an oberster Stelle der metrologischen Hierarchie in Deutschland. Die Kalibrierscheine der PTB dokumentieren eine auf nationale Normale rückgeführte Kalibrierung.

Zur Sicherstellung der weltweiten Einheitlichkeit der Maßeinheiten arbeitet die PTB mit anderen nationalen metrologischen Instituten auf regionaler europäischer Ebene in EURAMET und auf internationaler Ebene im Rahmen der Meterkonvention zusammen. Dieses Ziel wird durch einen intensiven Austausch von Forschungsergebnissen und durch umfangreiche internationale Vergleichsmessungen erreicht.

The Physikalisch-Technische Bundesanstalt *(PTB) in Braunschweig and Berlin is the National Metrology Institute and the supreme technical authority of the Federal Republic of Germany for metrology. The PTB comes under the auspices of the Federal Ministry of Economics and Energy. It meets the requirements for calibration and testing laboratories as defined in DIN EN ISO/IEC 17025.*

The central task of PTB is to realize, to maintain and to disseminate the legal units in compliance with the International System of Units (SI). PTB thus is at the top of the metrological hierarchy in Germany. The calibration certificates issued by PTB document a calibration traceable to national measurement standards.

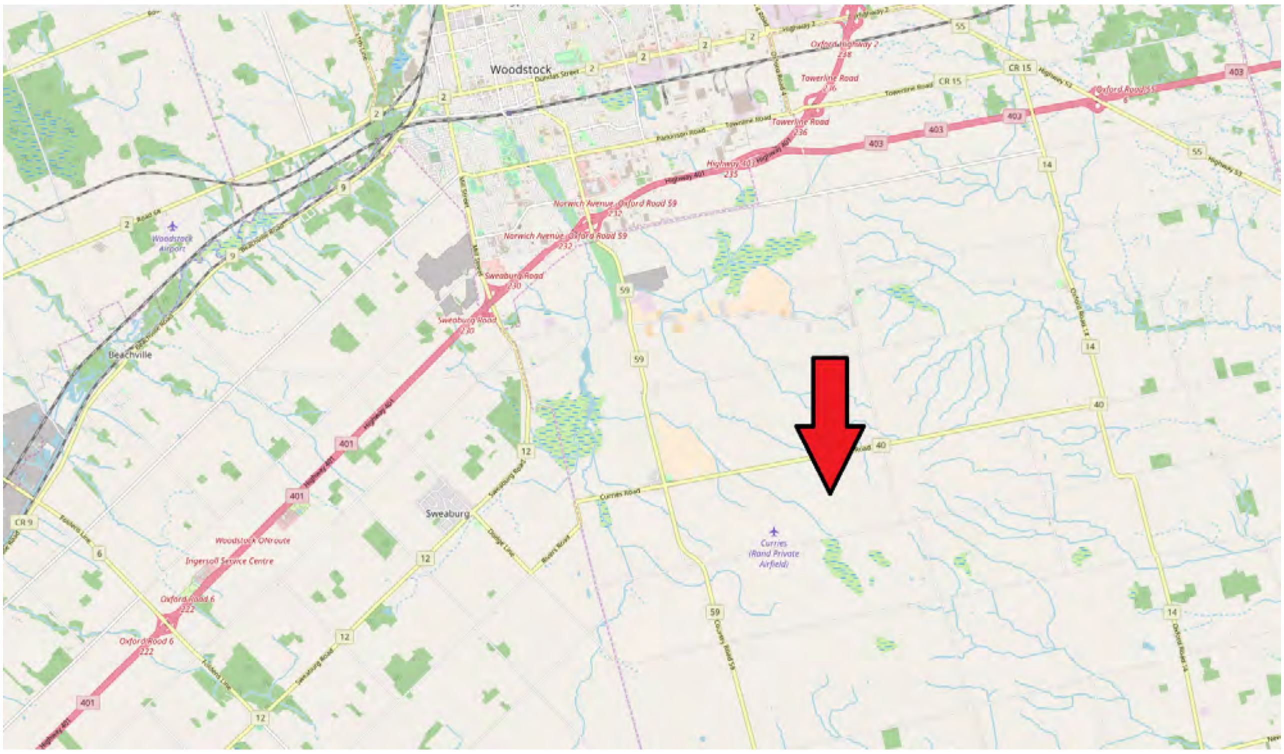
PTB cooperates with other national metrology institutes - at the regional European level within EURAMET and at the international level within the framework of the Metre Convention - with the aim of ensuring the worldwide coherence of the measurement units. This aim is achieved by an intensive exchange of the results of research work and by comprehensive international comparison measurements.

Physikalisch-Technische Bundesanstalt
Bundesallee 100
38116 Braunschweig
DEUTSCHLAND

Abbestraße 2-12
10587 Berlin
DEUTSCHLAND

9.74 Position of the test site

Source: www.openstreetmap.org



9.75 Photos

Photo 1: Photo of the microphone and board towards the measured turbine of the type Senvion MM92

Photo 2: Photo from the wind met mast towards the turbine

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our professionals are dedicated to helping our customers make the world safer, smarter and greener