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# Sound emission measurement according to IEC 61400-11

**at a wind turbine of the type**
**ENERCON E-82 E3**
**located in 26632 Ihlow/Simonswolde**
**(Germany)**

**Test Report No. M89 031/2**

| | |
|---|---|
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## Summary

For the company Enercon GmbH, sound emission measurements at a wind turbine (WT) of the type ENERCON E-82 E3 with a hub height of 98 m were carried out in 26632 Ihlow/Simonswolde, Germany.

The sound emission measurements were carried out on 24th August 2010 according to DIN EN 61400-11 (German version of IEC 61400-11) with the WT operated with a maximum electric power of 3000 kW and a maximum rotational speed from 6 rpm to 18 rpm.

Hereby a maximum sound power level of $L_{WA}$ = 105.4 dB(A) was determined in the standardised wind class of 10 m/s, which was calculated from the electrical power data of the WT.

Due to the noise impression on site no tonal or impulsive noise emitted by the wind turbine components was audible. An evaluation of impulsivity therefore was not applied. But to verify the noise impression related to the tonality, an evaluation of tonality according to IEC 61400-11 in combination with DIN 45681 was performed. The results have shown that no tone adjustments $K_{TN}$ in the vicinity of the WT were necessary.

For the uncertainty of the sound emission data, a value of $U_C$ = 0.8 dB was determined according to IEC 61400-11.

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# 1 Task

For the company Enercon GmbH, sound emission measurements at a wind turbine (WT) of the type ENERCON E-82 E3 with a hub height of 98 m are to be performed in 26632 Ihlow/Simonswolde, Germany.

The measuring set-up shall meet the requirements of DIN EN 61400-11 (German version of IEC 61400-11) with the WT operating with a maximum electric power of 3000 kW and a maximum rotational speed up to 18 rpm. Figure A 1 in Appendix A shows a layout plan with the position of the WT.

# 2 References

[1] IEC TS 61400-11 Wind turbines. Part 11: Acoustic noise measurement techniques. November 2002.

[2] IEC TS 61400-14 Wind turbines - Part 14: Declaration of apparent sound power level and tonality values. March 2005.

[3] DIN EN 61400-11: Wind turbine generator systems – Part 11: Acoustic noise measurement techniques. March 2007.

[4] DIN 45681: Determination of tonal components of noise and determination of a tone adjustment for the assessment of noise immissions. March 2005.

[5] DIN EN 61672 - 1 (IEC 61672-1:2002): Sound level meters . Part 1: Specifications (IEC 61672-1:2002); German version EN 61672-1:2003.

[6] DIN EN 60942 (IEC 60942:2003): Sound calibrators (IEC 60942:2003); German version EN 60942:2003.

[7] DIN 1333: Presentation of numerical data. February 1992.

[8] Fördergesellschaft Windenergie e.V:
Technische Richtlinien für Windenergieanlagen (FGW-Richtlinie) , Teil 1: Bestimmung der Schallemissionswerte, Revision 18, Stand 01.02.2008.

[9] Enercon GmbH:
E-mails of the Site Assessment department with certificate of the manufacturer, performance curve for 3000 kW, extract from minute average values of the WT plant Enercon E-82 E3; Aurich, August and September 2010.

# 3 Description of the wind turbine

## 3.1 Surroundings of the investigated WT

The surroundings of the investigated WT are shown in the Figures A 2 to A 4 in Appendix A.

As can be taken from the photos, the surroundings are characterized by agriculture. Within a large radius of the WT, the surrounding area is relatively even.

## 3.2 Technical data of the WT

The WT is a gearless machine, which is operated in partial load with variable speed and individual pitch control. The following specifications are valid:

| | |
|---|---|
| Manufacturer: | Enercon GmbH, Dreekamp 5, 26605 Aurich |
| Type: | ENERCON E-82 E3 |
| Serial No. : | 82001 |
| Data of the WT: | Rated power: 3000 kW, horizontal axis wind turbine<br>Height of the rotor centre above the ground: H = 98 m<br>Switch-on wind speed: 2.5 m/s<br>Rated wind speed: 16 m/s<br>Pitch power control, electric drive<br>Tower material: concrete |
| Rotor: | Rotor diameter: D = 82 m<br>Upwind turbine with active pitch control, in partial load operation with variable speed of 6 to 18 rpm<br>Independent control system for each rotor blade<br>Distance between rotor centre and tower centre line: 4.62 m |
| Generator: | E-82 E3 |
| Gear unit: | The plant is designed without any gear unit. |

The short version of the manufacturer's certificate is shown on figure D 3 in Appendix D.

# 4 Execution of the measurements

## 4.1 Time of the measurements

The measurements were carried out on 24 August 2010 between 03:50 p.m. and 08:28 p.m..

## 4.2 Description of the measuring set-up

According to [1], for the sound emission measurements the microphone was installed on a sound-reflecting board made of aluminium. The dimensions of the board are:

| | |
|---|---|
| Diameter | 1.1 m, |
| Thickness | 3.0 mm. |

According to [1], the reference point must be on the lee side of the WT in an angle of ± 15° with regard to the wind direction during the measurements. This position was observed (see Figure A 2 in Appendix A).

The wind direction was controlled before any single measurement and the position of the measuring board was adjusted along the prepared distance-line, if necessary.

The microphone was protected against wind-induced noise by means of two windscreens. For the first windscreen, one half of the original B&K foam ball with a diameter of 90 mm was used. The second windscreen was a set-up developed by Müller-BBM (see Figure A 4 in Appendix A). The frequency response of this screen had been checked in Müller-BBM's reverberation chamber. It resulted from this test that a frequency response correction was required for the evaluated frequency range which was taken into account during the further evaluations.

According to [1], the reference point for sound measurements must have a distance to the tower centreline of the WT of $R_O = H + D/2$ (permissible tolerance: ± 20 %). For the hub height of $H$ = 98,4 m and the rotor diameter of $D$ = 82 m it follows that $R_O$ = 139,4 m. Thus, taking into consideration the tolerance, the reference point must be located at a distance of $R_O$ = 111,5 m up to $R_O$ = 167,3 m. With a distance of $R_O$ = 153,8 m between reference point and the tower centreline of the WT, the requirement stated in [1] was fulfilled.

With a distance between tower centreline and centre of rotor of $R_T - R_f$ = 4.62 m and the vertical height difference between reference point and tower foundation of 0 m, an inclination angle $\phi$ = 31.9° results. Thus, the requirement of $25° \leq \phi \leq 40°$ according to [1] was fulfilled.

According to [1], an anemometer has to be installed in headwind direction in front of the WT at a height of between 10 m and hub height. The distance to the rotor level must be between 2**D* and 4**D.* Due to the described procedures in [8] related to WT with higher hub heights it is acceptable to set up the mast closer to the WT.

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Because of a technical failure with the mast no data were recorded with the wind speed indicator and the wind direction indicator. Instead of that the meteorological data of the equipment of an adjacent met mast were collected. This met mast is erected in a distance of approx. 142 m south of the E-82 E3. On figure A 3 in Appendix A the met mast is depicted.

The indicators on top of this met mast, in a height of 30 m above ground, are calibrated and therefore suitable for any further evaluation.

## 4.3 Measuring equipment

The measuring equipment used for the measurements on site and for the evaluation in the laboratory is listed in Table 1.

**Table 1.** Equipment for measurement and evaluation

| **Name** | **Manufacturer** | **Type** | **Serial No.** |
|---|---|---|---|
| Precision sound analyser | Brüel & Kjaer | 2260 | 2131750 |
| Microphone | Brüel & Kjaer | 4189 | 2097077 |
| Calibrator | Brüel & Kjaer | 4231 | 1821239 |
| Windscreen, primary | Brüel & Kjaer | UA0237 | - |
| Windscreen, secondary | Müller-BBM | - | - |
| Anemometer<br>Wind speed indicator<br>Wind direction indicator | <br>Deutsche Windguard<br>Deutsche Windguard | <br>TFC adv.<br>TFC | <br>06101657<br>0408408 |
| Weather station | Conrad | BAR 899 HG | 1006147 |
| Barometer | Brüel & Kjaer | UZ003 | - |
| Thermometer | - | - | - |
| Notebook | Dell | Latitude E6400 | - |
| Mobile measuring system | Müller-BBM Vibro-Akustik Systeme GmbH | PAK-Mobil MKII | - |
| Measuring and evaluation software | Müller-BBM Vibro-Akustik Systeme GmbH | PAK | Version 5.5 |
| Evaluation software | Müller-BBM | WEA_DaV | Version 1.2f |
| Laser range finder | Leica | LRF 1200 scan | 1136324 |

The applied precision sound analyser, the accompanying microphone and the calibrator were calibrated and fulfill the requirements of class 1 according to DIN EN 61672 [5] (precision sound analyser) respectively DIN EN 60942 [6] (calibrator).

The acoustic measuring chain was calibrated before the measurements.
The calibration was checked and confirmed after the measurements. All measuring and evaluation devices are checked regularly in our own calibration laboratory. They meet the requirements on measuring and evaluation equipment stated in [1].

## 4.4 Measured parameters

During the measurements, the following quantities were recorded and digitally saved by the PAK multi-channel measuring system as a function of time:

- Sound pressure level at the reference point (parallel recording and saving by a calibrated sound analyser)
- Wind speed and direction measured with the wind indicators of Müller-BBM
- Wind speed recorded with the anemometer of the WT
- Electric power $P_m$ and rotational speed measured at the WT

In addition, the atmospheric pressure $p$ and the air temperature $T_K$ at the beginning of each test series was taken from the weather station and documented.

## 4.5 Execution of the measurements

At the time of the measurements, the E-82 E3 was operated with a maximum electric power of 3000 kW. For this operational mode as well as for standstill of the WT, the following measuring times were realized:

- WT in operation with a maximum electric power of 3000 kW: 95 minutes
- WT during standstill, i.e. background noise measurements: 80 minutes

The following Table 2 gives an overview of the test runs and the observed weather conditions during the measurements. The stated 10 s averages of the wind speed and wind direction were determined from the data recorded with the wind speed and wind direction indicators of the met mast in a height of 30 m.

**Table 2.** Summary of the test runs considered in the evaluation, with accompanying weather conditions

| Test No. | Operational mode of the WT | Time | Weather station | | Anemometer at a height of 30 m | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Temperature in °C | Atmospheric pressure in hPa | Wind direction in ° | | | Wind speed in m/s | | |
| | | | | | Minimum | Maximum | Average | Minimum | Maximum | Average |
| M_01 | Standstill | 15:50 - 16:20 | 20 | 1003 | -- | -- | -- | 9 | 17 | 13 |
| M_03 | 3000 kW | 16:33- 16:41 | 20 | 1003 | -- | -- | -- | 11 | 17 | 15 |
| M_04 | 3000 kW | 17:05 - 17:35 | 20 | 1003 | -- | -- | -- | 8 | 18 | 13 |
| M_05 | 3000 kW | 17:44 - 17:58 | 19 | 1003 | 219 | 273 | 251 | 7 | 18 | 12 |
| M_06 | 3000 kW | 18:05- 18:21 | 18 | 1002 | 224 | 266 | 242 | 7 | 15 | 11 |
| M_07 | 3000 kW | 18:25- 18:52 | 16 | 1000 | 198 | 261 | 234 | 8 | 17 | 12 |
| M_08 | Standstill | 19:44- 20:14 | 15 | 1000 | 201 | 267 | 233 | 8 | 14 | 11 |
| M_09 | Standstill | 20:38- 20:58 | 13 | 1000 | 199 | 245 | 219 | 6 | 11 | 8 |

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The above-mentioned test runs are documented in detail in the Figures B 1 to B 13 in Appendix B. The time slices which were excluded from the evaluation because of disturbing background noise are marked with a grey shade. If required, further disturbing background noise was cut out in the laboratory during the evaluation.

Enercon provided the operating data of the investigated WT for the day measurement with [9]. These data are shown in Figure C 21 in Appendix C.

**Table 3.** Number of 10 s intervals recorded during the measurements, which were used for the evaluation

| **Test No.** | **Standardised wind class, m/s** | | | |
|---|---|---|---|---|
| | 7 | 8 | 9 | 10 |
| **WT in operation** | | | | |
| M_03 | -- | -- | 2 | 6 |
| M_04 | 7 | 31 | 31 | 19 |
| M_05 | 11 | 3 | 17 | 16 |
| M_06 | 10 | 25 | 31 | 17 |
| M_07 | 6 | 18 | 51 | 31 |
| **total** | **34** | **77** | **132** | **89** |
| | | | | |
| **Standstill of the WT** | | | | |
| M_01 | -- | 6 | 27 | 39 |
| M_08 | 22 | 59 | 50 | 26 |
| M_09 | 61 | 19 | 3 | -- |
| **Total** | **83** | **84** | **80** | **65** |

According to [1], measuring data for each wind speed class with a total measuring time of 180 s should be determined for the evaluation.

As shown in the above Table 3, during the measurements with the WT in operation as well as the measurements while the WT was in standstill, a sufficient number of 10 s averages according to [1] was determined in the wind classes 7 m/s to 10 m/s.

In the wind classes 6 m/s an insufficient number of 10 s averages was determined and therefore these values are not shown in Table 3.

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# 5 Evaluation and results regarding the sound emission of the WT

The most important target of the evaluation is to describe the sound emission of the WT as a function of wind speed. According to IEC 61400-11 [1], the so-called "standardised wind speed $V_S$" should be used as a reference value. This is the wind speed converted to reference conditions (at a height of 10 m and a roughness length of 0.05 m) assuming a logarithmic wind profile.

According to [1], the measured wind speed range can be divided into wind classes with a width of 1 m/s. These wind classes have to be arranged symmetrically and not overlapping to integer values of wind speed.

The first step in the evaluation consists in determining this standardised wind speed, which can then be correlated with the other measuring data.

## 5.1 Measurement of the wind speed

According to [1], the wind speed should be determined either

1. from the generated power output and the performance curve of the WT or
2. from the measurement with an anemometer.

Method 1 is obligatory for measurements within the scope of a certification or declaration of sound emission values.

For background noise measurements during standstill of the WT, the wind speed is determined from values measured by means of the anemometer at a height of 12 m.

In the following chapters, both methods are described.

### 5.1.1 Determination of the standardised wind speed from the measured electric power

The standardised wind speed $V_S$ during operation of the WT is determined according to the method described as preferable according to [1] from the measured electric power of the WT and the performance curve of the WT. The performance curve of the WT illustrates the relation of the wind speed $V_Z$ at the height of the rotor centre and the electric power $P_n$ generated by the WT for atmospheric standard conditions of 15°C and 101.3 kPa. The power curve was submitted by the manufacturer Enercon in [9]. It is a calculated power output curve and is shown in the form of a diagram and a table in Figure D 1 in Appendix D. For further evaluation, the power curve is approximated by a linearization of the individual data points. This linearization is shown in Figure D 2 in Appendix D.

As the investigated WT has an active pitch control, no correction of the measured electric power $P_m$ to the atmospheric standard conditions is required for the evaluation. Instead, according to [1] the measured power is used for the standardised electric power:

$$P_n = P_m \qquad (1)$$

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For systems with active pitch control, the wind speed $V_D$ determined from the performance curve must be corrected to the standard climatic conditions according to equation (4) from [1].

$$V_H = V_D \cdot \left( \frac{p_{ref} \cdot T_k}{p \cdot T_{ref}} \right)^{\frac{1}{3}} \text{ in m/s} \qquad (2)$$

$V_H$ corrected wind speed in hub height in m/s

$V_D$ wind speed derived from performance curve in m/s

$T_{ref}$ = 288 K, temperature at standard conditions

$T_k$ measured temperature in K

$p$ measured atmospheric pressure in kPa

$p_{ref}$ = 101.3 kPa, atmospheric pressure at standard conditions

With the weather data from the measurements, the following equation results:

$V_H = V_D \cdot 1{,}001$ (for $T_{min}$) und $V_H = V_D \cdot 1{,}009$ (for $T_{max}$)

According to [1], the wind speed $V_Z$ in hub height, which results from the performance curve for $P_n$, can be converted to the standardised wind speed $V_S$ by applying the following equation:

$$V_S = V_Z \cdot \left[ \ln\left( \frac{z_{ref}}{z_{0ref}} \right) \cdot \ln\left( \frac{H}{z_O} \right) \right] : \left[ \ln\left( \frac{H}{z_{0ref}} \right) \cdot \ln\left( \frac{z}{z_O} \right) \right] \text{ in m/s} \qquad (3)$$

$V_S$ standardised wind speed at a height of 10 m

$V_Z$ wind speed in hub height; in this case, the wind speed at hub height $V_H$ derived from the power curve and corrected to standard conditions

$z_{ref}$ reference height of 10 m

$z_{0ref}$ reference roughness length of 0.05 m

$H$ hub height, in this case $H$ = 98,4 m above the ground

$z$ height of the anemometer, here $z$ = H

$z_0$ roughness length at the measuring position, here $z_0$ = 0.05 m

For the existing geometry of the WT, the following equation results:

$V_S = V_z \cdot 0.699$

In all, the conversion of $V_D$ via $V_H$ to $V_S$ results in the following equation:

$V_S = V_D \cdot 0{,}699$ (for $T_{min}$) und $V_S = V_D \cdot 0{,}705$ (for $T_{max}$)

Using the conversion factors for the standardised wind speed and standardised power, a polynomial results, which describes the connection between measured electric power $P_m$ and the standardised wind speed $V_S$.

The corresponding corrections were considered in the evaluation.

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### 5.1.2 Determination of the standardised wind speed from the measurements with the anemometer

According to [1], for the determination of the wind speed during the background noise measurements and perhaps in some cases for the WT noise measurements, the results of the wind speed measurements with the anemometer of Müller-BBM should be used.

Corresponding to the method described in section 6.1.1, the wind speed data $V_z$ recorded with the equipment on top of the adjacent met mast (z = 30.0 m above the ground) should be converted to the standardised wind speed $V_S$ according to equation (3).

$$V_S = V_Z \cdot 0{,}828$$

## 5.2 Equivalent continuous sound pressure level during operation of the WT

Based on [1], the noise behaviour of a WT during emission measurements should be recorded and documented for the standardised wind speeds between 6 m/s and 10 m/s.

These standardised wind speeds are derived from the generated power by means of the power curve. In the present case, the rated power is 3000 kW.

According to [1], if 95 % of the rated power is obtained below the standardised wind class of 10 m/s, the measured values above 95 % of the rated power have to be corrected with the so-called nacelle anemometer. In this method, for all measuring data between 5 % and 95 % of the rated power of the WT, a linear regression between the wind speed $V_n$ recorded with the nacelle anemometer and the wind speed in hub height $V_H$ - determined from the electric power of the WT - is carried out. With the determined regression, the data of the nacelle anemometer, which are above 95 % of the rated power, are corrected.

The data pairs of the wind speed $V_H$ determined from the electric power of the WT and the wind speed $V_n$ recorded with the nacelle anemometer, which are used for calculating the regression, are shown in Figure C 1 in Appendix C.

Figure C 2 Appendix C gives an overview of the measured data used for the evaluation of the investigated WT. In the diagram showing the determined sound pressure levels depending on the standardised wind speed (at the bottom on the left in Figure C 2), those sound pressure levels are shown, which were measured directly and averaged over a period of 10 seconds. 10 seconds averages were used instead of 1 minute averages to maximise the precision and it is consistent with the procedures described in [8]. All measuring data shown in the diagram were used for calculating the regression.

Table 4 on page 15 shows the relation between the standardised wind speed and the electric power of the WT, which was determined from the measurements.

The results listed in Table 4 show that on the two days of measurements during normal operation of the WT, an electric power of approx. 2750 kW was achieved in the standardised wind class of 10 m/s. 95 % of the rated power of the WT (i.e. 2850 kW) are achieved for a standardised wind speed of approx. 10.5 m/s.

### 5.3 Equivalent continuous sound pressure level during standstill of the WT

During standstill of the WT, the standardised wind speed is determined from measurements with the anemometer of Müller-BBM. Apart from that, the evaluation for standstill of the WT is carried out in the same way as for operation of the WT. Table 4 on page 15 shows the results of the evaluation for standstill of the WT. They describe the wind-induced background noise and the disturbing noise at the reference position, which could not be suppressed.

### 5.4 Equivalent continuous sound pressure levels with background noise correction

In order to determine the sound pressure levels caused only by the WT, according to section 8.2 of [1] the measuring results during operation of the WT have to be corrected with the measuring results during standstill.

This background noise correction results in values $L_S$ for the energy-equivalent continuous sound pressure levels caused only by the WT at the reference position.

If the equivalent continuous sound pressure levels of the background noise $L_n$ during the measurements are by more than 6 dB below the levels $L_{S+n}$ (noise of the WT including background noise), the background noise correction is made according to equation (8) from [1]. For these measurements, this applies to the wind classes 7 m/s to 10 m/s. Within that correction a $\kappa$-factor of 1,0 – which is used for the correction of the measured wind speed - was applied.

Table 4 shows the corresponding values.

### 5.5 Sound power level of the WT as a function of the standardised wind speed

According to [1], the sound power level $L_{WA,k}$ of the WT is calculated from the sound pressure level at the reference position with background noise correction $L_{Aeq,c,k}$ according to the following equation:

$$L_{WA,k} = L_{Aeq,c,k} - 6 + 10 \lg \left( \frac{4 \pi R_1^2}{S_0} \right) \text{ in dB(A)} \qquad (4)$$

$L_{Aeq,c,k}$ A-weighted sound pressure level measured at reference conditions and with background noise correction for integer wind speed values; according to [1], this value corresponds to $L_S$ in Table 4.

$R_1$ diagonal distance between rotor centre and microphone;
$R_1$ consists of the distance between rotor centre and tower centreline, the distance between tower centreline and reference position and the vertical distance between the reference position and the rotor flange centre

$S_0$ reference area $S_0 = 1\ m^2$

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With the following dimensions/heights

- vertical distance between reference position and WT foundation: 0,0 m
- distance between rotor centre and the tower centreline: 4.62 m
- horizontal distance between microphone and the tower- outer face : 150.0 m
- diameter of the tower base: 7.5 m
- hub height: 98.4 m

for the diagonal distance between rotor centre and microphone a value of

$$R_1 = 186.4 \text{ m}$$

results, and for the relation between $L_{WA}$ and $L_{Aeq,c,k}$ the following equation:

$$L_{WA} = L_{Aeq,c,k} + 50.4 \text{ dB(A)}$$

Thus, for operation of the WT, the sound power levels $L_{WA,k}$ listed in Table 4 can be calculated.

**Table 4.** Evaluation in summary

| **Wind class $V_s$ in m/s** | **Standard-ised power $P_n$ in kW** | **Rotational speed [rpm]** | **WT and background noise ($L_{S+n}$) $L_{Aeq}$in dB(A)** | **Back-ground noise ($L_n$) $L_{Aeq}$ in dB(A)** | **Corrected level ($L_S$) $L_{Aeq,c,\,k}$ in dB(A)** | **Apparent Sound-power level $L_{WA,k}$ in dB(A)** |
|---|---|---|---|---|---|---|
| **Power curve: 3000 kW (mode 1)** | | | | | | |
| 7 | 1586,2 | 16,0 ** | 54,3 | 39,7 | 54,1 | 104,5 |
| 8 | 2035,2 | 16,4 ** | 54,4 | 42,5 | 54,1 | 104,5 |
| 9 | 2447,0 | 16,8 ** | 54,9 | 45,4 | 54,4 | 104,8 |
| 10 | 2747,0 | 17,2 ** | 55,8 | 48,2 | 55,0 | 105,4 |
| 10,5 * | 2850,0 | 17,3 ** | 55,9 | 49,6 | 54,7 | 105,1 |

* Wind speed at 95 % rated power
** derived from the recorded data

The data listed in Table 4 were determined from the regression analyses required according to [1], i.e.:

- fourth-degree regression for the WT noise
- linear regression for background noise

The individual data points and the calculated regression analyses are shown in Figure C 3 in Appendix C. The sound pressure levels determined at more than 95 % of the rated power are marked in the figure, as required according to [1].

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## 5.6 Sound power level of the WT

As already described in section 5.2, the noise behaviour of a WT shall be determined by means of sound emission measurements in the range of the standardised wind speeds between 6 m/s and 10 m/s.

In the present case, sound power levels at the investigated WT could be determined in the wind classes of 7 m/s to 10 m/s.

Figures C 5 to C 8 in Appendix C show the corresponding sound power level spectra in 1/3 octave bandwidth for the standardised wind classes 7 m/s to 10 m/s. The sound power levels in 1/3 octave and octave bandwidth are stated in a table beside the 1/3 octave spectrum.

Based on these measurements and evaluations, a maximum sound power level for the investigated WT of

$$L_{WA} = 105.4 \text{ dB(A)}$$

results.

## 5.7 Sound power level of the WT related to the normalized wind speed in hub height

In table 5 are listed the sound power levels related to the wind speed $V_H$ in hub height based on the results in table 4. The data used for the calculation of the sound power level are depicted in figure C 4 in Appendix C.

**Table 5.** Sound power level of the WT related to the normalized wind speed in hub height and 10 m height

| Wind speed in hub height $V_H$ in m/s | Wind speed in 10 m height $V_S$* in m/s | Sound power level $L_{WA,k}$ in dB(A) |
|---|---|---|
| 10,0 | 7,0 | 104,4 |
| 10,5 | 7,3 | 104,5 |
| 11,0 | 7,7 | 104,5 |
| 11,5 | 8,0 | 104,4 |
| 12,0 | 8,4 | 104,5 |
| 12,5 | 8,7 | 104,5 |
| 13,0 | 9,1 | 104,7 |
| 13,5 | 9,4 | 104,9 |
| 14,0 | 9,8 | 105,1 |
| 14,5 | 10,1 | 105,1 |
| 15,0 | 10,5 | 104,8 |

(*) The wind speed in 10 m height is derived by the division of the values of $V_H$ with the divisor ≈ 0,7 (see section 5.1.1).

## 5.8 Tonal components of the WT noise

According to [1] and [3], for the determination of tonal components 12 narrowband spectra have to be evaluated for a period of 10 seconds each. From these 12 spectra, the tone adjustment is determined as the average of the single values.

The evaluated spectra are shown in Figures C 9 to C 14 in Appendix C. Owing to the measuring data at hand, the evaluation of tonal components according to [1] in combination with [4] was carried out for the wind classes 7 to 10 m/s. Figures C 17 to C 20 in Appendix C show the comprehensive evaluation for each wind class.
Finally no tone adjustments $K_{TN}$ in the vicinity of the WT were determined.

## 5.9 Summarized results

The following Table 5 shows the summarized results of the evaluation.

**Table 6.** Apparent sound power levels and Tone adjustment

| **Wind class $V_s$ in m/s** | **Power $P_n$ in kW** | **Sound power level $L_{WA}$ in dB(A)** | **Tone adjustment $K_{TN}$ in dB** |
|---|---|---|---|
| 7 | 1586,2 | 104,5 | 0 |
| 8 | 2035,2 | 104,5 | 0 |
| 9 | 2447,0 | 104,8 | 0 |
| 10 | 2747,0 | 105,4 | 0 |

Thus, the apparent maximum sound power level of the WT at a standardised wind speed of 10 m/s is

$$L_{WA} = 105.4 \text{ dB(A)}.$$

The summarized results are also listed in the master sheet “noise” in the appendix E.

## 5.10 Remarks regarding computational accuracy and rounding

In this test report, all final results for level data are stated rounded to one position after the decimal point, taking into consideration the rounding regulations stated in DIN 1333, sheet 2 (February 1992). However, the calculations are performed by using all positions after the decimal point. Thus, it is guaranteed that no additional mistakes will occur by rounding.

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# 6 Measuring uncertainty

## 6.1 Influences on site

The influences on site on the noise measurements in the area of the base plate are estimated to be “very low” owing to the direct influence of the WT and owing to the distance to the nearest vegetation.

## 6.2 Measuring uncertainty type A and B

According to Annex D of [1] in combination with [8], the measuring uncertainty for the sound power level of the WT depending on the wind speed is calculated as follows:

- Measuring uncertainty $U_{A,s}$ for the measured values $L_{Aeq}$ during operation of the WT was estimated to 0,2 dB.
- For the measuring uncertainties $U_{B1}$ to $U_{B9}$ the typical values stated in Table D.1 in [1] are applied:
  - calibration $U_{B1}$ = 0.2 dB
  - measuring device $U_{B2}$ = 0.2 dB
  - sound-reflecting board $U_{B3}$ = 0.3 dB
  - measuring distance $U_{B4}$ = 0.1 dB
  - impedance $U_{B5}$ = 0.1 dB
  - turbulence $U_{B6}$ = 0.4 dB
  - wind speed $U_{B7}$ = 0.2 dB (calculated from the power output of the WT)
  - direction $U_{B8}$ = 0.3 dB
  - background noise $U_{B9}$ = 0.3 dB (see Table 4)

## 6.3 Total measuring uncertainty

For the combined total measuring uncertainty $U_c$, according to [1] the following equation is valid:

$$U_C = \sqrt{U_A^2 + U_{B1}^2 + U_{B2}^2 + \ldots + U_{B9}^2}$$

Thus, for the total sound power level $L_{WA}$ a total measuring uncertainty of **$U_C$ = 0.8 dB** results.

# 7 Apparent sound power level related to other hub heights

The determined apparent sound power levels of the investigated wind turbine can be converted to another hub height for a wind turbine of the same type. A method for calculating the corresponding values for different hub heights is described in [2] as well as in [8]. For this purpose the functional relation between the sound pressure levels and the wind speed value at 10 m, in fact the regression coefficients, is used (compare Figure C 3 in Appendix C).

The results of the aforementioned conversion of the determined apparent sound power levels to other hub heights are listed in table 7.

**Tabelle 7.** Apparent sound power levels related to other hub heights

| hub height | $L_{WA,P}$ | wind speed $V_{10,ref}$ 6 m/s | 7 m/s | 8 m/s | 9 m/s | 10 m/s | $v_{10,ref,95\%}$ | $L_{WA,P,95\%\ Pnenn}$ |
|---|---|---|---|---|---|---|---|---|
| **78 m** | $L_{WA,P}$ | -- | **104,5 dB(A)** | **104,5 dB(A)** | **104,7 dB(A)** | **105,3 dB(A)** | 10,8 m/s | -- |
| **85 m** | $L_{WA,P}$ | -- | **104,5 dB(A)** | **104,5 dB(A)** | **104,7 dB(A)** | **105,3 dB(A)** | 10,7 m/s | -- |
| **98 m** | $L_{WA,P}$ | -- | **104,5 dB(A)** | **104,5 dB(A)** | **104,8 dB(A)** | **105,4 dB(A)** | 10,5 m/s | **105,1 dB(A)** |
| **108 m** | $L_{WA,P}$ | -- | **104,5 dB(A)** | **104,5 dB(A)** | **104,9 dB(A)** | **105,4 dB(A)** | 10,4 m/s | **105,1 dB(A)** |
| **138 m** | $L_{WA,P}$ | -- | **104,5 dB(A)** | **104,5 dB(A)** | **105,1 dB(A)** | **105,4 dB(A) *** | 10,0 m/s | **105,4 dB(A)** |

(*) wind speed value at 10 m corresponding to 95 % of rated power

The extracts with the values for the different hub heights are pictured in Appendix F.

# Appendix A

## Layout plan and photos

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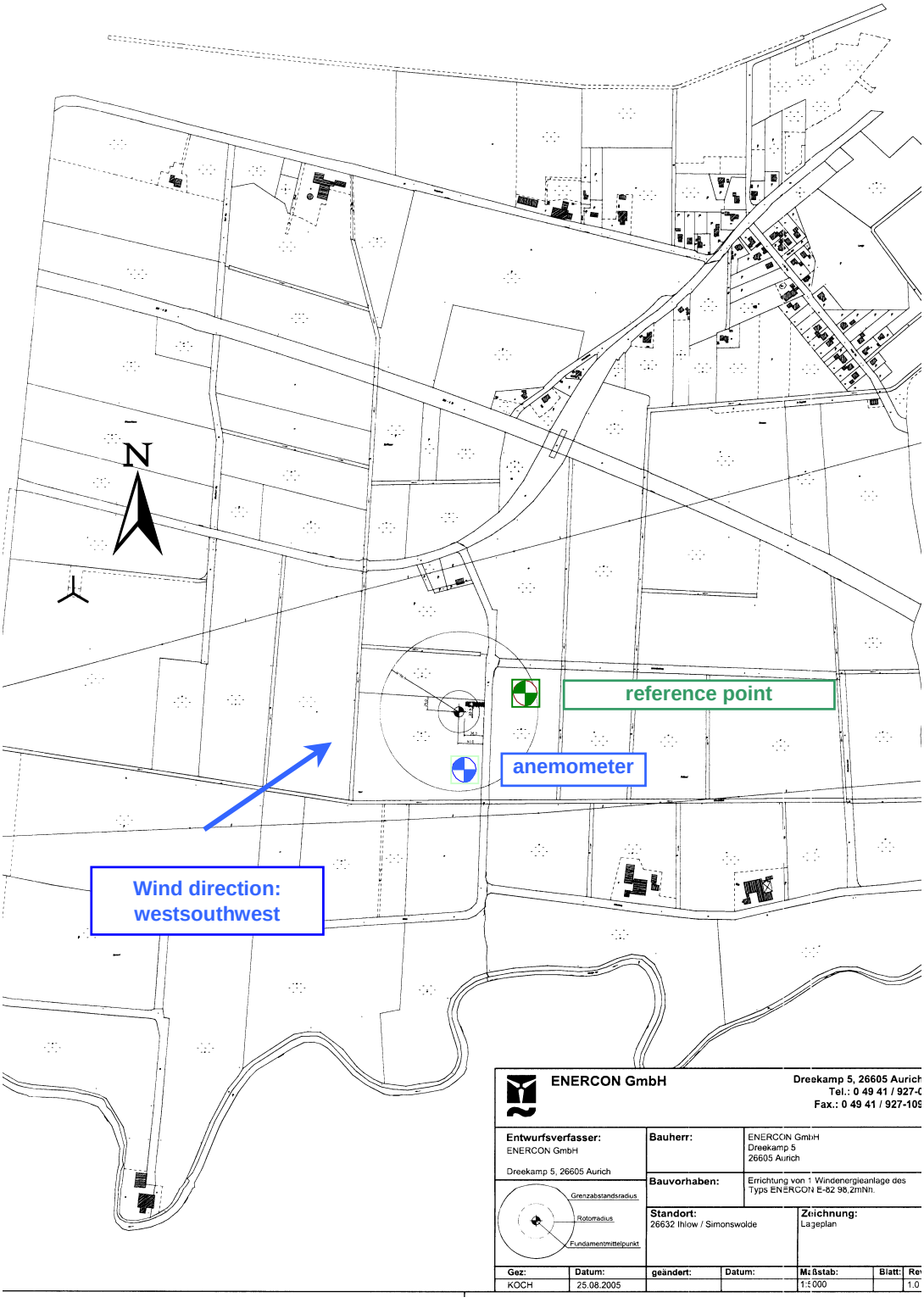



**Figure A 1.** Layout of the windfarm and the measuring positions at the WT (plan not true to scale)

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**Figure A 2.** View from the measuring board to the WT

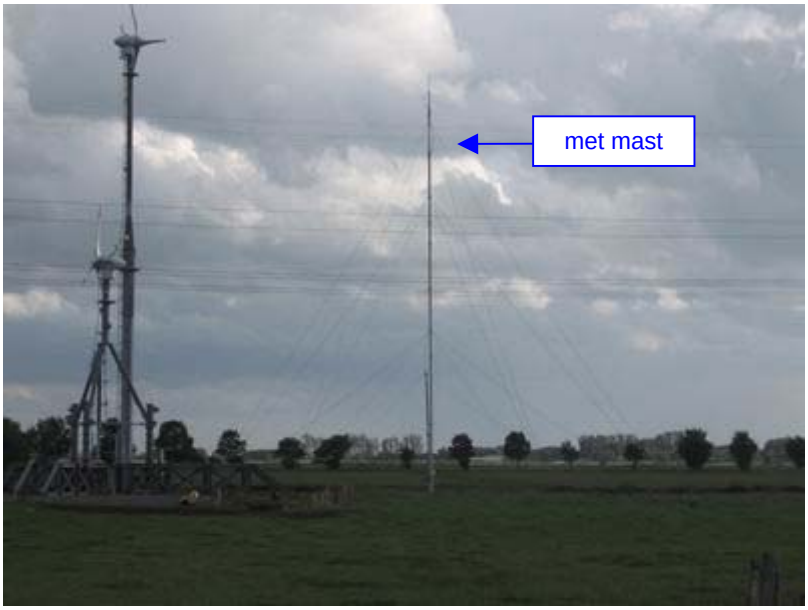



**Figure A 3.** View to the met mast

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**Figure A 4.** microphone (inside the secondary windscreen) with surroundings (grass)

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# Appendix B

## Documentation of the measurements

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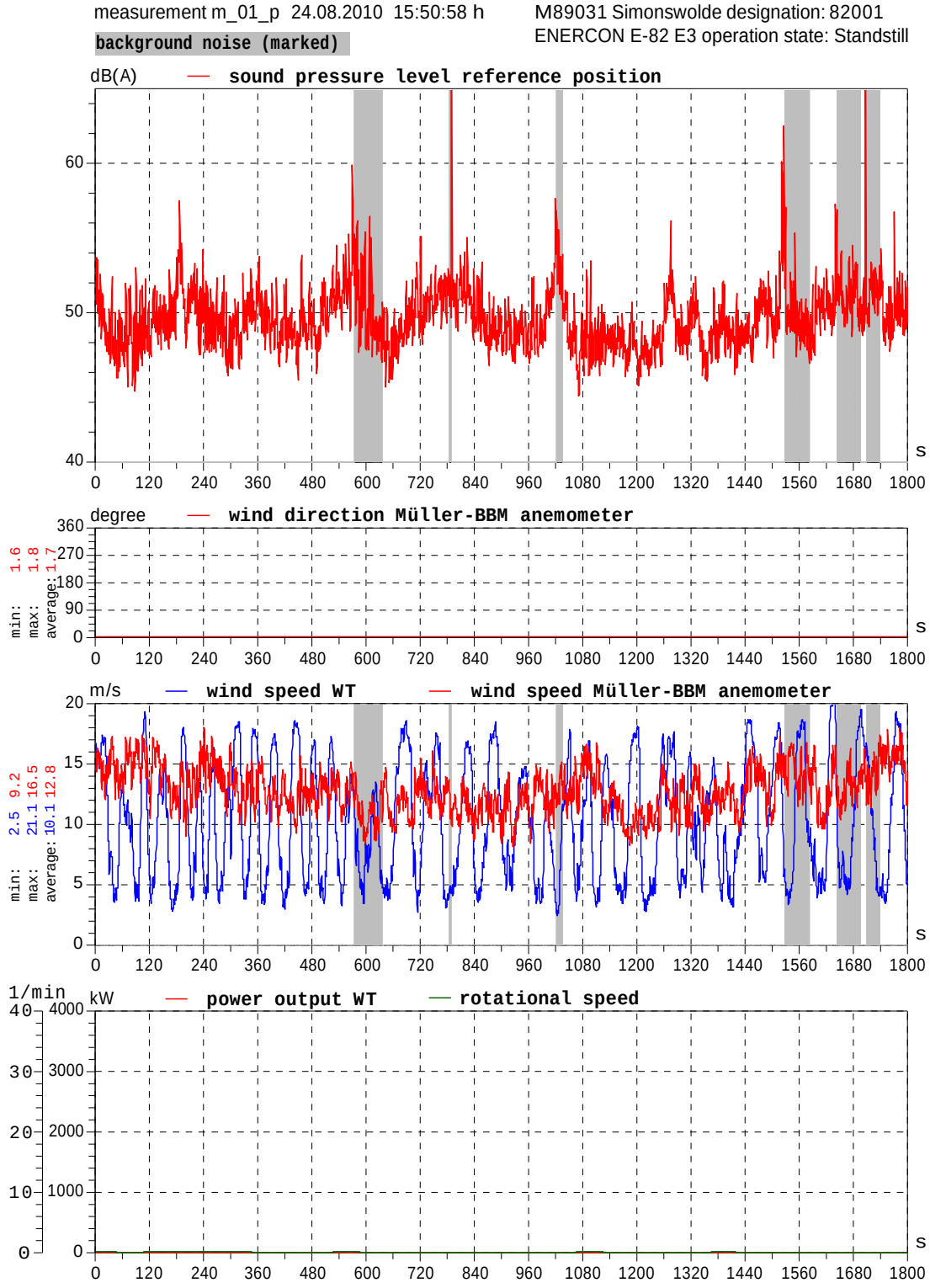



**Figure B 1.** Relevant measuring data of the measurement m_01

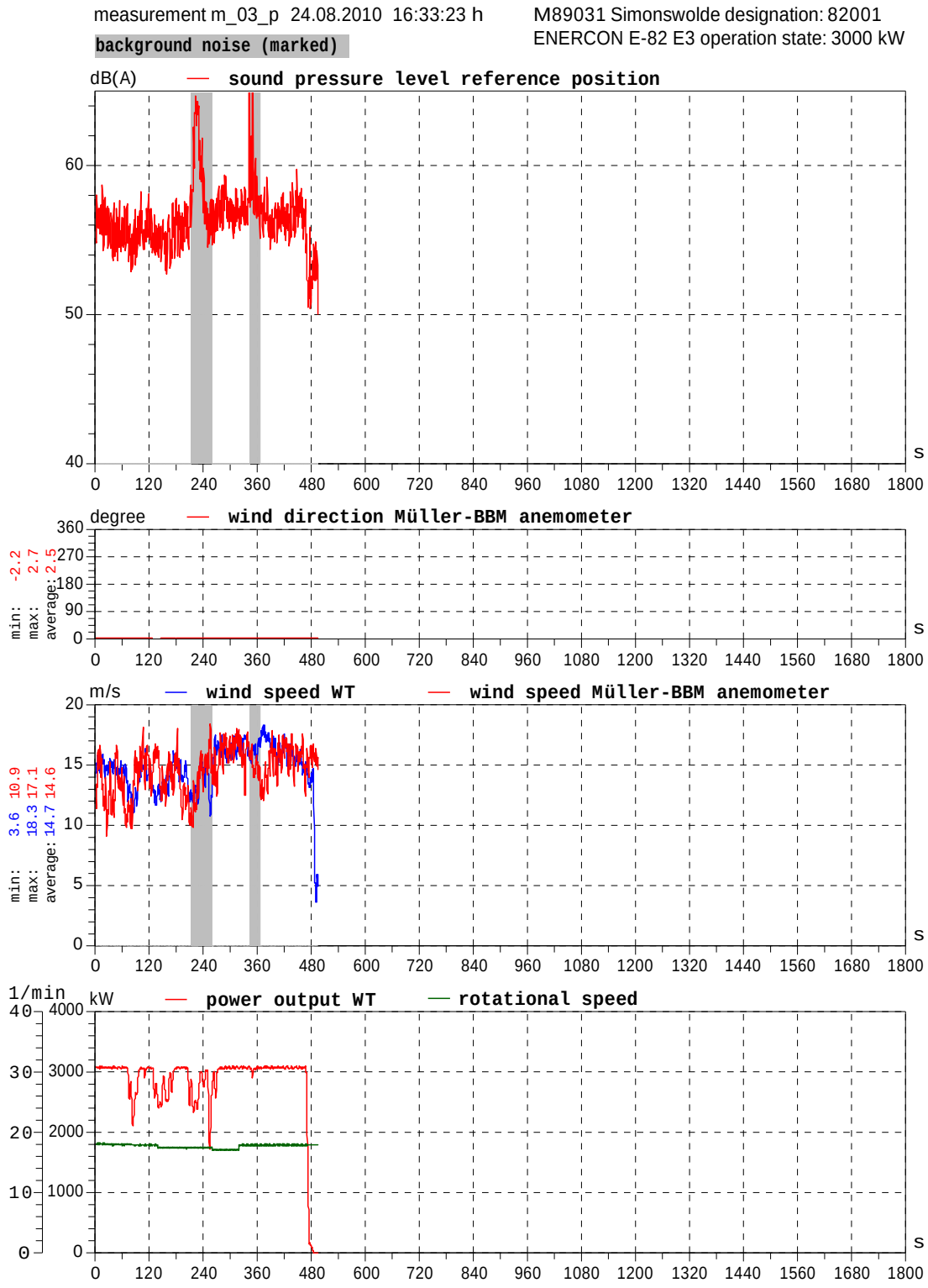



**Figure B 2.** Relevant measuring data of the measurement m_03

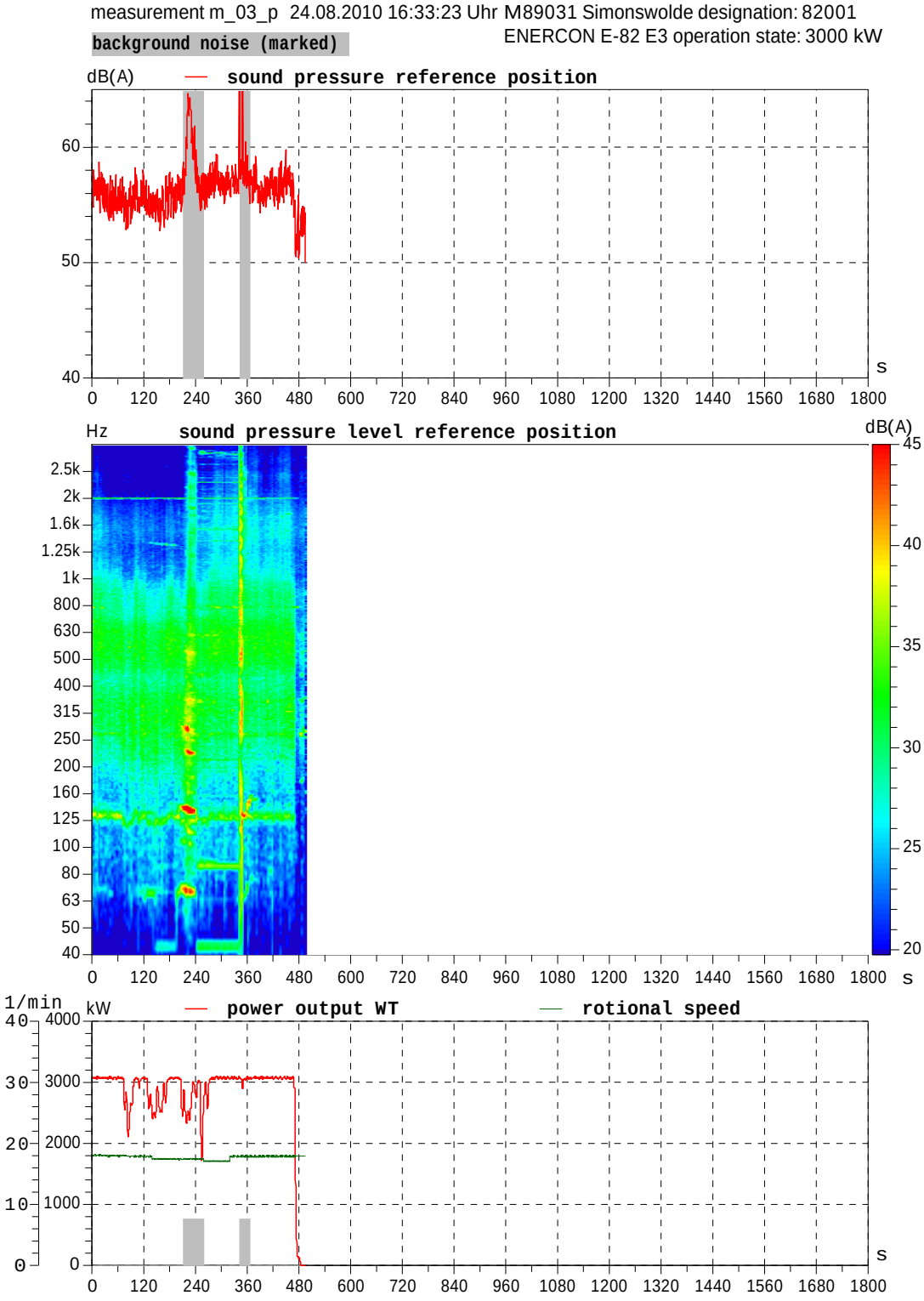



**Figure B 3.** Relevant measuring data and Campbell-Plot of the measurement m_03

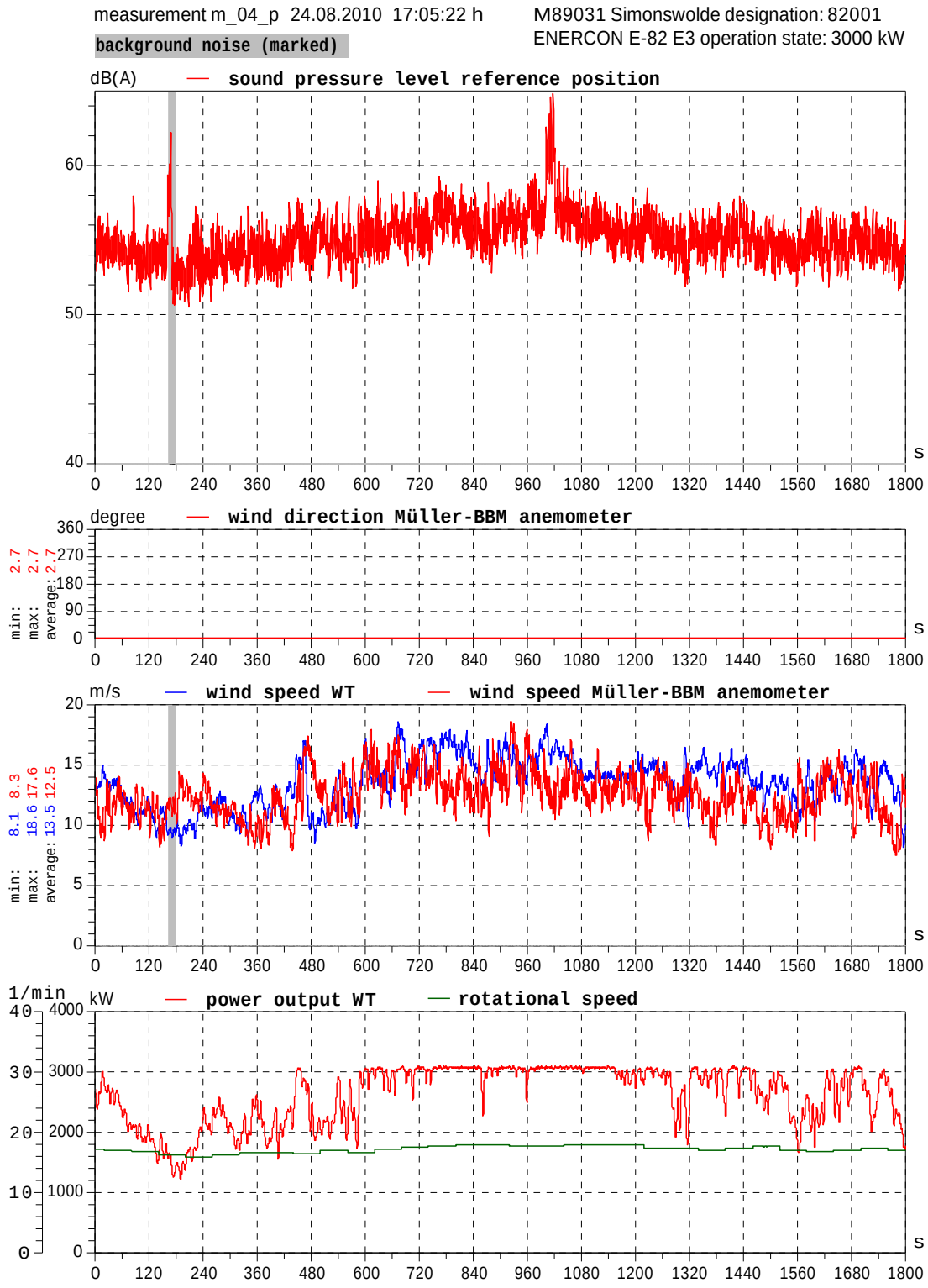



**Figure B 4.** Relevant measuring data of the measurement m_04

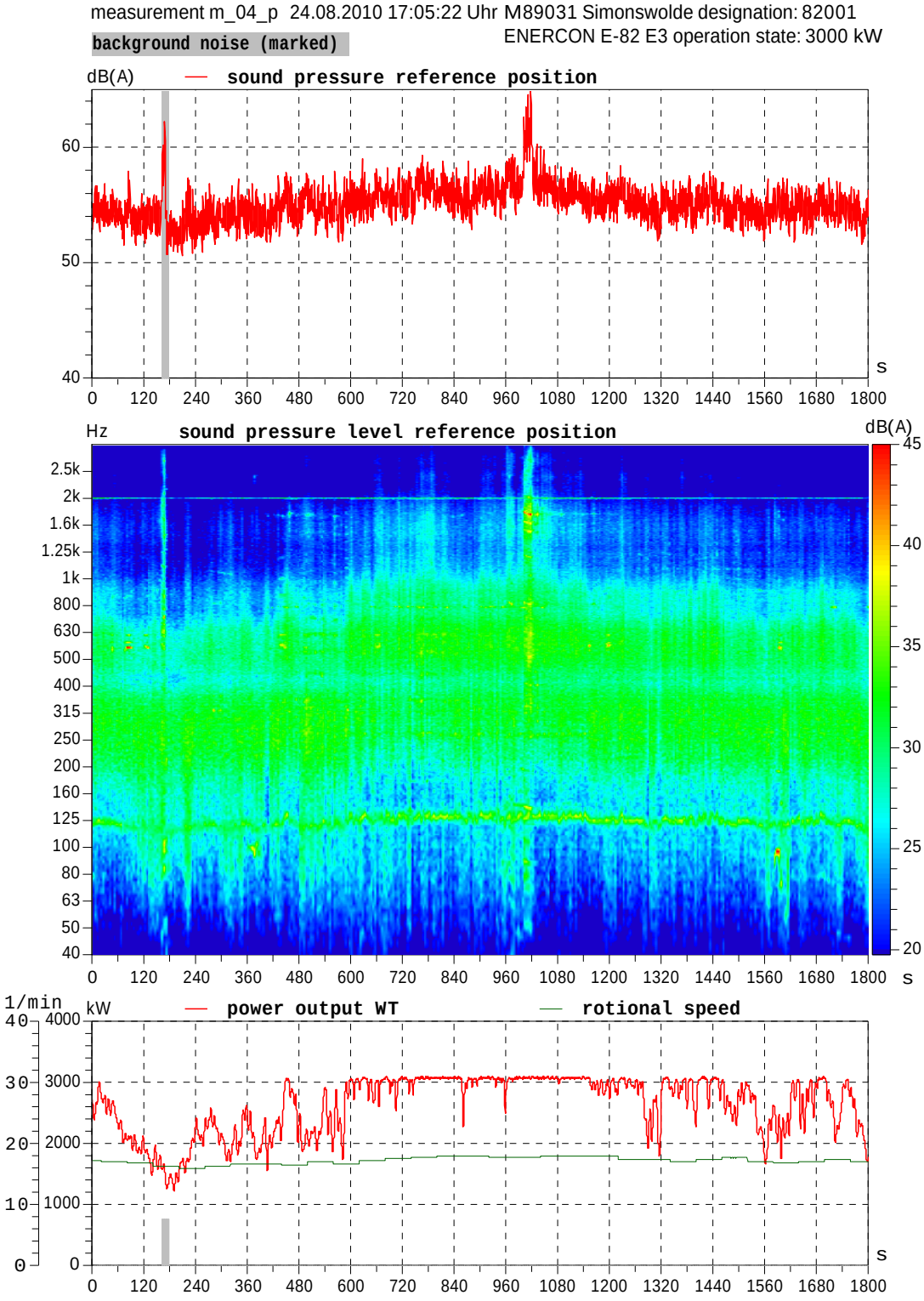



**Figure B 5.** Relevant measuring data and Campbell-Plot of the measurement m_04

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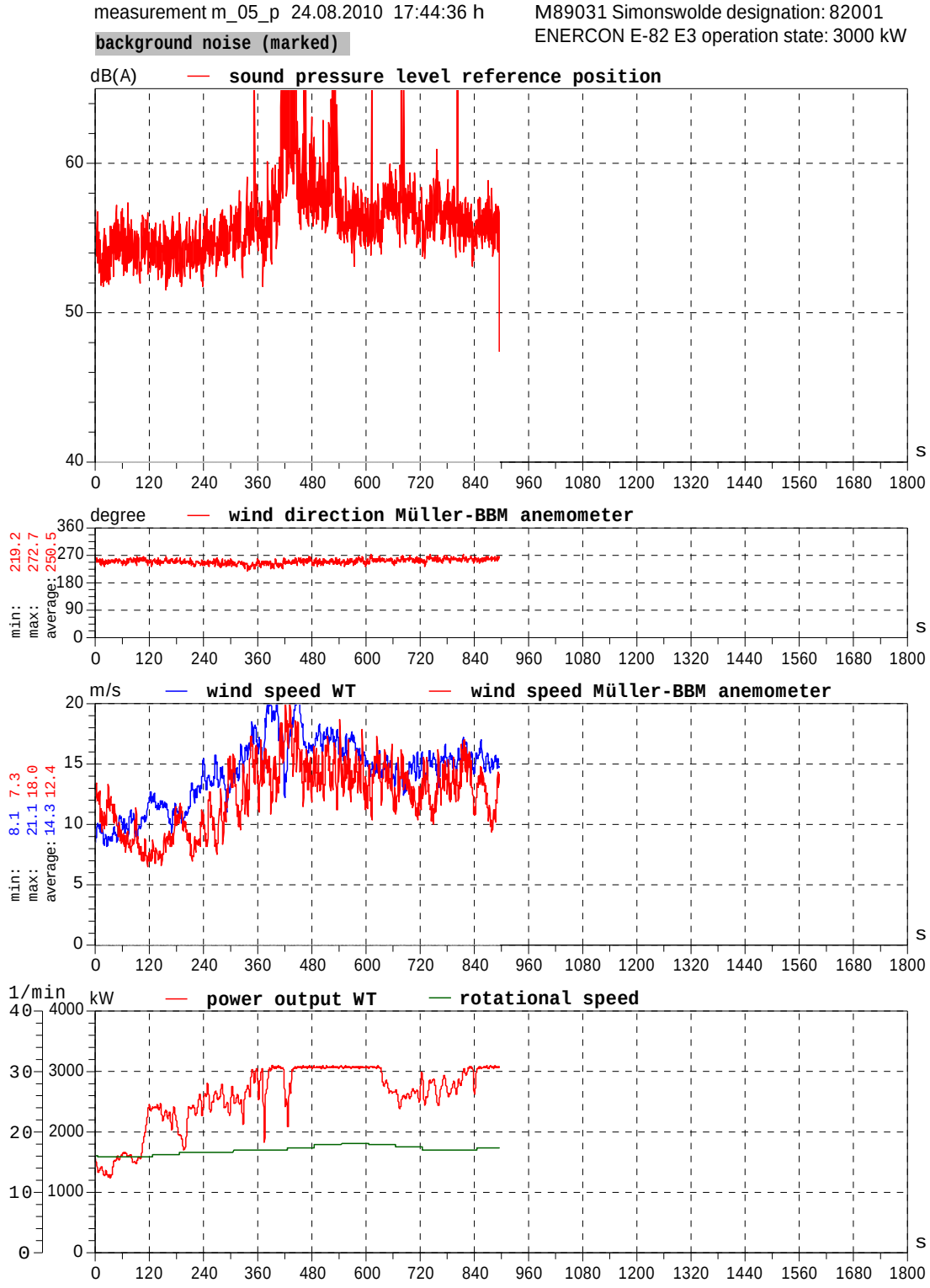



**Figure B 6.** Relevant measuring data of the measurement m_04

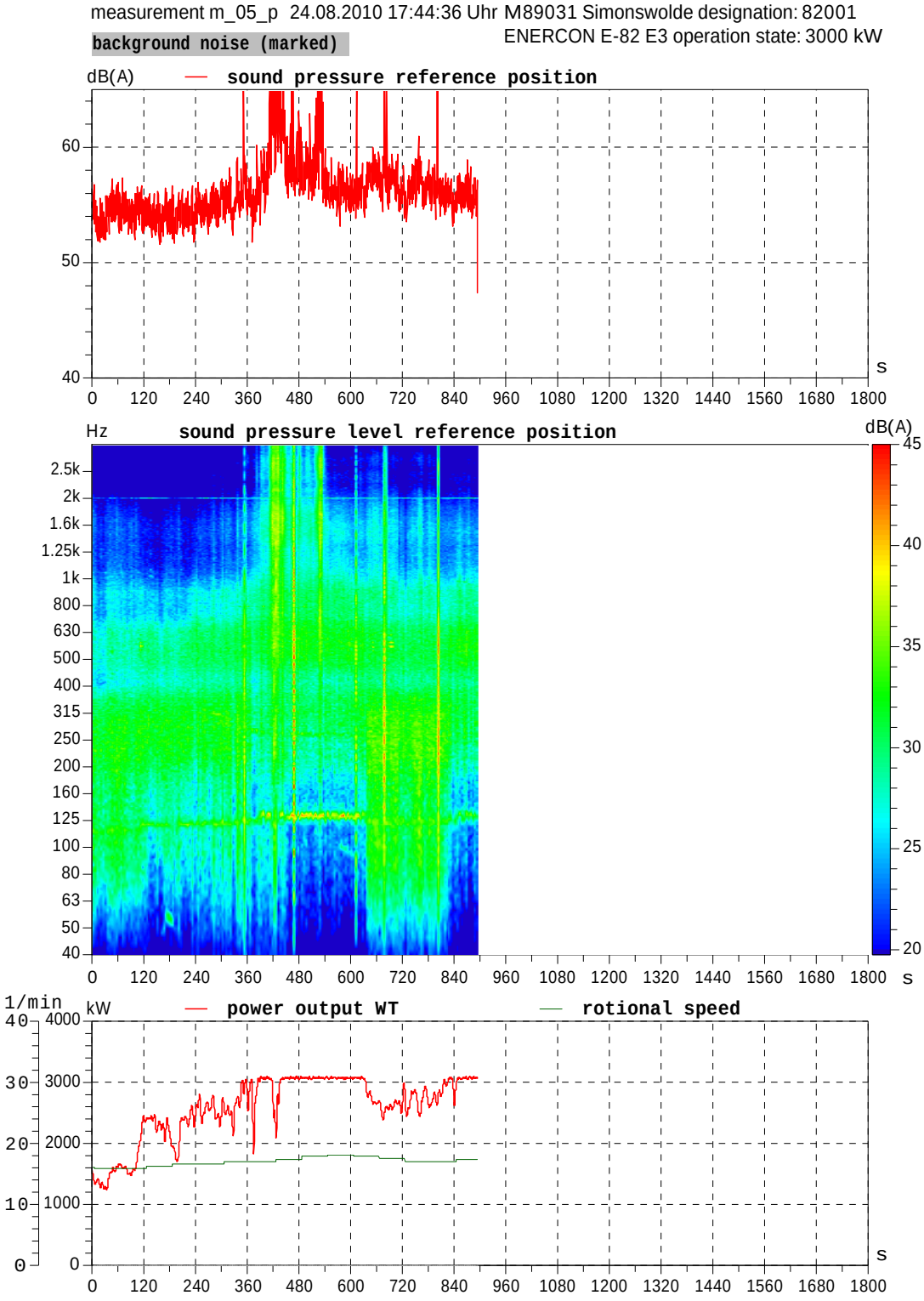



**Figure B 7.** Relevant measuring data and Campbell-Plot of the measurement m_05

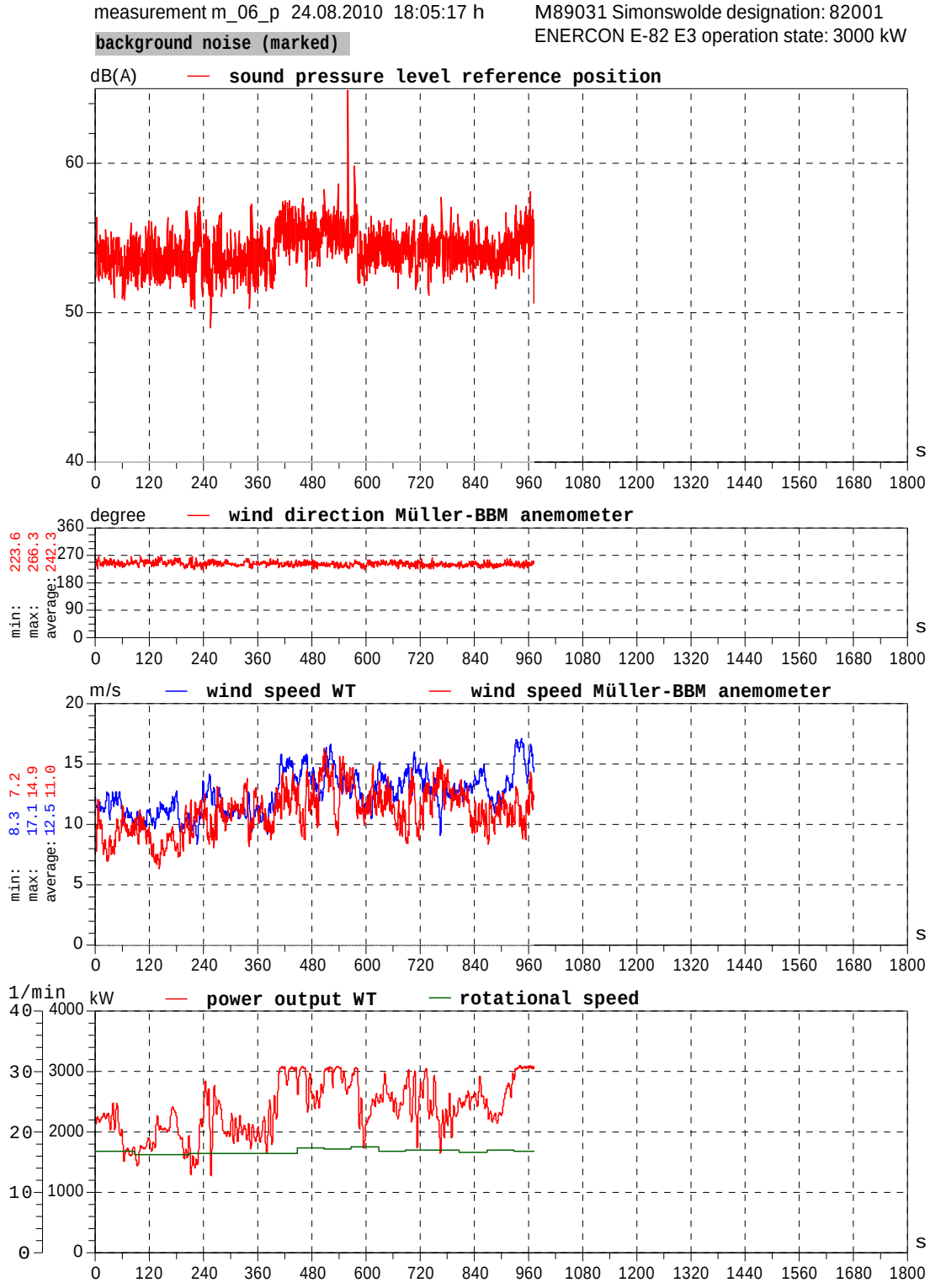



**Figure B 8.** Relevant measuring data of the measurement m_06

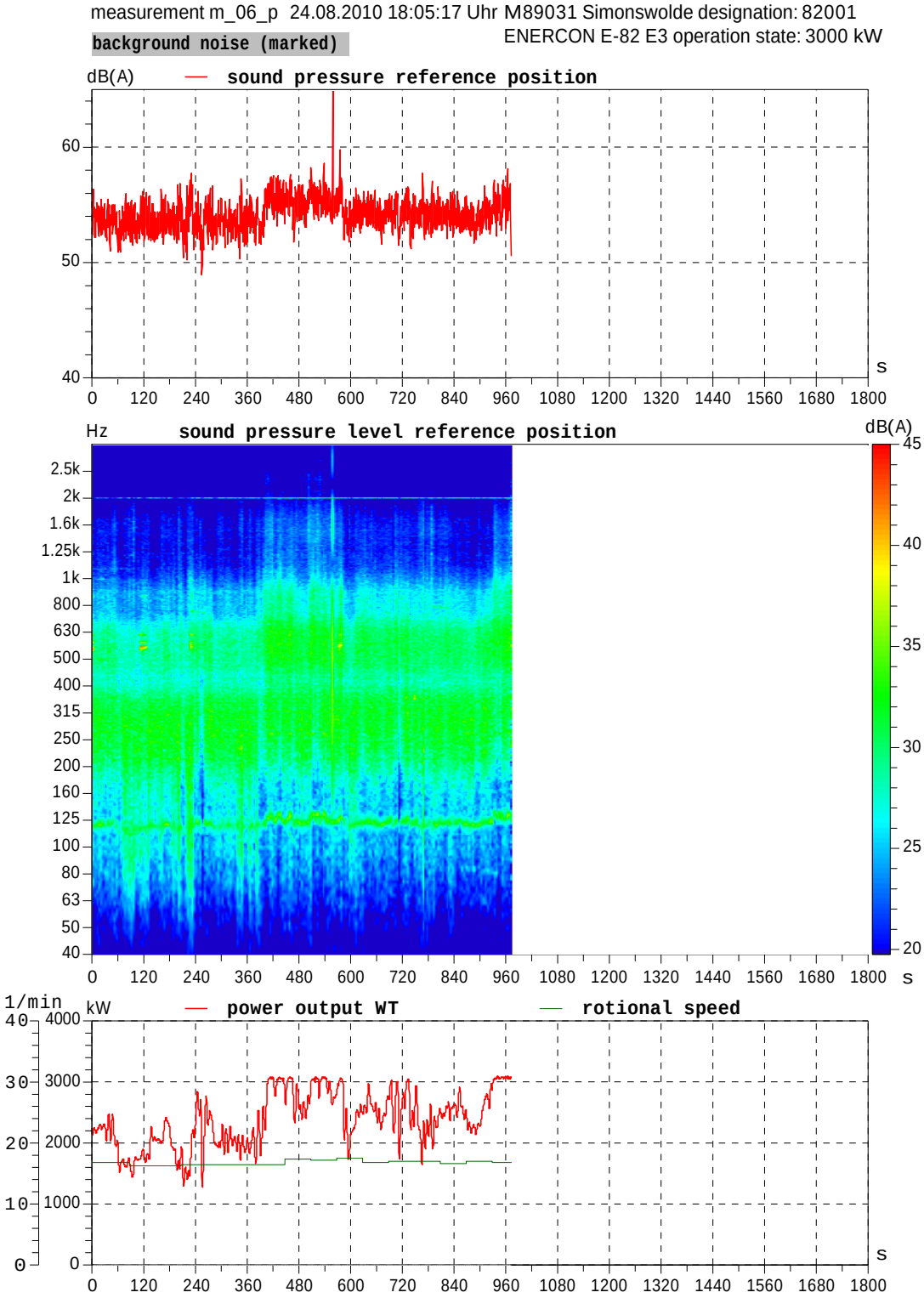



**Figure B 9.** Relevant measuring data and Campbell-Plot of the measurement m_06

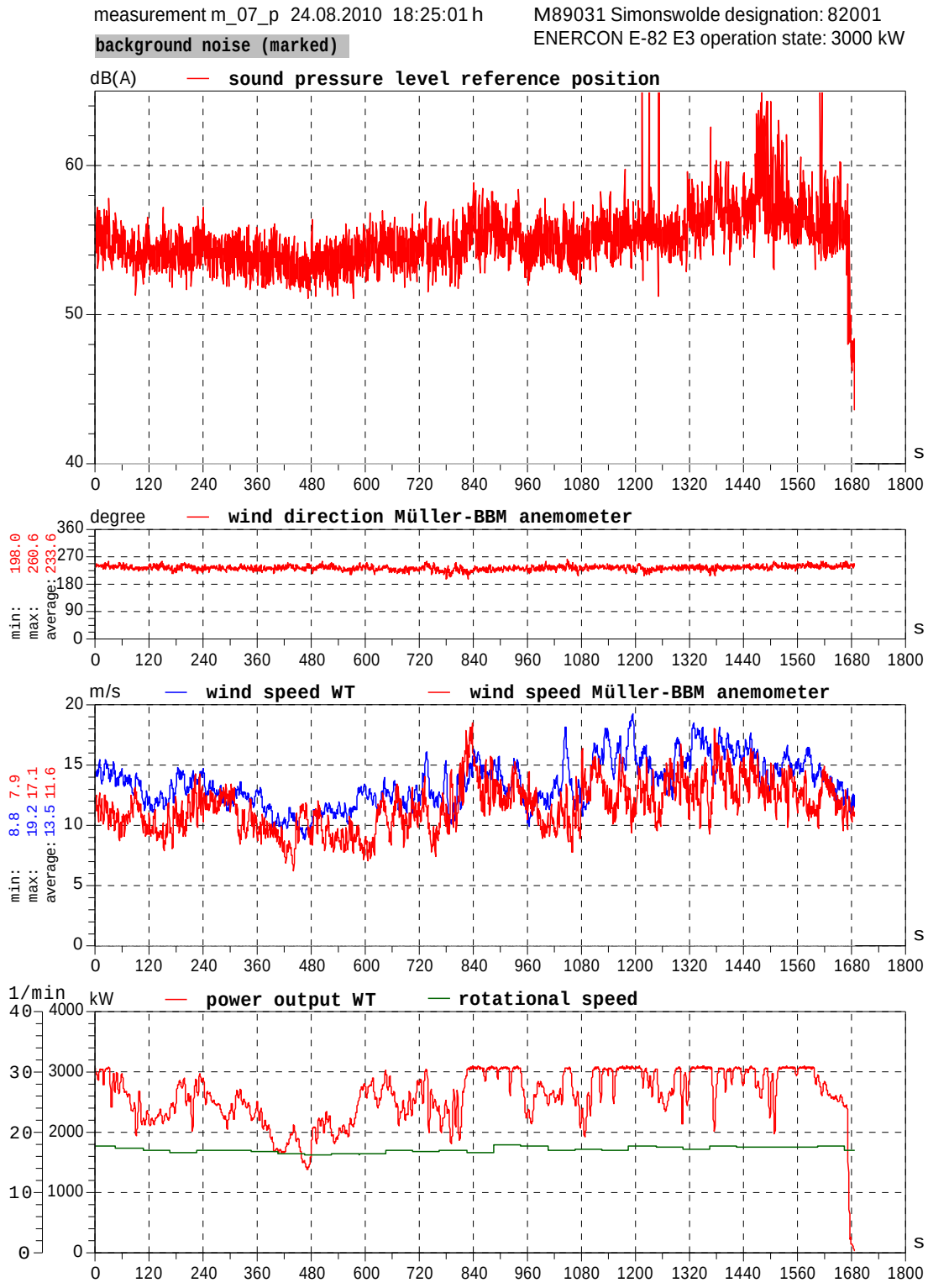



**Figure B 10.** Relevant measuring data of the measurement m_07

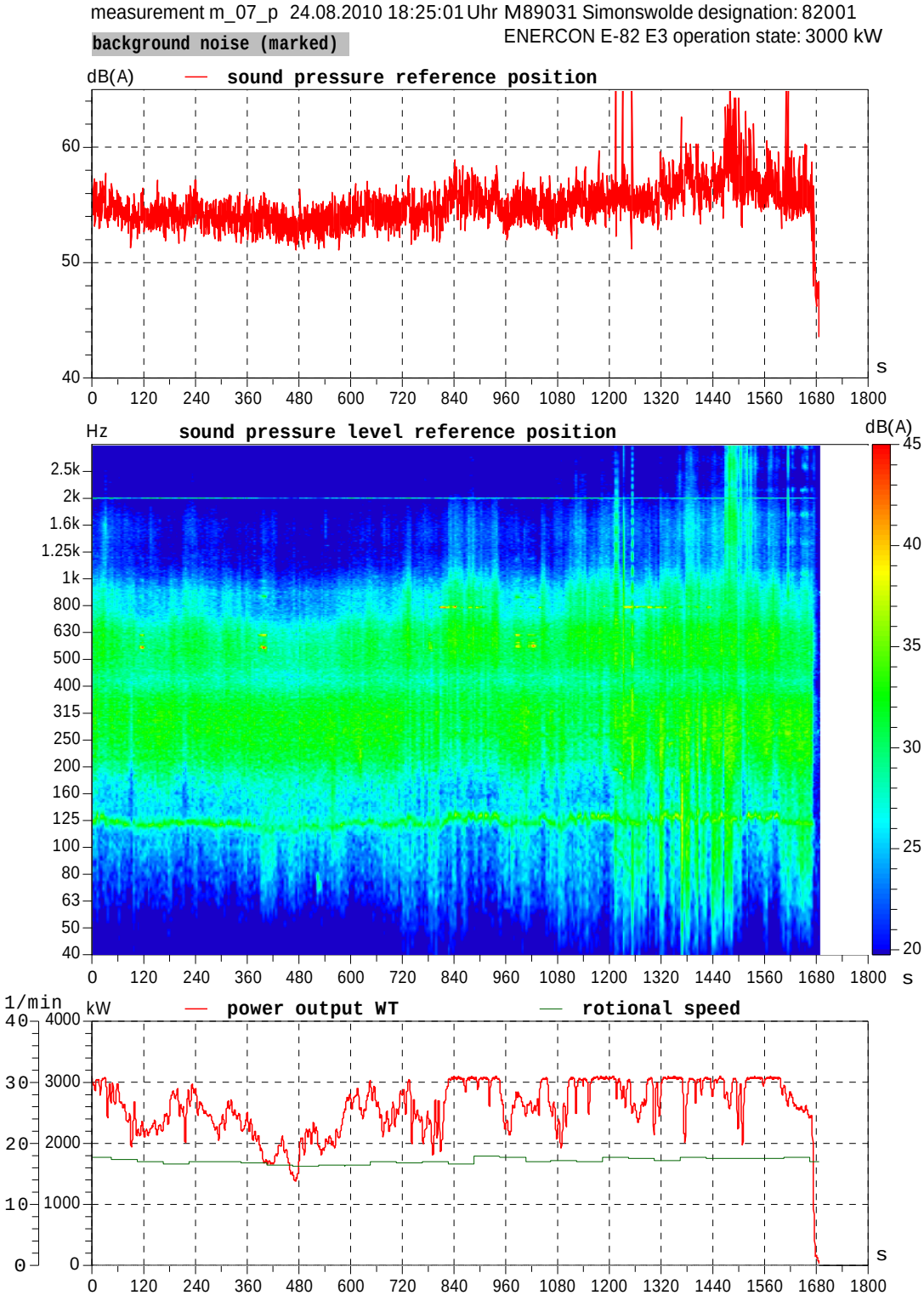



**Figure B 11.** Relevant measuring data and Campbell-Plot of the measurement m_07

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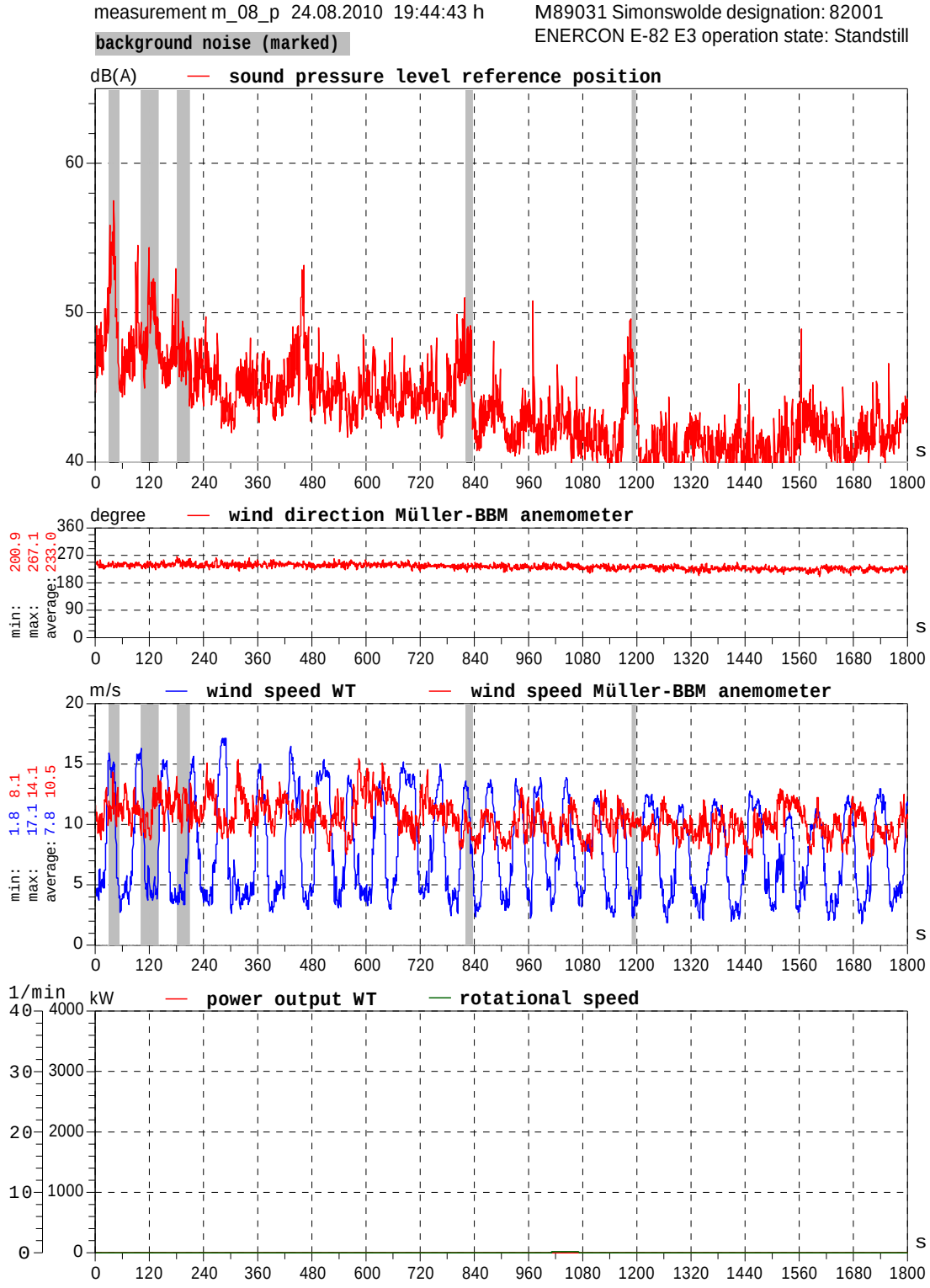



**Figure B 12.** Relevant measuring data of the measurement m_08

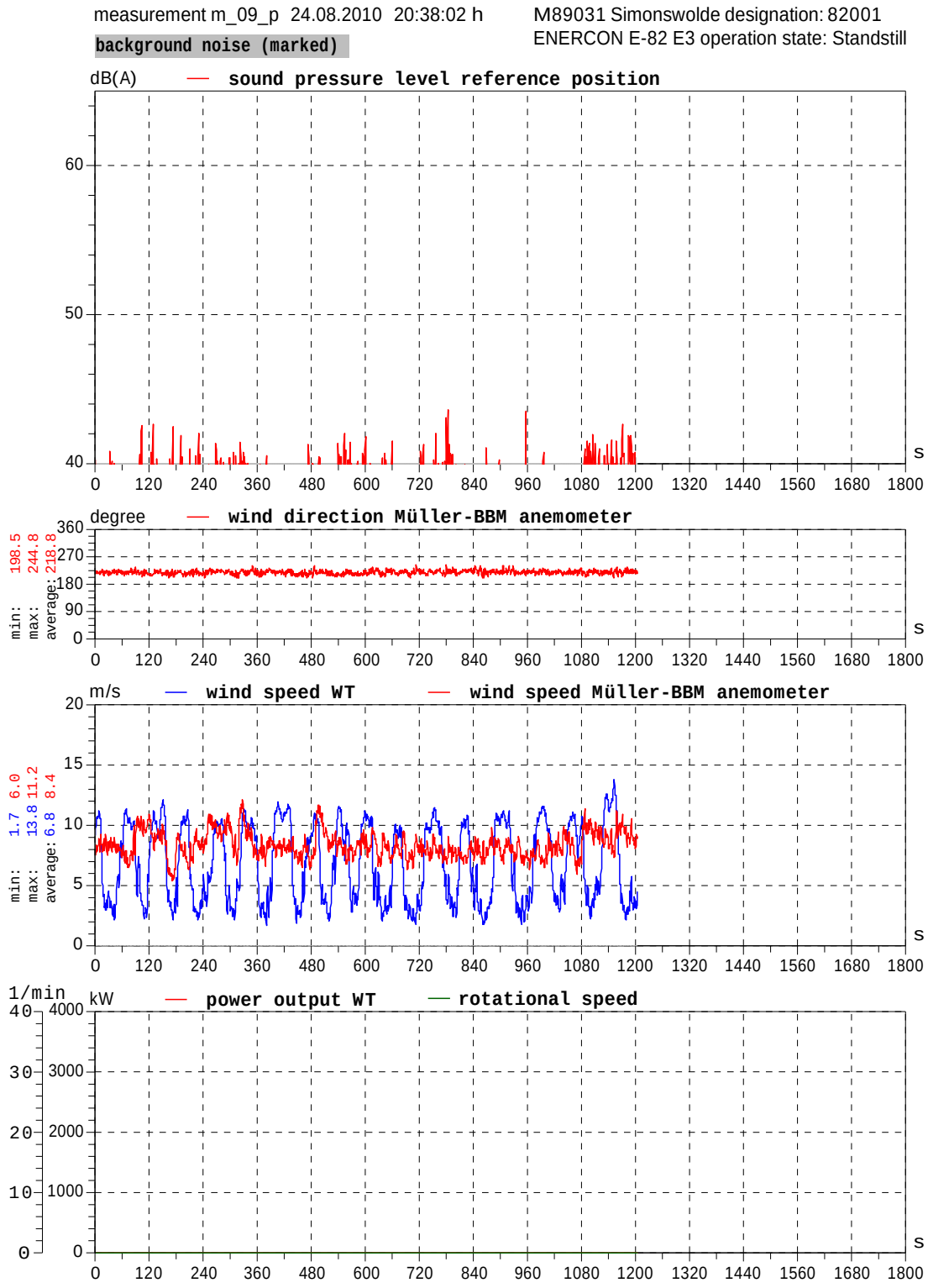



**Figure B 13.** Relevant measuring data of the measurement m_09

# Appendix C

## Results of the evaluation

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**WT-type: ENERCON E-82 E3 designation: 82001**
**WT-location: Simonswolde**
**measuring date: 24.08.2010**
**operation state: 3000 kW**

**data points for determination of regression between VH and Vn (nacelle anemometer method)**

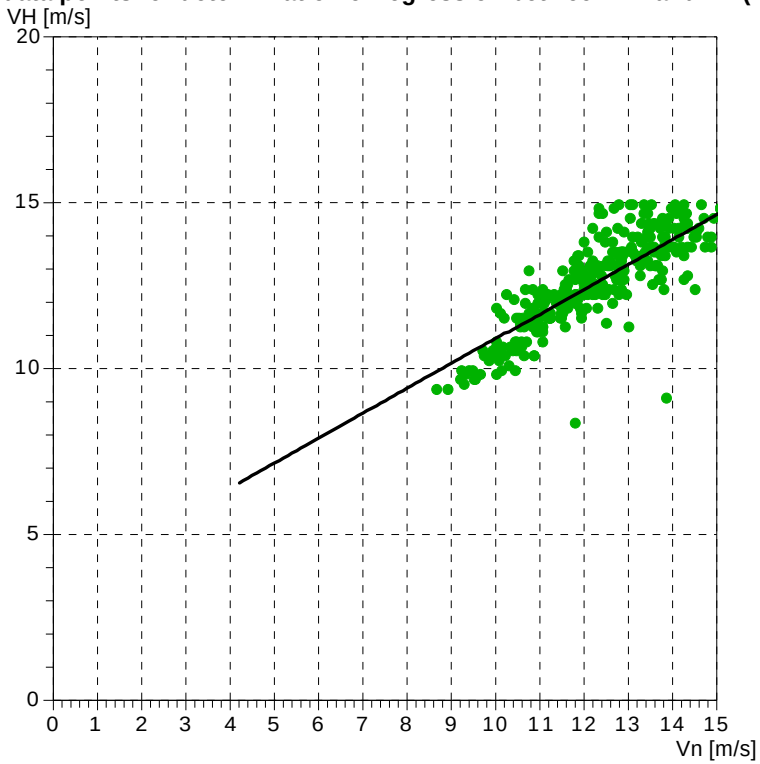



**Figure C 1.** Pair of variates to determine the regression between VH and Vn

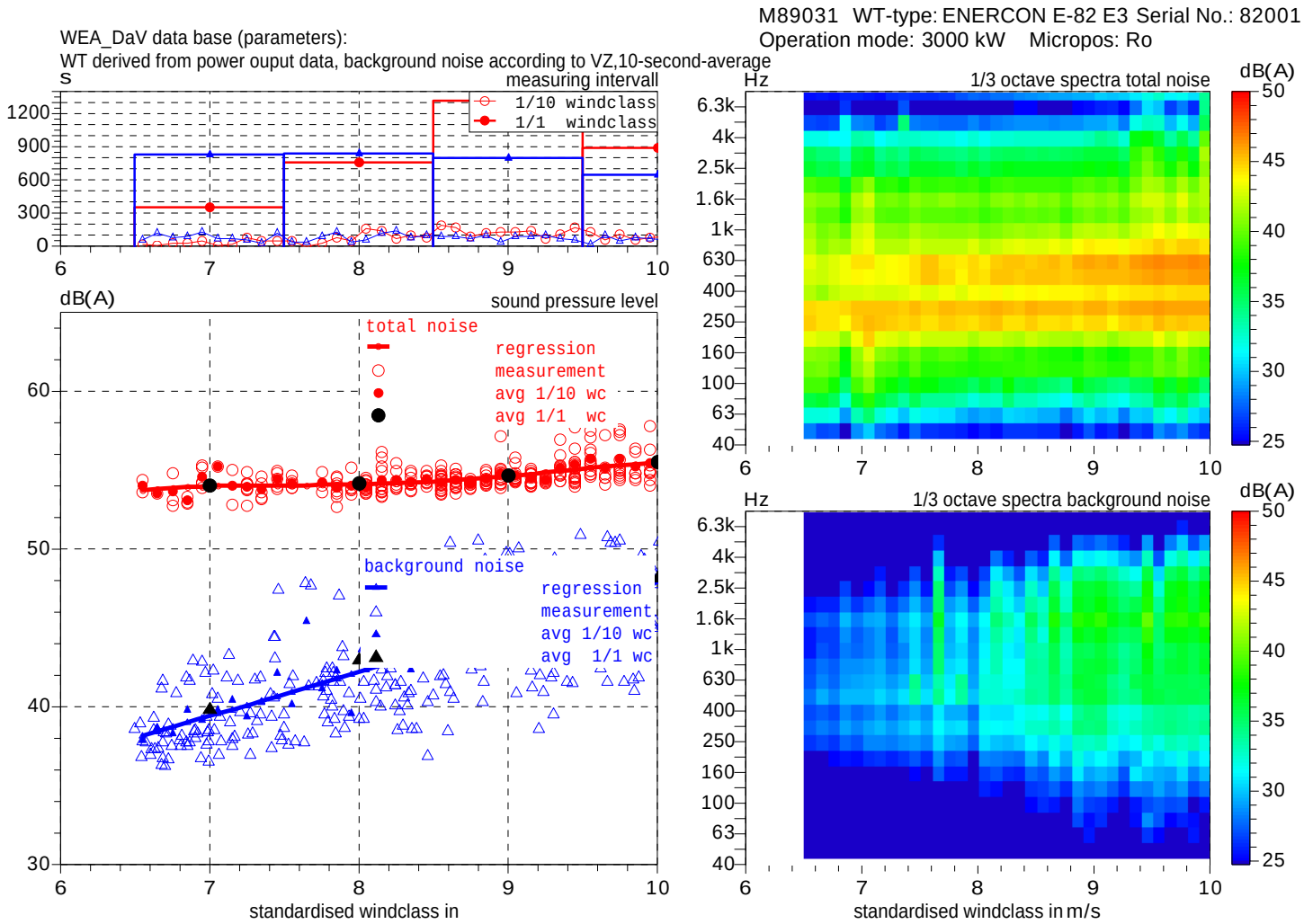



**Figure C 2.** Summary of the data used for the evaluation for WT at the reference point, average values and regressions

**WT-type: ENERCON E-82 E3 designation: 82001**
**WT-location: Simonswolde**
**date of measurement: 24.08.2010**
**operation state: Enercon E-82 E3**

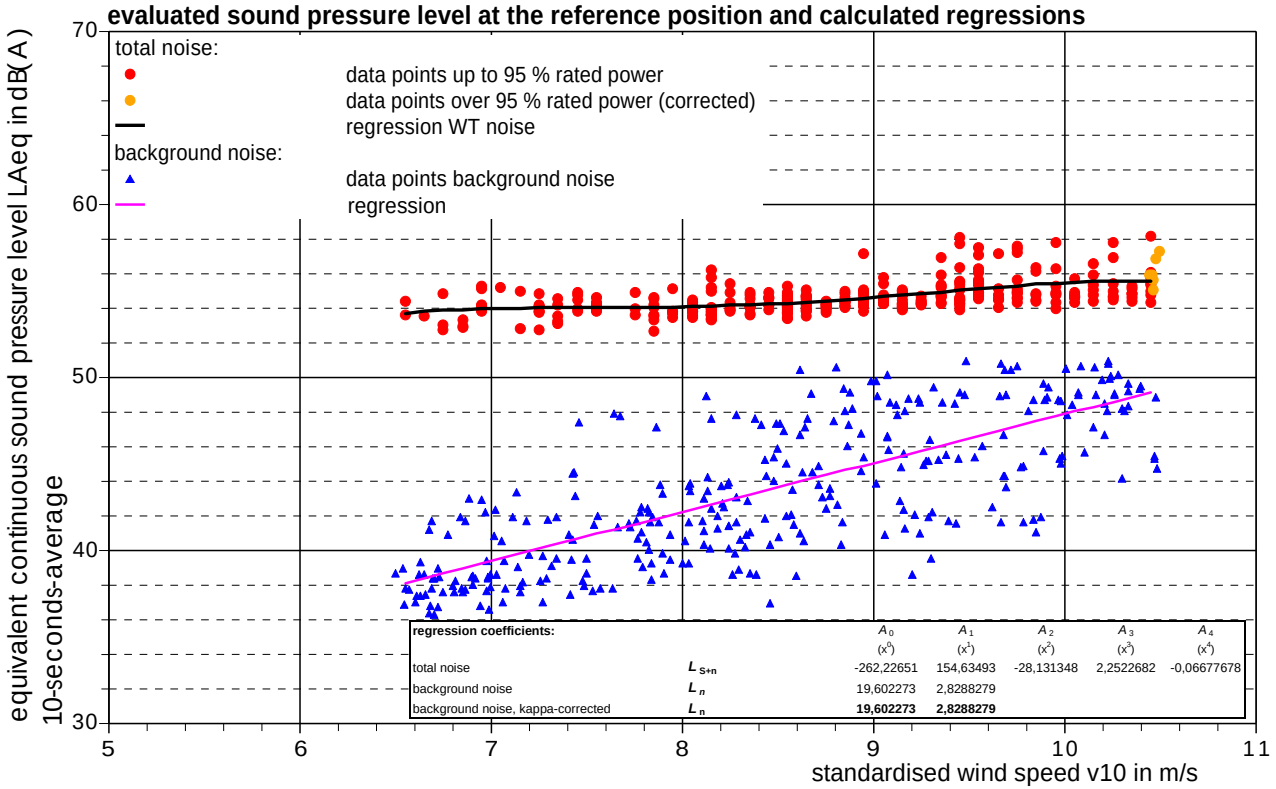



**Figure C 3.** Correlation between the sound pressure level and the standardised wind speed for the reference point and calculated regressions

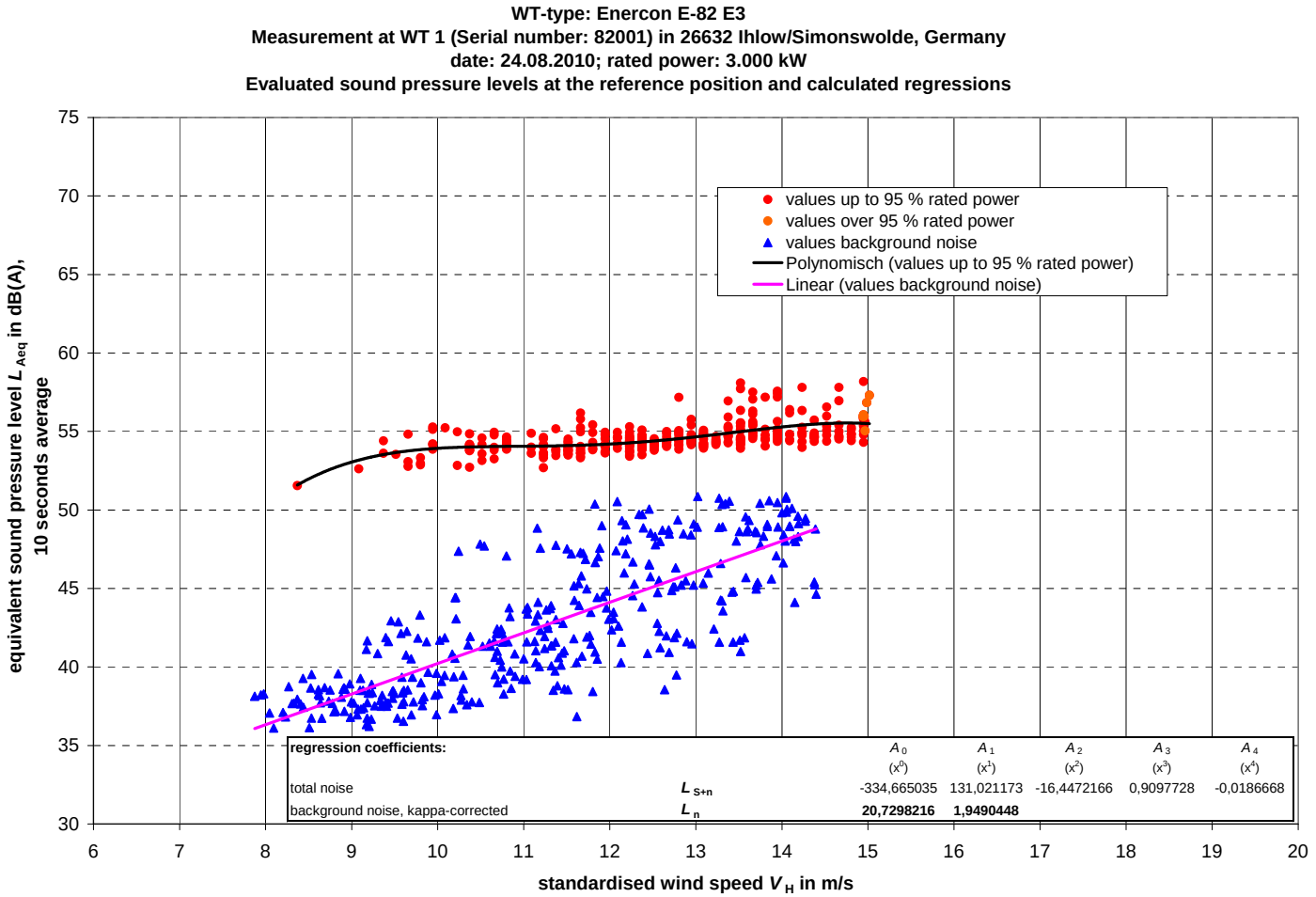
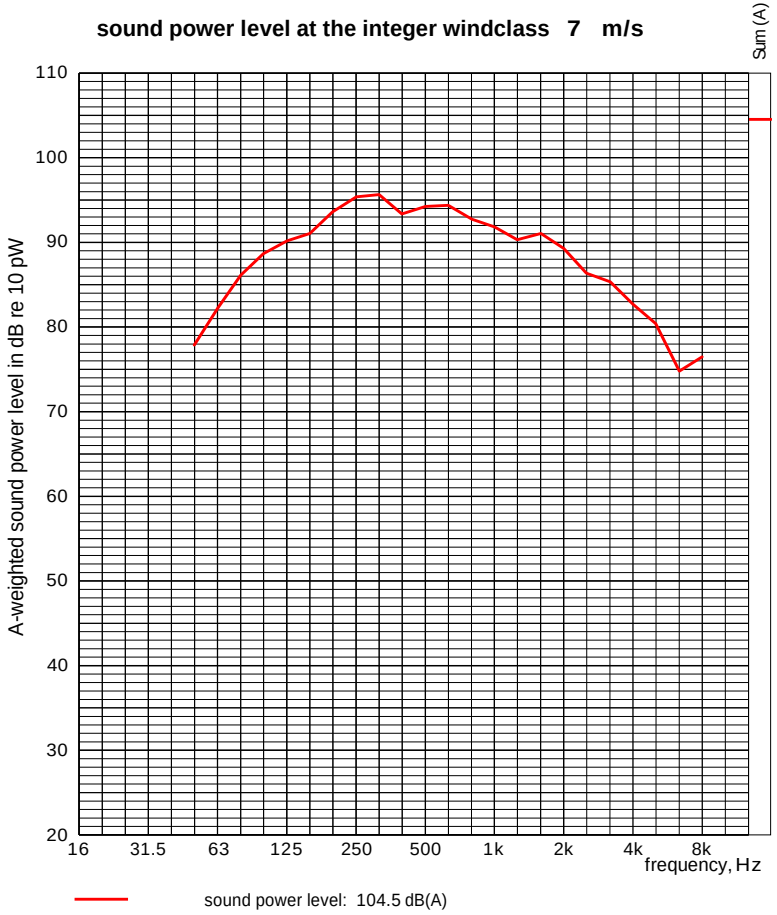



**Figure C 4.** Correlation between the sound pressure level and the standardised wind speed for the reference point and calculated regressions

**WT-type: ENERCON E-82 E3 Serial No.: 82001**
**WT-location: Simonswolde operation mode: 3000 kW**
**date of measurement: 24.08.2010**

**sound power level at the integer windclass 7 m/s**



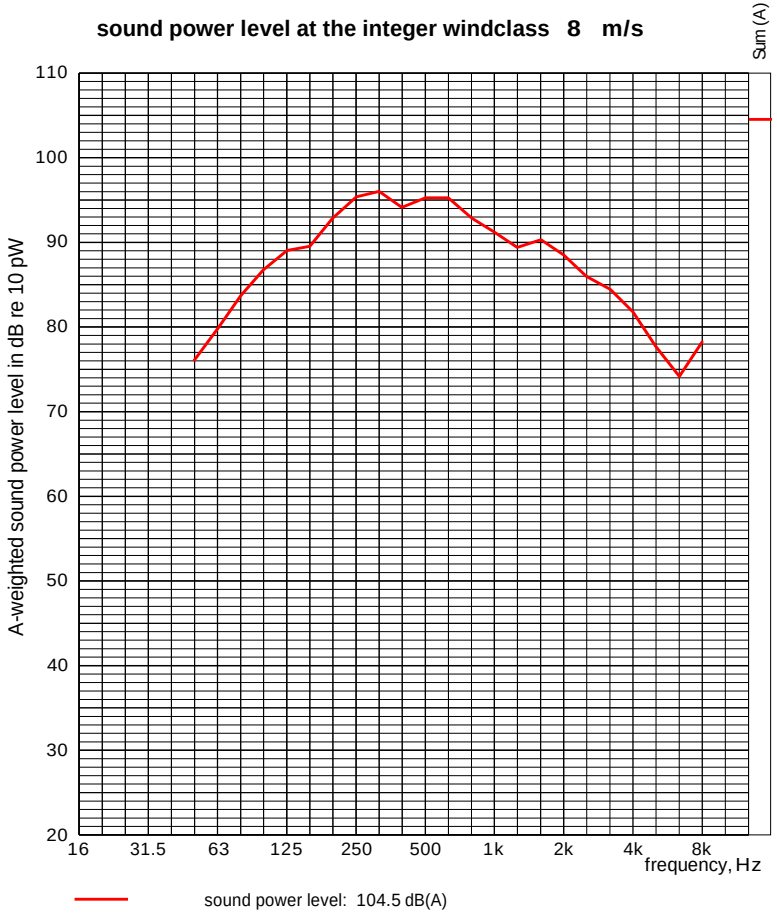

| 1/3 octave frequency (Hz) | octave frequency (Hz) | 1/3 octave band level dB(A) | octave band level dB(A) |
|---|---|---|---|
| 50 | 63 | 77,9 | 88,1 |
| 63 | | 82,3 | |
| 80 | | 86,1 | |
| 100 | 125 | 88,6 | 94,8 |
| 125 | | 90,2 | |
| 160 | | 91 | |
| 200 | 250 | 93,6 | 99,7 |
| 250 | | 95,4 | |
| 315 | | 95,6 | |
| 400 | 500 | 93,3 | 98,8 |
| 500 | | 94,2 | |
| 630 | | 94,4 | |
| 800 | 1k | 92,7 | 96,5 |
| 1k | | 91,8 | |
| 1,25k | | 90,4 | |
| 1,6k | 2k | 91,1 | 94,1 |
| 2k | | 89,3 | |
| 2,5k | | 86,3 | |
| 3,15k | 4k | 85,3 | 88,0 |
| 4k | | 82,7 | |
| 5k | | 80,5 | |
| 6,3k | 8k | 74,8 | 79,9 |
| 8k | | 76,5 | |
| 10k | | 73,4 | |

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**Figure C 5.** Sound power level for the wind class 7 m/s in third-octave bandwidth (diagram and table) and in octave bandwidth (table)

**WT-type: ENERCON E-82 E3 Serial No.: 82001**
**WT-location: Simonswolde operation mode: 3000 kW**
**date of measurement: 24.08.2010**

**sound power level at the integer windclass 8 m/s**



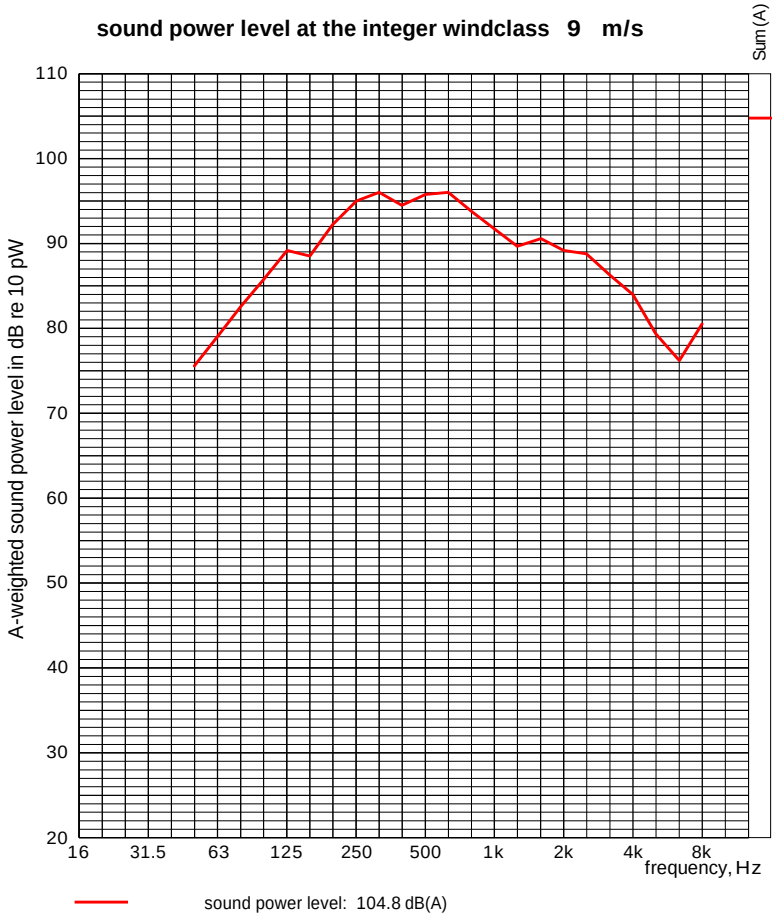

| 1/3 octave frequency (Hz) | octave frequency (Hz) | 1/3 octave band level dB(A) | octave band level dB(A) |
|---|---|---|---|
| 50 | 63 | 79,9 | 89,1 |
| 63 | | 83,7 | |
| 80 | | 86,8 | |
| 100 | 125 | 89,1 | 95,6 |
| 125 | | 89,5 | |
| 160 | | 92,9 | |
| 200 | 250 | 95,3 | 100,0 |
| 250 | | 96 | |
| 315 | | 94,1 | |
| 400 | 500 | 95,2 | 99,3 |
| 500 | | 95,2 | |
| 630 | | 92,9 | |
| 800 | 1k | 91,2 | 95,1 |
| 1k | | 89,4 | |
| 1,25k | | 90,3 | |
| 1,6k | 2k | 88,6 | 91,5 |
| 2k | | 86 | |
| 2,5k | | 84,5 | |
| 3,15k | 4k | 81,8 | 83,7 |
| 4k | | 77,7 | |
| 5k | | 74,1 | |
| 6,3k | 8k | 78,2 | 78,5 |
| 8k | | 63,4 | |
| 10k | | 63,6 | |

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**Figure C 6.** Sound power level for the wind class 8 m/s in third-octave bandwidth (diagram and table) and in octave bandwidth (table)

**WT-type: ENERCON E-82 E3 Serial No.: 82001**
**WT-location: Simonswolde operation mode: 3000 kW**
**date of measurement: 24.08.2010**

**sound power level at the integer windclass 9 m/s**




| 1/3 octave frequency (Hz) | octave frequency (Hz) | 1/3 octave band level dB(A) | octave band level dB(A) |
|---|---|---|---|
| 50 | 63 | 75,5 | 84,7 |
| 63 | | 79,1 | |
| 80 | | 82,5 | |
| 100 | 125 | 85,7 | 92,9 |
| 125 | | 89,2 | |
| 160 | | 88,6 | |
| 200 | 250 | 92,3 | 99,5 |
| 250 | | 95 | |
| 315 | | 96 | |
| 400 | 500 | 94,5 | 100,3 |
| 500 | | 95,7 | |
| 630 | | 96,1 | |
| 800 | 1k | 93,8 | 96,8 |
| 1k | | 91,7 | |
| 1,25k | | 89,7 | |
| 1,6k | 2k | 90,5 | 94,3 |
| 2k | | 89,2 | |
| 2,5k | | 88,8 | |
| 3,15k | 4k | 86,3 | 88,8 |
| 4k | | 83,9 | |
| 5k | | 79,4 | |
| 6,3k | 8k | 76,2 | 82,8 |
| 8k | | 80,5 | |
| 10k | | 75,8 | |

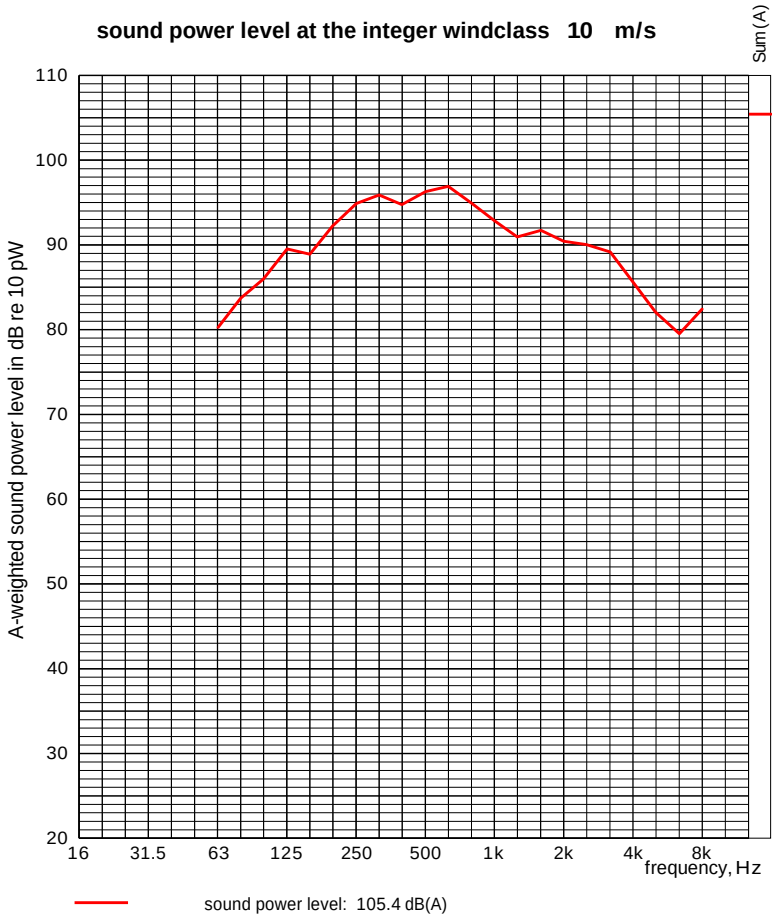
89031_20100824m_07_p

**Figure C 7.** Sound power level for the wind class 9 m/s in third-octave bandwidth (diagram and table) and in octave bandwidth (table)

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**WT-type: ENERCON E-82 E3 Serial No.: 82001**
**WT-location: Simonswolde operation mode: 3000 kW**
**date of measurement: 24.08.2010**

**sound power level at the integer windclass 10 m/s**




| 1/3 octave frequency (Hz) | octave frequency (Hz) | 1/3 octave band level dB(A) | octave band level dB(A) |
|---|---|---|---|
| 50 | 63 | 76,5 | 85,9 |
| 63 | | 80,3 | |
| 80 | | 83,7 | |
| 100 | 125 | 86 | 93,2 |
| 125 | | 89,5 | |
| 160 | | 88,9 | |
| 200 | 250 | 92,3 | 99,4 |
| 250 | | 94,9 | |
| 315 | | 95,9 | |
| 400 | 500 | 94,7 | 100,8 |
| 500 | | 96,3 | |
| 630 | | 96,9 | |
| 800 | 1k | 94,8 | 97,9 |
| 1k | | 92,8 | |
| 1,25k | | 91 | |
| 1,6k | 2k | 91,7 | 95,6 |
| 2k | | 90,4 | |
| 2,5k | | 90,1 | |
| 3,15k | 4k | 89,2 | 91,3 |
| 4k | | 85,6 | |
| 5k | | 82,1 | |
| 6,3k | 8k | 79,5 | 84,5 |
| 8k | | 82,4 | |
| 10k | | 72,7 | |

89031_20100824m_07_p

**Figure C 8.** Sound power level for the wind class 10 m/s in third-octave bandwidth (diagram and table) and in octave bandwidth (table)

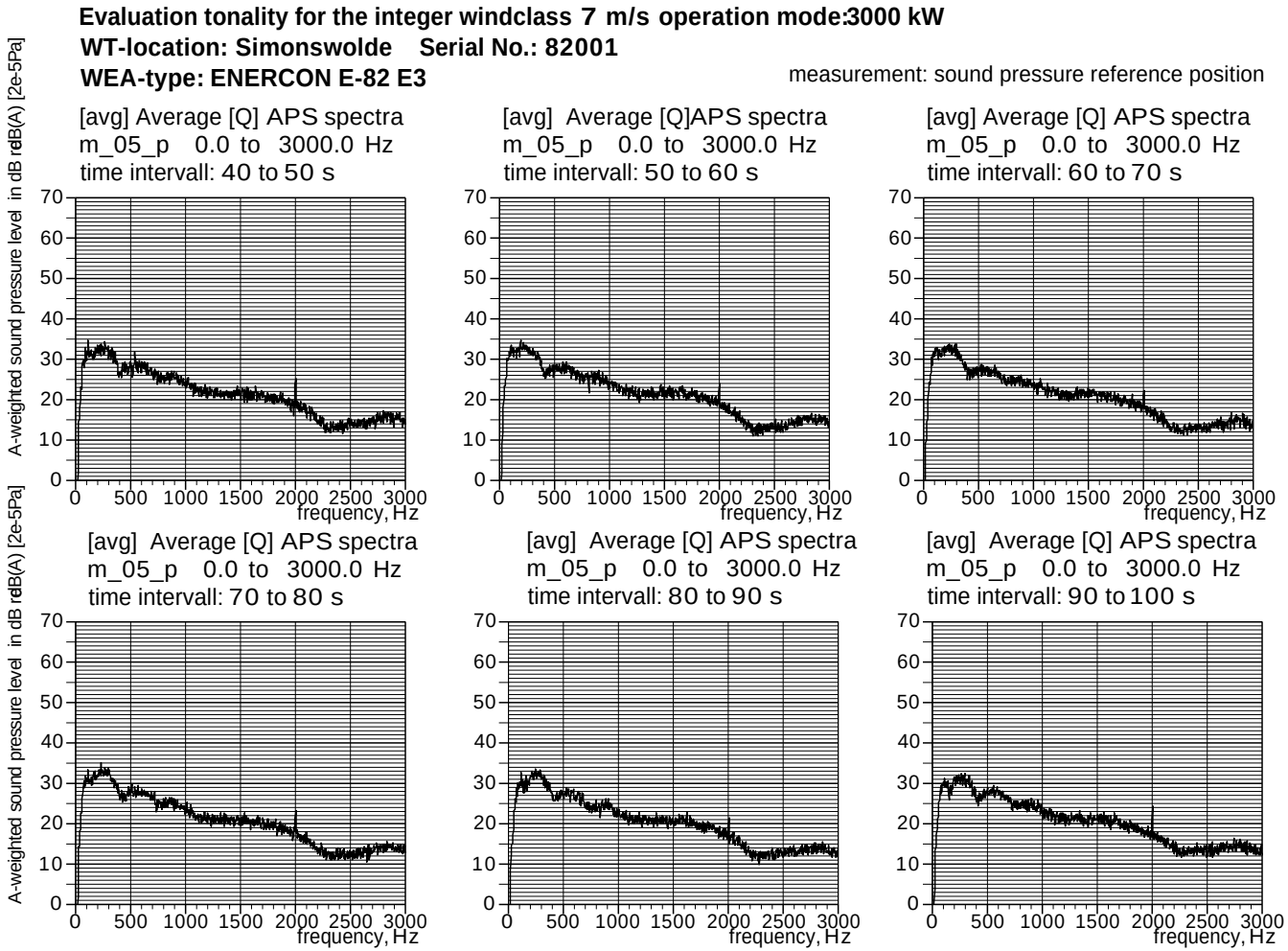



**Figure C 9.** Narrowband spectra ($\Delta f$ = 2 Hz) of the WT-noise at the standardised wind speed of 7 m/s

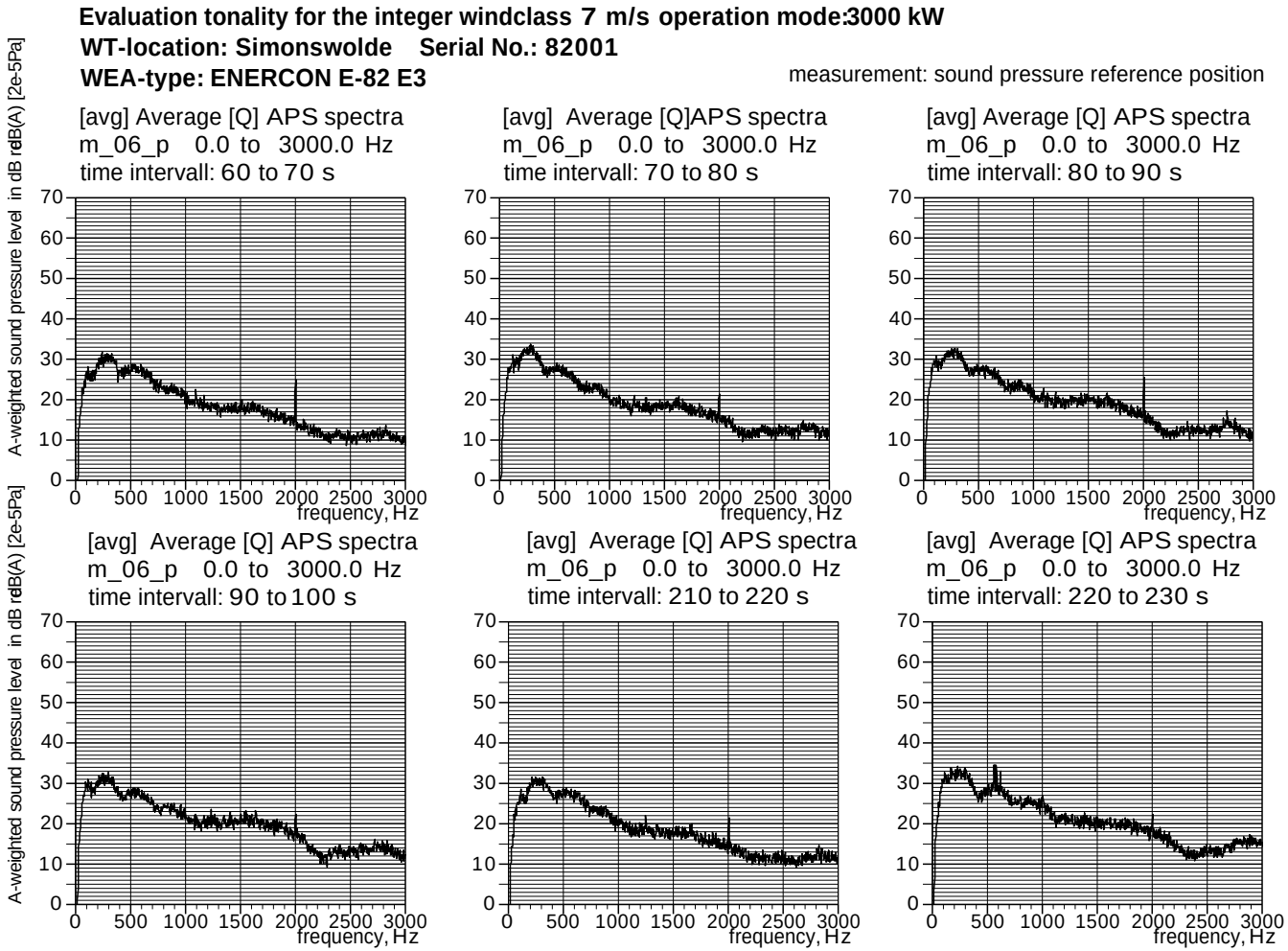



**Figure C 10.** Narrowband spectra (Δf = 2 Hz) of the WT-noise at the standardised wind speed of 7 m/s

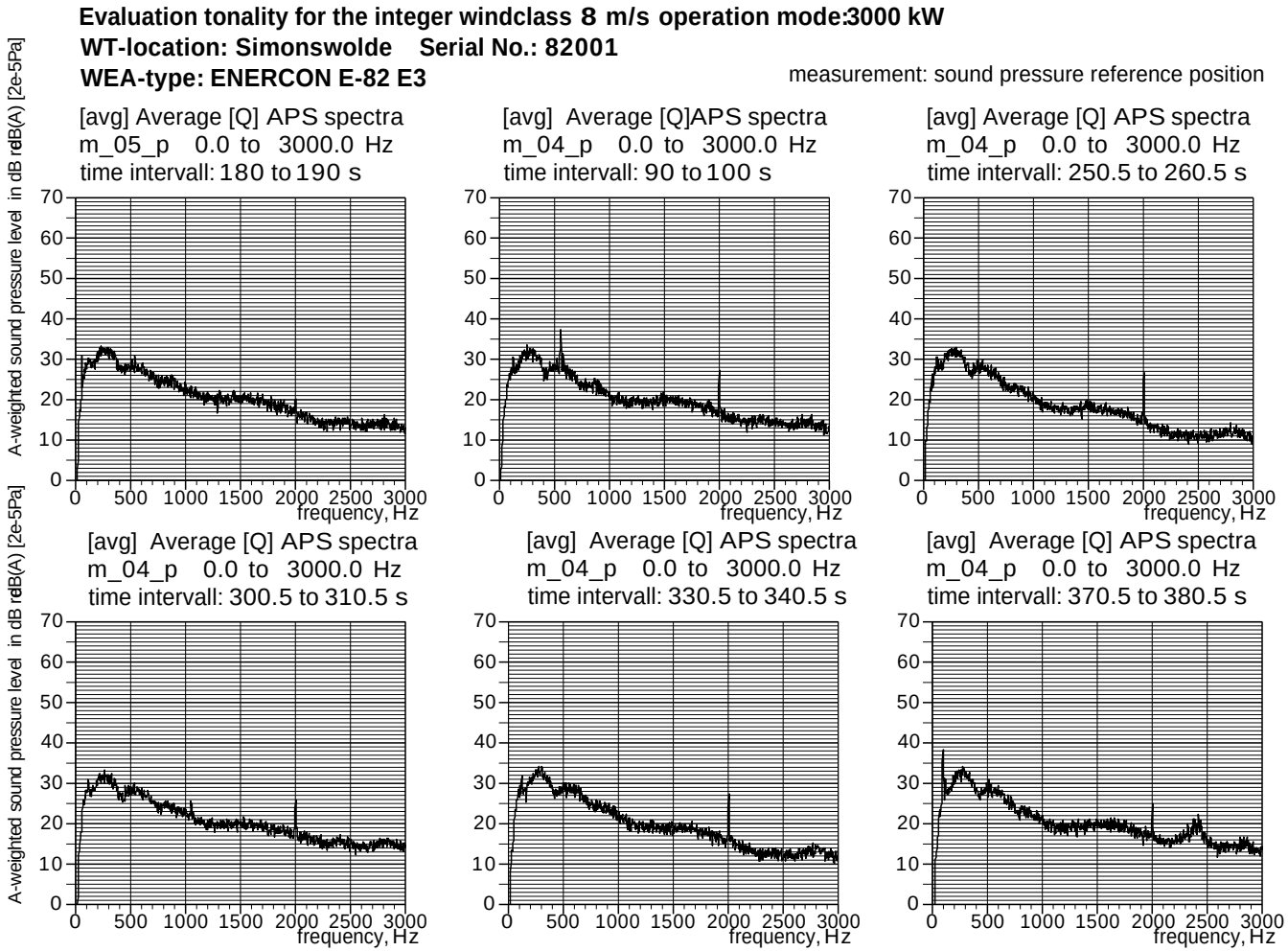



**Figure C 11.** Narrowband spectra (Δf = 2 Hz) of the WT-noise at the standardised wind speed of 8 m/s

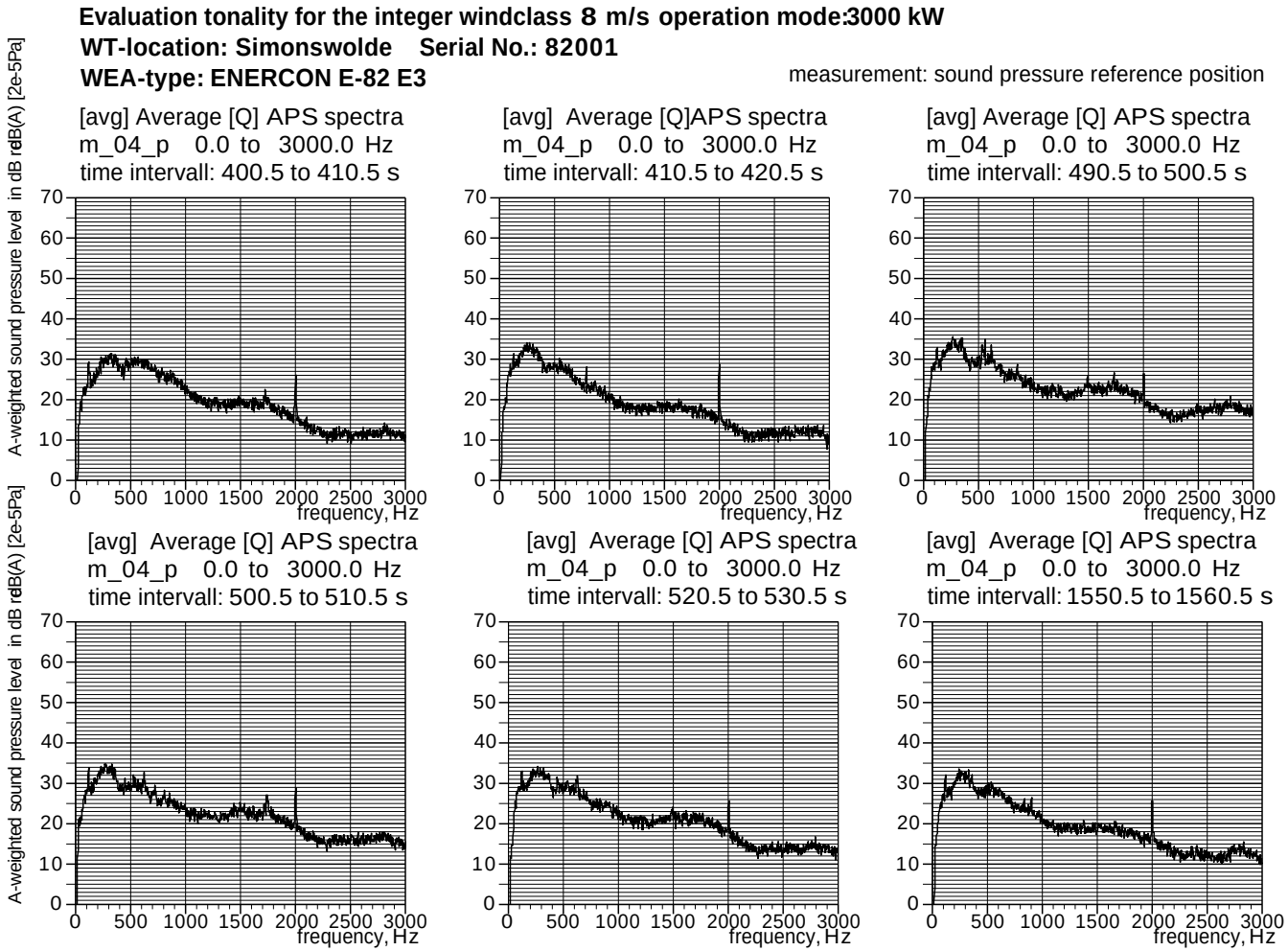



**Figure C 12.** Narrowband spectra (Δf = 2 Hz) of the WT-noise at the standardised wind speed of 8 m/s

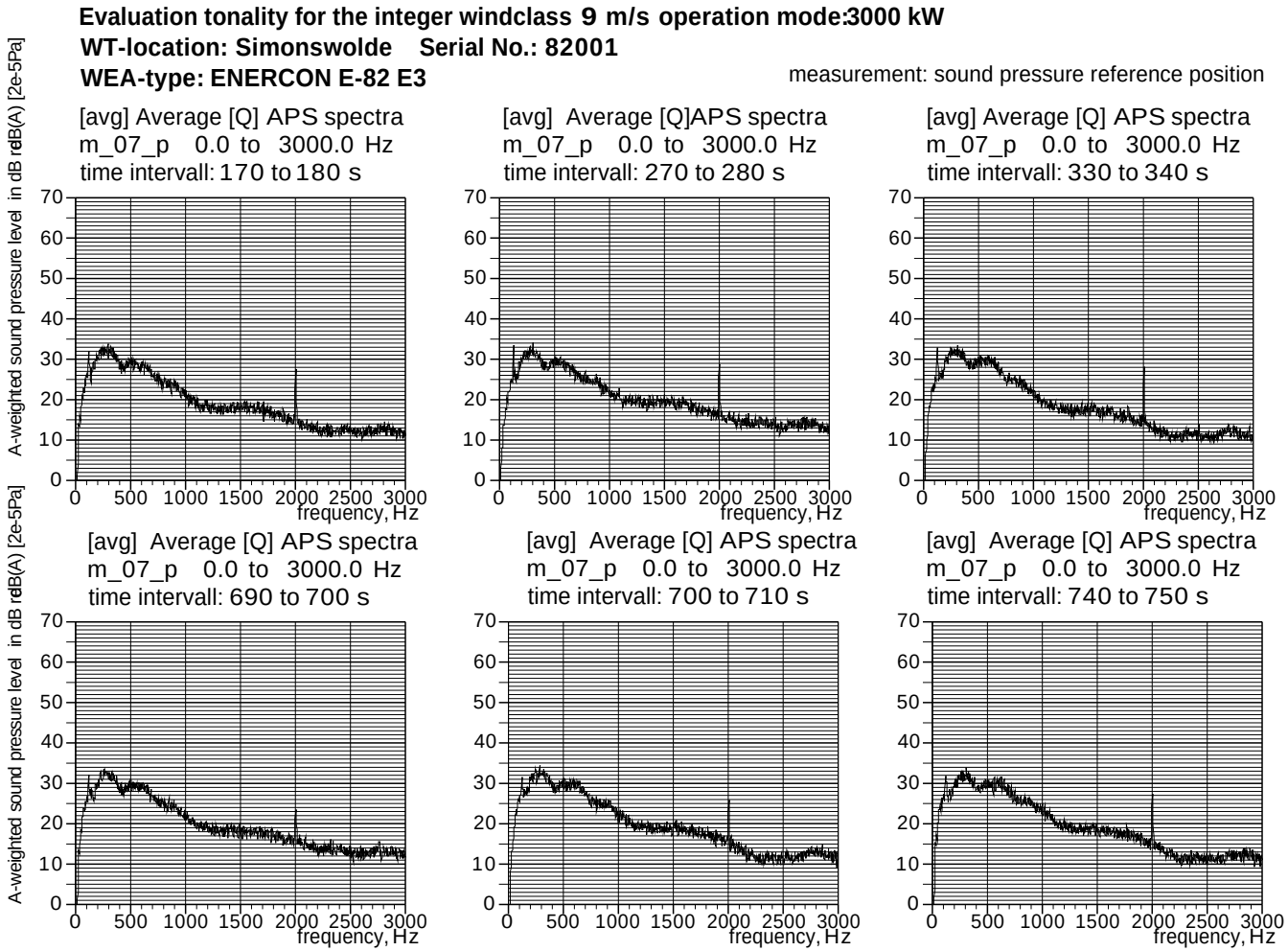



**Figure C 13.** Narrowband spectra (Δf = 2 Hz) of the WT-noise at the standardised wind speed of 9 m/s

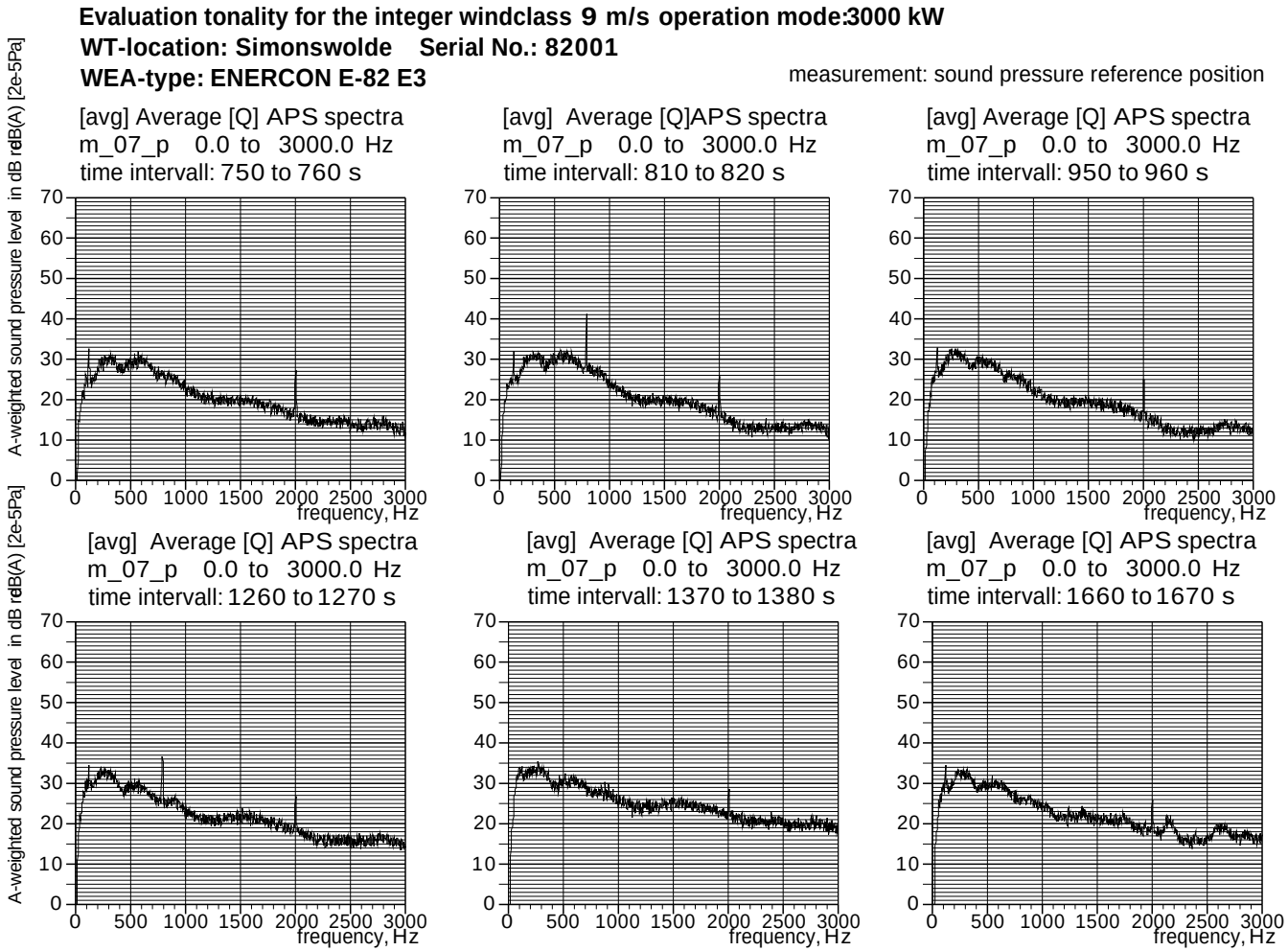



**Figure C 14.** Narrowband spectra (Δf = 2 Hz) of the WT-noise at the standardised wind speed of 9 m/s

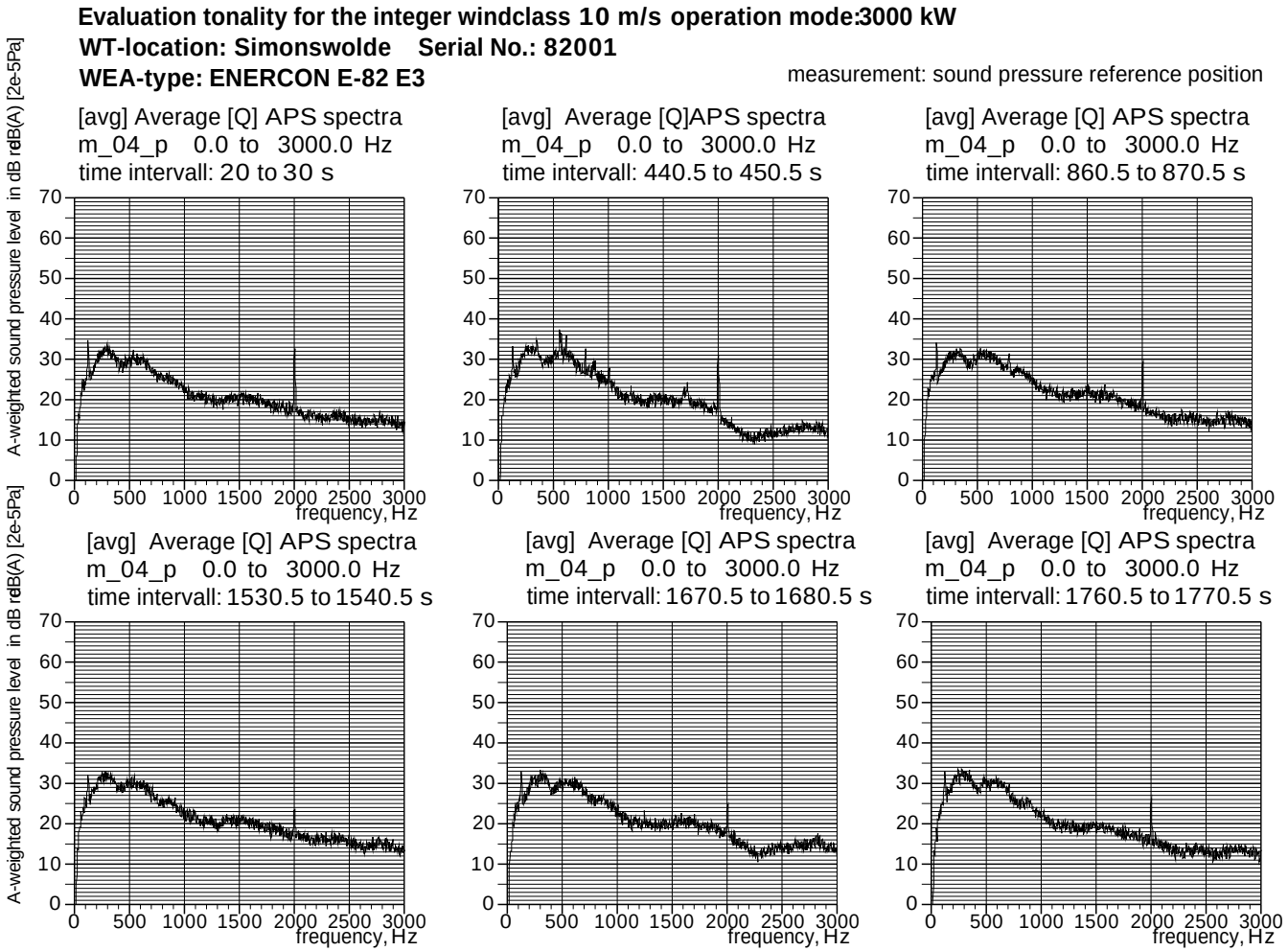



**Figure C 15.** Narrowband spectra (Δf = 2 Hz) of the WT-noise at the standardised wind speed of 10 m/s

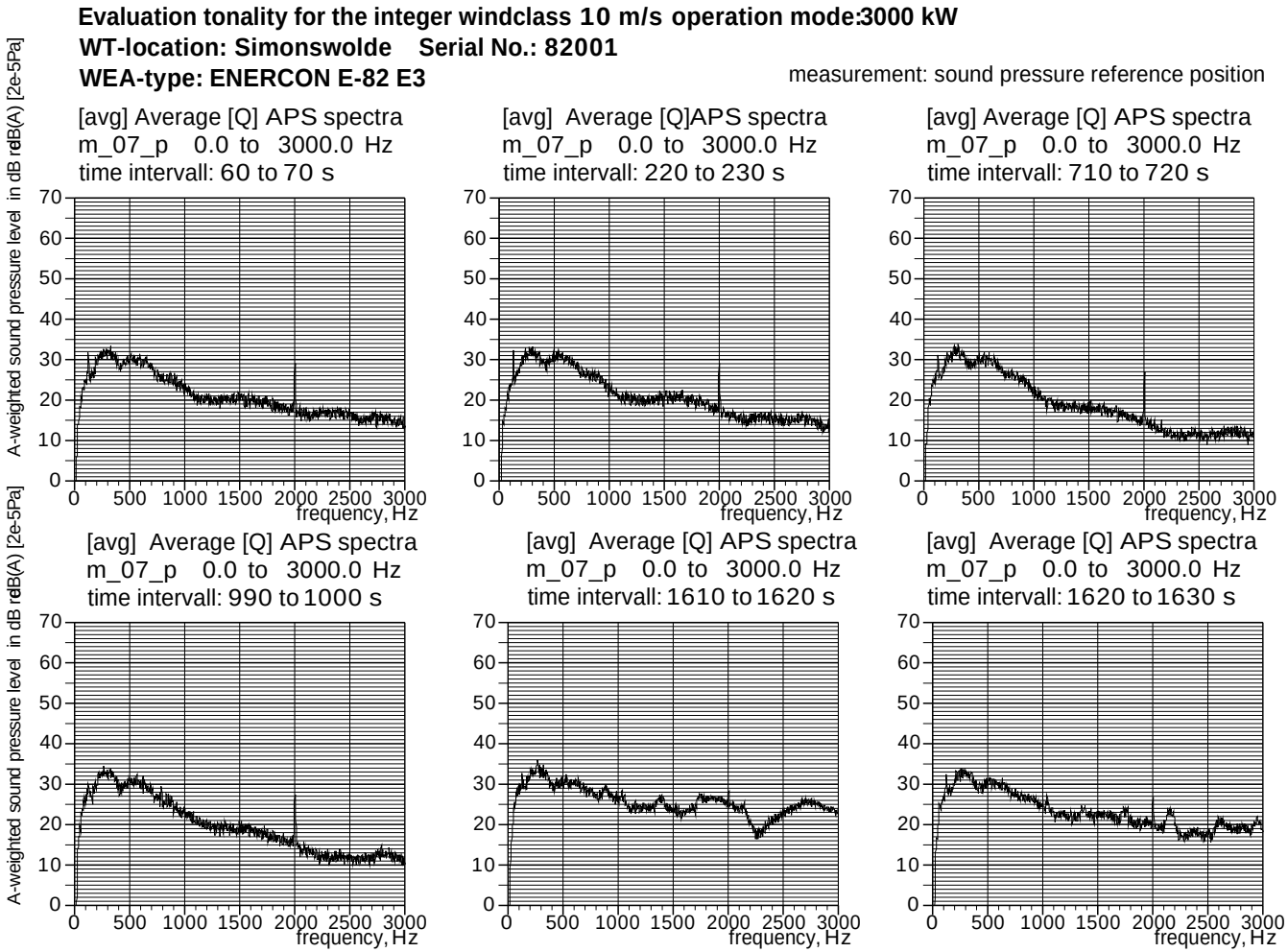



**Figure C 16.** Narrowband spectra (Δf = 2 Hz) of the WT-noise at the standardised wind speed of 10 m/s

| | |
|---|---|
| Project No.: | M89 031 |
| WT type | E-82 E3 |
| Location | Simonswolde |
| Rated power | 3000 kW |
| Wind class | 7 m/s |

| | |
|---|---|
| Frequency resolution: | 2 Hz |
| Frequency range: | 90 bis 2772 Hz |
| Averaged Delta_L: | -10 dB |
| Tone adjustment: | 0 dB |
| Uncertainty: | -- |

| Spectrum | Frequency | delta_L | Characteristic FG | FgStart | FgEnd | Ls | LT | LG | av | uncertainty |
|---|---|---|---|---|---|---|---|---|---|---|
| | [Hz] | [dB] | | [Hz] | [Hz] | [dB(A)] | [dB(A)] | [dB(A)] | [dB] | [dB] |
| 1: 89031_20100824_m_05_p_40_50_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 2: 89031_20100824_m_05_p_50_60_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 3: 89031_20100824_m_05_p_60_70_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 4: 89031_20100824_m_05_p_70_80_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 5: 89031_20100824_m_05_p_80_90_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 6: 89031_20100824_m_05_p_90_100_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 7: 89031_20100824_m_06_p_60_70_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 8: 89031_20100824_m_06_p_70_80_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 9: 89031_20100824_m_06_p_80_90_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 10: 89031_20100824_m_06_p_90_100_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 11: 89031_20100824_m_06_p_210_220_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 12: 89031_20100824_m_06_p_220_230_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |

**Figure C 17.** Results of the evaluation of tonality for the wind class 7 m/s

| | |
|---|---|
| Project No.: | M89 031 |
| WT type | E-82 E3 |
| Location | Simonswolde |
| Rated power | 3000 kW |
| Wind class | 8 m/s |

| | |
|---|---|
| Frequency resolution: | 2 Hz |
| Frequency range: | 90 bis 2772 Hz |
| Averaged Delta_L: | -7.38 dB |
| Tone adjustment: | 0 dB |
| Uncertainty: | 2.68 dB |

| Spectrum | Frequency [Hz] | delta_L [dB] | Characteristic FG | FgStart [Hz] | FgEnd [Hz] | Ls [dB(A)] | LT [dB(A)] | LG [dB(A)] | av [dB] | uncertainty [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1: 89031_20100824_m_04_p_90_100_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 2: 89031_20100824_m_04_p_250.5_260.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 3: 89031_20100824_m_04_p_300.5_310.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 4: 89031_20100824_m_04_p_330.5_340.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 5: 89031_20100824_m_04_p_370.5_380.5_PAK | 98 | 0,39 | Ton gefunden | 60 | 160 | 25,79 | 41,19 | 42,81 | -2,01 | 2,68 |
| 6: 89031_20100824_m_04_p_400.5_410.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 7: 89031_20100824_m_04_p_410.5_420.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 8: 89031_20100824_m_04_p_490.5_500.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 9: 89031_20100824_m_04_p_500.5_510.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 10: 89031_20100824_m_04_p_520.5_530.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 11: 89031_20100824_m_04_p_1550.5_1560.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 12: 89031_20100824_m_05_p_180_190_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |

**Figure C 18.** Results of the evaluation of tonality for the wind class 8 m/s

| | |
|---|---|
| Project No.: | M89 031 |
| WT type | E-82 E3 |
| Location | Simonswolde |
| Rated power | 3000 kW |
| Wind class | 9 m/s |

| | |
|---|---|
| Frequency resolution: | 2 Hz |
| Frequency range: | 90 bis 2772 Hz |
| Averaged Delta_L: | -7.24 dB |
| Tone adjustment: | 0 dB |
| Uncertainty: | 2.93 dB |

| Spectrum | Frequency | delta_L | Characteristic FG | FgStart | FgEnd | Ls | LT | LG | av | uncertainty |
|---|---|---|---|---|---|---|---|---|---|---|
| | [Hz] | [dB] | | [Hz] | [Hz] | [dB(A)] | [dB(A)] | [dB(A)] | [dB] | [dB] |
| 1: 89031_20100824_m_07_p_170_180_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 2: 89031_20100824_m_07_p_270_280_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 3: 89031_20100824_m_07_p_330_340_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 4: 89031_20100824_m_07_p_690_700_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 5: 89031_20100824_m_07_p_700_710_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 6: 89031_20100824_m_07_p_740_750_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 7: 89031_20100824_m_07_p_750_760_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 8: 89031_20100824_m_07_p_810_820_PAK | 786 | 0,67 | Ton gefunden | 720 | 858 | 26,24 | 42,76 | 44,70 | -2,61 | 2,93 |
| 9: 89031_20100824_m_07_p_950_960_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 10: 89031_20100824_m_07_p_1260_1270_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 11: 89031_20100824_m_07_p_1370_1380_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 12: 89031_20100824_m_07_p_1660_1670_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |

**Figure C 19.** Results of the evaluation of tonality for the wind class 9 m/s

| | |
|---|---|
| Project No.: | M89 031 |
| WT type | E-82 E3 |
| Location | Simonswolde |
| Rated power | 3000 kW |
| Wind class | 10 m/s |

| | |
|---|---|
| Frequency resolution: | 2 Hz |
| Frequency range: | 90 bis 2772 Hz |
| Averaged Delta_L: | -4.72 dB |
| Tone adjustment: | 0 dB |
| Uncertainty: | 1.55 dB |

| Spectrum | Frequency | delta_L | Characteristic FG | FgStart | FgEnd | Ls | LT | LG | av | uncertainty |
|---|---|---|---|---|---|---|---|---|---|---|
| | [Hz] | [dB] | | [Hz] | [Hz] | [dB(A)] | [dB(A)] | [dB(A)] | [dB] | [dB] |
| 1: 89031_20100824_m_04_p_20_30_PAK | 2000 | 1,48 | | 1856 | 2156 | 15,58 | 35,32 | 37,36 | -3,51 | 2,36 |
| 2: 89031_20100824_m_04_p_440.5_450.5_PAK | 2002 | 2,15 | | 1858 | 2158 | 14,81 | 35,22 | 36,59 | -3,52 | 2,06 |
| 3: 89031_20100824_m_04_p_860.5_870.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 4: 89031_20100824_m_04_p_1530.5_1540.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 5: 89031_20100824_m_04_p_1670.5_1680.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 6: 89031_20100824_m_04_p_1760.5_1770.5_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 7: 89031_20100824_m_07_p_60_70_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 8: 89031_20100824_m_07_p_220_230_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 9: 89031_20100824_m_07_p_710_720_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 10: 89031_20100824_m_07_p_990_1000_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 11: 89031_20100824_m_07_p_1610_1620_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |
| 12: 89031_20100824_m_07_p_1620_1630_PAK | -- | -- | keine Töne gefunden | -- | -- | -- | -- | -- | -- | -- |

**Figure C 20.** Results of the evaluation of tonality for the wind class 10 m/s

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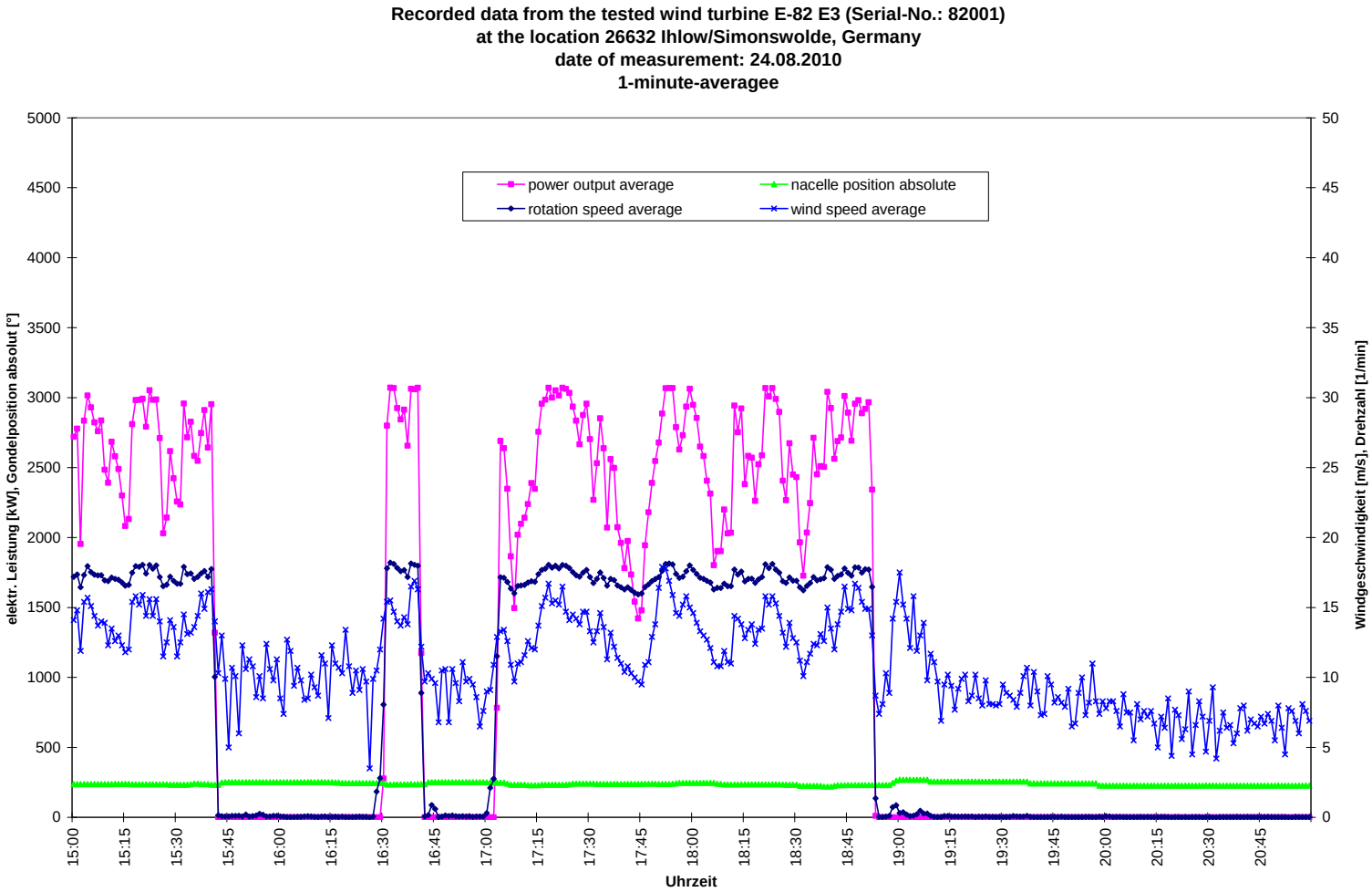



**Figure C 21.** System data recorded from the 2010-08-24 as one-minute average values

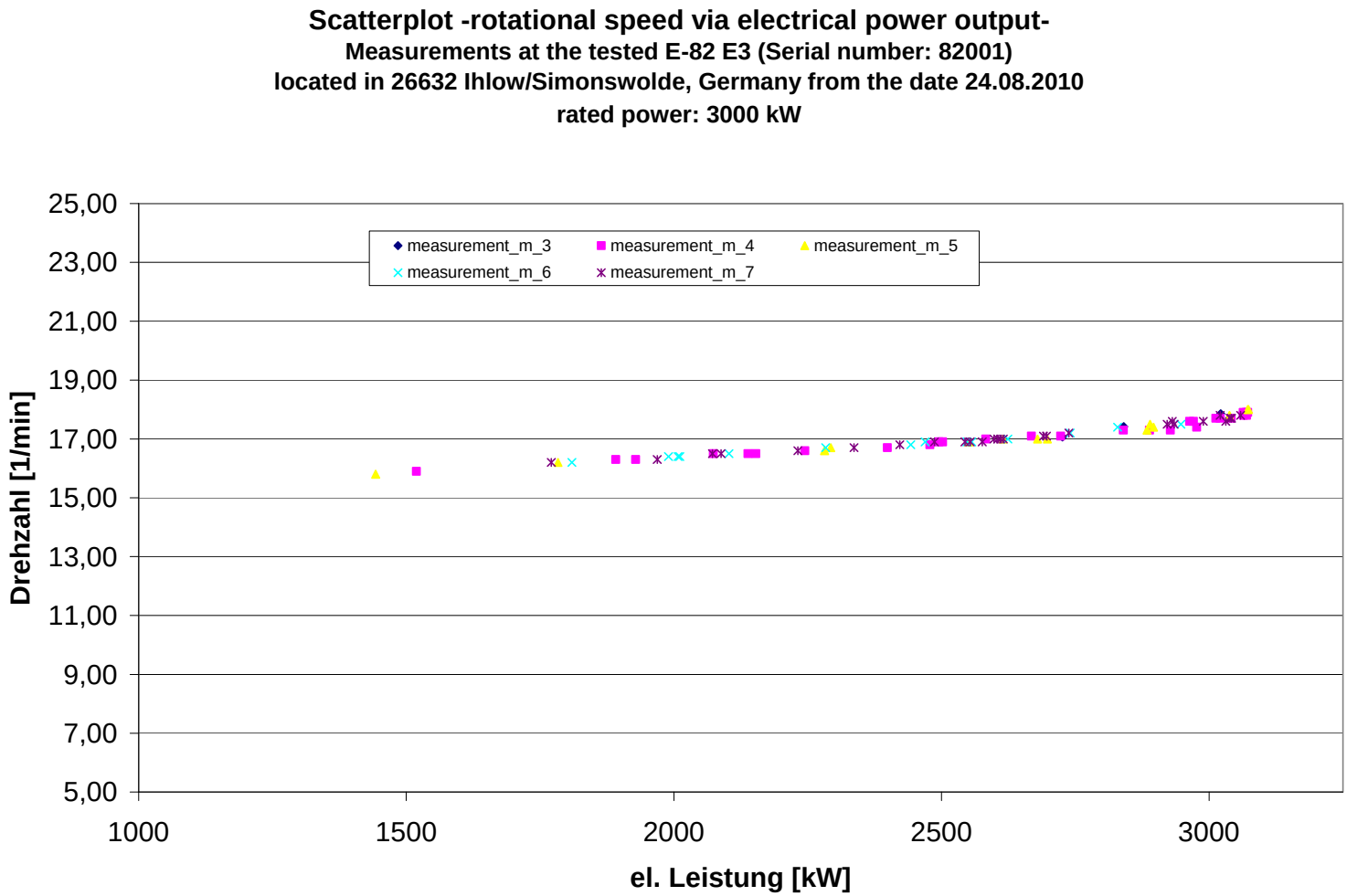



**Figure C 22.** Scatterplot of the measurements in 26632 Ihlow/Simonswolde, Germany

# Appendix D

**Calculated power curve,
power curve used for the evaluation (linearized),
certificate of the manufacturer**

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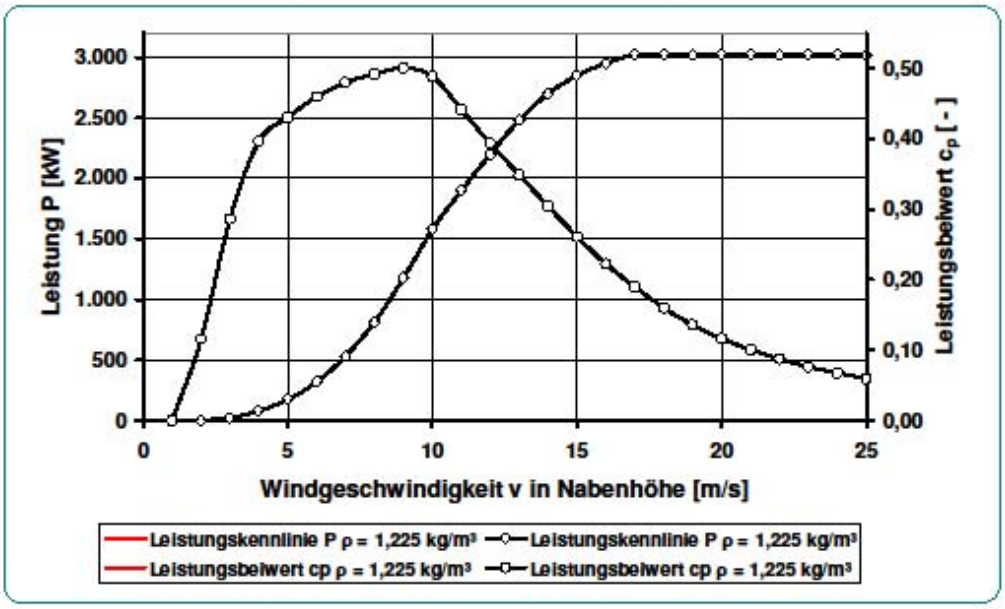
# Leistungskennlinie E-82 E3

ENERCON

**(in Abhängigkeit der Luftdichte)**

| Wind [m/s] | *Standardluftdichte ρ = 1,225 kg/m³* Leistungskennlinie P ρ = 1,225 kg/m³ [kW] | *Standardluftdichte ρ = 1,225 kg/m³* Leistungsbeiwert $c_p$ ρ = 1,225 kg/m³ [ - ] | *Veränderte Luftdichte ρ = 1,225 kg/m³* Leistungskennlinie P ρ = 1,225 kg/m³ [kW] | *Veränderte Luftdichte ρ = 1,225 kg/m³* Leistungsbeiwert $c_p$ ρ = 1,225 kg/m³ [ - ] |
|---|---|---|---|---|
| 1 | 0,0 | 0,00 | 0,0 | 0,00 |
| 2 | 3,0 | 0,12 | 3,0 | 0,12 |
| 3 | 25,0 | 0,29 | 25,0 | 0,29 |
| 4 | 82,0 | 0,40 | 82,0 | 0,40 |
| 5 | 174,0 | 0,43 | 174,0 | 0,43 |
| 6 | 321,0 | 0,46 | 321,0 | 0,46 |
| 7 | 532,0 | 0,48 | 532,0 | 0,48 |
| 8 | 815,0 | 0,49 | 815,0 | 0,49 |
| 9 | 1.180,0 | 0,50 | 1.180,0 | 0,50 |
| 10 | 1.580,0 | 0,49 | 1.580,0 | 0,49 |
| 11 | 1.900,0 | 0,44 | 1.900,0 | 0,44 |
| 12 | 2.200,0 | 0,39 | 2.200,0 | 0,39 |
| 13 | 2.480,0 | 0,35 | 2.480,0 | 0,35 |
| 14 | 2.700,0 | 0,30 | 2.700,0 | 0,30 |
| 15 | 2.850,0 | 0,26 | 2.850,0 | 0,26 |
| 16 | 2.950,0 | 0,22 | 2.950,0 | 0,22 |
| 17 | 3.020,0 | 0,19 | 3.020,0 | 0,19 |
| 18 | 3.020,0 | 0,16 | 3.020,0 | 0,16 |
| 19 | 3.020,0 | 0,14 | 3.020,0 | 0,14 |
| 20 | 3.020,0 | 0,12 | 3.020,0 | 0,12 |
| 21 | 3.020,0 | 0,10 | 3.020,0 | 0,10 |
| 22 | 3.020,0 | 0,09 | 3.020,0 | 0,09 |
| 23 | 3.020,0 | 0,08 | 3.020,0 | 0,08 |
| 24 | 3.020,0 | 0,07 | 3.020,0 | 0,07 |
| 25 | 3.020,0 | 0,06 | 3.020,0 | 0,06 |

**Kennlinien E-82 E3 mit Standardluftdichte**




Kennlinie E82 E3 berechnet Rev 2_0 Rev.: 2.0 Gedruckt am: 18.11.2009

**Figure D 1.** Power curve used for the evaluation

**WT-type: ENERCON E-82 E3**
**WT-location: Simonswolde**
**measuring date: 24.08.2010**

**power output curve used for evaluations (linearised)**

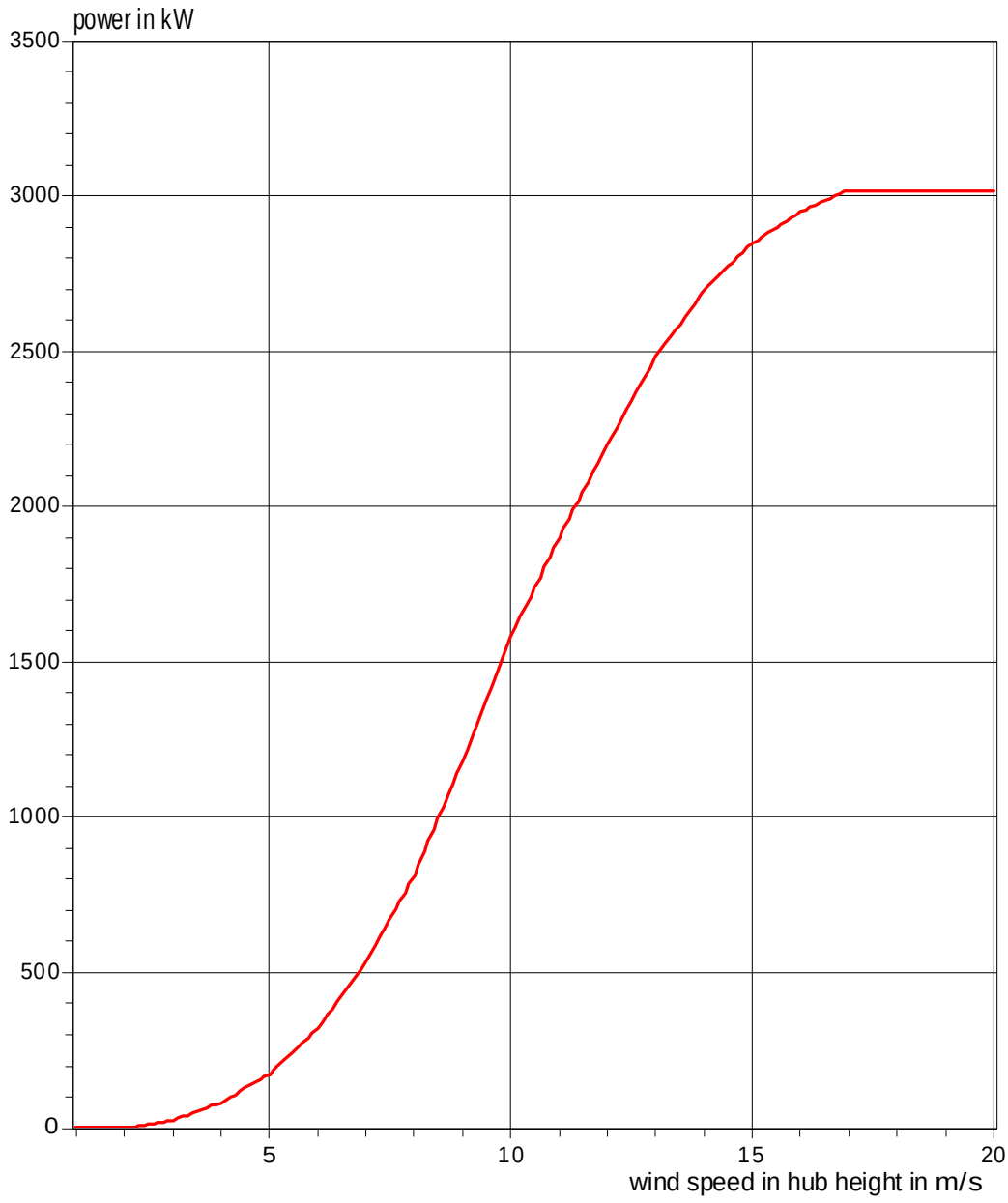



**Figure D 2.** Linearization calculated from the power curve for 3000 kW

**Herstellerbescheinigung, Kurzfassung für akustische Nachmessungen**
***Manufacturer´s certificate, Short version for control measurements of acoustic noise***

| | | | |
|---|---|---|---|
| **1. Allgemeine Informationen – *General informations*** | | | |
| Anlagenhersteller – *turbine manufacturer :* | | | ENERCON |
| Spezifische Anlagenbezeichnung – *specific turbine type name :* | | | E-82 E3 |
| Seriennummer der vermessenen WEA – *serial number of tested WT :* | | | 82001 |
| Standort der vermessenen WEA – *location of tested WT :* | | | 26629 Ihlow-Simonswolde |
| Koordinaten des Standortes – *coordinates of turbine location :* | | R: 2.592.266 / | H: 5.914.847 |
| Rotorachse – *rotor axis :* | horizontal – *horizontal* ☒ | | vertikal – *vertical* ☐ |
| Nennleistung – *rated power :* | | | 3,0 MW |
| Leistungsregelung – *power control :* | pitch ☒ | | stall ☐ |
| Nabenhöhe über Grund – *hub height above ground :* | | | 98,4 m |
| Nabenhöhe über Fundamentflansch – *hub height above top of foundation flange :* | | | 98,2 m |
| Nennwindgeschwindigkeit – *rated wind speed :* | | | 16 m/s |
| Ein- / Abschaltwindgeschwindigkeit – *cut–in / cut out wind speed :* | | 2,5 m/s / | 28 – 34 m/s |
| **2. Rotor – *Rotor*** | | | |
| Durchmesser – *rotor diameter :* | | | 82 m |
| Anzahl der Blätter – *number of blades :* | | | 3 |
| Nabenart – *kind of hub :* | pendelnd – *teetered* ☐ | | starr – *rigid* ☒ |
| Anordnung zum Turm – *position relative to tower :* | luv – *upwind* ☒ | | lee – *downwind* ☐ |
| Drehzahlbereich / Drehzahlstufen – *rot. speed range / stages of rot. speed:* | 6 – 18 Upm (Betrieb I) – *6 – 18 rpm (mode I)* | | |
| Rotorblatteinstellwinkel – *rotor blade pitch setting :* | | | variabel – *variable* |
| Konuswinkel – *cone angle :* | | | 0° |
| Achsneigung – *tilt angle :* | | | 5° |
| Horizontaler Abstand Rotormittelpunkt - Turmmittellinie – *horiz. distance between centre of rotor and tower centre line :* | | | 4,62 m |
| **3. Rotorblatt – *Rotor blade*** | | | |
| Hersteller – *manufacturer :* | | | ENERCON |
| Typenbezeichnung – *type :* | | | E-82-2 |
| Seriennummern der Rotorblätter – *serial numbers of rotor blades :* | 1: RoR 018 - 048 | 2: RoR 018 - 064 | 3: RoR 018 - 061 |
| Zusatzkomponenten (z.B. stall strips, Vortex-Gen., Turbulatoren) – *additional components (e.g. stall strips, vortex gen., trip strips):* keine – *none* | | | |
| **4. Getriebe – *Gearbox*** | | | |
| Hersteller – *manufacturer :* | | | entfällt – *non existent* |
| Typenbezeichnung – *type :* | | | entfällt – *non existent* |
| Seriennummer des Getriebes – *serial number of gear box :* | | | entfällt – *non existent* |
| Ausführung – *design :* | | | entfällt – *non existent* |
| Übersetzungsverhältnis – *gear ratio :* | | | entfällt – *non existent* |
| **5. Generator – *Generator*** | | | |
| Hersteller – *manufacturer :* | | | ENERCON |
| Typenbezeichnung – *type :* | | | E-82 E3 |
| Seriennummer des Generators – *serial number of generator :* | Rotor: D/D/042-3/0001 | | Stator: D/D/041-0/0001 |
| Anzahl – *number of generators :* | | | 1 |
| Art – *design :* | | | synchron, Ringgenerator |
| Nennleistung(en) – *rated power value(s) :* | | | 3.000 kW |
| Drehzahlbereich / Drehzahlstufen – *rot. speed range / stages of rot. speed:* | 6 – 18 Upm (Betrieb I) – *6 – 18 rpm (mode I)* | | |
| **6. Turm – *Tower*** | | | |
| Ausführung – *design :* | Gitter – *lattice* ☐ | Rohr – *tubular* ☒ | zylindrisch – *cylindrical* ☐ konisch – *conical* ☒ |
| Material – *material :* | | | Beton - *concrete* |
| Durchmesser - Turmfuß – *foot of the tower diameter:* | | | 7,50 m |
| **7. Betriebsführung / Regelung – *Control system*** | | | |
| Art der Leistungsregelung – *kind of power control :* | | | Pitch |
| Antrieb der Leistungsregelung – *actuation of power control :* | | | elektrisch – *electrical* |
| Hersteller der Betriebsführung / Regelung – *manufacturer of control system :* | | | ENERCON |
| Typenbezeichnung der Betriebsführung / Regelung – *control system type :* | | | CS82 |
| Bezeichnung der verwendeten Steuerungskurve – *designation of used control setup :* | | | ENERCON E-82 E3 Betrieb I |
| Bezeichnung / Messbericht der verwendeten Leistungskurve – *designation of power curve report :* | Leistungskennlinie E-82 E3 berechnet Rev 2.0 | | |

ENERCON
ENERCON GmbH
Dreekamp 5
26605 Aurich

i. A. H. Grotra

Stempel und Unterschrift des Herstellers
*manufacturer`s stamp and signature*
Aurich, 25.09.2010

**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.***

**Figure D 3.** Certificate of the manufacturer (short version)

# Appendix E

## Master sheet noise

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## Extract of test report — page 1/2

*Master Sheet "Noise", according to "Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"*
*Extract of test report according to Annex C of [1]*

Extract of test report M89 031/2
regarding noise emission of wind turbine (WT) Enercon E-82 E3

| General | | Technical specifications (manufacturer) | |
|---|---|---|---|
| Manufacturer: | Enercon GmbH | Rated power (generator): | 3.000 kW |
| | Dreekamp 5 | Rotor diameter: | 82 m |
| | 26605 Aurich | Hub height above ground: | 98 m |
| Serial number: | 82001 | Tower design: | tube tower |
| WT-location: | RW: 2.592.266 | material: | concrete |
| | HW: 5.914.847 | Power control: | pitch |
| **Complementations of rotor (manufacturer)** | | **Complementations of gear and generator (manufacturer)** | |
| blades: | Enercon GmbH | Manufacturer of gear: | --- |
| Type of blades: | E-82-2 | Type of gear: | --- |
| Pitch angel: | variable | Manufacturer of generator: | Enercon GmbH |
| Number of blades: | 3 | Type of generator: | E-82 E3 |
| Rated speed(s)/speed range: | 6 - 18 rpm (reduced) | Rated speed(s)/speed range: | 6 - 18 rpm (reduced) |

test report of power curve: Enercon GmbH: Calculated output curve of the E-82 E3 Rev. 2.0

| Noise emission parameter | Reference | | Noise emission values | Remarks |
|---|---|---|---|---|
| | Standardized wind speed at 10 m above ground | Electric power | | |
| Sound Power level $L_{WA,P}$ | 6 m/s | -- kW | -- dB(A) | [3] |
| | 7 m/s | 1586 kW | 104,5 dB(A) | |
| | 8 m/s | 2035 kW | 104,5 dB(A) | |
| | 9 m/s | 2447 kW | 104,8 dB(A) | |
| | 10 m/s | 2747 kW | 105,4 dB(A) | |
| | *10,5* m/s | *2850,0* kW | *105,1* dB(A) | [4] |
| Tonality (close-up range) $K_{TN}$ | 6 m/s | -- kW | -- dB | [3] |
| | 7 m/s | 1586 kW | 2,0 dB | |
| | 8 m/s | 2035 kW | 1,0 dB | |
| | 9 m/s | 2447 kW | 0,0 dB | |
| | 10 m/s | 2747 kW | --- dB | |
| | *10,5 m/s* | *2850,0* kW | --- *dB* | [4] |
| Impulsivity (close-up range) $K_{IN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1586 kW | --- dB | |
| | 8 m/s | 2035 kW | --- dB | |
| | 9 m/s | 2447 kW | --- dB | |
| | 10 m/s | 2747 kW | --- dB | |
| | *10,5* m/s | *2850,0* kW | --- *dB* | [4] |

**one third octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- |

**one third octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 77,9 | 82,3 | 86,1 | 88,6 | 90,2 | 91,0 | 93,6 | 95,4 | 95,6 | 93,3 | 94,2 | 94,4 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 92,7 | 91,8 | 90,4 | 91,1 | 89,3 | 86,3 | 85,3 | 82,7 | 80,5 | 74,8 | 76,5 | 73,4 |

**octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 88,1 | 94,8 | 99,7 | 98,8 | 96,5 | 94,1 | 88,0 | 79,9 |

**one third octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 79,9 | 83,7 | 86,8 | 89,1 | 89,5 | 92,9 | 95,3 | 96,0 | 94,1 | 95,2 | 95,2 | 92,9 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 91,2 | 89,4 | 90,3 | 88,6 | 86,0 | 84,5 | 81,8 | 77,7 | 74,1 | 78,2 | 63,4 | 63,6 |

**octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 89,1 | 95,6 | 100,0 | 99,3 | 95,1 | 91,5 | 83,7 | 78,5 |

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| one third octave sound power level at reference point $v_{10}$ = 9 m/s | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
| $L_{WA,P,Terz}$ | 75,5 | 79,1 | 82,5 | 85,7 | 89,2 | 88,6 | 92,3 | 95,0 | 96,0 | 94,5 | 95,7 | 96,1 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 93,8 | 91,7 | 89,7 | 90,5 | 89,2 | 88,8 | 86,3 | 83,9 | 79,4 | 76,2 | 80,5 | 75,8 |

| octave sound power level at reference point $v_{10}$ = 9 m/s | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| $L_{WA,P,Terz}$ | 84,7 | 92,9 | 99,5 | 100,3 | 96,8 | 94,3 | 88,8 | 82,8 |

| one third octave sound power level at reference point $v_{10}$ = 10 m/s | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
| $L_{WA,P,Terz}$ | 76,5 | 80,3 | 83,7 | 86,0 | 89,5 | 88,9 | 92,3 | 94,9 | 95,9 | 94,7 | 96,3 | 96,9 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 94,8 | 92,8 | 91,0 | 91,7 | 90,4 | 90,1 | 89,2 | 85,6 | 82,1 | 79,5 | 82,4 | 72,7 |

| octave sound power level at reference point $v_{10}$ = 10 m/s | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| $L_{WA,P,Terz}$ | 85,9 | 93,2 | 99,4 | 100,8 | 97,9 | 95,6 | 91,3 | 84,5 |

This test report extract is only valid with the manufacturer's certificate from 25.9.2010.
The declarations in this extract are only valid in combination with the test report M89 031/2 from 10.1.2011 [5]
(especially for calculations of sound propagation).

**Remarks:**

[1] Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte
Rev. 18 vom 01.02.2008 (Herausgeber: Fördergesellschaft Windenergie e.V., Stresemannplatz 4, D-24103 Kiel)
[2] IEC TS 61400-11 Wind turbines. Part 11: Acoustic noise measurement techniques. November 2002
[3] In this windclass no values were determined
[4] sound power level for the wind speed at 95 % rated power (v10 = 10,5 m/s) considering the conditions on the day of measurement, the power curve the above mentionted power curve and the hub height of the investigated WT
[5] Müller-BBM testreport M89 031/2 10.1.2011

Measured by: Müller-BBM GmbH
branch office Gelsenkirchen
Am Bugapark 1
D-45 899 Gelsenkirchen

MÜLLER-BBM GMBH
NIEDERLASSUNG GELSENKIRCHEN
AM BUGAPARK 1
45899 GELSENKIRCHEN
TELEFON (0209) 9 83 08 - 0

Schallemission FGW renewable energies 2011 Konformitätssiegel

Date of report: 2011-01-19

Dipl.-Ing. (FH) M. Köhl

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Accredited Testing Laboratory
according to DIN EN ISO/IEC 17025

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DAR
DGA-PL-2465.10

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# Appendix F

**Apparent sound power level related to other hub heights**
**(hub heights: 78 m, 85 m, 98 m, 108 m and 138 m)**

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## Extract of test report



*Master Sheet "Noise", according to "Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"*
*Method of calculating apparent sound power level to another hub height according to Annex C of [1] and [2]*

Extract of test report M89 031/2
regarding noise emission of wind turbine (WT) Enercon E-82 E3

| General | | Technical specifications (manufacturer) | |
|---|---|---|---|
| Manufacturer: | Enercon GmbH | Rated power (generator): | 3.000 kW |
| | Dreekamp 5 | Rotor diameter: | 82 m |
| | 26605 Aurich | Hub height above ground: | 78 m |
| Serial number: | 82001 | Tower design: | tube tower |
| WT-location: | RW: 2.592.266 | material: | concrete |
| | HW: 5.914.847 | Power control: | pitch |
| **Complementations of rotor (manufacturer)** | | **Complementations of gear and generator (manufacturer)** | |
| blades: | Enercon GmbH | Manufacturer of gear: | --- |
| Type of blades: | E-82-2 | Type of gear: | --- |
| Pitch angel: | variabel | Manufacturer of generator: | Enercon GmbH |
| Number of blades: | 3 | Type of generator: | E-82 E3 |
| Rated speed(s)/speed range: | 6 - 18 rpm (mode I) | Rated speed(s)/speed range: | 6 - 18 rpm (mode I) |

test report of power curve: Enercon GmbH: Calculated output curve of the E-82 E3 Rev. 2.0

| | Reference | | Noise emission parameter | Remarks |
|---|---|---|---|---|
| | Standardized wind speed at 10 m above ground | Electric power | | |
| Sound Power level $L_{WA,P}$ | 6 m/s | -- kW | -- dB(A) | [3] |
| | 7 m/s | 1463 kW | 104,5 dB(A) | |
| | 8 m/s | 1909 kW | 104,5 dB(A) | |
| | 9 m/s | 2343 kW | 104,7 dB(A) | |
| | 10 m/s | 2670 kW | 105,3 dB(A) | |
| | *10,8* m/s | *2850* kW | -- dB(A) | [3] |
| Tonality (close-up range) $K_{TN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1463 kW | --- dB | |
| | 8 m/s | 1909 kW | --- dB | |
| | 9 m/s | 2343 kW | --- dB | |
| | 10 m/s | 2670 kW | --- dB | |
| | *10,8 m/s* | *2850* kW | --- *dB* | [3] |
| Impulsivity (close-up range) $K_{IN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1463 kW | --- dB | |
| | 8 m/s | 1909 kW | --- dB | |
| | 9 m/s | 2343 kW | --- dB | |
| | 10 m/s | 2670 kW | --- dB | |
| | *10,8* m/s | *2850* kW | --- dB | [3] |

**one third octave sound power level at reference point $v_{10}$ =** 6 m/s

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**octave sound power level at reference point $v_{10}$ =** 6 m/s

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- |

**one third octave sound power level at reference point $v_{10}$ =** 7 m/s

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 77,8 | 82,2 | 86,0 | 88,5 | 90,1 | 90,9 | 93,5 | 95,3 | 95,5 | 93,2 | 94,1 | 94,3 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 92,6 | 91,7 | 90,3 | 91,0 | 89,2 | 86,2 | 85,2 | 82,6 | 80,4 | 74,7 | 76,4 | 73,3 |

**octave sound power level at reference point $v_{10}$ =** 7 m/s

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 88,0 | 94,8 | 99,7 | 98,7 | 96,4 | 94,0 | 88,0 | 79,8 |

**one third octave sound power level at reference point $v_{10}$ =** 8 m/s

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 79,9 | 83,7 | 86,8 | 89,1 | 89,5 | 92,9 | 95,3 | 96,0 | 94,1 | 95,2 | 95,2 | 92,9 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 91,2 | 89,4 | 90,3 | 88,6 | 86,0 | 84,5 | 81,8 | 77,7 | 74,1 | 78,2 | 63,4 | 63,6 |

**octave sound power level at reference point $v_{10}$ =** 8 m/s

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 89,1 | 95,7 | 100,0 | 99,4 | 95,2 | 91,5 | 83,8 | 78,5 |

**one third octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 75,4 | 79,0 | 82,4 | 85,6 | 89,1 | 88,5 | 92,2 | 94,9 | 95,9 | 94,4 | 95,6 | 96,0 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 93,7 | 91,6 | 89,6 | 90,4 | 89,1 | 88,7 | 86,2 | 83,8 | 79,3 | 76,1 | 80,4 | 75,7 |

**octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 84,6 | 92,7 | 99,3 | 100,1 | 96,7 | 94,2 | 88,7 | 82,7 |

**one third octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 76,4 | 80,2 | 83,6 | 85,9 | 89,4 | 88,8 | 92,2 | 94,8 | 95,8 | 94,6 | 96,2 | 96,8 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 94,7 | 92,7 | 90,9 | 91,6 | 90,3 | 90,0 | 89,1 | 85,5 | 82,0 | 79,4 | 82,3 | 72,6 |

**octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 85,7 | 93,0 | 99,2 | 100,7 | 97,8 | 95,4 | 91,2 | 84,4 |

This test report extract is only valid with the manufacturer's certificate from 25.9.2010.

The declarations in this extract are only valid in combination with the test report M89 031/2 from 19.1.2011 [4] (especially for calculations of sound propagation).

**Remarks:**

[1] Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte
Rev. 18 vom 01. February 2008 (Herausgeber: Fördergesellschaft Windenergie e.V., Stresemannplatz 4, D-24103 Kiel)

[2] IEC 61400-14 TS ed. 1, Declaration of Sound Power Level und Tonality Values of Wind Turbines, 2005-03

[3] In this windclass no values were determined

[4] The working point of 95% of the rated power, for which the maximum sound power level was stated, is according to the reference power curve and the hub height of the measured WT under standardized meteorological conditions v10= 10,8 m/s

[5] Müller-BBM testreport M89 031/2 from 19.1.2011

Measured by: Müller-BBM GmbH
branch office Gelsenkirchen
Am Bugapark 1
D-45 899 Gelsenkirchen

MÜLLER-BBM GMBH
NIEDERLASSUNG GELSENKIRCHEN
AM BUGAPARK 1
45899 GELSENKIRCHEN
TELEFON (0209) 9 83 08 - 0

Schallemission FGW renewable energies 2011 Konformitätssiegel

Date of report: 2011-01-19

Dipl.-Ing. (FH) M. Köhl

MÜLLER-BBM
Accredited Testing Laboratory
according to DIN EN ISO/IEC 17025
Deutscher Akkreditierungs Rat
DAR
DGA-PL-2465.10

## Extract of test report



*Master Sheet "Noise", according to "Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"*
*Method of calculating apparent sound power level to another hub height according to Annex C of [1] and [2]*

Extract of test report M89 031/2
regarding noise emission of wind turbine (WT) Enercon E-82 E3

| General | | Technical specifications (manufacturer) | |
|---|---|---|---|
| Manufacturer: | Enercon GmbH | Rated power (generator): | 3.000 kW |
| | Dreekamp 5 | Rotor diameter: | 82 m |
| | 26605 Aurich | Hub height above ground: | 85 m |
| Serial number: | 82001 | Tower design: | tube tower |
| WT-location: | RW: 2.592.266 | material: | concrete |
| | HW: 5.914.847 | Power control: | pitch |
| **Complementations of rotor (manufacturer)** | | **Complementations of gear and generator (manufacturer)** | |
| blades: | Enercon GmbH | Manufacturer of gear: | --- |
| Type of blades: | E-82-2 | Type of gear: | --- |
| Pitch angel: | variabel | Manufacturer of generator: | Enercon GmbH |
| Number of blades: | 3 | Type of generator: | E-82 E3 |
| Rated speed(s)/speed range: | 6 - 18 rpm (mode I) | Rated speed(s)/speed range: | 6 - 18 rpm (mode I) |

test report of power curve: Enercon GmbH: Calculated output curve of the E-82 E3 Rev. 2.0

| | Reference | | Noise emission parameter | Remarks |
|---|---|---|---|---|
| | Standardized wind speed at 10 m above ground | Electric power | | |
| Sound Power level $L_{WA,P}$ | 6 m/s | -- kW | -- dB(A) | [3] |
| | 7 m/s | 1503 kW | 104,5 dB(A) | |
| | 8 m/s | 1941 kW | 104,5 dB(A) | |
| | 9 m/s | 2370 kW | 104,7 dB(A) | |
| | 10 m/s | 2702 kW | 105,3 dB(A) | |
| | *10,7 m/s* | *2850 kW* | -- dB(A) | [3] |
| Tonality (close-up range) $K_{TN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1503 kW | --- dB | |
| | 8 m/s | 1941 kW | --- dB | |
| | 9 m/s | 2370 kW | --- dB | |
| | 10 m/s | 2702 kW | --- dB | |
| | *10,7 m/s* | *2850 kW* | --- *dB* | [3] |
| Impulsivity (close-up range) $K_{IN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1503 kW | --- dB | |
| | 8 m/s | 1941 kW | --- dB | |
| | 9 m/s | 2370 kW | --- dB | |
| | 10 m/s | 2702 kW | --- dB | |
| | *10,7 m/s* | *2850 kW* | --- dB | [3] |

**one third octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- |

**one third octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 77,9 | 82,3 | 86,1 | 88,6 | 90,2 | 91,0 | 93,6 | 95,4 | 95,6 | 93,3 | 94,2 | 94,4 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 92,7 | 91,8 | 90,4 | 91,1 | 89,3 | 86,3 | 85,3 | 82,7 | 80,5 | 74,8 | 76,5 | 73,4 |

**octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 88,0 | 94,8 | 99,7 | 98,7 | 96,5 | 94,1 | 88,0 | 79,8 |

**one third octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 79,9 | 83,7 | 86,8 | 89,1 | 89,5 | 92,9 | 95,3 | 96,0 | 94,1 | 95,2 | 95,2 | 92,9 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 91,2 | 89,4 | 90,3 | 88,6 | 86,0 | 84,5 | 81,8 | 77,7 | 74,1 | 78,2 | 63,4 | 63,6 |

**octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 89,1 | 95,7 | 100,0 | 99,4 | 95,2 | 91,5 | 83,8 | 78,5 |

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**one third octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 75,4 | 79,0 | 82,4 | 85,6 | 89,1 | 88,5 | 92,2 | 94,9 | 95,9 | 94,4 | 95,6 | 96,0 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 93,7 | 91,6 | 89,6 | 90,4 | 89,1 | 88,7 | 86,2 | 83,8 | 79,3 | 76,1 | 80,4 | 75,7 |

**octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 84,6 | 92,8 | 99,4 | 100,2 | 96,8 | 94,3 | 88,7 | 82,8 |

**one third octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 76,4 | 80,2 | 83,6 | 85,9 | 89,4 | 88,8 | 92,2 | 94,8 | 95,8 | 94,6 | 96,2 | 96,8 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 94,7 | 92,7 | 90,9 | 91,6 | 90,3 | 90,0 | 89,1 | 85,5 | 82,0 | 79,4 | 82,3 | 72,6 |

**octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 85,8 | 93,1 | 99,3 | 100,7 | 97,8 | 95,5 | 91,2 | 84,4 |

This test report extract is only valid with the manufacturer's certificate from 25.9.2010.
The declarations in this extract are only valid in combination with the test report M89 031/2 from 19.1.2011 [4]
(especially for calculations of sound propagation).

**Remarks:**

[1] Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte
Rev. 18 vom 01. February 2008 (Herausgeber: Fördergesellschaft Windenergie e.V., Stresemannplatz 4, D-24103 Kiel)

[2] IEC 61400-14 TS ed. 1, Declaration of Sound Power Level und Tonality Values of Wind Turbines, 2005-03

[3] In this windclass no values were determined

[4] The working point of 95% of the rated power, for which the maximum sound power level was stated, is according to the reference power curve and the hub height of the measured WT under standardized meteorological conditions v10= 10,7 m/s

[5] Müller-BBM testreport M89 031/2 from 19.1.2011

Measured by: Müller-BBM GmbH
branch office Gelsenkirchen
Am Bugapark 1
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Schallemission FGW renewable energies 2011 Konformitätssiegel

Date of report: 2011-01-19

Dipl.-Ing. (FH) M. Köhl

MÜLLER-BBM
Accredited Testing Laboratory
according to DIN EN ISO/IEC 17025
Deutscher Akkreditierungs Rat
DAR
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## Extract of test report

**page 1/2**

*Master Sheet "Noise", according to "Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"*
*Method of calculating apparent sound power level to another hub height according to Annex C of [1] and [2]*

Extract of test report M89 031/2
regarding noise emission of wind turbine (WT) Enercon E-82 E3

| General | | Technical specifications (manufacturer) | |
|---|---|---|---|
| Manufacturer: | Enercon GmbH | Rated power (generator): | 3.000 kW |
| | Dreekamp 5 | Rotor diameter: | 82 m |
| | 26605 Aurich | Hub height above ground: | 98 m |
| Serial number: | 82001 | Tower design: | tube tower |
| WT-location: | RW: 2.592.266 | material: | concrete |
| | HW: 5.914.847 | Power control: | pitch |
| **Complementations of rotor (manufacturer)** | | **Complementations of gear and generator (manufacturer)** | |
| blades: | Enercon GmbH | Manufacturer of gear: | --- |
| Type of blades: | E-82-2 | Type of gear: | --- |
| Pitch angel: | variabel | Manufacturer of generator: | Enercon GmbH |
| Number of blades: | 3 | Type of generator: | E-82 E3 |
| Rated speed(s)/speed range: | 6 - 18 rpm (mode I) | Rated speed(s)/speed range: | 6 - 18 rpm (mode I) |

test report of power curve: Enercon GmbH: Calculated output curve of the E-82 E3 Rev. 2.0

| | Reference | | Noise emission parameter | Remarks |
|---|---|---|---|---|
| | Standardized wind speed at 10 m above ground | Electric power | | |
| Sound Power level $L_{WA,P}$ | 6 m/s | -- kW | -- dB(A) | [3] |
| | 7 m/s | 1586 kW | 104,5 dB(A) | |
| | 8 m/s | 2035 kW | 104,5 dB(A) | |
| | 9 m/s | 2447 kW | 104,8 dB(A) | |
| | 10 m/s | 2747 kW | 105,4 dB(A) | |
| | *10,5* m/s | *2850* kW | *105,1* dB(A) | [3] |
| Tonality (close-up range) $K_{TN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1586 kW | --- dB | |
| | 8 m/s | 2035 kW | --- dB | |
| | 9 m/s | 2447 kW | --- dB | |
| | 10 m/s | 2747 kW | --- dB | |
| | *10,5 m/s* | *2850* kW | --- *dB* | [3] |
| Impulsivity (close-up range) $K_{IN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1586 kW | --- dB | |
| | 8 m/s | 2035 kW | --- dB | |
| | 9 m/s | 2447 kW | --- dB | |
| | 10 m/s | 2747 kW | --- dB | |
| | *10,5* m/s | *2850* kW | --- dB | [3] |

**one third octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- |

**one third octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 77,9 | 82,3 | 86,1 | 88,6 | 90,2 | 91,0 | 93,6 | 95,4 | 95,6 | 93,3 | 94,2 | 94,4 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 92,7 | 91,8 | 90,4 | 91,1 | 89,3 | 86,3 | 85,3 | 82,7 | 80,5 | 74,8 | 76,5 | 73,4 |

**octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 88,1 | 94,8 | 99,7 | 98,8 | 96,5 | 94,1 | 88,0 | 79,9 |

**one third octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 79,9 | 83,7 | 86,8 | 89,1 | 89,5 | 92,9 | 95,3 | 96,0 | 94,1 | 95,2 | 95,2 | 92,9 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 91,2 | 89,4 | 90,3 | 88,6 | 86,0 | 84,5 | 81,8 | 77,7 | 74,1 | 78,2 | 63,4 | 63,6 |

**octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 89,1 | 95,7 | 100,0 | 99,4 | 95,2 | 91,5 | 83,8 | 78,5 |

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**one third octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 75,5 | 79,1 | 82,5 | 85,7 | 89,2 | 88,6 | 92,3 | 95,0 | 96,0 | 94,5 | 95,7 | 96,1 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 93,8 | 91,7 | 89,7 | 90,5 | 89,2 | 88,8 | 86,3 | 83,9 | 79,4 | 76,2 | 80,5 | 75,8 |

**octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 84,7 | 92,9 | 99,5 | 100,3 | 96,9 | 94,4 | 88,8 | 82,9 |

**one third octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 76,5 | 80,3 | 83,7 | 86,0 | 89,5 | 88,9 | 92,3 | 94,9 | 95,9 | 94,7 | 96,3 | 96,9 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 94,8 | 92,8 | 91,0 | 91,7 | 90,4 | 90,1 | 89,2 | 85,6 | 82,1 | 79,5 | 82,4 | 72,7 |

**octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 85,8 | 93,1 | 99,3 | 100,8 | 97,9 | 95,5 | 91,3 | 84,5 |

This test report extract is only valid with the manufacturer's certificate from 25.9.2010.
The declarations in this extract are only valid in combination with the test report M89 031/2 from 19.1.2011 [4]
(especially for calculations of sound propagation).

**Remarks:**

[1] Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte
Rev. 18 vom 01. February 2008 (Herausgeber: Fördergesellschaft Windenergie e.V., Stresemannplatz 4, D-24103 Kiel)

[2] IEC 61400-14 TS ed. 1, Declaration of Sound Power Level und Tonality Values of Wind Turbines, 2005-03

[3] In this windclass no values were determined

[4] The working point of 95% of the rated power, for which the maximum sound power level was stated, is according to the reference power curve and the hub height of the measured WT under standardized meteorological conditions v10= 10,5 m/s

[5] Müller-BBM testreport M89 031/2 from 19.1.2011

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Schallemission FGW renewable energies 2011 Konformitätssiegel

Date of report: 2011-01-19

Dipl.-Ing. (FH) M. Köhl

## Extract of test report

**page 1/2**

*Master Sheet "Noise", according to "Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"*
*Method of calculating apparent sound power level to another hub height according to Annex C of [1] and [2]*

Extract of test report M89 031/2
regarding noise emission of wind turbine (WT) Enercon E-82 E3

| General | | Technical specifications (manufacturer) | |
|---|---|---|---|
| Manufacturer: | Enercon GmbH | Rated power (generator): | 3.000 kW |
| | Dreekamp 5 | Rotor diameter: | 82 m |
| | 26605 Aurich | Hub height above ground: | 108 m |
| Serial number: | 82001 | Tower design: | tube tower |
| WT-location: | RW: 2.592.266 | material: | concrete |
| | HW: 5.914.847 | Power control: | pitch |
| **Complementations of rotor (manufacturer)** | | **Complementations of gear and generator (manufacturer)** | |
| blades: | Enercon GmbH | Manufacturer of gear: | --- |
| Type of blades: | E-82-2 | Type of gear: | --- |
| Pitch angel: | variabel | Manufacturer of generator: | Enercon GmbH |
| Number of blades: | 3 | Type of generator: | E-82 E3 |
| Rated speed(s)/speed range: | 6 - 18 rpm (mode I) | Rated speed(s)/speed range: | 6 - 18 rpm (mode I) |

test report of power curve: Enercon GmbH: Calculated output curve of the E-82 E3 Rev. 2.0

| | Reference | | Noise emission parameter | Remarks |
|---|---|---|---|---|
| | Standardized wind speed at 10 m above ground | Electric power | | |
| Sound Power level $L_{WA,P}$ | 6 m/s | -- kW | -- dB(A) | [3] |
| | 7 m/s | 1618 kW | 104,5 dB(A) | |
| | 8 m/s | 2066 kW | 104,5 dB(A) | |
| | 9 m/s | 2472 kW | 104,9 dB(A) | |
| | 10 m/s | 2777 kW | 105,4 dB(A) | |
| | *10,4* m/s | *2850* kW | *105,1* dB(A) | [3] |
| Tonality (close-up range) $K_{TN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1618 kW | --- dB | |
| | 8 m/s | 2066 kW | --- dB | |
| | 9 m/s | 2472 kW | --- dB | |
| | 10 m/s | 2777 kW | --- dB | |
| | *10,4 m/s* | *2850* kW | --- *dB* | [3] |
| Impulsivity (close-up range) $K_{IN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1618 kW | --- dB | |
| | 8 m/s | 2066 kW | --- dB | |
| | 9 m/s | 2472 kW | --- dB | |
| | 10 m/s | 2777 kW | --- dB | |
| | *10,4* m/s | *2850* kW | --- dB | [3] |

**one third octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- |

**one third octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 77,9 | 82,3 | 86,1 | 88,6 | 90,2 | 91,0 | 93,6 | 95,4 | 95,6 | 93,3 | 94,2 | 94,4 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 92,7 | 91,8 | 90,4 | 91,1 | 89,3 | 86,3 | 85,3 | 82,7 | 80,5 | 74,8 | 76,5 | 73,4 |

**octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 88,1 | 94,8 | 99,7 | 98,8 | 96,5 | 94,1 | 88,1 | 79,9 |

**one third octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 79,9 | 83,7 | 86,8 | 89,1 | 89,5 | 92,9 | 95,3 | 96,0 | 94,1 | 95,2 | 95,2 | 92,9 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 91,2 | 89,4 | 90,3 | 88,6 | 86,0 | 84,5 | 81,8 | 77,7 | 74,1 | 78,2 | 63,4 | 63,6 |

**octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 89,1 | 95,7 | 100,0 | 99,4 | 95,2 | 91,5 | 83,8 | 78,5 |

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**one third octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 75,6 | 79,2 | 82,6 | 85,8 | 89,3 | 88,7 | 92,4 | 95,1 | 96,1 | 94,6 | 95,8 | 96,2 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 93,9 | 91,8 | 89,8 | 90,6 | 89,3 | 88,9 | 86,4 | 84,0 | 79,5 | 76,3 | 80,6 | 75,9 |

**octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 84,8 | 93,0 | 99,6 | 100,4 | 96,9 | 94,4 | 88,9 | 82,9 |

**one third octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 76,5 | 80,3 | 83,7 | 86,0 | 89,5 | 88,9 | 92,3 | 94,9 | 95,9 | 94,7 | 96,3 | 96,9 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 94,8 | 92,8 | 91,0 | 91,7 | 90,4 | 90,1 | 89,2 | 85,6 | 82,1 | 79,5 | 82,4 | 72,7 |

**octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 85,8 | 93,1 | 99,3 | 100,8 | 97,9 | 95,5 | 91,3 | 84,5 |

This test report extract is only valid with the manufacturer's certificate from 25.9.2010.
The declarations in this extract are only valid in combination with the test report M89 031/2 from 19.1.2011 [4]
(especially for calculations of sound propagation).

**Remarks:**

[1] Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte
Rev. 18 vom 01. February 2008 (Herausgeber: Fördergesellschaft Windenergie e.V., Stresemannplatz 4, D-24103 Kiel)

[2] IEC 61400-14 TS ed. 1, Declaration of Sound Power Level und Tonality Values of Wind Turbines, 2005-03

[3] In this windclass no values were determined

[4] The working point of 95% of the rated power, for which the maximum sound power level was stated, is according to the reference power curve and the hub height of the measured WT under standardized meteorological conditions v10= 10,4 m/s

[5] Müller-BBM testreport M89 031/2 from 19.1.2011

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Schallemission FGW renewable energies 2011 Konformitätssiegel

Date of report: 2011-01-19

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MÜLLER-BBM
Accredited Testing Laboratory
according to DIN EN ISO/IEC 17025
Deutscher Akkreditierungs Rat
DAR
DGA-PL-2465.10

## Extract of test report



*Master Sheet "Noise", according to "Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte"*
*Method of calculating apparent sound power level to another hub height according to Annex C of [1] and [2]*

Extract of test report M89 031/2
regarding noise emission of wind turbine (WT) Enercon E-82 E3

| General | | Technical specifications (manufacturer) | |
|---|---|---|---|
| Manufacturer: | Enercon GmbH | Rated power (generator): | 3.000 kW |
| | Dreekamp 5 | Rotor diameter: | 82 m |
| | 26605 Aurich | Hub height above ground: | 138 m |
| Serial number: | 82001 | Tower design: | tube tower |
| WT-location: | RW: 2.592.266 | material: | concrete |
| | HW: 5.914.847 | Power control: | pitch |
| **Complementations of rotor (manufacturer)** | | **Complementations of gear and generator (manufacturer)** | |
| blades: | Enercon GmbH | Manufacturer of gear: | --- |
| Type of blades: | E-82-2 | Type of gear: | --- |
| Pitch angel: | variabel | Manufacturer of generator: | Enercon GmbH |
| Number of blades: | 3 | Type of generator: | E-82 E3 |
| Rated speed(s)/speed range: | 6 - 18 rpm (mode I) | Rated speed(s)/speed range: | 6 - 18 rpm (mode I) |

test report of power curve: Enercon GmbH: Calculated output curve of the E-82 E3 Rev. 2.0

| | Reference | | Noise emission parameter | Remarks |
|---|---|---|---|---|
| | Standardized wind speed at 10 m above ground | Electric power | | |
| Sound Power level $L_{WA,P}$ | 6 m/s | -- kW | -- dB(A) | [3] |
| | 7 m/s | 1746 kW | 104,5 dB(A) | |
| | 8 m/s | 2184 kW | 104,5 dB(A) | |
| | 9 m/s | 2590 kW | 105,1 dB(A) | |
| | 10 m/s | 2850 kW | 105,4 dB(A) | |
| | *10,0* m/s | *2850* kW | *105,4* dB(A) | [3] |
| Tonality (close-up range) $K_{TN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1746 kW | --- dB | |
| | 8 m/s | 2184 kW | --- dB | |
| | 9 m/s | 2590 kW | --- dB | |
| | 10 m/s | 2850 kW | --- dB | |
| | *10,0 m/s* | *2850* kW | --- *dB* | [3] |
| Impulsivity (close-up range) $K_{IN}$ | 6 m/s | -- kW | --- dB | [3] |
| | 7 m/s | 1746 kW | --- dB | |
| | 8 m/s | 2184 kW | --- dB | |
| | 9 m/s | 2590 kW | --- dB | |
| | 10 m/s | 2850 kW | --- dB | |
| | *10,0* m/s | *2850* kW | --- dB | [3] |

**one third octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**octave sound power level at reference point $v_{10}$ = 6 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | --- | --- | --- | --- | --- | --- | --- | --- |

**one third octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 77,9 | 82,3 | 86,1 | 88,6 | 90,2 | 91,0 | 93,6 | 95,4 | 95,6 | 93,3 | 94,2 | 94,4 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 92,7 | 91,8 | 90,4 | 91,1 | 89,3 | 86,3 | 85,3 | 82,7 | 80,5 | 74,8 | 76,5 | 73,4 |

**octave sound power level at reference point $v_{10}$ = 7 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 88,1 | 94,8 | 99,7 | 98,8 | 96,5 | 94,1 | 88,1 | 79,9 |

**one third octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ 1/3\ octave}$ | 80,0 | 83,8 | 86,9 | 89,2 | 89,6 | 93,0 | 95,4 | 96,1 | 94,2 | 95,3 | 95,3 | 93,0 |
| frequency | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,\ 1/3\ octave}$ | 91,3 | 89,5 | 90,4 | 88,7 | 86,1 | 84,6 | 81,9 | 77,8 | 74,2 | 78,3 | 63,5 | 63,7 |

**octave sound power level at reference point $v_{10}$ = 8 m/s**

| frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,\ octave}$ | 89,2 | 95,7 | 100,1 | 99,4 | 95,2 | 91,6 | 83,8 | 78,6 |

**one third octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 75,8 | 79,4 | 82,8 | 86,0 | 89,5 | 88,9 | 92,6 | 95,3 | 96,3 | 94,8 | 96,0 | 96,4 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 94,1 | 92,0 | 90,0 | 90,8 | 89,5 | 89,1 | 86,6 | 84,2 | 79,7 | 76,5 | 80,8 | 76,1 |

**octave sound power level at reference point $v_{10}$ = 9 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 85,0 | 93,1 | 99,8 | 100,5 | 97,1 | 94,6 | 89,1 | 83,1 |

**one third octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 76,5 | 80,3 | 83,7 | 86,0 | 89,5 | 88,9 | 92,3 | 94,9 | 95,9 | 94,7 | 96,3 | 96,9 |
| Frequenz | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 |
| $L_{WA,P,Terz}$ | 94,8 | 92,8 | 91,0 | 91,7 | 90,4 | 90,1 | 89,2 | 85,6 | 82,1 | 79,5 | 82,4 | 72,7 |

**octave sound power level at reference point $v_{10}$ = 10 m/s**

| Frequenz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| $L_{WA,P,Terz}$ | 85,9 | 93,2 | 99,4 | 100,8 | 97,9 | 95,6 | 91,3 | 84,5 |

This test report extract is only valid with the manufacturer's certificate from 25.9.2010.
The declarations in this extract are only valid in combination with the test report M89 031/2 from 19.1.2011 [4]
(especially for calculations of sound propagation).

**Remarks:**

[1] Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte
Rev. 18 vom 01. February 2008 (Herausgeber: Fördergesellschaft Windenergie e.V., Stresemannplatz 4, D-24103 Kiel)

[2] IEC 61400-14 TS ed. 1, Declaration of Sound Power Level und Tonality Values of Wind Turbines, 2005-03

[3] In this windclass no values were determined

[4] The working point of 95% of the rated power, for which the maximum sound power level was stated, is according to the reference power curve and the hub height of the measured WT under standardized meteorological conditions v10= 10 m/s

[5] Müller-Bbm testreport M89 031/2 from 19.1.2011

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Schallemission FGW renewable energies 2011 Konformitätssiegel

Date of report: 2011-01-19

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MÜLLER-BBM
Accredited Testing Laboratory
according to DIN EN ISO/IEC 17025

Deutscher Akkreditierungs Rat DAR
DGA-PL-2465.10

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