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Acoustic report for a wind turbine type REpower MM 92 at Chemin d`Ablis / France, operation mode 2050 kW

Measurement 2009-01-22

Full Report

2009-03-13

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Acoustic report for a wind turbine type RE-power MM 92 at Chemin d`Ablis / France, operation mode 2050 kW

Report SE09001B4

Location:	Windfarm Chemin d`Ablis, WEC No. E 14, Ser.-No. R90223

Customer:	REpower Systems AG Rödemis Hallig D-25813 Husum / Germany

Supplier:	windtest grevenbroich gmbh Frimmersdorfer Str. 73 D-41517 Grevenbroich / Germany

Date of Order:	2008-12-23	**Order Number:**	09 0004 06

Auditor:

Dipl.-Ing. Thomas Fischer

Editor:

Dipl.-Ing. David Rode

Grevenbroich, 2009-03-13

1 Conceptual formulation

windtest grevenbroich gmbh (windtest) was ordered 2008-12-23 by REpower Systems AG to:

- determine the apparent sound power level as characteristic parameters of noise emission in accordance with IEC 61400-11 [1] of a wind energy converter (WEC), type REpower MM 92, hub height H = 80 m (including base), located at Chemin d`Ablis / France (WEC E 14, Ser.-No. R90223).

2 Measurement execution

2.1 Measurement procedure selection

Methods of measurement and determination were, according to the order, based on the following regulation: „IEC 61400-11, Wind energy turbine generator systems – Part 11: Acoustic noise measurement techniques, 2002-12“ [1].

The apparent sound power level and tonality for various integer wind speeds at a height of 10 m as well as for that wind speed at a height of 10 m, at which the WEC operates at about 95 % of its rated power (in case this is reached below a wind speed of 10 m/s in 10 m height) are specified.

2.2 Measurement object

The object to be measured was a WEC, type REpower MM 92, during continuous operation in normal operation mode (Fig. 1).

2.2.1 Acoustic sources

The sound of a WEC is the combination of several single acoustic sources. Components like generator, gears, hydraulic pumps, fans, transformers and converter are mentioned here as examples. The sound emissions of the different sources leave the apertures in the gondola (nacelle) and the tower directly and are as well transferred as mechanical vibrations by the machine housing. Some of these sources can cause tonality noises.

The noise created by aerodynamical effects, represents the second essential acoustic source. They are caused by the rotation of the rotor blades. These wideband noises depend on the blade tip speed in first place and in the second on the blade profile and the pitch angle.

The technical data of the WEC are as stated in Tab 1. More detailed information about the components of the WEC are given in the manufacturer’s specification in the appendix.

Tab. 1: Technical data of the WEC

Manufacturer	REpower Systems AG
WEC type	REpower MM 92
Serial No.	R90223
Location	Chemin d`Ablis
Rated power	2050 kW
Performance control	Pitch
Hub height ab. ground	80 m
Tower design	conical steel tube
Position of blades to the tower	luv
Number of blades	3
Rotor diameter	92,5 m
Blade type	RE 45.2
Rotational speed / range	7,8 – 15,0 rpm
Gear type	CPNHZ-224/G50115XB
Generator type	DASAA 5025-4UA

Fig. 1: WEC REpower MM 92

2.3 Measurement location

The WEC is situated with further WECs at Chemin d`Ablis. The environment is used agriculturally.

2.4 Measurement setup

The installation of the measuring point was chosen according to [1]. The measurement of noise emission was performed using a microphone mounted on a soundproof board (diameter 1 m) in $R_{0,chosen}$ = 102 m distance to the centre of the WEC tower (comp. Fig. 2).

$$R_0 = H + D/2 \pm 20\% \quad \text{(H: hub height; D: rotor diameter)}$$

The sound pressure levels (operating noise (BG) and background noise (HG)) were recorded by a sound pressure level meter. Additionally the sound was recorded with a digital audio tape (DAT) recorder. The damping influence of the secondary wind screen is less than 0,1 dB and is not taken into account any further.

The electrical power of the WEC was measured by a special electronical device from the manufacturer and was analogue-to-digital transformed and saved onto the hard disk of a computer.

As the WEC of type REpower MM 92 can be operated in different operational modes, the generator speed of the turbine has been recorded while measuring. Additionally the wind speed at hub height was measured, too. The information has been taken from the control panel of the WEC by a special electronical device and was stored onto the hard disk of the computer.

Wind direction and wind speed at a height of 10 m were measured by a wind vane and anemometer fixed on a mast in a distance of 54 m upwind from the WEC (see Fig. 3). Signals were also analogue-to-digital transformed and saved onto the hard disk of the computer.

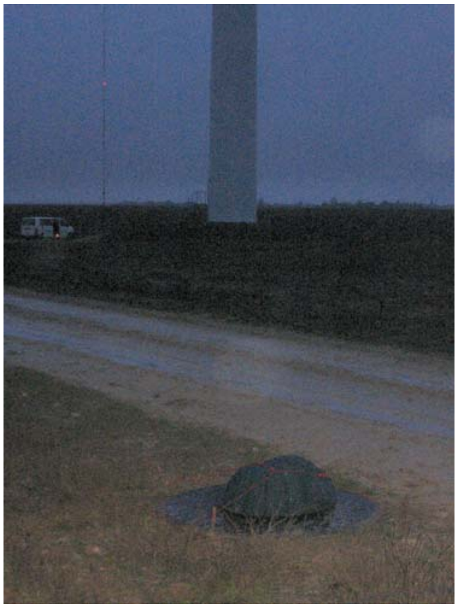


Fig. 2: Microphone

Fig. 3: Wind measuring mast

All recordings of meteorological, acoustical and WEC data were synchronised with an accuracy of less than one second.

All devices used for recording signals are listed in Tab. 2.

To ensure accuracy of data and measurement at any time, all devices are revised within certain periods as stated in [1]. All acoustic measurement instruments were calibrated before and after measurement with an acoustic calibrator.

Tab. 2: Used measuring devices

Device	Manufacturer / type / serial No.	Calibrated until	Internal device No.
Devices acoustic			
Microphone	Norsonic, Type 1220, Serial No. 28411	31.12.10	WTGMT 034/2
Noise level meter	Norsonic 110, Serial No. 19604	31.12.10	WTGMT 034/1
Calibrator	Brüel & Kjaer, Type 4231, Serial No. 2162810	12.09.09	WTGMT 269
Tascam HD-P2	Frontier / 0290104		WTGMT 1542
Primary wind screen	Norsonic		
Secondary wind screen	Windtest, Schulze-Brakel		WTGMT 1137
Devices meteorological measurments			
Wind measuring mast 11,40 m	Teksam Clark-Mast, Type OT 12M/HP, Serial No. 6K4820		WTGMT 996
Anemometer	Vector, Type A100L2, Serial No. 6034	19.01.11	WTGMT 501
Wind vane	Thies, Type 4.3124.30.012, Serial No. 705033		WTGMT 1134
Signal transformer	Schuhmann, Type Waz5 Pro RTD		WTGMT 788
Barometer	Vaisala, Type PTB100A		WTGMT 743
Thermometer/hygrometer	Galltec, Type KPC 2/6 ME		WTGMT 776
Devices hardware + software			
Data logger	IMC µ-MUSYCS, Serial No. 99031200		WTGMT 364
Computer	Asus L8400, Serial No. 12NG032430		WTGPC 179

2.5 Measuring performance

The measurement was performed 2009-01-22 from 16:00 until 19:40. During the measurement of the sound emissions, the neighbouring WEC (no. E 15) was taken out of operation. The appeared wind speeds at a height of 10 m above ground ranged from 4 m/s up to 11 m/s (10 s average). The produced effective power ranged from 750 kW up to 2200 kW (10-s-average). While measuring the noise emission, the WEC was operated in normal mode (2050 kW).

Sound pressure level, effective power, rotational speed, as well as wind speed and wind direction at a height of 10 m were measured and recorded simultaneously.

Periods with disturbing noises (as passing cars, planes, etc.) during the measurement have been excluded later during the analysis of apparent sound power level for operating noise and background noise.

2.6 Meteorological conditions

The temperature, the air pressure and the humidity have been measured meanwhile the measurement. The meteorological conditions were as stated in Tab. 3.

Tab. 3: Meteorological conditions during time of measurement

cloudiness	cloudy
air pressure	978 hPa
air temperature	7 °C
relative atmospheric humidity	96 %

3 Measurement Results

3.1 Directional characteristic

From subjective listening tests no obvious directional characteristic of the operating sound could be found.

3.2 Subjective sense of noise

Mainly aerodynamic noise from rotating blades could be noticed. Furthermore, low tonality noise could be noticed sometimes at some wind speeds in the nearby vicinity of the WEC and at the reference position. On the whole, the operating sound of the WEC can be stated as inconspicuous.

3.3 Sound pressure level

For the analysis of noise characteristics within different wind conditions, the measured parameter (as 1 sec. values) are differentiated and analysed according to their state. It is distinguished between periods of operating noise („BG“, state = 1) and background noise with stopped WEC („HG“, state = 0,5). State = 0 means, that the data are excluded from the analysis, because of disturbances, partly missing data, different operating modes etc. The measured raw data are shown in Fig. 4.

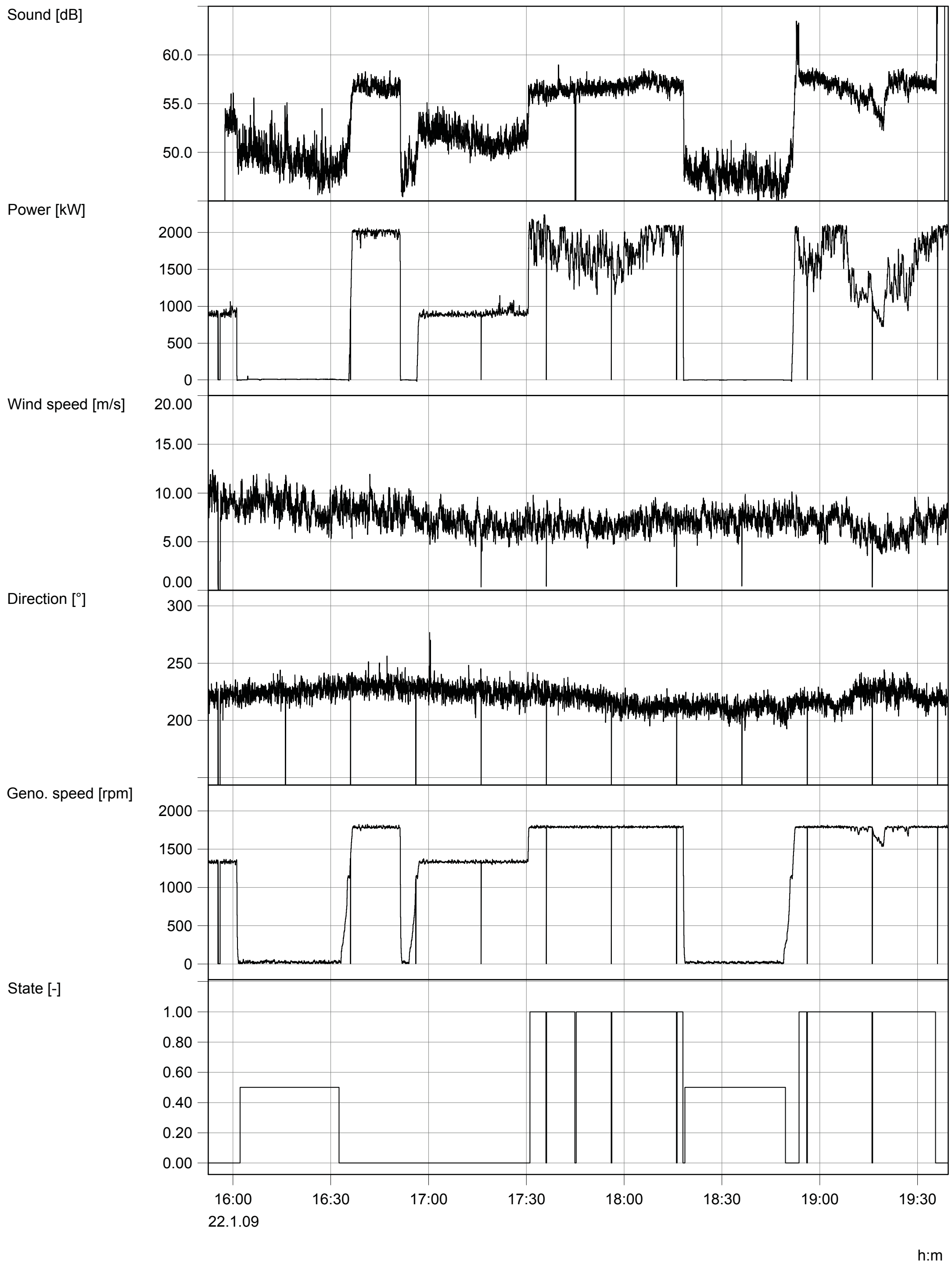


Fig. 4: Measurement data

From the time charts of effective power, wind speed, wind direction and sound pressure level all values with state = 1 or state = 0,5 were extracted. Arithmetical average over 10 s of wind speed, wind direction and electric power were calculated and the corresponding energetic average of sound pressure level were used for the following evaluation of the sound characteristics of the WEC. (Fig. 5 and Fig. 7*)*

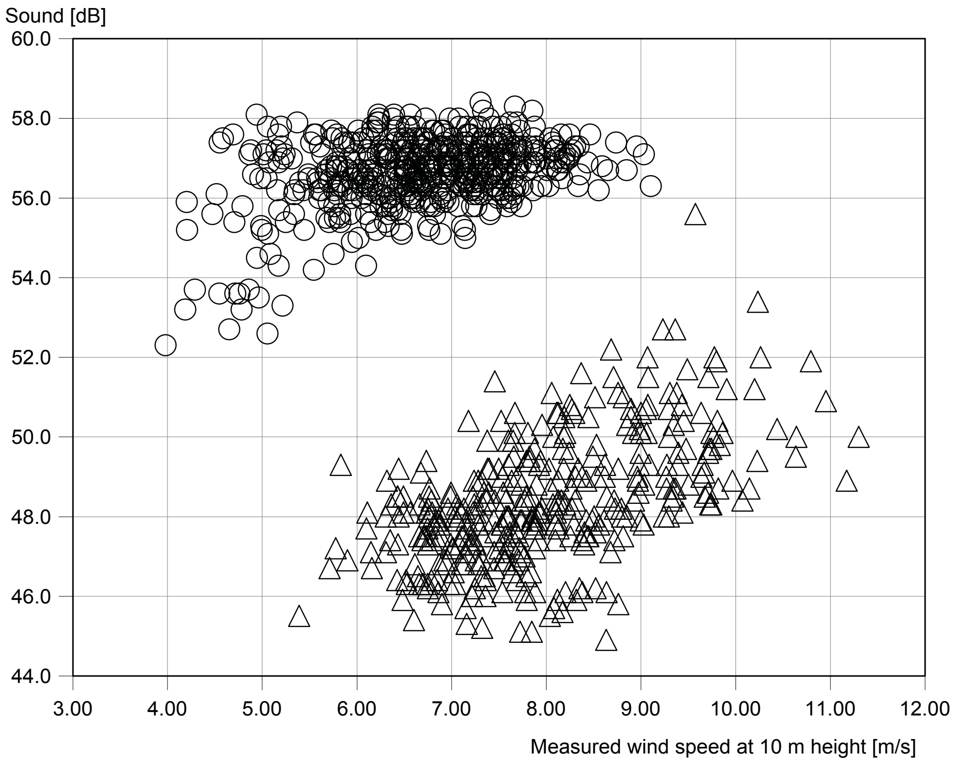


Fig. 5: Sound pressure level (operating noise O and background noise Δ)versus measured wind speed at 10m height

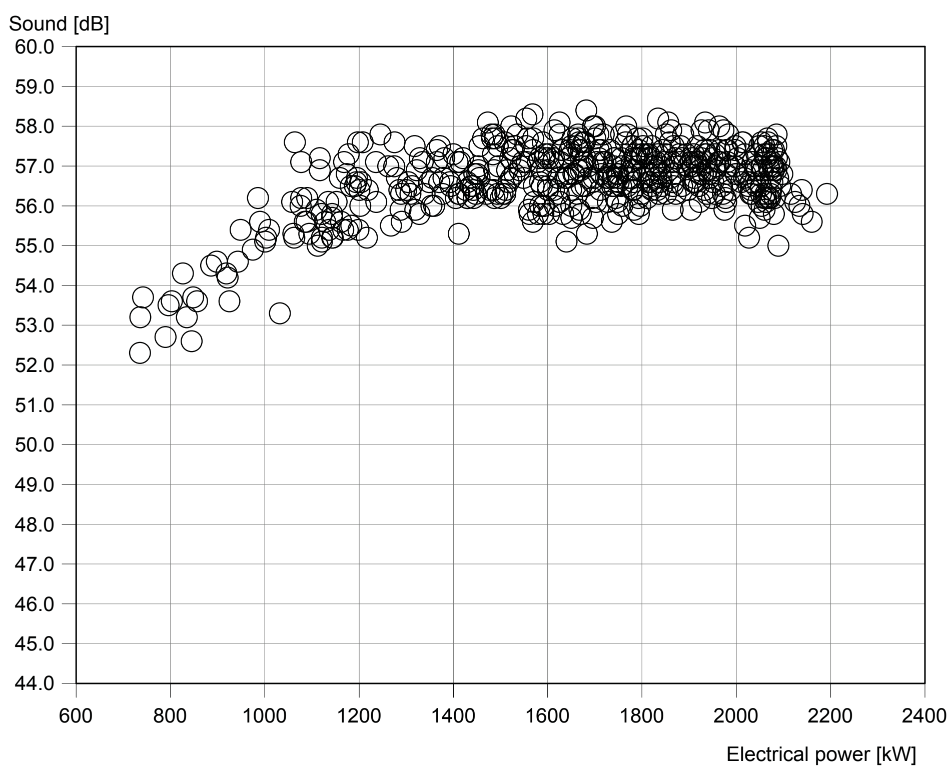


Fig. 6: Sound pressure level versus electrical power

3.4 Apparent sound power level

According to the first method of wind speed determination in [1], the measured effective power is transformed into a wind speed at hub height by means of the power curve of the WEC.

The wind speed at hub height is corrected according to [1] with regard to air density and reference height (10 m above ground), applying a logarithmic approximation, with the reference length z_0 0,05 m.

$$v_{p10} = v_H \cdot \frac{\ln 10/z_0}{\ln H/z_0} \quad \text{with } z_0 = 0{,}05 \text{ m, } H = 80 \text{ m}$$

From both the resulting standardised wind speeds and the simultaneously measured wind speeds at the wind measuring mast, a correction factor κ was determined for the measured wind speeds.

$$\kappa = \frac{v_{p10}}{v_{mess,10}} \quad \text{and} \quad v_{mess,10,korr} = \kappa \cdot v_{mess,10}$$

For this measurement the correction factor has a value κ = 1,05. The κ-factor was used to correct the measured background wind speeds. For data pairs, which exhibit an average electric power over 95 % of rated power, a similar procedure for the wind speed determination has been applied according to [3. Therefore, for all measured data with electrical power between 5 % and 95 % of rated power, a linear correction function from the standardised wind speed (calculated from the power and the power curve) and from the measured wind speed of the nacelle anemometer has been determined. This correction function has then been applied to the nacelle anemometer wind speeds for all data pairs with electrical power above 95 % of rated power. For this reason the values might stray into the wind speed region below 95 % of rated power. Data points over 95 % of rated power, but with corrected measured wind speed below the wind speed corresponding to 95 % of rated power, are omitted.

Deviating from [1], a regression curve of 3rd order has been applied. The 2nd order regression is not well suited to give a correct representation of the measured sound values over a wide wind speed range as shown here.

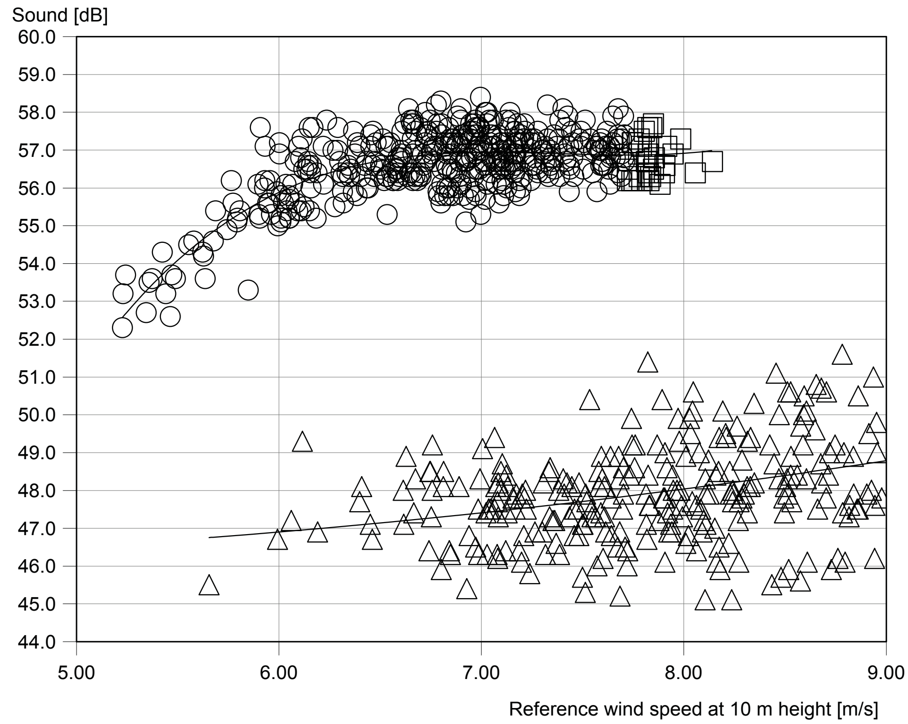


Fig. 7: Sound pressure level versus standardised wind speed
*Regression operating O: - 127,62 + 75,212 * X – 10,1976 * X^2 + 0,45994 * X^3 [dB]*
*Regression background noise Δ: 46,38 – 0,277 * X + 0,0604 * X^2 [dB]*
□ Measurement data above 95 % of rated power

For integer values of wind speed from 6 m/s up to 8 m/s the difference of operating noise and background noise has been determined from the regression equations. By means of that level difference ΔL_{Aeq} the background noise correction has been applied to the measured operating noise with the following equation:

$$L_{Aeq,c} = 10\lg\left[10^{(0{,}1*L_{Aeq,BG+HG})} - 10^{(0{,}1*L_{Aeq,HG})}\right]$$

From the background corrected sound pressure level $L_{Aeq,c}$ the apparent sound power level L_{WA} was calculated for all wind speeds from 6 m/s up to 8 m/s as follows:

$$L_{WA} = L_{Aeq,c} - 6\mathrm{dB} + 10 \cdot \log(4\pi \cdot \frac{R_i^2}{1\mathrm{m}^2}) \qquad \mathrm{dB}$$

with $R_i = \sqrt{(R_o + N_A)^2 + (H - h_A)^2}$

and R_0 = 102 m, N_A = 3,15 m, H = 80 m, h_A = -1 m

The apparent sound power levels of the WEC REpower MM 92 in the present configuration (normal operation mode) are listed in Tab. 4.

Tab. 4: Apparent sound power level of WEC REpower MM 92, 2050 kW

Wind speed at 10 m height (v_{10m})	BIN 6 5,5–6,5 m/s	BIN 7 6,5–7,5 m/s	7,7 m/s[1)]	BIN 8 7,5–8,5 m/s
Operating noise ($L_{Aeq, BG}$ / dB)	55,9	56,9	56,9	56,9
Background noise ($L_{Aeq, HG}$ / dB)	46,9	47,4	47,8	48,0
Difference level (ΔL_{Aeq} / dB)	9,0	9,5	9,1	8,9
Corrected noise ($L_{Aeq,c}$ / dB)	55,3	56,4	56,3	56,3
Sound power level (L_{WA} / dB)	**102,8**	**103,9**	**103,8**	**103,8**
Electrical Power (P / kW)	1181	1688	1948	2006

1) 95 % of rated power

From the shown data above 95 % of rated power (Fig. 7) it is obvious, that no increase of sound power level for higher wind speeds has to be expected.

3.5 Further sound characteristics

No distinct impulsive character noise could be noticed. Further special sound characteristics, which might be supposed to draw attention on the WEC, could not be noticed.

3.6 Level of single noise events

Single events like starting or stopping the WEC, which exceeded the normal operating noise to a noteworthy content, could not be noticed.

3.7 Tonality analysis

The noise (operating and background) is sampled with 40 kHz and a 20 kHz antialiasing filter and then Fourier transformed. For each wind speed bin 12 samples of operating noise are used, each of them 10 s duration. The frequency resolution is 2 Hz, therefore 20 spectra of 0.5 s time windows have to be averaged. A Hanning window is applied. For background noise a 2 minute sample is used, with a frequency resolution of 2 Hz, too. From these spectra tonal audibilities $\Delta L_{a,k}$ are determined according to [1].

3.7.1 Results of the tonality analysis

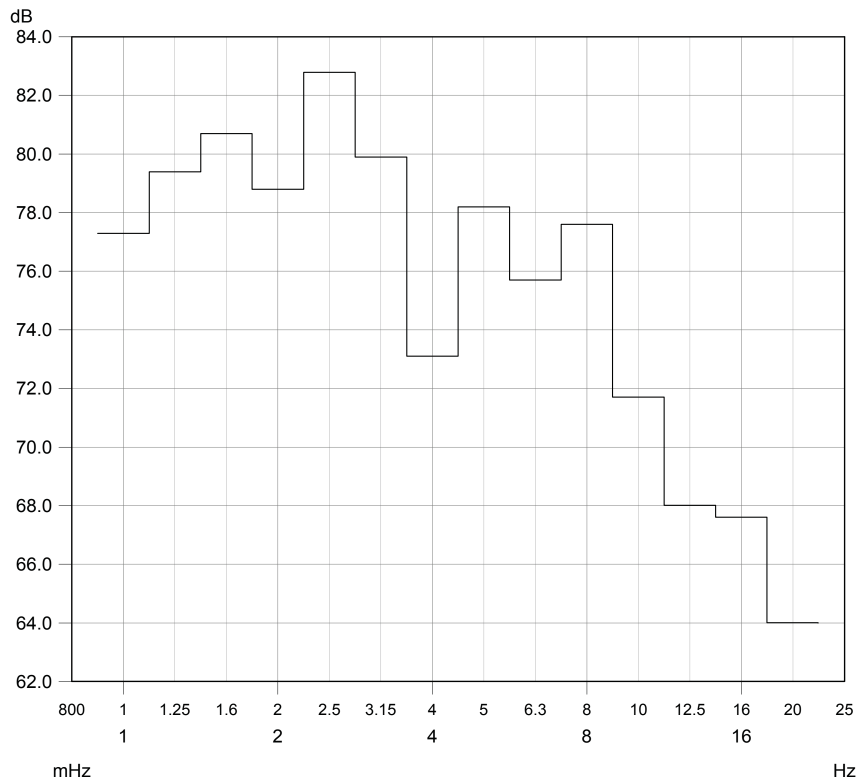
The operating noise of the REpower MM 92 contains low tonal components in a different wind speed range from 5 m/s up to rated power, which lead to values $\Delta L_{a,k} < -3$ dB. These components are so low that they do not lead to any tonality to be stated according to [1]. So there is no requirement to report the values [1].

Note 1: Tonality sounds can be noticed subjectively at some times and some wind speeds at (150 Hz, 300 Hz and 2500 Hz).

Note 2: The stated tonality is only valid for the nearby vicinity of the WEC. These values cannot be transferred directly to longer distances (several 100 meter).

3.8 Third octave measurements at low frequencies

During the noise emission measurement in the normal operation mode (2050 kW), a third octave measurement at low frequencies was performed by using the noise level meter at reference position. Third octave frequencies at 1 Hz – 20 Hz were measured. The produced electrical power of the WEC was during that measurement permanently at rated power.



Measured third octave sound power level, sum level = 89,2 dB			
middle frequency [Hz]	sound power level [dB]	middle frequency [Hz]	sound power level [dB]
1	77,30	5	78,20
1,25	79,40	6,3	75,70
1,6	80,70	8	77,60
2	78,80	10	71,70
2,5	82,80	12,5	68,00
3,15	79,90	16	67,60
4	73,10	20	64,00

3.9 Turbulence intensity

The turbulence intensity (TI) has been determined according to [1] from the measured wind speed averages of 10 minute time series and the corresponding standard deviations. The turbulence intensity has been 13 % on average. This value is measured in 10 m height and cannot be compared directly to values in other documents like site assessment evaluations.

3.10 Operating mode

Deviating to [1] and as demanded from the manufacturer, details about the operating mode (measured rotational generator speed versus measured electrical power) are not presented in this report. This information can be inquired at the manufacturer, if necessary.

4 Sound power levels for different hub heights

4.1 Calculation basics

The recalculation of the apparent sound power levels for wind turbines of same type but different hub heights is performed according to the “Technische Richtlinie für Windenergieanlagen, Teil 1” [3], Appendix C.

At first, the wind speed $v_{10,i}$ is calculated by application of a logarithmic height profile, at which the measured WEC (in this case at $h_{N,\ measured}$ = 80 m) generates the same electric output power as the WEC with the new hub height will do at the chosen wind speed $v_{10,ref}$ in 10 m height:

$$v_{10,i} = v_{10,ref} \cdot \frac{\ln(h_{N,new} / z_0)}{\ln(h_{N,measured} / z_0)}$$

A reference length of z_0 = 0.05 m is adopted.

For these wind speeds the operating and background noises are calculated from the regression equations (s. Chapter 3.4). In the following, analogue to the calculations for the measured wind turbine, the apparent sound power levels are calculated from the background noise corrected operating noises and the measuring distance.

Note: No distinct statement about noteworthy changes in tonality or impulsivity can be made for the new hub heights, because no measurements have been done for these hub heights.

4.2 Sound power levels for the new hub heights

For the measured wind turbine under test (with a hub height of $h_{N,\ measured}$ = 80 m) this leads to the following sound power levels for the new hub heights:

Tab. 5: Sound power levels for new hub heights

	BIN 6 5,5–6,5 m/s	**BIN 7** 6,5–7,5 m/s	**BIN 8** 7,5–8,5 m/s	**103,7 dB** 1)
L_{WA} / dB H_{neu} = 68,5 m	102,4	103,9	103,7	7,9 m/s
L_{WA} / dB H_{neu} = 78,5 m	102,7	103,9	103,8	7,7 m/s
L_{WA} / dB H_{neu} = 100 m	103,2	103,9	103,9	7,5 m/s

1) 95 % rated power are reached at the stated wind speed in 10 m height

Note: The sound power level L_{WA} at 95 % of rated power does not change by definition, only the wind speed at 10 m height changes, at which 95 % of rated power are reached.

5 Measurement uncertainty

5.1 Measurement uncertainty type A

From the measured sound pressure levels and the calculated sound pressure levels (regression analysis) the measurement uncertainty type A has been calculated at a wind speed of 6 m/s as a reference value. According to [1] a value is calculated for the average stray of single data points with regard to the regression curve:

$$U_A = \sqrt{\frac{\sum (L_{Aeq,mess} - L_{Aeq,bin})^2}{N-2}}$$

The data analysis gives a value of U_A = 0,69 dB.

Deviating from [1], here the uncertainty of the regression value is used for the further calculations instead of the average stray of single data points. Therefore, the number of data points within the wind speed bin has to be taken into account as $1/\sqrt{N}$. This leads to a value of

$U_{A,regr}$ = 0,07 dB.

5.2 Measurement uncertainty type B

The uncertainty of measurement type B was estimated as shown in Tab. 6:

Tab. 6: Measurement uncertainty type B

	margin of errors ± a	likely error $U_a = a/\sqrt{3}$
acoustic calibrator UB1	± 0,3 dB	0,17 dB
sound pressure level meter UB2	± 0,3 dB	0,17 dB
sound proof board UB3	± 0,5 dB	0,29 dB
measurement distance UB4	± 0,1 dB	0,06 dB
air impedance UB5	± 0,2 dB	0,12 dB
turbulence UB6	± 0,7 dB	0,40 dB
wind speed UB7	± 0,3 dB	0,17 dB
wind direction UB8	± 0,5 dB	0,29 dB
background UB9	± 0,6 dB	0,35 dB

5.3 Estimation of the measurement uncertainty U_c

From the measurement uncertainties type A and B results the combined uncertainty U_C of the given sound power level for 6 m/s:

$$U_C = \sqrt{U_{A,regr}^2 + U_{B1}^2 + U_{B2}^2 + U_{B3}^2 + U_{B4}^2 + U_{B5}^2 + U_{B6}^2 + U_{B7}^2 + U_{B8}^2 + U_{B9}^2}$$

U_C = 0,8 dB

This value can be taken as a reference value for the uncertainties of the sound power levels at other wind speeds as well.

6 Summary

As ordered by the customer REpower Systems AG, windtest grevenbroich gmbh has measured the noise emission of a WEC type REpower MM 92 with a hub height of 80 m (including the base) according to IEC 61400-11 [1].

The measurement has been performed on 2009-01-22 in Chemin d`Ablis on the WEC with the serial no. R90223 and the wind farm no. E14, in normal operation mode (2050 kW).

A distinct directional characteristic could not be measured for this turbine. Single noise events, exceeding the average noise of the turbine more than 10 dB could not be noticed. Nor any other special noise characteristics like impulsivity could be stated.

The tonality analysis according to IEC 61400-11 [2] for the measured WEC noise in 102 m distance, shows no tonality for the analysed wind bins.

Generally speaking, the operating noise of the wind turbine REpower MM 92 can be stated to be inconspicuously.

For the given sound power levels a measurement uncertainty of typical 0,8 dB has been found.

The data analysis gives the following noise values for the single wind speed bins:

Tab. 7: Measurement results for the REpower MM 92, normal operation mode 2050 kW

Wind speed at 10 m height (v_{10m})	**BIN 6 5,5–6,5 m/s**	**Bin 7 6,5–7,5 m/s**	**7,7 m/s 1)**	**BIN 8 7,5–8,5 m/s**
Sound power level L_{WA} [dB]	**102,8**	**103,9**	**103,8**	**103,8**
Tonal audability $\Delta L_{a,k}$ [dB]	0	0	0	0
Impulsivity K_{IN} [dB]	0	0	0	0
Elektrical power [kW]	1181	1688	1948	2006

1) 95 % of rated power

It is assured that the testing of the sound performance of the WEC REpower MM 92 was performed according to the state of technology, independently and impartially and to the best of our knowledge and conscience.

The results presented in this report only refer to and apply on this WEC.

Grevenbroich, 2009-03-13

Dipl.-Ing. David Rode

windtest grevenbroich gmbh

Schallemission FGW Fördergesellschaft Windenergie 2009 Konformitätssiegel

7 Bibliography

[1] IEC 61400-11, Wind turbine generator systems - Part 11: Acoustic noise measurement techniques
Second edition, 12-2002

[2] IEC 61400-11:2002, Amendment 1: Wind turbine generator systems - Part 11: Acoustic noise measurement techniques, June 2006

[3] Technische Richtlinien für Windenergieanlagen, Revision 17, Stand 01.02.2008 Teil1: Bestimmung der Schallemissionswerte, Herausgeber: Fördergesellschaft Windenergie e. V., Stresemannplatz 4, 24103 Kiel

8 Abbreviations

ΔL	-	level difference	dB
$\Delta L_{a,k}$	-	tonal audibility	dB
BG	-	operating noise	-
D	-	rotor diameter	m
f_T	-	tonal frequency	Hz
H	-	hub height	m
h_A	-	height of measuring microphone	m
HG	-	background noise	-
κ	-	correction factor	-
L_{Aeq}	-	equivalent, A-weighted continuous sound pressure level	dB
$L_{Aeq,c}$	-	background corrected sound pressure level	dB
$L_{Aeq,mess}$	-	measured sound pressure level	dB
$L_{Aeq,regr}$	-	calculated sound pressure level	dB
L_T	-	tone level	dB
L_{WA}	-	A-weighted sound power level	dB
N	-	number of values	-
N_A	-	horizontal distance between rotor centre and tower centre	m
P	-	electrical power	kW
R_0	-	horizontal distance between WEC and sound proof board	m
R_i	-	radius of cover surface	m
U_a, U_b, U_c	-	measurement uncertainties	dB

9 Appendix

REpower Systems

Herstellerbescheinigung, Kurzfassung für akustische Nachmessungen
Manufacturer's certificate, short version for control measurements of acoustic noise

1. Allgemeine Informationen – General information	
Anlagenhersteller – turbine manufacturer:	REpower Systems AG
Spezifische Anlagenbezeichnung – specific turbine type name:	MM92
Seriennummer der vermessenden WEA – serial number of tested WT:	90223
Standort der vermessenden WEA – location of tested WT:	Chemin d'Ablis
Kooridnaten des Standortes – coordinates of turbine location:	583820 / 2384807
Rotorachse – rotor axis:	horizontal – horizontal ☒ vertikal – vertical ☐
Nennleistung – rated power:	2050 kW
Leistungsregelung – power control:	pitch ☒ stall ☐
Nabenhöhe über Grund – hub height above ground:	80 m
Nabenhöhe über Fundamentflansch – hub height above top of foundation flange:	78,2 m
Nennwindgeschwindigkeit – rated wind speed:	12,5 m/s
Ein- / Abschaltwindgeschwindigkeit – cut-in / cut-out wind speed:	3 / 24 m/s
2. Rotor – Rotor	
Durchmesser – rotor diameter:	92,5 m
Anzahl der Blätter – number of blades:	3
Nabenart – kind of hub:	pendelnd – teetered ☐ starr – rigid ☒
Anordnung zum Turm – position relative to tower:	Luvseitig
Drehzahlbereich/Drehzahlstufen – rotor speed range/stages of rotor speed:	7,8 – 15,0 rpm
Rotorblatteinstellwinkel – rotor blade pitch setting:	variabel (0-91°)
Konuswinkel – cone angel:	3,5°
Achsneigung – tilt angle:	5°
Horizontaler Abstand zwischen Rotormittelpunkt und Turmmittellinie – horizontal distance between centre of rotor and tower centre line:	3150 mm
3. Rotorblatt – Rotor blade	
Hersteller – manufacturer:	A&R
Typenbezeichnung – type:	RE45.2
Seriennummer der Rotorblätter – serial number of rotor blades:	0007/0008/0009
Zusatzkomponenten (z.B. strips, Vortex-Gen., Turbulatoren) – additional components (e.g. stall strips, vortex gen., trip strips):	-
4. Getriebe – Gearbox	
Hersteller – manufacturer:	Eickhoff
Typenbezeichnung – type:	CPNHZ-224/G50115XB
Seriennummer des Getriebes – serial number of gear box:	22639
Ausführung – design:	Planeten-Stirnrad
Übersetzungsverhältnis – gear ratio:	120
5. Generator – Generator	
Hersteller – manufacturer:	VEM
Typenbezeichnung – type:	DASAA 5025-4UA
Seriennummer des Generators – serial number of generator:	2353344
Anzahl der Generatoren – number of generators:	1
Art des Generators (z.B. synchron, asynchr.) – kind of generator (e.g. synchronous, asynchr.):	asynchron
Nennleistung(en) – rated power values(s):	2080 kW
Drehzahlbereich/Drehzahlstufen – rotor speed range/stages of rotor speed:	900-1800 rpm
6. Turm – Tower	
Ausführung – design:	Gitter – lattice ☐ Rohr – tubular ☒ zylindrisch – cylindrical ☐ konisch – conical ☐
Material – material:	Stahl
Durchmesser Turmfuß – foot of the tower diameter	4300 mm
7. Betriebsführung / Regelung – Control system	
Art der Leistungsregelung – kind of power control:	pitch
Antrieb der Leistungsregelung – actuation of power control:	elektrisch
Hersteller der Betriebsführung / Regelung – manufacturer of control system:	REguard Control
Typenbezeichnung der Betriebsführung / Regelung – control system type:	MPC270
Bezeichnung der verwendeten Steuerungskurve – designation of used control setup:	Standard
Bezeichnung / Messbericht der verwendeten Leistungskurve – designation of power curve report:	[illegible]M.LK.11-A A

REpower Dokumenten-Nummer	Rev.
D-2.9-VM.HB.13-A	B
Freigabe	Datum

27.2.09

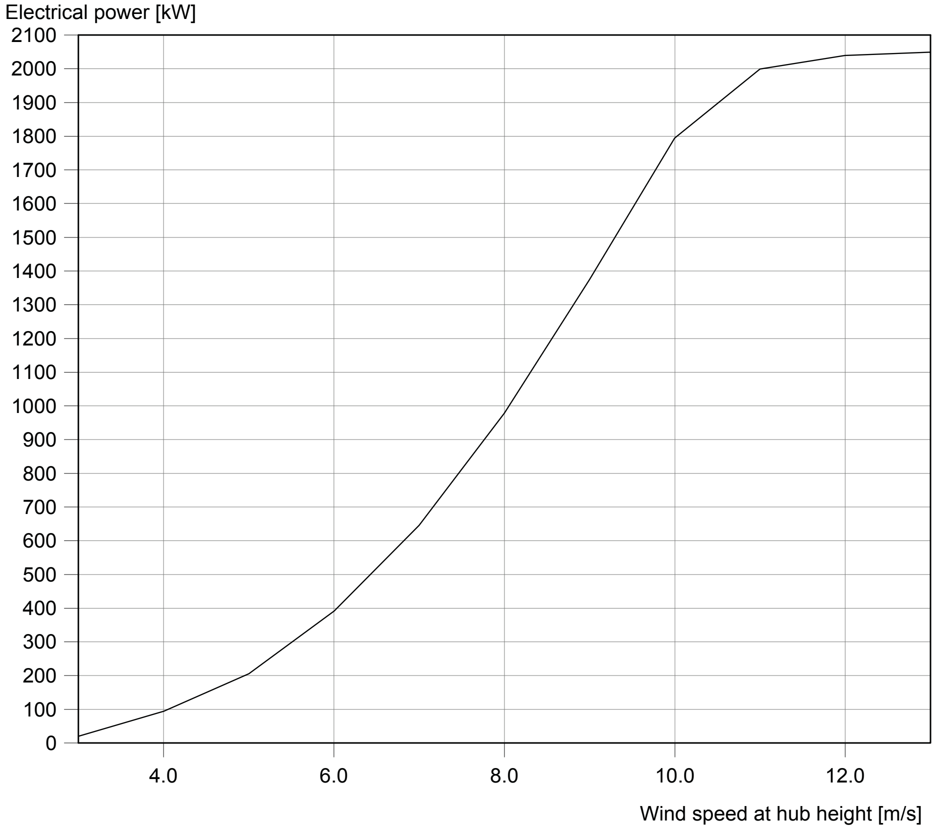
REpower Systems AG
Hollesenstraße 15, 24768 Rendsburg
Tel.: +49-(0)-4331-94 56-2000
Fax: +49-(0)-4331-94 56-2915

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

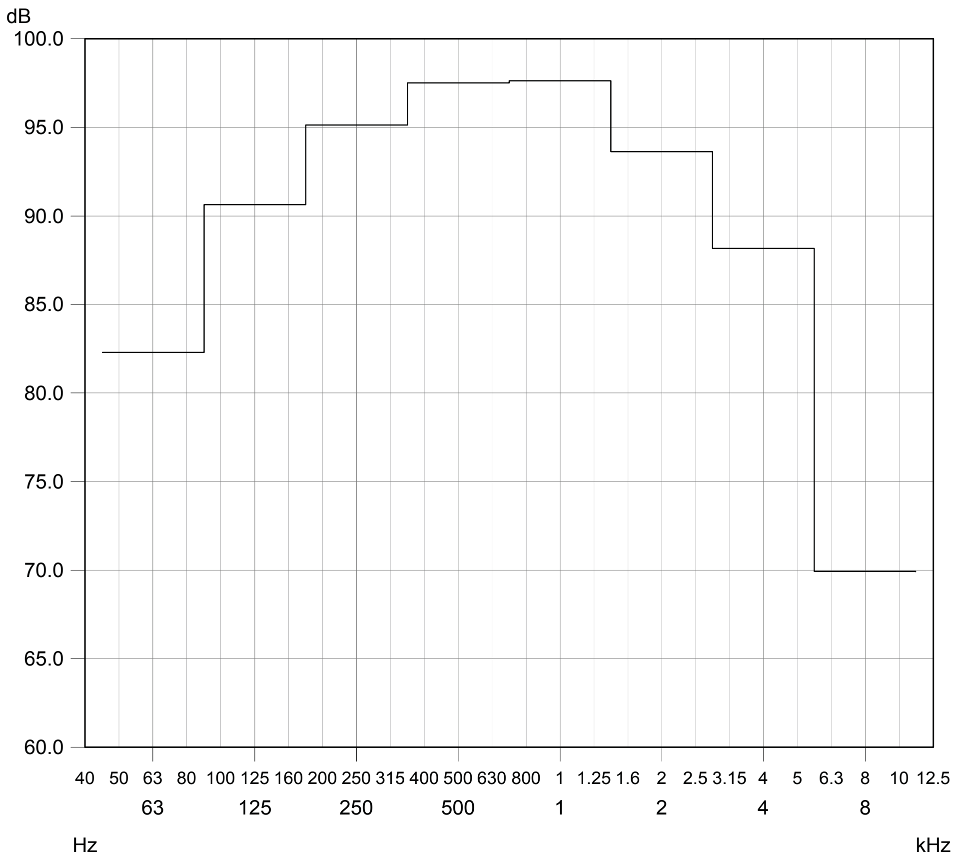
Der Hersteller der Windenergieanlage bestätigt, dass die WEA, deren Schallemission, Leistungskurve und elektrische Eigenschaften in den Prüfberichten abgebildet sind, die o.g. Eigenschaften aufweist. – The manufacturer of the wind turbine (WT) confirms that the WT whose noise level, performance curve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

Used power curve REpower MM 92

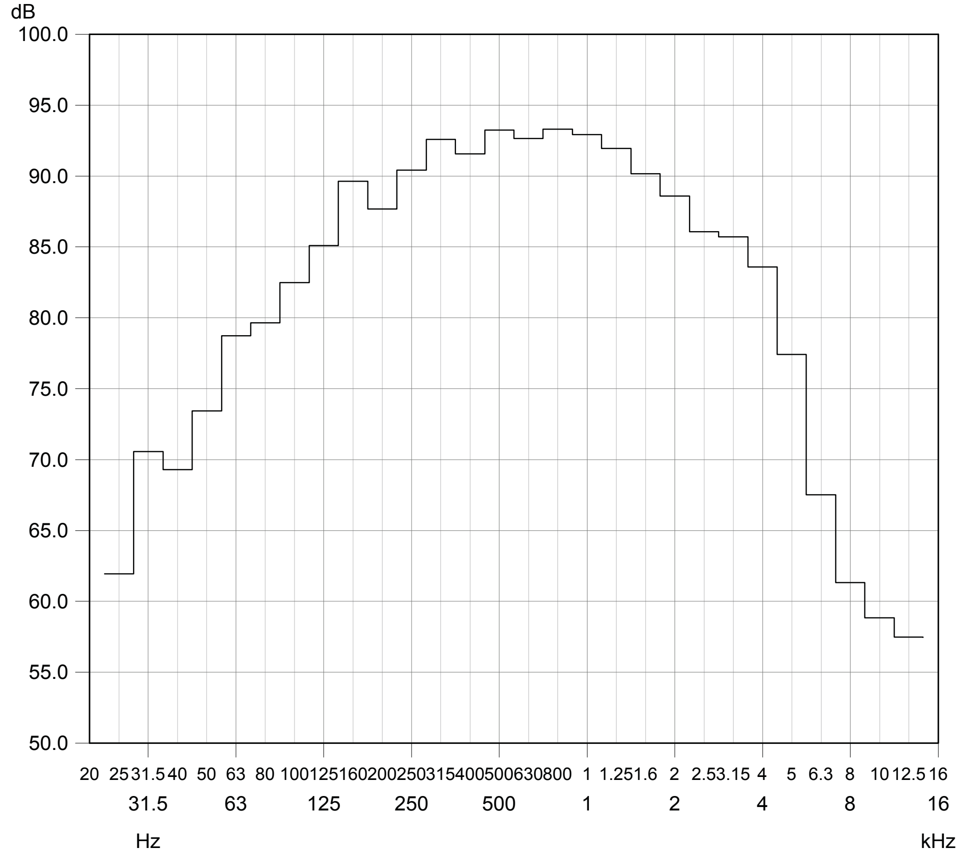
Source: REpower, Document-No.: C-2.9-VM.LK.11-A Rev.: A



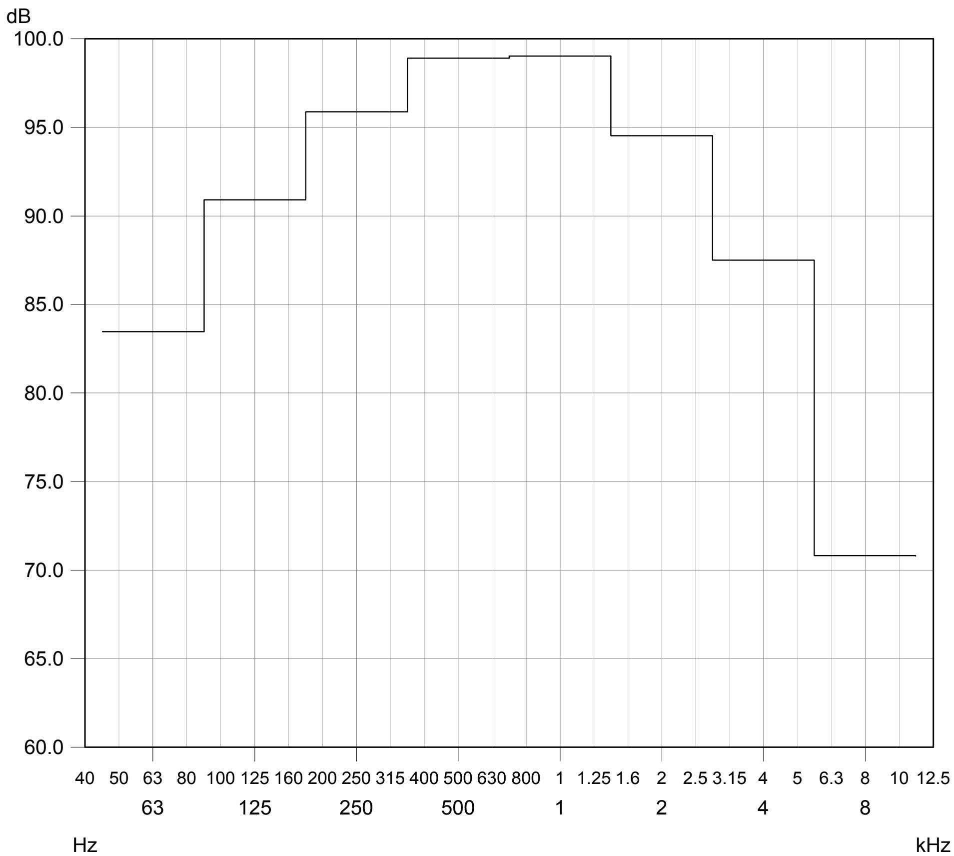
WG [m/s]	P [kW]	WG [m/s]	P [kW]
2	0	8	979
3	20	9	1375
4	94	10	1795
5	205	11	2000
6	391	12	2040
7	645	13	2050



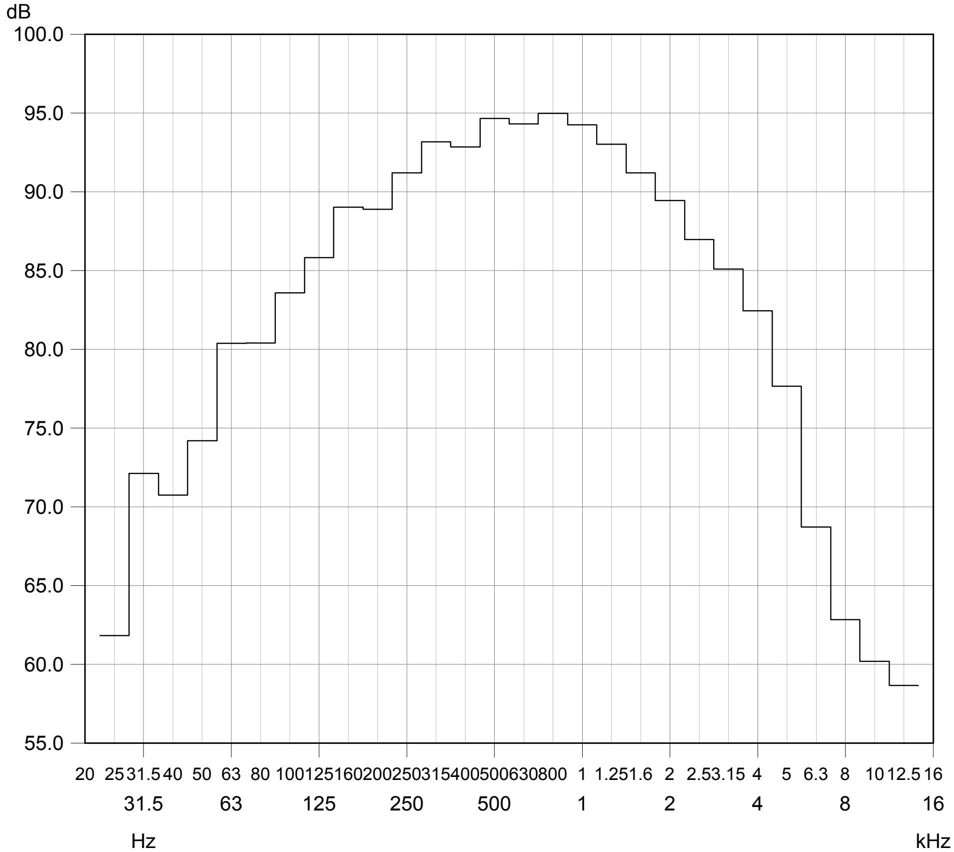
Octave sound power level at 6 m/s, sum level = 102,8 dB			
Middle frequency [Hz]	Sound power level [dB]	Middle frequency [Hz]	Sound power level [dB]
63	82,29	1000	97,65
125	90,64	2000	93,63
250	95,15	4000	88,17
500	97,53	8000	69,91



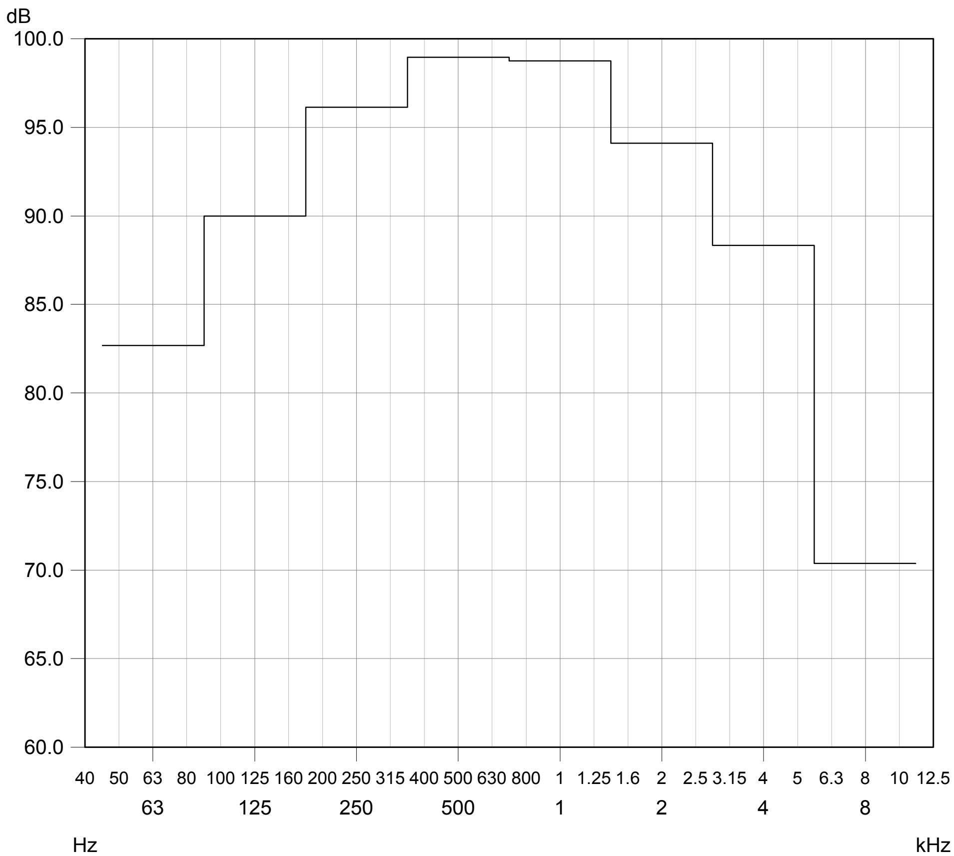
Third octave sound power level at 6 m/s, sum level = 102,8 dB			
Middle frequency [Hz]	Sound power level [dB]	Middle frequency [Hz]	Sound power level [dB]
25	61,92	630	92,66
31,5	70,56	800	93,31
40	69,29	1000	92,94
50	73,42	1250	91,96
63	78,72	1600	90,17
80	79,66	2000	88,61
100	82,49	2500	86,08
125	85,11	3150	85,72
160	89,65	4000	83,59
200	87,69	5000	77,43
250	90,43	6300	67,51
315	92,58	8000	61,32
400	91,56	10000	58,83
500	93,24	12500	57,47



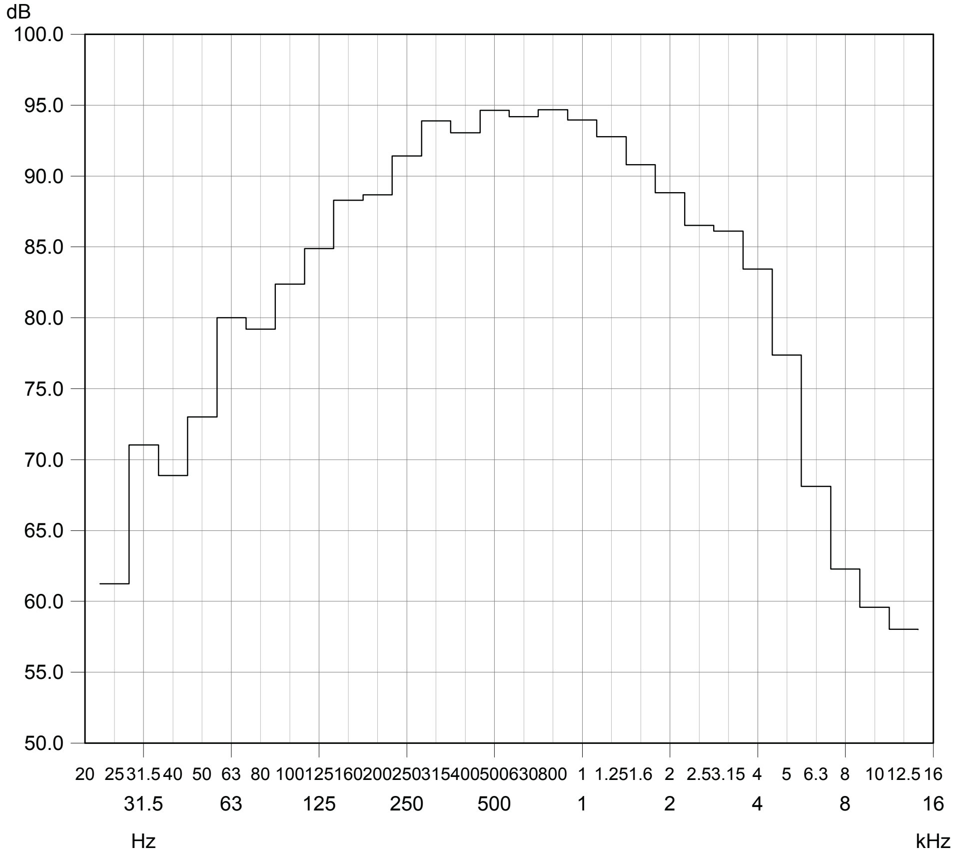
Octave sound power level at 7 m/s, sum level = 103,9 dB			
Middle frequency [Hz]	Sound power level [dB]	Middle frequency [Hz]	Sound power level [dB]
63	83,46	1000	99,03
125	90,92	2000	94,53
250	95,89	4000	87,51
500	98,91	8000	70,81



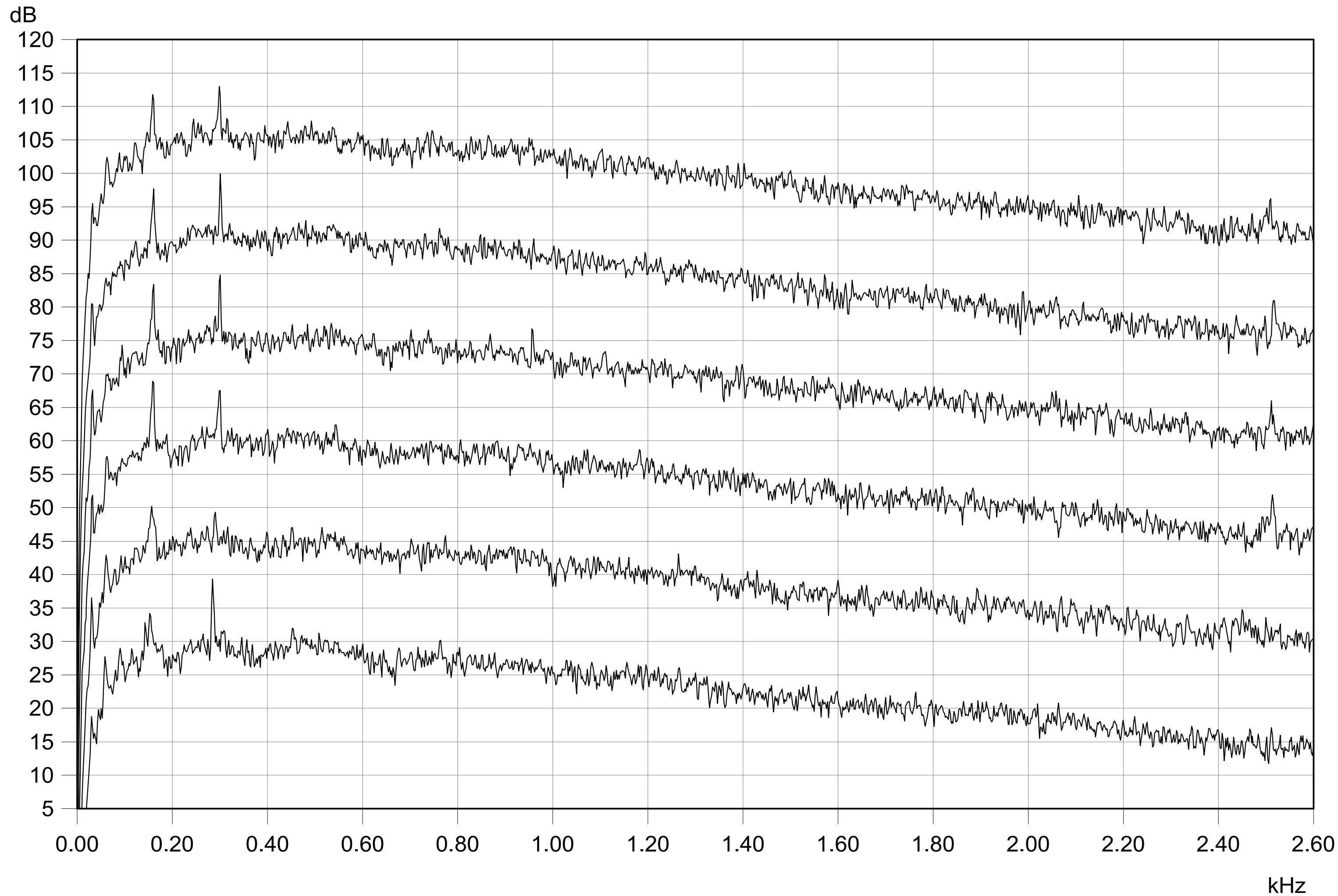
Third octave sound power level at 7 m/s, sum level = 103,9 dB			
Middle frequency [Hz]	Sound power level [dB]	Middle frequency [Hz]	Sound power level [dB]
25	61,82	630	94,32
31,5	72,11	800	95,00
40	70,74	1000	94,27
50	74,19	1250	93,03
63	80,38	1600	91,21
80	80,41	2000	89,45
100	83,60	2500	86,98
125	85,82	3150	85,10
160	89,03	4000	82,46
200	88,91	5000	77,65
250	91,22	6300	68,72
315	93,17	8000	62,84
400	92,86	10000	60,17
500	94,67	12500	58,65



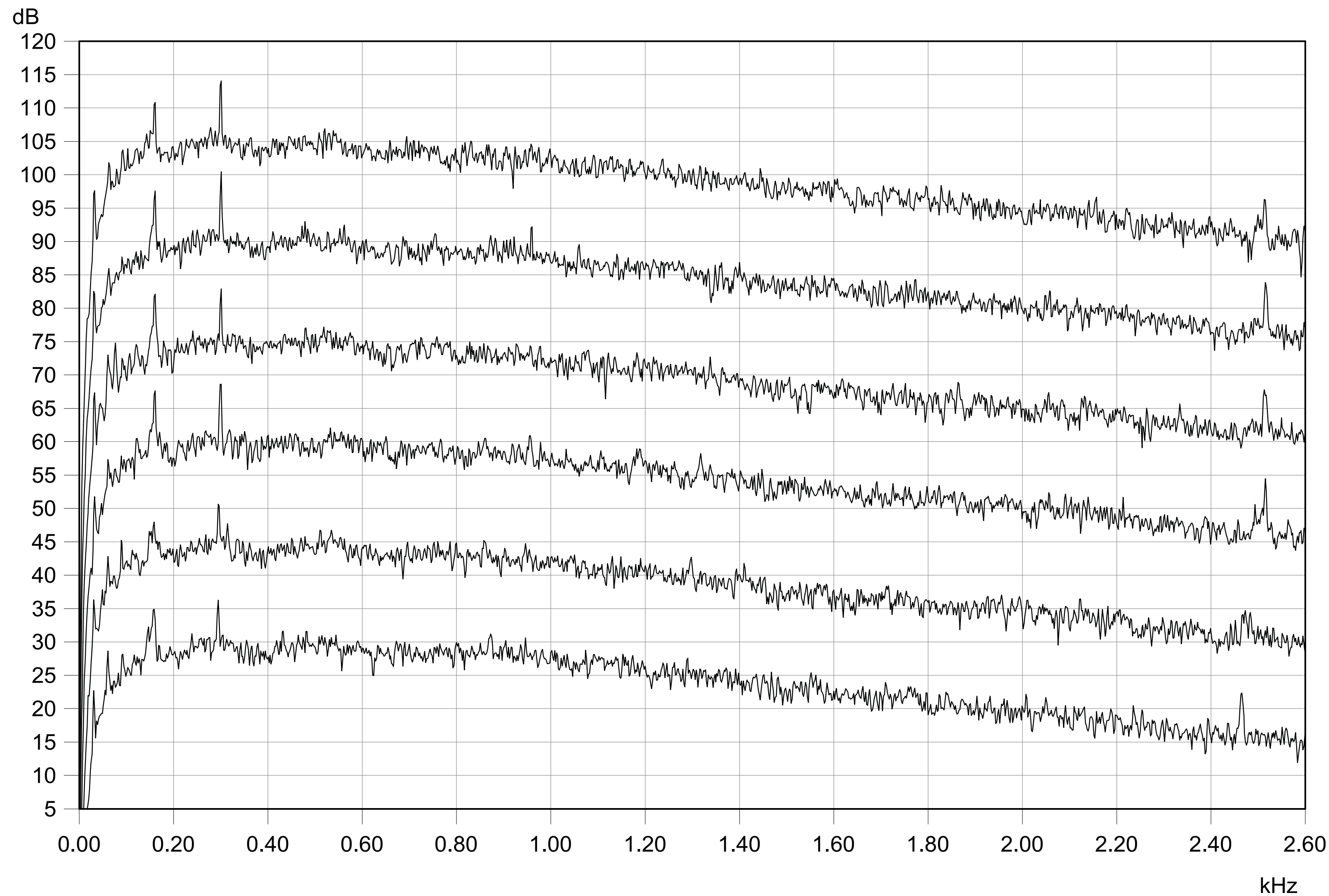
Octave sound power level at 8 m/s, sum level = 103,8 dB			
Middle frequency [Hz]	Sound power level [dB]	Middle frequency [Hz]	Sound power level [dB]
63	82,68	1000	98,77
125	90,01	2000	94,10
250	96,15	4000	88,33
500	98,97	8000	70,38



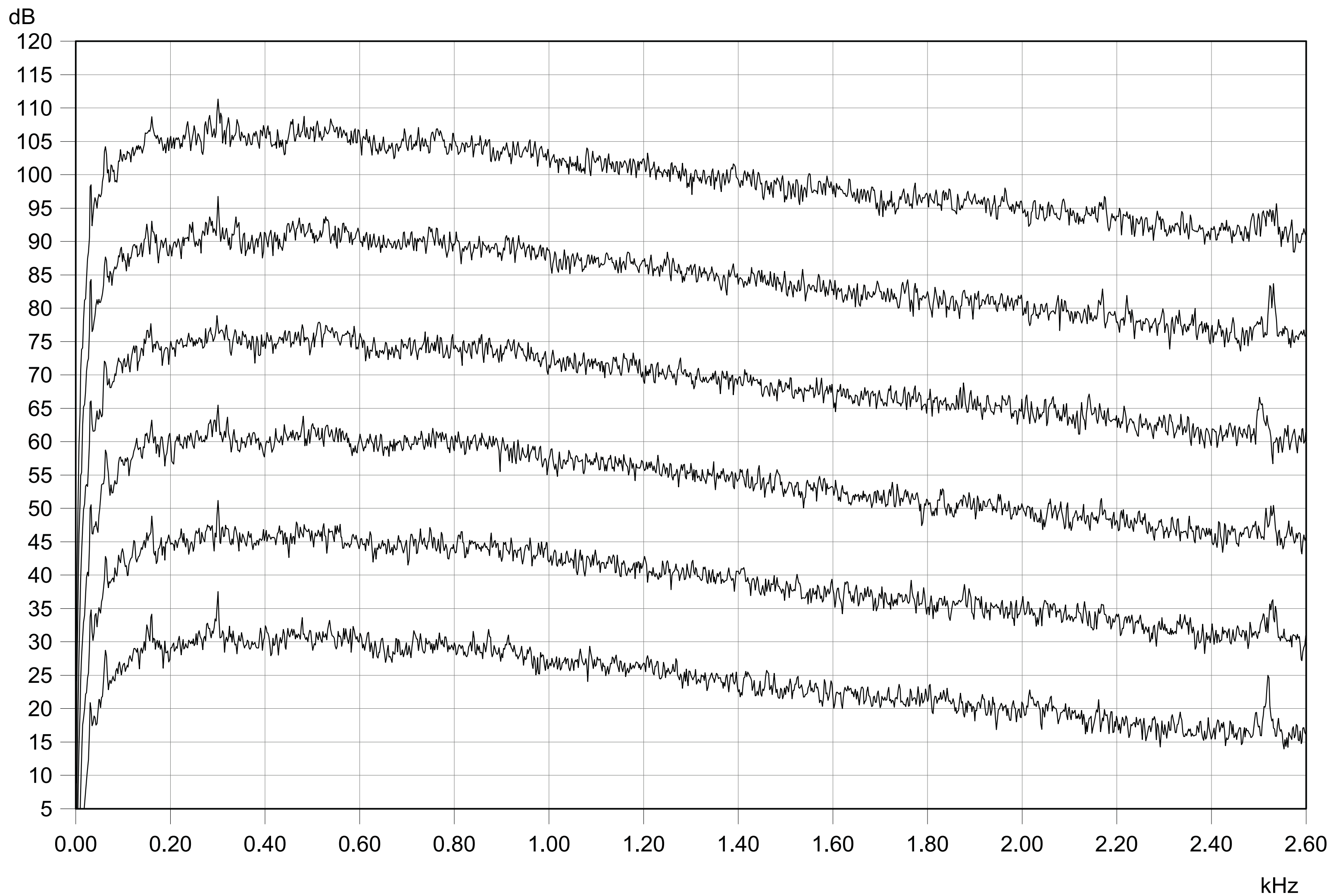
Third octave sound power level at 8 m/s, sum level = 103,8 dB			
Middle frequency [Hz]	Sound power level [dB]	Middle frequency [Hz]	Sound power level [dB]
25	61,24	630	94,21
31,5	71,03	800	94,69
40	68,87	1000	93,96
50	73,01	1250	92,79
63	80,01	1600	90,81
80	79,21	2000	88,83
100	82,40	2500	86,53
125	84,88	3150	86,12
160	88,31	4000	83,46
200	88,68	5000	77,38
250	91,44	6300	68,11
315	93,90	8000	62,26
400	93,05	10000	59,57
500	94,65	12500	58,02



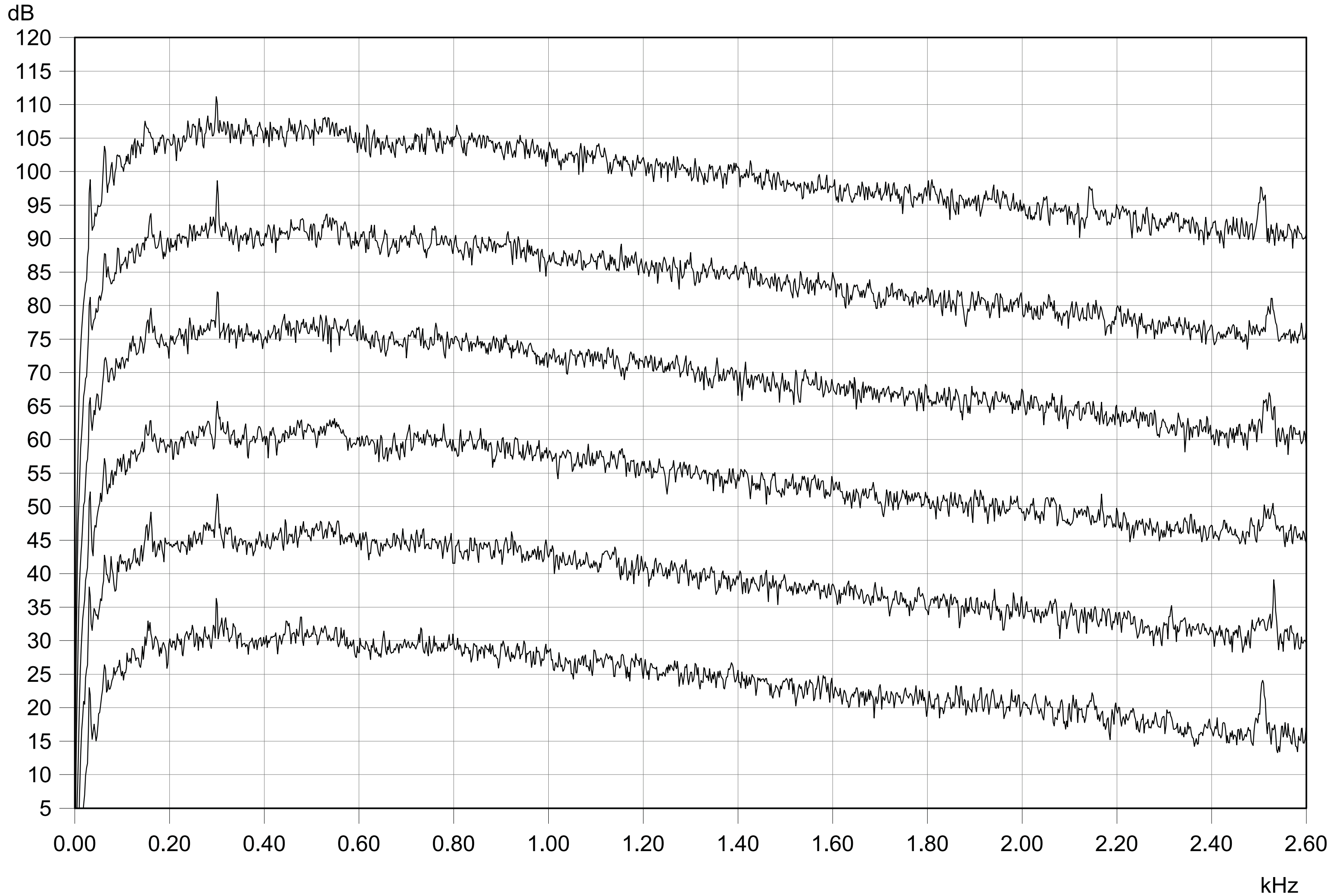
Spectra 1 – 6, at 6 m/s (upper spectra shifted by 15 dB each, no. 1 at top)



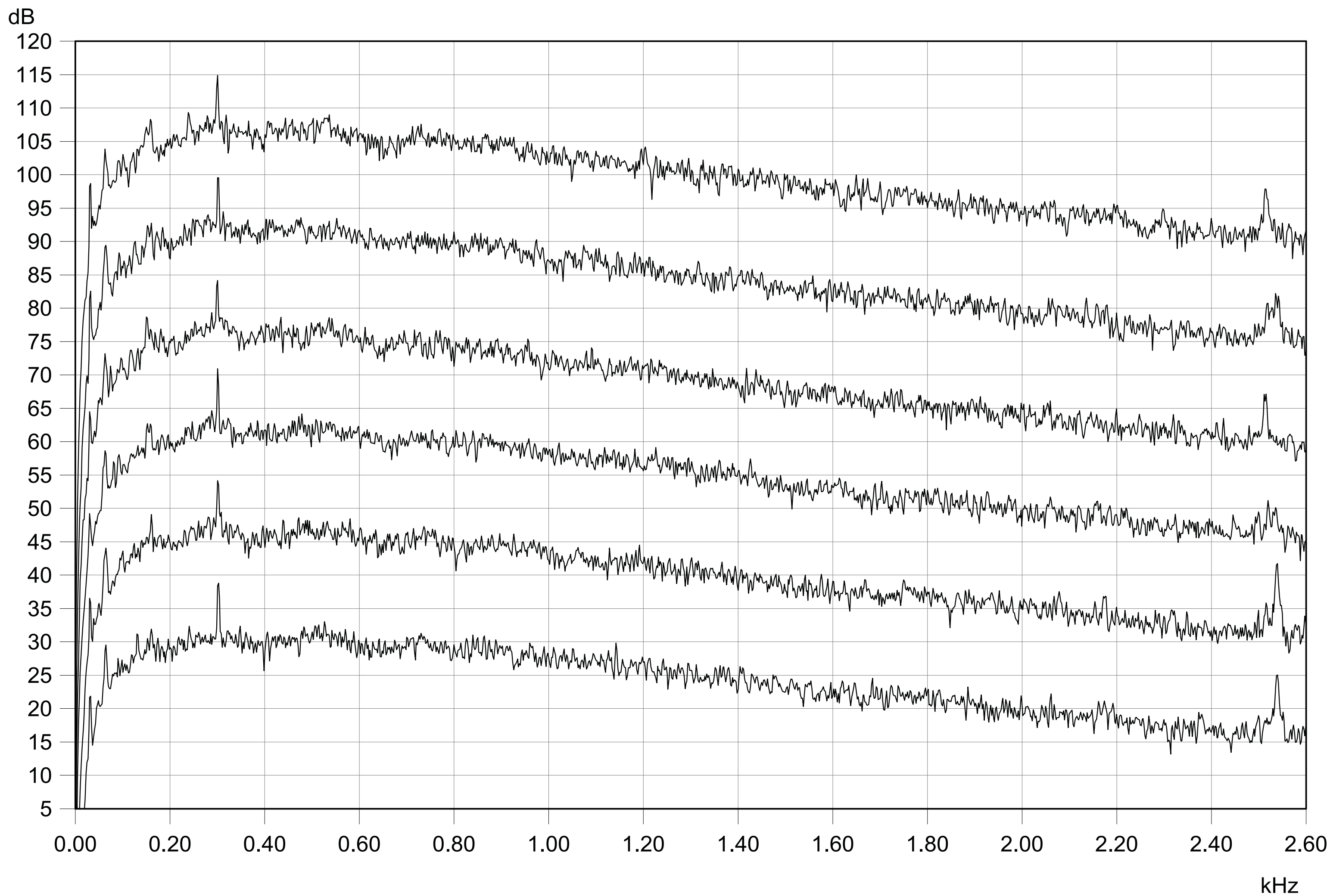
Spectra 7 – 12, at 6 m/s (upper spectra shifted by 15 dB each, no. 7 at top)



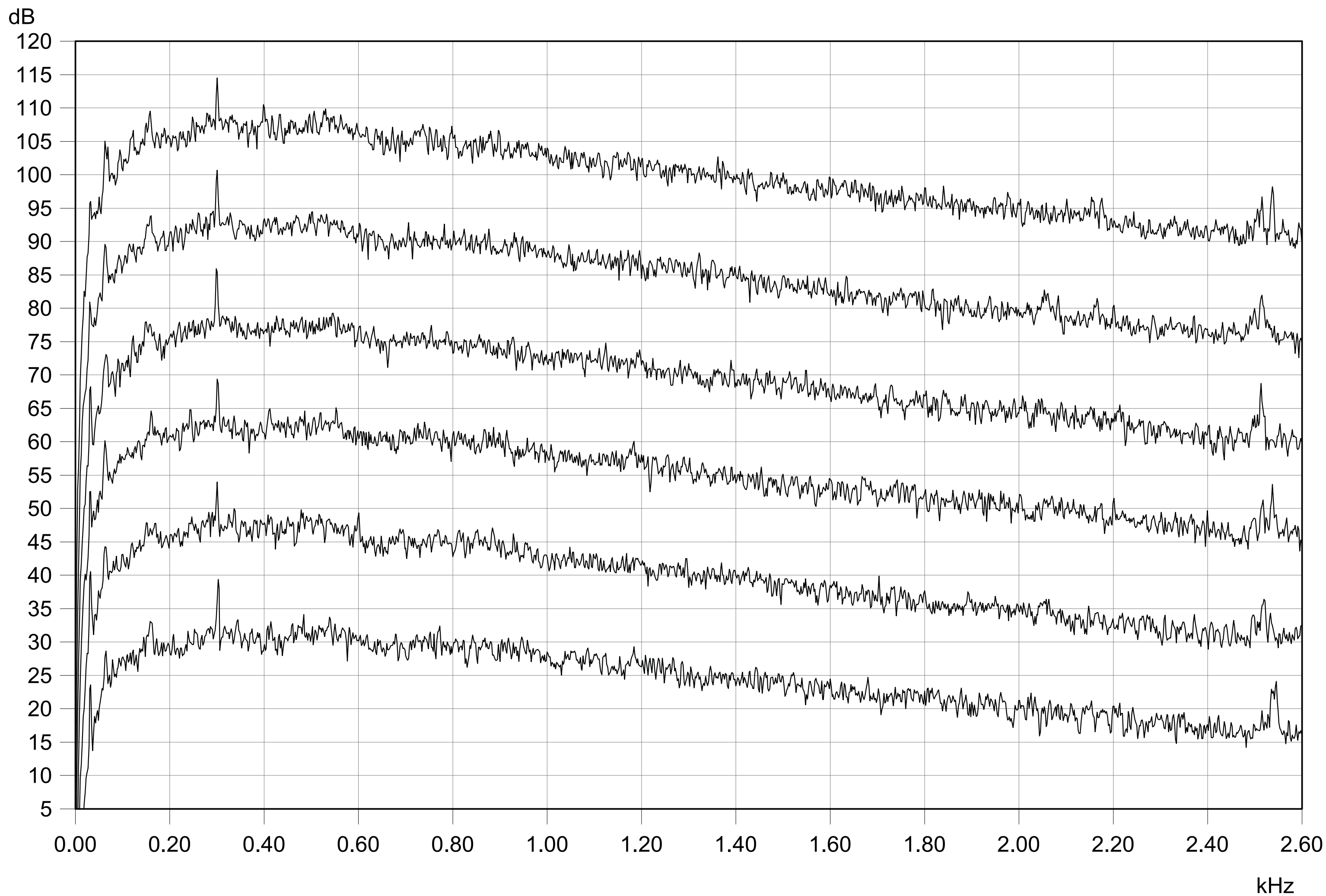
Spectra 1 – 6, at 7 m/s (upper spectra shifted by 15 dB each, no. 1 at top)



Spectra 7 – 12, at 7 m/s (upper spectra shifted by 15 dB each, no. 7 at top)



Spectra 1 – 6, at 8 m/s (upper spectra shifted by 15 dB each, no. 1 at top)



Spectra 7 – 12, at 8 m/s (upper spectra shifted by 15 dB each, no. 7 at top)