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001

ACOUSTIC NOISE MEASUREMENTS AT A LAGERWEY LW18/80 WIND TURBINE NEAR SLOOTDORP

J.J.D. van Dam
P.W. Vink

AUGUST 1999

Abstract

At request of Lagerwey Windturbine b.v. acoustic noise measurements have been carried out at the LW18/80 wind turbine at Mr. A. de Zwart's property near Slootdorp. The measurements have been performed to determine the sound power level in compliance with the IEC-standard. The results are presented as a function of wind speed.

Principal:
Lagerwey Windturbine BV
P.O. Box 279
3770 AG Barneveld
the Netherlands

ECN projectnumber:
8.41050

ECN is registered as a Sterlab, under number L324, for Acoustic Noise Measurements according to IEC 61400-11 (Final Draft)

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1. INTRODUCTION

At request of Lagerwey Windturbine b.v. acoustic noise measurements have been carried out at the LW18/80 located at Mr. De Zwart's property, Schelpenbolweg 26 in Slootdorp, The Netherlands, on March 11, 1999. The measurements have been performed to determine the apparent sound power level in compliance with the current IEC standard (ref. [1]). The measurement results are documented in this report. The results are only valid for the tested turbine with the settings at the date of the measurements.

2. WIND TURBINE

The tested wind turbine is constructed by Lagerwey Windturbine b.v. Its type identification is LW18/80. The wind turbine has a two blade rotor with a diameter of 18 meter and operates upwind with a variable speed. At the time of the measurements the blades were equipped with a serrated trailing edge near the tip, over a length of approximately 2 meters, see Figure 3. The hub height is 40 m. More wind turbine data can be found in Appendix 1.

Since the turbine can be operated at a number of variable settings such as rotational speed range, the data in appendix 1 are supplemented with indicative measurements of the wind speed on the nacelle, the electric output power and the rotor speed. These were read from the display of the PLC and are momentary values. The measurements have been carried out on 11 March 1999 between 15:00 and 18:00.

3. SITE

The turbine is located on the property of Mr. de Zwart. On the south-west side of the turbine the farm house is located. On the north-west and eastern side of the turbine flat farmland is located. At the time of the measurements the farmland on the east side contained some small vegetation (<10 cm). The land at the western side contained no vegetation. A map of the site is given in Figure 1 and Figure 2. Photographs of the test site are given in Figure 4.

4. INSTRUMENTS

An overview of the used instruments is given below.

Instrument	Make and type	Serial nr	Remark
Microphone	B&K, 4176	1072780	
Windscreen	B&K 90 mm		half sphere
Pre-amplifier	B&K, 2669	1888893	
Amplifier	B&K, 5935L	1920972	
Groundboard			wood, D = 1 m, th = 18 mm
Acoustical calibrator	B&K, 4231	1771109	
Anemometer + Vane	Lambrecht, 99.14512.908734	562029.0075	
Meteo-mast			h = 10 m
Air pressure + temp.	Lambrecht, precision	90970	
DAT recorder	TEAC, RD-130TE	512777	
Analyser	B&K, 2133	1407166	

The relevant calibration sheets can be found in appendix 2. At the time of the measurement the calibration interval of the microphone, the pre-amplifier and the acoustical calibrator were expired with two days. Immediately after the measurements these instruments were re-calibrated and no deviations were found.
The calibration sheet of the amplifier included in Appendix 2 shows that the instrument was found to be out of specifications and needed adjustment. This concerns the polarisation voltage, which is not used during the measurements and thus has no influence on the measurement results.

5. MEASUREMENTS AND RESULTS

5.1 General

The acoustic measurements have been carried out at a horizontal distance of 49 m from the rotor plane in the downwind direction. Measurements have been performed with the turbine parked (background measurement) and with the turbine in operation. Additionally calibration measurements have been performed with the microphone in the acoustical calibrator. The acoustic signal has been recorded with the DAT recorder, together with the clock-time.
At a distance of 36 meter a mast was placed with an anemometer and wind vane. This mast has a height of 10 meter. The signal of the anemometer was simultaneously recorded on DAT tape with the acoustic signal.
During the measurements the air temperature and pressure have been written down manually. The temperature and pressure were 10°C and 1020 hPa respectively.
For an indication of the turbine's behaviour during the measurements, the wind speed on the nacelle, the electric power and the rotational speed were read from the display of the PLC and written down. These data can be found in Appendix 2.
After the measurements were performed the 1-minute averaged sound pressure levels have been determined using the analyser at ECN in Petten.
In Petten the recorded signal from the anemometer was analysed using a data acquisition PC, giving the one-minute averaged values of the wind speed. The turbulence intensity of the wind speed is given in Figure 5.

5.2 Apparent sound power

The background sound level, measured as a function of the wind speed at hub height, is given in figure 6. The sound level measured during turbine operation is given in figure 7, with and without the background correction. The wind speed data have been converted to the wind speed at reference conditions ($h = 10$ m, $z_0 = 0.05$ m) and the background corrected sound levels are converted to the apparent sound power levels. The results are given in figure 8.
During the measurements the wind speed was below 8 m/s under reference conditions. The 1-minute period that resulted in the measurement point closest to 7.5 m/s and closest to the interpolated sound power of 91.8 dB(A) has been used to determine the 1/3 octave band spectrum of the sound pressure at the measurement position. This spectrum has been corrected for the background spectrum, measured as close as possible to the target wind speed and the resulting spectrum has been normalised to 91.8 dB(A). The resulting spectrum is presented in figure 9 and in table 1, both in 1/3 and in 1/1-octave bands.

The 1/24 octave spectrum of the 1-minute period closest to the wind speed under reference conditions of 7.5 m/s and closest to the regression line is presented in Figure 10. A peak is present in the spectrum at the frequency of 404 Hz.

Table 1: Sound power spectrum at a wind speed of 7.5 m/s at reference conditions (h =10 m, z_0 = 0.05)

Frequency (Hz)	Level [dB(A)]	
	1/3 octave	1/1 octave
25	42.0	52.9
31.5	45.8	
40	51.5	
50	53.5	64.4
63	58.6	
80	62.6	
100	64.4	71.6
125	63.5	
160	69.8	
200	69.7	76.9
250	71.8	
315	73.9	
400	81.7	84.8
500	79.3	
630	78.5	
800	80.4	87.2
1000	83.0	
1250	83.3	
1600	83.8	87.2
2000	82.1	
2500	80.1	
3150	77.3	87.0
4000	76.0	
5000	73.9	
6300	66.8	67.4
8000	58.3	
10000	49.5	

6. UNCERTAINTY ESTIMATION

The uncertainty of the apparent sound power level at a wind speed at reference conditions of 7.5 m/s has been estimated in compliance with ref. [1], annex D.4.
The type A uncertainty has been determined using formula D.1. This resulted in a type A uncertainty of 0.67 dB(A). The type B uncertainties 1 through 8 are taken identically to table D.1 and the type B uncertainty due to the background correction is taken equal to the correction itself, 0.9 dB(A). This results in a type B uncertainty of 1.16 dB(A)
In this way the combined uncertainty of the apparent sound power level at a wind speed at reference conditions of 7.5 m/s is estimated as 1.34 dB(A).
The uncertainty in the wind speed dependence of the sound power level is estimated as follows. Since most Type B uncertainties (as mentioned in Table D.1 of ref.[1]) are independent of wind speed it is assumed that the Type A uncertainty is much larger then the Type B uncertainty. The uncertainty is therefor estimated to be equal to the Type A uncertainty, the type A uncertainty is calculated as 0.13 dB(A)/m/s.

7. DEVIATIONS FROM THE IEC-STANDARD

7.1 Wind speed

The target wind speed for the apparent sound power level is 8 m/s under reference conditions. To determine this sound power level at least 25% of the data points has to be at a wind speed above 8 m/s. During these measurements the wind speed under reference conditions did not exceed the 8 m/s, thus the apparent sound power level has been determined at a wind speed of 7.5 m/s under reference conditions.

8. SUMMARY OF THE RESULTS

On 11 March 1999, the LW18/80 wind turbine had the following acoustic characteristics:

- Apparent sound power level at reference conditions (h = 10 m, z_0 = 0.05 m) wind speed of 7.5 m/s is 91.8 dB(A) with a standard uncertainty of 1.34 dB(A).
- The corresponding apparent sound power spectrum is given in table 1.
- The sound power level as function of the wind speed at reference conditions (h = 10 m, z_0 = 0.05 m) is given in figure 8.

9. FIGURES

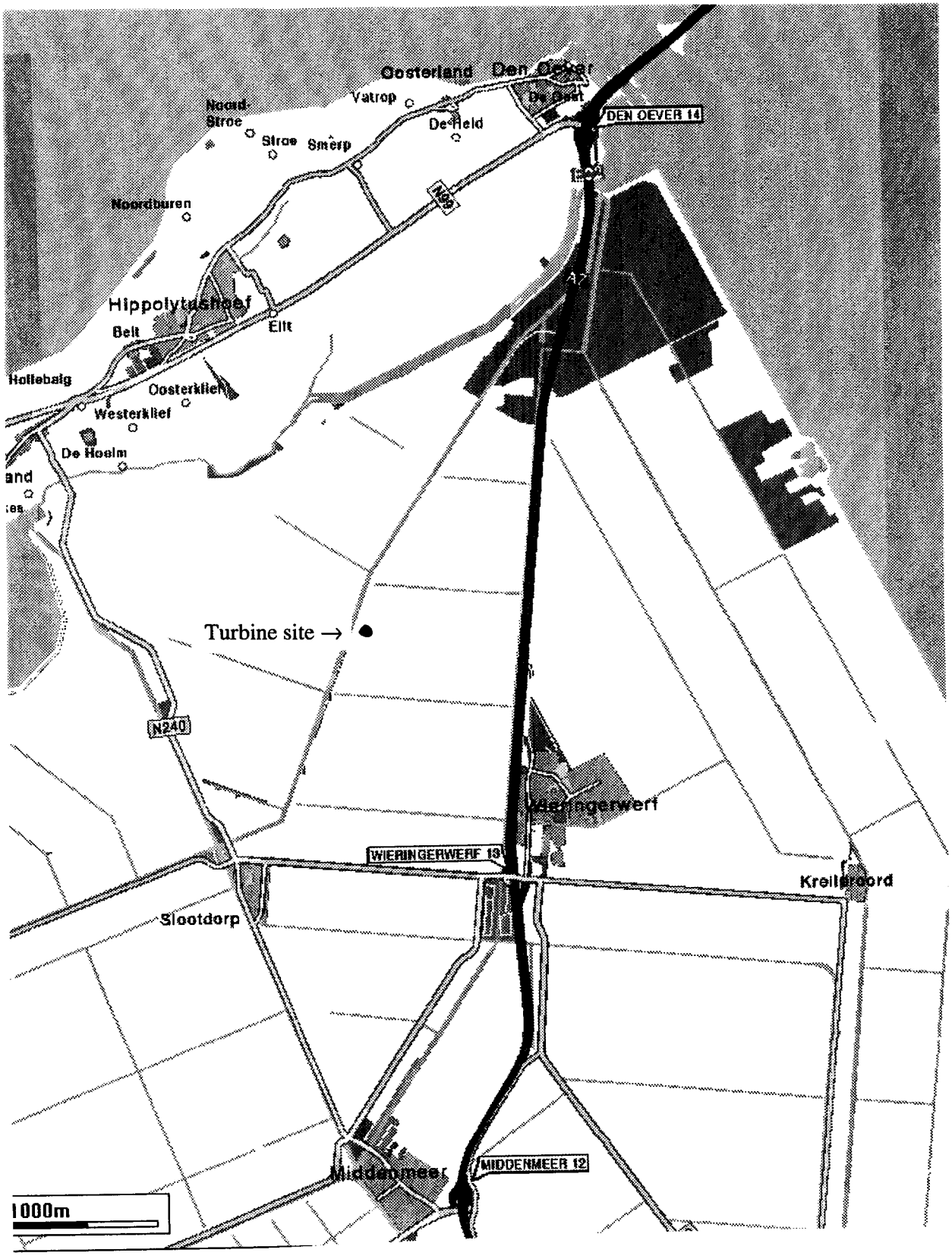

Figure 1: Turbine location

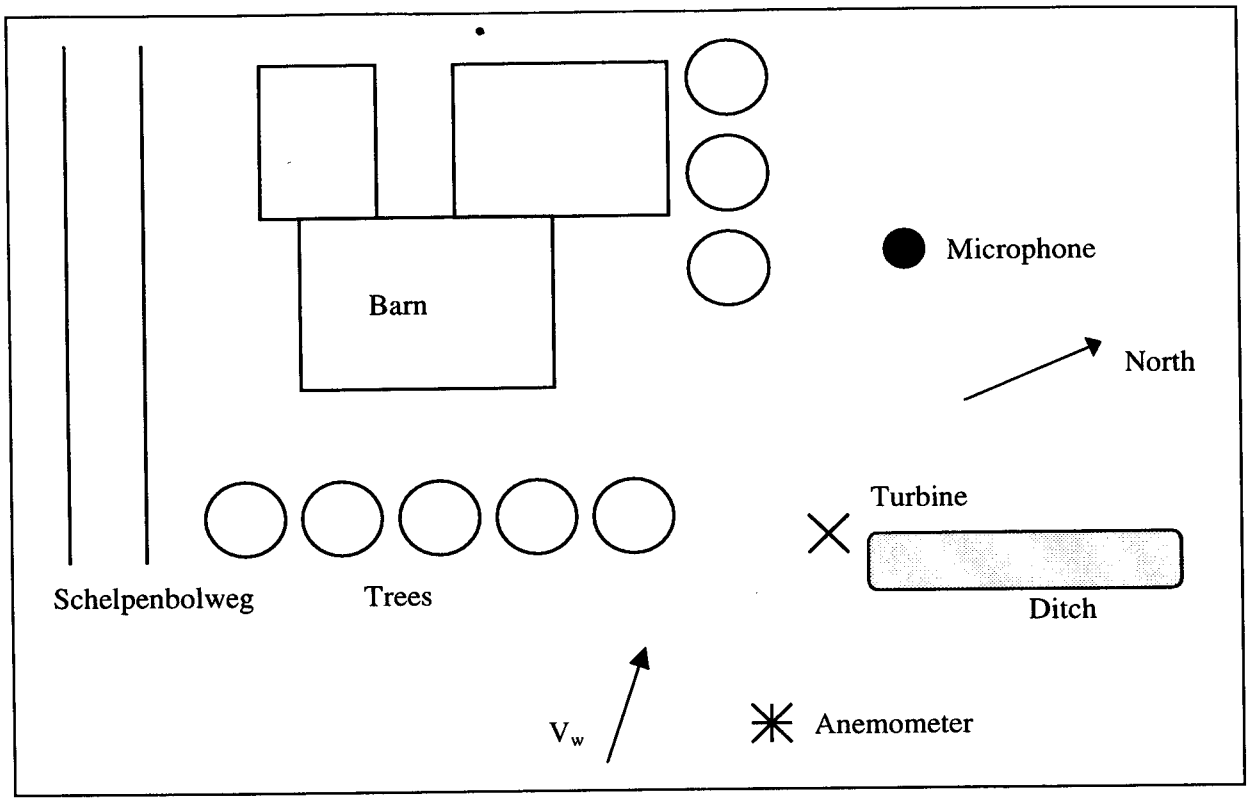

Figure 2: Detailed sketch of the measurement location (not to scale).



Figure 3: Photograph of the serrated trailing edge

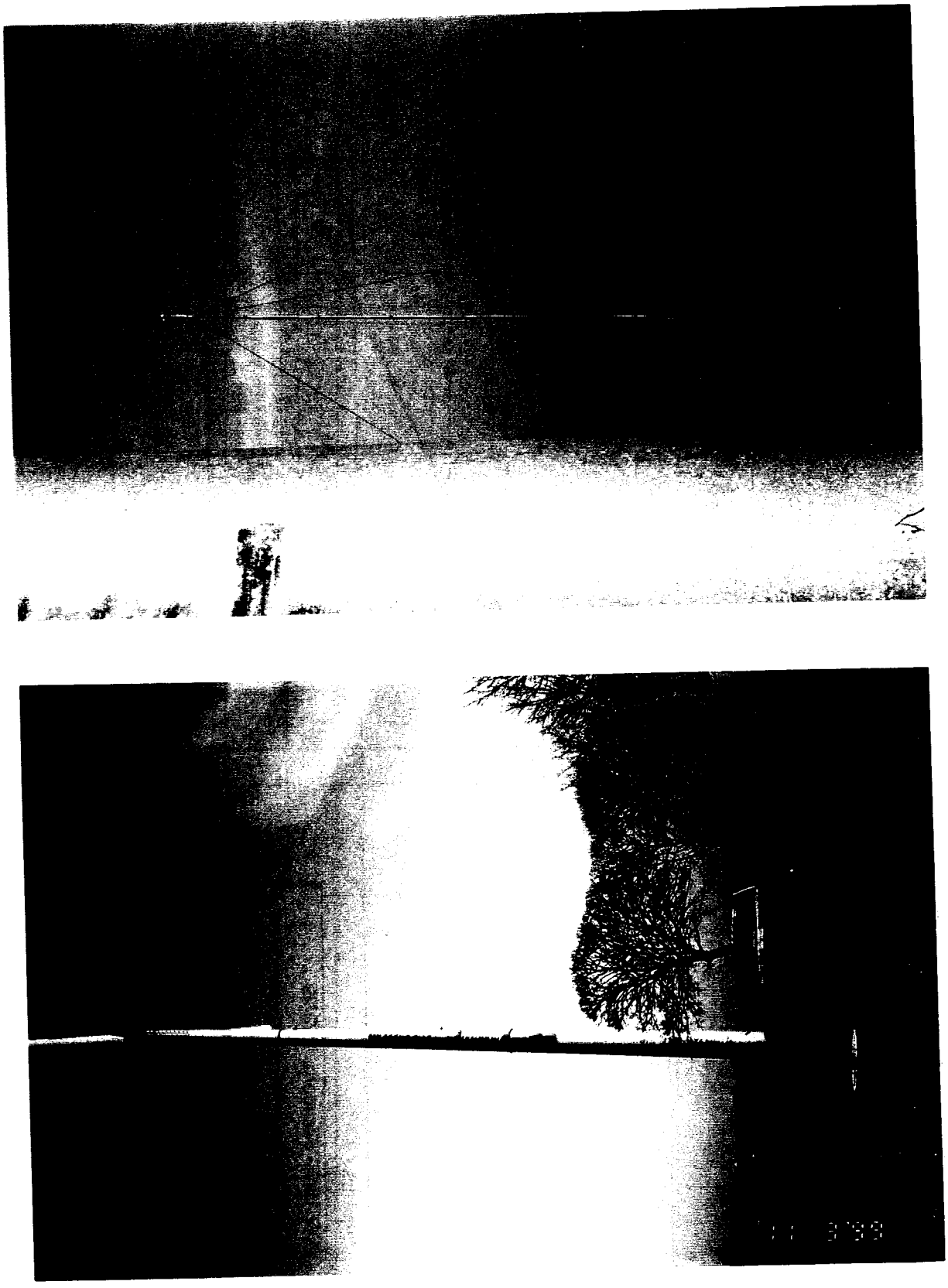

Figure 4: Photographs of the test site

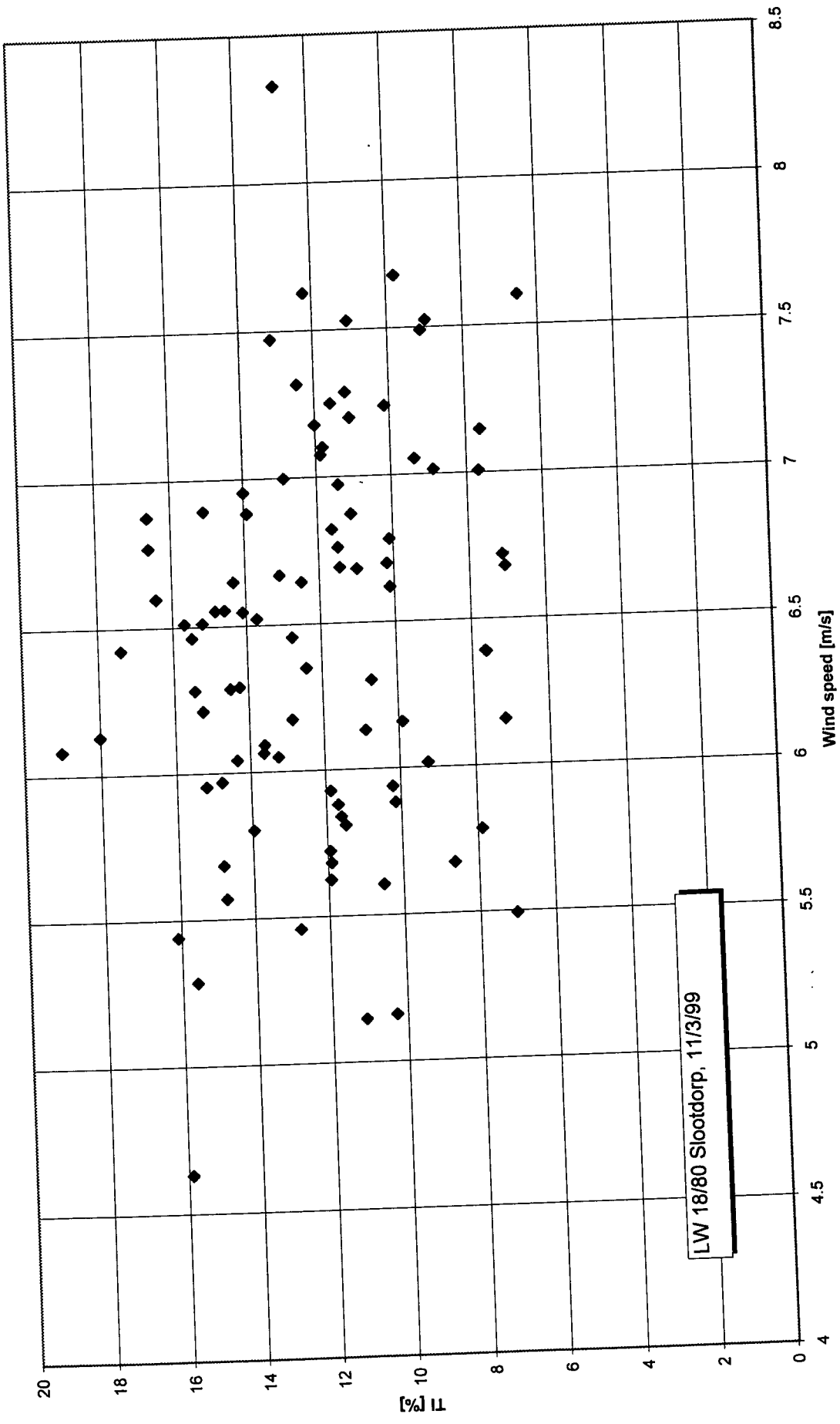

Figure 5: Measured turbulence intensity, 1-minute averaged values

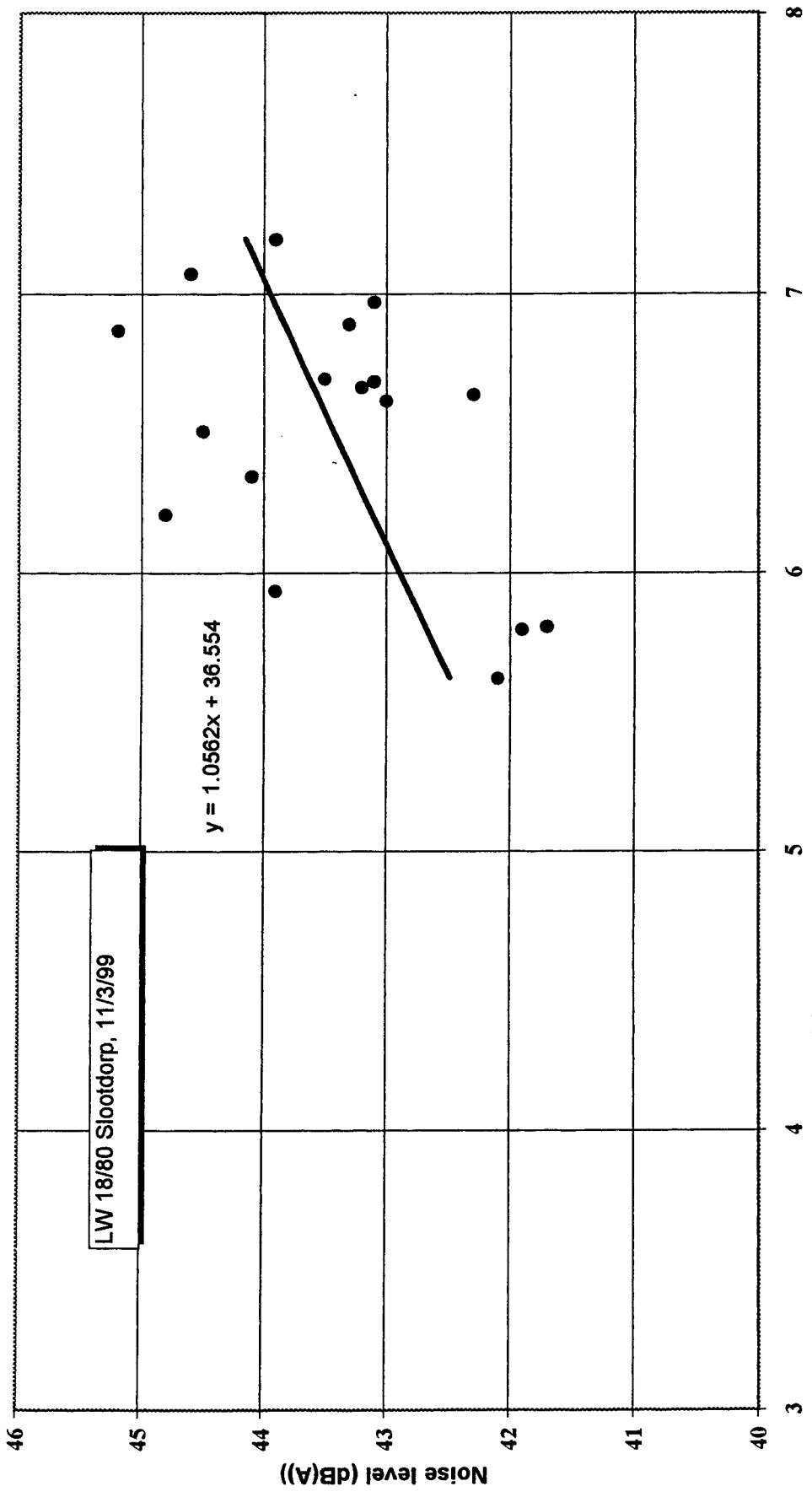

Figure 6: Background noise level as a function of wind speed at 10m heigth, 1-minute averaged values

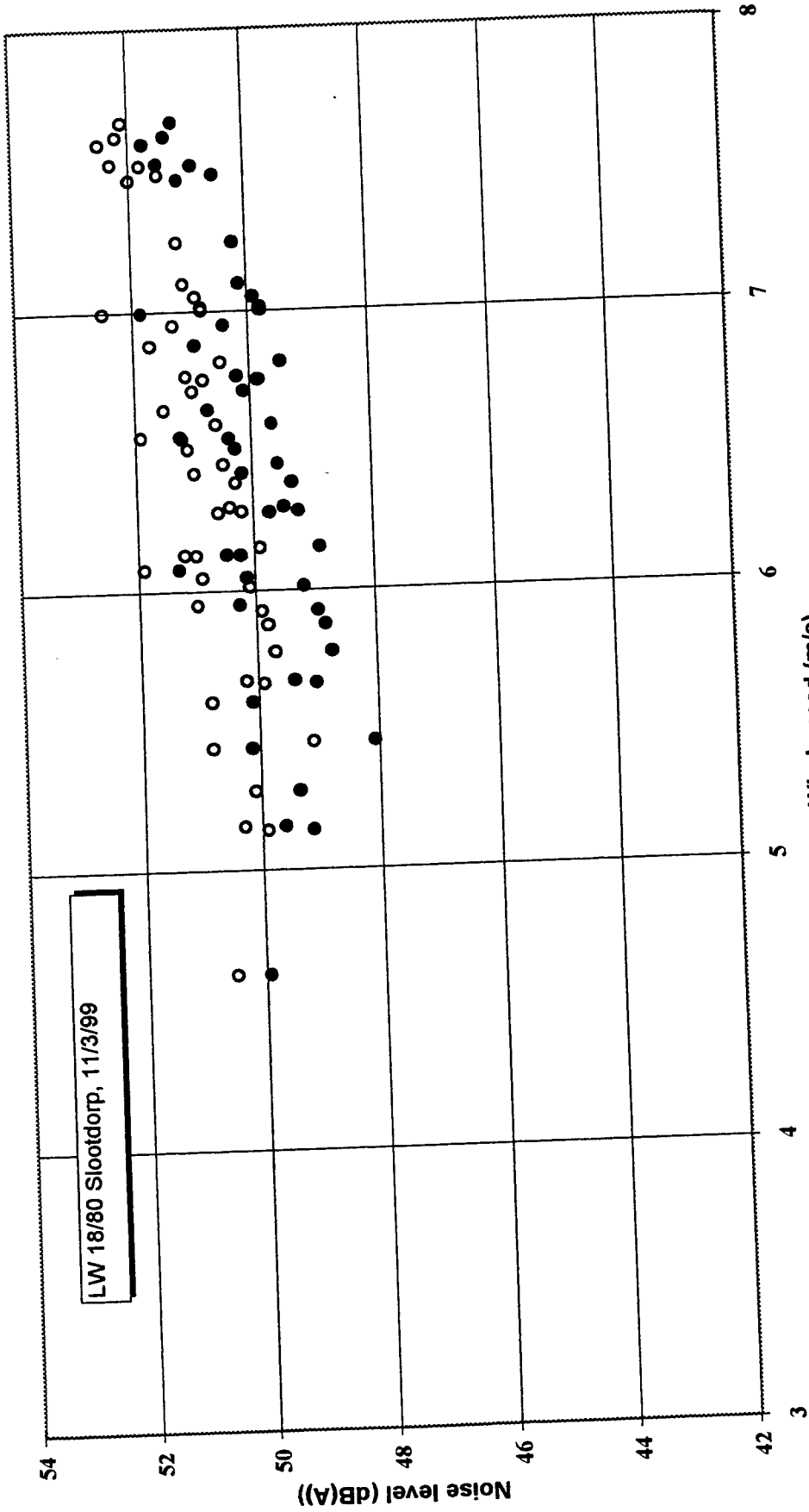

Figure 7: Wind turbine noise level as a function of the wind speed at 10m heigth.
(Filled markers excl. background, open markers incl. background)

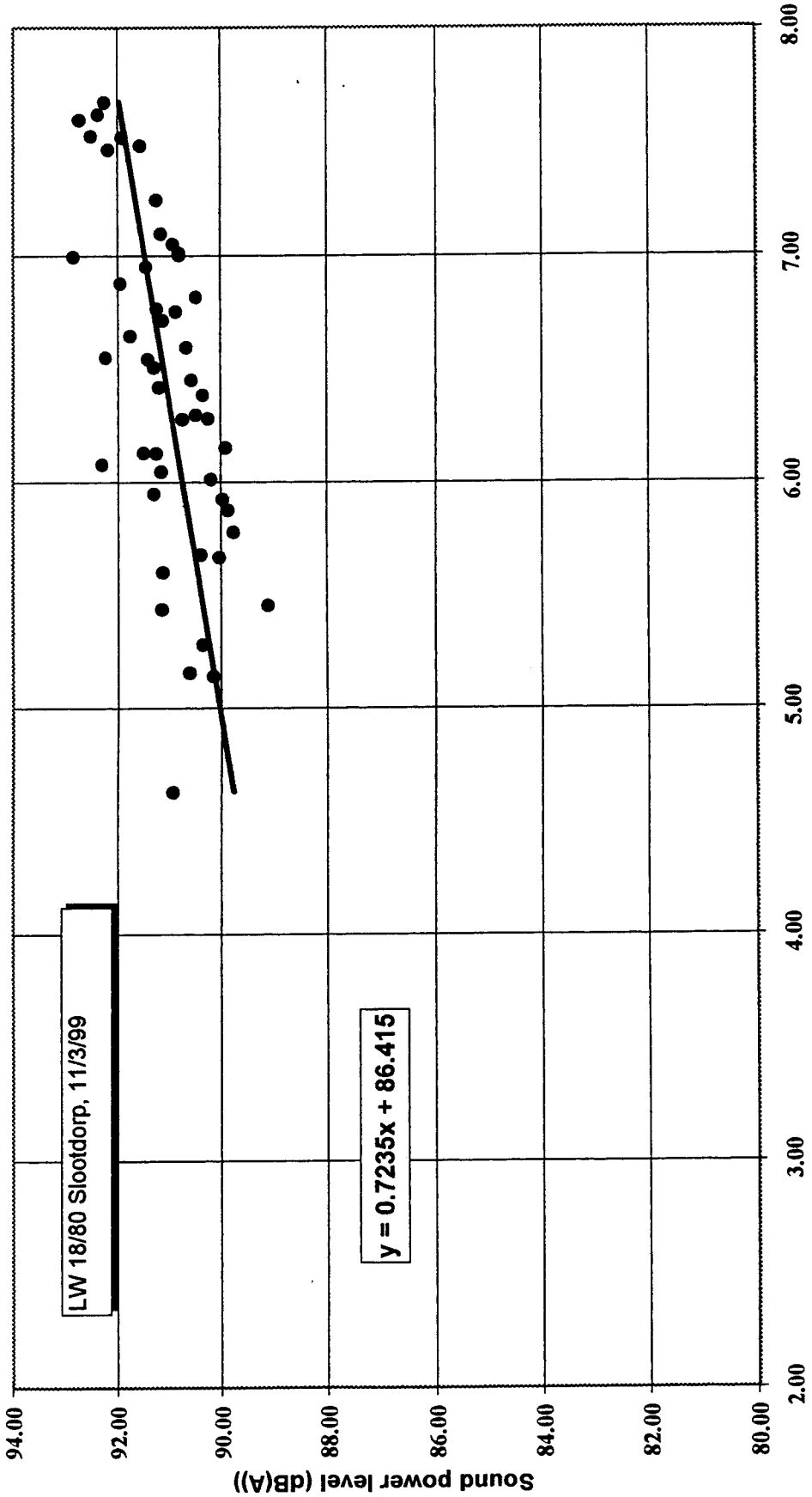

Figure 8: Sound power level as a function of the wind speed at reference conditions

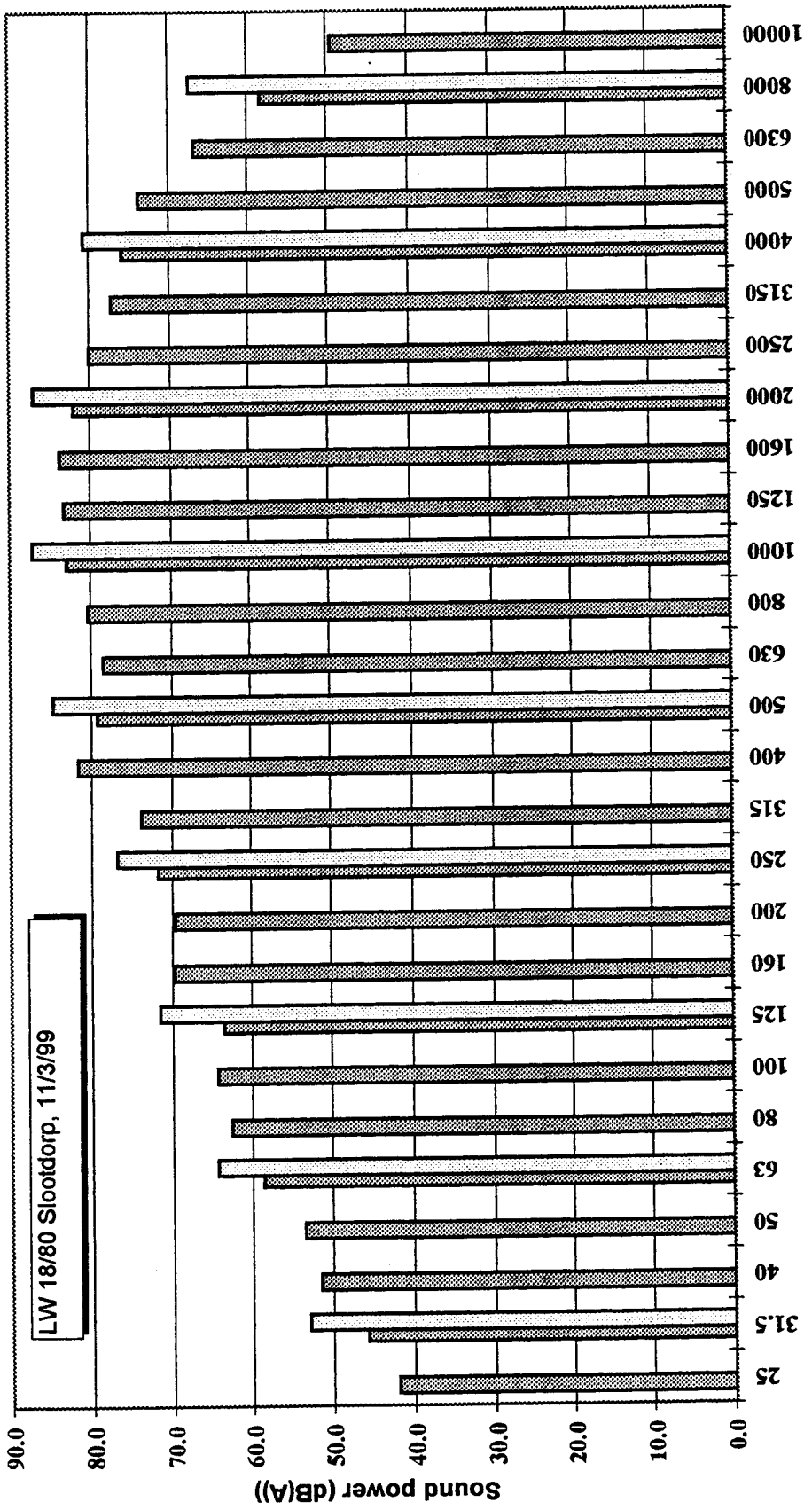

Figure 9: Sound power spectrum in 1/1 and 1/3 octave bands at a wind speed of 7.5 m/s at reference conditions (h= 10m , z_0=0.05)

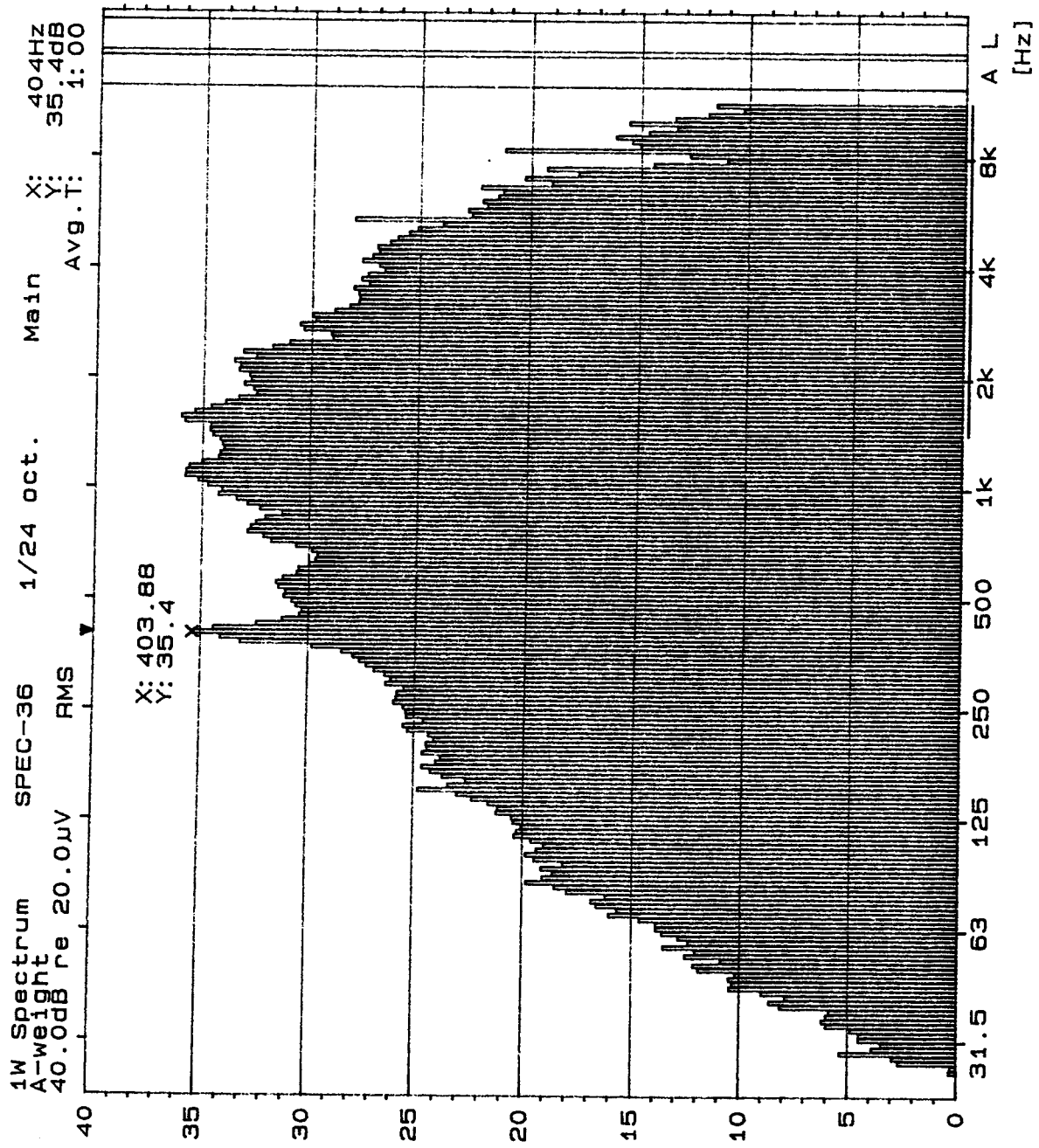

Figure 10: Narrow band spectrum at a reference wind speed of 7.5 m/s

10. REFERENCES

[1] IEC 61400-11 standard: Wind turbine generator systems-Part 11: Acoustic noise measurement techniques (DIS-1998-01)

APPENDIX 1: TECHNICAL DESCRIPTION TURBINE

TECHNICAL DESCRIPTION OF THE TESTED WIND TURBINE
(MANUFACTURERS DECLARATION FOR ACOUSTIC NOISE MEASUREMENTS)

Owner : Mr. A. de Zwart
Schelpenholweg 26
1774 NE Slootdorp

TURBINE

• Manufacturer : Lagerwey Windturbine BV		
• Type	: LW18/80	
• Serial number	: 480 (nacelle number)	
• Rated power	: 80	kW
• Rated wind speed	: 13	m/s

BLADES

• Manufacturer	: ATV	
• Type	: 18/80	
• # blades	: number 800 and 810	
• Pitch angle	: 1.3 degr. at tip	

CONTROL

• Power control	: Pitch	
• Pitch control	: variable	
• Software version	: LW80.03 µP	

ROTOR

• Configuration	: Horizontal axis	
• Orientation	: Upwind	
• Diameter	: 18	m
• Rotor centre height	: 40	m
• Rated RPM	: 110	rpm
• Horizontal distance from rotorcentre to tower axis	: 2,35	m
• Rotor control devices	: springs + dampers	

GENERATOR(S)

• Manufacturer	: ABB	
• Type	: M2CA280SA4V2	
• Rated power	: 80	kW
• Nominal RPM	: 2200	rpm

GEARBOX

• Manufacturer	: Flender	
• Type	: SZNK 1225 R	

TOWER

• Tower height	: 40	
• Construction type	: tubular	

Signature turbine manufacturer :

Date : 24 Jun. 99

Manufacturers stamp :

Lagerwey Windturbine BV
Postbus 278 8070 AG Bunneveld
Tel.: 0342 - 422424
Fax: 0342 - 428361

APPENDIX 2: TURBINE BEHAVIOUR

The data given below was read from the display of the PLC and are momentary values. Wind speed is on top of the nacelle.

V [m/s]	rotor speed [rpm]	Power [kW]
5	59	11
6	60	13
4	59	9
7	61	19
8	62	21
7	61	16
7	64	29
8	62	18
6	59	19
6	62	17
7	62	21
5	62	16
8	63	21
6	64	25
7	63	23
9	65	38
10	64	30
8	64	32
7	62	25
6	60	13
8	62	27
10	65	32
9	64	32
8	64	31
7	63	20
6	61	21

V [m/s]	rotor speed [rpm]	Power [kW]
7	62	26
7	63	26
9	65	33
9	65	25
8	61	22
6	61	20
8	63	24
7	62	20
6	61	20
6	61	19
8	62	27
5	61	20
8	63	27
7	61	15
6	60	17
8	64	37
9	66	35
7	62	18
4	56	7
6	64	24
7	62	27
9	65	33
6	60	15
9	65	28
6	61	20
9	63	26

APPENDIX 3: CALIBRATION SHEETS OF USED INSTRUMENTS

Notitie aan: Erwin Werkhoven

Kopie voor: Toine Curvers en Peter Vink

Betreft: Verifikatie DAT-recorder DEGL0167

Van: Nico van der Borg

Datum: 14 april 1998

Op 10 april 1998 heb ik de DAT-recorder DEGL0167 geverifieerd op de juiste werking. De werkwijze daarvoor sluit aan bij het KVOV30 (zie bijlage). Aanvullende details betreffende de werkwijze zijn hieronder weergegeven alsmede de resultaten van de verificatie.

Werkwijze:

1. Opname

Met de DAT-recorder is een aantal malen gedurende 1 minuut rose ruis opgenomen. Het ruis-signaal is verkregen uit de akoestische analysator DEGL0132. De gekozen signaalsterkte hiervan was (in dB's t.o.v. de referentie in de analysator): -6, -36 en -60. De gevoeligheid van de DAT-kanalen was ingesteld op 2 V, overeenkomend met het bereik dat toegepast wordt voor geluidmetingen. De bovengenoemde signaalsterkte van -6 dB t.o.v. de analysator referentie gaf een uitsturing van de DAT-recorder van ongeveer -5 dB (zichtbaar op de LED-jes). Bij de lagere signaalniveau's werd de DAT dus bedreven op ongeveer -35 dB en -59 dB t.o.v. de volledige uitsturing. Het spectrum van de opgenomen signalen is bij elk experiment gelijktijdig aan het opnemen geanalyseerd met de akoestische analysator DEGL0132 waarbij de inputgevoeligheid aangepast is aan de signaalsterkte. Het gelijktijdig opnemen en analyseren van het signaal is gedaan door "gelijktijdig" de recorder en de analyser te starten met hun startknoppen. Het verschil in gelijktijdigheid wordt ingeschat op 1 of 2 seconden. Enkele opnames zijn gedaan op de DAT-kanalen 1 en 2 met de standaard tape-snelheid (overeenkomend met een nominaal frequentiebereik van 20 kHz per kanaal) en enkele opnames zijn gedaan op de DAT-kanalen 1 t/m 8 met de standaard tape-snelheid (overeenkomend met een nominaal frequentiebereik van 5 kHz per kanaal). Een overzicht van de opnames is gegeven in de tabel.

serie	signaalsterkte (dB tov analyser)	Kanalen	analyser gevoeligheid	Uitsturing DAT (dB tov max)
6	-6	1 t/m 8	3 V	ca -5
7	-36	1 t/m 8	80 mV	ca -35
8	-6	1 en 2	3 V	ca -5
9	-36	1 en 2	80 mV	ca -35
10	-60	1 en 2	6 mV	ca -59

2. Weergave

De opgenomen signalen zijn weergegeven met dezelfde DAT-recorder en de signalen zijn per kanaal afzonderlijk geanalyseerd met dezelfde analysator met dezelfde gevoeligheid als vermeld in de tabel. Ook bij de weergave is geprobeerd zo precies mogelijk dezelfde tijdsperioden van 1 minuut te analyseren en naar schatting is ook hierbij een onzekerheid opgetreden van 1 of 2 seconden. De spectra van de weergegeven signalen zijn verminderd (in dB's) met de spectra van de bijbehorende inputsignalen. De resultaten zijn voor de verschillende opnameseries en voor de verschillende kanalen gegeven in de figuren. **In de bovenste lijn van elk figuur staat de kode van de meting (bv S06CH01 = serie 6, kanaal 1).** De frequentie-karakteristiek van de DAT-recorder is volgens de specificaties +0.5 dB tot -1 dB over de frequentiebereiken van 20 kHz (2 kanalen) en 5 kHz (8 kanalen). De resultaten laten zien dat hieraan voldaan wordt bij DAT-uitsturingen van ca -5 en ca -35 dB. Bij de uitsturing van ca -59 dB wijken enkele 1/12 oktaafbanden af tot 1 à 2 dB.

Conclusie.

De DAT-recorder functioneert volgens specifaties mits de signaalniveau's voldoende hoog zijn (meer dan -35 dB t.o.v. de ingestelde DAT-gevoeligheid).

MdBoer

Goedgekeurd

instrumentbeheerder.
20-4-'99.

[NLR] APROPOS DATA-SYSTEM Wed Apr 29 11:10:09 1998 PROC. 11

MEASURED: 20 04 1998 COMPUTED: 29 04 1998 <11:10:07> VERSION: C04

volgnr : 141

KALIBRATIERAPPORT : A9801

ECN
Lambrecht anemometer
DEWS 0230

Luchttemperatuur : 281.3 [K]
Luchtdruk : 100814 [Pa]

C0 = .533404E+00
C1 = .935153E-01

V0 = Vcalc + afw
Vcalc = C0 + C1*Anemo

MC	V0 [m/s]	Anemo [---]	Vcalc [m/s]	afw [m/s]
1	1.921	15.900	2.020	-.099
2	3.968	36.300	3.928	.040
3	6.029	59.400	6.088	-.060
4	8.316	83.100	8.305	.012
5	10.264	104.100	10.268	-.005
6	12.209	124.900	12.213	-.004
7	14.165	145.600	14.149	.016
8	16.116	166.000	16.057	.059
9	18.074	187.400	18.058	.015
10	20.041	208.900	20.069	-.028
11	22.010	230.200	22.061	-.050
12	23.986	251.300	24.034	-.048
13	25.015	261.900	25.025	-.010
14	23.046	240.600	23.033	.013
15	21.070	219.800	21.088	-.018
16	19.036	197.500	19.003	.033
17	17.014	175.700	16.964	.050
18	14.826	152.900	14.832	-.005
19	13.053	133.900	13.055	-.002
20	11.047	112.400	11.045	.003
21	9.053	90.700	9.015	.037
22	7.066	69.500	7.033	.034
23	5.017	47.400	4.966	.051
24	3.129	28.100	3.161	-.032
MC	V0	Anemo	Vcalc	afw



Brüel & Kjær Benelux

Certificate of Conformance

Type no.	: 2669	ENERGIEONDERZOEKCENTRUM NEDERLAND DUURZAME ENERGIE WINDLAB E.WERKHOVEN ID. NR. DEST0008
Serial no.	: 1888893	
Description	: Preamplifier	
Customer name	: Energieonderzoek Centrum Nederland - Petten	
Certificate no	: 23816-3	

At the time of calibration, this certifies that the above product was calibrated in accordance with applicable Brüel & Kjær procedures.

At planned intervals Brüel & Kjær measurement standards are calibrated traceable to international standards, natural physical constants or consensus standards.

The initial test found your instrument WITHIN-SPECIFICATION.

No adjustment and/or repair was necessary to ensure performance to published operating specifications.

Supporting documentation relative to traceability is on file and is available for examination upon request.

The recommended calibration interval is 12 months and the calibration due date based on this interval is 09-03-1999.

Remarks or special requirements:

Calibration date: 09-03-1998.

Calibration Manager: T.J.A. Kouwenhoven

Performed by: MB

Brüel & Kjær Benelux
Postbus 1205
3430 BE NIEUWEGEIN NEDERLAND
Telefoon 030-6039994 Telefax 030-6041894

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Reproduction of the entire certificate is allowed. Parts of the certificate may only be reproduced after written authority.

Brüel & Kjær Benelux
Certificate of Conformance

Type no.	:	2669
Serial no.	:	1888893
Description	:	Preamplifier
Customer name	:	ECN Zon & Windlab
Certificate no.	:	25237-1
Customer ID	:	

At the time of calibration, this certifies that the above product was calibrated in accordance with applicable Brüel & Kjær procedures.

At planned intervals Brüel & Kjær measurement standards are calibrated traceable to international standards, natural physical constants or consensus standards.

The initial test found your instrument WITHIN-SPECIFICATION.

No adjustment and / or repair was necessary to ensure performance to published operating specifications.

Supporting documentation relative to traceability is on file and is available for examination on request.

The recommended calibration interval is 12 months and the calibration due date based on this interval is 01-04-2000.

Remarks or special requirements:

Calibration date: 01-04-1999

Calibration Manager:

T.Oskam

Performed by:

KD

Brüel & Kjær Benelux
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Certificate of Conformance

Type no.	:	4176
Serial no.	:	1072780
Description	:	Prepolarized Condenser Microphone Cartridge
Customer name	:	ECN Zon & Windlab
Certificate no.	:	25237-2
Customer ID	:	

At the time of calibration, this certifies that the above product was calibrated in accordance with applicable Brüel & Kjær procedures.

At planned intervals Brüel & Kjær measurement standards are calibrated traceable to international standards, natural physical constants or consensus standards.

The initial test found your instrument WITHIN-SPECIFICATION.

No adjustment and / or repair was necessary to ensure performance to published operating specifications.

Supporting documentation relative to traceability is on file and is available for examination on request.

The recommended calibration interval is 12 months and the calibration due date based on this interval is 01-04-2000.

Remarks or special requirements:

Calibration date: 01-04-1999

Calibration Manager: Performed by:

T.Oskam KD

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Brüel & Kjær Benelux

Certificate of Conformance

ENERGIEONDERZOEKCENTRUM NEDERLAND
DUURZAME ENERGIE WINDLAB
E.WERKHOVEN
ID. NR. DEST0010

Type no.	:	4176
Serial no.	:	1072780
Description	:	Prepolarized Condenser Microphone Cartridge
Customer name	:	Energieonderzoek Centrum Nederland - Petten
Certificate no	:	23816-4

At the time of calibration, this certifies that the above product was calibrated in accordance with applicable Brüel & Kjær procedures.

At planned intervals Brüel & Kjær measurement standards are calibrated traceable to international standards, natural physical constants or consensus standards.

The initial test found your instrument WITHIN-SPECIFICATION.

No adjustment and/or repair was necessary to ensure performance to published operating specifications.

Supporting documentation relative to traceability is on file and is available for examination upon request.

The recommended calibration interval is 12 months and the calibration due date based on this interval is 09-03-1999.

Remarks or special requirements:

Calibration date: 09-03-1998.

Calibration Manager:

T.J.A. Kouwenhoven

Performed by:

MB

Brüel & Kjær Benelux
Postbus 1205
3430 BE NIEUWEGEIN NEDERLAND
Telefoon 030-6039994 Telefax 030-6041894

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Brüel & Kjær Benelux
Certificate of Conformance

Type no.	:	5935
Serial no.	:	1920972
Description	:	Dual Microphone Supply
Customer name	:	ECN-DE Duurzame Energie Windlab
Certificate no.	:	24608-1
Customer ID	:	DEGL 0202

At the time of calibration, this certifies that the above product was calibrated in accordance with applicable Brüel & Kjær procedures.

At planned intervals Brüel & Kjær measurement standards are calibrated traceable to international standards, natural physical constants or consensus standards.

The initial test found your instrument OUTSIDE-SPECIFICATION.

Adjustment and / or repair was necessary to ensure performance to published operating specifications.

Supporting documentation relative to traceability is on file and is available for examination on request.

The recommended calibration interval is 12 months and the calibration due date based on this interval is 07-10-1999.

Remarks or special requirements:

Calibration date: 07-10-1998

Calibration Manager: T.J.A. Kouwenhoven

Performed by: WS

Brüel & Kjær Benelux
Postbus 1205
3430 BE NIEUWEGEIN NEDERLAND
Telefoon 030-6039994 Telefax 030-6041894

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Brüel & Kjær Benelux

Certificate of conformance

Type no.	:	2133
Serial no.	:	1407166
Description	:	Dual Channel Real-time Frequency Analyzer
Customer name	:	Energieonderzoek Centrum Nederland - Petten
Certificate no	:	23546-1

At the time of calibration, this certifies that the above product was calibrated in accordance with applicable Brüel & Kjær procedures.

At planned intervals Brüel & Kjær measurement standards are calibrated traceable to international standards, natural physical constants or consensus standards.

The initial test found your instrument WITHIN-SPECIFICATION.

No adjustment and/or repair was necessary to ensure performance to published operating specifications.

Supporting documentation relative to traceability is on file and is available for examination upon request.

The recommended calibration interval is 12 months and the calibration due date based on this interval is 08-12-1998.

Remarks or special requirements:

Calibration date: 08-12-1997.

Calibration Manager:

T.J.A. Kouwenhoven

Performed by:

FS

Brüel & Kjær Benelux
Postbus 1205
3430 BE NIEUWEGEIN NEDERLAND
Telefoon 030-6039994 Telefax 030-6041894

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Brüel & Kjær
Spectris Benelux BV

Kalibratie Centrum

NKO Nederlandse Kalibratie Organisatie

Reg. nr. K 057

NKO-CERTIFICAAT

Pagina 1 van 1 Certificaatnummer: 108835

Aanvrager: ECN Zon & Wind Windlab

Onderzocht:

Kalibrator: 4231 No 1771109

Fabrikaat: Brüel & Kjær.

Omgevingscondities: Temperatuur 23 °C ± 1 °C
Rel. vochtigheid 32 % ± 5 %

Wijze van onderzoek:

Het onderzoek is uitgevoerd met behulp van:
Microfoon B&K 4180, Adaptor B&K UC 0210,
Akoestische Kalibrator B&K 4226 ser.nr. 1476102
Voltmeter Datron 1281 ser.nr. 18663-3

Resultaat: Ok

Geluiddrukniveau	94,1 dB
Frequentie	0999,9 Hz
Vervorming	0,3 %

De kalibrator is getoetst aan de eisen zoals gespecificeerd in IEC 942 klasse 1. Met B&K procedure CHKP423x Versie 2.12.98.
De onzekerheden van de gebruikte referenties en meetmethoden zijn gedeponeerd bij de RvA en op aanvraag verkrijgbaar.

Herleidbaarheid is ten overstaan van de RvA aangetoond.

Datum onderzoek: 20.4.1999 Datum certificaat: 20.4.1999

Uitgevoerd door

WS

Plettenburg 7 3439 LW Nieuwegein
Postbus 1205 3430 BE Nieuwegein
Tel. (030) 6039994 Fax (030) 6041894

Dit certificaat wordt verstrekt onder het voorbehoud dat noch de NKO, noch Spectris Benelux BV enigerlei aansprakelijkheid aanvaardt. Reproductie van het volledige certificaat is toegestaan. Gedeelten van het certificaat mogen slechts worden gereproduceerd na verkregen toestemming van Spectris Benelux BV

DEST 0010

Brüel & Kjær B K
Spectris Benelux BV

Kalibratie Centrum

NKO Nederlandse Kalibratie Organisatie

Reg. nr. K 057

NKO-CERTIFICAAT

Pagina 1 van 1 Certificaatnummer: 107460

Aanvrager: ENERGIEONDERZOEK CENTRUM NEDERLAND - PETTEN
DUURZAME ENERGIE WINDLAB
E.WERKHOVEN

Onderzocht: ID. NR. DEGL 0436

Kalibrator: 4231 No 1771109

Fabrikaat: Brüel & Kjær.

Omgevingscondities:

Temperatuur	21 °C	± 1 °C
Rel. vochtigheid	35 %	± 5 %

Wijze van onderzoek:

Het onderzoek is uitgevoerd met behulp van:
Drukmicrofoon B&K 4134 en
Multifunctionele Akoestische Kalibrator B&K 4226.

Resultaat: Ok

Geluiddrukniveau	94,1 dB
Frequentie	0999,9 Hz
Vervorming	0,3 %

De kalibrator is getoetst aan de eisen zoals gespecificeerd in IEC 942 klasse 1.
De onzekerheden van de gebruikte referenties en meetmethoden zijn gedeponeerd bij de NKO en op aanvraag verkrijgbaar.

Herleidbaarheid is ten overstaan van de NKO aangetoond.

Datum certificaat: 9.3.1998 Datum onderzoek: 9.3.1998

Uitgevoerd door

MB

Plettenburg 7 3439 LW Nieuwegein
Postbus 1205 3430 BE Nieuwegein
Tel. (030) 6039994 Fax (030) 6041894

Dit certificaat wordt verstrekt onder het voorbehoud dat noch de NKO, noch Spectris Benelux BV enigerlei aansprakelijkheid aanvaardt. Reproductie van het volledige certificaat is toegestaan. Gedeelten van het certificaat mogen slechts worden gereproduceerd na verkregen toestemming van Spectris Benelux BV.

	Date: August 1999	Number of report: ECN-CX—99-044
Title	Acoustic noise measurements at a Lagerwey LW 18/80 wind turbine near Slootdorp	
Author(s)	J.J.D. van Dam, P.W. Vink	
Principal(s)	Lagerwey Windturbine B.V.	
ECN project number **Principal's order number**	8.41050 Fax dd.11-03-'99 Ref. TW990350	
Programme(s)	n.a.	

Abstract

At request of Lagerwey Windturbine b.v. acoustic noise measurements have been carried out at the LW18/80 wind turbine at Mr. A. de Zwart's property near Slootdorp. The measurements have been performed to determine the sound power level in compliance with the IEC-standard. The results are presented as a function of wind speed.

The determined apparent sound power level at a wind speed of 7.5 m/s at reference conditions (h = 10 m, z_0 = 0.05 m) is 91.8 dB(A) with a standard uncertainty of 1.34 dB(A).

Key words Acoustics, Wind turbine, measurements, sound power level.

Authorization	Name	Signature	Date
Checked	A.P.W.M. Curvers		5-8-99
Approved	L.G.J. Janssen		5-8-'99
Authorized	H.J.M. Beurskens		5/8