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**BWEA Acoustic Performance Test
of a QR5 v2.0 Wind Turbine
for MCS Certification**

A Report for

Quiet Revolution Ltd

Reference No: QUR006

**Report No: 2013/197
Issue 1**

Date: May 2013



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BWEA Power Performance Test of a QR5 v2.0 Wind Turbine for MCS Certification

A report for

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Approved by: Lynn Hunter



For
Michael Valente
Managing Director
Date: May 2013

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1 INTRODUCTION

Quiet Revolution Ltd is seeking certification for the QR5 v2.0 wind turbine under the UK MCS Scheme. This report presents the results of the acoustic performance test, which was carried out in accordance with the BWEA Small Wind Turbine Performance and Safety Standard.

2 APPLICABLE STANDARDS AND REFERENCE DOCUMENTS

Except where noted, the execution of the acoustic performance measurements and analysis of relevant data were undertaken in compliance with the following standards and related documents:

- MCS006:Issue 1.5 – Product certification scheme requirements: micro and small wind turbines
- BWEA small wind turbine performance and safety standard dated 29 February 2008
- IEC 61400-11: 2002 (incorporating Amendment No. 1) Wind turbine generator systems – Part 11: Acoustic noise measurement techniques
- IEC TS 61400-14:2005 Wind turbine generator systems – Part 14: Declaration of apparent sound power level and tonality values
- ISO 1996-2:2007 Acoustic – Description, Measurement and Assessment of Environmental Noise – Part 2: Determination of Environmental Noise Levels

3 TEST WIND TURBINE CONFIGURATION

The QR5 v2.0 is a vertical axis wind turbine with a rotor comprising three helical blades with two integral spoked hubs. The test turbine was installed and then commissioned by Quiet Revolution at NEL's Myres Hill test site on 23 October 2012.

A summary of the wind turbine system configuration is presented in Table 1. The test results presented in this report are applicable only to the wind turbine system configuration described in Table 1.

4 DESCRIPTION OF TEST SITE

NEL's Myres Hill wind turbine test site is located in high moorland within the Whitelee Forest area above Eaglesham, south of Glasgow, and is centred at Ordnance Survey grid reference NS 568 467.

5 DESCRIPTION OF MEASUREMENT EQUIPMENT

Table 2 lists the measurement instrumentation used in the acoustic performance tests. Calibration certificates are given in the Appendix.

6 ACOUSTIC PERFORMANCE MEASUREMENTS

Audible noise measurements were undertaken at Myres Hill test site on 4 April 2013, and covered a wind speed range of 4.2 to 10.9 m/s.

6.1 Measurement Procedure

A photograph showing the test arrangement is shown in Figure 1.

In order to isolate the controller noise from the turbine and represent a realistic installation where the controller would not be located in such close proximity to the turbine, at the request of Quiet Revolution, for the purpose of tests the control cabinet was housed within an acoustic damper. A photograph of the acoustic damper is shown in Figure 2.

A cup anemometer was mounted on a 10 m high mast located 10 m upwind of the turbine. Noise measurements were made using a microphone located at the centre of a 1 m diameter ground-mounted board located 32.2 m downwind from the turbine. A wind vane monitored the direction of the wind.

Wind speed and directional data were sampled at a frequency of 1 Hz and stored as 20 second averages. Noise was recorded in 10-second periods and subsequently processed into averages for 20-second periods.

Simultaneous noise and wind speed measurements were made with the turbine running and then, as part of the same measurement session, with it parked. Data were filtered to remove data points where either the noise board position was outwith the valid sector ($\pm 60^\circ$ relative to the wind direction) or the anemometer mast position was not in the valid sector ($\pm 90^\circ$ upwind of the turbine for an anemometer mounted at hub).

Filtering was also performed to discard data where there had been interference due to extraneous noise events (e.g. passing aircraft).

6.2 Acoustic Performance Results

Figure 3 shows the audible noise data, as a function of wind speed, from the measurement session with the turbine running and also for the turbine parked (i.e. background levels).

6.3 Declared Noise Levels

The key results of the regression analysis of noise data are shown in Figure 3 as red lines for the sound pressure levels. These are the background-corrected values with an uncertainty component added (1.645σ), as per the requirements of IEC TS 61400-14:2005. In effect, these are guaranteed levels in which there is a 95 % confidence level that they will not be exceeded on the acoustically-reflective board. These guaranteed levels at the board are used to derive the declared levels and other parameters shown in Table 3.

The overall uncertainty of the measurement has been calculated using the approach described in IEC 61400-11:2002 Annex D to include not only the uncertainty of the individual regressions but also a wider range of parameters that may have affected the measurement accuracy. The combined uncertainty is given in Table 3.

A noise immission map (Noise Label) is presented in Figure 4.

6.4 Tonal Analysis

The 1/3rd octave spectra of each individual 10 s measurement were analysed for the presence of tones using the 1/3rd octave spectra method in Annex D of ISO 1996-2:2007. Figures 5 and 6 show examples of spectra at the cut-in wind speed and at 8 m/s, respectively. There was no evidence of any tones.

The upper graphs in the Figure 5 and 6 shows the measured sound pressure at each 1/3rd octave band centre frequency whereas the lower graphs show the measured sound pressure levels normalised to the total dB(A).

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- 2 Measurement Instrumentation used in Acoustic Tests
- 3 Derived Noise Emission and Noise Immission Levels for a wind speed of 8 m/s at Rotor Centre Height

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- 2 Photograph of the Acoustic Damper
- 3 Audible Noise (as Measured at the Ground Board) as a Function of Wind Speed
- 4 Noise Immission Map (Noise Label) for the Quiet Revolution QR5 v2.0 Wind Turbine
- 5 Example of the Measured and Normalised Spectra at Cut-in Wind Speed
- 6 Example of the Measured and Normalised Spectra at a Wind Speed of 8 m/s

TABLE 1 TEST WIND TURBINE CONFIGURATION

Turbine Manufacturer	Quiet Revolution Ltd
Turbine Type	QR5 v2.0
Turbine Serial No.	SN200
Year of Production	2012
Rotor Diameter (m) – manufacturer's data	3.1
Rated Rotor Speed (r/min) – manufacturer data	240 at rated power
Rated Power (kW) – manufacturer's data	4
Wind Speed at Rated Power (m/s)	11
Blade Manufacturer	Quiet Revolution Ltd
Blade Type	Helical (VAWT)
Blade Serial Nos.	as per Turbine s/n
Number of Blades	Three
Blade Pitch (i.e. fixed or variable)	Fixed
Blade Pitch Angle/Range (degrees)	Not supplied
Rotor Hub Height (m)	20.6
Tower Type	Hinged two section tubular steel.
Turbine Control System	Quiet Revolution
Control Software Version	v2002
Control Hardware	Quiet Revolution
Conductor Size (mm ²)	6
Conductor Material	Copper
Conductor Type	BS5467 Steel Wire Armoured PVC Cable - 3 Phase, Neutral and Earth
Conductor Length (m)	c. 55
Connector Type	Screwed Terminals
Measured Resistance between Inverter and Load (Ω)	Not provided
Voltage Settings for Over/Under Voltage Protection (V)	264/217
Grid Voltage at Test Site (V)	234-247
Grid Frequency at Test Site (Hz)	50

TABLE 2 MEASUREMENT INSTRUMENTATION USED IN ACOUSTIC TESTS

PARAMETER	INSTRUMENT	MANUFACTURER	TYPE	SERIAL NUMBER	CALIBRATION CERTIFICATE.REF.	CALIBRATION LABORATORY
Sound Level	Microphone	Brüel & Kjær	4189	2643613	C1206004	Brüel & Kjær (UKAS 0174)
Sound Level	Handheld Analyser	Brüel & Kjær	2250	2653893	C1206004	Brüel & Kjær (UKAS 0174)
Sound Level	Calibrator	Brüel & Kjær	4231	2651818	C1205999	Brüel & Kjær (UKAS 0174)
Wind Speed	Anemometer	Vector Instruments Ltd	A100R/K	11441/CZAR	11310536 02/2013	Deutsche WindGuard (DAR DKD-K-36801)
-	Datalogger	Campbell Scientific Ltd	CR1000	6242	N/A	N/A

TABLE 3 DERIVED NOISE EMISSION AND NOISE IMMISSION LEVELS FOR A WIND SPEED OF 8 m/s AT ROTOR CENTRE HEIGHT

PARAMETER	SYMBOL	VALUE
Apparent Emission Sound Power Level (dB(A) re 10^{-12} W)	$L_{Wd,8m/s}$	86.5
Combined Uncertainty (68% confidence level) (dB)	σ	1.9
95% Confidence Limit (dB)	1.645σ	3.1
Noise Slope at 8 m/s (dB/m/s)	S_{dB}	2.38
Declared Apparent Emission Sound Power Level, (dB(A) re 10^{-12} W)	$L_{Wd,8m/s}$	90
Immission Sound Pressure Level at 60 m at 8 m/s (dB(A) re 20 μ Pa)	$L_{p,60m}$	47
Immission Sound Pressure Level at 25 m at 8 m/s (dB(A) re 20 μ Pa)	$L_{p,25m}$	54



FIGURE 1 PHOTOGRAPH SHOWING ACOUSTIC TEST ARRANGEMENT



FIGURE 2 PHOTOGRAPH OF THE ACOUSTIC DAMPER

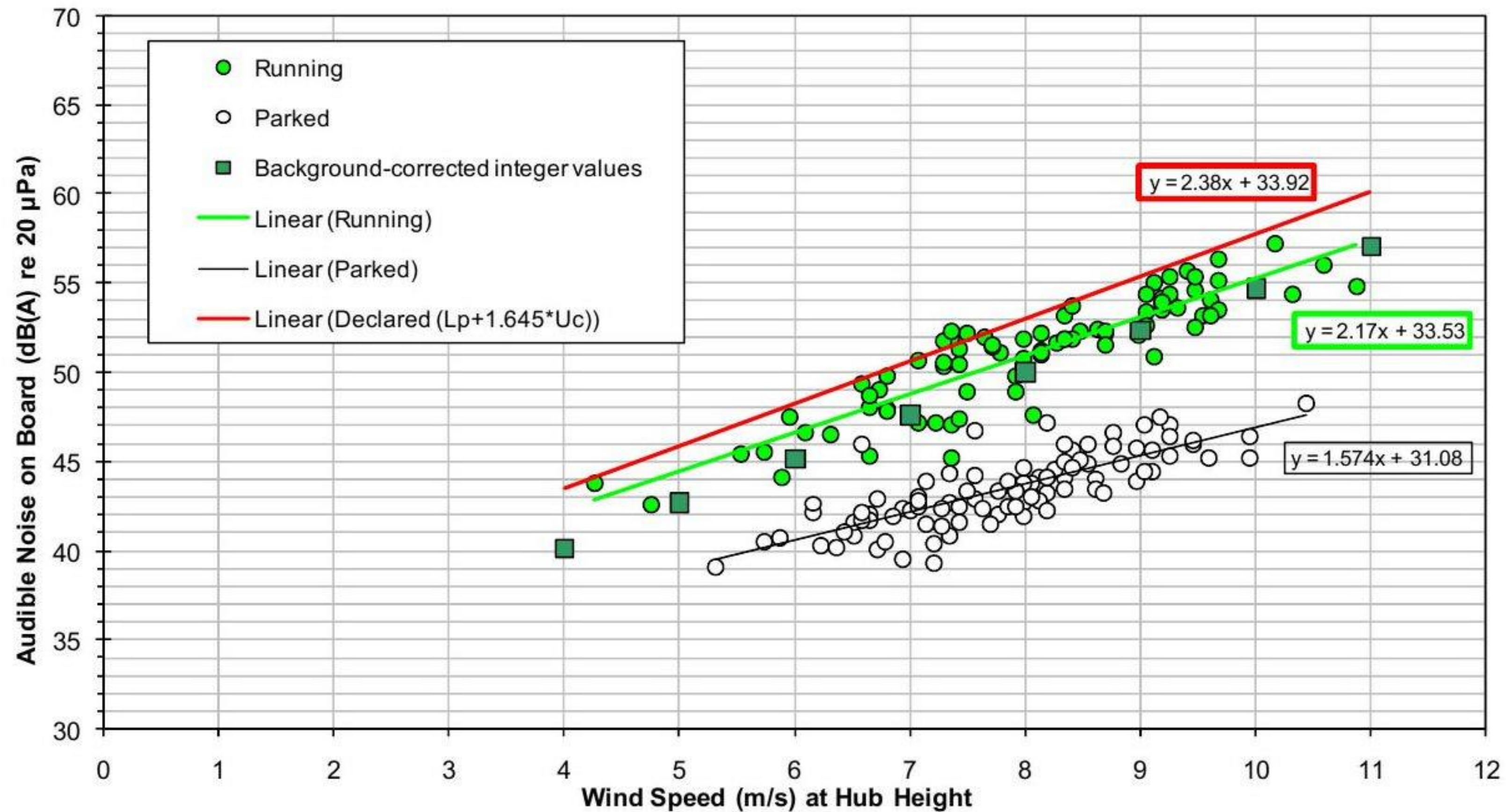


FIGURE 3 AUDIBLE NOISE (AS MEASURED AT THE GROUND BOARD) AS A FUNCTION OF WIND SPEED

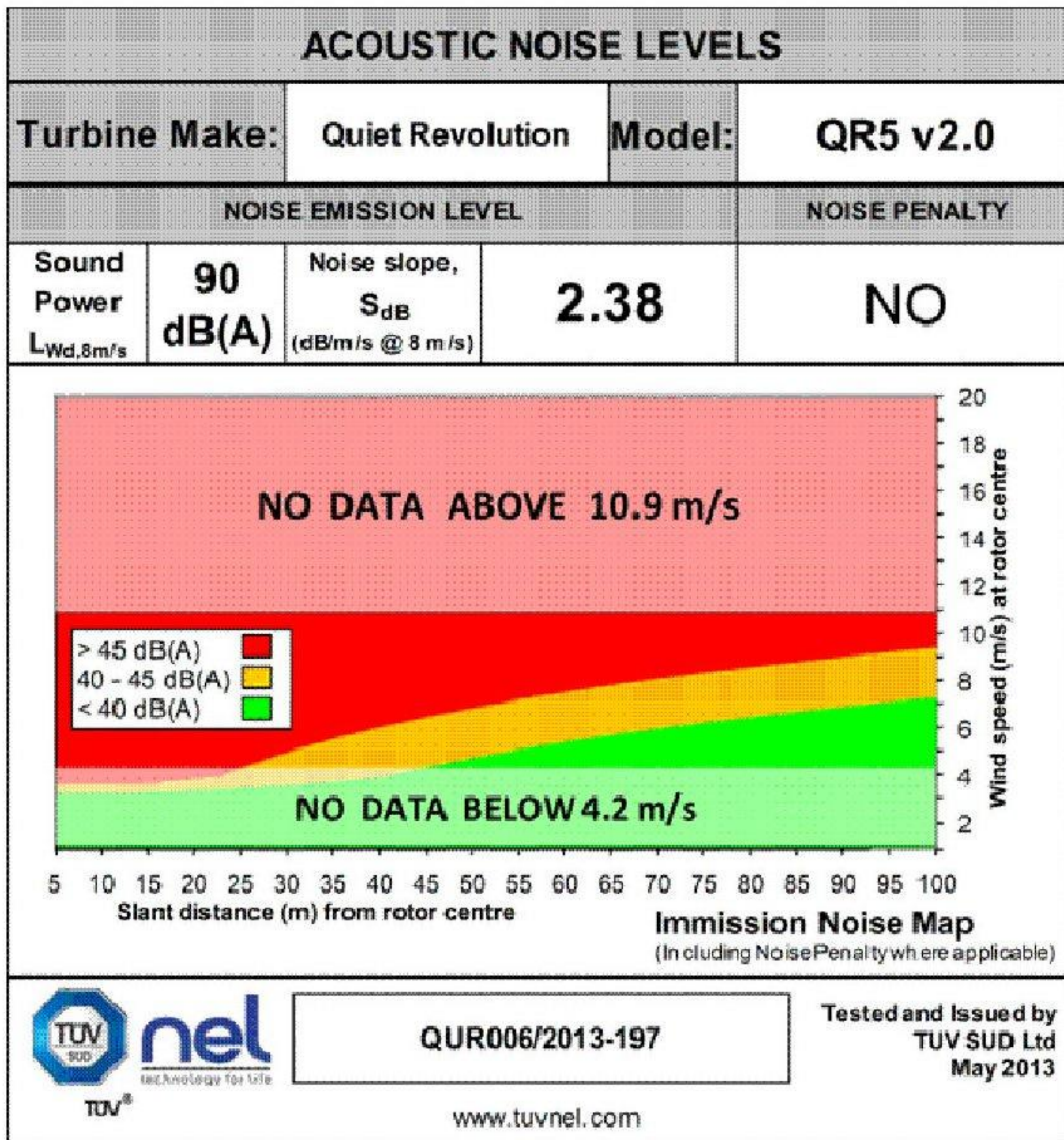


FIGURE 4 NOISE IMMISSION MAP (NOISE LABEL) FOR THE QUIET REVOLUTION QR5 V2.0 WIND TURBINE

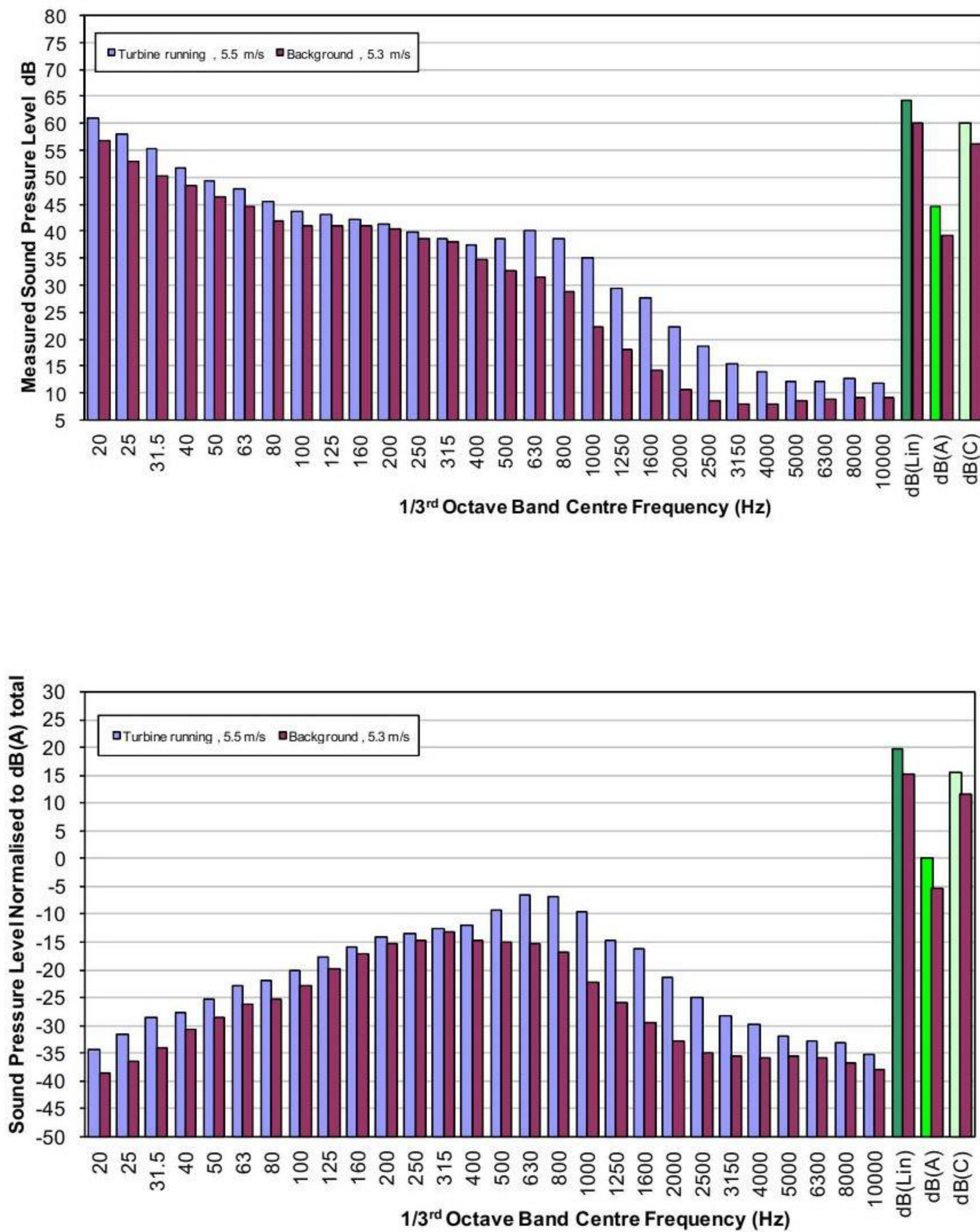


FIGURE 5 EXAMPLE OF THE MEASURED AND NORMALISED SPECTRA AT CUT-IN WIND SPEED

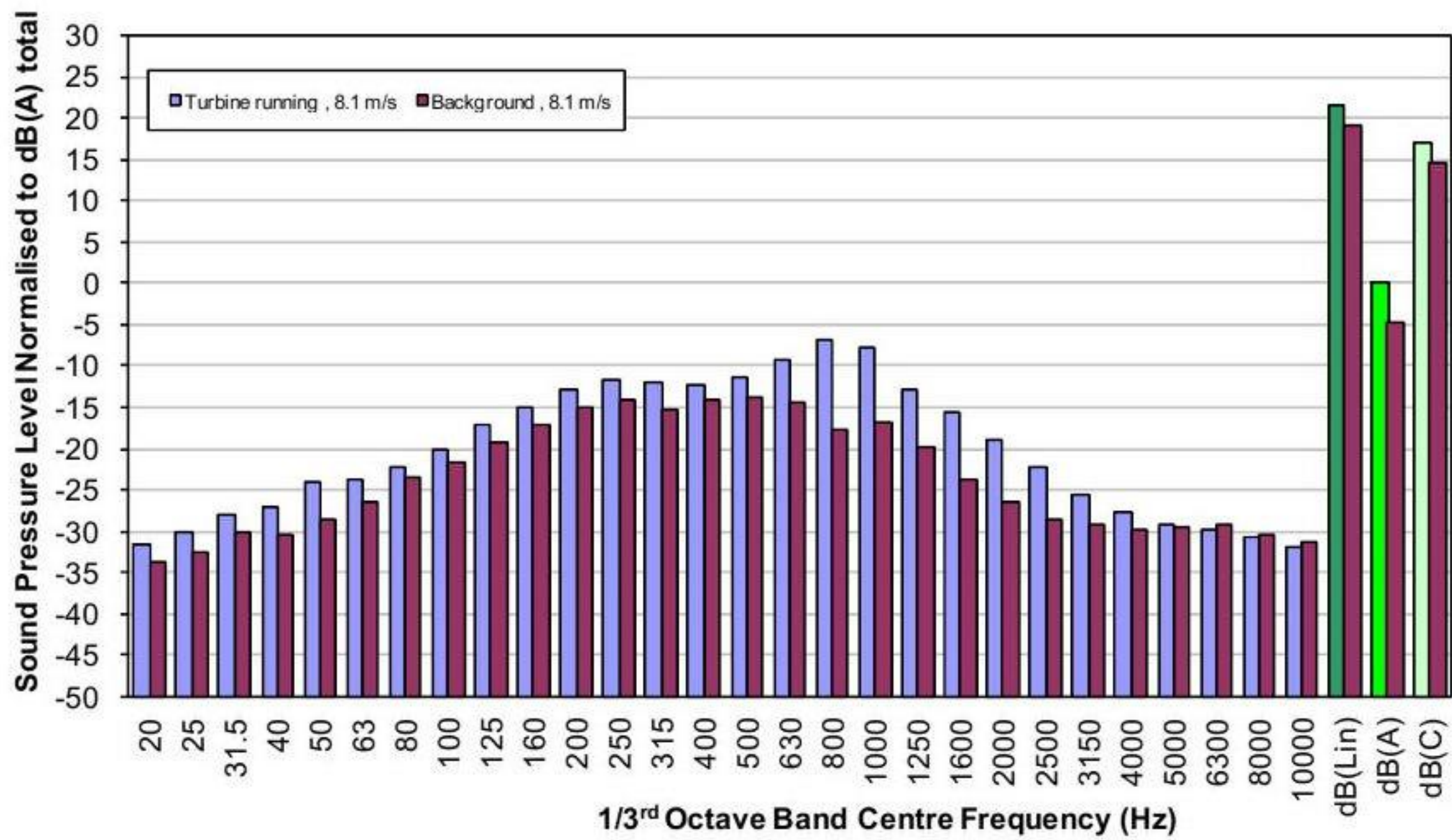
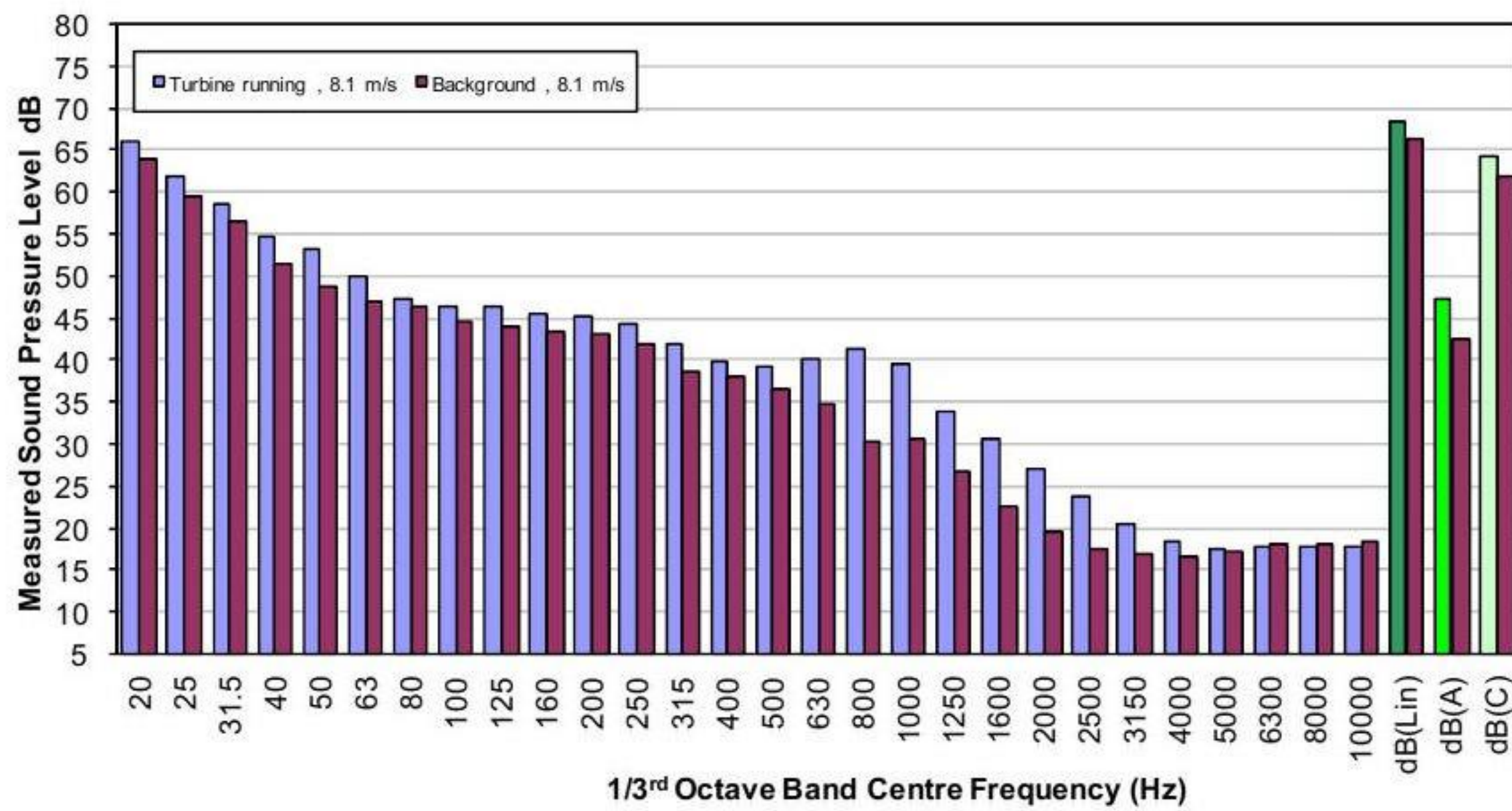


FIGURE 6 EXAMPLE OF THE MEASURED AND NORMALISED SPECTRA AT A WIND SPEED OF 8 m/s

APPENDIX
CALIBRATION CERTIFICATES



The Calibration Laboratory
Skodsborgvej 307, DK-2850 Nærum, Denmark




CERTIFICATE OF CALIBRATION

No: C1205999

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CALIBRATION OF

Calibrator: Brüel & Kjær Type 4231

No: 2651818 Id: -

1/2 Inch adaptor: Brüel & Kjær Type UC-0210

Pattern Approval: None

CUSTOMER

TUV NEL Ltd

Scottish Enterprise Technology Park

East Kilbride

G75 0QF Glasgow

United Kingdom

Measured level within
low and upper limit
Uncertainty < 0.2 dB

CALIBRATION CONDITIONS

Preconditioning: 4 hours at 23°C ± 3°C

Environment conditions: Pressure: 101.9 kPa, Humidity: 46 % RH, Temperature: 23.2 °C

SPECIFICATIONS

The Calibrator Brüel & Kjær Type 4231 has been calibrated in accordance with the requirements as specified in IEC60942-2003 Annex B Class 1. The accreditation assures the traceability to the international units system SI.

PROCEDURE

The measurements have been performed with the assistance of Brüel & Kjær acoustic calibrator calibration application software Type 7794 (version 2.4) by using procedure P_4231_D04.

RESULTS

Calibration Mode: Calibration as received.

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of calibration: 2012-08-10

Date of issue: 2012-08-10



Lene Petersen
Calibration Technician



Nils Johansen
Approved Signatory

Reproduction of the complete certificate is allowed. Parts of the certificate may only be reproduced after written permission.

CERTIFICATE OF CALIBRATION

No: C1205999

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1. Visual Inspection

OK

2. Measured Values

All stated values are valid at the following environmental reference conditions:

Pressure	101.3 kPa
Temperature	23.0 °C
Relative Humidity	50.0 %

2.1 Sound Pressure Levels

The sound pressure level is measured using the sound calibration comparison method.

Nominal Level [dB]	Accept Limit Lower [dB]	Accept Limit Upper [dB]	Measured Level [dB]	Measurement Uncertainty [dB]
94.00	93.89	94.11	93.97	0.09
114.00	113.89	114.11	113.99	0.09

2.2 Frequency

Nominal Level [Hz]	Accept Limit Lower [Hz]	Accept Limit Upper [Hz]	Measured Frequency [Hz]	Measurement Uncertainty [Hz]
1000	990.10	1009.90	999.98	0.10

2.3 Total Distortion

Distortion mode: ☒ TD ☐ THD

Calibration Level [dB]	Accept Limit [%]	Measured Distortion [%]	Measurement Uncertainty [%]
94	2.25	0.48	0.25
114	2.25	0.56	0.25

Note: Acceptance limits are reduced by measurement uncertainty to assure that measured value expanded by the actual expanded uncertainty does not exceed the specified limits as stated in the standard.

CERTIFICATE OF CALIBRATION

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3. Calibration Equipment

	Instrument	Inventory No.
Reference Sound Source	Brüel & Kjær, Type 4228	124228022
PULSE Analyzer	Brüel & Kjær, Type 3560-C	123560010
Transfer Microphone	Brüel & Kjær, Type 4192-E-001	154192013

4. Comments

The sound calibrator has been shown to conform to the class 1 requirements for periodic testing, described in Annex B of IEC 60942:2003 for the sound pressure level(s) and frequency(ies) stated, for the environmental conditions under which the tests were performed. However, as public evidence was not available, from a testing organization responsible for pattern approval, to demonstrate that the model of sound calibrator conformed to the requirements for pattern evaluation described in Annex A of IEC 60942:2003, no general statement or conclusion can be made about conformance of the sound calibrator to the requirements of IEC 60942:2003.

CERTIFICATE OF CALIBRATION

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DANAK

The Danish Accreditation and Metrology Fund - DANAK - is managing the Danish accreditation scheme based on a contract with the Danish Safety Technology Authority under the Danish Ministry of Economics and Business Affairs who is responsible for the legislation on accreditation in Denmark.

The fundamental criteria for accreditation are described in DS/EN ISO/IEC 17025: "General requirements for the competence of testing and calibration laboratories", and in DS/EN ISO/IEC 15189 "Medical laboratories - Particular requirements for quality and competence" respectively. DANAK issues guidance documents to clarify the requirements in the standards, where this is considered to be necessary. These will mainly be drawn up by the "European co-operation for Accreditation (EA)" or the "International Laboratory Accreditation Co-operation (ILAC)" with a view to obtaining uniform criteria for accreditation worldwide. In addition, the Danish Safety Technology Authority issues Technical Regulations prepared by DANAK with specific requirements for accreditation that are not contained in the standards.

In order for a laboratory to be accredited it is, among other things, required:

- that the laboratory and its personnel are free from any commercial, financial or other pressures, which might influence their impartiality;
- that the laboratory operates a documented management system, and has a management that ensures that the system is followed and maintained;
- that the laboratory has at its disposal all items of equipment, facilities and premises required for correct performance of the service that it is accredited to perform;
- that the laboratory has at its disposal personnel with technical competence and practical experience in performing the services that they are accredited to perform;
- that the laboratory has procedures for traceability and uncertainty calculations;
- that accredited testing, calibration or medical examination are performed in accordance with fully validated and documented methods;
- that accredited services are performed and reported in confidentiality with the customer and in compliance with the customer's request;
- that the laboratory keeps records which contain sufficient information to permit repetition of the accredited test, calibration or medical examination;
- that the laboratory is subject to surveillance by DANAK on a regular basis;

Reports carrying DANAK's accreditation mark are used when reporting accredited services and show that these have been performed in accordance with the rules for accreditation.

CERTIFICATE OF CALIBRATION

Date of issue: 10 August 2012
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Certificate Number: C1206004



Brüel & Kjær

The Calibration Laboratory
Skovsborgvej 307, DK-2850 Nærum, Denmark
Tel: +45 45 800 500 Fax: +45 45 801 405
Email: ukservice@bksv.com

Approved Signature

CALIBRATION OF:

Sound Level Meter:	Brüel & Kjær Type 2250	No: 2653893	Id: -
Microphone:	Brüel & Kjær Type 4189	No: 2643613	
Associated Calibrator:	Brüel & Kjær Type 4231	No: 2651818	
Calibrator Certificate:	C1205999	Calibrator Level:	93.97 dB SPL
SLM Software Version:	BZ7224 Version 2.4		

Date of calibration: 10 August 2012

CUSTOMER:

TUV NEL Ltd
Scottish Enterprise Technology Park
East Kilbride
G75 0QF Glasgow
United Kingdom

Customer Ref: Service Contract

CALIBRATION CONDITIONS:

Preconditioning: 12 hours at 23°C ± 3°C
Environment conditions: Air Temperature: 23.0 °C, Air Pressure: 101.9 kPa, Relative Humidity: 46.0 %RH

SPECIFICATIONS:

The Sound Level Meter Brüel & Kjær Type 2250 has been calibrated in accordance with the requirements as specified in BS7580: Part 1: 1997.

PROCEDURE:

The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System 3630 with application software type 7763 (version 4.7 - DB: 4.60) by using procedure 2250-4189.

RESULTS:

Unless otherwise stated herein, the reported uncertainty is based upon a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with DANAK requirements. The uncertainties refer to the measured values only with no account being taken of the ability of the device under test to maintain its calibration.

Note: Calibration as received.

This certificate is issued in accordance with the laboratory accreditation requirements of DANAK, it provides traceability of measurement to recognised national standards, and to units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full, except with the prior written consent of the issuing laboratory.

CERTIFICATE OF CALIBRATION

Certificate Number:
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1. Calibration Note

As a type approval of 2250 using UA1404/4189-90 protection grid does not exist the Laboratory has calibrated the Sound Level Meter as a standard 2250 i.e. the microphone protection grid has been changed to the original DB3420 during calibration.

2. Summary

4.1. Preliminary Inspection (5.3)	Passed
4.2. Setting up (5.4)	Passed
4.3. General (5.5.1)	Passed
4.4. Self-generated noise (5.5.2)	Passed
4.5. Linearity, reference range SPL (5.5.3)	Passed
4.6. Linearity, reference range Leq (5.5.3)	Passed
4.7. Frequency weighting A (5.5.4)	Passed
4.8. Frequency weighting C (5.5.4)	Passed
4.9. Frequency weighting Lin (5.5.4)	Passed
4.10. Time weighting Fast (5.5.5)	Passed
4.11. Time weighting Slow (5.5.5)	Passed
4.12. Peak response (5.5.6)	Passed
4.13. R.M.S. accuracy (5.5.7)	Passed
4.14. Time weighting 1 (5.5.8)	Passed
4.15. Time averaging (5.5.9)	Passed
4.16. Pulse range and sound exposure level (5.5.10 and 5.5.11)	Passed
4.17. Overload indication, Non-integrating (5.5.12)	Passed
4.18. Overload indication, Integrating (5.5.12)	Passed
4.19. Acoustic calibration at 1000 Hz (5.6.1)	Passed
4.20. Acoustic test at 125 and 8000 Hz (5.6.2)	Passed
4.21. Response to sound calibrator (5.6.3)	Passed

STATEMENT OF RESULT:

- THE SOUND LEVEL METER CONFORMS TO BS7580: PART1:1997 VERIFYING CONFORMANCE TO BS EN 60651:1994, BS EN 60804:1994 AND BS3539:1986.

Instruments used in the verification procedure were traceable to national standards. The method of acoustic calibration employed a standard sound pressure calibrator. The test results were corrected for the difference between the free field and pressure response of the microphone supplied. The uncertainty of the standard calibrator is not included in the applied tolerances. The instrument was calibrated without a windscreen, consult manufacturer's manual if using a windscreen. The upper limit of the primary indicator range is 10dB less than the corresponding indicator range. The sound level meter was manufactured in accordance with BSEN60651:1994 Type 1, and BSEN60804:1994 or BSEN60804:2001 Type 1 if an integrating meter, and has been pattern evaluated and approved by a European National Institute of Metrology.

Note on measurements

Measurements close to or at the upper limit of a measuring range may produce an overload indication. Similarly measurements close to or at the lower limit of a measuring range may produce an under-range indication. This is not to be interpreted as an error of the instrument under calibration, but an indication that the signal has reached the limit of the measuring range.

CERTIFICATE OF CALIBRATION

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3. Instruments

	Instrument	Inventory No.
Generator	Brüel & Kjær, Type 3560	123560015
Amplifier/Divider	Brüel & Kjær, Type 3111	123111005
Voltmeter	Agilent, Type 34970A	142101034
Calibrator	Brüel & Kjær, Type 4226	124226021
Adaptor	Brüel & Kjær, Type WA-0302-R 15 pF	150503010

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4. Measurements

4.1. Preliminary Inspection (5.3)

Inspection of instruments submitted for calibration.

Routine Passed

4.2. Setting up (5.4)

Test and adjust sound level meter using the supplied calibrator.

			Status
Certificate Value of the associated calibrator	93.97	dB SPL	
Coupler Free-field Correction	0.15	dB	
SPL before adjustment	93.83	dB SPL	
SPL after adjustment	93.82	dB SPL	

4.3. General (5.5.1)

Electrical tests have been performed with the microphone replaced by a capacitive adaptor.

Routine Passed

4.4. Self-generated noise (5.5.2)

The self-generated noise has been measured using a shortcircuit on the input of the capacitive adaptor. If 'underrange' indicated, the level was below the minimum measurable value.

	Measured [dB SPL]	Status
Noise FW A	13.27	
Noise FW C	14.21	
Noise FW Lin	19.34	

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4.5. Linearity, reference range SPL (5.5.3)

The Linearity of the Sound Level Meter has been tested relative to the reference sound pressure level as indicated on the reference range using a continuous sinusoidal signal Frequency of 4000 Hz. The lowest test level is determined by the noise as measured in 5.5.2.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
94 dB Ref.	94.00	93.99	-0.20	0.20	-0.01	0.12	
10 dB Rel. Ref.	29.99	30.09	-0.70	0.70	0.10	0.30	
31 dB Rel. Ref.	30.99	31.09	-0.70	0.70	0.10	0.30	
32 dB Rel. Ref.	31.99	32.07	-0.70	0.70	0.08	0.30	
33 dB Rel. Ref.	32.99	33.07	-0.70	0.70	0.08	0.30	
34 dB Rel. Ref.	33.99	34.06	-0.70	0.70	0.07	0.30	
39 dB Rel. Ref.	38.99	39.02	-0.70	0.70	0.03	0.30	
44 dB Rel. Ref.	43.99	44.01	-0.70	0.70	0.02	0.30	
49 dB Rel. Ref.	48.99	49.00	-0.70	0.70	0.01	0.30	
54 dB Rel. Ref.	53.99	53.99	-0.70	0.70	0.00	0.30	
59 dB Rel. Ref.	58.99	58.99	-0.70	0.70	0.00	0.30	
64 dB Rel. Ref.	63.99	63.99	-0.70	0.70	0.00	0.30	
69 dB Rel. Ref.	68.99	68.99	-0.70	0.70	0.00	0.30	
74 dB Rel. Ref.	73.99	74.00	-0.70	0.70	0.01	0.30	
79 dB Rel. Ref.	78.99	79.00	-0.70	0.70	0.01	0.30	
84 dB Rel. Ref.	83.99	84.00	-0.70	0.70	0.01	0.30	
89 dB Rel. Ref.	88.99	88.99	-0.70	0.70	0.00	0.30	
99 dB Rel. Ref.	98.99	98.99	-0.70	0.70	0.00	0.30	
104 dB Rel. Ref.	103.99	104.00	-0.70	0.70	0.01	0.30	
109 dB Rel. Ref.	108.99	109.00	-0.70	0.70	0.01	0.30	
114 dB Rel. Ref.	113.99	114.01	-0.70	0.70	0.02	0.30	
119 dB Rel. Ref.	118.99	119.01	-0.70	0.70	0.02	0.30	
124 dB Rel. Ref.	123.99	124.02	-0.70	0.70	0.03	0.30	
129 dB Rel. Ref.	128.99	129.02	-0.70	0.70	0.03	0.30	
134 dB Rel. Ref.	133.99	134.02	-1.00	1.00	0.03	0.30	
135 dB Rel. Ref.	134.99	135.02	-1.00	1.00	0.03	0.30	
136 dB Rel. Ref.	135.99	136.02	-1.00	1.00	0.03	0.30	
137 dB Rel. Ref.	136.99	137.02	-1.00	1.00	0.03	0.30	
138 dB Rel. Ref.	137.99	138.02	-1.00	1.00	0.03	0.30	
139 dB Rel. Ref.	138.99	139.02	-1.00	1.00	0.03	0.30	
140 dB Rel. Ref.	139.99	140.02	-1.00	1.00	0.03	0.30	

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4.6. Linearity, reference range Leq (5.5.3)

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB Leq]	[dB Leq]	[dB]	[dB]	[dB]	[dB]	
94 dB Ref.	94.00	93.98	-0.20	0.20	-0.02	0.12	
10 dB Rel. Ref.	29.98	30.08	-0.70	0.70	0.10	0.30	
31 dB Rel. Ref.	30.98	31.05	-0.70	0.70	0.07	0.30	
32 dB Rel. Ref.	31.98	32.04	-0.70	0.70	0.06	0.30	
33 dB Rel. Ref.	32.98	33.05	-0.70	0.70	0.07	0.30	
34 dB Rel. Ref.	33.98	34.02	-0.70	0.70	0.04	0.30	
39 dB Rel. Ref.	38.98	39.01	-0.70	0.70	0.03	0.30	
44 dB Rel. Ref.	43.98	44.00	-0.70	0.70	0.02	0.30	
49 dB Rel. Ref.	48.98	48.98	-0.70	0.70	0.00	0.30	
54 dB Rel. Ref.	53.98	53.98	-0.70	0.70	0.00	0.30	
59 dB Rel. Ref.	58.98	58.98	-0.70	0.70	0.00	0.30	
64 dB Rel. Ref.	63.98	63.99	-0.70	0.70	0.01	0.30	
69 dB Rel. Ref.	68.98	68.99	-0.70	0.70	0.01	0.30	
74 dB Rel. Ref.	73.98	73.99	-0.70	0.70	0.01	0.30	
79 dB Rel. Ref.	78.98	78.99	-0.70	0.70	0.01	0.30	
84 dB Rel. Ref.	83.98	83.99	-0.70	0.70	0.01	0.30	
89 dB Rel. Ref.	88.98	88.99	-0.70	0.70	0.01	0.30	
99 dB Rel. Ref.	98.98	98.99	-0.70	0.70	0.01	0.30	
104 dB Rel. Ref.	103.98	103.99	-0.70	0.70	0.01	0.30	
109 dB Rel. Ref.	108.98	108.99	-0.70	0.70	0.01	0.30	
114 dB Rel. Ref.	113.98	114.00	-0.70	0.70	0.02	0.30	
119 dB Rel. Ref.	118.98	119.01	-0.70	0.70	0.03	0.30	
124 dB Rel. Ref.	123.98	124.01	-0.70	0.70	0.03	0.30	
129 dB Rel. Ref.	128.98	129.01	-0.70	0.70	0.03	0.30	
134 dB Rel. Ref.	133.98	134.01	-0.70	0.70	0.03	0.30	
135 dB Rel. Ref.	134.98	135.01	-0.70	0.70	0.03	0.30	
136 dB Rel. Ref.	135.98	136.01	-0.70	0.70	0.03	0.30	
137 dB Rel. Ref.	136.98	137.01	-0.70	0.70	0.03	0.30	
138 dB Rel. Ref.	137.98	138.01	-0.70	0.70	0.03	0.30	
139 dB Rel. Ref.	138.98	139.01	-0.70	0.70	0.03	0.30	
140 dB Rel. Ref.	139.98	140.01	-0.70	0.70	0.03	0.30	

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4.7. Frequency weighting A (5.5.4)

The frequency weighting has been tested at octave intervals from 31.5 Hz to 12.5 kHz relative to 1000 Hz at the specified reference level. The measured values have been corrected for the effect of body influence.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
1000Hz Ref.	94.00	94.00	-0.20	0.20	-0.07	0.12	
31.623Hz	54.53	54.59	-1.50	1.50	-0.04	0.20	
63.096Hz	67.73	67.81	-1.50	1.50	0.18	0.20	
125.89Hz	77.83	77.90	-1.00	1.00	0.17	0.20	
251.19Hz	85.33	85.36	-1.00	1.00	0.10	0.20	
501.19Hz	90.71	90.77	-1.00	1.00	0.26	0.20	
995.3Hz	95.13	95.21	-1.00	1.00	0.09	0.20	
1981.1Hz	94.93	95.00	-1.00	1.00	0.18	0.20	
3943.3Hz	92.83	92.90	-1.00	1.50	0.29	0.20	
7943.3Hz	89.63	89.74	-0.00	1.00	0.26	0.20	

4.8. Frequency weighting C (5.5.4)

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
1000Hz Ref.	94.00	94.00	-0.20	0.20	-0.07	0.12	
31.623Hz	60.93	61.02	-1.50	1.50	-0.01	0.20	
63.096Hz	83.13	83.19	-1.50	1.50	0.16	0.20	
125.89Hz	93.71	93.83	-1.00	1.00	0.20	0.20	
251.19Hz	93.93	94.00	-1.00	1.00	0.14	0.20	
501.19Hz	93.93	94.03	-1.00	1.00	0.32	0.20	
995.3Hz	93.73	93.84	-1.00	1.00	0.12	0.20	
1981.1Hz	93.13	93.21	-1.00	1.00	0.19	0.20	
3943.3Hz	90.93	91.00	-1.00	1.50	0.29	0.20	
7943.3Hz	87.73	87.82	-0.00	1.00	0.24	0.20	

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4.9. Frequency weighting Lin (5.5.4)

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
1000Hz Ref.	94.00	94.00	-0.20	0.20	-0.07	0.12	
31.623Hz	93.93	94.03	-1.50	1.50	0.00	0.20	
63.096Hz	93.93	94.00	-1.50	1.50	0.17	0.20	
125.89Hz	93.93	94.00	-1.00	1.00	0.17	0.20	
251.19Hz	93.93	94.00	-1.00	1.00	0.14	0.20	
501.19Hz	93.93	94.00	-1.00	1.00	0.29	0.20	
995.3Hz	93.93	94.01	-1.00	1.00	0.09	0.20	
1981.1Hz	93.93	94.03	-1.00	1.00	0.21	0.20	
3943.3Hz	93.93	94.01	-1.00	1.50	0.30	0.20	
7943.3Hz	93.93	93.56	-0.00	1.00	0.28	0.20	

4.10. Time weighting Fast (5.5.5)

Time weighting was tested by comparing the response of a single sinusoidal burst with the response of a continuous sinusoidal signal at a level 4 dB below the upper limit of the primary indicator range. The test frequency is 2000 Hz.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
Ref. 126 dB	126.00	126.04	-0.20	0.20	0.04	0.20	
Burst Meas. 126 dB	125.04	125.04	-1.00	1.00	0.00	0.20	

4.11. Time weighting Slow (5.5.5)

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
Ref. 126 dB	126.00	126.00	-0.20	0.20	0.00	0.20	
Burst Meas. 126 dB	121.90	121.97	-1.00	1.00	0.07	0.20	

4.12. Peak response (5.5.6)

The onset time of the peak detector has been tested by comparing the response to a 100 µs rectangular pulse with the response to a 10 ms reference pulse of the same amplitude and polarity.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
10 ms Pos Ref.	129.00	129.03	-0.20	0.20	0.03	0.20	
100 µs Pos	129.03	127.63	-2.00	0.00	-1.40	0.20	
10 ms Neg Ref.	129.00	129.01	-0.20	0.20	0.01	0.20	
100 µs Neg	129.01	127.56	-2.00	0.00	-1.45	0.20	

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4.13. R.M.S. accuracy (5.5.7)

The r.m.s. accuracy has been tested on the reference range for a crest factor of 3 by comparing the response to a sequence of tone bursts with that for a continuous sinusoidal signal of 2000Hz at a level at 2 dB below the upper limit of the primary indicator range.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
Ref. 128 dB	128.00	128.04	-0.20	0.20	0.04	0.20	
Burst Mean 128 dB	128.04	128.33	-0.50	0.50	0.29	0.20	

4.14. Time weighting I (5.5.8)

Time weighting impulse has been tested by comparing the response of a single sinusoidal burst with a duration of 5 ms, and a repetitive burst with the duration of 5 ms and a repetition frequency of 100 Hz, with the response of a continuous sinusoidal signal at a level at the upper limit of the primary indicator range. The test frequency is 2000 Hz.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
Ref. 130 dB	130.00	130.04	-0.20	0.20	0.04	0.20	
Seq. Burst Mean 130 dB	121.34	121.18	-2.00	2.00	-0.06	0.20	
Cont. Burst Mean 130 dB	122.34	122.24	-1.00	1.00	-0.10	0.20	

4.15. Time averaging (5.5.9)

The time averaging has been tested on the reference range by comparing the response to a continuous sinusoidal signal of 4000 Hz, with that for a sequence of tone bursts having the same equivalent level.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB Leq]	[dB Leq]	[dB]	[dB]	[dB]	[dB]	
Ref. Cont.	110.00	109.99	-0.20	0.20	-0.01	0.20	
Leq 1/1000	109.99	109.94	-1.00	1.00	-0.05	0.20	
Ref. Cont.	100.00	99.99	-0.30	0.30	-0.01	0.20	
Leq 1/10000	99.99	99.94	-1.00	1.00	-0.05	0.20	

4.16. Pulse range and sound exposure level (5.5.10 and 5.5.11)

The Pulse range has been tested by comparing the response to a single sinusoidal burst with the theoretical value of the equivalent continuous level of the test signal. The Sound Exposure Level where available has been determined using the same test signals.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB Leq]	[dB Leq]	[dB]	[dB]	[dB]	[dB]	
Ref. Cont., 78	78.00	77.99	-0.20	0.20	-0.01	0.20	
Leq 10msec, 78	47.99	48.00	-1.70	1.70	0.01	0.20	
SEL 10msec, 78	57.99	58.00	-1.70	1.70	0.01	0.20	
Ref. Cont., 135	135.00	135.01	-0.20	0.20	0.01	0.20	
Leq 10msec, 135	105.01	105.00	-1.70	1.70	-0.01	0.20	
SEL 10msec, 135	115.01	115.00	-1.70	1.70	-0.01	0.20	

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4.17. Overload indication, Non-integrating (5.5.12)

Non-integrating mode. The overload indicator has been tested using a sequence of tone bursts as specified in BS7580 clause 5.5.7. The level of the tone bursts was increased until an overload indication occurred. The level was then reduced by 1dB so that no indication occurred. The level was further reduced by 3dB and the meter indication recorded.

	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
Non-integrating	131.71	131.71	-0.40	0.40	0.00	0.10	

4.18. Overload indication, Integrating (5.5.12)

Integrating Mode. The overload indicator has been tested using single sinusoidal bursts with duration of 1 ms at a frequency of 4000 Hz. The level of the burst was increased until the meter just indicated a permanent overload. The signal was then reduced by 1dB. With a continuous signal of the same amplitude applied the meter indication was recorded.

	Continuous Level	Expected	Measured	Accept - Limit	Accept + Limit	Deviation	Uncertainty	Status
	[dB Leq]	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
Integrating	141.51	101.51	101.44	-2.20	2.20	-0.07	0.10	

4.19. Acoustic calibration at 1000 Hz (5.6.1)

The complete instrument has been calibrated at reference conditions, 1000 Hz at 94 dB. A correction in accordance with manufacturers data was made for the difference between the free field and pressure response of the microphone supplied to determine the adjustment level. If a correction for the effect of body influence is required so that the meter reads correctly, this has also been included in the determination.

	Coupler Pressure Le	Mic. Correction C4226	Body Influence bi	Adjustment Level	Status
	[dB SPL]	[dB]	[dB]	[dB SPL]	
Ref. Conditions	94.00	0.10	-0.07	94.00	

4.20. Acoustic test at 125 and 8000 Hz (5.6.2)

The complete instrument has been tested using continuous acoustical signals of 125 Hz and 8000 Hz relative to the reference reading at 1000Hz. Corrections in accordance with manufacturers data were made for the difference between the free field and pressure response of the microphone supplied to determine the expected reading. Manufacturers data for body influence has been used in calculating the corrected measured readings representing use within free field conditions.

	Coupler Pressure Le	Mic. Corr. C4226	Body Influence bi	Measured	Corrected Measured	Free Field Level	Response (Ref Ref)	Expected	Accept - Limit	Accept + Limit	Deviation	Un- certainty	Status
	[dB SPL]	[dB]	[dB]	[dB SPL]	[dB SPL]	[dB SPL]	[dB]	[dB SPL]	[dB]	[dB]	[dB]	[dB]	
1000Hz Ref.	94.00	0.10	-0.07	94.01	94.01	94.04	0.00	0.00	-0.20	0.20	0.00	0.20	
125.89Hz	94.07	0.00	0.00	78.05	77.98	77.98	-16.06	-16.10	-1.00	1.00	0.04	0.20	
7943.3Hz	93.45	2.80	-0.08	89.66	90.21	92.95	-1.11	-1.10	-3.00	1.30	-0.01	0.40	

4.21. Response to sound calibrator (5.6.3)

The response to the associated Sound Calibrator has been recorded.

	Measured	Uncertainty	Coverage Factor	Status
	[dB SPL]	[dB]	[k]	
Ref.	94.10	0.20	2.13	

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DANAK

The Danish Accreditation and Metrology Fund - DANAK - is managing the Danish accreditation scheme based on a contract with the Danish Safety Technology Authority under the Danish Ministry of Economics and Business Affairs who is responsible for the legislation on accreditation in Denmark.

The fundamental criteria for accreditation are described in DS/EN ISO/IEC 17025: "General requirements for the competence of testing and calibration laboratories", and in DS/EN ISO/IEC 15189 "Medical laboratories - Particular requirements for quality and competence" respectively. DANAK uses guidance documents to clarify the requirements in the standards, where this is considered to be necessary. These will mainly be drawn up by the "European co-operation for Accreditation (EA)" or the "International Laboratory Accreditation Co-operation (ILAC)" with a view to obtaining uniform criteria for accreditation worldwide. In addition, the Danish Safety Technology Authority issues Technical Regulations prepared by DANAK with specific requirements for accreditation that are not contained in the standards.

In order for a laboratory to be accredited it is, among other things, required:

- *that the laboratory and its personnel are free from any commercial, financial or other pressures, which might influence their impartiality;*
- *that the laboratory operates a documented management system, and has a management that ensures that the system is followed and maintained;*
- *that the laboratory has at its disposal all items of equipment, facilities and premises required for correct performance of the service that it is accredited to perform;*
- *that the laboratory has at its disposal personnel with technical competence and practical experience in performing the services that they are accredited to perform;*
- *that the laboratory has procedures for traceability and uncertainty calculations;*
- *that accredited testing, calibration or medical examination are performed in accordance with fully validated and documented methods;*
- *that accredited services are performed and reported in confidentiality with the customer and in compliance with the customer's request;*
- *that the laboratory keeps records which contain sufficient information to permit repetition of the accredited test, calibration or medical examination;*
- *that the laboratory is subject to surveillance by DANAK on a regular basis;*

Reports carrying DANAK's accreditation mark are used when reporting accredited services and show that these have been performed in accordance with the rules for accreditation.

The uncertainties quoted for the measurement shown are based on an estimated confidence probability of not less than 95% using a coverage factor $k=2$.

Deutsche WindGuard
Wind Tunnel Services GmbH, Varel



akkreditiert durch die / accredited by the

Deutsche Akkreditierungsstelle GmbH

als Kalibrierlaboratorium im / as calibration laboratory in the



Deutschen Kalibrierdienst



Kalibrierschein
Calibration certificate

Calibration mark

1310536
D-K- 15140-01-00
02/2013

Gegenstand Object	Cup Anemometer	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Hersteller Manufacturer	Windspeed LTD Denbighshire LL18 2AB	Die DAkkS ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Typ Type	A 100 R	Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
Fabrikat/Serien-Nr. Serial number	Body: 11441 Cup: CZAR	This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).
Auftraggeber Customer	TUV NEL Ltd UK Glasgow G75 0QU	The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.
Auftragsnummer Order No.	VT130181	The user is obliged to have the object recalibrated at appropriate intervals.
Anzahl der Seiten des Kalibrierscheines Number of pages of the certificate	3	
Datum der Kalibrierung Date of calibration	01.02.2013	

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

Datum Date	Leiter des Kalibrierlaboratoriums Head of the calibration laboratory	Bearbeiter Person in charge
01.02.2013		

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Page

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Kalibriergegenstand Object	Cup Anemometer
Kalibrierverfahren Calibration procedure	IEC 61400-12-1 – Power performance measurements of electricity producing wind turbines – 2005-12 ISO 3966 – Measurement of fluid in closed conduits – 2008-07
Ort der Kalibrierung Place of calibration	Windtunnel of Deutsche WindGuard, Varel
Messbedingungen Test Conditions	wind tunnel area ¹⁾ 10000 cm ² anemometer frontal area ²⁾ 200 cm ² diameter of mounting pipe ³⁾ 27 mm blockage ratio ⁴⁾ 0.020 [-] blockage correction ⁵⁾ 1.000 [-]
Umgebungsbedingungen Test conditions	air temperature 20.5 °C ± 0.1 K air pressure 1001.1 hPa ± 0.3 hPa relative air humidity 36.3 % ± 2.0 %
Akkreditierung Accreditation	05/2011
Anmerkungen Remarks	Calibrated with 405 Type Single Mount
Auswertesoftware Software version	7.4

¹⁾ Querschnittsfläche der Auslassdüse des Windkanals

²⁾ Vereinfachte Querschnittsfläche (Schattenwurf) des Prüflings inkl. Montagerohr

³⁾ Durchmesser des Montagerohrs

⁴⁾ Verhältnis von 2) zu 1)

⁵⁾ Korrekturfaktor durch die Verdrängung der Strömung durch den Prüfling

Anmerkung: Aufgrund der speziellen Konstruktion der Messstrecke ist keine Korrektur nötig.

Remark: Due to the special construction of the test section no blockage correction is necessary

Dieser Kalibrierschein wurde elektronisch erzeugt
This calibration certificate has been generated electronically

Deutsche WindGuard
Wind Tunnel Services GmbH, Varel



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D-K-
15140-01-00
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Kalibrierergebnis:
Result:

File:	1310536	
Test Item (1/s)	Tunnel Speed (m/s)	Uncertainty (k=2) (m/s)
3.097	4.116	0.053
4.619	6.080	0.053
6.106	7.906	0.053
7.531	9.743	0.053
9.111	11.704	0.053
10.629	13.646	0.053
12.188	15.616	0.053
13.744	17.566	0.053
15.276	19.489	0.053
16.799	21.374	0.053
18.299	23.214	0.053
19.774	25.002	0.053
21.282	26.794	0.053
22.805	28.557	0.053

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

Die Deutsche Akkreditierungsstelle GmbH ist Unterzeichnerin der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Die weiteren Unterzeichner innerhalb und außerhalb Europas sind den Internetseiten von EA (www.european-accreditation.org) und ILAC (www.ilac.org) zu entnehmen.

The expanded uncertainty assigned to the measurement results is obtained by multiplying the standard uncertainty by the coverage factor $k = 2$. It has been determined in accordance with DAkkS-DKD-3. The value of the measurand lies within the assigned range of values with a probability of 95%.

The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

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Wind Tunnel Services GmbH, Varel



Anhang
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1 Detailed Calibration Results

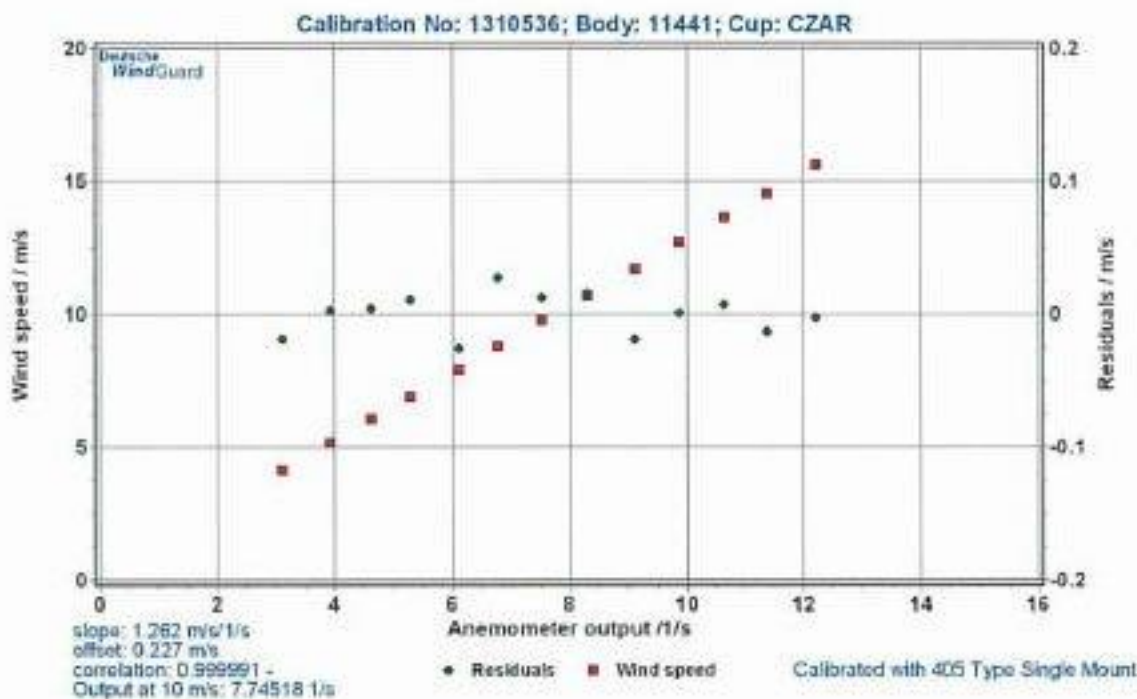
DKD calibration no. 1310536
Serial no. 1 Body: 11441
Serial no. 2 Cup: CZAR
Date 01.02.2013
Air temperature 20.5 °C
Air pressure 1001.1 hPa
Humidity 36.3 %



Linear regression analysis

Slope 1.26181 (m/s)/(1/s) ± 0.00161 (m/s)/(1/s)
Offset 0.2270 m/s ± 0.013 m/s
St.err(Y) 0.013 m/s
Correlation coefficient 0.999991

Remarks no



Deutsche WindGuard Wind Tunnel Services is accredited by MEASNET and by the Deutsche Akkreditierungsdienst – DAkkS (German Accreditation Service). Registration: D-K-15140-01-00

Deutsche WindGuard
Wind Tunnel Services GmbH, Varel



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2 Instrumentation

Pos.	Sensor	Manufa.	Type	Range
1	Pitot static tube	Airflow	NPL 8 mm	-
2	Pitot static tube	Airflow	NPL 8 mm	-
3	Pitot static tube	Airflow	NPL 8 mm	-
4	Pitot static tube	Airflow	NPL 8 mm	-
5	Pressure transducer	Setra	C 239	250 Pa
6	Pressure transducer	Setra	C 239	250 Pa
7	Pressure transducer	Setra	C 239	250 Pa
8	Pressure transducer	Setra	C 239	250 Pa
9	El. Barometer	Vaisala	3.11.57.10.000	800hPa -1200 hPa
10	El. Thermometer	Galltec	KPK 1/6-ME	10° C - 40° C
11	El. Humidity sensor	Galltec	KPK 1/6-ME	0-100 %
12	Wind tunnel control	-	-	-
13	CAN-BUS / PC	esd	24 x 16 bit	-

Table 1 Description of the data acquisition system

Remark: Last Re-accreditation see page 2

3 Photo of the calibration set-up



Calibration set-up of the anemometer calibration in the wind tunnel of Deutsche WindGuard, Varel. The anemometer shown may differ from the calibrated one. Remark: The proportion of the set-up is not true to scale due to imaging geometry.

4 Deviation to IEC procedure

The calibration procedure is in all aspects in accordance with the IEC 61400-12-1 Procedure

5 References

- [1] D. Westermann, 2009 – Verfahrensweisung DKD-Kalibrierung von Windgeschwindigkeitssensoren
- [2] IEC 61400-12-1 12/2005 – Power performance measurements of electricity producing wind turbines
- [3] ISO 3966 2008 – Measurement of fluid flow in closed conduits

Deutsche WindGuard
Wind Tunnel Services GmbH, Varel

