

Micro Wind Turbines

The Application of BS EN 61400 – 11

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Wind Turbines & Noise

- Sources of Noise
 - Aerodynamic, mechanical
- Location
 - Coming soon to your next door neighbour's house!
- Noise (Source) Level
 - Depends on rotor speeds and hence wind speed.
- Acoustic Features
 - Spectral, temporal(?)



Noise Assessment

- Likely to require a comparison of predicted noise level:
 - with background noise
 - with other appropriate guidance
- Therefore need to know source noise level and spectra under all operating conditions to enable appropriate predictions and comparisons to be carried out.
- May also require an assessment of tonal content.



The Problem

| WT MODEL | WT 1000 (0.6kW) | WT 2500 (2.5kW) | WT 6000 (6kW) | WT 15000 (15kW) |
|-----------------------------------|---|-----------------------------|-----------------------------|-----------------------------|
| Cut In (m/s) ¹ | 2.5 | | | |
| Cut Out m/s | None! | | | |
| Survival m/s | 65 | | | |
| Rated (m/s) | 12 | | | |
| Rotor Type | Downwind, Self Regulating | | | |
| No. of Blades | 3 | | | |
| Blade Material | Polypropylene | Polypropylene | Wood/Epoxy | Glass Polypropylene |
| Rotor Diameter(m) | 2.55 | 3.5 | 5.5 | 9 |
| Generator Type | Brushless, Direct Drive, Permanent Magnet | | | |
| Battery charging | 12 , 24 or 48V DC | 24 or 48V DC | 48V DC | 48V DC |
| Grid connect with Inverter | 230Vac 50Hz or 240 Vac 60Hz | 230Vac 50Hz or 240 Vac 60Hz | 230Vac 50Hz or 240 Vac 60Hz | 230Vac 50Hz or 240 Vac 60Hz |
| Direct Heating | n/a | 120Vac or 240Vac | 120Vac or 240Vac | 120Vac or 240Vac |
| Rated RPM | 500 | 300 | 200 | 140 |
| Annual Output ² | 900-1,500 kWh | 2,500 – 5,000 kWh | 6,000 – 12,000 kWh | 15,000 – 30,000 kWh |
| Head Weight (kg) | 70 | 190 | 500 | 1100 |
| Mast Type | Tilt-up, tapered, self-supporting, no guy wires (Taller guyed towers also available on request) | | | |
| Hub Height (m) | 5.5 or 12 | 6.5 or 11 | 9 or 15 | 15 |
| WT Found (m) | 1x1x1 or 1.6x1.6x1 | 1.6x1.6x1 or 2.5x2.5x1 | 2.5x2.5x1 or 3x3x1.2 | 3.7x3.7x1.2 |
| Winch Found (m) | 0.65x0.65x0.65 | 0.65x0.65x0.65 or 1x1x1 | 1x1x1 or 1.5x1.5x1 | 1.5x1.5x1.2 |
| Tower Weight (kg) | 120 or 350 | 241 or 445 | 360 or 656 | 1200 |
| Mechanical Brake | No | Yes | Yes | Yes |
| Noise ³ @ 5m/s | 35 dBA | 40 dBA | 45 dBA | 48 dBA |
| Noise @ 20m/) | 55 dBA | 60 dBA | 65 dBA | 65 dBA |
| Rotor Thrust (kN) | 2.5 | 5 | 10 | 26 |
| Sample of UK commercial customers | British Telecom / Scottish Youth Hostel Association / British Rail / Irish Lighthouse Authority UK Lighthouse Authority / T-mobile /Orange / Saudi Aramco / Shell / B&Q / BP / Sainsbury's | | | |

¹ 1 metre/second = 2.24 miles per hour=3.6kph.

² Based on an ideal site and average wind speed of 5m/s - please refer to our website at [www.windenergy.co.uk](#) for further information

³ All readings taken with an ATP SL-25 dBA meter at the base of the tower at a height of 1.5m.

* A car passing 20m away @ approx 40 mph is 70-80dBA



The Problem

| | | | | |
|---------------------------|--------|--------|--------|--------|
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A (Micro) Turbine



The Solution

BRITISH STANDARD

BS EN
61400-11:2003

Wind turbine generator systems —

Part 11: Acoustic noise measurement
techniques

The European Standard EN 61400-11:2003 has the status of a
British Standard

ICS 27.180

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BSi
British Standards



What does it Cover?

1 Scope

This part of IEC 61400 presents measurement procedures that enable noise emissions of a wind turbine to be characterised. This involves using measurement methods appropriate to noise emission assessment at locations close to the machine, in order to avoid errors due to sound propagation, but far enough away to allow for the finite source size. The procedures described are different in some respects from those that would be adopted for noise assessment in community noise studies. They are intended to facilitate characterisation of wind turbine noise with respect to a range of wind speeds and directions. Standardisation of measurement procedures will also facilitate comparisons between different wind turbines.

The procedures present methodologies that will enable the noise emissions of a single wind turbine to be characterised in a consistent and accurate manner. These procedures include the following:

- location of acoustic measurement positions;
- requirements for the acquisition of acoustic, meteorological, and associated wind turbine operational data;
- analysis of the data obtained and the content for the data report; and
- definition of specific acoustic emission parameters, and associated descriptors which are used for making environmental assessments.

The standard is not restricted to wind turbines of a particular size or type. The procedures described in this standard allow for the thorough description of the noise emission from a wind turbine. If, in some cases, less comprehensive measurements are needed, such measurements are made according to the relevant parts of this standard.



What does it provide?

- Sound power level at integer V_{10} wind speeds
- 1/3 octave band spectra
- Analysis of tonal noise

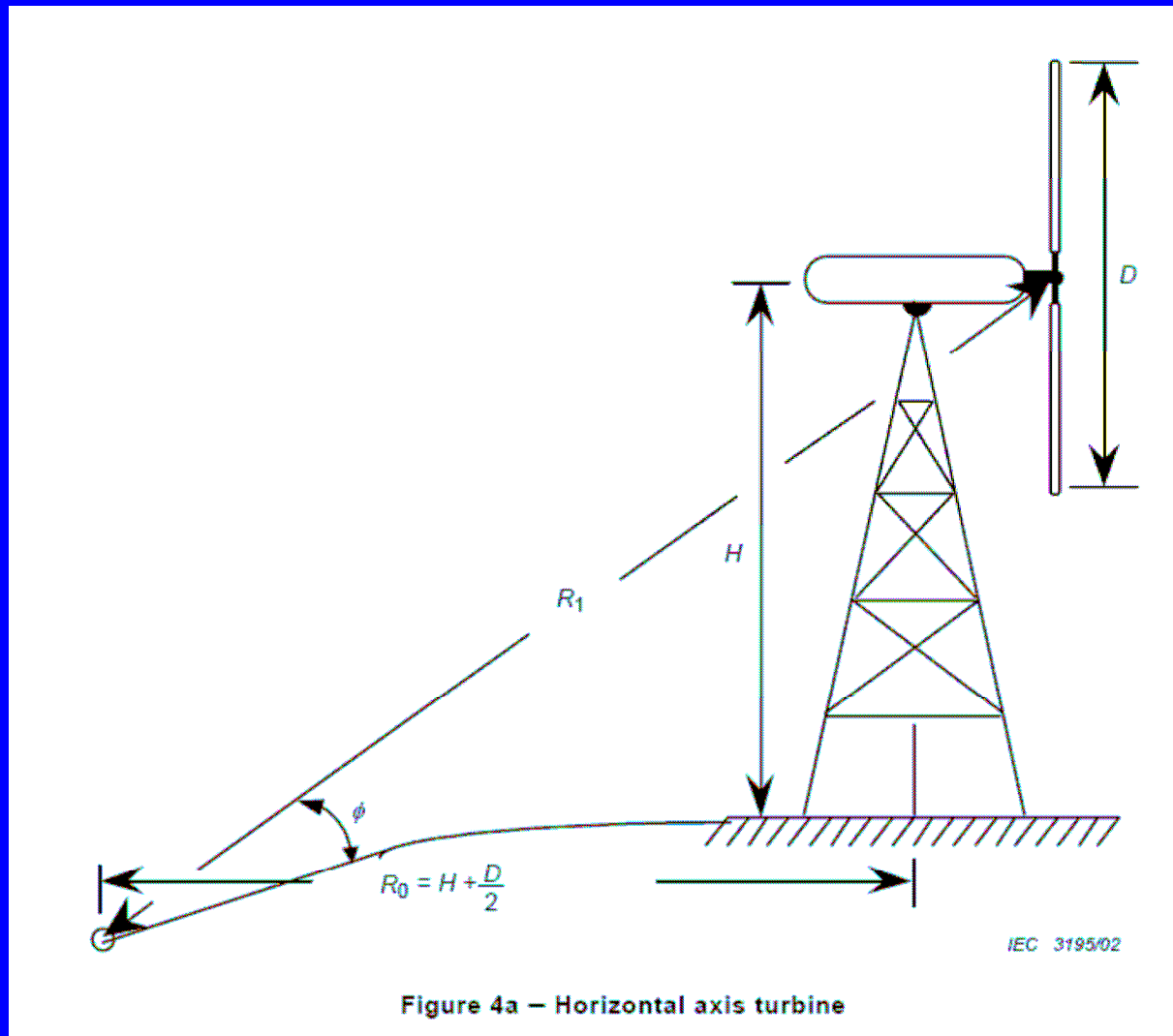


Equipment

- Logging Sound Level Meter (Type / Class 1)
- Real Time Third Octave Band Analyser
- Real Time Narrow Band / FFT Analyser
OR
- DAT, Hard Disk or Solid State Audio Recorder
(results processed elsewhere)
- Calibrator
- Mast, Anemometer, Wind Vane and Data Logger



Measurement Location



Microphone Configuration (1)

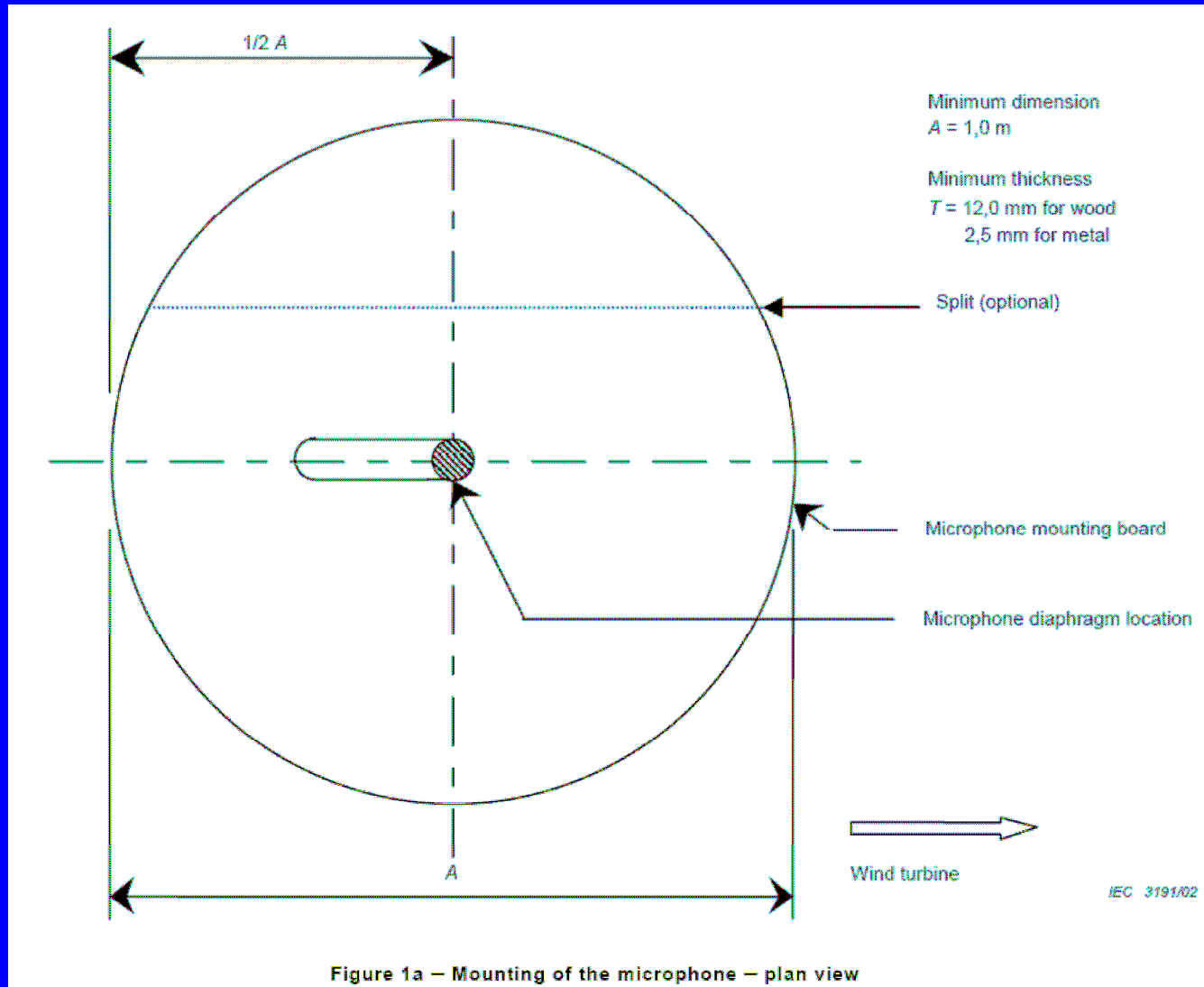
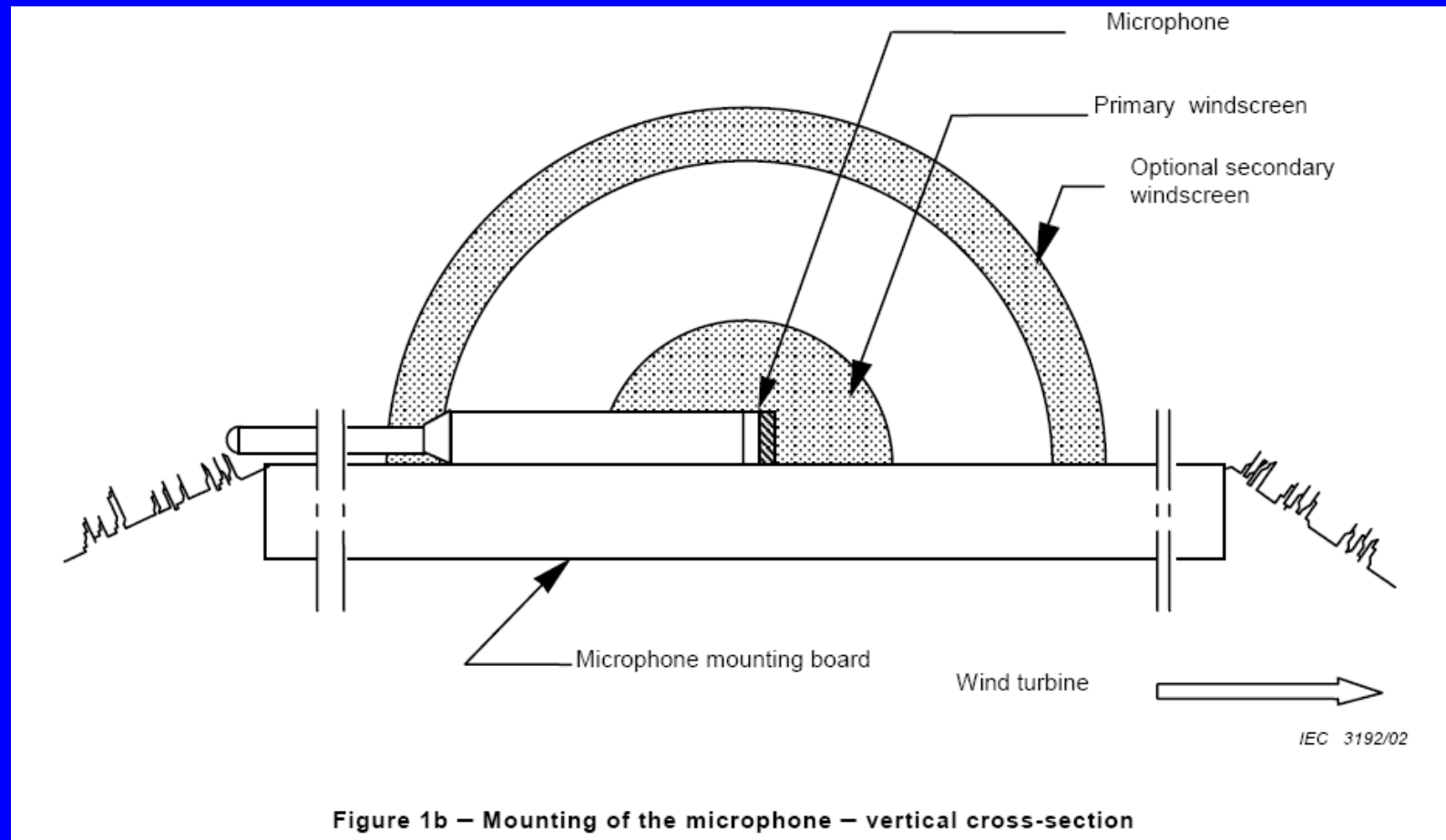


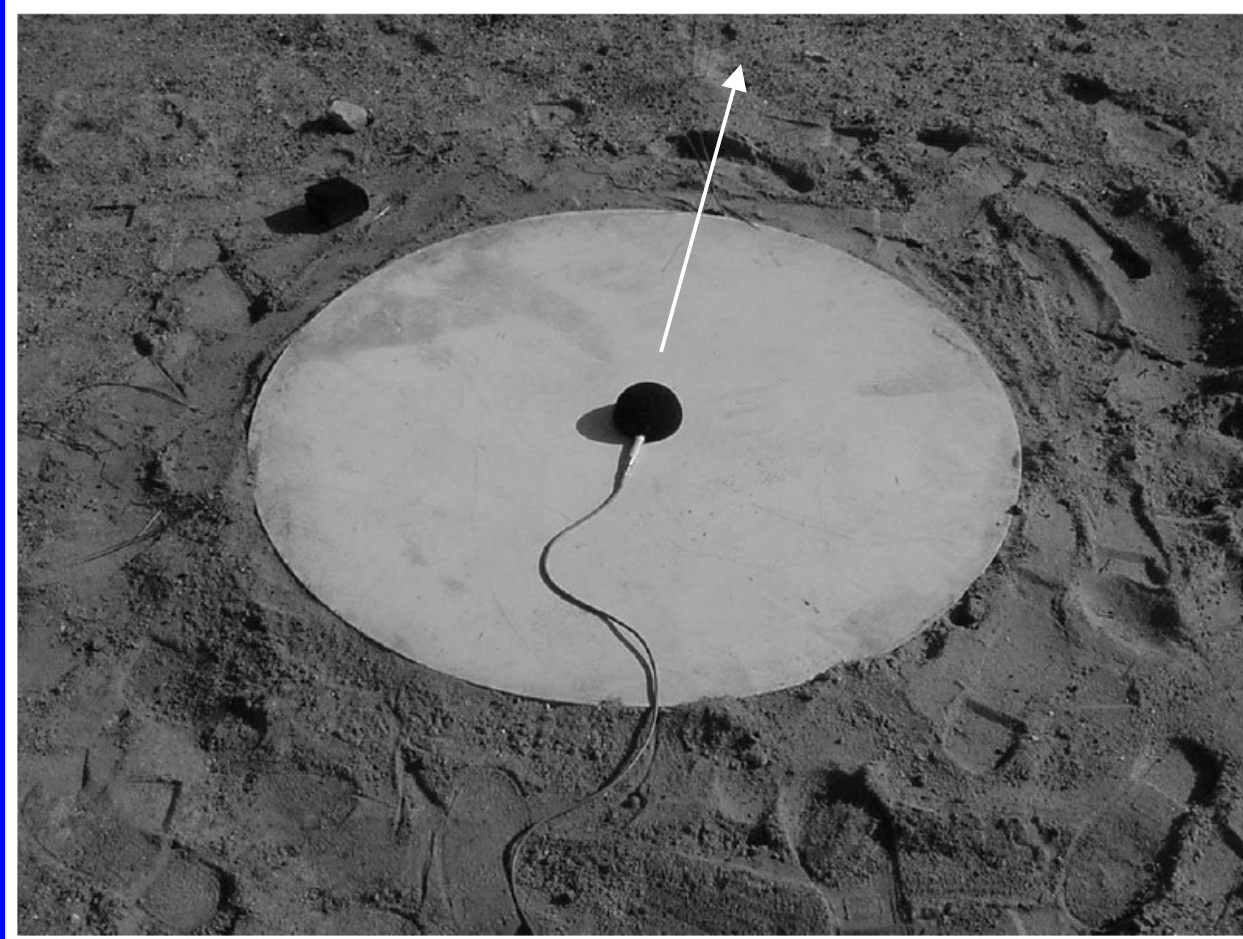
Figure 1a – Mounting of the microphone – plan view



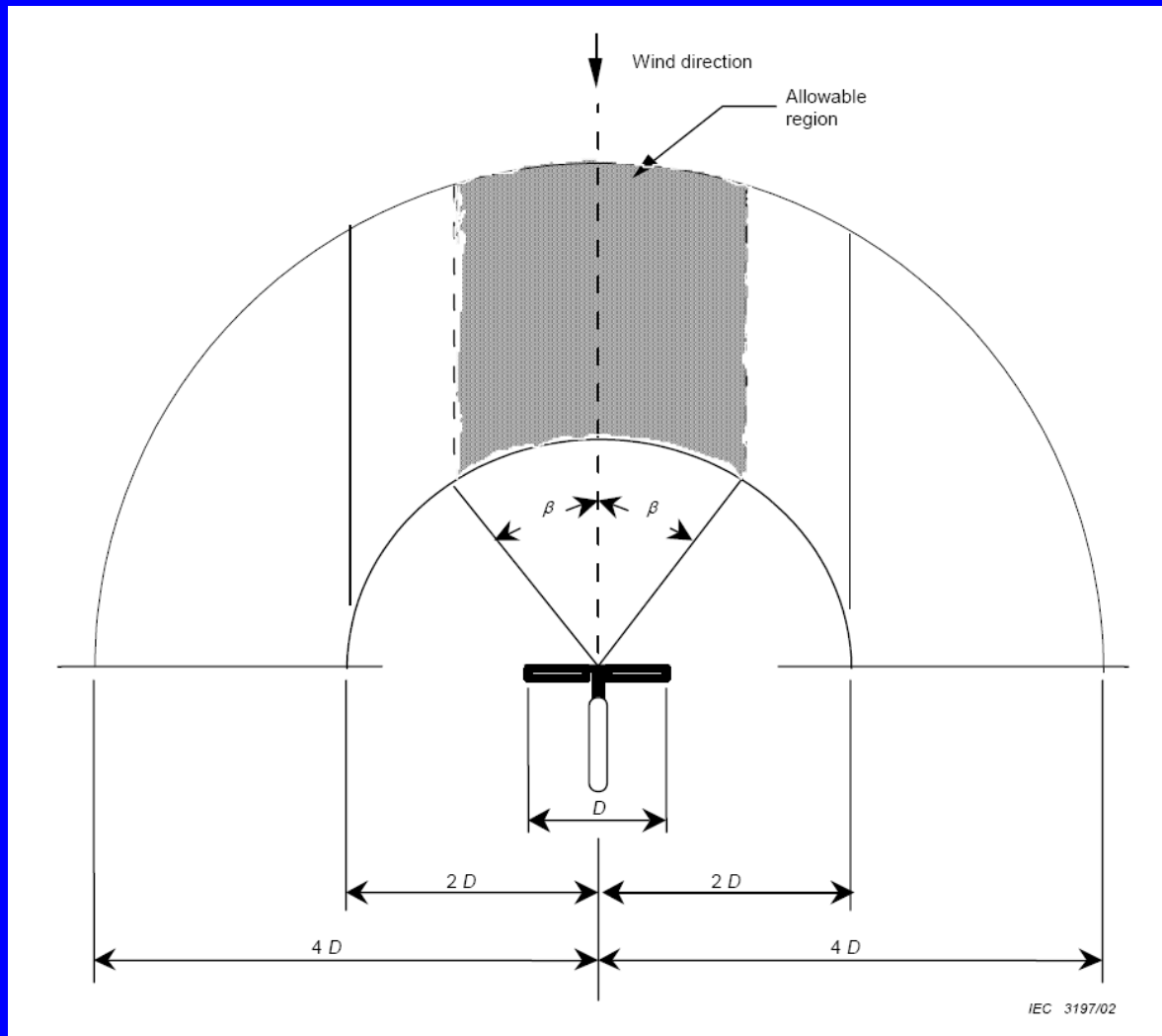
Microphone Configuration (2)



Microphone Configuration (3)



Anemometer



The angle β is given by:

$$\beta = \frac{z - z_{ref}}{H - z_{ref}} (\beta_{max} - \beta_{min}) + \beta_{min}$$

where

z is the anemometer height, see Figure 6;

z_{ref} is the reference height of 10 m;

H is the height of the rotor centre

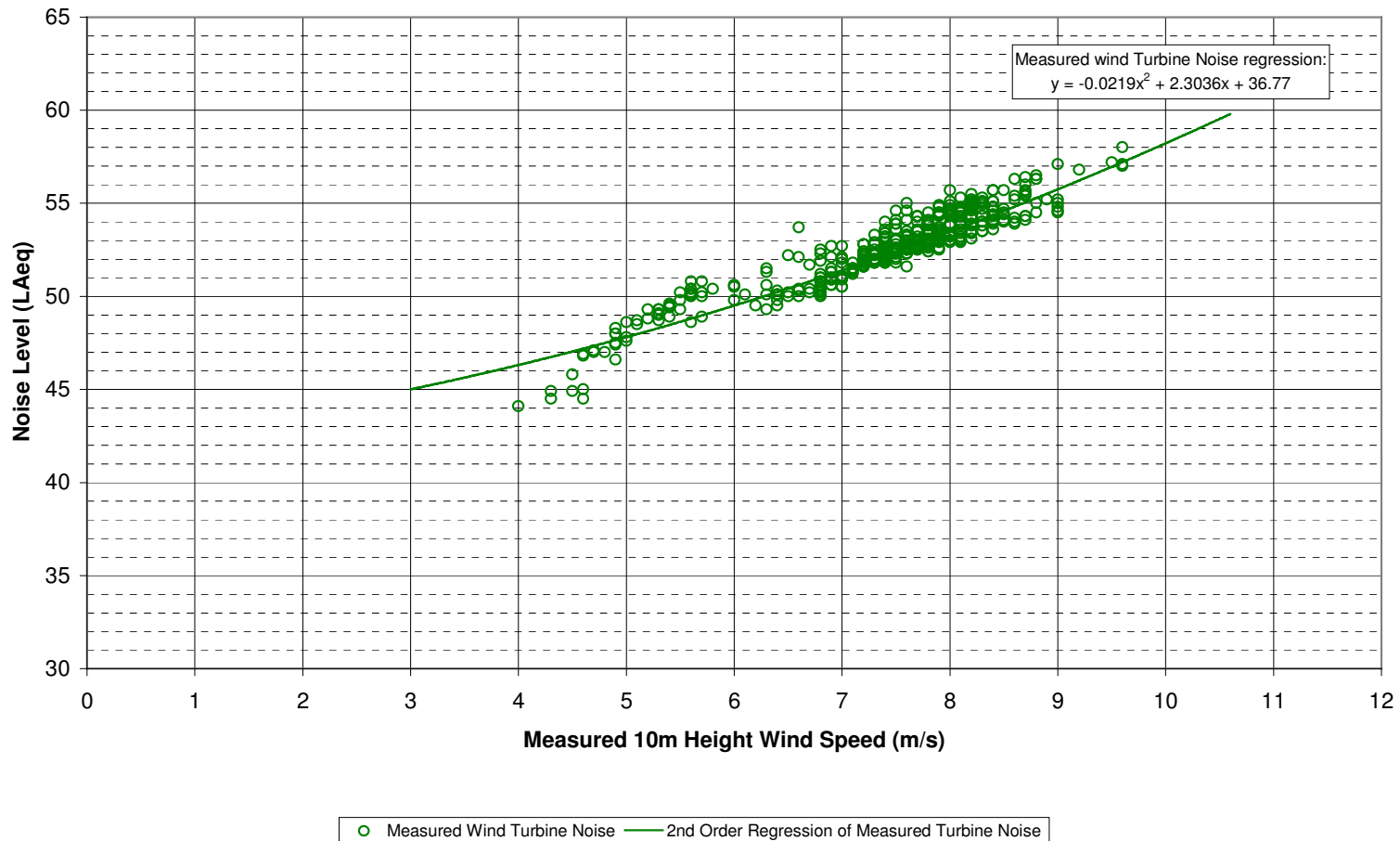
β_{max} is the maximum angle for β , $\beta_{max} = 90^\circ$;

β_{min} is the minimum angle for β , $\beta_{min} = 30^\circ$



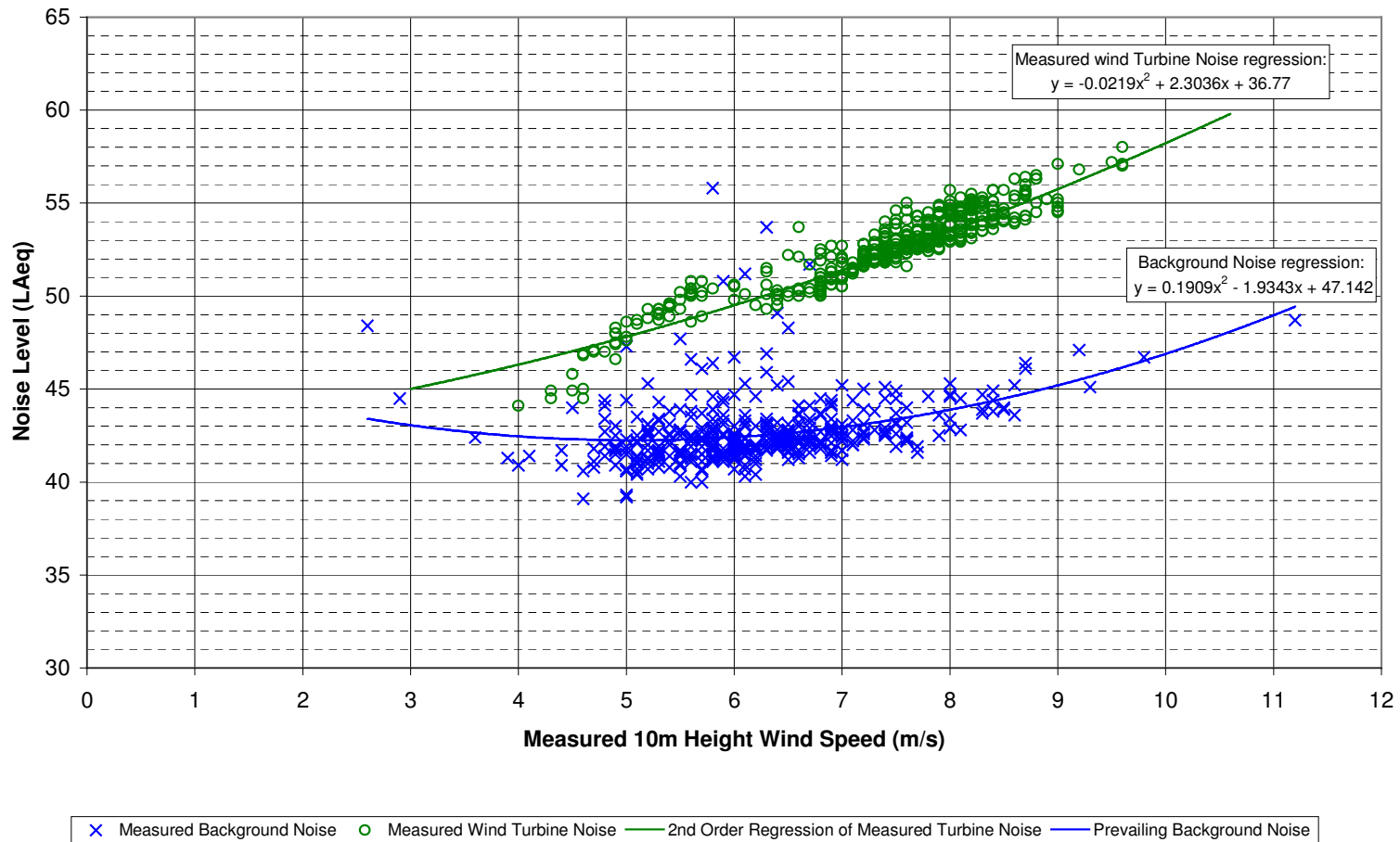
Results

Noise against Wind Speed for Turbine Measurements



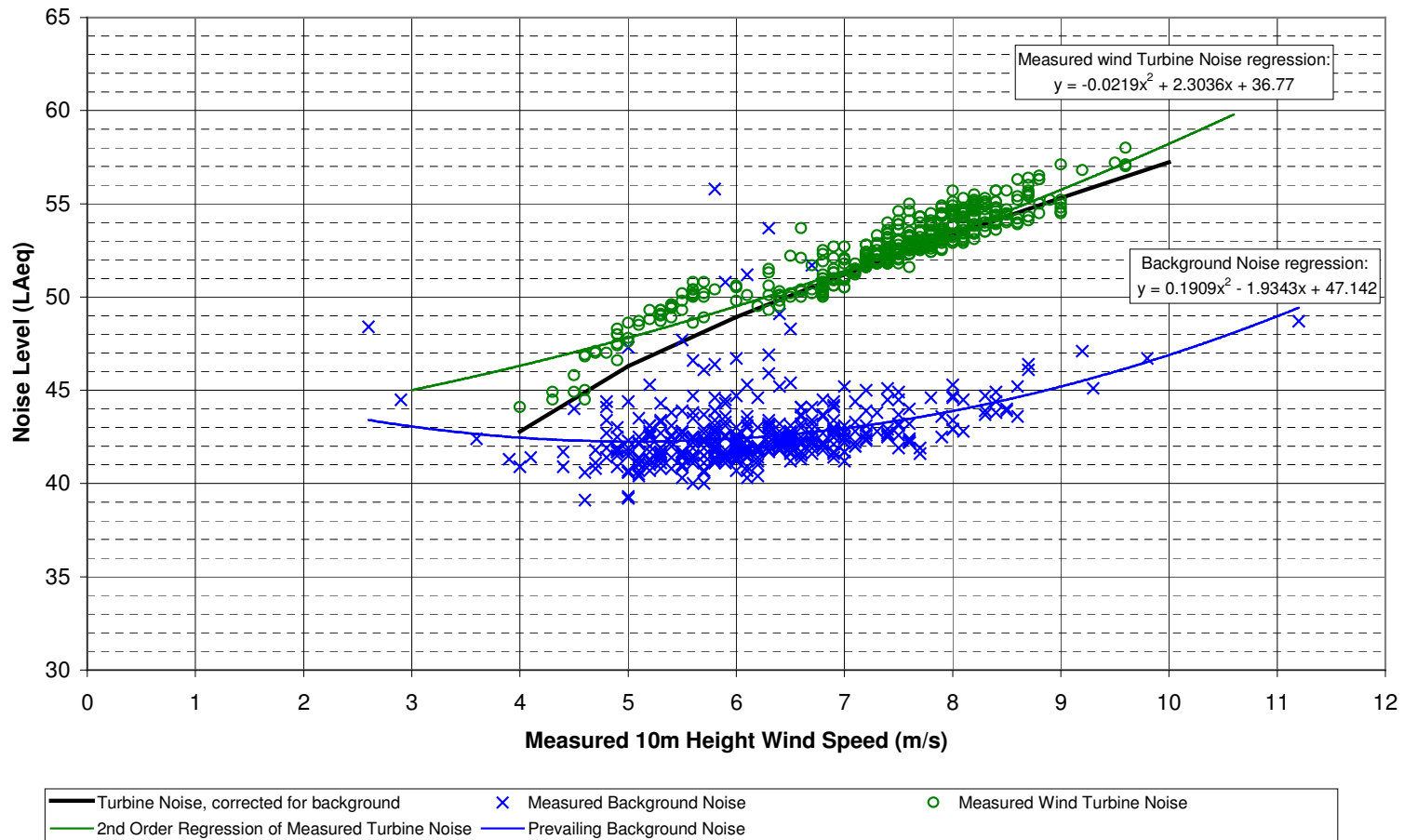
Results

Noise against Wind Speed for Turbine Measurements



Results

Noise against Wind Speed for Turbine Measurements



Derived Sound Power Level

$$L_{WA,k} = L_{Aeq,c,k} - 6 + 10 \lg \left[\frac{4 \pi R_1^2}{S_0} \right] \quad (9)$$

where

$L_{Aeq,c,k}$ is the background corrected A-weighted sound pressure level at the integer wind speeds and under reference conditions;

R_1 is the slant distance in meters from the rotor centre to the microphone as shown in Figure 4; and

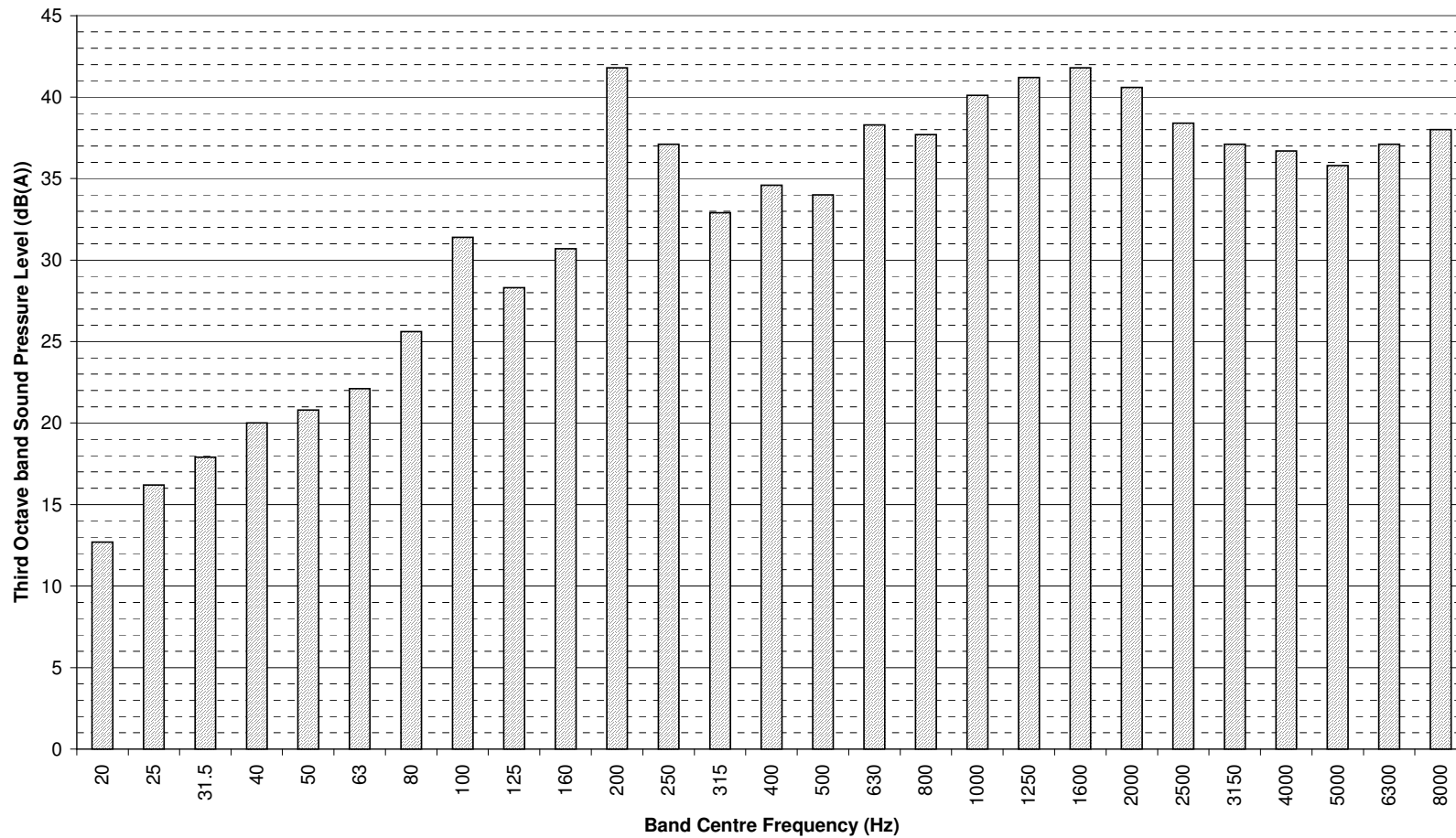
S_0 is a reference area, $S_0 = 1 \text{ m}^2$.

The 6 dB constant in equation (9) accounts for the approximate pressure doubling that occurs for the sound level measurements on a ground board.

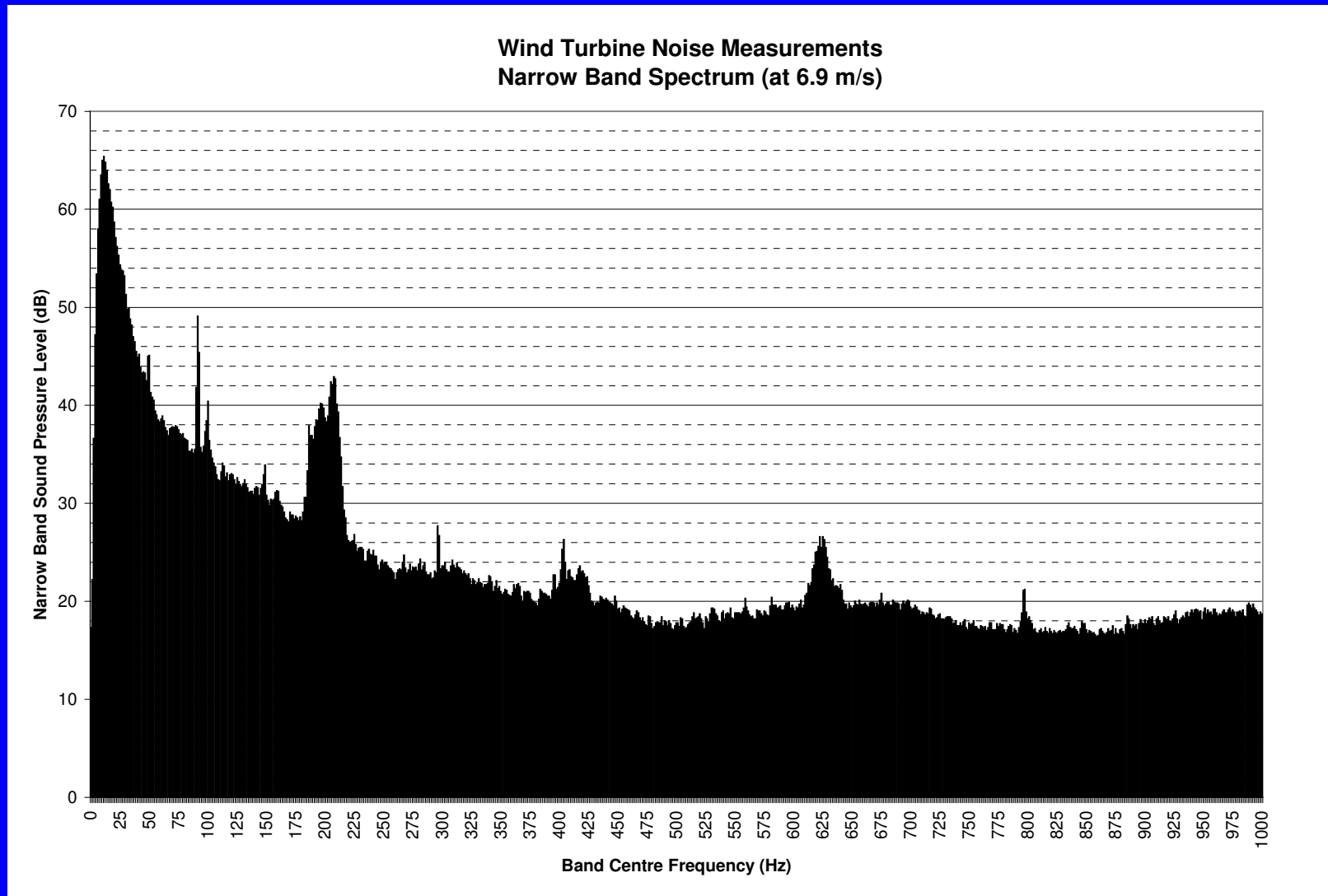


One Third Octave Band Levels

Wind Turbine Noise Measurements
A-Weighted Third Octave Band Spectrum at 7.7 m/s

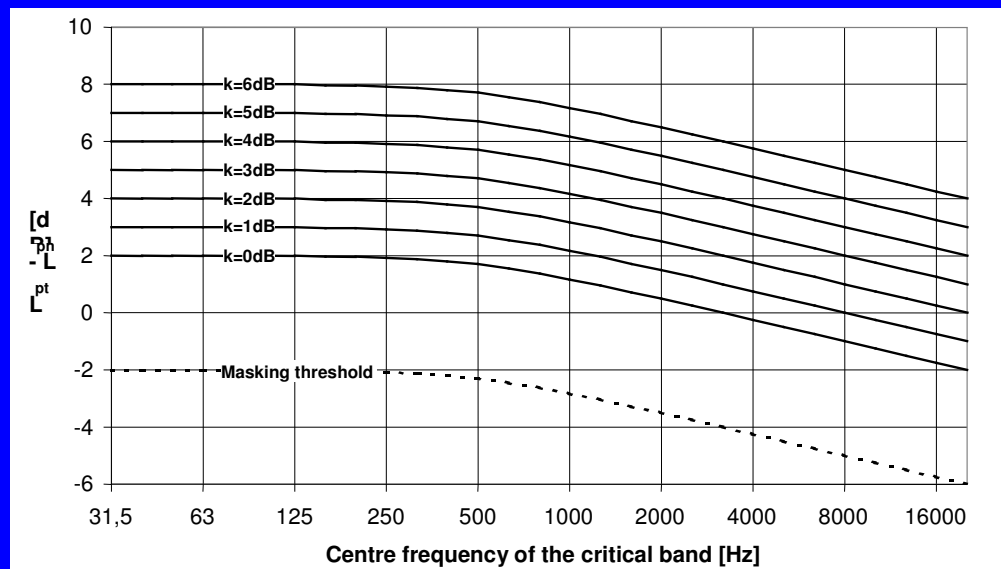


Narrow Band Spectrum



Narrow Band Analysis

- Determine SPL of Tone(s) within Critical Band (1)
[CB \cong 100 Hz for $f_c < 500$ Hz and $0.2f_c$ for $f_c > 500$ Hz]
- Determine SPL of Critical Band Noise Level in Absence of Tone(s) (2)
- Determine Tonality [= (2)-(1)] (3)
- Determine Audibility [= (3) – Audibility Threshold]



Noise Report

- Sound Power Levels at Integer Wind Speeds
(Preferably over as wide a range as possible)
- Octave or 1/3 Octave Band Levels for Predictions
- Tonal Assessment for Possible Application of Penalty
or (preferably) to prove that no penalty is required.



Conclusions

- Detailed noise data can and should be provided for micro-wind turbines.
- Measurements should be carried out to requirements of BS EN 61400-11.
- Provides for overall sound power level, 1/3 octave spectra and tonality assessment.
- This allows a proper assessment of impact to be carried out.

