BWEA

Delivering the UK's wind, wave and tidal energy

British Wind Energy Association
Small Wind Turbine Performance and Safety Standard
29 Feb 2008

1   General Information

1.1   Purpose

This standard was created by the small wind turbine industry, scientists, state officials, and consumers to provide consumers with realistic and comparable performance ratings and an assurance the small wind turbine products certified to this standard have been engineered to meet carefully considered standards for safety and operation. The goal of the standard is to provide consumers with a measure of confidence in the quality of small wind turbine products meeting this standard and an improved basis for comparing the performance of competing products.

1.2   Overview

1.2.1   This performance and safety standard provides a method for evaluation of wind turbine systems in terms of safety, reliability, power performance, and acoustic characteristics. This standard for small wind turbines is derived largely from existing international wind turbine standards developed under the auspices of the International Electrotechnical Commission (IEC). Specific departures from the IEC standards are provided to account for technical differences between large and small wind turbines, to streamline their use, and to present their results in a more consumer-friendly manner. The equivalent BS (British Standard) are quoted for ease of use.

1.2.2   No indirect or secondary standards references are intended. Only standards directly referenced in this standard are embodied.

1.3   Scope

1.3.1   This standard generally applies to small wind turbines for both on-grid and off-grid applications.

1.3.2   This standard applies to wind turbines having a rotor swept area of 200 m2 or less. In a horizontal-axis wind turbine this equates to a rotor diameter of ~ 16 m (~ 52 ft)

1.3.3   A turbine system includes the wind turbine itself, the turbine controller, the inverter, if required, wiring and disconnects, and the installation and operation manual(s).

1.3.4   In cases where several variations of a turbine system are available, it is expected that a full evaluation would be performed on one of the most representative arrangements. Other variations, such as different power output forms, need only be evaluated or tested in the ways in which they are different from the base configuration. For example, a wind turbine available in both grid-intertie and battery charging versions would need separate performance tests if both versions were to be certified, but would not need a separate safety evaluation in most cases.

1.3.5   Except as noted in Sections 2.1.1, 4.2, 5.2.6, 5.2.7, and 6.1.4.1, towers and foundations and support structures are not part of the scope of this standard because it is assumed that conformance of the tower structure to the International Building Code, Uniform Building Code or their local equivalent

will be required for a building permit.

1.4 Compliance

1.4.1 Compliance with this standard must be certified by an independent certification body itself accredited to the requirements of EN 45011 by UKAS or an equivalent accreditation body (for example, a member of EA: European Co-operation for Accreditation).

1.4.2 Test data may be taken, analyses may be performed, and test reports may be submitted by any party, including the manufacturer, but they must be provided in a manner acceptable to an accredited certifying body[1].

1.4.3 As an interim measure to 1.4.1 self-certification may be undertaken by the manufacturer subject to the ongoing consent of the British Wind Energy Association (BWEA).

1.5 Definitions

1.5.1 Per BS EN 61400-12-1:2006 (Performance); BS EN 61400-11:2003 (Acoustic Noise); and BS EN 61400-2:2006 (Design Requirements).

1.5.2 Additional Definitions

1.5.2.1 BWEA Reference Power: The wind turbine's power output at 11.0 m/s (24.6 mph) per the power curve from BS EN 61400-12-1.

1.5.2.2 BWEA Reference Annual Energy: The calculated total energy that would be produced during a one-year period at an average wind speed of 5.0 m/s (11.2 mph), assuming a Rayleigh wind speed distribution, 100% availability, and the power curve derived from BS EN 61400-12-1 (sea level normalized).

1.5.2.3 BWEA Reference 60m Sound Level, $L_p,60m$. The sound pressure level in dB(A) re 20 µPa rounded up to the nearest dB, at an observer distance of 60 m from the rotor centre (i.e. a slant distance) and calculated from the Declared Apparent Emission Sound Power Level when the turbine is subjected to a wind speed of 8 m/s at its rotor centre. The 60 m distance is representative of the closest observer distance expected for a turbine toward the larger size of small wind turbines.

1.5.2.4 BWEA Reference 25m Sound Level, $L_p,25m$. The sound pressure level in dB(A) re 20 µPa rounded up to the nearest dB, at an observer distance of 25 m from the rotor centre (i.e. a slant distance) and calculated from the Declared Apparent Emission Sound Power Level when the turbine is subjected to a wind speed of 8 m/s at its rotor centre. The 25 m distance is representative of the closest observer distance expected for a micro or domestic size turbine.

1.5.2.5 Cut-in Wind Speed: The lowest wind speed at which a wind

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[1] Unless conducted by an accredited and independent test laboratory, this will normally require that the certification authority be involved well before the commencement of data gathering, and the certification authority are likely to require intense scrutiny of the entire process.

turbine will begin to have power output[2].

    1.5.2.6   Cut-out Wind Speed: The wind speed above which, due to control function, the wind turbine will have no power output.

    1.5.2.7   Maximum Power: The maximum one-minute average power output a wind turbine in normal steady-state operation will produce (peak instantaneous power output can be higher).

    1.5.2.8   Maximum Voltage: The maximum voltage the wind turbine will produce in operation including open circuit conditions.

    1.5.2.9   Maximum Current(s): The maximum current(s) the wind turbine will produce on each side of the systems control or power conversion electronics.

    1.5.2.10   Overspeed Control: The action of a control system, or part of such system, which prevents excessive rotor speed.

    1.5.2.11   Power Form: Physical characteristics which describe the form in which power produced by the turbine is made deliverable to the load.

    1.5.2.12   Rotor Swept Area: Projected area perpendicular to the wind direction swept by the wind turbine rotor in normal operation (un-furled position). If the rotor is ducted, the area inscribed by the ducting shall be included.

    1.5.2.13   Turbulence Intensity: The standard deviation of 1-second wind speed data divided by the mean of 1-second wind speed data averaged over a period of 1-minute.

1.6   Units

    1.6.1   The primary units will be SI (metric). The inclusion of secondary units in the English system is recommended [e.g., 10 m/s (22.4 mph)].

1.7   Test Turbine and Electronics

    1.7.1   Tested wind turbines and their associated electronics shall conform to the specific requirements of the governing IEC / BS EN wind generator standard for each test, but incorporating any amendments contained in this standard.

2   Performance Testing

2.1   Wind turbine performance shall be tested and documented in a test report per the latest edition of BS EN 61400-12-1, but incorporating the additional guidance provided in this section.

    2.1.1   In Section 5.1, Wind Turbine and Electrical Connection[3]: When characterizing performance, the wind turbine generator system shall include the following components, as appropriate: the turbine; turbine tower; turbine

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[2] As determined per Section 2.1.6

[3] These section numbers refer to Section 5.1 of BS EN 61400-12-1 here, and similarly to the relevant standards referenced elsewhere.

controller, regulator, or inverter; wiring between the turbine and the load; transformer; and dump load. Power shall be measured at the connection to the load such that the losses in the complete wind turbine system are included[4].

2.1.2 Battery banks are not considered to be part of the wind turbine system for battery-charging wind turbines, but they are considered to be part of the system for grid-connected wind turbines that incorporate a battery bank.

2.1.3 Also in Section 5.1, Wind Turbine and Electrical Connection: The wind turbine shall be connected to an electrical load that is representative of the load for which the turbine is designed.

2.1.4 Also in Section 5.1, Wind Turbine and Electrical Connection: The wind turbine shall be installed using the manufacturer's specified mounting system. If a wind turbine is not supplied with a specific mounting system, the generator should be mounted at a hub height of at least 10 meters.

2.1.5 The total wire run length, measured from the base of the tower, must be at least 8 rotor diameters and the wiring is to be sized per the manufacturer's installation instructions.

2.1.6 The cut-in wind speed is the first wind speed bin in the averaged power curve that is positive.

2.1.7 Also in Section 5.1, Wind Turbine and Electrical Connection: The voltage regulator in a battery-charging system shall be capable of maintaining voltage at the connection of the turbine to the batteries within normal operating limits over the full range of power output of the turbine. During testing the manufacturer shall declare a **nominal battery voltage** that shall be within the range of 2.1 volts per cell to 2.5 volts per cell and that **nominal battery voltage** shall be the same for both the duration test and for the power curve test. The voltage regulator in a battery-charging system shall be capable of maintaining voltage at the connection of the turbine to the batteries within 10% of the nominal battery voltage over the full range of power output of the turbine. The 1-minute average of the load voltage must be within 5% of the nominal battery voltage to be included in the usable data set.

2.1.8 In Section 5.2.1, Location of meteorological mast: If it is more practical to mount the anemometer on a long boom that is connected to the turbine tower, a separate meteorological mast is not required. To minimize the potential for the wake from the anemometer, the wind vane and their mounting hardware to influence flow into a small rotor, all such components shall be located at least 3 meters away from any part of the rotor provided that the measurement anemometer is placed between 2-4 rotor diameters from the turbine (as per section 5.2.1 of BS EN 61400-12-1: 2006). In addition, the anemometer mounting should be configured to minimize its cross-sectional area above the level that is 1.5 rotor diameters below hub

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[4] For the avoidance of doubt the inverter is considered to be a system component, i.e. power shall therefore be power delivered after the inverter (power injected into the grid for grid-connected wind turbines; similarly power delivered to the batteries for battery-charging wind turbines).

height.

2.1.9 In Section 6.1, Electric power: Turbine output power shall be measured at the connection to the load.

2.1.10 In Section 6: In addition to electric power, voltage at the connection to the load shall be measured to ensure compliance with the requirements listed below.

2.1.11 In Section 6.4, Air density: The air temperature sensor and the air pressure sensor shall be mounted such that they are at least 1.5 rotor diameters below hub height even if such mounting results in a location less than 10 m above ground level.

2.1.12 In Section 6.6, Wind turbine generator status: Monitoring of small wind turbine status is required only when the turbine controller provides an indication of turbine faults.

2.1.13 In Section 7.3, Data collection: Preprocessed data shall be of 1-minute duration. In Section 7.4, Data rejection: Select data sets shall be based on 1-minute periods.

2.1.14 In Section 7.6, Database: The database shall be considered complete when it has met the following criteria:

2.1.14.1 Each wind speed bin between 1 m/s below cut-in and 14 m/s shall contain a minimum of 10 minutes of sampled data.

2.1.14.2 The total database contains at least 60 hours of data with the small wind turbine operating within the wind speed range.

2.1.14.3 The database shall include 10 minutes of data for all wind speeds at least 5 m/s beyond the lowest wind speed at which power is within 95% of Maximum Power (or when sustained output is attained).

2.1.15 In Section 8.1, Data normalization: For turbines with passive power control such as furling or blade fluttering, the power curve shall be normalized using Equation 3 (wind speed adjustment), Equation 2 (power adjustment), or an alternate method. Documentation must be provided to justify the use of an alternate method.

2.1.16 In Section 8.3, Annual energy production (AEP): In cases where the small wind turbine does not shut down in high winds, AEP measured and AEP projected shall be calculated as though cut-out wind speed were the highest, filled wind speed bin or 25 m/s, whichever is greater.

2.1.17 In Section 9, Reporting format: In addition to the information listed in clause 9, the description of the wind turbine and the test set-up shall include:

2.1.17.1 wiring sizes, conductor material, types, lengths and connectors used to connect the wind turbine to the load;

2.1.17.2 measured resistance of wiring between the inverter and the load or between the turbine and the load if no inverter is used;

2.1.17.3 voltage setting(s) for any over or under-voltage protection devices that

are part of the small wind turbine generator system;

2.1.17.4   nominal battery bank voltage (e.g., 12, 24, 48 volts);

2.1.17.5   battery bank size (i.e., amp-hour capacity), battery type and age; and

2.1.17.6   description including make, model, and specifications of the voltage regulation device used to maintain the battery bank voltage within specified limits.

2.2 The Performance Test Report shall include the turbulence intensity for each data set (sequential, unbroken, time series) so that the reviewers can pass judgment on the appropriateness of the test site.

3 Acoustic Sound Testing

3.1 The acoustic noise from a wind turbine shall be expressed as:

3.1.1   a "**Declared Apparent Emission Sound Power Level, $L_{Wd,8m/s}$**" in dB(A) re 10^{-12} Watts for a wind speed of 8 m/s at rotor centre height together with a "**Wind Speed Dependence, S_{dB}**" value in dB/m/s for the Declared Apparent Emission Sound Power Level. These are obtained from measurement of the turbine as described in Section 3.3.

3.1.2   an "**Immission Sound Pressure Level at 60m, $L_{p,60m}$**" in dB(A) re 20 µPa at a slant distance of 60 m for a wind speed of 8 m/s at rotor centre height. (i.e. the BWEA Reference 60 m Sound Level). This is calculated from the Declared Apparent Emission Sound Power Level, $L_{Wd,8m/s}$, assuming hemispherical propagation.

3.1.3   an "**Immission Sound Pressure Level at 25m, $L_{p,25m}$**" in dB(A) re 20 µPa at a slant distance of 25 m for a wind speed of 8 m/s at rotor centre height. (i.e. the BWEA Reference 25 m Sound Level). This is calculated from the Declared Apparent Emission Sound Power Level, $L_{Wd,8m/s}$, assuming hemispherical propagation.

3.1.4   an "**Immission Noise Map**" showing zones where audible incident (free field) sound pressure level is likely to fall in the 40 – 45 dB(A) range and how this is affected by slant distances from the rotor centre and wind speed at the rotor centre. This is calculated from the Declared Apparent Emission Sound Power Level, $L_{Wd,8m/s}$, and its wind speed dependence, S_{dB}, given in Section 3.1.1 assuming hemispherical propagation. The noise map will cover from cut-in speed to, where relevant, cut-out speed.

3.1.5   an indication of whether the turbine has any particular **Character** to its noise that would make its presence more noticeable.

3.2 The acoustic noise data as described in Section 3.1 shall be summarised in a "**Noise Label**". An example Noise Label is given in Figure 1. The scales of the label shall be from 1m/s to 18m/s and 5m to 100m, and the minimum coverage of the data on the label shall be from 1m/s to 11m/s and 5m to 100m. Areas of no data shall be clearly indicated.
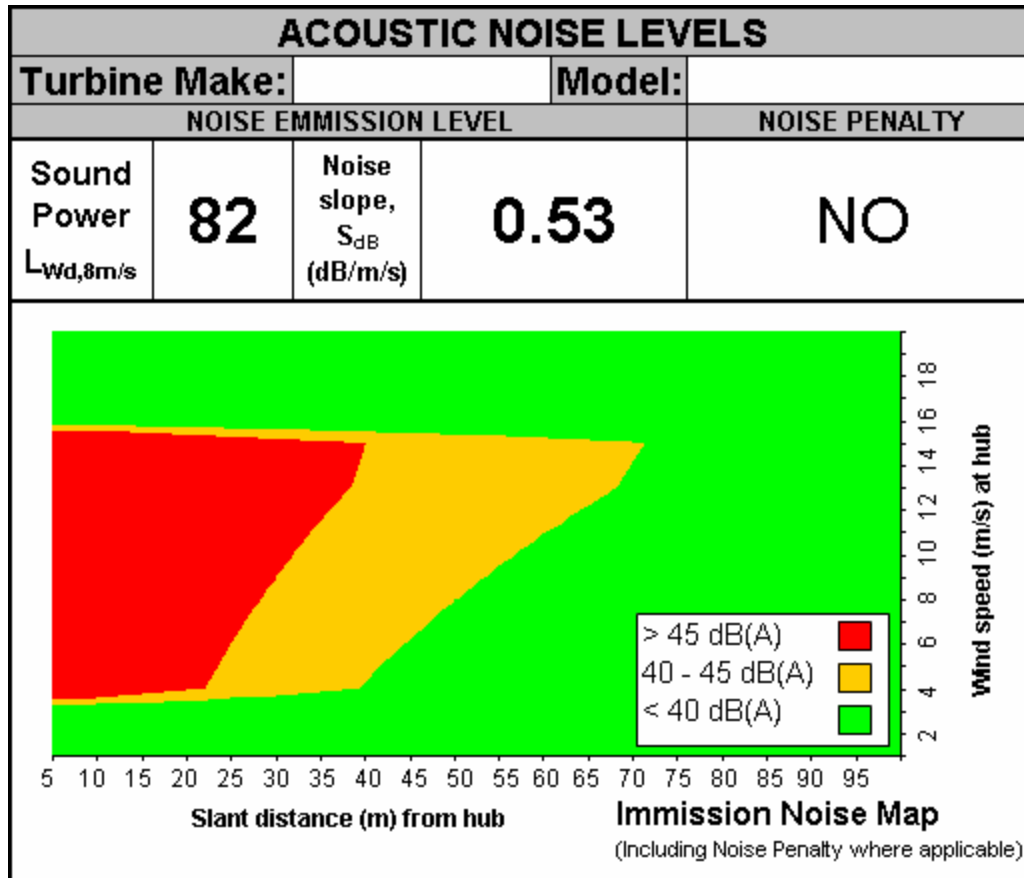
Figure 1. Example Noise Label

3.3 Appendix A provides further explanatory notes on the Noise Label and how the information can be used to assess the likely audible noise immission level for a particular distance from a planned or given installation.

Note: It should be stressed that the noise label is a summary of the acoustic information. More complete details on the measured noise levels and calculations need to be kept as part of the product Technical File held and maintained by the turbine manufacturer, or his representative, as justification for his CE marking of the product.

3.4 Acoustic **Noise Emission** gathered simultaneously with wind speed shall be measured in general accordance with BS EN 61400-11: 2003 but with the exceptions as follows:

3.4.1 The averaging period, t, for noise and wind speed data shall be at least t = 4*D seconds (i.e. 4 * rotor diameter, where D is expressed in metres) subject to a minimum period of 10 s. For a VAWT the rotor diameter is the effective rotor diameter, i.e. sqrt (d*h*4/π), presented to the wind. Shorter periods can be used and combined to give a 10 second or longer average consistent with t = 4*D.

3.4.2 The wind speed shall be measured, not derived from a turbine power curve.

3.4.3   The wind speed shall be referred to the rotor centre height, H, not 10m. If wind speed is measured at other than rotor centre height then it shall be corrected to rotor centre height using a power law as described in IEC 61400-11: 2003. The minimum wind speed measurement height to be used is 5m.

3.4.4   The anemometer shall initially be positioned 2 to 4 D directly upwind of the turbine rotor. To allow for the fact that small turbines yaw frequently, wind speed values will be accepted as long as the anemometer is within the upwind sector (i.e. ± 90° of the directly upwind direction to give a 180° arc).

3.4.5   The noise measurement will be made on a 1 m diameter ground-mounted board initially positioned at a distance R_o = the rotor tip height (i.e. H + D/2 for a HAWT) directly downwind of the rotor. To allow for the fact that small turbines yaw frequently, noise values will be accepted as long as the board is substantially within the downwind sector (i.e. ± 60° of the directly downwind direction to give a 120° arc).

3.4.6   The raw measured wind speed, not wind bins, shall be used to plot noise versus wind speed. At least 100 wind-speed noise data pairs shall be collected with data in valid sectors as described in 3.4.4, and 3.4.5 above.

3.4.7   Wind-speed versus noise data shall cover a range from cut-in wind speed to 11.0m/s as a minimum, and data should cover up to cut-out wind speeds if possible particularly for turbines that have speed control mechanisms.

3.4.8   To enable the effects of background noise to be established, wind speed versus noise data shall be captured for the turbine running and for the turbine parked. Background noise data need not cover the same range of wind speeds as for the turbine running but sufficient to establish the background noise versus wind speed relationship for the test site.

3.4.9   The reference wind speed shall be 8 m/s at the rotor centre height.

3.4.10 A linear regression of the wind speed versus noise with the turbine running will be used to give the board sound pressure level for a wind speed of 8 m/s at the rotor centre height. This will be corrected for background noise (again from a linear regression) also for a rotor centre wind speed of 8 m/s. This corrected value of board sound pressure level at 8 m/s shall be used to calculate the **Apparent Emission Sound Power Level, $L_{W,8m/s}$**, using spherical propagation and a board-correction of 6 dB.

3.4.11 The **Wind Speed Dependence, S_{dB}**, will be calculated as the slope of the linear regression of noise versus wind speed with turbine running in 3.4.10 above.

3.4.12 In the case of turbines that exhibit a noise wind speed characteristic that consists of two or more separate linear areas (e.g. as might be the case for turbines that have a speed-control cut-in region) then two or more separate linear regressions shall be fitted and used to plot the Immission Noise Map. One of these linear regressions shall span the range from at least 4.0 m/s to 10.0 m/s. Only the regression that spans the 8.0 m/s reference wind speed shall be used in the calculation of the Apparent Emission Sound Power

Level.

3.4.13 The uncertainty of the measurement (standard deviation, σ) shall be estimated including the uncertainty of the linear regression of noise versus wind-speed obtained in 3.4.10 with the turbine running.

3.4.14 The **Declared Apparent Emission Sound Power Level, L$_{Wd,8m/s}$** shall be calculated using the approach of IEC 61400-14: 2005 from the Apparent Emission Sound Power Level L$_{W,8m/s}$. Where tests on only one turbine of a current design configuration have been performed this is:

$$L_{Wd,8m/s} = L_{W,8m/s} + 1.645\,\sigma \qquad \text{(Eq.1)}$$

This equates to a 95% confidence level that the noise will be below this value at the reference wind speed.

3.4.15 The **Frequency content** based only on 1/3rd octave band analysis of the noise is acceptable. For fixed speed turbines, a plot of band levels at the reference wind speed (8 m/s) is sufficient. For variable speed turbines this shall be supplemented by plots at cut-in wind speed and the wind speed at which speed control commences. Each 1/3rd octave plot should show the dB(Lin) total, the dB(A) total and the dB(C) total for the spectrum.

3.4.16 The **Character** of the noise is assessed only for tonality. The method as in BS EN 61400-11 can be used but the simpler method as in ISO 1996-2:2007 Annex D based only on 1/3rd octave band data is acceptable as follows:

The turbine is declared tonal if any 1/3rd octave band (in any of the spectra from section 3.4.16) is higher than its adjacent bands by:

> 15 dB in the low frequency bands (50 to 125 Hz)
>
> 8 dB in the mid-frequency bands (160 to 400 Hz)
>
> 5 dB in the high frequency bands (500 to 10000 Hz)

3.4.17 If the turbine is declared tonal from the analysis in 3.4.16, the Noise Label must show the Noise Penalty as "YES" and the penalty applied, P, = 5 dB. If the turbine is not declared tonal, the Noise Penalty will be shown as "NO" and the penalty applied = 0 dB.

3.5. An estimation of the **Noise Immission** from the turbine, including **Noise Penalty, P**, will be made as follows:

3.5.1. The Immission Sound Pressure Level in dB(A) re 20 µPa at any slant distance X metres from the rotor centre for a wind speed of 8 m/s at rotor centre height is calculated using hemispherical propagation as follows:

$$L_{p,Xm} = L_{Wd,8m/s} + P - 10.Log_{10}(2.\pi.X^2) = L_{Wd,8m/s} + P - 8 - 20.Log_{10}(X) \quad \text{(Eq. 2)}$$

3.5.2. The "**Immission Sound Pressure Level at 60m, L$_{p,60m}$**" in dB(A) re 20 µPa for a wind speed of 8 m/s at the rotor centre height (i.e. the BWEA Reference 60 m Sound Level) is calculated as follows:

$$L_{p,60m} = L_{Wd,8m/s} + P - 43.5dB \qquad \text{(Eq. 3)}$$

3.5.3. The "**Immission Sound Pressure Level at 25m, L_{p,25m}**" in dB(A) re 20 µPa at for a wind speed of 8 m/s at the rotor centre height (i.e. the BWEA Reference 25 m Sound Level) is calculated as follows:

$$L_{p,25m} = L_{Wd,8m/s} + P - 36dB \qquad \text{(Eq. 4)}$$

3.5.4. Data for the "**Immission Noise Map**" is calculated over a range of wind speeds V m/s at rotor centre height using the following process:

a) Through a rearrangement of equation (2), the slant distance X metres required to give a target noise level of Y dB from a source of sound power level L_W dB is given by:

$$X_{YdB} = 10^{\left(\frac{L_W + P - 8 - Y}{20}\right)} \qquad \text{(Eq. 5)}$$

b) At a given wind speed V m/s at rotor centre height this gives:

$$X_{YdB} = 10^{\left(\frac{L_{Wd,8m/s} + S_{dB}(V-8) + P - 8 - Y}{20}\right)} \qquad \text{(Eq. 6)}$$

c) Hence the distances required for a given wind speed V m/s at rotor centre height are for levels if 45 dB(A) and 40 dB(A) respectively:

$$X_{45dB} = 10^{\left(\frac{L_{Wd,8m/s} + S_{dB}(V-8) + P - 53}{20}\right)} \qquad \text{(Eq. 7)}$$

$$X_{40dB} = 10^{\left(\frac{L_{Wd,8m/s} + S_{dB}(V-8) + P - 48}{20}\right)} \qquad \text{(Eq. 8)}$$

d) If the Noise emission has two or more separate linear regions as described in Section 3.4.12 above, then equations (7) and (8) need to use the data from both slope regions rather than just the one. This will give a "kink" point in the Immission Noise Map. Appendix A provides some comment on this and other features of the Immission Noise Map.

4 Strength and Safety

4.1 Except as noted below, mechanical strength of the turbine system will be assessed using either the simple equations in Section 7.4 of BS EN 61400-2:2006 in combination with the safety factors in Section 7.8, or the aeroelastic modeling methods in Section 7.9. Evaluation of, as a minimum, the blade root, main shaft and the yaw axis (for HAWT's) will be performed using the outcome of these

equations. A quick check of the rest of the structure for obvious flaws or hazards will be done and if judged needed, additional analysis may be required.

4.2   Variable speed wind turbines are generally known to avoid harmful dynamic interactions with towers. Single/dual speed wind turbines are generally known to have potentially harmful dynamic interactions with their towers. Therefore, in the case of single/dual speed wind turbines, such as those using either one or two induction generators, the wind turbine and tower(s) must be shown to avoid potentially harmful dynamic interactions. A variable speed wind turbine with dynamic interactions, arising for example from control functions, must also show that potentially harmful interactions are likewise avoided.

4.3   Other safety aspects of the turbine system will be evaluated including:

4.3.1   procedures to be used to operate the turbine;

4.3.2   provisions to prevent dangerous operation in high wind;

4.3.3   methods available to slow or stop the turbine in an emergency or for maintenance; and

4.3.4   adequacy of maintenance and component replacement provisions.

4.4   A Safety and Function Test shall be performed in accordance with Section 9.6 of BS EN 61400-2:2006.

5 Duration Test

5.1   To establish a minimum threshold of reliability, a duration test shall be performed in accordance with the BS EN 61400-2:2006 Section 9.4.

5.2   The following are additions and clarifications to this standard, none of which shall be interpreted as a reduction in the requirements of this standard:

5.2.1   The test shall continue for 2500 hours of power production.

5.2.2   The test must include at least 25 hours in wind speeds of 15 m/s (33.6 mph) and above.

5.2.3   Downtime and availability shall be reported and an availability of 90% is required.

5.2.4   Minor repairs are allowed, but must be reported.

5.2.5   If any major component such as blades, main shaft, generator, tower, controller, or inverter is replaced during the test, the test must be restarted.

5.2.6   The turbine and tower shall be observed for any tower dynamics problems during the duration test and the test report shall include a statement of the presence or absence of any observable problems.

6 Reporting and Certification

6.1   For each model to be certified the manufacturer shall submit to an accredited certifying body for review and certification:

6.1.1 Summary Report, containing a power curve, an AEP curve, the Noise Label, and the measured sound pressure levels (Section 9.4 of BS EN 61400-11:2003 as modified or extended by Section 3 of this BWEA standard).

This report, once approved by an accredited certifying body, is to be made publicly available

6.1.2 Performance Test Report

6.1.3 Acoustic Test Report including the Noise Label

6.1.4 BWEA Reference Annual Energy

6.1.5 BWEA Reference 60m Sound Level, Lp,60m

6.1.6 BWEA Reference Power, at 11.0 m/s (24.6 mph)

6.1.7 Wind Turbine Strength and Safety Report

6.1.7.1 The tower top design loads shall be reported

6.1.8 Duration Test Report

6.2 The manufacturers of certified wind turbines must also abide by the labeling requirements of Section 7.

7 Labeling

7.1 BWEA Reference Annual Energy (BWEA RAE) shall be provided in any product literature or advertising in which product specifications are provided.

7.1.1 The BWEA RAE shall be rounded to no more than 3 significant figures.

7.1.2 The form of presentation can be in plain text, but the preferred form is
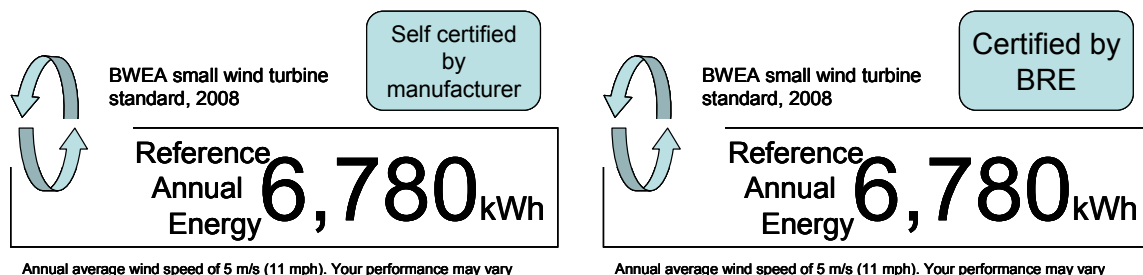
(example of self certified form on left; externally certified form on right[5]):

7.2 The manufacturer shall use BWEA Reference Power if a rated power is specified.

7.3 The manufacturer shall provide the Noise Label in any product literature or advertising in which product specifications are provided.

7.4 Other recommended performance specifications are:

7.4.1 Cut-in Wind Speed

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[5] Insert name of manufacturer, or alter the example of BRE to any other certification authority as appropriate.

7.4.2 Cut-out Wind Speed

7.4.3 Maximum Power

7.4.4 Maximum Voltage

7.4.5 Maximum Current(s)

7.4.6 Overspeed Control

7.4.7 Power Form

7.5 The use of more detailed performance characterizations, such as power curves or estimated energy output graphs or tables, is allowed so long as this material was included in the certification.

8 Changes to Certified Products

8.1 It is anticipated that certified wind turbines will occasionally be changed to provide one form of improvement or another. In some cases such changes will require review by an accredited certifying body and possible changes to the certified product parameters. The following guidance is provided concerning when product changes will require review by an accredited certifying body:

8.1.1 Any changes to a certified wind turbine that will have the cumulative effect of reducing BWEA Reference Power or BWEA Reference Annual Energy by more than 10% will require retesting and recertification by an accredited certifying body. Only those characteristics of the wind turbine affected by the design change(s) would be reviewed again.

8.1.2 Any changes to a certified wind turbine that will have the cumulative effect of raising the BWEA Reference Sound Level by more than 1 dBA will require retesting and recertification by an accredited certifying body. Only those characteristics of the wind turbine affected by the design change(s) would be reviewed again.

8.1.3 Any changes to a certified wind turbine that could reduce the strength and safety margins by 10%, or increase operating voltages or currents by 10%, will require resubmission of the Wind Turbine Strength and Safety Report and recertification by an accredited certifying body.

8.1.4 Any changes to a certified wind turbine that could materially affect the results of the Duration Test will require retesting, submission of a new Duration Test Report, and recertification by an accredited certifying body.

8.2 For the first two years after turbine certification the manufacturer is required to notify the accredited certifying body of all changes to the product, including hardware and software. The accredited certifying body will determine whether the need for retesting and additional review under the guidelines provided in Section 8.1.

8.3 The use of Engineering Change Orders or their equivalent is recommended.

9 References and Appendices

9.1 References[6].

9.1.1 BS EN 61400-12-1: 2006, Wind Turbines: Power performance measurement of grid connected wind turbines.

9.1.2 BS EN 61400-11:2003, Wind turbine generator systems: Acoustic noise measurement techniques. (Note: identical to IEC 61400-11:2002)

9.1.3 IEC 61400-11:2006 Wind Turbine Generator Systems – Part 11: Acoustic noise measurement techniques (Note: new consolidated version of 2002 edition)

9.1.4 BS EN 61400-2:2006 , Wind turbine generator systems: Design requirements of small wind systems.

9.1.5 IEC TS 61400-14:2005 Wind turbines – Part 14: Declaration of apparent sound power level and tonality values

9.1.6 BS 7445-2:1991 (identical to ISO 1996-2:1987) Description and measurement of environmental noise. Guide to the acquisition of data pertinent to land use.

9.1.7 BS 7445-1:2003 Description and measurement of environmental noise. Guide to quantities and procedures.

9.1.8 ISO 1996-2:2007 Acoustics - Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels.

9.1.9 BS ISO 9611: 1996 Acoustics – Characterisation of sources of structureborne sound with respect to sound radiation from connected structures – Measurement of velocity at the contact points of machinery when resiliently mounted.

9.1.10 MIS 3003: Microgeneration Installation Standard: Requirement for contractors undertaking the supply, design, installation, set to work commissioning, and handover of micro and small wind turbine systems.

9.1.11 BS 4142: Method for rating industrial noise affecting mixed residential and industrial areas.

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[6] The British Standards (BS) are the official English Language versions of the respective European Standards (EN) which in turn correspond to the International Standards published by the IEC.

Appendix A

NOTES ON THE USE OF NOISE LABEL INFORMATION

A.1   Notes on Features of the Immission Noise Map

The example Noise Label is shown in Figure A.1 containing the Noise Map. The map is plotted at levels of 40 and 45 dB(A) since these are most relevant to the levels used for planning purposes. The map is plotted from the cut-in wind speed up to the cut-out wind speed for the given turbine.
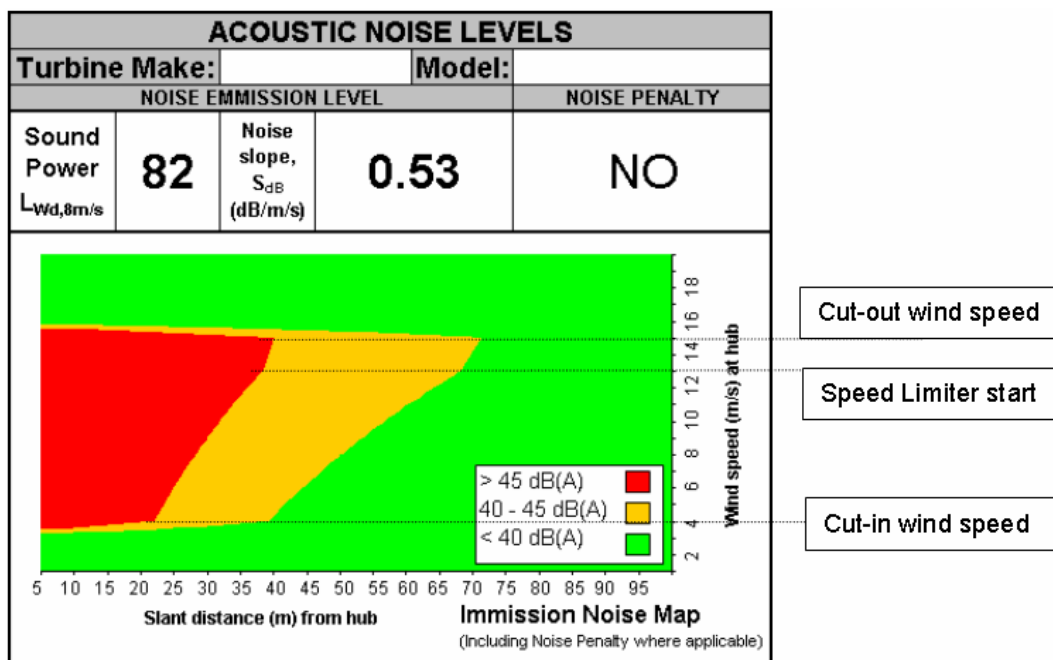

Figure A.1 Small Wind Turbine Noise Label Example – features

However, some designs of turbine do not have a cut-out speed but achieve protection to high winds by various mechanisms such as furling their blades or yawing the turbine to cross-wind. In these cases the red and orange zones of the Noise Map will continue up to the wind scale maximum.

When a turbine starts to encounter high winds it generally has some form of in-built speed control or speed protection and that may manifest itself as a change in the acoustic output of the turbine. It can be expected that in this circumstance there may be a "kink point" in the Noise map as labelled in figure A.1.

A.2   Use of Noise Map Information to Assess Site Suitability

The following procedure can be used to assist an installer or consumer in considering the suitability of a prospective site. The procedure can also be used by the turbine manufacturer when considering the suitability of a specific region of the country for a given size of turbine.

The procedure is based on the use of the NOABL mean wind speed database which provides wind data at 45m, 25m and 10m height in 1 km squares covering Great Britain and Northern Ireland. More information is available at www.bwea.com/noabl/index.html. Equivalent wind speed maps could be used in other countries as the starting point for this procedure.

a)   Find the National Grid reference for the location being considered. This can be obtained from a map or from the Postcode (Zipcode) if a suitable conversion programme is available.

Shorten the reference to the NOABL required format; e.g. if the Grid Reference is NS641532, then the NOABL input value is NS 64 53.

b)   Use NOABL to get the average annual wind, $V_{avg,10}$ at 10m height for the location.

c)   Assume a Rayleigh wind distribution, calculate the 90% wind $V_{90,10}$ for 10 m height as:

$$V_{90,10} = 1.52 * V_{avg,10}$$

d)   Apply a wind correction factor from 10m height using a power law (in accordance with IEC 61400-2) to get an estimate of wind at the installed rotor centre height, H, as:

$$V_{90,H} = V_{90,10} * \left(\frac{H}{10}\right)^{0.2}$$

e)   Draw a horizontal line on the Immission Noise Map at the $V_{90,H}$ wind speed.

f)   Read-off the distance for the 45 dB(A) and 40 dB(A) values.

g)   Compare these distances with the slant distance to the nearest noise sensitive location(s) for the planned installation.

In general any location(s) that lie in the Red region are unlikely to be given planning permission. Locations that lie in the Green region would generally be acceptable. Locations that lie in the Amber region may or may not be acceptable depending on factors such as national or local planning legislation.

As an example, consider a site where the NOABL wind was 5 m/s at 10 m height and a turbine to be installed at 7 m rotor centre height and the nearest noise sensitive location was 50 m away. This will give a $V_{90,10}$ speed of 7.6 m/s and a $V_{90,H}$ speed of 7.1 m/s. When plotted on the turbine's Immission Noise Map, figure A.2, this gives approximate slant distances of 26 and 47 m for 45 and 40 dB(A) respectively. Hence in this example the 50 m proposed installation would be acceptable if the relevant threshold was 40dB(A) for planning permission.
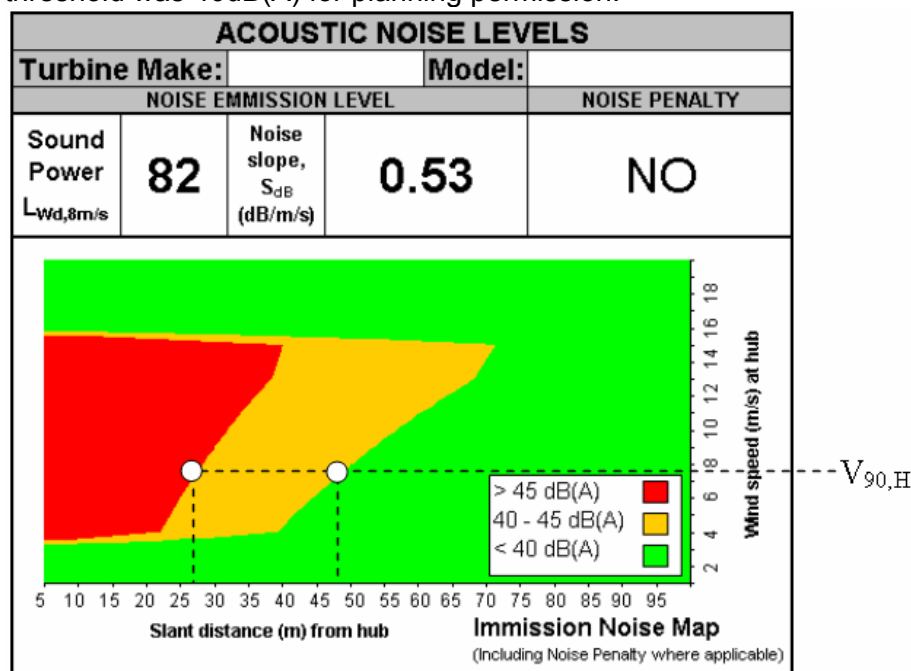

Figure A.2 Small Wind Turbine Noise Label – Example to assess site suitability

Note: This procedure provides a conservative estimate since it does not further reduce the wind strength in step d) based on local obstructions and hence errs on the side of the general public rather than the turbine manufacturer. If there are buildings or other obstructions in the vicinity of the turbine then further weighting factors could be applied to account for wind-shadow effects (for example see MCS standard MIS 3003). This in general will lower the $V_{90,H}$ value and result in closer allowable slant distances.

A.3 Local Background Noise

Almost regardless of what the actual absolute level of noise is that is produced by a given turbine, whether or not that turbine will be audibly noticeable at a given location will be heavily dependent on the local background noise at that location.

Ignoring wind and weather effects, i.e. under calm conditions, typical background noise levels range from 35 dB(A) (quiet) to 50 dB(A) (noisy) in an urban setting.

For a given location, background sound levels depend greatly on the presence of trees, buildings, fences and also on the proximity of roads, railways, air routes and other sound sources (i.e. anything other than the turbine). In certain locations, wildlife noise, particularly from birds, is also a factor in background noise. Noise from passive sources (e.g. trees, fences, telephone wires, pylons, aerials, overhead cables etc..) is strongly affected by the wind strength and wind direction. Wind strength and direction also affect propagation from distant noise sources such as roads, railways and aircraft. As the turbine noise increases with wind strength, so will the background noise.

Few studies have been carried out to show how background noise varies as wind strength at high wind speed although some urban studies have looked at the 1-5 m/s region. The larger collection of background noise data at high wind speed is probably available from site assessments or from data collected during turbine noise certification exercise. For turbine noise measurements, noise measurements are intentionally made on a ground mounted board (with windshield) to remove the microphone from the wind-shear region and hence minimise the noise floor. This allows measurement to be made at high wind speeds.

From a range of wind turbine measurements (carried out by TUV NEL) on different test sites both in the UK and Europe, background noise, $L_{p,bgd}$, due to the wind was found to vary greatly from site to site but a typical level in the middle of a country field as a function of wind speed, V, at 10 m height is shown to approximately follow a line:

$$L_{p,bgd} = 28 + 2.25 * V \qquad\qquad (Eq. A.1)$$

It should be noted these measurements were obtained for a microphone on a ground mounted board and the microphone fitted with a primary windshield only. Lower background noise may be achievable by use of a primary and a secondary windshield.

At 8 m/s the background noise might be expected to be ~46 dB(A) and vary from 37 to 70 dB(A) from cut-in wind speeds of 4 m/s through to cut-out wind speeds of 18 m/s. Basically the nearer to trees, power lines, telephone lines, fences, buildings etc… one is the higher the background noise so the 33-70 dB(A) figure could be an underestimate of the local background noise.

With the lack of any other data on background noise at high wind speeds, equation (Eq. A.1) can be taken as a worst-case scenario (i.e. the lowest ambient noise) for a rural background since the test site noise measurement locations are generally well away from obstructions and other noise sources and, as mentioned above, are noise at ground level.

Noise from the turbine alone, including noise penalty, P, where P = 5 dB if the Noise Penalty is shown as YES on the Noise Label, P = 0 dB otherwise; at any distance, X m away, i.e. $L_{p,Xm}$; and at a wind speed, V m/s at the rotor centre; can be obtained from the simple $L_{Wd,8m/s}$ level and the Noise Slope, S_{dB}, using:

$$L_{p,Xm} = L_{Wd,8m/s} + S_{dB}*(V-8) + P - 8 - 20*Log_{10}(X) \qquad \text{(Eq. A.2)}$$

This gives a 6 dB reduction in level every time the distance away is doubled. Alternatively, there is a 6 dB increase in level every time the distance is halved.

BS 4142 is commonly used to assess whether a certain level of noise above background will increase the likelihood of complaint. The broad rules under which BS 4142 operates are that a "noise rating level" (i.e. the noise level once corrected for the presence of tones or other noise characteristics, that is, including the Noise Penalty) of 10 dB above the background noise is likely to give rise to complaint, one only 5 dB above background would be marginal and one 10 dB below background is unlikely to give rise to complaint.

Comparing the results of equations (Eq. A.1) and (Eq. A.2) for a given wind speed and distance gives a very approximate but simple means of estimating whether the turbine noise will be noticeable above background in rural situations.

If the turbine on its own is of the same level as the background it will still be noticeable when it either cuts-in or cuts-out. Only a few dB lower than background is generally needed for the background noise to dominate and the turbine to be unnoticed.

Assessment however has to be made on a case-by-case basis since background noise is so location specific.