Wind turbine sound power testing

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Outline

What is sound power testing?

Why do we do it?

How do we do it?

What to be aware of

Receptor guarantees vs sound power guarantees
Sound power testing

- Measurements to determine the sound power level of an individual turbine

- Sound power level is distance/site independent measure of sound output of a turbine

- Measure downwind at approx. 130 m from turbine across suitable range of wind speeds

- Analyse measured levels (controlling for known factors) to determine sound power level

- May also include tonality, amplitude modulation and impulsivity tests
Sound power vs sound pressure

• Sound power level is a measure of the sound emitted by a source that is independent of distance. Units: dB re $10^{-12}$ W.

• Sound pressure level is the actual sound level at a particular distance/position from a source. Units: dB re 20 $\mu$Pa.

• Sound pressure level is dependent on sound power (and other factors).

• From a sound power level for turbines at a site, the sound pressure level can be predicted considering other relevant factors such as site layout, distance and topography.

• Therefore, sound power can be determined from sound pressure measurements near to the source if we can control other factors – sound power testing.
Why do sound power testing?

• Provides a non site dependent (and therefore transferable) measure of the noise produced by a particular turbine model.

• Assess compliance with contractual guarantees provided by OEM.

• Assessing site compliance based on sound power – not currently done in Australia but is in parts of Europe.

• Investigate Special Audible Characteristics – normally tonality.
How do we do it?


- Measure downwind of turbine at hub height + ½ diameter using a microphone laid flat on an acoustically reflective board:

  - The ground board is used to provide a consistent reflection from the ground between sites.
What does the Standard require?

• Wind speeds of 0.8-1.3x the speed at 85% rated power (2012).

• Measurements in 10-second intervals with at least 10 data points required for each half-integer wind speed.

• Noise with turbine ON to be at least 3 dB higher than with it OFF across frequency range – normally have to switch off nearest turbine.

• Same amount of data points required with turbine OFF as with turbine ON.

• Downwind ±15° only. Optional crosswind and upwind positions provided but rarely used.

• Allowable measurement angle to turbine hub of 25 to 40°.
What does the Standard require?

Measured sound pressure levels are binned for each half-integer wind speed with the turbine ON and turbine OFF.

The turbine ON measurements (corrected for turbine OFF) are used to calculate sound power levels for the wind turbine at each half-integer speed considering:

• the measured sound pressure levels
• the measurement distance and angle
• frequency content of the sound.

Uncertainty for the sound power level reported at each wind speed to address variation in noise levels and possible equipment/measurement errors.

The tonal audibility of potential tones is determined at each half-integer wind speed and reported if audibility exceeds -3.0 dB.
What changed in IEC 61400-2012 version?

In terms of end result not a lot actually changed between 2006 and 2012… Which is good – you should still get the same sound power level at the end of the day.

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Wind speed height</td>
<td>Standardised 10 m</td>
<td>Hub height</td>
<td>No significant difference as 2006 used standardised 10 m related to hub height by a fixed amount.</td>
</tr>
<tr>
<td>Wind speed bins</td>
<td>Results reported for integer wind speeds</td>
<td>Results reported for half-integer speeds</td>
<td>Provides additional information but overall sound power unlikely to change significantly with half-integer steps.</td>
</tr>
<tr>
<td>Measurement period</td>
<td>Minimum 1-minute</td>
<td>10-second</td>
<td>More data points required in 2012 but lower overall measurement duration required.</td>
</tr>
<tr>
<td>Determining average</td>
<td>Polynomial trendline fitted across speeds preferred</td>
<td>Binned at each half-integer speed</td>
<td>2012 provides a better result. Bin method was already employed in many cases as a deviation to 2006.</td>
</tr>
<tr>
<td>Tonality</td>
<td>Two periods nearest to each integer speed</td>
<td>Average over all data in each bin</td>
<td>Likely to get a more representative result with 2012 but still limited to same wind conditions</td>
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</table>
What to be aware of with IEC 61400-11

**Wind conditions**
Testing can be labour-intensive, so selecting appropriate wind conditions to eliminate return visits is important. Desire winds from a steady direction over a wide range of speeds.

**Background data**
Data with the turbine OFF is almost more important than that with it ON. Need good background data for all speeds to produce accurate results.

**Secondary windshields**
Standard allows for optional secondary windshields. Unlikely to be necessary for the A-weighted sound power level but could provide more accuracy of lower frequency sound power levels.
What to be aware of with IEC 61400-11

Variability
IEC sound power tests are typically highly repeatable. Sound power levels over repeated tests are unlikely to differ by more than 1 dB at any wind speed.

However, some factors can influence the calculated sound power level:
• Measurement distance – distance correction methodology in Standard is not perfect
• Measurement angle – very important that the angle of incidence is above 25º
• Groundboard – poor contact between the groundboard and ground increases measured noise levels
• Tonality – while downwind is worst case for overall sound, this is unlikely to be the case for tonality
Receptor vs sound power guarantees

Until recently, OEMs were required to provide sound power guarantees for their turbines which applied at the turbine only.

Nowadays, almost all contracts include a request for a receptor guarantee where the OEM guarantees compliance with State/National guidelines at receptors.

With respect to sound power testing:
• Receptor guarantees mean that there is unlikely to be a requirement for it on Australian sites in the future.
• Even if this is the case, however, an understanding of the process is still important to enable interpretation of data provided for turbines during the planning stage of a site.
Receptor vs sound power guarantees

A brief survey of OEMs raised the following concerns about receptor guarantees:
• While OEMs can control turbine sound power, they typically have little or no control over other factors that influence compliance at receptors (e.g. distance, layout, wind conditions, landowner agreements etc). Therefore increased risk for the OEMs.
• May have a price premium, and potentially capacity reduction, as a result of the above.
• Where a receptor guarantee is provided, it is unlikely that any guarantee would be provided regarding sound power.
• Australia is almost unique in requiring receptor guarantees, although requests have started to arise in the UK.

And finally an interesting comment:
• A sound power test at a turbine provides a very clear pass or fail.
• However it can be very difficult to establish compliance or non-compliance clearly at a receptor due to the influence of background noise.
• Even if non-compliance is established, it may not be a result of turbines being louder than stated.
Conclusion

• Sound power testing is important to assess the sound output independent of other factors that influence noise at receptors.

• Accurate sound power data is critical for accurate noise modelling of a site.

• The IEC 61400-11 Standard is applied globally for this purpose and provides repeatable test results for turbines.

• However, there are items to be aware of that can introduce variability to the results.

• With the emergence of receptor guarantees, does sound power testing have a future in Australia?
Thank you

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