Appendix 11

A New IEA Document for the Measurement of Noise Immission from Wind Turbines at Receptor Locations

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ABSTRACT

A new IEA guide on acoustic noise was recently completed by an international expert group. In this guide [1], several practical and reliable methods for determining wind turbine noise immission at receptor locations are presented: three methods for equivalent continuous A-weighted sound pressure levels and one method for A-weighted percentiles. In the most ambitious method for equivalent sound levels, the noise is measured together with the wind speed at two locations: one at the microphone and the other at the turbine site. With this approach, the turbine levels can be corrected for background sound and the immission level can be determined at a certain target speed. Special importance is attached to the problem of correcting for background noise and to techniques for improving the signal-to-noise ratio. Thus, six methods are described which can be used in difficult situations.

1. INTRODUCTION

A starting point for the work of the IEA group has been the practice developed by local and national authorities for specifying limits for the noise from wind turbines. Such limits are usually expressed as an immission level, that is a level to be measured in a relevant noise sensitive area. Immission limits can, in principle, be verified by measurements in the same way as noise immission limits for other outdoor sources such as road traffic, aircraft, industries etc. However, a major problem when measuring noise immission from wind turbines is the presence of the wind. Another important factor is the fact that the immission levels specified by the authorities tend to be low. Thus, the background noise is often of the same order of magnitude as the sound level from the turbine, which makes reliable measurement results difficult to achieve.

An immission limit is usually specifed for a certain wind speed at the turbine. However, that wind speed will never occur during a measurement. For this reason, an interpolation scheme must be used.

In addition to the requirements on broadband sound, usually expressed as an equivalent sound level or an A-weighted percentile, the requirements often contain a penalty for audible tones. Such tones are defined in different ways in different countries. The presence of different methods is a severe drawback for an international industry, which prefers a single method.

Thus, a major part of the work of the IEA group has been devoted to these three issues.

2. MEASUREMENT OF EQUIVALENT SOUND LEVELS

According to the main method, the noise level is measured with a microphone at a height of 1.5 m above the ground together with the wind speed at the turbine site and also close to the microphone. The instrument configuration is illustrated in Figure 1.

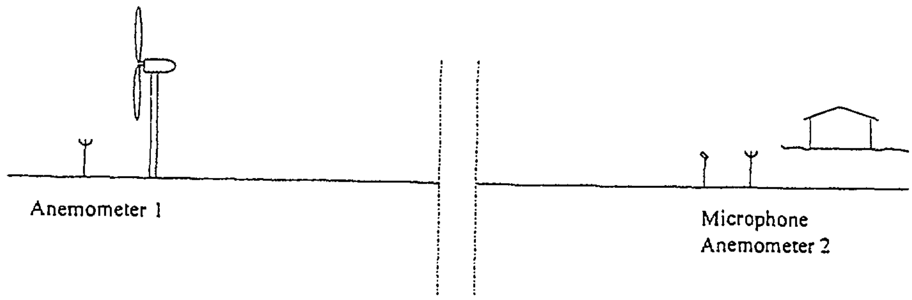

Figure 1. Illustration of instrument configuration for measurement of equivalent sound levels

The sound level is measured simultaneously with the wind speed at the two anemometer positions and averaged over the same time intervals (each interval 1 - 10 min, number of intervals ≥ 10). These measurements are carried with the turbine or turbines in operation. Before and/or after these measurements the background sound (with the turbine(s) parked) is measured and averaged over similar time intervals together with the wind speed at the microphone. It is now possible to plot the total sound level from the first measurement and the background sound alone as a function of the wind speed at the microphone, see Figure 2, and to determine the sound level from the turbine(s) alone.

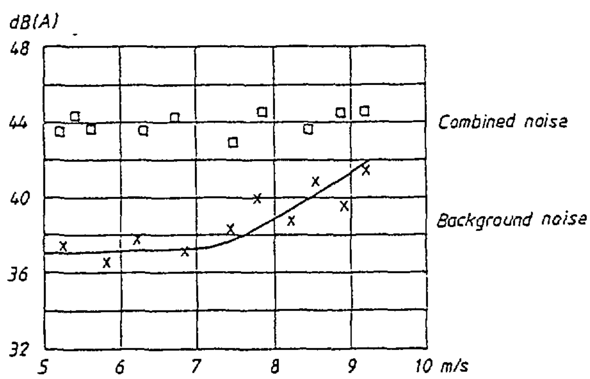

Figure 2. Plotting of combined sound level (sound from turbine(s) and background) and background sound level as a function of the wind speed at the microphone.

The level of the sound from the turbine(s) is finally plotted as a function of the wind speed at the turbine site, and the level at a target wind speed, often 8 m/s at 10 m height, is determined, see Figure 3.

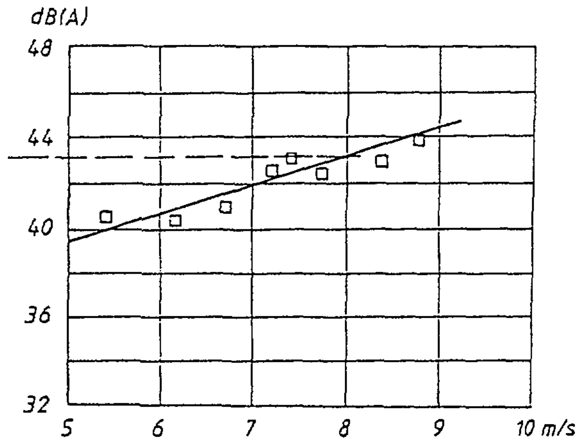

Figure 3. Determination of the turbine sound level at the target wind speed (here 8 m/s).

The measurement of the wind speed at the turbine site must be undertaken with caution. In the case of a single turbine, the speed should in the first place be obtained from an anemometer at hub height or from the electric output together with the power curve. If an anemometer is used, it should be placed according to Figure 4.

An anemometer at a height of 10 m and placed in front of the turbine tower can also be used.

In the case of a wind farm, the anemometer should be placed in a position which is relevant for the sound generation, see the two examples of Figure 5.

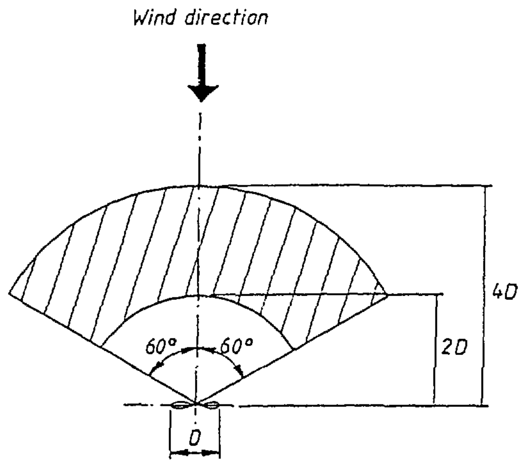

Figure 4. Recommended position of the turbine site anemometer for the case that the anemometer is positioned at hub height. D is diameter of wind turbine rotor.

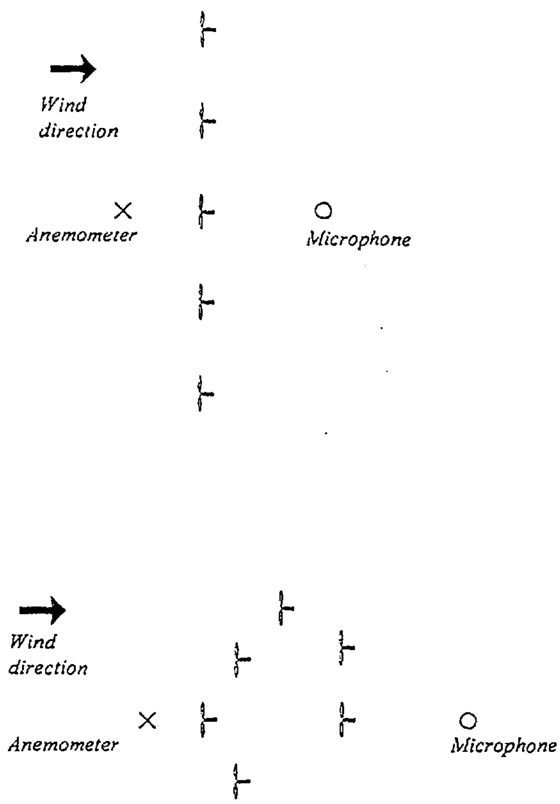

Figure 5. The upper part of the figure illustrates a case where the wind speed should preferably be measured at the closest turbine, while the lower part illustrates the case where the wind speed should be measured at an undisturbed position in the vicinity of the group of turbines.

Two methods, which are simplified with respect to the wind speed measurement, are also described in the document. The very limited use of these methods in practice is pointed out in the document.

3. MEASUREMENT OF A-WEIGHTED PERCENTILES

As an alternative to a measurement of an equivalent sound level, one or several A-weighted percentiles can be determined.

In this case, the sound from one or several wind turbine(s) is measured at receptor locations together with the wind speed, obtained from an anemometer positioned on a meteorological mast at the wind turbine or wind farm site. The background sound is also measured as a function of the wind speed obtained from the same anemometer. A procedure for obtaining a conservative estimate of the levels of the turbine(s) alone is described.

This method is used if the limits are expressed in percentiles and in particular where the noise immission limits are related to ambient sound measured previously at the receptor location. The technique is applicable for measurement of any A-weighted percentile. However, it should be noted that the percentiles L_{A10}, L_{A90} and L_{A95} are the ones most often used in practice.

4. MEASUREMENT TECHNIQUES FOR CASES OF LOW SIGNAL-TO-NOISE RATIOS

Noise immission measurements around a wind turbine will often be influenced by background sound. If the equivalent sound level of the turbine together with the background is more than 3 dB over that of background alone, the level of the turbine can be determined directly. However, it is a common experience that the signal-to-noise ration is lower. Then one or several of the following methods can be used:

- change of time of day for measurements from, for instance, day to night,
- repositioning of microphone to a position at the same distance and sound propagation conditions but with a lower background sound level,
- use of a secondary (and larger) wind screen,
- use of a large vertical measurement board, see Figure 6.

Two approximate methods are also described. One uses measurements at a lower wind speed together with a correction for the change in source strength. The other uses measurements at a reduced distance together with an appropriate correction.

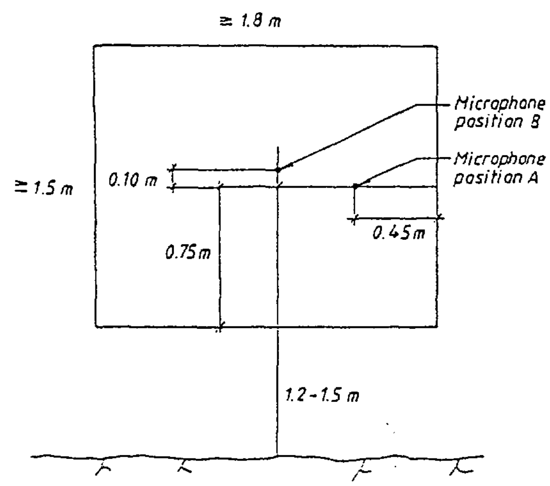

Figure 6. Position of the microphone on the large measurement board. Front view. Microphone position A is recommended when the board is used to reduce the influence from sources or reflecting surfaces shielded by the board. Microphone position B is recommended when the board is used to reduce the wind induced microphone noise.

5. EVALUATION OF TONES

Two methods are presented for the analysis of the tones. According to method I, at least five RMS spectra are obtained with a bandwidth of typically 2 - 5 Hz and an averaging time of 1 - 2 min. For method II at least 50 short term spectra are obtained with time weighting 'F' and an averaging time of 0.2 - 0.5 sec.

For boths methods, the analysis of the tonality comprises four steps:

- identification of the lines in the spectra as either tones, masking noise or neither,
- calculation of masking level,
- calculation of tonal noise level,
- evaluation of tonality.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

[1] S. Ljunggren (ed), Recommended Practices for Wind Turbine Testing. 4. Acoustics. Measurement of Noise Immission from Wind Turbines at Noise Receptor Locations (in print - the document will be available through the members of the IEA standing Committee).

[2] O. Fégeant, Measurement of Noise Immission from Wind Turbines at Receptor Locations: Use of a Vertical Microphone Board to Improve the Signal-to-Noise Ratio. EWEC 97.