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Measurement Report

Measurement of the Infrasound Radiation

Nordex N80

This document is the translation of the document "Messung der Infraschall-Abstrahlung einer Windenergieanlage des Typs NORDEX N80" (*NXX-6-noise-infrasonic-de*) of the Institute for Technical and Applied Physics (ITAP GmbH) of 10.06.2003 and shall only be used with the original document.

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1 Task

For wind turbines (WTG) with nominal power of more than 1 MW there are nearly no data concerning infrasound. Therefore the NORDEX Energy GmbH instructed the Institute for Technical and Applied Physics (ITAP GmbH) to measure the infrasound radiation of a NORDEX N80. The turbine is located at the test field of the German wind energy institute (DEWI) at Wilhelmshaven. The WTG has a nominal power of 2.5 MW, the rotor diameter and the hub height are 80 m.

2 Measurement

The measurement was carried out on May 14th, 2003 between 10 a.m. and 3 p.m.
The position of the tested WTG as well as the neighbouring turbines are shown at figure 1 (Bild 1: Site and environment of the tested WTG). The turbines A (nominal power 1.3 MW) and B (1.65 MW) have been switched off during the measurement. Turbine C (600 kW) and D (500 kW) could not be switched off.
The background noise at the measurement site was caused by thunderstorms, military airplanes, noise of a concrete factory as well as noise of turbine C. Measurement periods with disturbances have been excluded of the evaluation as far as possible.
The measuring setup is outlined at figure 2 (Bild 2: Outline of measurement setup). At a distance of 200 m to the turbine in downwind direction there were installed two microphones (Brüel & Kjær 4190 with pre-amplifier Brüel & Kjær 5935) at a distance of 5 m between each other. The microphones were located at ground level and are equipped with a special windbreak for low frequencies. The signals of the microphone have been recorded (DAT-recorder Sony DTC-ZE700) and later analysed with a correlation method for the reduction of wind induced background noise [1]. For this a double channelled signal analyser (Hewlett-Packard 35670a) has been used. The suitability of the measurement chain for frequencies down to 0.7 Hz has been verified at the laboratory before.

3 Results

In the infrasound area wind turbines are emitting a line spectrum where the distances of the lines equals the Blade Passing Frequency (BPF). At a rotational speed of e.g. 15/min the BPF is 3 x 15/60 Hz = 0.75 Hz. Because of the variability of the rotational speed of the turbine the sound energy is continuously blurred in the frequency range.

> Remark: The wind speeds mentioned in the following are related to a measurement with the nacelle anemometer of the NORDEX N80

3.1 G-weighted sound level

The usual A-weighted level is not suitable for a single value of the infrasound level. Therefore the G-weighted level has been calculated according to ISO 7196 [3]. Figure 3 (Bild 3: G-weighted noise level at a distance of 200m from the WTG before and after switch-off at 1:56 p.m. At 2:17 p.m. turbine B has been restarted.) shows the time dependent behaviour of the G-level before and after the switch-off of the N80 (floating 60 sec averages). This is the sum of the WTG and all background noise levels during the measurement period. The background noise is mainly caused by noise of airplanes. Nevertheless the reduction at switch-off is definitely recognisable.

3.2 1/3-octave spectrum

Figure 4 (Bild 4: typical 1/3-octave spectrum and auditory threshold according to DIN 45680) shows a typical 1/3-octave spectrum and the auditory threshold according to DIN 45680 [2]. The power output of the WTG was about 1100 kW at that time.

3.3 Dependancy of the wind speed

Figure 5 (Bild 5: Measured G-weighted noise pressure level depending on power of the turbine) shows the G-weighted noise pressure level depending on the power of the turbine. These are averages of 16 sec. Figure 6 (Bild 6: Measured G-weighted noise pressure level depending on wind speed) shows the same data depending on wind speed. The regression results in an increase of the level of 0.75 dB per 1 m/s increase of the wind speed.
It is possible to calculate the mean turbine noise level without background noise based on the background level at switched-off turbine (and a suitable regression) – also shown at figure 6. These values are shown in table 1 (Tabelle 1: Average G-weighted level of the turbine at a distance of 200 m without background noise, rounded to integer dB-values). It can be seen that the level increases of 1 dB per 1 m/s.

4 Evaluation of the results

For infrasound the scale of sensations from "noticeable" to "very loud" lies within a very much smaller range than for higher frequencies. Therefore the auditory threshold often is used as guideline value for the disturbance caused by infrasound.
Figure 4 shows that the measured 1/3-octave levels at the low frequency range up to 30 Hz are clearly below the mean auditory threshold according to DIN 45680 [2]. At 10 Hz this value is 95 dB. To take into account the individual variation of the auditory threshold Vercammen [4] suggests a lower value of 86 dB with a decrease of 12 dB per octave with increasing frequency. These threshold levels also are not reached. Therefore the noise of the WTG is not noticeable in the infrasound range.
The G-weighting [3] was created especially for the frequency range of 1…20 Hz. As guideline value is applied that noise with 100 dB(G) is just audible whereas levels of 90 dB(G) and lower are normally not noticeable. The measured values of less than 65 dB(G) are far below this.

5 Standards and literature

[1] K. Bethke, H. Remmers: Messung und Bewertung von tieffrequentem Schall. In: Fortschritte der Akustik. Plenarvorträge der 24. Deutschen Jahrestagung für Akustik, p. 472, Oldenburg 1998
[2] DIN 45680 (March 1997): Messung und Bewertung tieffrequenter Geräuschimmissionen in der Nachbarschaft
[3] ISO 7196 (1995): Acoustics – Frequency weighting for infrasound measurements
[4] M. L. S. Vercammen (1992): Low-Frequency Noise Limits. J. Low Freq. Sound Vib. 14, 105-107

6 Summary

The noise emission of a wind turbine of the type NORDEX N80 has been measured at low frequencies of down to 0.5 Hz at a distance of 200 m. The G-weighted infrasound level as well as the 1/3-octave level up to 30 Hz were clearly below the human auditory threshold. There are no indications that the infrasound of the turbine poses risks or impairments to human beings.