Project: A healthy society - towards the optimal management of wind turbine noise

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D3.2 The proposal of methodology for infrasounds' measurements and recording

Projekt: **Healthy society - towards optimal management of wind turbines' noise**

UAM AKUSTIX AGH SINTEF IOŚ-PIB

GIG Państwowy Instytut Badawczy — Instytut Medycyny Pracy im. prof. J. Nofera — PSEW

D3.2 The proposal of methodology for infrasounds' measurements and recording

Executive summary

In this report instrumentation for infrasounds' measurements of wind turbines is specified. Specifications of equipment for acoustic measurements, including the wind shields under consideration, are presented. In addition, requirements for non-acoustic instruments such as weather measurement equipment are specified. Acoustic and non-acoustic measurement procedures are described.

Measurement validation of the proposed method was conducted. Based on the measurement results, it can be concluded that the best of the tested variants, in terms of measuring noise from wind turbines in the low-frequency range, is the microphone's position on a board following IEC 61400-11. Thus, it is not necessary to use different wind shields for the audio and infrasound bands in acoustic measurements of wind turbines. In both cases, measurement on a board with a double wind shield works well.

Authors	Date of submission	Confidentiality level
Tadeusz Wszołek Maciej Kłaczyński Paweł Małecki Dominik Mleczko Paweł Pawlik Bartłomiej Stępień	31.III.2022	It can be made available on the project website: https://hetman-wind.ios.edu.pl

1. Instrumentation

1.1 Acoustics instruments

The measuring device should fulfill the IEC 61672-1:2013 requirements for class 1 meters and have valid calibration certificate. In particular, it is required that sound level meters and analyzers are declared by the manufacturer as a device with the widest possible range of measurement frequencies from 1 Hz to 20 kHz with sound pressure signal recording function. The device should be able to measure A-, C- and G- weighted levels and 1/3-octave band spectra with center frequencies ranging from 1 Hz to 315 Hz. The filters should fulfill the IEC 61260-1:2014 standard for class 1 filters. Equivalent sound levels in the 1/3 octave bands should be determined simultaneously. The device should be able to set a specific interval for determining equivalent sound levels in 1/3 octave bands. The system should be able to measure the spectrum with a time resolution of at least 100 ms to possibly identify the presence of amplitude modulation.

Measurement consistency

Using an acoustic calibrator, the sound measurement system shall be calibrated immediately before and after the measurement session with at least one reference frequency. The calibrator should fulfill the requirements of IEC 60942:2003 Class 1 and be used under the specified environmental conditions and have valid calibration certificate.

Recommended wind shield

To measure infrasound noise from an operating wind turbine, it is recommended to use a measurement system in which the microphone is mounted in the center of a flat hard board, with the microphone membrane in a plane normal to the board and the microphone axis facing the wind turbine as in Figure 1 and Figure 2. The measuring board is circular with a diameter of at least 1000 mm and made of a material that is acoustically "hard", such as plywood or hard particle board with a thickness of at least 12 mm, or metal with a thickness of at least 2.5 mm. The microphone is equipped with two wind shields. The first one - half of a standard wind shield with a diameter of not less than 90 mm made of polyurethane foam, and the second wind shield in the form of a sphere made of polyurethane foam with open cells and a diameter of not less than 500 mm. An additional wind shield allows to obtain a good signal-to-noise ratio for low frequencies in solid winds. The additional wind screen should have a documented effect of its presence on the measurement result in the 1/3 octave bands. The overall effect of the shield on the measurement result, particularly the reflection and amplification of the sound from the circular board, should be considered when giving the final result. An example of a shield is shown in Figure 3. This type of solution is used in measurements carried out following ISO 61400-11 IEC:2012.

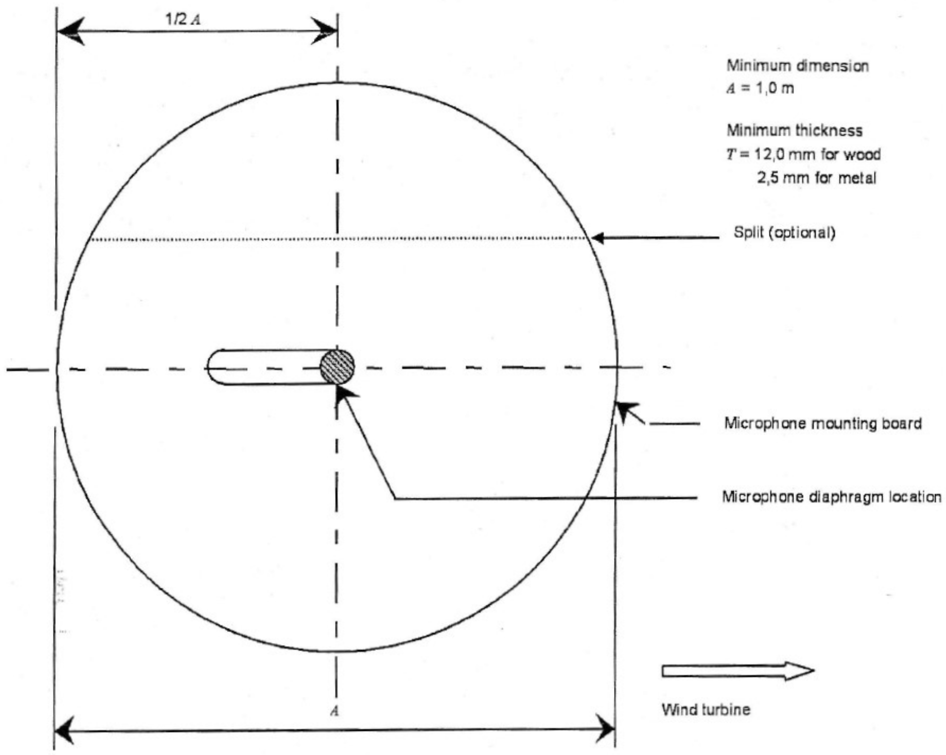

Figure 1. Mounting the microphone - top view ISO 61400-11 IEC:2012

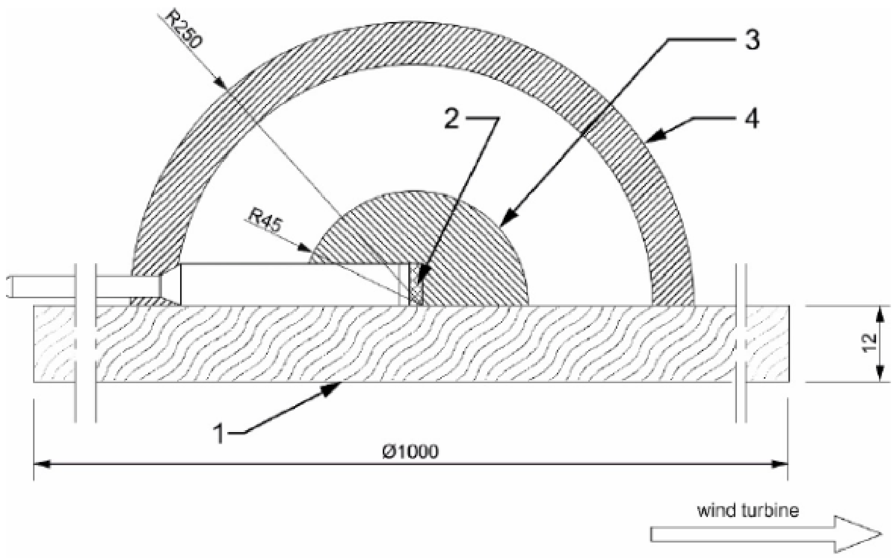

Figure 2. Mounting the microphone - vertical cross-section ISO 61400-11 IEC:2012

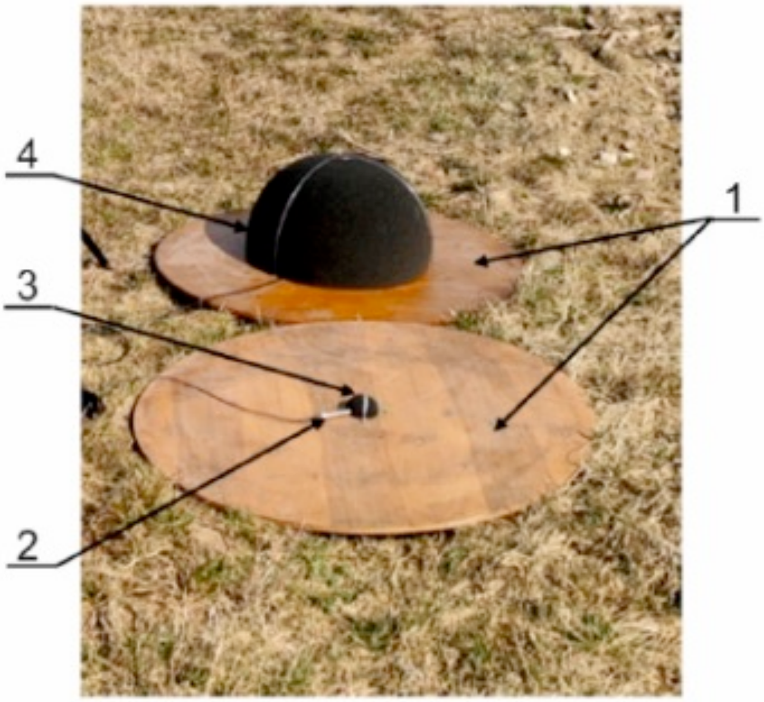

Figure 3. Example of a wind turbine infrasound noise measurement kit. (1)—wooden measuring board, (2)—microphone, foam windshield: (3)—inner and (4)—outer

Optional wind shield

In the case of WTN, an essential point of contention is the influence of low-frequency components, including infrasound. In infrasound measurements of wind turbine noise, it is acceptable instead of a set: a microphone placed on a circular board with a double wind shield, a set of the double-shell type consisting of a standard spherical wind shield with a diameter of 90 mm made of polyurethane foam and a second shield covered with a double thin fabric (the recommended composition is 90% nylon with 10% admixture of polyurethane or cotton, which is used, among others, in pop-filters) with high flexibility and a diameter of not less than 300 mm placed at the height of 1.5 m above ground level. An example solution of such shield is shown in Figure 4. The additional double wind shield should have a documented effect of its presence on the measurement result in 1/3 octave bands.

Figure 41. An alternative set of double wind shield for measuring wind turbine infrasound noise.

The insertion loss of this wind set should be less than 1 dB from 1 Hz to 500 kHz.

1.2 Non-acoustic Instruments

The wind speed measurement device should have an accuracy of not worse than ±0.2 m/s in the measurement range from 4m/s to 12 m/s, according to ISO 61400-11 IEC:2012 and have valid calibration certificate It should have the ability to synchronize with acoustic measurement devices. It should have the ability to average over specified time intervals and the ability to record measurement data.

- Requirements for environmental measurement apparatus:Wind speed:
  measurement range: 0 m/s to 50 m/s
  accuracy: ±0.2 m/s (4m/s to 12 m/s)
  ±0.5 m/s (for the remaining range)

- Wind direction:
  measurement range: 1°-360° equivalent of 16 points (22.5°) on the wind rose
  accuracy: 5°

- Temperature;
  measurement range: -20°C to +65°C
  accuracy: 0.5°C

- Humidity;
  measurement range: 20% to 98% RH
  accuracy: 5% RH

- Atmospheric pressure:
  measurement range: 900 hPa to 1100.0 hPa
  accuracy: 1 hPa

- Precipitation:
  measurement range: 0 mm to 6553 mm
  accuracy: 0.2 mm (1 mm > 2000 mm)

2. Acoustic measurement and measurement procedure

The measurement should be performed simultaneously at least in two places:

1) a point located on the boundary of the noise protection zone.

2) a reference point at a distance H+D/2 from the turbine in the direction of point 2, (recommended for turbine operation control purposes).

where:

H - vertical distance from the ground to the center of the turbine rotor;

D - diameter of the turbine rotor.

The measurement should be made under favorable propagation conditions (downwind, ± 30 degrees).

Measurements should be performed with a wind speed at the hub height of 0.8 to 1.3 of the wind speed at which the turbine reaches 85% of maximum (electric) power. This usually corresponds to a wind speed of 6 to 10 m/s at the height of 10 m. This requirement is necessary to be met for short-term (daily) measurements. This requirement does not apply to measurements used to determine long-term indicators, where the only condition is the selection of days on which the turbine operates.

Recording noise levels continuously at reference time T using G correction filter and 1/3 octave bands with averaging time of 10 min with recording with statistical levels LG5, LG10, LG50, LG90, LG95.It is recommended that statistical levels be used for selection of samples without interference. Samples for which the difference between $\boldsymbol{L_{Geqzm,10min}}$, and LG50 is not more than 3 dB are used for further calculations. On the other hand, recording interruptions introduced by the performer of measurements are allowed due to the elimination of accidental interference.

The requirement for continuous recording is due to the lack of sound level G curves as a function of wind speed as it is for the audible band in wind turbine manufacturers' specifications.

From the selected 10-minute $\boldsymbol{L_{Geqzm,10min}}$, measurements, we determine the equivalent level $\boldsymbol{L_{Geqzm}}$ at the reference time $\boldsymbol{T}$.

This result should be corrected for the influence of the acoustic background $\boldsymbol{L_{Gt}}$.

The value of the sound level G emitted into the environment by the wind turbine L_GeqT is obtained according to the formula:

$$L_{GeqT} = 10lg(10^{0,1L_{Geqzm}} - 10^{0,1L_{Gt}})$$

Where:

L_{GeqT} – G-weighted sound level emitted to the environment by the wind turbine at reference time T corrected for the effect of the acoustic background,

L_{Geqzm} - the measured equivalent G-weighted level,

L_{Gt} - the background G-weighted sound level.

Duration of a single measurement sample - at least 10 minutes of pure measurement - without interference from other sources, e.g. passing aircraft, passing cars, etc. The measurement should allow to determine the equivalent sound level in 1/3 octave bands for the entire reference time T. Sample splitting allows rejection of samples with interference and uncertainty analysis.

There should also be an analysis of the uncertainty of determining the equivalent level. Due to the possible significant scatter of the analyzed data and asymmetric probability distributions, it is recommended to determine the left and right uncertainties. The result of a noise level measurement is considered correct if the Type A expanded uncertainty (with a confidence level of 95%) of the left and right equivalent sound level G is less than or equal to 3 dB.

In order to determine the daily indices $L_{Geq\,D}$, $L_{Geq\,N}$ (and for the use of long-term levels, the indices L_D, L_E and L_N should be determined with the frequency correction characteristic G), the measurement should be carried out around the clock. Daily indices can also be used to determine long-term (annual) indices taking into account the days when the turbine was not operating.

In the absence of continuous monitoring, daily indicators can be determined from a dozen randomly selected days during the year when the turbine was operating. An analysis of the uncertainty due to the lack of data for the entire year and the risks associated with obtaining data from other sources should also be carried out. The indicator value is considered correct if the expanded uncertainty Type A (with a confidence level of 95%) of the left and right sides is less than or equal to 3 dB.

Infrasound noise measurements are performed under the following conditions:

1) specified in the instrument's manual;

2) range:

a) temperature from –10°C to 50°C,

b) humidity from 25% to 98%,

c) atmospheric pressure from 900 hPa to 1100 hPa,

d) lack of precipitation.

If measurements of wind turbine infrasound noise are made under conditions other than those specified above, the necessity of making measurements under these conditions should be justified in the measurement report, and an analysis should be made of the effect of these conditions on the measurement reliability and on the result uncertainty.

3. Non-acoustic measurements procedure

The wind speed measurement device should be placed at the measurement point at a short distance from the measurement microphones. Wind speed measurement should be made at the height of the measurement microphone to determine the effect of wind on it. For sound pressure measurements on the measurement board, measuring the wind speed at an altitude of 1.5 meters above the ground is recommended.

The wind speed measuring device should be capable of measuring the average wind speed at intervals synchronized with acoustic measurements and the recommended interval of 1 min. It should give the maximum and minimum speeds in the measured interval and the average wind direction. Temperature, atmospheric pressure, and humidity should be measured and recorded with at least a 1-hour interval at an altitude of 1.5 meters above the ground.

In the situation where measurements are made with the participation of the wind farm manager, wind speed waveforms measured at the height of the nacelle or determined from the power generated by the turbine during the measurements at 10-minute intervals should be obtained from the manager. The average wind speed will allow the determination of the time window for the measurement samples for short-term (daily) measurements to determine the $L_{Geq\ D}$ and $L_{Geq\ N}$ index when the turbine is operated under the conditions specified in 2.

In the absence of data from the wind farm manager on the wind speed at the height of the nacelle. The wind speed should be measured with a weather station using a mast with a height of min. 10 m. This measurement should be carried out at intervals of 10 minutes, coinciding with the noise level sampling period. Noise measurement should be carried out for wind speeds of 6 to 10 m/s at a height of 10 m for short-term (daily) measurements in order to determine $L_{Geq\ D}$ and $L_{Geq\ N}$ for turbine operation under the conditions specified in Section 2.

4. Measurement validation of the proposed method

In order to verify the suitability of wind shields in application to low-frequency noise measurements, the sound pressure generated by the "Kościuszko" ventilation shaft belonging to The "Wieliczka" Salt Mine, Małopolska, Poland, was measured. This source was chosen because it generates sound covering the low-frequency band regardless of wind conditions. This made it possible to determine the effect of wind on the measurement result using various methods (Table 1).

Table 1. Sound pressure measurement methods

Nr	Microphone location and type of wind shield used
1	4m tripod with classic wind shield
2	1.5m tripod with classic wind shield
3	Board at ground level with half windscreen (primary windscreen IEC 61400-11)
4	Board at ground level with double wind shield (IEC 61400-11)
5	1m tripod with classic wind shield placed in the tent functioning as a second shield

Acoustic pressure signals were recorded using a multi-channel measurement system consisting of NI 9234 measurement cards. It allows simultaneous measurements at all points with a sampling frequency of 51.2 kHz. 1/2′′ G.R.A.S. 46AE microphones were used for the measurements. Wind speed was measured for a period of 1 minute using a Davis Vantage VUE station. The microphone arrangement is shown in Figure 5.

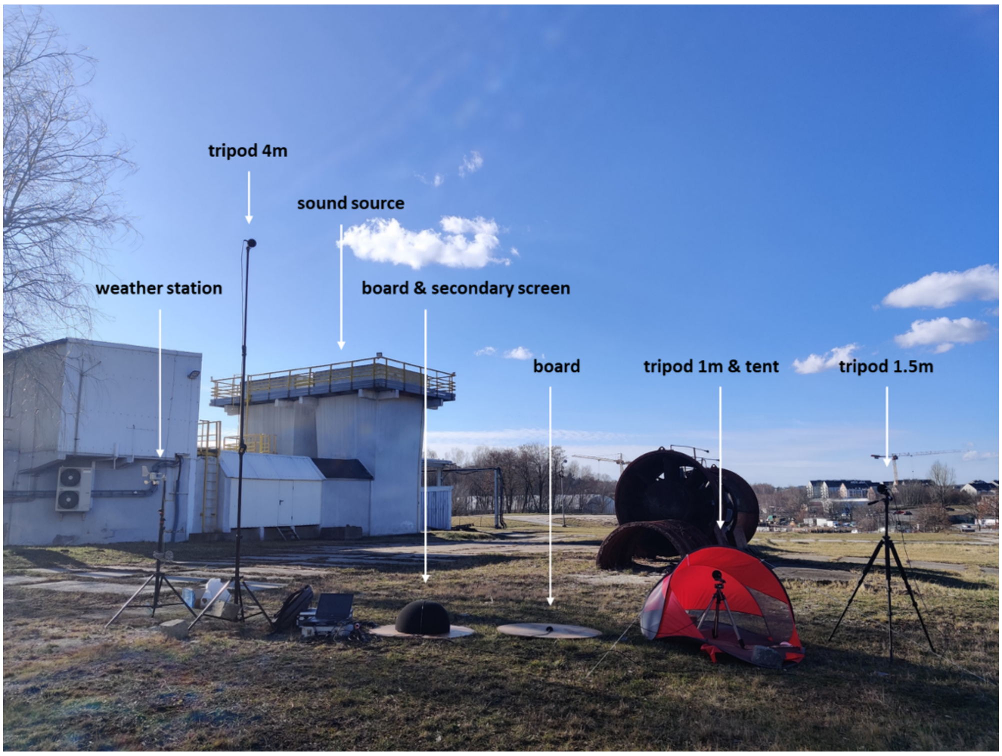

Figure 5. Arrangement of measurement microphones.

Figure 6 summarizes the 1/3 octave spectra for all measurement variants in windless conditions. In bands below 50 Hz, no significant differences can be seen between measurements at 4 m, 1.5 m, on board, and on a board with a double wind shield. Significant differences are visible for the band with a 160 Hz band. The most considerable amplitude values for this frequency were obtained on the board, while the lowest values were obtained at the height of 4 m.

Signific larger values were obtained for tripod measurements in the bands from 400 Hz to 4 kHz. The higher amplitudes in these bands may be due to the presence of other sources, i.e.: traffic, birds singing, and trucks working in the mine further away.

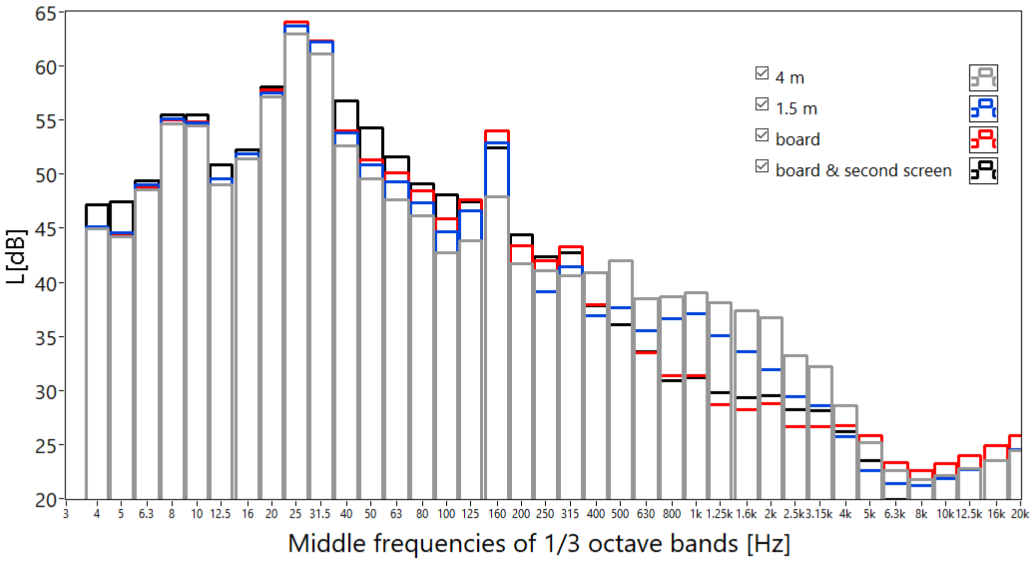

Figure 6. Ventilation shaft noise, 1/3 octave spectrum - wind speed 0 m/s

Next, the measurement signals recorded with the wind blowing at an average speed of 5 m/s were analyzed. Figure 7 shows the spectra of the signals determined for a 10-minute time frame. Such a long time window was used due to the numerous wind gusts, which significantly affected the values of the amplitudes of the 1/3 octave bands at low frequencies.

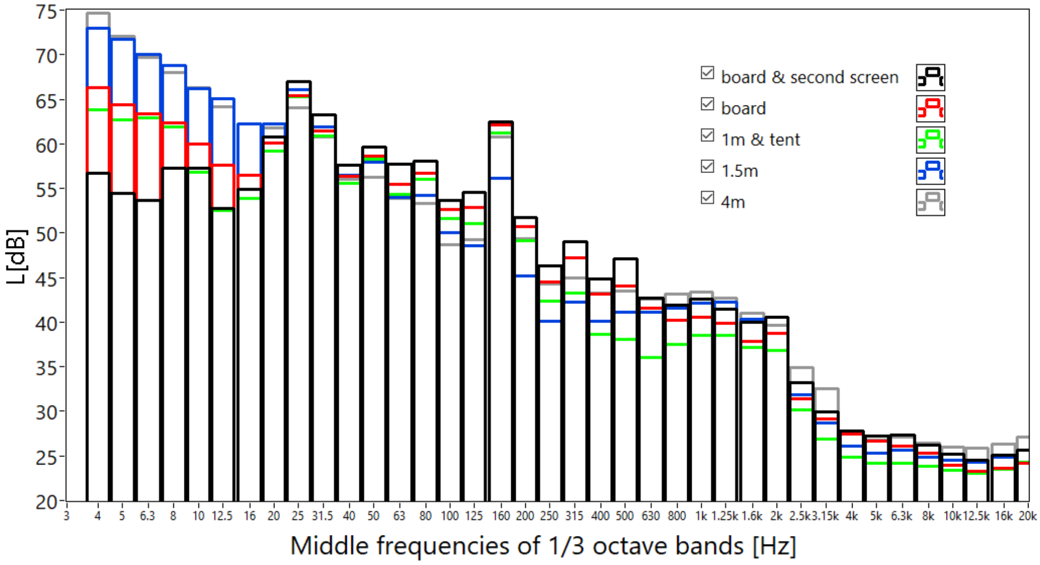

Figure 7. Ventilation shaft noise, 1/3 octave spectrum - wind speed 5,0 m/s

The most considerable discrepancies in the results, depending on the shield used (and the height of the microphone's position), were observed in bands below 20 Hz (Figure 7). The most similar values of levels, compared to measurements in windless weather (Figure 6), were recorded using a board with a double wind shield. More significant variations in the results can be observed only in the 3 Hz and 4 Hz bands - slightly higher values during windy conditions were registered on the board. However, it should be remembered that the noise generated from the cooling fan contains mainly low frequencies (up to 160 Hz), and their spectral structure and levels were similar in both measurement sessions. In contrast, higher frequencies come "from the environment," which may have been different in the two measurement sessions. As expected, the most significant interference in the low-frequency range was registered at microphones placed on tripods with a single traditional wind shield. Marked interference was also registered on the board, but with a single wind shield, as in the case with a microphone placed in a tent.

The measurement set shown in Table 1 was tested under real conditions at a wind farm in Łęki Dukielskie. The measure was realized at a distance of 130 m from the turbine (Figure 8).

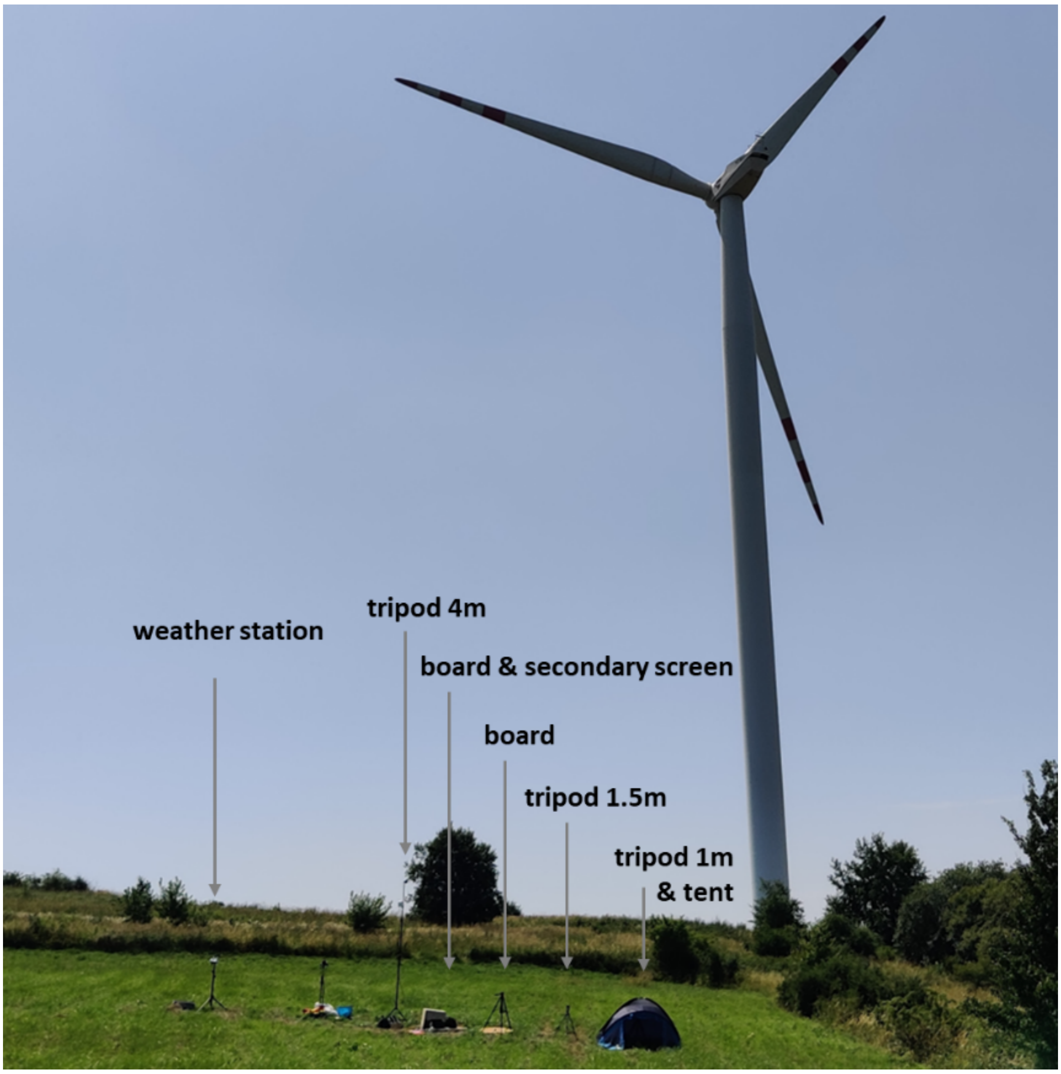

Figure 8. The arrangement of measurement microphones - wind farm.

Figure 9 shows the 1/3 octave spectrum of signals recorded at an average wind of 2.1 m/s, determined for a 10-minute time frame. The numerical values and the 95% confidence interval limits are shown in Table 2. Due to the asymmetric distributions of sound pressure level values, the confidence intervals were determined using the percentiles method.

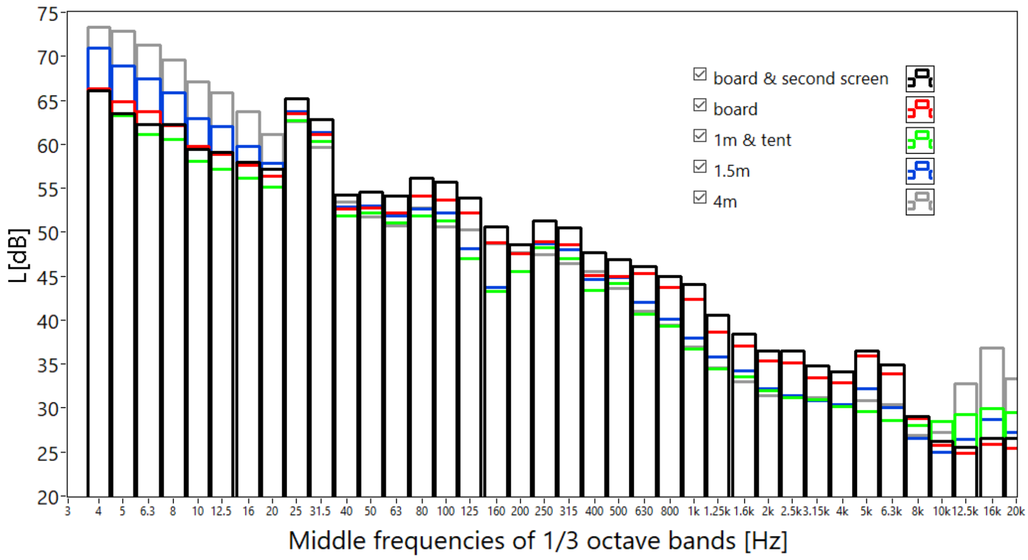

Figure 9. Wind turbine noise, 1/3 octave spectrum, average wind speed - 2.1 m/s, max wind speed - 4.5 m/s

Table 2. 1/3 octave bands sound pressure levels and confidence interval limits for tested measurement methods, average wind speed - 2.1 m/s, max wind speed - 4.5 m/s

1/3 octave mid. freq. [Hz]		**4**	**5**	**6.3**	**8**	**10**	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**
Board & second screen	L	**66.2**	**63.6**	**62.4**	**62.3**	**59.6**	**59.1**	**58.1**	**57.3**	**65.3**	**62.9**	**54.3**	**54.7**	**54.2**	**56.3**	**55.7**	**54.0**	**50.7**	**48.7**
	U+(L)	3.2	3.9	4.1	3.8	3.2	3.6	3.5	3.3	4.8	3.0	3.2	3.1	3.3	2.7	3.0	1.7	1.7	1.8
	U-(L)	5.2	4.8	5.0	6.1	5.0	5.0	6.0	4.8	3.1	7.3	4.2	4.6	2.9	3.1	4.0	2.2	3.4	2.6
Board	**L**	**66.5**	**64.9**	**63.8**	**62.3**	**59.9**	**58.9**	**57.7**	**56.5**	**63.6**	**61.2**	**52.7**	**52.9**	**52.3**	**54.2**	**53.8**	**52.3**	**49.0**	**47.6**
	U+(L)	5.0	7.5	5.4	4.3	4.9	4.7	4.2	4.0	4.7	3.3	3.2	2.9	3.5	2.5	2.9	1.6	1.8	2.0
	U-(L)	6.0	6.7	7.9	6.8	6.5	6.1	5.5	4.5	3.1	7.3	4.1	4.4	2.8	3.1	3.9	2.1	3.4	2.8
1m & tent	**L**	**66.2**	**63.3**	**61.2**	**60.7**	**58.1**	**57.3**	**56.3**	**55.3**	**62.9**	**60.4**	**52.0**	**52.4**	**51.2**	**52.0**	**51.4**	**47.2**	**43.4**	**45.6**
	U+(L)	5.0	4.2	4.1	3.9	3.7	2.8	3.5	2.5	4.8	3.0	3.2	2.7	3.1	2.4	3.3	2.3	2.4	1.8
	U-(L)	5.1	6.2	4.7	5.4	4.5	4.6	5.2	4.3	2.9	7.4	3.9	4.2	3.1	3.3	4.7	3.9	3.9	3.0
1.5m	**L**	**71.1**	**69.0**	**67.6**	**66.0**	**63.0**	**62.1**	**59.9**	**57.9**	**63.8**	**61.4**	**53.0**	**53.1**	**52.0**	**52.7**	**52.3**	**48.2**	**43.8**	**45.6**
	U+(L)	6.7	6.4	6.5	6.6	6.4	7.5	5.9	4.9	4.3	3.2	3.6	2.9	3.3	2.6	2.8	1.9	2.8	1.9
	U-(L)	8.6	9.6	10.4	7.5	9.3	7.5	6.7	5.8	3.6	7.4	3.6	4.1	3.3	3.3	4.9	3.5	4.0	2.9
4m	**L**	**73.4**	**72.9**	**71.4**	**69.6**	**67.2**	**65.9**	**63.8**	**61.2**	**62.7**	**59.7**	**53.6**	**51.8**	**50.8**	**52.8**	**50.7**	**50.4**	**48.8**	**47.8**
	U+(L)	6.0	7.5	6.5	7.1	6.8	7.1	7.9	7.9	6.2	6.8	9.0	8.1	5.9	2.7	3.1	2.7	2.1	2.2
	U-(L)	9.9	10.9	11.3	9.8	10.5	10.4	10.3	8.9	5.2	10.8	9.4	5.5	4.3	3.3	4.4	2.4	3.3	3.1

In Table 4, large uncertainty values (reaching up to 11.3 dB) can be observed for measurements at 4 m height. The large widths of the confidence intervals are due to the considerable influence of wind gusts. It is worth mentioning that uncertainty values above 10 dB occur in the 6 presented bands. Similar uncertainty values were obtained for measurements at the height of 1.5m (maximum 10.4 dB). The best values were obtained for the measurement on the board with a double wind shield. The maximum value of the expanded uncertainty is 7.3 dB. The results are also similar for the measurement in a tent.

Figure 10 shows the 1/3-octave spectrum of signals recorded at an averaged wind speed of 3.5 m/s, determined for a time frame of 10 minutes. Comparing these results with those recorded at a wind speed of 2.1 m/s (Figure 9), it is evident that there is a significant increase in the value of the recorded sound pressure level for a single-shielded board in the center frequency band below 25 Hz. This indicates an increase in interference from wind speeds of 4.5 m/s.

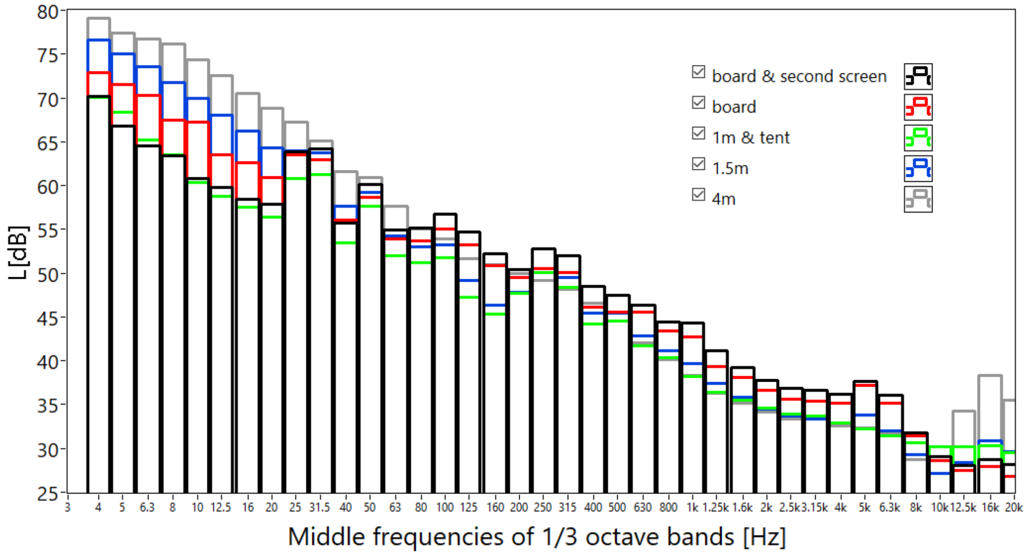

Figure 10. Wind turbine noise, 1/3 octave spectrum, average wind speed – 3.5 m/s, max wind speed – 6.7 m/s

Table 3 shows the numerical values of sound levels along with confidence intervals. It is noticeable that the lowest values of the levels occur for the measurement on the board with an additional wind shield and the measurement in a tent. However, the measurement on the board with additional shielding has a much smaller scatter. This indicates less sensitivity to wind gusts.

Table 3. *1/3 octave bands sound pressure levels and confidence interval limits for tested measurement methods*, average wind speed - 3.5 m/s, max wind speed - 6.7 m/s

1/3 octave mid. freq. [Hz]		**4**	**5**	**6.3**	**8**	**10**	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**
	L	**70.3**	**67.0**	**64.7**	**63.5**	**60.9**	**59.9**	**58.6**	**58.0**	**64.0**	**64.4**	**55.8**	**60.3**	**55.0**	**55.3**	**56.8**	**54.8**	**52.4**	**50.6**
	$U^{+}(L)$	3.6	5.5	3.1	2.7	2.8	2.7	2.5	2.6	3.6	1.7	2.7	2.7	2.0	1.7	2.0	1.7	1.8	1.2

Board & second screen	$U^-(L)$	5.7	4.3	4.7	5.1	4.4	4.9	4.9	4.9	2.6	4.8	5.0	4.8	2.7	2.5	2.5	1.7	2.2	1.9
Board	**L**	**73.0**	**71.6**	**70.4**	**67.6**	**67.3**	**63.6**	**62.7**	**61.0**	**63.6**	**63.0**	**56.2**	**58.8**	**54.0**	**53.8**	**55.1**	**53.4**	**51.0**	**49.6**
	$U^+(L)$	6.7	3.9	7.0	6.1	8.9	6.3	5.7	5.2	3.8	2.1	2.3	2.6	1.6	1.7	1.6	1.8	1.6	1.3
	$U^-(L)$	8.2	9.6	10.3	8.9	10.3	7.0	7.6	7.5	3.2	4.7	5.0	5.0	2.7	2.5	2.2	2.2	2.4	2.0
1m & tent	L	**70.2**	**68.4**	**65.4**	**63.6**	**60.4**	**58.9**	**57.7**	**56.5**	**60.9**	**61.3**	**53.6**	**57.8**	**52.1**	**51.3**	**51.9**	**47.3**	**45.4**	**47.9**
	$U^+(L)$	5.1	5.6	6.4	4.0	4.2	4.7	2.4	2.9	3.8	1.6	2.4	2.8	1.9	1.7	2.0	1.6	2.0	1.4
	$U^-(L)$	5.8	7.4	6.9	5.9	5.9	5.7	4.9	4.4	4.2	4.3	4.4	4.8	2.8	2.7	3.5	2.4	2.0	2.4
1.5m	**L**	**76.8**	**75.1**	**73.7**	**71.9**	**70.1**	**68.2**	**66.3**	**64.4**	**64.1**	**63.8**	**57.8**	**59.4**	**54.4**	**53.2**	**53.4**	**49.3**	**46.4**	**48.0**
	$U^+(L)$	6.1	6.3	7.0	7.4	7.0	7.7	7.3	7.7	4.0	4.8	5.2	3.2	3.2	2.6	2.6	2.2	2.3	1.8
	$U^-(L)$	11.8	12.7	12.6	11.6	12.8	10.1	10.1	9.7	4.5	4.6	6.5	6.1	3.6	3.0	3.2	3.0	3.2	2.4
4m	**L**	**79.3**	**77.5**	**76.8**	**76.2**	**74.5**	**72.7**	**70.6**	**68.9**	**67.4**	**65.2**	**61.7**	**61.0**	**57.7**	**55.2**	**54.0**	**51.8**	**51.1**	**50.0**
	$U^+(L)$	5.5	5.9	5.6	7.5	7.9	7.3	7.7	7.1	7.2	7.0	8.3	6.7	8.6	6.4	4.9	3.5	2.1	1.2
	$U^-(L)$	11.5	13.3	13.1	13.4	11.4	12.6	12.2	11.9	8.5	7.4	13.0	11.0	7.6	5.4	3.7	3.1	2.2	1.9

Analyzing the FFT spectrum for frequencies below 10 Hz (Figure 11), it is noticeable that there is clear masking of the characteristic frequencies of the turbine operation for all signal recording methods except for the signals recorded on the double-shielded board and for the microphone placed in the tent. The results shown in Figures 9 and 10 confirm the best effectiveness of the double wind shield (on the board) in reducing wind interference in the lowest frequency bands.

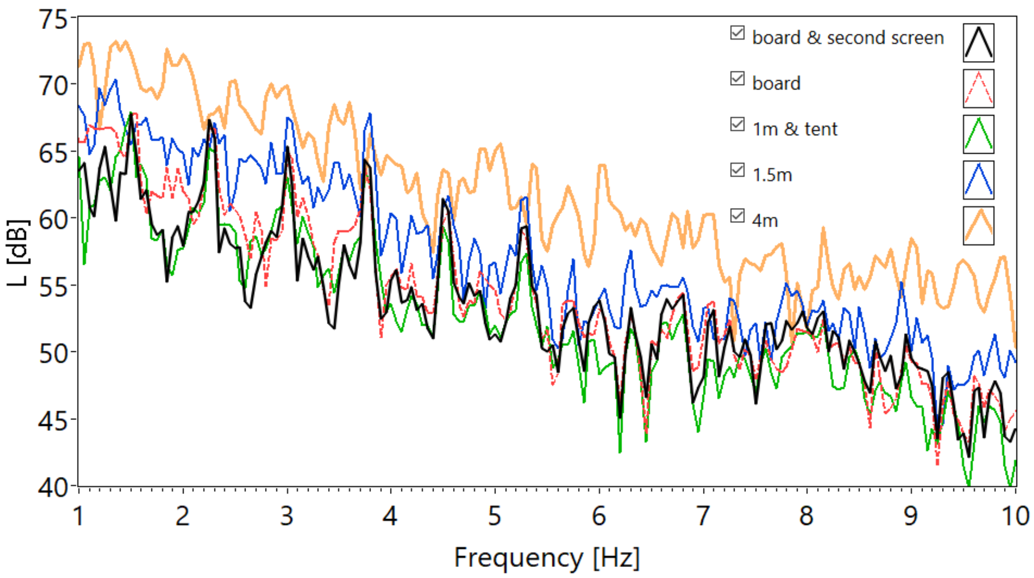

Figure 11. Wind turbine noise, FFT spectrum, average wind speed – 3.5 m/s, max wind speed – 6.7 m/s

In summary, for measurements made with an average wind speed of 2.1 m/s with gusts up to 4.5 m/s, the best results were obtained for measurement on a board with a double wind shield and measurement in a tent. However, for higher wind speeds (average speed of 3.5 m/s with gusts up to 6.7 m/s), the measurement on a board with a double wind shield proved to be the best, which is indicated by the lowest dispersion of results.

In summary, it can be stated that the best of the tested variants, in terms of measuring noise from wind turbines in the low-frequency range, is the microphone's position on a board following IEC 61400-11. Thus, it is not necessary to use different wind shields for the audio and infrasound bands in acoustic measurements of wind turbines. In both cases, measurement on a board with a double wind shield works well.