G.R.A.S.
SOUND & VIBRATION

Application Note
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Windscreens – Practical Guidelines for Acoustic Measurements in Situations with Wind Flow

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Introduction

Even a very gentle wind flow may seriously affect sound pressure measurements with a normal microphone. Pressure fluctuations in the airflow and turbulence created around the microphone will generate relatively large output signals from the microphone. These pressure fluctuations will not be associated with the acoustic signals that should be measured. At any given wind speed, the level of pressure fluctuations will be heavily dependent on the degree of turbulence in the airflow.

Especially for outdoor measurements of sound pressure levels, the effect of wind-induced noise signals on the measurement microphones should be considered. This is true even with what on the Beaufort Scale is called a "Gentle breeze", corresponding to around 15.5 km/h (or 10 mph). Depending on the degree of turbulence in the airflow, such a gentle breeze will induce pressure fluctuations on the microphone corresponding to sound pressure levels around 50-70 dB(A).

Airflow may not only be a problem during outdoor measurements. Ventilation and air condition systems may also create airflow during measurements in-door, and that may also seriously affect the measurements. Similarly, measurements in wind tunnels and air ducts may require the use of windscreens or other solutions to enable precise acoustic measurements.

	Mean wind speed		
Beaufort wind scale	km/h	mph	Descriptive wind terms
0	<1	<1	Calm
1	3	2	Light air
2	8.5	5.5	Light breeze
3	15.5	10	Gentle breeze
4	24	15.5	Moderate breeze
5	33.5	21.5	Fresh breeze
6	43.5	28	Strong breeze
7	55.5	35	Near gale
8	68	42.5	Gale
9	81.5	50.5	Severe gale
10	95.5	59	Storm
11	110	68	Violent storm
12	>118		Hurricane

Fig. 1. *The Beaufort wind scale*

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Noise Induced on Microphone without Windscreen

The noise induced on the microphone diaphragm when placed in wind depends on the degree of turbulence in the airflow. Figure 2 shows the wind-induced signal on a ½" measurement microphone when placed in low turbulent and high turbulent airflow. It can be seen that at low frequencies the noise generated by the high turbulence airflow is around 20 dB higher than the noise generated by low turbulence.

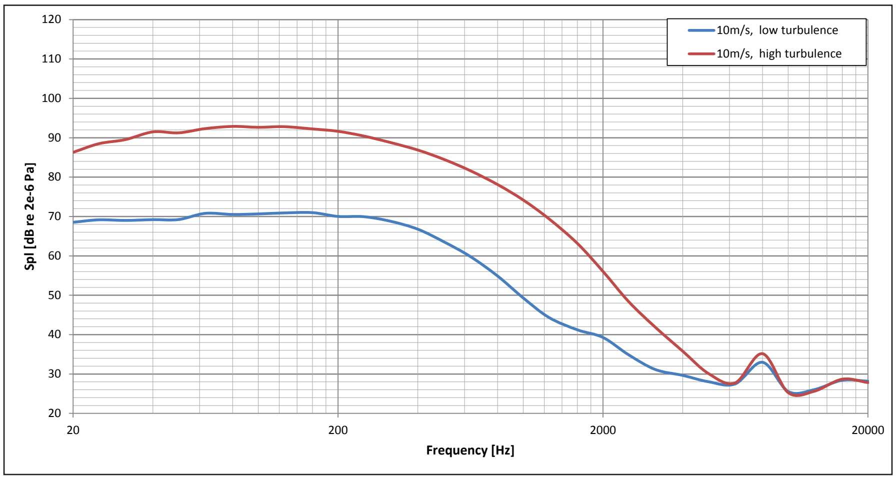

Fig. 2. Noise induced on microphone at 10 m/s air flow speed.

Both for low and high turbulence the noise induced on the microphone increases with increased air speed.

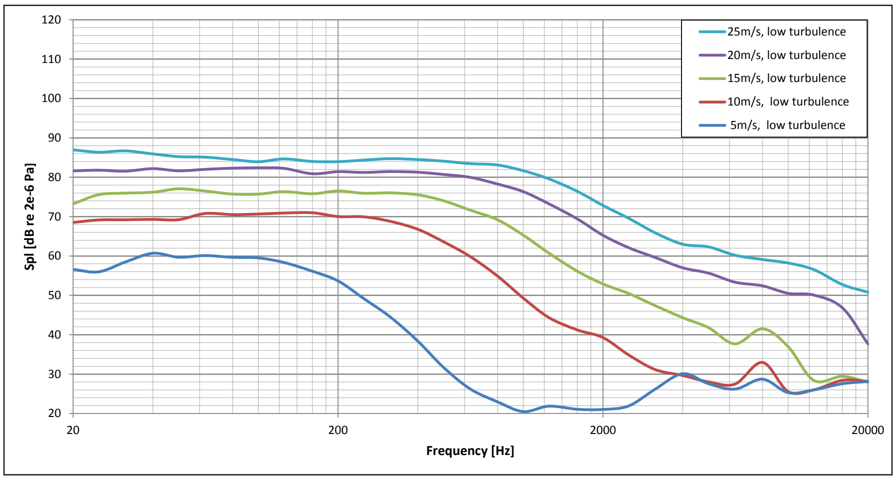

Fig. 3. Wind induced noise with low turbulence, no windscreen.

The induced fluctuations are dominated by low frequency signals and the level increases with wind speed.

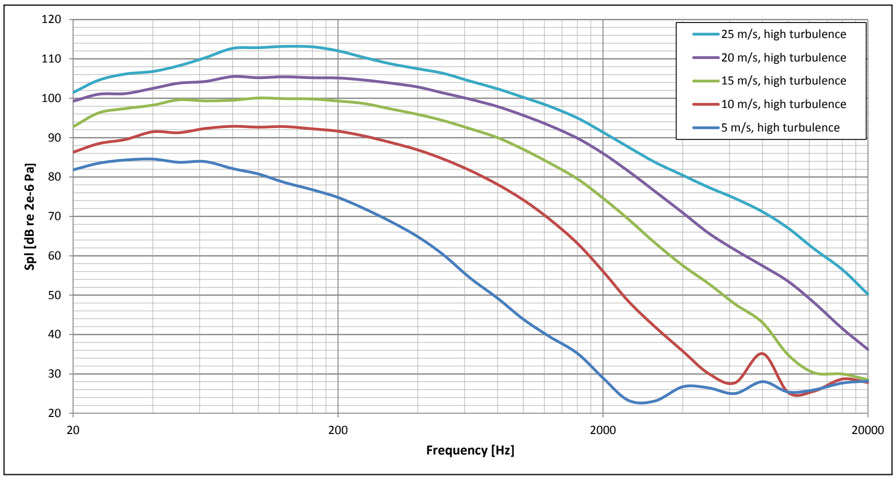

Fig. 4. Wind induced noise with high turbulence, no windscreen.

The induced fluctuations are dominated by low frequency signals and the level increases with wind speed. Compared to low turbulence flow, the levels are significantly higher.

Influence of Airflow Orientation

The spectra in fig Fig. 2 to 4 are all for wind arriving at the microphone from the front, e.g. 0 deg incidence as defined in Fig. 5a.

Turning the microphone 90 deg. so that the microphone diaphragm is parallel to the flow direction (Fig. 5b), gives a slight reduction in the flow induced noise signal at mid frequencies, but results in a significantly higher level at higher frequencies.

Influence of Microphone Size

One may intuitively assume that the effect of the wind flow may be reduced by reducing the size of the microphone so that the disturbance of airflow is minimized. This gives however only minor reductions at low frequencies, but increases the noise induced signal at higher frequencies.

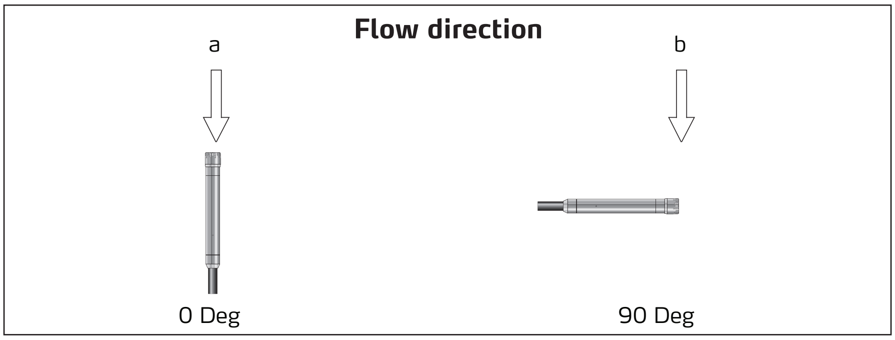

Fig. 5. *Air flow direction relative to microphone orientation.*

The spectra in Fig. 2 to Fig. 4 are all for wind arriving at the microphone from the front, e.g. 0° incidence as defined in Fig. 5a.

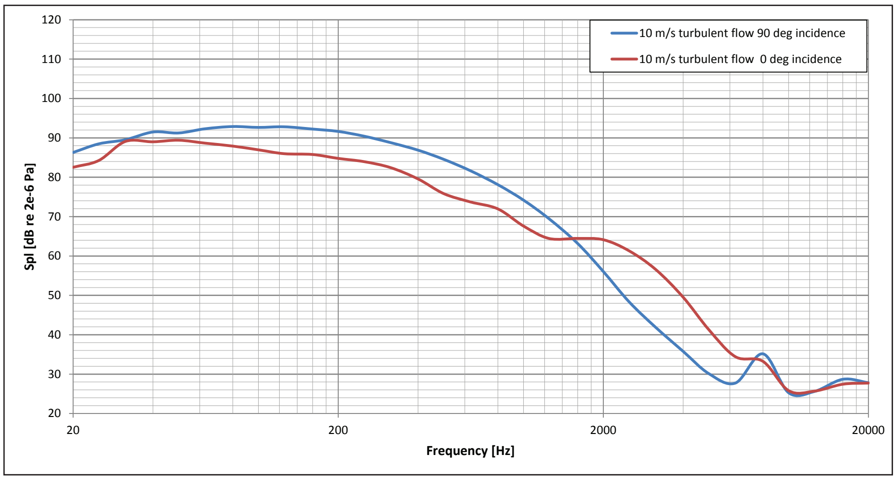

Fig. 6. *Wind induced noise signals for 0 deg and 90 deg flow incidence.*

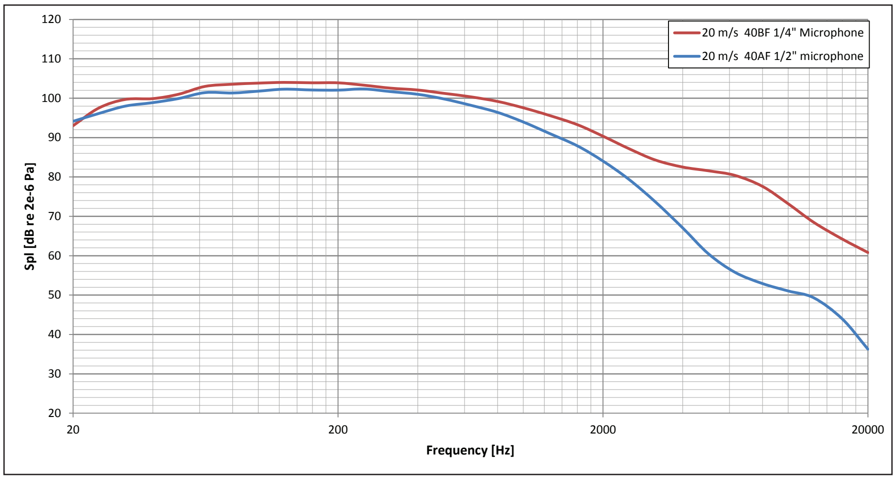

Fig. 7. *Wind induced noise for 1/2" and 1/4" microphones for 0 deg. incidence.*

At high frequencies the noise signal is increased for the 1/4" microphone, due to the smaller diaphragm area and thereby reduced pressure averaging over the diaphragm area.

Influence of Windscreen on Airflow
The flow induced pressure signals on the microphone diaphragm can be reduced considerably by using a windscreen. The windscreen is mounted over the microphone so that the pressure sensitive microphone diaphragm is completely surrounded by a layer of foam material. This is typically made of an open-cell structure foam with minimum acoustical attenuation.

The size of the windscreen is a compromise between several contradicting factors. In order to minimize the airflow at the microphone position inside the windscreen, the windscreen should be as large as possible. However, a very large windscreen will disturb both the airflow and the acoustical field. As illustrated in figure 9, a large windscreen will disturb the flow and create turbulence behind the microphone. Furthermore, the change in the flow may not be permissible if the measurements are performed in a wind tunnel with high demand for flow stability. Also, at high flow speeds the windscreen material will be compressed by the flow pressure and this will compromise both the wind noise reduction of the windscreen and change the acoustical transmission through the windscreen material.

The GRAS windscreen AM0069 is a 90 mm. diameter open cell foam windscreen for ½" measurement microphone.

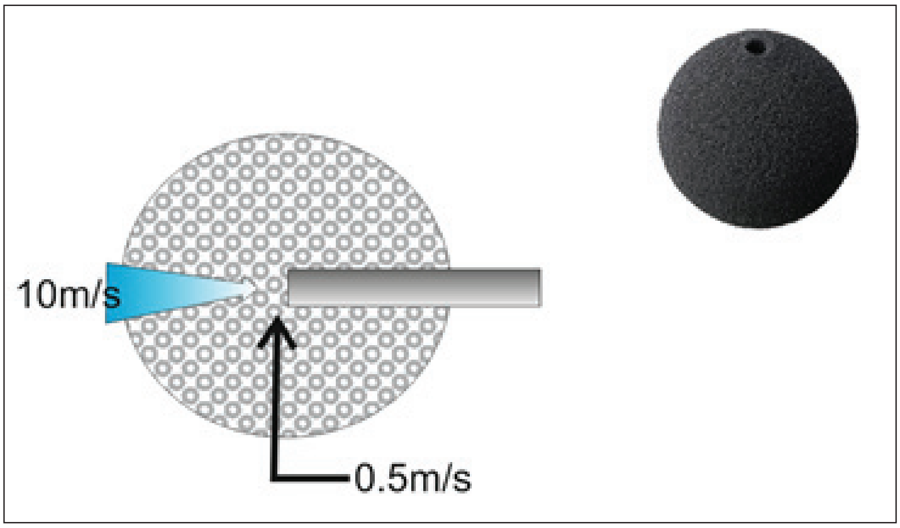

Fig. 8. *Windscreen structure.*

The open-cell structure ensures that the acoustical pressure fluctuations can be transmitted through the material to reach the microphone diaphragm, while at the same time the airflow velocity is gradually reduced, so that it is significantly reduced at the diaphragm position.

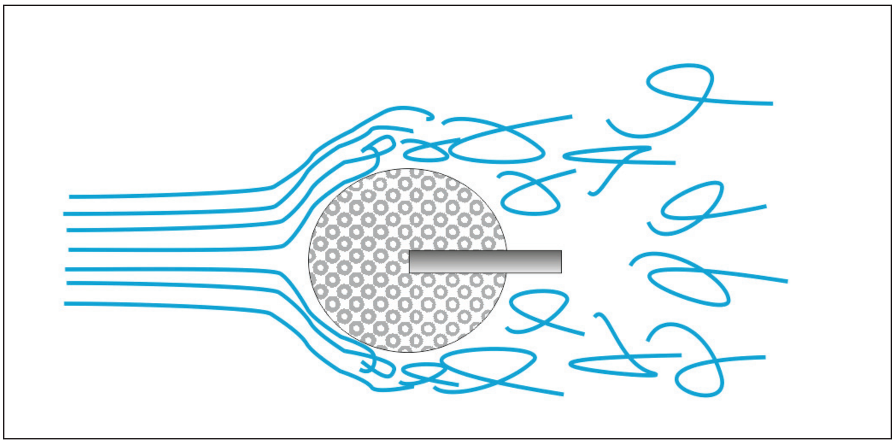

Fig. 9. *Effects of windscreen.*

A windscreen creates acoustical noise that may not be distinguishable from the acoustical signal which should be measured. This effect increases with increased windscreen size.

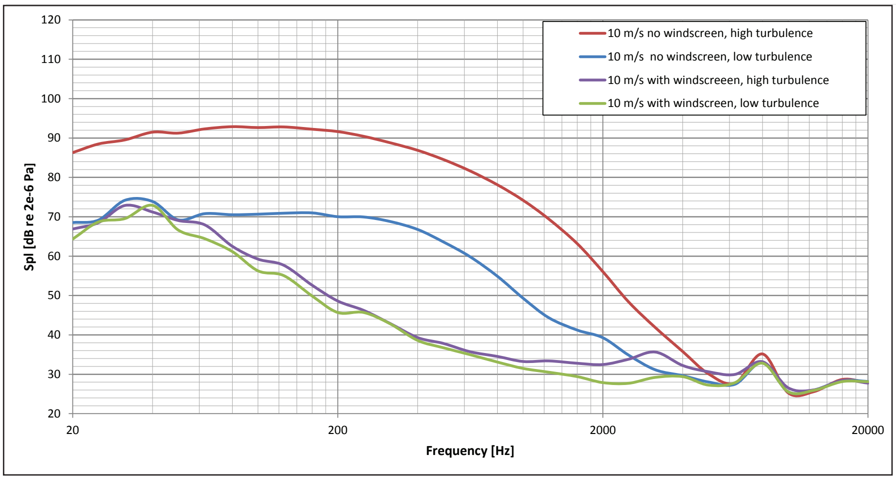

Fig. 10. *wind induced noise reduction with 90 mm windscreen AM0069*

Acoustic Influence of Windscreen
The effect of the windscreen is obtained by comparing the results of measurements performed with and without windscreen. The measurements were performed in an anechoic chamber using a random broadband noise signal.

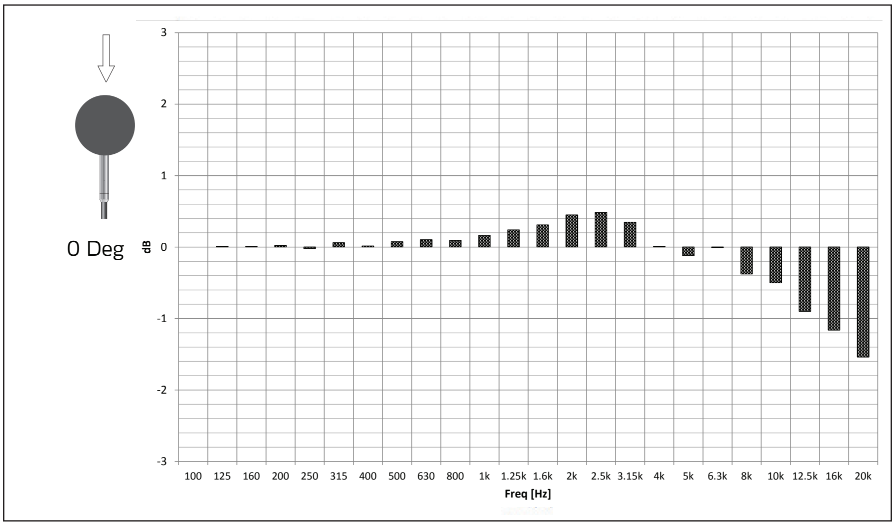

Fig. 11. *Effects of 90 mm windscreen on the frequency response for 46AF 1/2" free-field microphone, 0 deg incidence.*

The effect is very small below approximately 200 Hz. In the frequency range from 250 Hz to 4 kHz, the windscreen causes a small amplification of the signal with a maximum amplification of 0.6 dB at 2.5 kHz. At 8 kHz and frequencies above, the windscreen causes a decrease of the frequency response.

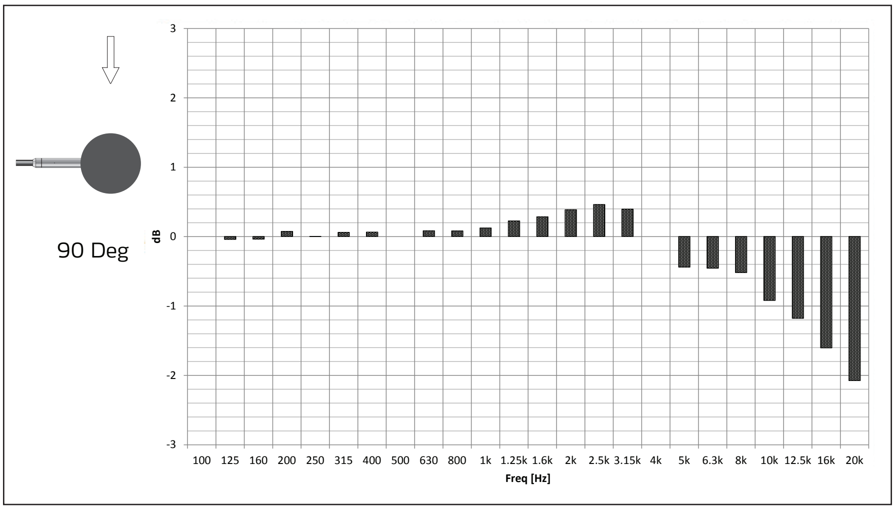

Fig. 12. *Effect of 90 mm windscreen on the frequency response for 46AF ½" free field microphone, 90 deg incidence.*

For 90 degree incidence (parallel to the microphone diaphragm), the result is almost the same for low frequencies, while the attenuation at high frequencies is increased.

Conclusion

Even moderate airflow speeds may seriously affect pressure measurements with normal microphones. Depending on the degree of turbulence in the airflow, a flow corresponding to a gentle breeze will induce noise levels around 50-70 dB(A). These levels will increase with increasing wind speed.

Without wind protection, the wind induced noise will dominate, and the acoustical signals that should be measured will not be distinguishable from the noise.

Airflow generated noise can be attenuated with a windscreen that completely surrounds the microphone. Such a windscreen must be large enough to reduce the flow generated noise, but at the same time small enough to not disturb the sound field too much. A 90 mm diameter windscreen is a good compromise between these conflicting factors.

An open cell foam structure ensures that the airflow velocity is significantly reduced at the diaphragm position, while at the same time the acoustical pressure fluctuations reach the diaphragm virtually unharmed.

In this way, significant attenuation of flow induced noise can be achieved at the cost of only very minor changes to the frequency response.

Appendix A

Influence of Windscreen on Flow

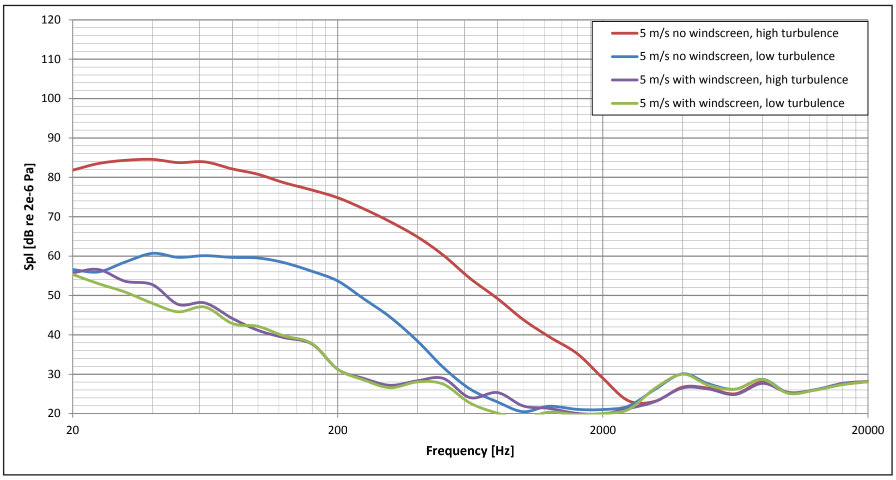

Fig. 13. *Effect of 90 mm windscreen at 5 m/s*

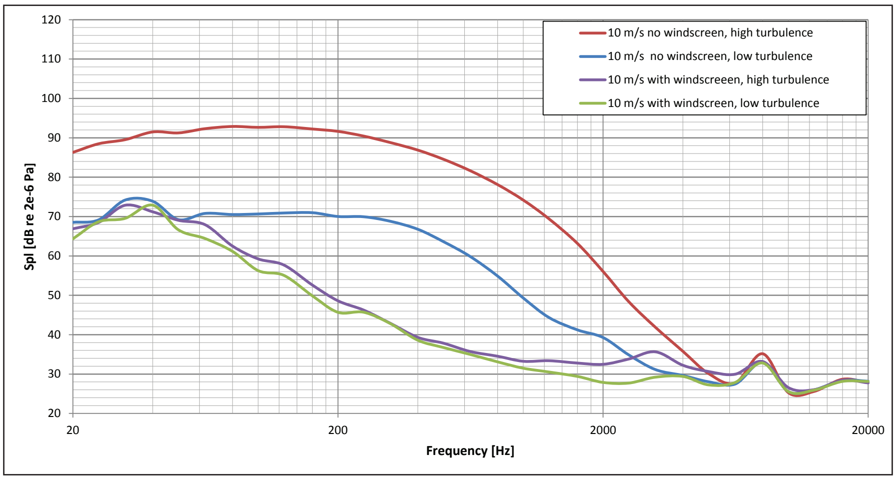

Fig. 14. *Effect of 90 mm windscreen at 10 m/s*

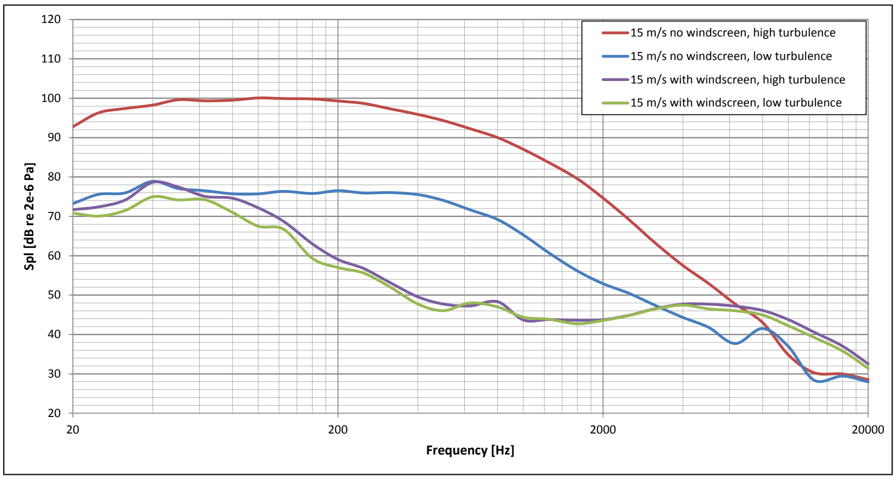

Fig. 15. *Effect of 90 mm windscreen at 15 m/s*

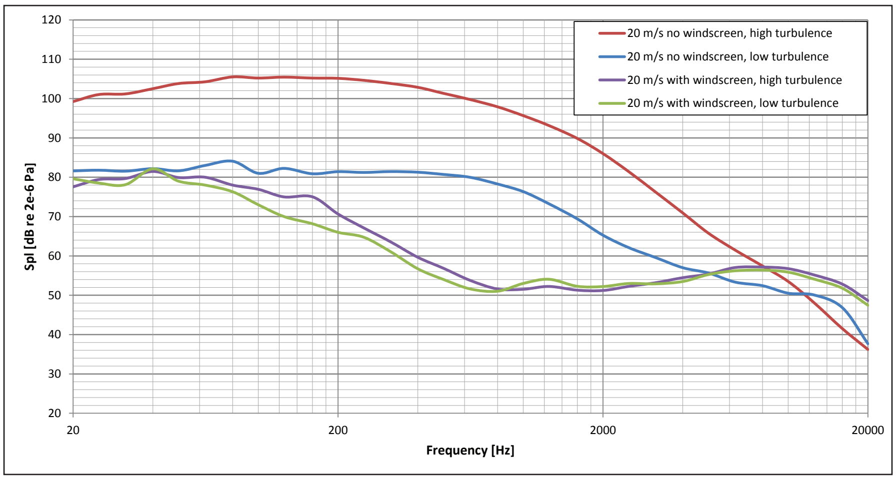

Fig. 16. *Effect of 90 mm windscreen at 20 m/s*

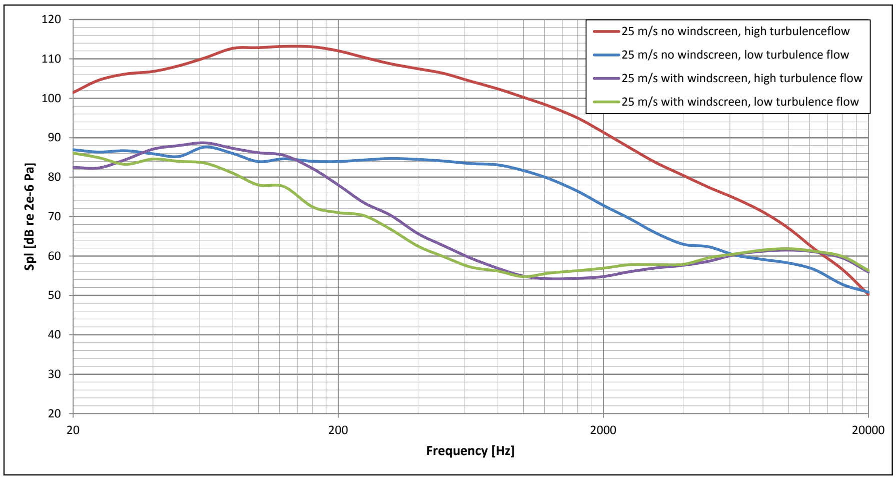

Fig. 17. *Effect of 90 mm windscreen at 25 m/s*

Appendix B

Influence of Windscreen on Frequency Response on 46AF 1/2" Free-field Microphone

Freq [Hz]	0 Deg incidence [db]	90 Deg incidence [db
100	0.00	0.00
125	0.01	-0.04
160	0.01	-0.04
200	0.02	0.07
250	-0.02	0.00
315	0.06	0.06
400	0.01	0.06
500	0.07	0.00
630	0.10	0.08
800	0.09	0.08
1000	0.16	0.12
1250	0.24	0.23
1600	0.31	0.29
2000	0.45	0.39
2500	0.48	0.46
3150	0.35	0.40
4000	-0.01	0.00
5000	-0.12	-0.44
6300	-0.01	-0.46
8000	-0.38	-0.52
10000	-0.50	-0.92
12500	-0.90	-1.18
16000	-1.16	-1.61
20000	-1.54	-2.08