

INSERTION LOSS AND WIND-INDUCED NOISE RESULTS FOR SECONDARY WINDSCREENS

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1 Introduction

Outdoor sound pressure level measurements in the presence of wind are inherently problematic, due to wind-induced noise generated at the microphone [1]. In many applications, measurements in high wind conditions can be avoided, but in the case of wind turbine noise measurements, it is inappropriate to avoid windy conditions entirely, as the acoustic output of wind turbines tends to increase with wind speed. As a result, various schemes such as the use of ground boards, large foam windscreens, and secondary windscreens, are employed to reduce wind-induced self-noise.

HGC Engineering investigated the insertion loss of various oversize windscreen designs, as well as the reduction of wind-induced noise offered by these designs. This paper describes the windscreens tested, and presents the insertion loss and wind-induced noise data.

2 Background

2.1 Descriptions of windscreens

Two primary windscreens and two secondary windscreens were tested. The primary windscreens were open-cell spherical foam windscreens of 76 mm (WS1) and 178 mm (WS7), both manufactured by ACO Pacific. The primary windscreens were placed directly on the microphone.

The secondary windscreens were custom made by HGC Engineering and featured a spherical wire frame, 610 mm in diameter, surrounded by one of two interchangeable covers made of “thick” or “thin” speaker grill cloth. The microphone was placed in the center of the sphere, as shown in Figure 1.

2.2 Measurement description

Insertion loss testing of the windscreen combinations was completed in a school gymnasium with dimension of approximately 21 m by 29 m by 7 m high. The room was qualified in accordance with ISO 3741, Annex C. A reference sound source was used to generate sound in the gym, and measurements were then conducted with various wind screens in place over the microphone.

The wind-induced noise testing was completed in a field, during the nighttime to minimize the ambient sound. The location was chosen because of low ambient sound, flat terrain, and the availability of permission from the landowner. Wind speed was measured continuously

throughout the sound level measurements, and the data was aggregated by wind speed.



Figure 1: Secondary windscreen shown with and without speaker grill cloth cover.

2.3 Instrumentation

Audio frequency sound levels were recorded using Norsonic N140 and Svantek 977 sound level meters, each connected to ½” microphones. The microphones were set at a height of approximately 1.5 m above grade.

The sound level meters measured and recorded spectral (frequency-dependent) 10-second L_{EQ} sound level data, and audio recordings were made. Correct calibration of the sound level meters was verified using an acoustic calibrator manufactured by Brüel & Kjær.

An ILG Electric Ventilating Co. centrifugal fan driven by a ¼ HP, 3400 RPM motor was used as a reference sound source during the insertion loss testing. Calibration of the reference sound source was previously completed to ANSI S12.51, ISO 6926, and AHRI 250 test standards.

Ten-second average wind speed and direction were recorded using an RMYoung Wind Monitor (model 05103) connected to a Campbell Scientific CR800 datalogger.

3 Measurement data

The results of the insertion loss testing are shown in Figures 2 and 3. The data are illustrated in terms of the difference between the windscreen under test, and the no-windscreen condition. The results of the wind induced noise testing are shown in Figures 4 and 5. The data are illustrated in terms of the difference between the windscreen under test, and a 76 mm windscreen. Most of the collected data fell into the 3, 4, 5, or 6 m/s bins during the test.

4 Discussion

4.1 Insertion loss

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The data show that when used individually, the 76 mm, 178 mm, and both secondary windscreen variants exhibit negligible insertion losses (less than +/- 1 dB) at most frequencies. However, at frequencies above about 6,300 Hz, the insertion loss of the 178 mm windscreen was found to increase, reaching approximately 2 dB at 10,000 Hz and approximately 3.5 dB at 16,000 Hz. This is comparable to manufacturer's data. The significance of these observations depends on the frequency content of the source under assessment.

When primary and secondary windscreens are used simultaneously, all combinations exhibit insertion losses of less than 1 dB at frequencies between 40 and 4,000 Hz. Above 4,000 Hz, both combinations utilizing the 178 mm primary windscreen had insertion losses increasing to 2 dB at about 8,000 Hz and 4 dB at 16,000 Hz. Combinations using the 76 mm primary windscreen conditions show insertion losses greater than 1 dB above about 10,000 Hz.

4.2 Wind-induced noise reduction

As expected, the 178 mm windscreen outperformed the 76 mm windscreen when used by itself. The addition of a secondary windscreen increased the performance of any primary windscreen. The most dramatic changes were observed at low frequencies, below roughly 160 Hz.

At low wind speeds (4 m/s average), the secondary plus primary windscreen combinations all performed similarly, outperforming the primary windscreens, and providing about 5 to 15 dB of improvement at low frequencies when compared to the 76 mm windscreen. At higher wind speeds (6 m/s average) the thin secondary windscreen outperformed the thick secondary windscreen in all tested conditions. Surprisingly, the thin secondary used alone performed the best overall at higher windspeeds. Further investigation of this observation is warranted.

At low frequencies, the secondary windscreen combinations generally outperformed the 178 mm primary windscreen, by up to 5 dB or more at the lowest frequencies. The significance of the potential improvement will again depend on the frequency content of the source under investigation.

In real world applications, there are considerations beyond acoustic performance. The use of a large secondary windscreen presents logistical and technical challenges. Large secondary windscreens can be difficult to transport due to size and fragility. Additionally, when required to be placed at elevated heights above the ground, a large secondary windscreen can frequently be subjected to high wind forces and thus may require specialized towers or guy wires to stabilize the assembly. Careful engineering of such structures is needed to avoid self-noise generated by the tower or wires, which can potentially negate the acoustic improvements at high wind speeds.

5 Conclusion

The present analysis indicates that a secondary windscreen can reduce wind-induced noise significantly, compared to a

76 or 178 mm windscreen, and also provide a lower insertion loss at high frequencies than the 178 mm windscreen.

While a large secondary windscreen can reduce wind-induced self-noise, the benefits may be negated by technical and logistical challenges of using a large windscreen in practice.

References

- [1] Kendrick, P., Von-Hunerbein, SUM., Cox, T.J., The effect of microphone wind noise on the amplitude modulation of wind turbine noise and its mitigation. Acoustic Society of America, 140 (1), July 2016.

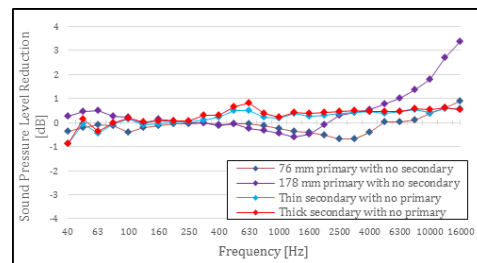


Figure 2: Comparison of windscreen insertion loss, reverberant gym, referenced to no windscreen – single windscreen

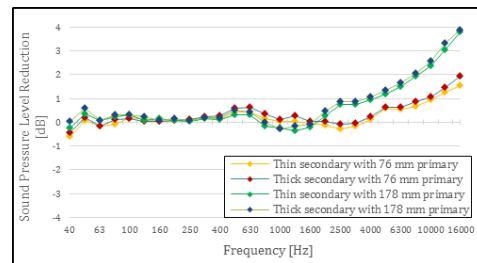


Figure 3: Windscreen insertion loss [dB], reverberant gym, referenced to no windscreen – double windscreen

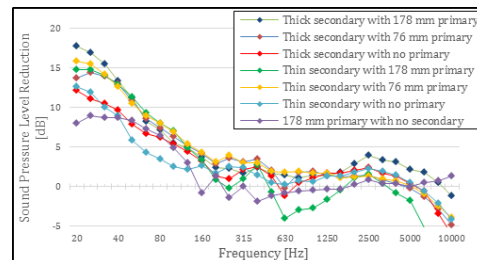


Figure 4: Sound pressure level reduction, referenced to 76 mm primary windscreen, 4 m/s average wind speed.

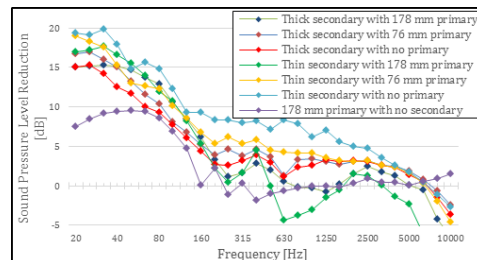


Figure 5: Sound pressure level reduction, referenced to 76 mm primary windscreen, 6 m/s average wind speed.