SOUND ATTENUATION OF ACOUSTIC SHIELDS

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1 Introduction

Symphonic music is characterized by having wide frequency content and highly variable sound levels including high peak levels. In many occasions, the sound levels exceed 85 dBA, the golden limit for the noise to be "safe" and not posing hearing hazard.

Many studies have been conducted to measure noise exposure of classical orchestra players [1-3]. Each study found many points toward a potential risk of hearing loss and the need of some form of noise control to reduce the noise exposure of musicians. Other than the use of hearing protectors, use of acoustic shields is often recommended.

Acoustic shields are devices used for controlling sound energy reaching musicians seated in front of loud instruments (mainly brass). They consist of plastic plates, mounted on a pole and located at the head level of the musician intended to be protected. There have been studies where attenuations of those devices were measured in laboratory environments. The object of the present study was to assess the attenuation in a real-life situation, with musicians seated in an orchestra pit. This was done in our case, during 10 National Ballet of Canada performances of the ballet Le Petit Prince. Each set of measurements was done using two dosimeters: one located on the shield, and the other attached to the shoulder of the musician intended to be protected. The attenuation was obtained as the difference between both measurements.

2 Method

2.1 Participants, shields and instruments

Sixteen musicians from the National Ballet of Canada Orchestra participated in the study. They were seated in areas of highest sound levels as per the study of Qian et al [4]. Sound levels were recorded by Bruel & Kjaer personal noise dosimeters types 4445 and 4448. Each measurement consisted of a pair of readings from dosimeters located in front, where the protected musician is seated, and behind the shield. One dosimeter was set up on the shoulder of the musician seated in front of the shield to measure the musician's actual noise exposure. The second dosimeter was set on the shield stand, positioned in the center of and 10 cm away from the shield, representing the noise exposure behind the shield.

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Two types of acoustic shields are used by the orchestra: Wenger and Manhasset, model 2000. Wenger shields are made of clear polycarbonate 57 cm by 43 cm. The Manhasset shields have larger dimensions: 65 cm by 55 cm, and they are made of Lexan polycarbonate. The thickness of both types of shields is of 6 mm. Since the density of the material is 1,200 kg/m^3, the surface density is 7.2 kg/m^2, much lower than the 25 kg/m^2 required for a highway noise barrier. The transmission loss, according to the mass low is around 22 dB at 500 Hz.

2.2 Measurements

All dosimeters started recording approximately 1/4 hour before the start of each performance. They were not paused during intermissions and continued running until the end of the show. Musicians were advised not to generate any artifact noises by yelling at, breathing heavily towards, or accidentally touching the instruments.

There were a total of 27 paired measurements in this study. The attenuation of each shield was calculated as the difference of the sound exposures in dB(A) measured by the dosimeters located on both side of the shields. The performances took place at the *Four Seasons Centre for the Performing Arts*, a 2,071 seat theatre with an orchestra pit beneath the stage. The pit measures 15.5 meters in width, 6.4 meters in depth (the stage protrudes 3.3 meters over the pit, while 3 meters is unobstructed from above), and the stage is 2.4 meters above the floor of the pit.

3 Results

Measurements were performed in a real work situation, meaning that the influence of the location of the shield and the instruments in the perimeter of the player were not taken into consideration. All shields remained at the same location throughout the course of this study. Therefore, it cannot be definitely stated that one type of shield is better than the other because there is the possibility that both types may perform identically when located at the same spot.

The results of individual attenuations measured on both types of shields: W (Wenger) and M (Manhasset) shown in Figure 1. It shows significant variations between individual tests and an overall better performance for the Manhasset shields, compared to the Wenger. Table 1 shows a summary of the results for both shields.

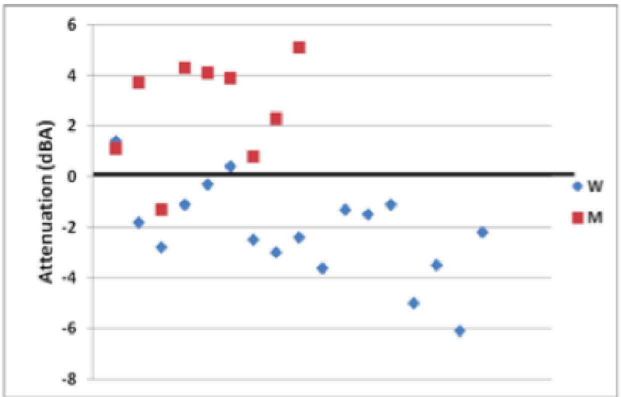

Figure 1: Individual attenuation

The authors were also interested in the variation of attenuations for a given shield (and same setting) during different performances. For that reason, the attenuation of some shields was repeated twice and three times while the shields selected for repeated measurements were selected at random. The average of the variations was 2 dBA, while the range was 4.0 – 0.4 dBA. Therefore variations were within the range of the accuracy of a field noise measurement and therefore not considered significant.

As expected from Table 1, the average attenuation of all shields pooled together is negative. The standard deviation is quite large, showing a large variation among attenuations.

Table 1: Results of the measurements

	Wenger	Manhasset
Average attenuation	-2.14	2.67
St. Error	0.45	0.7

4 Conclusion

The high number of uncontrolled variables, which is generally unavoidable in a study of this kind, made it difficult to come to general conclusions. The size of the shield's surface area is too small compared to the distances from the source to the shield and from the shield to the receiver. This gives way to a larger diffraction effect around all four edges of the device. Therefore, the flow of acoustical energy around the shield becomes as significant as the flow through the shield thus significantly reducing the resulting attenuation.

The distance and the location of the head of the player behind the shield also vary during a music session due to the fact that musicians move around in their chairs during performance, resulting in an ever larger diffraction effect.

Another factor is the sound from the musicians located on the sides of the protected colleague. The shield not only offers no protection from these musicians, but may even increase their sound exposure due to sound reflected from the shields. In those circumstances, the sound of the instrument behind the musician is not as important as the lateral and front contributions, thus reducing the benefit of the shield. Sound reflection is a significant factor contributing to musicians' elevated noise exposure, and this is especially true for those musicians seated close to the walls of the pit and also because the shields are made from polycarbonate, which is a reflective material. On top of the sound coming from reflections and other musicians, there is also sound generated by the protected musician himself, that contributes to his exposure. (This may explain some or all the negative attenuation results obtained in the present study). In summary, musicians are exposed to the sound coming from their own instruments, sounds coming from other instruments, and sounds reflected by the walls, the floor, and the shields.

Results also show a significant difference between the attenuations from both types of shields. This could be caused by the difference in the size of the Plexiglas boards. The Manhasset's surface is almost 50% larger than the Wenger's, and this is something that may explain the difference in attenuation.

Finally, for this population, the attenuation was not significantly affected between different sessions. This appears to indicate that players do perform at approximately the same sound level between performances. This was already studied by Qian et al [4] who arrived at the same conclusion that the inter-performances' variations are not significant.

References

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