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TECHNICAL MEMORANDUM

Project	**11319 Amadeus Orchestra Screens Mk2**		
Date	18 April 2016	**Memo No**	M001
Memo to	John Locke, Amadeus	**Copies to**	File 11319
From	Mat Tuora AMIOA	**Checked by**	Adrian James FIOA

AMADEUS ACOUSTIC SHIELDS

1 INTRODUCTION

We have been appointed by Amadeus Acoustic Solutions Ltd to measure the acoustic performance of two proprietary acoustically absorbent orchestral screens, also known as “Acoustic shields”. The purpose of these screens is to protect orchestral players from the very high sound levels emanating from some other instruments in the orchestra, particularly for those players sitting in front of brass and percussion instruments.

We undertook similar measurements for Amadeus Acoustic Solutions Ltd in 2005 (our reports 9775M001 and 9775M002) on their original design of screen. This was a freestanding screen consisting of two layers of clear polycarbonate. The layer facing the source instrument is perforated in order to provide some acoustic absorption and diffusion of the incident sound. This is designed to reduce the “colouration” effect reported by some brass players when plain acoustically reflective screens are located in front of them.

The latest designs of shield use the same principle of two clear polycarbonate layers, one of which is perforated, with an air gap between the layers. Overall, however, the new screens are smaller and lighter than the previous version. We tested two types, one freestanding and one fixed to the back of the Amadeus Opus 1 Musicians’ Posture Chair. Both screens were approximately 500 mm wide, 400mm high and 40mm in overall thickness.

This report describes our measurement methodology and discusses the effectiveness of the Amadeus Orchestra screens both in term of the insertion loss that they provide and the level of sound reflected back to the player.

2 MEASUREMENT METHODOLOGY

There is no national or international standard for the measurement of acoustic characteristics of screens specifically for orchestral use. We have therefore measured the insertion loss in accordance with the standard BS EN ISO 11821:1997 “Acoustics – measurement of the in situ sound attenuation of a removable screen”. We measured this in free field conditions, where there is no reflected sound from surfaces around the screen.

The source was a loudspeaker emitting constant broadband noise from a pink noise source. The resultant level was measured in terms of Leq,30 seconds in one-third octave bands using two calibrated NTi XL2-TA real time acoustic analysers. One acoustic analyser was used to measure sound at the listening position of the player protected by the screen and a second was used to measure the level of sound being reflected back to the source. Measurements were repeated, averaged and checked for repeatability. Background noise was also measured and found to be more than 10 dB below the source noise for all measurements above 100 Hz.

All equipment was fully calibrated in accordance with the requirements of BS EN ISO 11821:1997 and with the more stringent requirements of BS EN ISO 16283-1:2014. The overall accuracy of this engineering measurement method is estimated as being within +/- 0.5 dB from 500 Hz upwards and +/- 1 dB from 100 Hz to 500 Hz.

Figure 1 shows schematically the layout and microphone positions for the measurements on the freestanding screen, and Figure 2 shows the same information for the measurements on the chair-mounted screen. In both cases the source height was chosen to represent typical height for a trumpet or percussion instruments, and the microphone protected by the screen was located at approximately ear height for a player seated in front of such an instrument. The overall dimensions were typical of those encountered in a symphony orchestra. The perforated (absorbent) side of the screen faced the source.

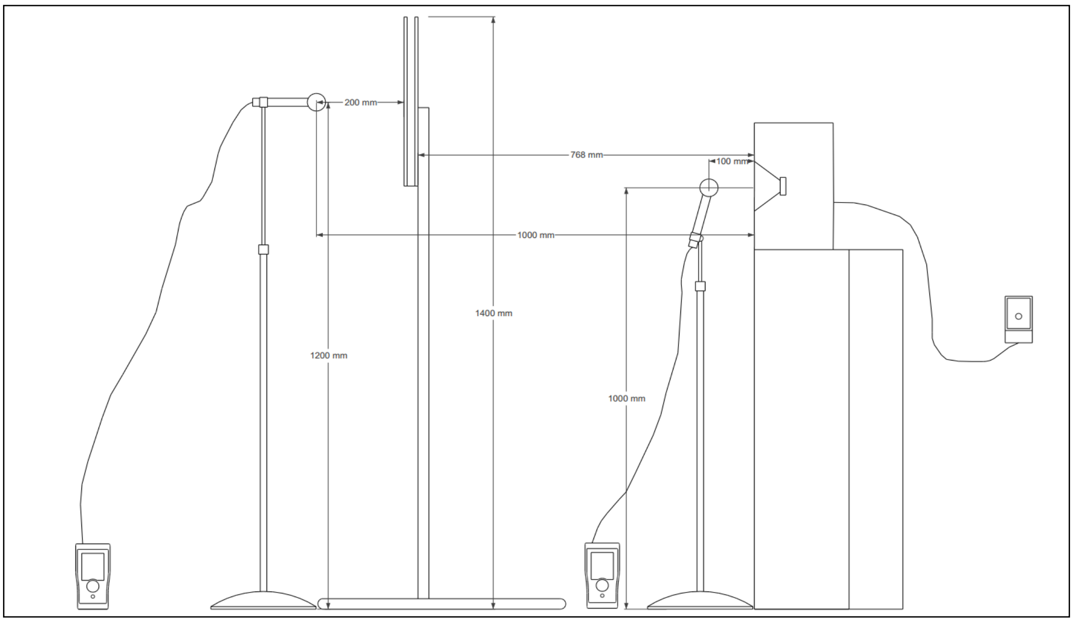


Figure 1 – section through free-standing screen and measurement equipment showing dimensions

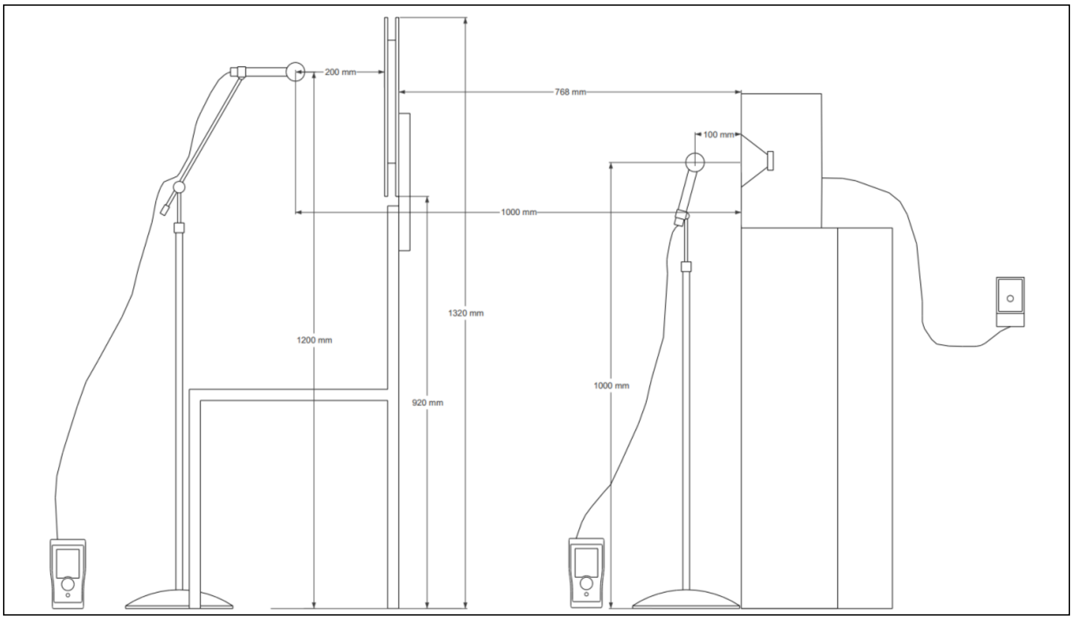
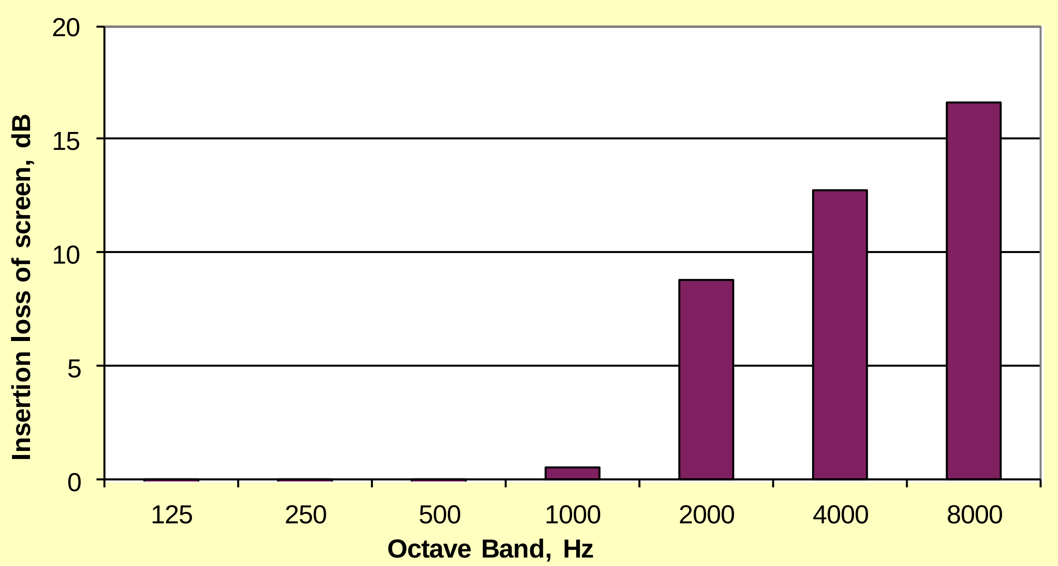


Figure 2 – section through screen fixed to chair and measurement equipment showing dimensions

The Leq sound level measured at the microphone with and without the screen was measured and the insertion loss is the reduction in level with the screen in place. Note that BS EN ISO 11821:1997 refers to measurements of the maximum noise level but we measured Leq as being more accurate and reproducible as well as more relevant to the case of orchestral noise.

The average insertion loss provided by the freestanding screen is shown in Figure 3. For simplicity this is shown in octave bands. The insertion loss increases with frequency, and this is consistent with the theory for acoustic screening. At frequencies below 500 Hz there was no measurable improvement within the accuracy of the measurements, and again this is consistent with the theory.

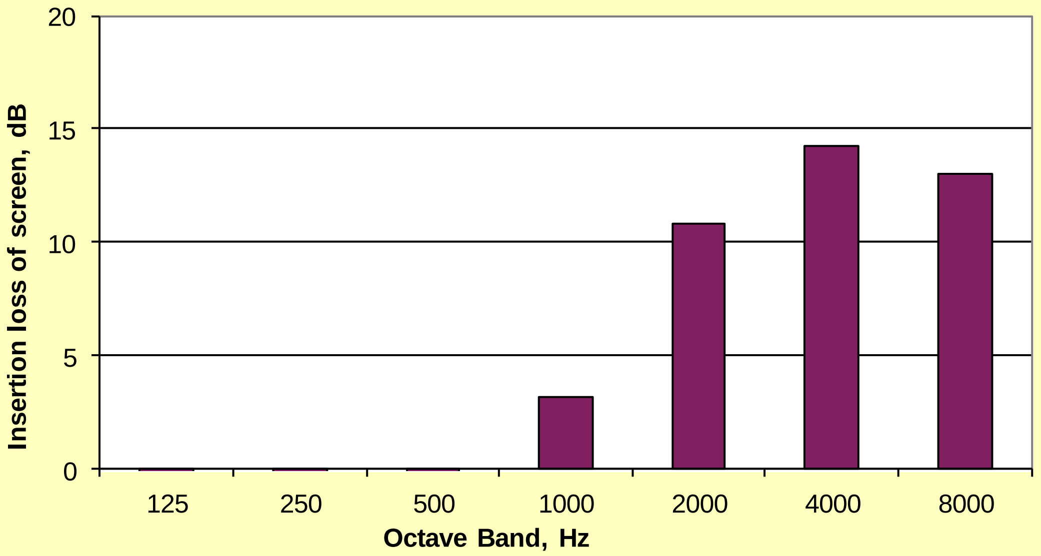
Figure 3 – Insertion loss of free standing screen



The overall A-weighted insertion loss for the free-standing screen using a theoretical pink noise source would be 7.8 dBA. We would expect better results from instruments which emit high levels of high-frequency noise (including harmonics).

The average insertion loss measured over the chair-mounted screen is shown in Figure 4. Again, the insertion loss increases sharply with frequency, and there was no measurable improvement below 500 Hz.

Figure 4 – Insertion loss of chair mounted screen



The overall A-weighted insertion loss for the screen attached to the player's seat using a theoretical pink noise source would be 8.8 dBA. Again, the insertion loss obtained in practice will vary with the frequency content of the instrument.

In both cases the results of the measurements are, of course, sensitive to the precise location of the source, screen and receiver. This is because the level behind the screen is affected by constructive and destructive interference of sound waves as these are diffracted around the edges of the screen. In theory, at lower frequencies where the wavelengths are similar to the dimensions of the screen, it is possible for there to be an increase of up to 3 dB at specific locations because of constructive interference effects. We found that it was possible to measure this effect at some frequencies below 800 Hz, but in practice this effect is not audible and is much smaller than the reduction in level at higher frequencies at which the ear is also more sensitive.

3 REFLECTIONS – MEASUREMENTS IN LABORATORY CONDITIONS

Orchestral screens are generally located at head height and are therefore required to be visually transparent. Most such screens are made of single sheets of Perspex or polycarbonate. These materials are acoustically reflective and hence tend to reflect sound back towards the source. For example, for the test described above, we would expect to measure an increase (up to 3 dB) at the source because of reflections from the screen.

It is not possible to measure the effective acoustic absorption of orchestra screens in accordance with the usual acoustics standards, because this would need 10 m^2 of screen in a reverberation chamber. We therefore measured directly the increase in sound level at the source using the experimental setup shown in Figures 1 and 2. For both types of screen style we measured levels at the source in the following conditions:

- Without any screen present,
- With the Amadeus orchestra screen
- With a single sheet of 8mm plywood mounted in place of the screen.

Figure 5 – Measurements in free field of reflections from the seat mounted screen

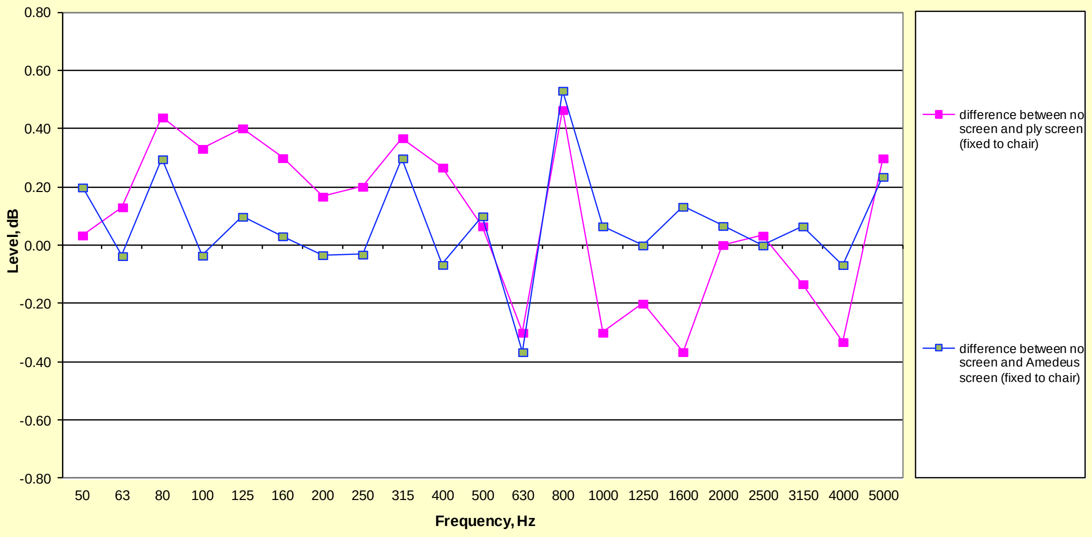
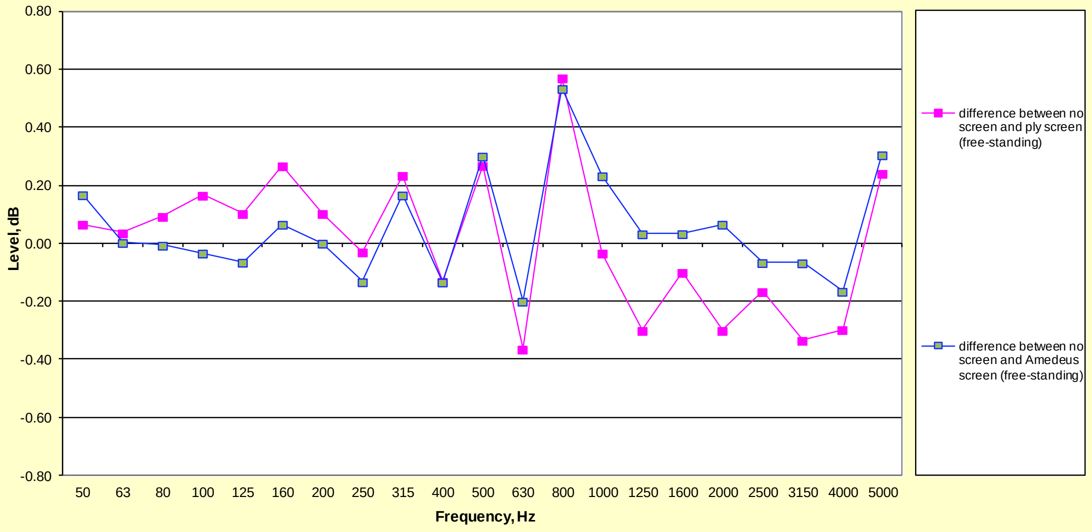


Figure 6 – Measurements in free field of reflections from the free-standing screen



It can be seen that the differences are very small (less than 1 dB at all frequencies) and well within the potential for measurement error. However, we do not expect that these results are due to measurement variation as they are consistent over several measurements, and indeed consistent between different mounting styles. It is likely that at some frequencies there is destructive interference between incident and reflected sound. The presence of the screen also changes the acoustic impedance in front of the loudspeaker, effectively changing the radiation characteristics of the source. These are known "near-field effects" which occur because of the proximity of the screen to the source.

It is also possible that the perforations in the screen result in a higher level of diffusion or "scattering" of the sound so that less sound is reflected directly back towards the player. This cannot, however, be measured accurately in this type of experiment.

It should be noted that the differences between perforated and unperforated screens were greater for the previous model of screen which was both larger and heavier than the current models. This is not surprising as we would expect a smaller, lighter screen to reflect less sound than a larger, heavier one.

These effects are of technical interest but not really significant in the context of the levels experienced by orchestral players.

4 NON-TECHNICAL DISCUSSION AND CONCLUSIONS

We have undertaken tests on the two screens provided in accordance with the only existing standard for such tests, which is BS EN ISO 11821:1997 "Acoustics – measurement of the in situ sound attenuation of a removable screen". To the best of our knowledge Amadeus is the only company to have these tests undertaken, and hence the performance figures quoted here may be, at first sight, lower than those from at least one other company which claims an impossibly high performance without the benefit of proper measurement.

In summary, the results of our tests on the Amadeus screens show that at frequencies above about 500 Hz (in musical terms, that is roughly the octave above middle C) both screens provide good attenuation, and the performance increases with increasing frequency or pitch. Broadly this means that the screens make more difference to a musician seated in front of a trumpet than to one on front of a tuba. Roughly speaking, the overall sound pressure level from a trumpet immediately behind the screen would be reduced by about 3 dBA. This does not sound very significant but in terms of permissible noise dose under the Noise at Work legislation, it would double the amount of time for which players could rehearse or perform before reaching the "Action Noise dose" at which, legally, they should stop playing. Several orchestras operate a rota of players, limiting the weekly rehearsal and performance time as a function of the "loudness" of the repertoire to comply with this legislation.

The high-frequency performance of the screens will also help to reduce the effect of sharp impulses such as cymbal crashes and side drums. This is often (wrongly) described as the cause of "Acoustic shock". From the experience of our acousticians both taking measurements and playing in orchestras, we can confirm that anything that reduces the amount of noise from percussion to the players in front is worthwhile both physically and psychologically.

The performance of the chair-mounted screen is measurably better than that of the free-standing version. In practice, the chair-mounted screen is closer to the player's ears and therefore the path difference between the direct sound and the sound diffracted around the screen is greater. In non-technical terms, the chair-mounted screen gets in the way of sound waves over a larger angle. It is also, of course, more convenient to install and use than a separate free-standing screen.

The noise reduction of any screen is dictated by its weight – heavier materials perform better at lower frequencies – and by the geometry, as after a certain point the performance is limited by the sound travelling around the edges of the screen. In that respect the Amadeus shields do exactly what we would expect and are probably as good as could be achieved by screens of these weights and sizes. Their benefit over other types of screen are their visual transparency, ease of use and convenience through being attached to the back of the Opus chair, and that the perforated back of the screen appears to reduce reflections back towards the source. This is important because in the past brass players have refused to have other types of screens in front of them because of "colouration" effects from reflections off the backs of the screens.

Overall, therefore, we would expect the chair-mounted Acoustic Shield in particular to have significant advantages over other types of orchestral screen.

Report Status

Revision	Date	Prepared by	Checked by
-	18 April 2016	Mat Tuora AMIOA	Adrian James FIOA

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