Static insertion loss, transmission loss and noise reduction testing of an acoustic louvre

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ABSTRACT

Previous research by the authors into the testing and performance quantification of acoustic louvres shows that while performance indicators such as static insertion loss, transmission loss and noise reduction are frequently used by louvre manufacturers, they may not accurately represent the in-situ sound insulation performance. To examine the relationship between static insertion loss, transmission loss and noise reduction, a single stage acoustic louvre has been tested in accordance with standard and non-standard test methodologies. The testing included reverberant-to-reverberant testing using a transmission loss suite; this is the most common method utilised by manufacturers for testing of acoustic louvres. Other test methodologies were chosen to replicate the typical installation of acoustic louvres and involved reverberant-to-free-field in the external wall of a reverberation chamber and at the outlet of a duct discharging into free-field conditions. The results obtained for each test methodology are compared with relevant theory and each other to determine the advantages and disadvantages of each performance indicator and test methodology. The results show that static insertion loss obtained using reverberant-to-direct testing provides the most detailed information about the sound insulation performance of an acoustic louvre.

1 INTRODUCTION

Hayne et al. (2018) presented a brief review of the common uses of acoustic louvres, design features and performance characteristics to enable an understanding of the acoustic performance indicators required by acousticians. Their analysis determined that:

- Transmission loss testing between reverberant spaces may be unsuitable for acoustic louvres due to the coupling that exists between the source and receiver rooms. While there are several methods that can be implemented to reduce the uncertainty in the transmission loss performance due to this coupling, transmission loss testing does not quantify the directionality of the louvre.
- Testing an acoustic louvre using a reverberant to direct methodology closely replicates the most common use of acoustic louvres. If the static insertion loss is measured using measurement locations positioned away from the test specimen the directionality of the louvre can be quantified. Conversely, measuring in the near-field of the louvre allows the noise reduction to be measured at the expense of being able to quantify the directionality.
- In-duct static insertion loss measurements utilise the same measurement method used for acoustic attenuators. However, as acoustic louvres are rarely (if ever) located in ducts the insert loss performance measured using this method may not be applicable to louvres mounted in the external wall of the plantroom. In addition, in-duct measurements do not allow the directionality to be measured.

This paper is a follow-up to the 2018 paper where a single stage acoustic louvre has been tested in accordance with standard and non-standard test methodologies to examine the relationship between static insertion loss, transmission loss and noise reduction.

2 TEST FACILITY

The testing was conducted at the Acran Acoustic Testing Laboratory. The facility consists of two resiliently isolated reverberation chambers, a source room and a receiver room, separated by an aperture into which test samples of various sizes are mounted for sound reduction testing. The walls and ceiling to each reverberation chamber are constructed from 150mm thick concrete. The receiver room contains 16 stationary diffuser panels made out of medium-density fibreboard (Vallis et al. 2015).

Table 1: Details of the Acran Acoustic Testing Laboratory

Parameter	Source Room	Receiver room
Volume (m^3)	95	170
Surface area (m^2)	129	174
Test aperture area (m^2)	9.55	9.55
Ratio of largest to smallest dimension	1.00	1.49

3 TEST SAMPLE

The test sample consisted of a single stage acoustic louvre as shown in Figure 1. The black and silver colouring of the louvre has no significance beyond differentiating the louvre from Acran's commercially available louvres. The louvre was sized to be 1.0 m x 1.0 m to allow it to be rotated in the test openings. A structural frame was used to hold five aerodynamically-shaped blades. Each blade had a smooth metal finish on the top surface and a perforated surface on the underside to expose the sound-absorbing in-fill.

Figure 1: Photo of the louvre used in the testing

4 TEST INSTRUMENTATION

All measurements were conducted using a Brüel & Kjær Type 2250 hand-held analyser, which was field calibrated before and after each measurement using a Norsonic Nor1256 sound calibrator. The reverberation times were measured and calculated using the in-built software of the hand-held analyser, using the interrupted method.

The sound source consisted of pink noise played through two active speakers; a Mackie SRM 450 and dB Technologies Opera Lyric 412. In every instance, the speakers were located in, and pointed towards, diagonal corners of the source room.

5 TEST METHODOLOGIES

5.1 Static Insertion Loss

Static insertion loss (IL_{static}) is defined as the arithmetic change in sound levels with and without the acoustic louvre in place, given by

$$IL_{static} = L_{(no\ louvre)} - L_{(louvre)} \quad dB \tag{1}$$

where $L_{(no\ louvre)}$ is the sound pressure level measured without the louvre in place and $L_{(louvre)}$ is the sound pressure level measured with the louvre in place. To measure the static insertion loss two test configurations were used:

1. The test specimen was mounted in the external wall of the source room as shown in Figure 2; and
2. The test specimen was mounted at the exit of a 2.5 m long unlined metal duct (cross section 1 m x 1 m) that linked the source room to the building exterior as shown in Figure 3.

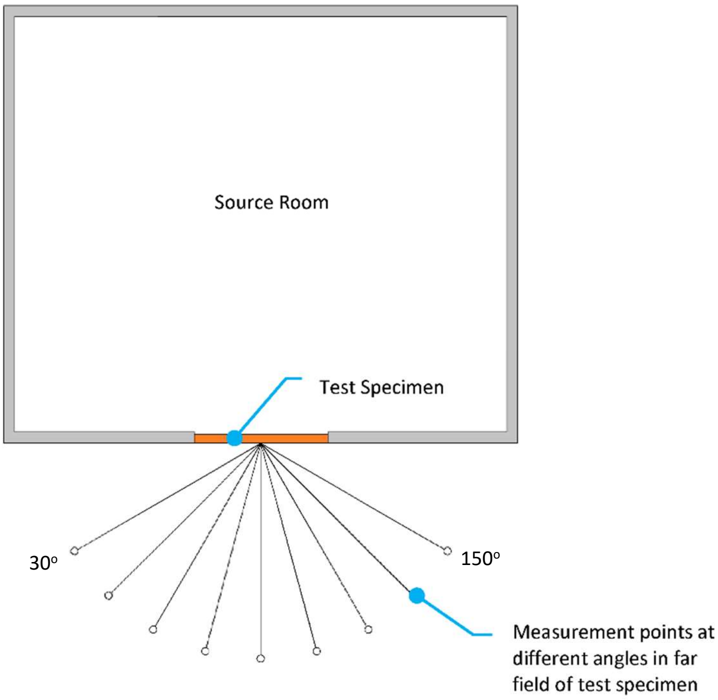

Figure 2: Configuration 1 for the static insertion loss testing

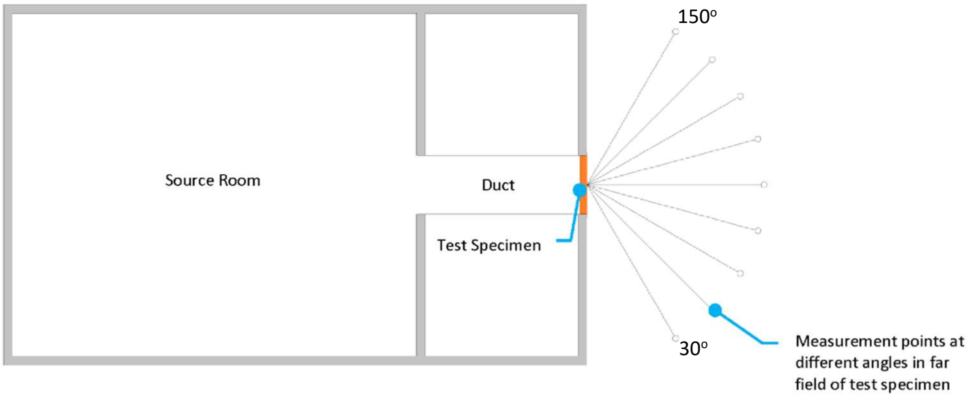

Figure 3: Configuration 2 for the static insertion loss testing

For both configurations, measurements are made in the far field (3 m from the centre of the louvre) with and without the louvre in the aperture. Equation (1) was then used to calculate the static insertion loss. By rotating the louvre in the aperture by 90° and making measurements in the far field at different angles (15° increments between 30° and 150°), the directionality of the louvre could be measured. The test arrangements closely matched the draft test guideline released by the HEVAC Association Acoustics Group (1991).

5.2 Transmission Loss

Transmission loss or sound reduction testing is the most common method used to determine the sound attenuation performance of acoustic louvres. A transmission loss suite as shown in Figure 4 is required to conduct this type of testing. The transmission loss suite consists of a source room and a receiver room. The two rooms are acoustically decoupled from each other and separated by a test aperture into which test samples are installed. The size and design of the source and receiver rooms is usually set by the requirement to ensure that a diffuse sound field required for reverberant measurements is established in the receiver room down to 100Hz.

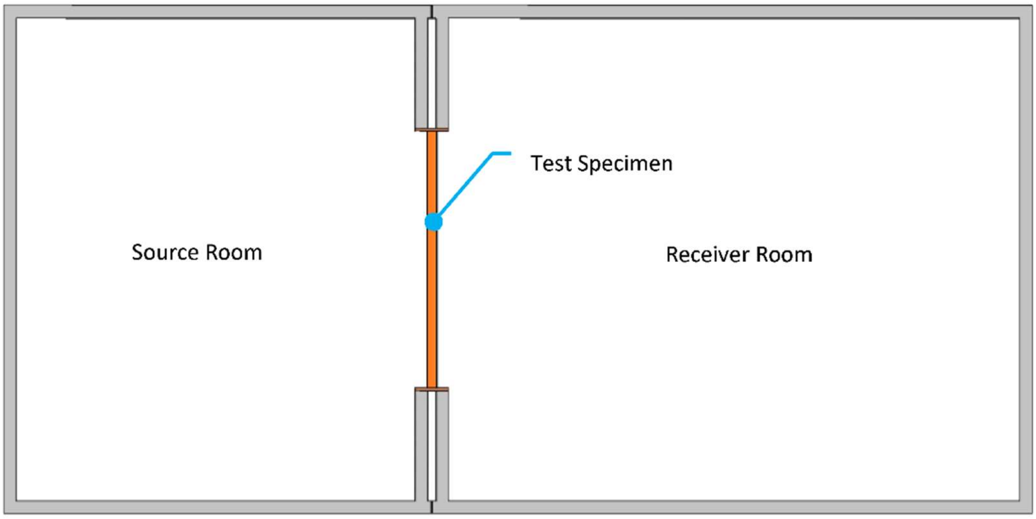

Figure 4: Schematic of the transmission loss suite

The test methodology is detailed in AS 1191 (2002), ISO 10140-2 (2010) and equivalent standards, with the transmission loss or sound reduction indices being determined using

$$L_R \cong \overline{L_S} - TL + 10\log_{10}\left[\frac{S_w}{R_c}\right] \quad \text{dB} \tag{2}$$

where L_R is the sound pressure level at a point in the receiver room, $\overline{L_s}$ is the temporal and spatial average sound pressure level in the source room, S_w is the area of the test element and R_c is the room constant, given by $R_c = \frac{(S_T\overline{\alpha})}{(1-\overline{\alpha})}$, where $\overline{\alpha}$ is the total mean absorption coefficient and S_T is the total area of the absorbing surfaces.

5.3 Noise Reduction

The noise reduction (NR) is the arithmetic difference in sound levels between the source and receiver sound pressure levels,

$$NR = L_S - L_R \quad \text{dB} \tag{3}$$

Noise reduction can be measured using the methodology in Section 2.3 ‘Test Procedure for Measuring Transmission Loss in Non-Laboratory Type Configuration’ of the superseded standard ASTM E336-67T (1967). That method involves measuring the reverberant field in the source room and the near-field external to the test sample. Another methodology involves making measurements of the average sound pressure level in the source room close to the test specimen and in the near-field external to the louvre as shown in Figure 6. The noise reduction and transmission loss can then be determined using:

$$\overline{L_S} - L_R = NR \cong TL + 6 \quad \text{dB} \tag{4}$$

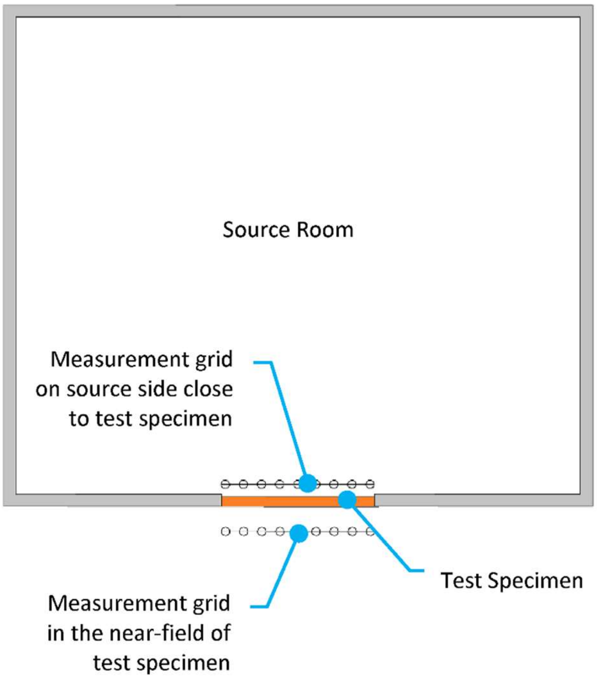

Figure 6: Measurement locations for the noise reduction testing

6 RESULTS AND DISCUSSION

6.1 Static Insertion Loss

The static insertion loss results are compared in Figures 8, 9, 10 and 11. In Figure 8 the test arrangement was as shown in Figure 2, while in Figure 10 the louvre was mounted flush at the end of an unlined 2.5 m long metal duct as shown in Figure 7. Due to the presence of a hedge and security fence, the insertion loss was only able to be measured between 30° and 105° for the louvre at the end of the metal duct.

Figure 7: Metal duct and flush mounted louvre flush with the wall at end of duct

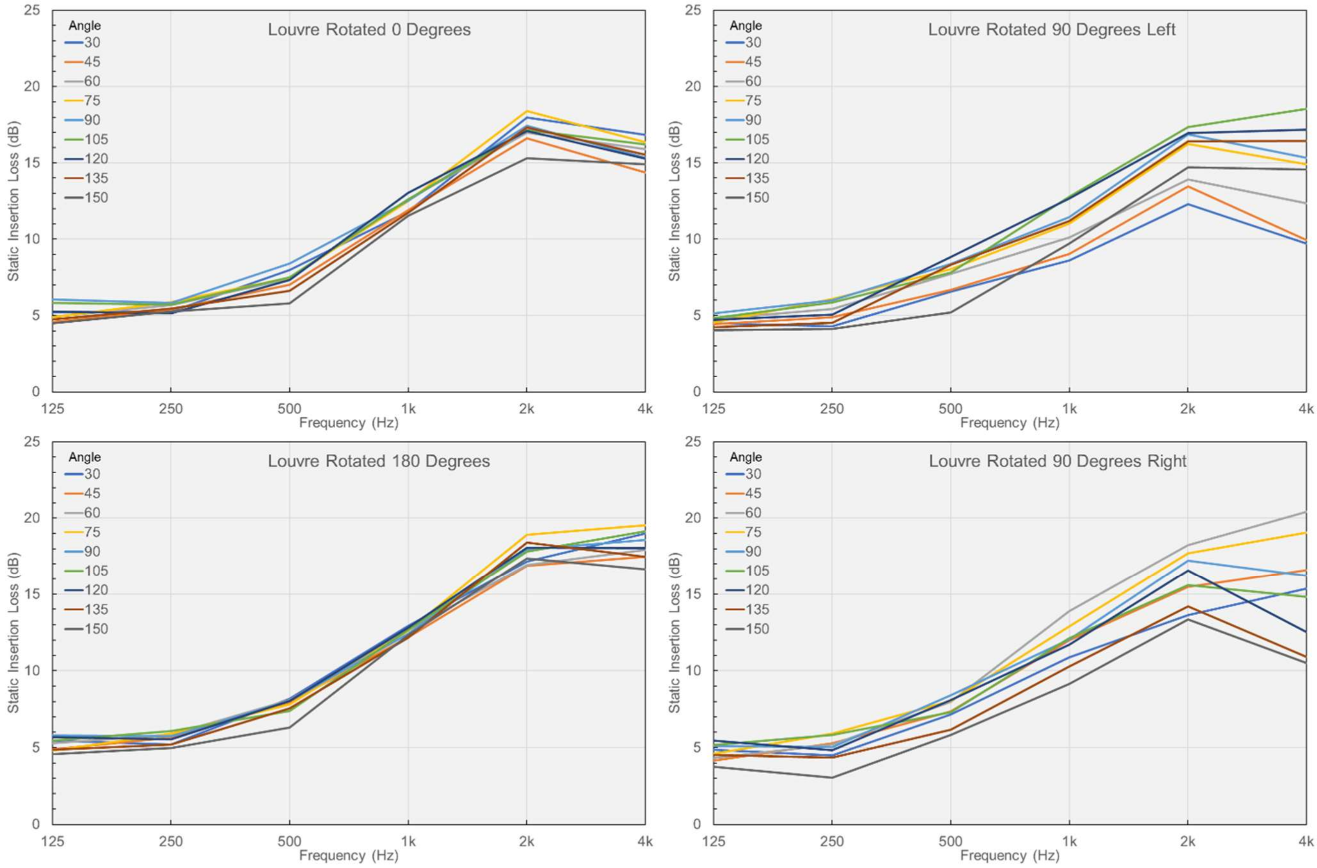

Figure 8: Static insertion loss for the louvre in the external wall of the test facility at different orientations

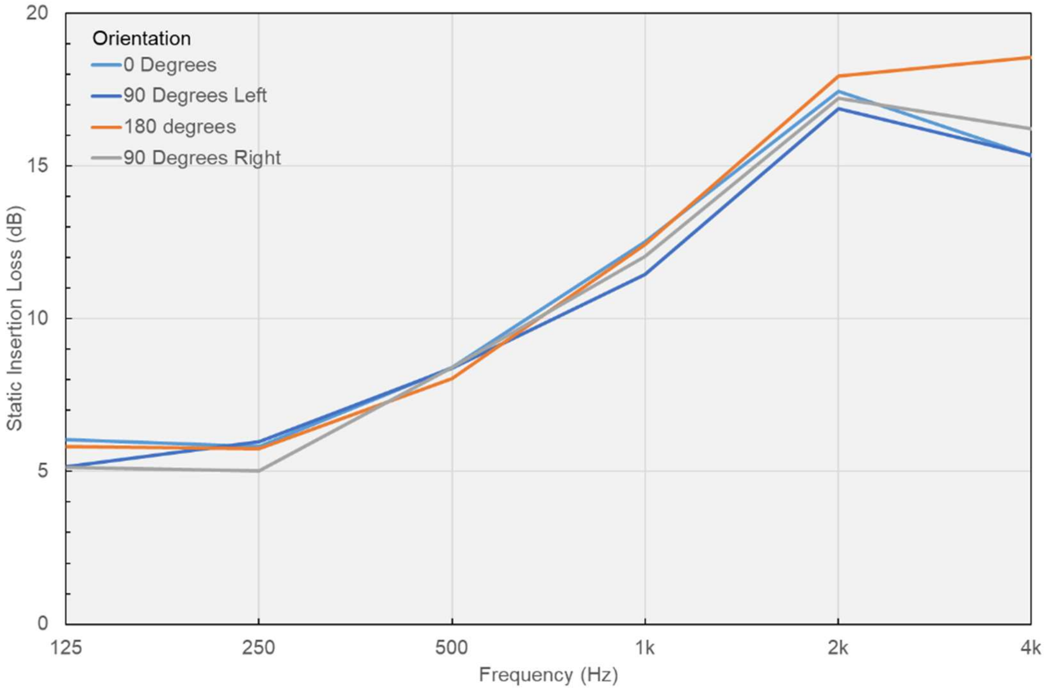

Figure 9: Static insertion loss at 90° with the louvre in the external wall of the test facility at different orientations

Figures 8, 9 and 10 clearly show the directionality exhibited by acoustic louvres, particularly at mid-to-high frequencies. Figure 11 shows the difference between the static insertion loss measured at 90° to the louvre and at 30° with the louvre located in the external wall of the test facility and at the end of the duct.

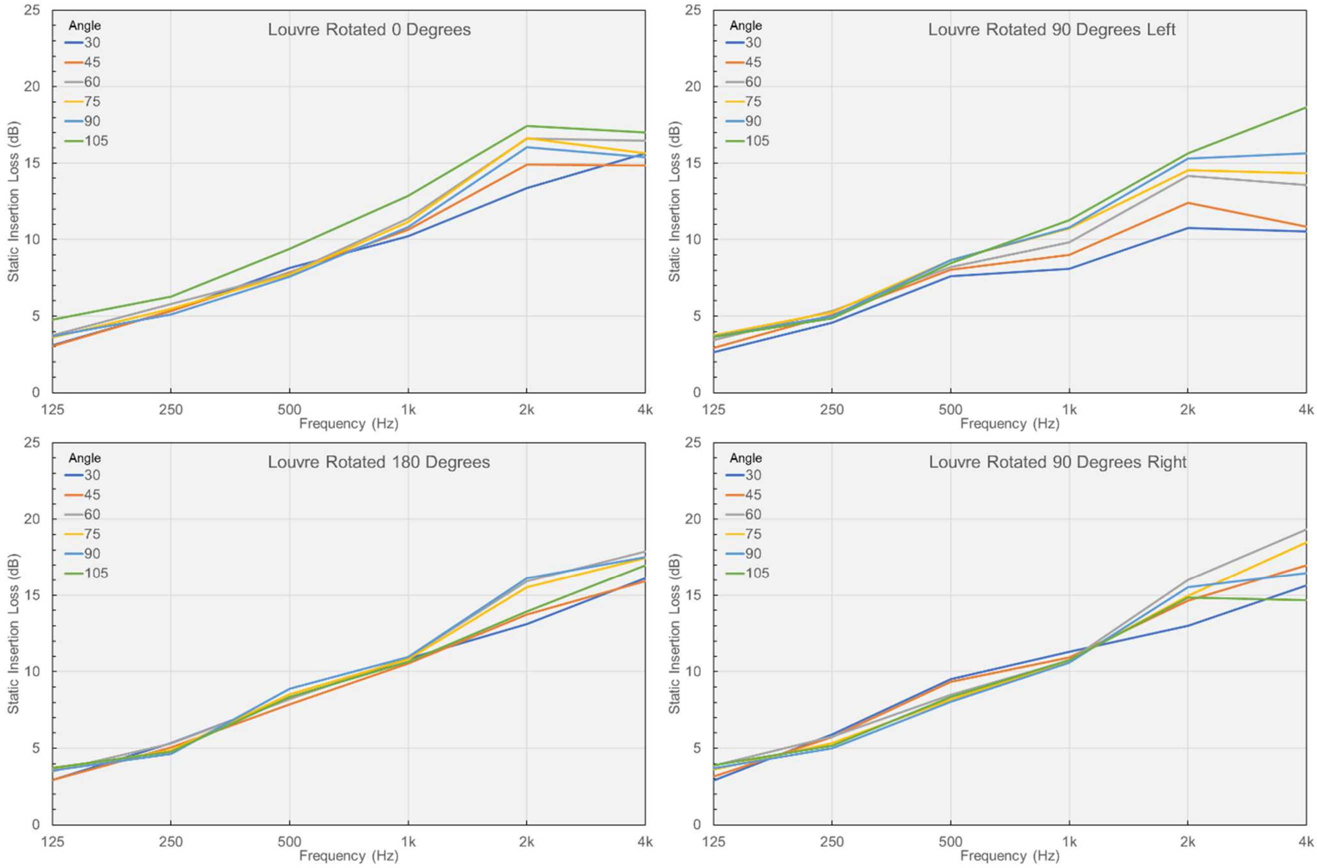

Figure 10: Static insertion loss with the louvre at the end of the duct for different orientations

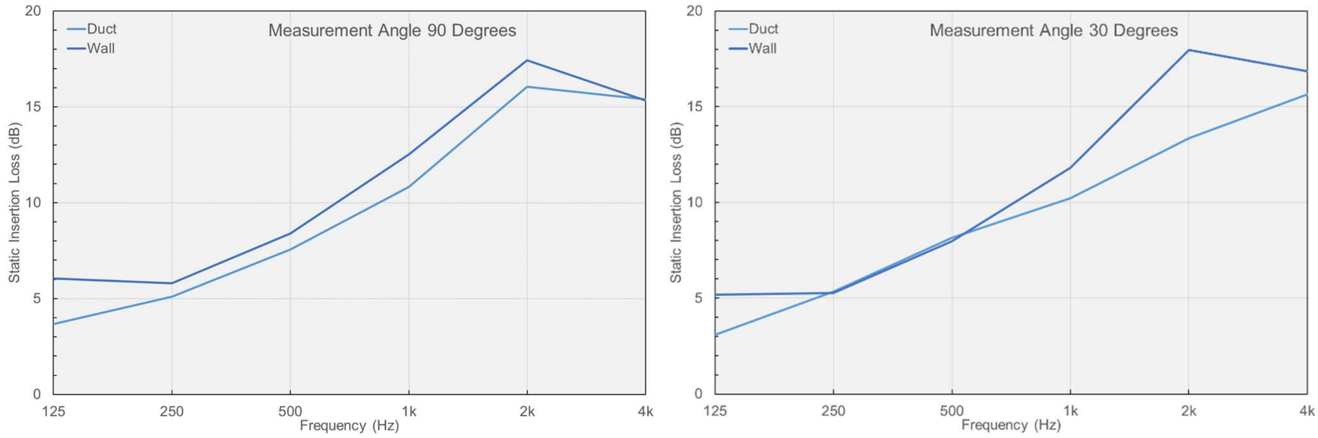

Figure 11: Comparison of static insertion loss measurement angle and directivity for louvre located in the external wall of the test facility and at the end of the duct

6.2 Transmission Loss

The transmission loss was determined by testing from the source room to the receiver room and testing from the receiver room to the source room. The transmission loss results are presented in Figure 12. It can be seen that 500 Hz and at higher frequencies there is good agreement, however below 500 Hz the results diverge.

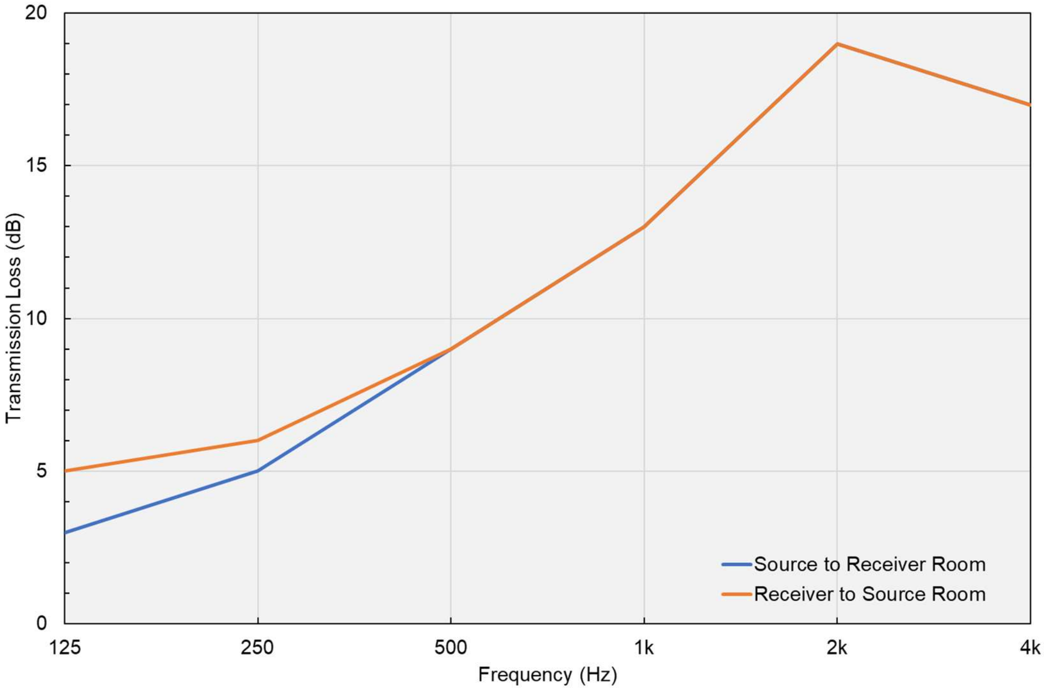

Figure 12: Transmission loss results

6.3 Noise Reduction

Figure 13 shows the measured noise reductions. Results obtained using measurements in the near-field on the source and receive sides of the test sample and using the ASTM E336-67T method, are compared with the noise reduction obtained by adding 6 dB to the transmission loss results for the source to receive room. It can be seen that, depending upon the method used to measure the noise reduction, there is up to a 4.5 dB difference between the measured noise reduction and the noise reduction determined from the transmission loss.

The results presented in Figure 13 show that determining the noise reduction from transmission loss test results will result in an overstatement of the acoustic performance of the louvre across most of the octave bands. The 4.5 dB difference is in agreement with results of Lyons (1994), who found that errors of up to 5 dB can be expected when the transmission loss is less than 15 dB.

The results in Figure 13 indicate that it might be possible to correct the transmission loss results to account for the coupling between the source and receiver rooms, using a technique such as that proposed by Bies and Pickles (1974) and Bies and Davies (1977).

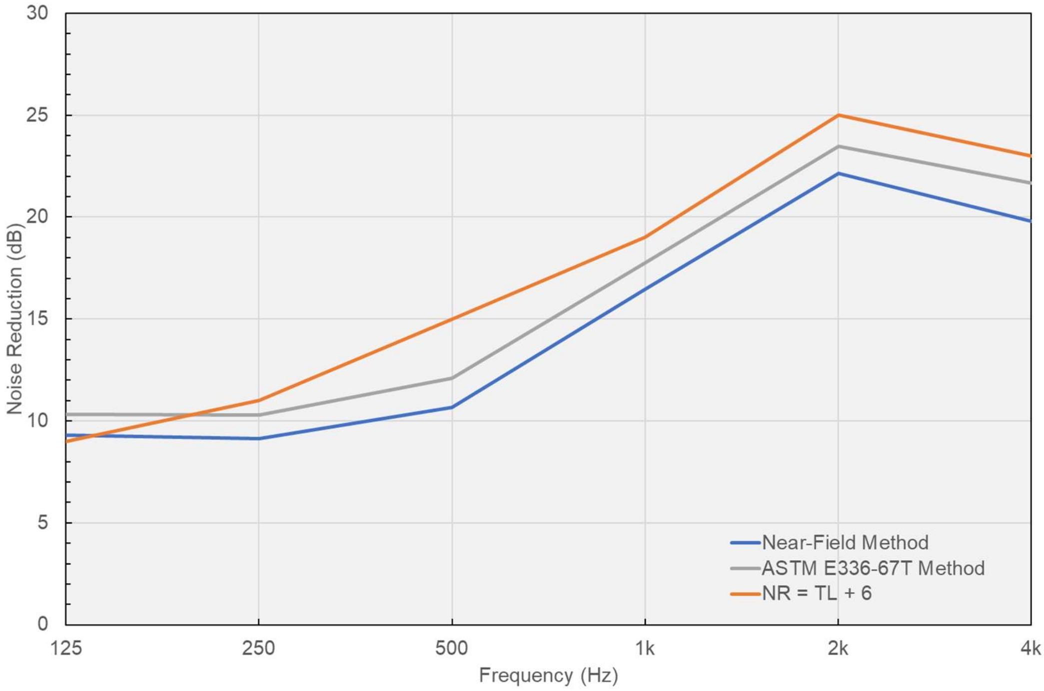

Figure 13: Measured and calculated noise reductions

6.4 Comparison Between Results

Figure 14 presents a comparison between results in terms of the 'noise reduction', calculated where required by adding 6 dB to the transmission loss or average insertion loss (i.e. averaged across all measurement angles and louvre orientations). It can be seen that the maximum difference in performance is around 4.5 dB at 500 Hz and 2 kHz.

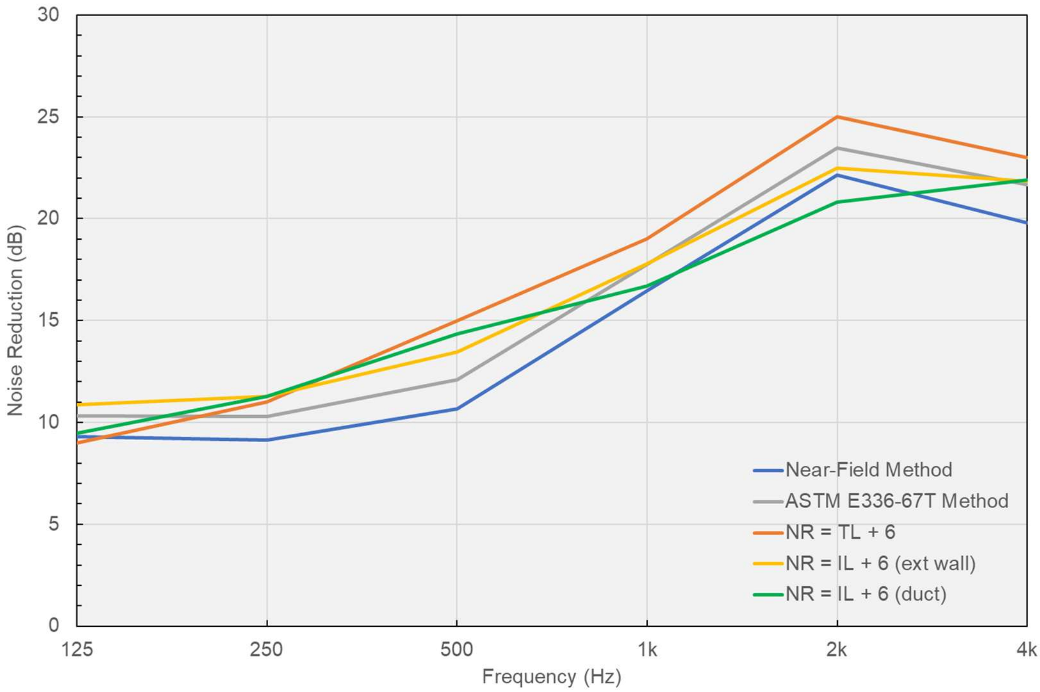

Figure 14: Comparison between 'noise reduction' results obtained using the different methods

7 CONCLUSIONS

The results of the testing conducted to date indicate that:

- Acoustic louvres are directional and hence, in some design situations, the directionality of the louvre will need to be taken into account.
- The directionality of a louvre varies depending upon whether the louvre is in the wall of a plantroom or at the end of a duct.
- The test methodology where the louvre is placed in the external wall of the test facility is recommended as it allows the directionality of the louvre to be measured.
- Caution needs to be taken when using acoustic louvres that have been tested in a transmission loss suite, as the inferred acoustic performance is likely to be higher than the in-situ performance of the louvre.

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