Acoustics Paper Preparation 2024 - Effectiveness of Acoustic Lagging Pipes in Outdoor Environments

Neil Macabenta (1)

(1) Neil Macabenta, Northrop Consulting Engineers, NSW, Australia

Abstract - Mitigation measures to control pipe or duct breakout noise can be limited, especially when access to the pipe for servicing or maintenance is a primary requirement. Pipe lagging is a cost effective mitigation measure to control pipe breakout noise but is rarely used in outdoor applications. This paper provides a case study where acoustic lagging was applied in an outdoor environment. As part of the study, measurements were taken before and after the acoustic lagging was applied to determine the in-situ performance of the acoustic lagging. The findings indicate that specific types of acoustic lagging can significantly reduce noise break out from pipes. Further research could explore optimising lagging materials and techniques to further reduce noise break out.

1 INTRODUCTION

1.1 Pipe Breakout Noise Mechanisms

There are three main types of modes that can cause sound to radiate from the walls of a pipe or air conditioning duct. These modes include “breathing”, “bending” and “ovaling” modes.

Breathing mode vibration occurs when the natural frequency of the pipe matches the frequency of the fluid flow, causing the pipe to vibrate. This is similar to how a flute vibrates when air is blown across its opening. The resultant noise caused by this vibration can produce a persistent low pitched humming or moaning.

Bending mode vibration relates to when the pipe bends in response to the fluid flow. The bending can be caused by factors such as uneven fluid pressure or flow rate, changes in fluid density or other external factors that cause the pipe to flex or bend. This bending motion can cause the pipe to vibrate at its natural frequency, which can typically result in a high pitched whistling or screeching sound.

Ovaling occurs when the cross-sectional shape of the pipe becomes distorted, typically from circular to oval due to changes in pressure. This distortion can cause the pipe to vibrate. Ovaling modes can be caused by a variety of factors, including fluid pressure, external loads or stresses or thermal expansion or contraction.

In either mode, the vibration induced noise can be mitigated by externally wrapping the pipe with a layer of porous absorbent material (acoustic lagging). The sound energy losses can be attributed to the reflection of sound energy at the porous material. Additional losses occur when the sound travels through the material (Bies & Hansen, 2003).

1.2 Acoustic Lagging Calculation Methods and Predictions

Bies and Hansen have detailed formula to calculate the insertion loss of external acoustic lagging at low and mid frequencies (Bies & Hansen, 2003). Analysis undertaken by Kanapathipillai and Bryne, provide more detailed methodology in predicting acoustic lagging insertion loss and compare the predictions to experimental measurements (Kanapathipillai & Bryne, 1996).

Further studies by Lacis and Kanapathipillai use MATLAB computer program to calculate insertion loss for different types of acoustic lagging by varying pipe diameter, flow resistivity and thicknesses (Lacis & Kanapathipillai, 2006).

Most studies focus on prediction or laboratory tested performance, however there is minimal data that present in situ insertion loss data. The basis of this paper is to present measured in situ insertion loss data for a pipe that was acoustically lagged in an outdoor environment.

2 CASE STUDY

The following case study considered a site that was designed to extract polluted air and filter the air before discharging it to the environment. The site consisted of a fan that was housed within an acoustic enclosure. The inlet and outlet of the fan was connected to fibreglass pipes that had a wall thickness of 6-8mm. The diameter of the pipe was 600 metres and spanned over 40 metres in length, including multiple bends at different junctions.

The noise emissions from the site were exceeding the noise criteria. It was identified that the noise from the fan was breaking out through the pipe walls. It was likely that the pipe was vibrating under a bending mode as it was observed that the air flow within the pipe fluctuated significantly.

Considering spatial limitations and the serviceability of the pipe, it was not feasible or reasonable to build an acoustic enclosure around the pipe. Therefore, it was proposed to externally lag the pipe with acoustic lagging (Soundlag 4525C) to minimise the noise breakout through the pipes. Soundlag 4525C consists of a thin aluminium foil facing and 25mm of convoluted foam.

3 METHODOLOGY

The in situ insertion loss was determined by measuring the noise from the pipe wall before and after the acoustic lagging was applied. The measurements were undertaken using an NTI XL2 (Class 1) sound level meter. The sound level meter was installed at 1.5 metres above the ground and 1 metre from the pipe wall.

Field calibration was checked before and after each measurement. No significant drift in calibration was recorded.

4 RESULTS

The difference between the measurements prior to the acoustic treatment (unmitigated) and after (mitigated) were used to determine the insertion loss of the acoustic lagging. The results are tabulated in Table 1 and presented graphically in Figure 1.

Table 1 – Measured insertion losses

Frequency	Sound pressure level (Leq,1min dBA)		Insertion Loss dB	
	Unmitigated	Mitigated	Measured	Manufacturer's data
25	59.3	59.6	-0.3	-
31.5	53.6	49.8	3.8	-
40	53.2	51	2.2	-
50	52.4	50.6	1.8	-
63	51.3	51.1	0.2	-
80	57.1	54.8	2.3	-
100	65.8	61.3	4.5	5.6
125	64.4	60.2	4.2	8.5
160	67.8	63.2	4.6	2.7
200	59.8	54	5.8	2
250	55.1	52.8	2.3	5.2

315	61.6	57.1	4.5	5.8
400	59.4	52	7.4	8.2
500	60.1	49.4	10.7	10.8
630	61.9	47.4	14.5	15.4
800	64.8	47.4	17.4	17.2
1k	58.9	43.3	15.6	20.2
1.25k	54	39.1	14.9	22.4
1.6k	49.6	35.8	13.8	24.1
2k	44.8	37.2	7.6	27.4
2.5k	42.6	36.1	6.5	30.9
3.15k	42.5	35.8	6.7	34.1
4k	43.7	34.2	9.5	36.3
5k	44.1	33.3	10.8	35.7
6.3k	35.9	31.4	4.5	-
8k	31	29.2	1.8	-
10k	28	26.6	1.4	-
		Overall Insertion Loss	**5.2 dB/ 10.8 dBA**	**25 dB**

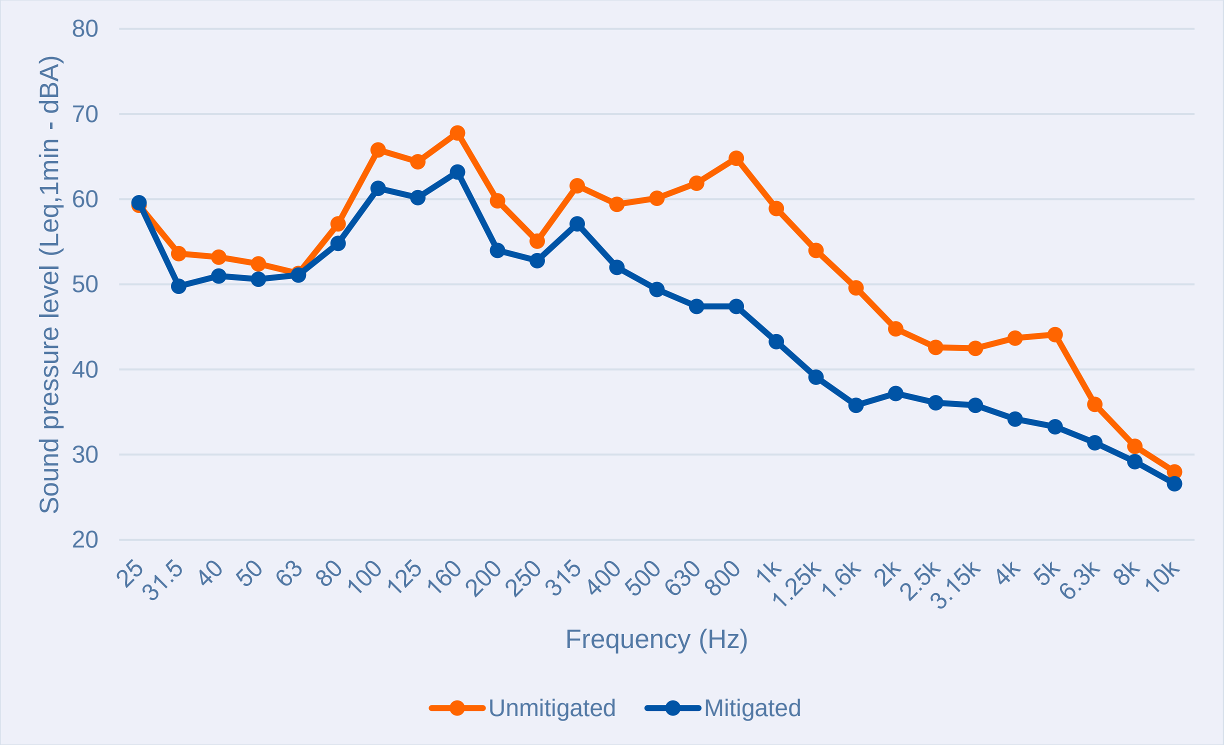

Figure 1 – Unmitigated and mitigated comparison

5 DISCUSSION

Based on the measured noise levels presented in Table 1, the acoustic lagging was able to reduce the noise at the site by 10.8 dBA. Consistent with Bies and Hansen (Bies & Hansen, 2003), the noise reduction at low frequencies (below 250 Hz) is minimal.

It was noted that there were higher wind speeds on the day the post mitigation measurements were taken (Column 3 in Table 1), and therefore there is potential that the measured noise levels could be higher due to higher background noise levels.

Due to spatial restrictions and serviceability factors, acoustic lagging could not be applied to the entire extent of the pipes. Approximately, 90% of the pipe was externally lagged. There is potential that additional noise would breakout from the unlagged sections of the pipe.

These factors could account for the lower measured insertion losses when compared to the manufacturer's data (Pyrotek).

6 CONCLUSION

In conclusion, it was found that external acoustic lagging of the pipe was effective in reducing noise breakout through the walls of the pipe. The acoustic lagging provided a 10.8 dBA insertion loss. It was noted that the insertion losses at low frequencies were minimal.

Furthermore, the measured insertion losses were lower than the manufacturer’s data (Pyrotek) which was attributed to higher background noise levels during the post mitigation measurements and the potential for noise breakout from unlagged sections of the pipe.

Further studies should be undertaken to compare the performance of other materials such as mass loaded vinyl.

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