Mitigating Rubbish Truck Noise – A Case Study

Dr. Harvey Law (1), Dr. Michael Hayne (2) and Dr. Marek Kiezkowski (1)

(1) Megasorber Pty Ltd, Melbourne, Australia
(2) SoundBASE Consulting Engineers, Brisbane, Australia

Abstract – This paper explores the challenges of mitigating noise produced by rubbish trucks, particularly the sharp sounds generated when recyclable glass bottles fall from collection bins into trucks. During this process, maximum noise levels reach 118 dB(A), significantly higher than the truck's operational noise level of approximately 85 dB(A). The objective was to reduce the noise levels as much as possible, ideally aligning them with Environmental Protection Agency (EPA) guidelines. The study considered two types of rubbish trucks – Side Loaders and Rear Loaders – both of which are highly weight-sensitive. Since redesigning the trucks was not feasible, the noise mitigation measures needed to be suitable for retrofitting existing vehicles. To achieve this, repeatable testing methods were developed to simulate the noise produced by falling glass bottles. Noise levels were measured before and after implementing noise reduction treatments. This paper presents the results of these treatments and offers further recommendations for minimising noise levels in similar situations.

1 INTRODUCTION

The clash of metal as containers hit the sides or tops of trucks can be strikingly loud, particularly when amplified by the early morning quiet – often when the only thing you want is more sleep (Paulo Henrique Trombetta Zannin, Ferdinado Quadros, Felipe Luz De Oliveira and Eriberto Oliveira Do Nascimento, 2018) (Miller, 2004)

While the typical operational noise of a rubbish truck remains below 85 dB(A), the impact noise generated by recycled materials, especially glass bottles, can reach maximum levels up to 118 dB(A). The challenge lies in addressing this issue without redesigning the trucks, which are already optimised for weight considerations and height clearances. This study focuses on exploring lightweight soundproofing solutions for two types of rubbish trucks: Rear Loaders and Side Loaders. To do so, repeatable testing methods were developed to simulate the noise created by falling glass bottles, with noise levels measured before and after the implementation of soundproofing treatments.

2 THE NOISE SOURCES AND CONDITIONS

Figure 1 illustrates the schematic representation of a Rear Loader rubbish truck and provides details of the internal structure. The primary source of noise stems from glass bottles being tipped into the hopper, followed by the sweep and pack mechanism typical in rear loading rubbish trucks. Significant noise is also generated by the hydraulic system.

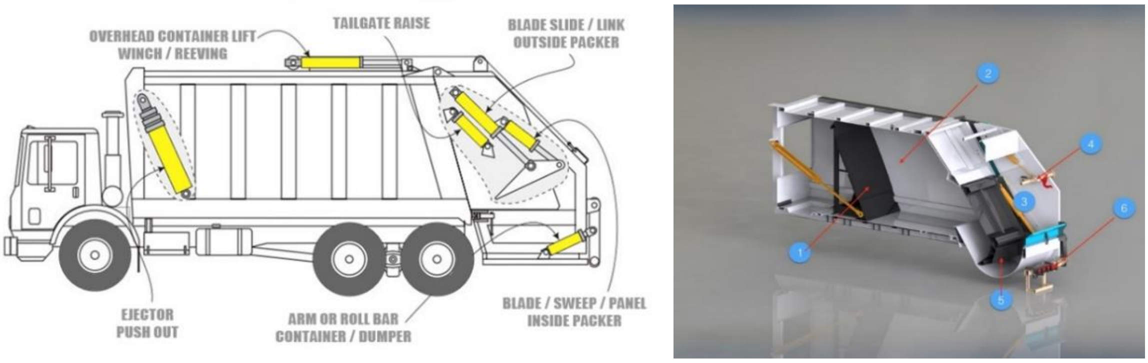


Figure 1 – Schematic drawing of the rubbish truck and internal structure of the rubbish truck

Although a Side Loader rubbish truck has a different layout, the same basic noise generating mechanisms and causes exist. Potential noise reduction options were identified, including modifications to the hopper, reducing noise radiated from other surfaces, lowering the tipping height of the glass bottles, and deploying acoustic barriers. Importantly to the client, any modifications must not compromise the truck's operational efficiency.

Due to the abrasive nature of glass, surface treatments to cushion the impact within the hopper are not feasible. Instead, a viable option involves applying either a constrained or unconstrained damping layer beneath the hopper's sheet metal. To address noise radiating from other surfaces, resilient isolation of the hopper or increasing the mass and stiffness of elements that re-radiate noise would be necessary.

Reducing the tipping height of the bin presents challenges, as a safety rail at 1,200mm is required. However, modifying the pivot arm used for lifting and tipping the bin could potentially change the tipping angle, thereby reducing the drop height of the glass bottles. Alternatively, the height from which the bottles fall could be minimised by installing limp flaps at the top of the opening or using other methods to cushion the bottles' fall.

3 TEST SET-UPS AND NOISE LEVELS BEFORE THE ACOUSTIC TREATMENT

The rubbish truck's operations produce noise primarily during three key processes: (1) Bottle Tipping (also known as bin emptying or bottle dropping), (2) Pack & Sweep, and (3) a combined operation of Bottle Tipping + Pack & Sweep. The aim of the tests was to measure the noise levels and frequency ranges associated with each process to develop the acoustic treatment plan.

Noise measurements were conducted inside a recycling warehouse, with microphones positioned as close as safely possible to the truck. Figure 2 shows the test setup for a Rear Loader truck. At the rear of the truck, the microphone was placed 3.5 meters from the vehicle's centre, positioned approximately 45° to the left (from a top-down view). Noise levels were recorded for each Bottle Tipping cycle, with every third cycle including the Pack & Sweep process.

Figure 2 – The Rear Loader rubbish truck, the bin with 750 glass bottles and the microphone set-up

The average times recorded for each operation were:

1) Bottle Tipping (750 bottles): 9 seconds
2) Bottle Tipping + Pack & Sweep: 35 seconds

The average L_{Amax} noise levels were:

1) Bottle Tipping (750 bottles): 116 dB(A)
2) Bottle Tipping + Pack & Sweep: 118 dB(A)
3) Pack & Sweep alone: 99 dB(A)

Figure 3 presents the noise frequency spectra for these operations. The data shows that the noise peaks at around 3000 Hz, with a smaller peak at 160 Hz. During the 'Bottle Tipping' process, the noise level reached 116 dB(A), which is 17 dB(A) higher than the 'Pack & Sweep' operation, making it the dominant noise source. While 'Pack & Sweep' generates about 99 dB(A), the combined 'Bottle Tipping + Pack & Sweep' operation reached 118 dB(A), approximately 2 dB(A) higher than 'Bottle Tipping' alone.

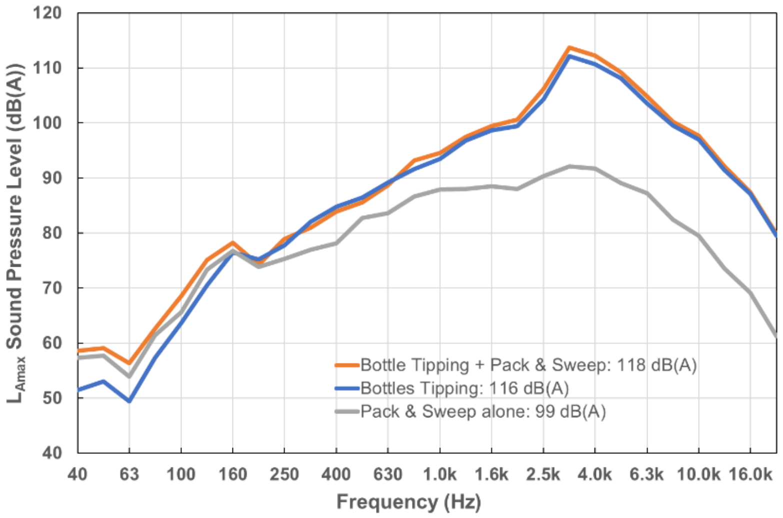


Figure 3 – The noise frequency spectrum before the acoustic treatment of a Rear Loader

Figure 4 compares the noise levels between Rear Loader and Side Loader trucks. The Rear Loader consistently generated about 10 dB(A) more noise than the Side Loader.

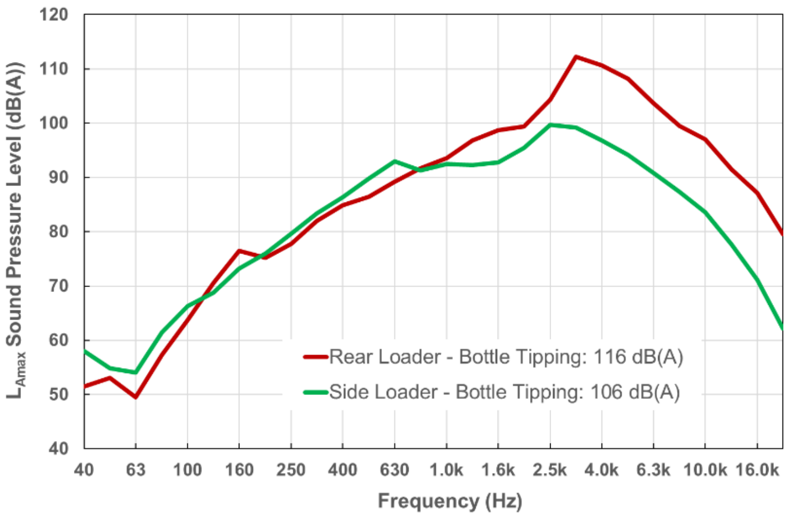


Figure 4 – The noise frequency spectrum for Rear Loader and Side Loader

4 ACOUSTIC TREATMENT PLAN AND MATERIALS

Based on the noise measurement results, the primary goal was to minimise the noise produced during the Bottle Tipping operation. The following noise control strategies were recommended to mitigate noise from bottle impacts and mechanical operations:

1) *Damping of the Hopper Underside*

   Applying a damping material to the underside of the 6mm steel forming the hopper base to help reduce the noise generated by the crashing bottles. This treatment reduces vibrations and sound radiation from the steel surface, lowering noise levels during operations. However, providing sufficient damping for 6mm thick steel is challenging. Two lightweight damping systems were developed and evaluated:

   - Preferred option: *Megasorber DT2S* – A self-adhesive vibration-damping tile designed specifically for thick metal plates.

- Economic option: *Megasorber D14* – A 2 mm thick self-adhesive vibration-damping sheet, which requires two layers for effective performance.

2) *Flexible Acoustic Barrier*

To contain the noise generated during tipping operations, a lightweight, flexible acoustic barrier was proposed. This barrier closes the gap between the top of the tailgate and the bin's limit bar, as illustrated in Figure 5 and Figure 6. It needs to be adjustable, allowing for modifications to the limit bar while ensuring optimal noise containment. The barrier must therefore be flexible, tough, durable, and suitable for outdoor use. To meet these requirements, Megasorber BG6 was selected.

3) *Acoustic Absorption on Internal Surfaces*

Acoustic absorption materials applied to the internal vertical surfaces of the hopper's tailgate to absorb sound energy and reduce reflected noise within the hopper. To protect these materials, they are housed behind a perforated 4mm steel facing, ensuring both durability and acoustic performance. Megasorber FG25 with a *Soundmesh G8* facing was selected due to its sound absorption performance in the 400 Hz to 4,000 Hz frequency range.

This acoustic treatment plan targets noise at its source through a combination of damping, containment, and absorption. Figures 5 and 6 illustrate the acoustic treatment plans for both Rear Loader and Side Loader trucks.

Rear loader – Acoustic Treatments

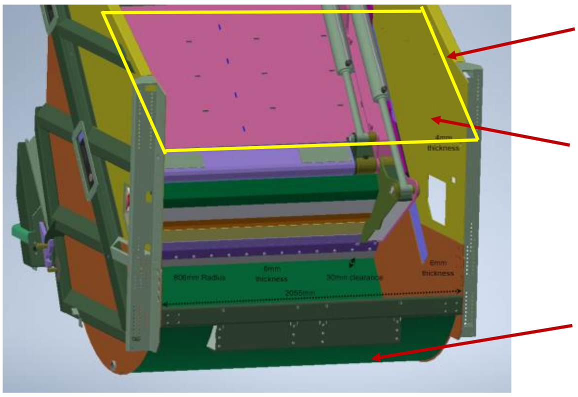


Figure 5 –Rear Loader Acoustic treatment plan

Side Loader – Acoustic Treatments

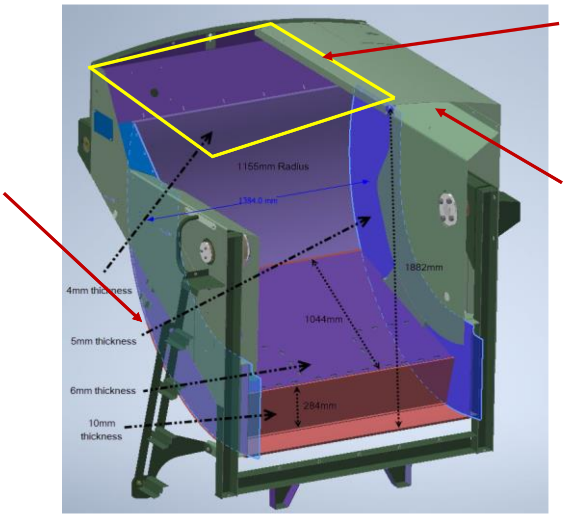


Figure 6 – Side Loader Acoustic treatment plan

5 PROOF OF CONCEPT TESTING – SIDE LOADER

A Side Loader truck was made available for the *Proof of Concept Testing*, and a staged acoustic treatment was applied. The following details outline the materials used in each phase:

1) *Cushioning to Pendulum Surface*: The material is Megasorber PN8, an 8 mm thick sound-absorbing material.
2) *Mass damping applied to the exterior of the hopper*: The material is Megasorber D14, designed to minimise vibrations and reduce noise generated by surface vibrations.
3) Absorption and acoustic screening over the top of the hopper: Materials are a combination of Megasorber BG8 (which serves as a sound barrier) layered on top of Megasorber FG50 (for sound absorption).

Figures 7 and 8 illustrate the precise cutting of materials to match the required shapes and the installation process on the truck. While Figure 7 represents the acoustic treatment plan, Figure 8 demonstrates the application of the materials on the Side Loader.

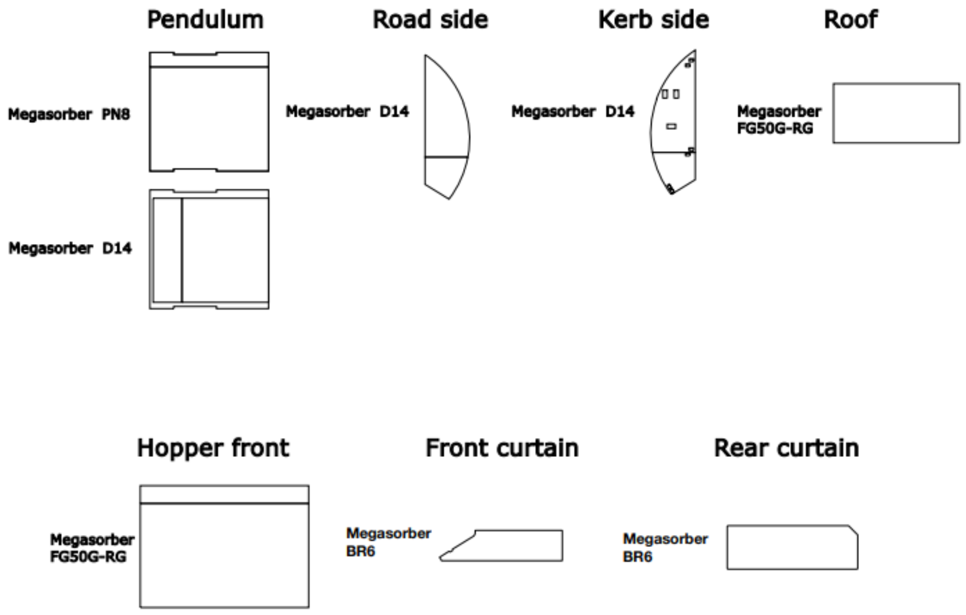


Figure 7 – Acoustic treatment plan for Rear Loader

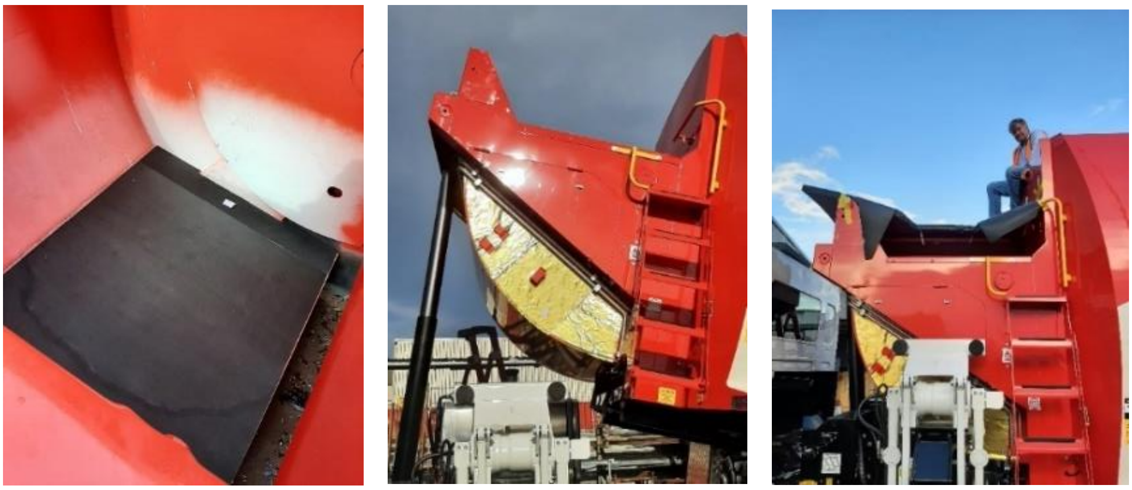


Figure 8 – Installation of the acoustic treatments

5.1 Test Setup and Methodology

The measurements were conducted outdoors in free-field conditions, ensuring that no nearby surfaces affected the sound readings. Figure 11 shows the position of the Precision Sound Analyser (Norsonic Nor140), which was placed 3.5 meters from the pivot arm of the Side Loader truck, at an angle of approximately 45° (with 0° being directly in front of the pivot arm, perpendicular to the truck) and 1.6 meters above the ground. Additionally, an environmental noise meter (Norsonic Nor139 with microphone extension cable) was set at an angle of about 55° and elevated to a height of 7.4 meters.

Figure 9 – Side Loader rubbish truck and the noise measurement set-up

Controlled testing was carried out using a 240 L bin with 30 bottles inside for each trial. Although full 240 L bins were requested for the testing, the client was only able to provide a single 240 L bin of bottles, requiring the testing to be conducted with only 30 bottles per bottle tip. The pendulum was positioned in the home position, parallel to the truck's body floor.

The tests were conducted in four stages:

1) No treatment.
2) Cushioning to the pendulum surface.
3) Mass damping applied to the exterior of the hopper.
4) Absorption and partial acoustic screening over the top of the hopper.

The test regime comprised:

1) Background noise measurements with the truck idling.
2) Three dry lifts with an empty bin.
3) Five lifts with bottles in the bin – no acoustic treatment.
4) Pack and sweep the contents from the previous five lifts.
5) Four lifts with bottles in the bin – treatment applied to the top surface of the pendulum.
6) Pack and sweep the contents from the previous four lifts.
7) Four lifts with bottles in the bin – vibration damping sheets applied to the external sides and underside of the hopper.
8) Pack and sweep the contents from the previous four lifts.

9) Four lifts with bottles in the bin – absorption material added to the underside of the top cover and an acoustic curtain used to partially cover the opening.
10) Pack and sweep the contents from the previous four lifts.

5.2 Measurement Results and Analysis

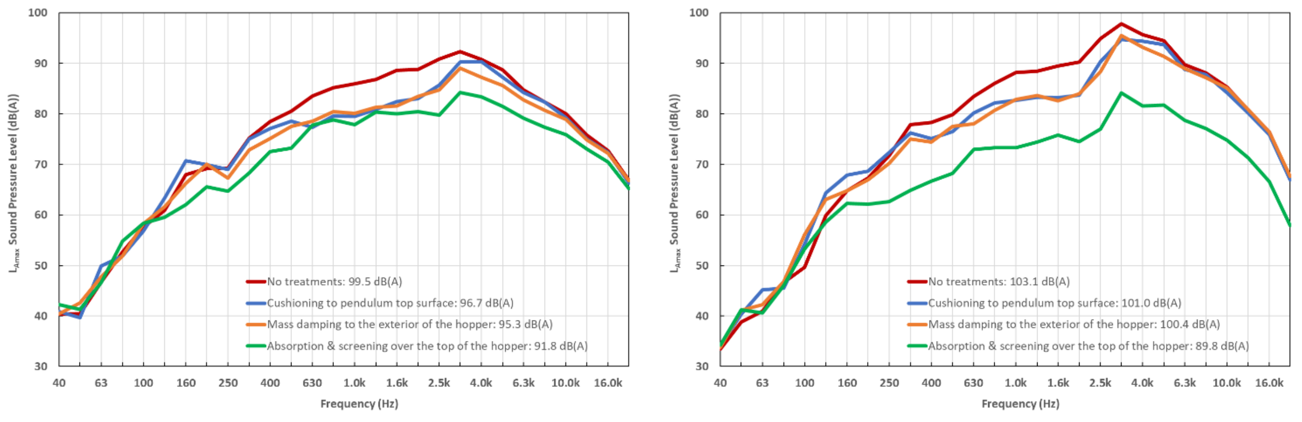
The test results for the ‘Bottle Tipping’ and ‘Pack & Sweep’ stages with each level of acoustic treatment are summarised in Tables 1 and 2, respectively. The frequency spectrums corresponding to these results are presented in Figures 10 and 11.

Table 1 – Average emitted sound pressure levels and decrease due to the acoustic treatment – Bottle Tipping

Measurement	Average L_{Amax} Sound Pressure Level (dB(A))			
	1.6 m above Ground		7.4 m above Ground	
	Average	Decrease	Average	Decrease
No treatment	99.5	N/A	103.1	N/A
Cushioning to pendulum surface	96.7	2.8	101.0	2.1
Mass damping to exterior surface of hopper	95.3	1.4	100.4	0.6
Absorption and screening over top of hopper	91.8	3.5	89.8	10.6

Table 2 – Overall emitted sound pressure levels and decrease due to the acoustic treatments – Pack & Sweep

Measurement	Overall L_{Amax} Sound Pressure Level (dB(A))			
	1.6 m above Ground		7.4 m above Ground	
	Overall	Decrease	Overall	Decrease
No treatment	98.0	N/A	97.0	N/A
Cushioning to pendulum surface	92.4	5.6	91.5	5.5
Mass damping to exterior surface of hopper	89.9	2.5	87.8	3.7
Absorption and screening over top of hopper	89.2	0.7	85.3	2.5

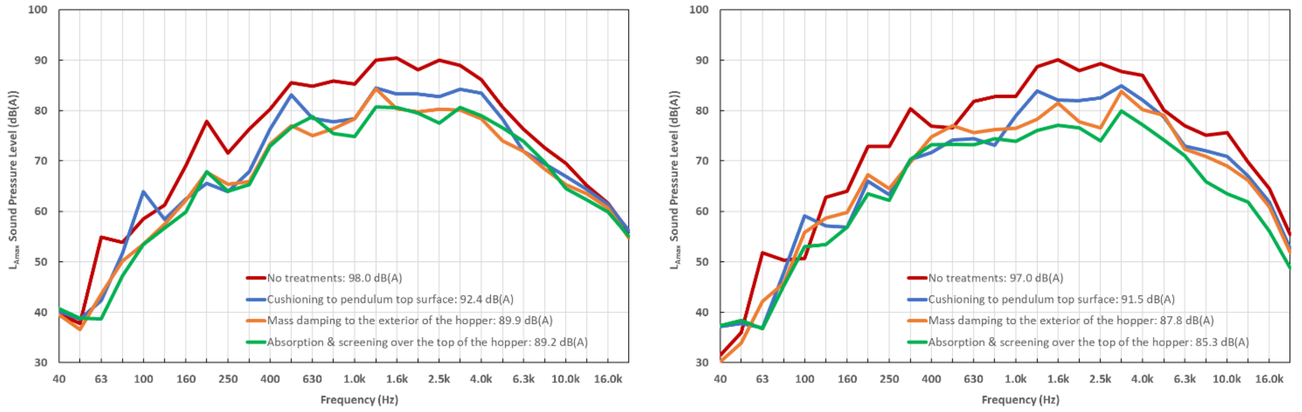


(a) 1.6 m above Ground *(b) 7.4 m above Ground*

Figure 10 – Bottle Tipping noise levels before and after acoustic treatment measured at 1.6 m and 7.4m above ground

The results indicate that absorption and acoustic screening over the top of the hopper offers the most significant overall sound reduction during the bottle tipping process. During testing, the screen was loosely secured; a properly designed and fitted screen would likely yield even greater noise reduction. This treatment is especially effective for sound mitigation for receivers located above the truck, such as inner-city apartment buildings.

The effect of the sound absorption material applied to the underside of the top cover could not be isolated, as it was tested in combination with the screen. However, the pendulum surface treatment successfully reduced impact noise. Unfortunately, due to the abrasive nature of glass, this treatment may not be durable in the long term.



(a) 1.6 m above Ground *(b) 7.4 m above Ground*

Figure 11 – Pack and Sweep noise levels before and after acoustic treatment measured at 1.6 m and 7.4 m above ground

Lastly, the mass damping applied to the exterior of the hopper offers less noise reduction than expected. This is because the majority of the impact noise was generated when bottles struck the pendulum base and arms rather than the hopper walls. In cases where a full 240 L bin or larger is emptied, bottles will strike the hopper walls more frequently, potentially increasing the effectiveness of the damping treatment.

6 CONCLUSIONS

The methodology for testing bottle-dropping impact noise in rubbish trucks was successfully implemented and assessed. The acoustic treatments applied demonstrated effectiveness in reducing overall sound levels during operation. Of the treatments tested, acoustic screening over the hopper opening was the most effective in significantly reducing noise levels during bin emptying. Meanwhile, the damping treatment proved to be the most effective for minimising noise during the pack and sweep operation.

7 FURTHER STUDY

This study demonstrates a methodology for testing bottle drop impact noise in rubbish trucks. To enhance the understanding of acoustic treatment effectiveness, we recommend conducting tests on Side Loader trucks with fully loaded bins, rather than the 30 bottle test used in this study. Additionally, testing on Rear Loader trucks would provide valuable insights into the broader applicability of the acoustic treatments.

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