The effectiveness of utilising a damping compound for attenuating rainfall noise on metal roofing

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ABSTRACT

Rainfall on metal roofing can often result in undesired noise, caused by raindrops impacting the highly resonant metal sheeting. An investigation was conducted on the effectiveness of applying Pyrotek Decidamp® SP80, a sprayable water-based damping compound, to the underside of corrugated metal roofing in order to reduce rainfall noise. A common insulation material typically used for reducing rainfall noise was also tested in combination with the damping material. Testing was conducted to ISO 10140-5 using heavy rainfall on standard residential corrugated metal roofing, along with thicker industrial corrugated metal roofing. Testing was also conducted to ISO 10140-2 in order to measure the improvement in transmission loss. The test results revealed that the damping compound was highly effective in reducing rainfall noise and increasing transmission loss on metal roofing, concluding that it could be a viable solution on its own or as an element of a more comprehensive system.

1 INTRODUCTION

Metal roofing is a popular construction material in many parts of the world, particularly in Australia. It features a variety of benefits but also possesses disadvantages. One detriment is its tendency to exhibit excessive noise during events of rain. This is primarily due to the minimal internal damping of metal roofing. The net effect is an increase of the noise level within the interior of the building, significantly in the case of high rainfall rates, which can reduce speech intelligibility and cause disruption to activities such as sleep or any task which requires concentration.

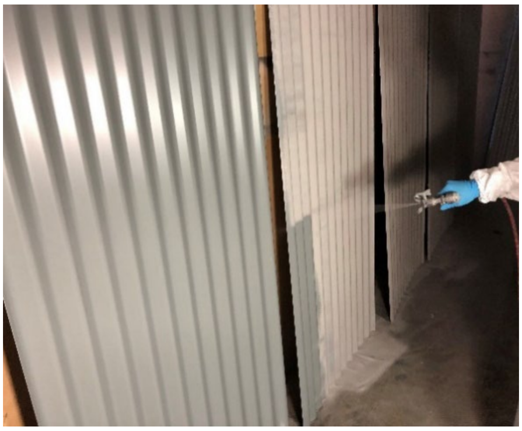
This paper details and discusses results gathered from testing a variety of metal roofing systems for rainfall noise insulation and transmission loss. The primary focus was to measure the reduction of rainfall noise through the use of a damping compound applied to the rear side of the panels at a thickness of 1 mm (dry film thickness). A system was also tested with a common insulation material to measure the combined effect with the damping compound.

2 TEST SPECIMENS

Two nationally common metal roofing materials were chosen for testing: one as a typical standard/residential option and the other as a typical industrial option. The standard roofing was COLORBOND®, supplied as 0.42 mm thick corrugated steel. The industrial roofing was COLORBOND® Ultra, supplied as 0.48 mm thick corrugated steel. Both roofing materials were corrugated with the same standard Lysaght Custom Orb design, which is a sinusoidal wave pattern with a rib depth of 16 mm.

The metal roofing sheets were installed using 50 mm long roofing screws, with the standard 1.5 rib/93 mm overlap to cover the width. Two sheets utilising a 100 mm overlap were used to cover the length, as single sheets could not be used due to transport constraints. GIB® Sound Seal, a flexible acoustic sealant, was used on the under-side perimeter to ensure the roofing was sealed against the frame.

The damping compound used was Pyrotek Decidamp® SP80, which is specifically developed for building and construction use. The compound is water-based, easily sprayable and exhibits a high damping loss factor. It was sprayed onto the rear side of the roofing panels after cleaning to achieve a dry film thickness of 1 mm (± 0.25 mm) and was allowed adequate time to fully cure. The application process onto a corrugated surface did not pose any challenges.

Photographs 1 & 2: Spraying the damping compound onto the corrugated roofing panels

Bradford™ Anticon™ 80 LD was chosen as the insulation material. The foil-faced 11 kg/m^3 density insulation is 80 mm thick and is commonly specified for use with metal roofing. It was installed between the rafters and metal roofing, with minimal sag between the rafters. The foil side was installed appropriately facing downwards. "LD" specifies that the foil was for light duty applications where the supports are spaced ≤600 mm, such as this application.

The aim was to test both the standard and industrial roofing bare and treated with the damping compound. In addition, it was desired to measure the further improvement with the inclusion of the foil-faced 80 mm 11 kg/m^3 insulation with the treated industrial roofing system. A summary of the test plan is shown in table 1 below.

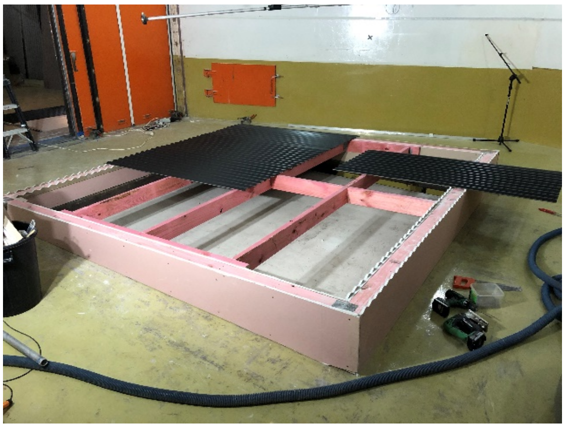
Table 1: Summary of the tested roofing systems

Test	Roofing	Damping	Insulation
1	COLORBOND® 0.42 mm	Nil	Nil
2	COLORBOND® 0.42 mm	Decidamp® SP80 1 mm	Nil
3	COLORBOND® Ultra 0.48 mm	Nil	Nil
4	COLORBOND® Ultra 0.48 mm	Decidamp® SP80 1 mm	Nil
5	COLORBOND® Ultra 0.48 mm	Decidamp® SP80 1 mm	Bradford Anticon LD 80 mm

3 METHODOLOGY

Testing was conducted at The University of Auckland, New Zealand through Acoustics Testing Services, utilising their vertically orientated chambers. The upper chamber "A", the source room, had a volume of 208 m^3 and the lower chamber "B", the receiving room, had a volume of 153 m^3.

A timber ceiling frame with rafters spaced at 600 mm was constructed into the 3.2 x 3.2 m aperture between the two chambers. The border of the frame was constructed to achieve a higher transmission loss than the highest performing roofing system under test. The top and bottom perimeters of the frame were cut to match the corrugation pattern of the sheets, whilst the side perimeters were cut to meet to the corresponding height. The entire perimeter was lined with a 3 mm thick closed-cell foam to aid in sealing. The frame achieved a surface area of 10.24 m^2 and a pitch of 5°, which met the criteria of the test standards.




Photograph 3 (left): The test frame during construction, with multiple roofing sheets in place for test fitting
Photograph 4 (right): A test system installed, before the addition of polyester insulation into the guttering and reservoir

It was desired to measure both the airborne sound insulation and rainfall sound insulation. The airborne sound insulation measurements were conducted in accordance with ISO 10140-2:2010 (ISO, 2010), where the transmission loss is measured by generating sound on one side of a system and measuring how much sound is received on the opposite side of the system. The weighted sound reduction index, R_w, and spectrum adaptation, C_{tr}, were calculated to ISO 717-1:2013 (ISO, 2013). The sound transmission class, STC, was calculated to ASTM E413-16 (ASTM, 2016).

The rainfall sound insulation measurements were conducted in accordance with ISO 10140-5:2010 (ISO, 2010), where a consistent and specific flow of raindrops are deposited onto the top of a system, and the resulting noise is measured below the system. The rainfall system was designed to output the heavy rainfall type defined in ISO 10140-1:2016 (ISO, 2016), with a rainfall rate of 40 mm/h, a drop diameter of 5 mm and a fall velocity of 5 m/s. The lower classification of intense rainfall (rainfall rate of 4 to 15 mm/h, drop diameter of 1 to 2 mm and a fall velocity of 2 to 4 m/s) was not tested, opting to only test the rainfall type with the highest intensity. The water was collected through standard roof guttering at the low end of the pitched roof that ran into a reservoir which was emptied after each system test. The guttering and entrance points of the reservoir were lined with polyester insulation to avoid water impact noise.


Photograph 5 (left): The rainfall system mounted above the frame within a diffusor
Photograph 6 (right): The lower receiving chamber, displaying the underside of a system and the frame

4 RESULTS

4.1 Test 1 & 2 - Standard 0.42 mm corrugated steel roofing (T1822-1 & T1822-2)

4.1.1 Rainfall sound intensity

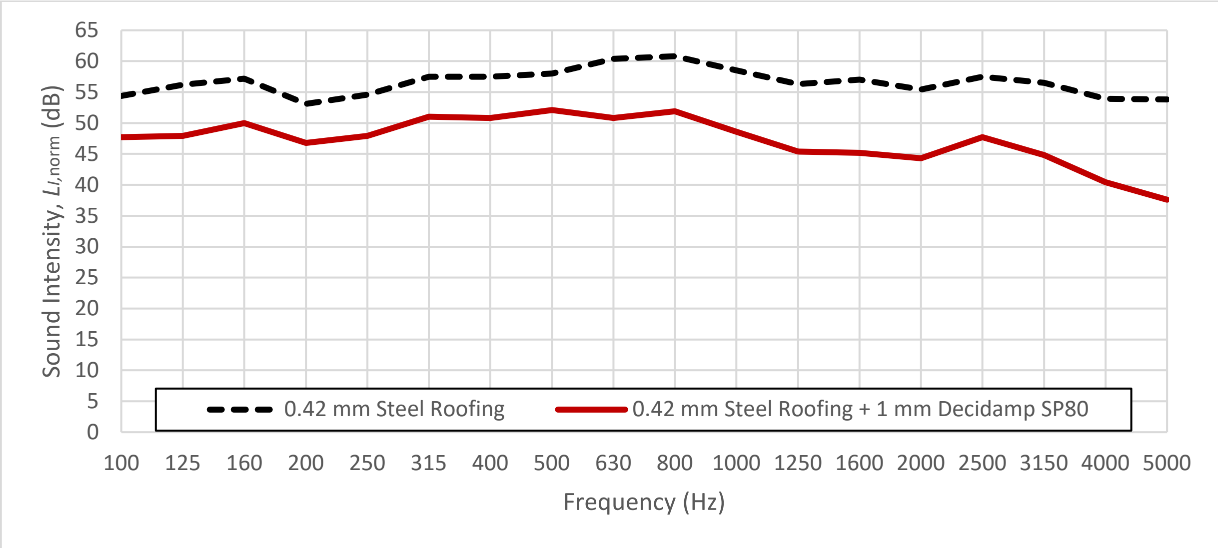


Figure 1: Rainfall sound intensity results for standard 0.42 mm steel roofing

4.1.2 Transmission loss

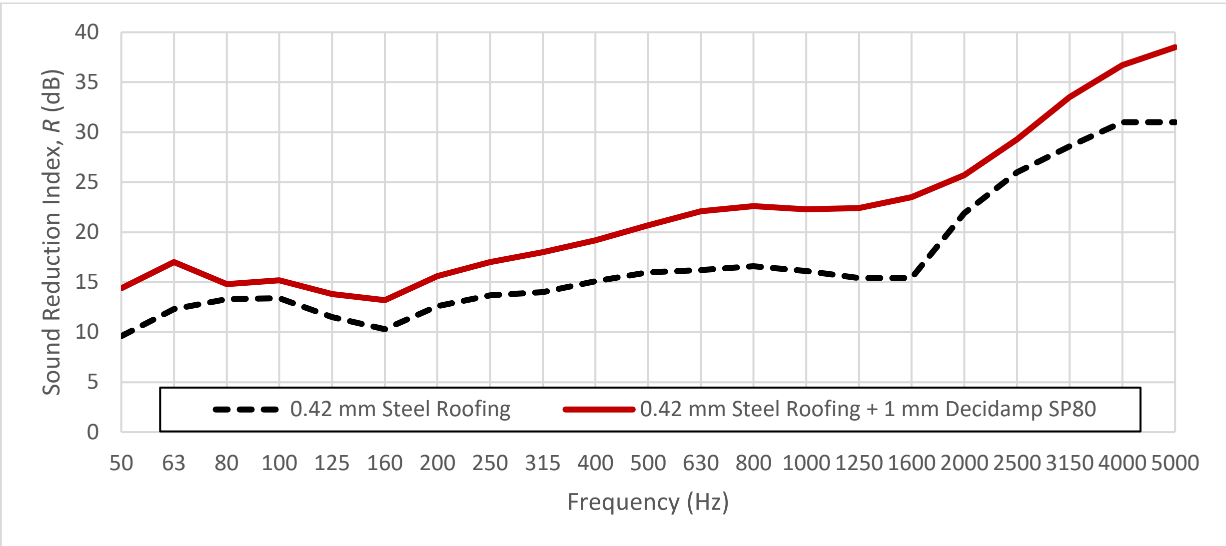


Figure 2: Transmission loss results for standard 0.42 mm steel roofing

4.1.3 Summary

Table 2: Summary of results for standard 0.42 mm steel roofing

Parameter	Untreated	Treated	Improvement
L_{IA} (L_{IAnorm})	74.3 (68.2)	64.1 (58.5)	10.2 (9.7)
R_w (C; C_{tr})	18 (-1; -2)	23 (0; -2)	5 (1; 0)
STC	18	24	6

4.2 Test 3 & 4 - Industrial 0.48 mm corrugated steel roofing (T1822-3 & T1822-4)

4.2.1 Rainfall sound intensity

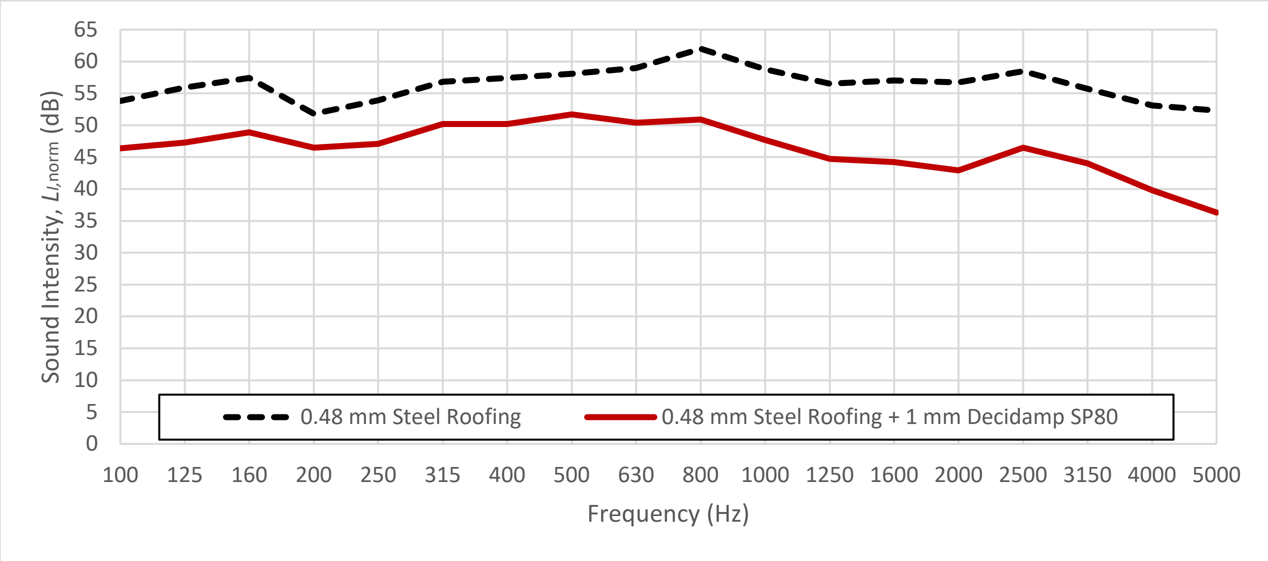


Figure 3: Rainfall sound intensity results for industrial 0.48 mm steel roofing

4.2.2 Transmission loss

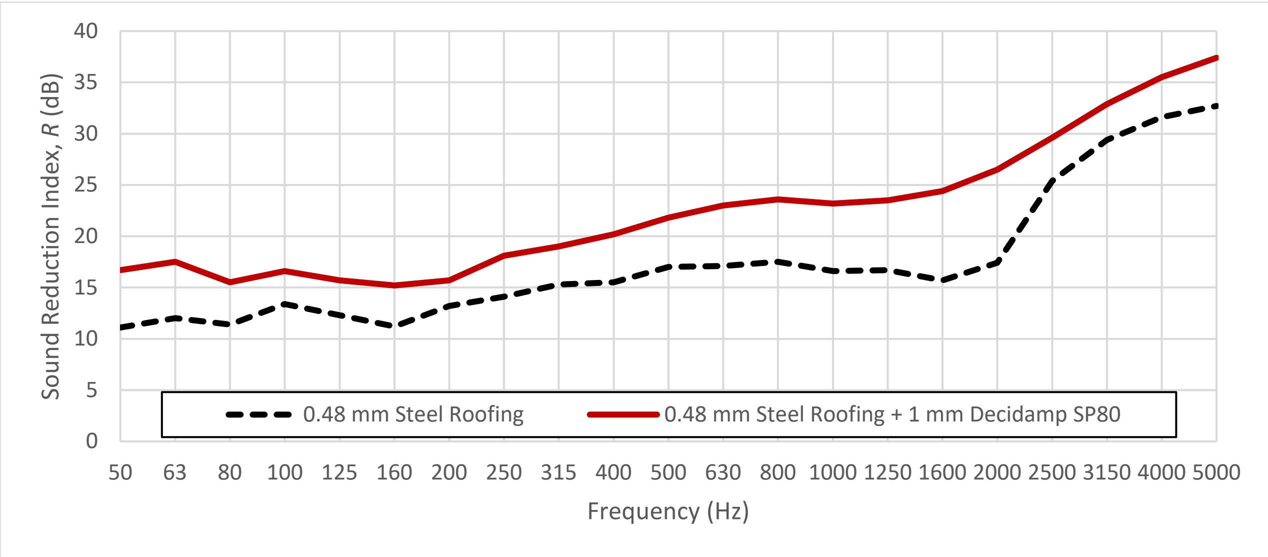


Figure 4: Transmission loss results for industrial 0.48 mm steel roofing

4.2.3 Summary

Table 3: Summary of results for industrial 0.48 mm steel roofing

Parameter	Untreated	Treated	Improvement
L_{IA} (L_{IAnorm})	74.6 (68.4)	63.2 (57.6)	11.4 (10.8)
R_w (C; C_{tr})	18 (0; -2)	24 (0; -2)	6 (0; 0)
STC	18	24	6

4.3 Test 3 & 5 - Industrial 0.48 mm corrugated steel roofing with insulation (T1822-3 & T1822-5)

4.3.1 Rainfall sound intensity

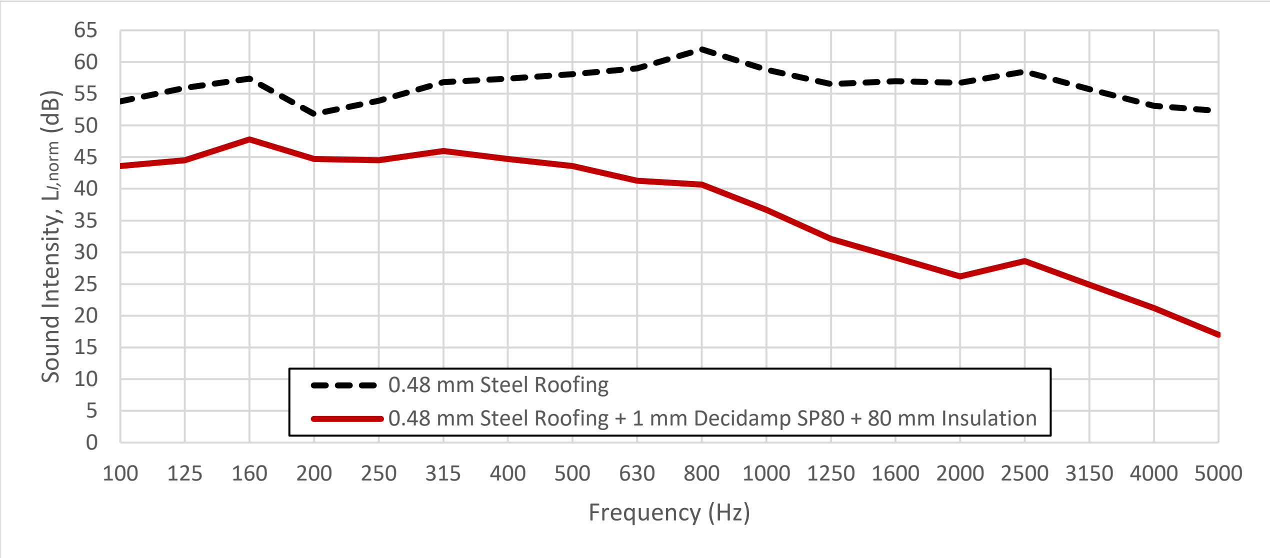


Figure 5: Rainfall sound intensity results for industrial 0.48 mm steel roofing with Decidamp SP80 and insulation

4.3.2 Transmission loss

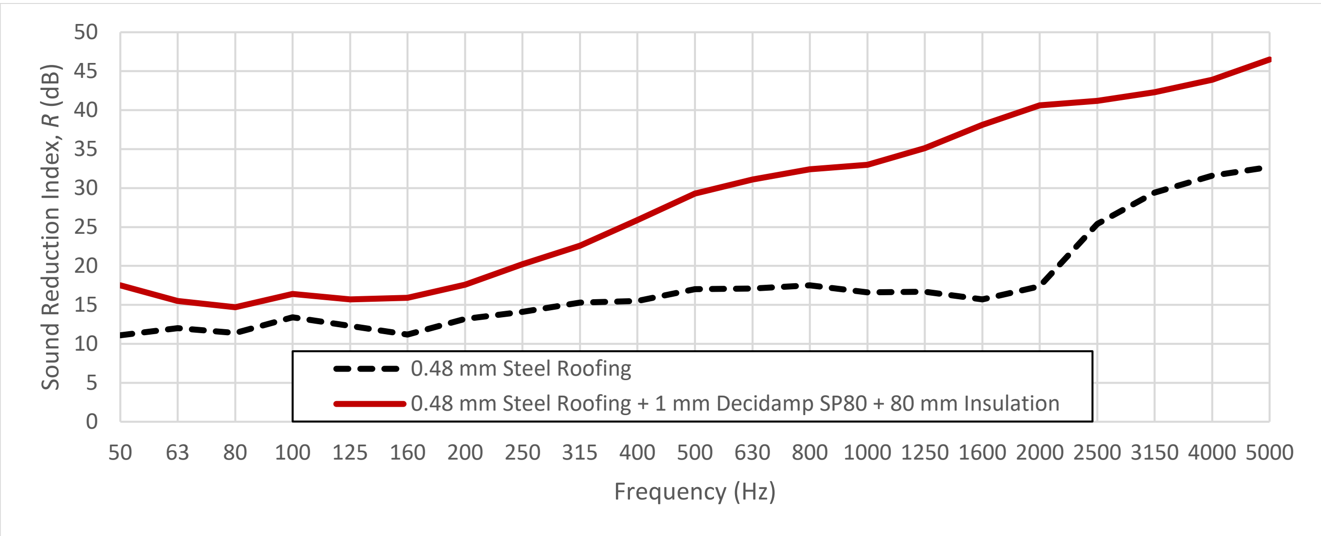


Figure 6: Transmission loss results for industrial 0.48 mm steel roofing with Decidamp SP80 and insulation

4.3.3 Summary

Table 4: Summary of results for industrial 0.48 mm steel roofing with Decidamp SP80 and insulation

Parameter	Untreated	Treated	Improvement
L_{IA} (L_{IAnorm})	74.6 (68.4)	52.8 (48.3)	21.8 (20.1)
R_w (C; C_{tr})	18 (0; -2)	31 (-1; -5)	13 (-1; -3)
STC	18	32	14

4.4 Summary of all results

Table 5: Summary of all results

System	L_{IA} ($L_{IA\text{norm}}$)	R_w (C; C_{tr})	STC
Standard 0.42 mm corrugated steel	74.3 (68.2)	18 (-1; -2)	18
Standard 0.42 mm corrugated steel + 1 mm Decidamp® SP80	64.1 (58.5)	23 (0; -2)	24
Improvement over untreated	10.2 (9.7)	5 (1; 0)	6
Industrial 0.48 mm Steel	74.6 (68.4)	18 (0; -2)	18
Industrial 0.48 mm corrugated steel + 1mm Decidamp® SP80	63.2 (57.6)	24 (0; -2)	24
Improvement over untreated	11.4 (10.8)	6 (0; 0)	6
Industrial 0.48 mm corrugated steel + 1 mm Decidamp® SP80 + 80 mm 11 kg/m^3 insulation	52.8 (48.3)	31 (-1; -5)	32
Improvement over untreated	21.8 (20.1)	13 (-1; -3)	14

5 DISCUSSION

In both cases, a 1 mm dry film thickness coating of Decidamp® SP80 reduced the rainfall sound intensity by 10 to 11 dB and improved the R_w by 5 to 6 points. This considerable improvement in both rainfall sound intensity and airborne transmission loss is due to the significant increase in damping and a 34-41% increase in surface density. The performance difference between standard 0.42 mm sheeting and industrial 0.48 mm sheeting was insignificant but expected considering the minimal difference in physical properties. Improvement was recorded over the entire measured frequency spectrum across all results for both airborne and rainfall noise insulation.

The inclusion of foil-faced 80 mm thick 11 kg/m^3 insulation onto the industrial metal roofing treated with 1 mm Decidamp® SP80 achieved another 10 dB reduction in rainfall sound intensity and improved the R_w by 7 further points. The overall 20-22 dB reduction in rainfall sound intensity and 13 point R_w improvement as a system over the bare metal roofing is significant, especially when considering the surface density is only increased by 55% (shown in table 6 below). However, the improvement after installing the insulation was only significant from 315 Hz onwards in the case of both rainfall noise insulation and airborne noise insulation. At 250 Hz and below, the improvement was insignificant with a difference of less than 3 dB. It is theorised that insulation contributes damping so it should be reiterated that for this testing the insulation was installed tightly against the underside of the roofing with the foil-facing on the opposite side - it is likely that it would be less effective if spaced away from the roofing or if it was installed with the foil-facing against the roofing. Furthermore, it could be theorised that the foil-facing further improves performance (when installed in the correct orientation) and therefore insulation materials lacking a foil-facing could perform worse compared to those with a foil-facing.

Table 6: Summary of surface densities (kg/m^2)

System	Surface Density (kg/m^2)	Surface Density Increase over Untreated (%)
Standard 0.42 mm corrugated steel	4.35	-
Standard 0.42 mm corrugated steel + 1 mm Decidamp® SP80	6.15	41
Industrial 0.48 mm Steel	5.23	-
Industrial 0.48 mm corrugated steel + 1mm Decidamp® SP80	7.03	34
Industrial 0.48 mm corrugated steel + 1 mm Decidamp® SP80 + 80 mm 11 kg/m^3 insulation	8.09	55

Whilst the reduction due to the application of Decidamp® SP80 was significant, it is theorised that the performance could be greater in an actual installation. In this case of testing, Decidamp® SP80 was applied to the roofing sheets before installation to allow panels to be immediately tested, without the need to wait for paint to cure. This allowed for a faster turnaround in laboratory testing but did not seal the overlaps between metal sheeting panels. We hypothesise that sealed overlaps will result in higher performance, with sealed overlaps normally occurring when Decidamp® SP80 is applied after installation of metal sheeting panels as per the recommended installation method. Furthermore, entire system performance could be greater in an actual installation due to the tests utilising two sheets with an overlap instead of the recommended single sheet per span. Although care was taken when installing the roofing sheets, especially when joining, it may have negatively impacted performance.

Further research could be conducted into the effectiveness of Decidamp® SP80 on thicker, typically 0.55 mm, stainless steel roofing which is often installed in speciality applications or highly corrosive environments. However, the data collected on the industrial 0.48 mm thick roofing indicates that it would be effective. Also, the inclusion of a flexible mass loaded barrier into each system, including both Decidamp® SP80 treated and untreated systems, could result in another viable solution for treating rainfall noise.

6 CONCLUSIONS

A damping compound, Decidamp® SP80, proved to be effective in reducing rainfall noise and increasing transmission loss when applied to the lower facing of corrugated metal roofing at a thickness of 1 mm (dry film thickness). It reduced the rainfall sound intensity by 10 to 11 dB and improved the airborne transmission loss by 5 to 6 R_w points. When combined with 80 mm thick 11 kg/m^3 density foil-faced insulation, performance over an untreated system improved by 20 dB for rainfall noise insulation and 13 R_w points for airborne transmission loss, proving to be a highly effective solution when combined and indicates that Decidamp® SP80 could be an effective element in a more comprehensive system.

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