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EXPERIMENTAL IMPACT OF DOORS, SEALANT, AND OPENINGS ON THE WEIGHTED SOUND REDUCTION INDEX OF SHIPBUILDING WALL SYSTEMS

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Sound insulation performance of lightweight shipbuilding partition walls is highly sensitive to installation details and unintended leakage paths. In practice, laboratory-rated wall systems may not achieve the expected weighted sound reduction index (R_W) when doors, perimeter joints, and local openings are introduced. This paper presents the results of a systematic laboratory investigation into the impact of typical installation-related modifications on the airborne sound insulation performance of a commonly applied shipbuilding wall system.

Airborne sound insulation measurements were performed in accordance with ISO 10140-2 (within the ISO 10140 series), and single-number ratings were determined according to ISO 717-1. A reference wall configuration was first tested, after which controlled modifications were introduced, including partial sealing of perimeter profiles, installation of a fire-rated door under different mounting conditions, removal of a door lock cylinder, installation of a power socket, partial removal of sealant, and creation of a localized panel opening. For each configuration, the corresponding R_W value was determined and compared with the relevant reference configuration.

The results show that installation-related leakages can reduce R_W by up to 5 dB, even when the primary wall construction remains unchanged. Door installation resulted in a reduction of more than 3 dB, while sealing the door-frame gap recovered approximately 3 dB, indicating that frame leakage is the dominant transmission path. Partial removal of perimeter sealant caused a further reduction of approximately 3 dB. In contrast, removal of the door cylinder and installation of a socket had negligible influence.

Sound intensity measurements using a Microflown Scan & Paint 3D system were performed for selected configurations. R_W values derived from intensity-based power estimates showed good agreement with laboratory measurements and proved effective in identifying dominant leakage locations. The findings highlight the critical importance of installation detailing in achieving the intended acoustic performance of shipbuilding wall systems.

Keywords: weighted sound reduction index (R_W), airborne sound insulation, leakage paths, sound intensity measurements

1. Introduction

Increasing demands for acoustic comfort onboard ships have led to stricter requirements for airborne sound insulation between accommodation spaces. These requirements are commonly expressed in terms of the weighted sound reduction index R_W or the apparent sound reduction index R'_W, evaluated according to ISO 717-1 [1]. In shipbuilding practice, partition walls are usually tested in laboratory conditions according to ISO 10140-2 [2] before installation. In this study, laboratory values of R_W are considered, focusing on the influence of installation-related modifications under controlled conditions.

In practice, however, the acoustic performance of installed wall systems may deviate significantly from laboratory expectations due to installation-related details such as insufficient perimeter sealing, leakage around door frames, and local openings [3]. Even small discontinuities may provide efficient transmission paths for airborne sound and thereby reduce the effective sound insulation of the complete partition.

This study investigates the influence of typical installation-related modifications on the airborne sound insulation performance of a commonly used lightweight shipbuilding wall system. Laboratory measurements were performed for a series of controlled modifications, including partial sealing of perimeter profiles, installation of a fire-rated door, removal of a door cylinder, installation of a power socket, partial removal of sealant, and creation of a local opening. In addition, sound intensity measurements were carried out for selected configurations using a Microflown Scan & Paint 3D system in order to identify dominant leakage locations and estimate the sound reduction index from transmitted sound power.

The results provide insight into the relative importance of different leakage mechanisms and support improved detailing and installation practice for lightweight shipbuilding partitions.

2. Test Setup and Measurement Programme

The test object was a lightweight shipbuilding partition wall consisting of prefabricated sandwich panels mounted in steel profiles. The tested wall panels (FTG 50 Panel – PB1503) consisted of two 1.2 mm galvanized steel sheets with a 48 mm mineral wool core (120 kg/m³). Each panel had dimensions of 3000 mm × 560 mm. In several configurations, a B-15 class fire door (DB1502) was installed, consisting of two 0.6 mm steel sheets with a 34 mm mineral wool core (180 kg/m³). The door dimensions were 2090 mm × 1060 mm × 38 mm. Figure 1 illustrates the mounting details, including the U-profiles, sealing tape, and panel connections, which are critical for controlling acoustic leakage. Figure 2 shows the fully installed wall.

Figure 1: Wall assembly and mounting details.

Figure 2: Installed wall assembly.

The wall system was installed in the standard laboratory opening between two reverberant rooms at FORCE Technology Aarhus, Denmark, with testing carried out by FORCE Technology. The test element area was 10.9 m², the source room volume 117.7 m³, and the receiving room volume 50.7 m³. The panels were mounted in U-profiles with compressed sealing tape, while the perimeter joints were sealed in the reference configuration in order to minimize unintended leakage. Airborne sound insulation measurements were carried out according to ISO 10140-2, and the weighted sound reduction index R_W was determined according to ISO 717-1.

A schematic overview of the laboratory setup is presented in Figure 3 and 4. Rooms 1 and 3 were used.

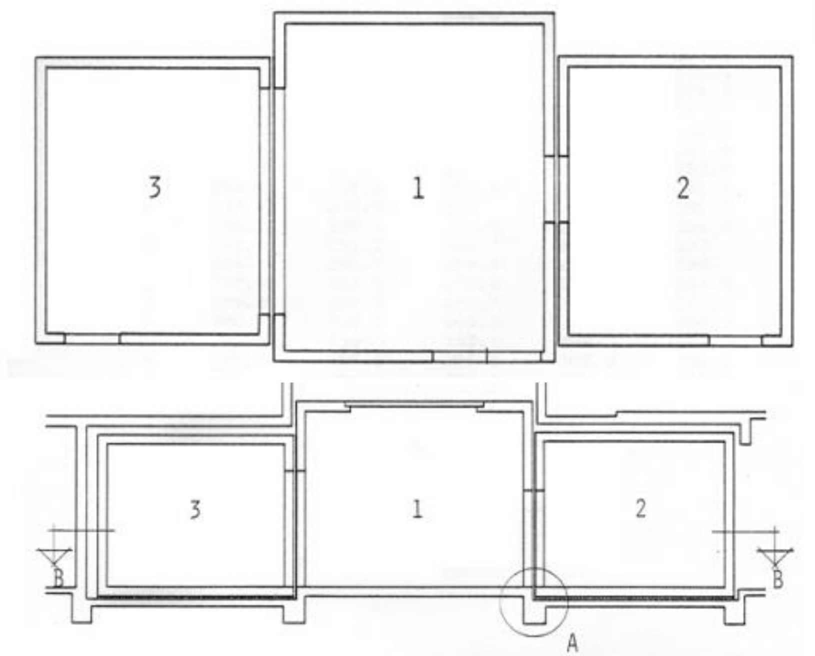


Figure 3: Laboratory configuration: horizontal, vertical section in the measurement rooms

Figure 4: Detail of the horizontal section to install the wall system between rooms 1 and 3.

The measurement programme consisted of thirteen configurations (M01–M13) investigating incomplete perimeter sealing, door installation, door-frame leakage, socket openings, partial sealant removal, and a local wall opening. Configuration M03 was used as the reference case for the wall-only setup, while M05 was used as the reference case for the wall-with-door setup. Sound intensity measurements using a Microflown Scan & Paint 3D system were additionally performed for M03 and M11 on the receiving side of the wall. These measurements were used to identify dominant leakage locations and to estimate the sound reduction index from transmitted acoustic power.

Table 1 provides an overview of the test configurations and the corresponding measured R_W values.

Table 1: Overview of test configurations and corresponding R_W values.

Test name	Description	R_W (dB)
M01	Wall panels + 30% sealing + plastic cover	27.9
M02	Same as M01 without plastic cover	27.9
M03	Wall panels fully sealed	28.4
M04	Wall panels + door + counter frame not properly closed	25.3
M05	Wall panels + door correctly installed	25.2
M06	Same as M05 without door cylinder	25.3
M07	Door frame sealed with tape	28.6
M08	Same as M07 with door cylinder installed	28.6
M09	Tape removed, door pressed into seal	27.3
M10	Opening for socket created	28.6
M11	Socket installed	28.7
M12	50% sealant removed + profile removed	25.7
M13	Same as M12 + panel opening (12 × 19 cm)	23.7

Here, 30% sealing refers to approximately 30% of the total perimeter length of the U-profiles being sealed with acoustic sealant, while the remaining perimeter was left unsealed.

3. Results

The results of the airborne sound insulation measurements are presented in this section. The weighted sound reduction index R_W was determined for each test configuration according to ISO 717-1 based on the measured sound reduction spectrum obtained from ISO 10140 measurements.

Configuration M03 is used as the reference configuration for the wall panels without door installation. Configuration M05 is used as the reference configuration for the wall system with the door installed under normal mounting conditions.

Incomplete perimeter sealing reduced R_W by approximately 0.5 dB relative to the fully sealed wall (M03), while the plastic cover had no measurable influence (M01–M02).

Installation of the door reduced R_W from 28.4 dB (M03) to approximately 25.2 dB (M05), i.e. by more than 3 dB. In contrast, removing the door cylinder had negligible influence (M06), and an intentionally not fully closed counter frame (M04) produced only a marginal change.

Sealing the gap around the door frame with tape increased R_W from 25.2 dB (M05) to 28.6 dB (M07), indicating that the dominant transmission path in the door configuration is leakage around the frame rather than the door leaf. Reinstalling the cylinder did not change this result (M08). After removal of the tape, R_W decreased to 27.3 dB (M09). The corresponding sound reduction index spectra for three representative configurations are shown in Figure 5.

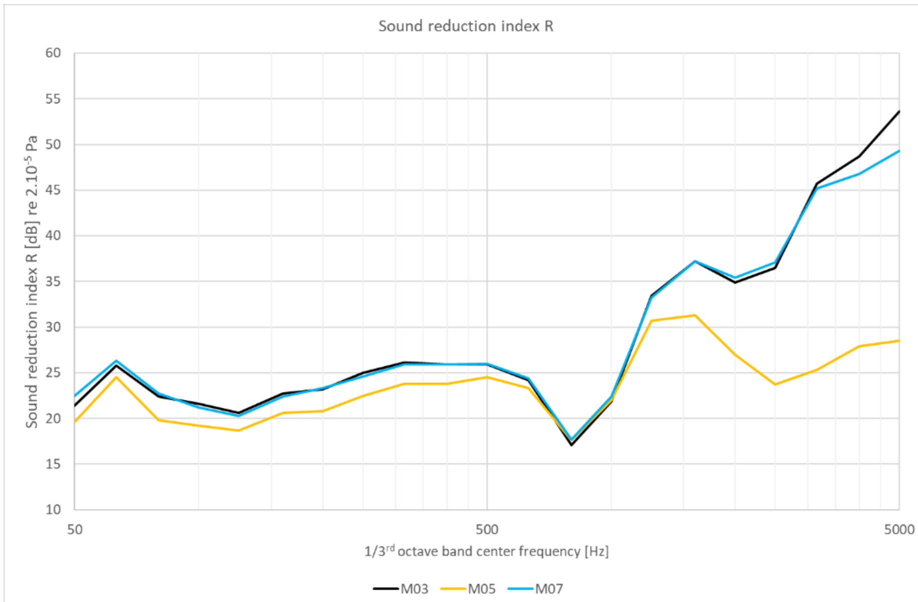


Figure 5: Sound reduction index spectra for three configurations.

The socket opening had no measurable effect on the single-number rating: M10 and M11 both yielded $R_W \approx$ 28.6–28.7 dB. Partial removal of perimeter sealant together with removal of one profile strip reduced R_W from 28.6 dB (M07) to 25.7 dB (M12). An additional local panel opening further reduced the value to 23.7 dB (M13), corresponding to a total reduction of almost 5 dB.

4. Sound Intensity Analysis

Sound intensity measurements were carried out for configurations M03 and M11 using a Microflown Scan & Paint 3D system [4]. The intensity-based approach does not fully replicate the standardized ISO 10140 procedure but provides an engineering-level estimate of the sound reduction index based on transmitted acoustic power. The scanned area covered approximately 73% of the wall surface on the receiving side, and the resulting maps represent the transmitted acoustic energy in the frequency range from 100 Hz to 3150 Hz.

For M03, the transmitted sound energy was distributed relatively evenly over the wall surface, with local increases near the left vertical joint and the upper right corner. For M11, where the door frame was sealed with tape, the dominant transmission occurred near the upper left corner of the assembly. These results indicate that structural details such as joints, corners, and profile connections act as dominant transmission paths. The intensity measurements were also used to estimate the sound reduction index of the wall system from the ratio between incident and transmitted acoustic power:

$$R = 10\log_{10}\left(\frac{W_{in}}{W_{out}}\right) \quad (1)$$

The incident acoustic power W_{in} was estimated from the measured sound pressure level in the source room and the wall surface area, assuming diffuse sound field conditions. The transmitted acoustic power W_{out} was obtained from the measured sound intensity. A more detailed description of the intensity-based method is provided in [5].

For M03, the estimated R_W values were 30–31 dB, compared with a measured value of 28 dB. For M11, the estimated value was approximately 30 dB, compared with a measured value of 29 dB. Despite the partial scan coverage, the agreement with the laboratory measurements is within typical measurement uncertainty (approximately 1–2 dB), which supports the use of sound intensity measurements as a diagnostic tool for identifying dominant leakage locations. Figure 6 presents intensity maps for the M11 configuration across several frequency ranges, with a spatial resolution of 25 mm, highlighting key leakage areas, particularly at high frequencies.

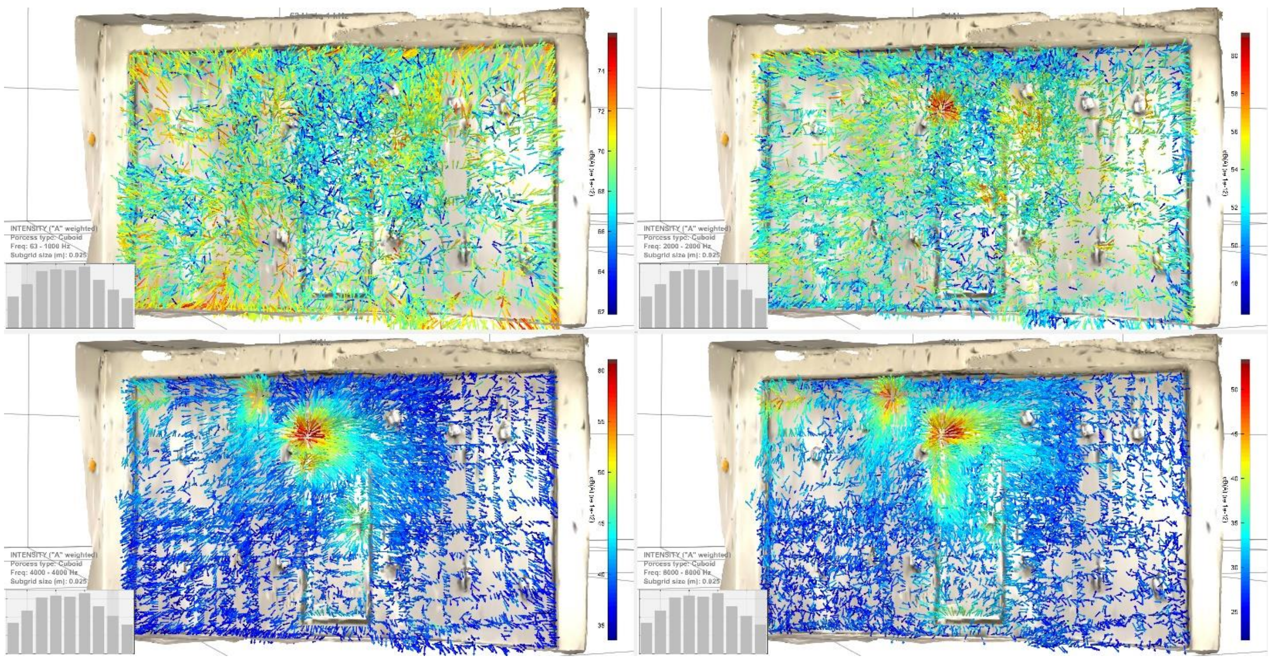
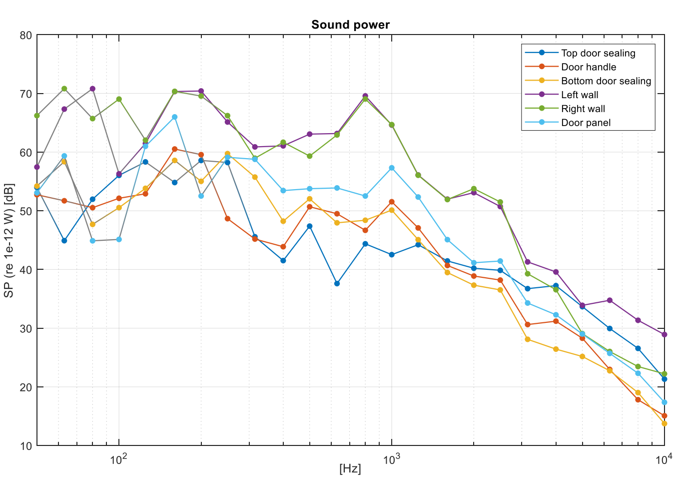


Figure 6: Microflown intensity maps of 63 Hz to 1 kHz (top left), 2 kHz (top right), 4 kHz (bottom left) and 8 kHz (bottom right) for the M11 configuration.

In addition, by analyzing the sound intensity field on the receiving side, it is possible to segment the surface into panels and quantify their contribution. The combination of the spatially averaged intensity with the panel area yields the panel sound power level (L_w). Figure 7 shows the resulting sound power ranking, allowing the quantification of the dominant radiating areas across different frequency ranges.



Panel	Area (m^2)	L_w (dB)
Left Wall	3.9	45.4
Right Wall	4.2	42.7
Top door sealing	0.24	42.3
Door panel	0.7	38.5
Door handle	0.17	36.2
Bottom door sealing	0.27	33.1

Figure 7: Sound power ranking of main sound sources identified in the M11 condition.

5. Discussion and Conclusions

The measurements indicate that the airborne sound insulation performance of lightweight shipbuilding partition walls is strongly influenced by installation details and potential leakage paths. The most significant effect was observed for the door configuration: installation of the door reduced R_W by more than 3 dB, while sealing the gap around the door frame recovered approximately the same amount. This shows that the dominant transmission path is leakage around the frame rather than the door leaf itself.

Small localized openings such as a removed door cylinder or an electrical socket had negligible influence on the overall sound insulation performance. In contrast, larger discontinuities such as partial removal of perimeter sealant or a local wall opening caused clear reductions in R_W, up to almost 5 dB in total. These reductions are consistent with the expected influence of leakage area on airborne sound transmission.

The 3D sound intensity measurements confirmed that sound transmission was concentrated at structural details such as joints, corners, and profile connections rather than uniformly across the wall surface. In addition, the intensity-based estimates of R_W showed good agreement with the laboratory measurements, supporting their use as a diagnostic tool for identifying dominant leakage locations. The remaining differences may partly be attributed to the partial scan coverage and the assumptions involved in the power estimation. A more detailed discussion on measurement uncertainty and intensity-based methods is beyond the scope of this paper but is addressed in separate work by the authors [5].

Overall, the results underline that the acoustic performance of lightweight shipbuilding wall systems depends not only on the wall elements themselves, but also to a large extent on installation quality and sealing details. Careful attention to perimeter sealing and door-frame connections is therefore essential to achieve the intended sound insulation performance in practice.

REFERENCES

1 ISO 717-1:2020. Acoustics – Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation.

2 ISO 10140-2:2021. Acoustics – Laboratory measurement of sound insulation of building elements – Part 2: Measurement of airborne sound insulation.

3 Kalis, J., Macleane, L. and Keizer, T. Measurement Uncertainty and Precision for Sound Insulation Measurements On Board of a Ship, *Proceedings of ICSV26*, Montreal, Canada (2019).

4 Microflown Technologies, Scan & Paint 3D, https://www.microflown.com/products/sound-localization-systems/scan-paint-3d, (accessed April 2026).

5 Macleane, L., Fernandez Comesaña, D., Sound Intensity Measurements for Identifying Dominant Transmission Paths in Shipboard Partition Walls, *Proceedings of the BNAM 2026*, Gothenburg, Sweden (2026).