

The background image shows a modern interior space with a curved, wood-paneled ceiling and walls. The ceiling is covered with numerous white, rectangular acoustic baffles arranged in a grid pattern. The lighting is warm and focused, highlighting the texture of the wood and the geometric shapes of the baffles. In the lower part of the image, there are arched openings and windows, suggesting a multi-level or open-plan design.

BUILDING ACOUSTIC FUNDAMENTALS

Sound insulation

Building acoustics is an essential part of the design process. Understanding acoustic theory, terminology and best practice are key factors in specifying compliant systems and providing suitable acoustic performance economically to clients.

This whitepaper explores the basic acoustic principles of sound and details how to produce accurate, complete and comprehensible acoustic specifications and schedules for consultants, contractors, and relevant authorities.

Sound insulation versus sound absorption

Sound insulation and sound absorption are two very different aspects of acoustics, and it is important to distinguish between the two. Each needs to be considered separately to achieve a successful overall result.

Sound insulation is the reduction of sound travelling from one room to another through a wall, floor or ceiling. It is a measure of how well a building element isolates noise between one space and another.

There are two main Standards that determine sound insulation performance rating:

- AS/NZS ISO 717 'Acoustic – Rating of sound insulation in buildings and building elements'.
- ASTM E413: 'Classification for Rating Sound Insulation'.

In Australia, the AS/NZS ISO 717 is generally used, and will be the basis for acoustic rating referred to throughout this whitepaper.

Sound absorption is related to the amount of reverberation (echo) within a room and has a direct affect on sound quality and intelligibility. This is essential in buildings such as schools, hospitals and other spaces where speech intelligibility and good acoustics is important.

There are three ratings for sound absorption:

- NRC: Noise Reduction Coefficient
- SAA: Sound Absorption Average
- Alpha-w: weighted sound absorption coefficient.

NRC and Alpha-w are most commonly used in Australia.

What is sound?

Sound is what we call the vibration that travel through air. Sound can be broken down into three different areas:

- Frequency (pitch): the rate at which waves vibrate. Measured as cycles per second or more commonly, Hertz (Hz).
- Amplitude (loudness): the intensity of the sound measured in decibels (dB).
- Complexity (timbre): the mixture of sounds that determines the sound's uniqueness.

Sound insulation rating: R_w

The Weighted Sound Reduction Index, R_w , is the rating derived from laboratory acoustic testing and is used to compare the sound-insulating ability of walls, floors, windows or doors.

Since R_w is an index, the higher the R_w rating, the better the sound insulation.

In most buildings, R_w values of 35 to R_w 55 are most common, with R_w 40 often given to internal walls between rooms in a building.

The R_w rating is based on sound pressure measurements (logarithmic dB scale, not linear). Relatively small changes in the R_w rating of 1 dB to 2 dB are generally not perceptible, changes of 3 dB to 5 dB are noticeable and changes of 8 dB to 10 dB are often perceived as being twice (or half) as loud.



Sound insulation rating: C_{tr}

C_{tr} is the spectrum adaptation term which was introduced to account for low frequency sound levels. The C_{tr} term is always used in conjunction with the R_w to provide a modified rating that is intended to take into account high bass (low frequency) outputs found in home theatres and music systems.

The C_{tr} is always a negative number, typically between -1 to -15, depending on the type of construction. Steel studs typically have a C_{tr} correction of approximately -8.

A large negative C_{tr} value does not always mean poor low frequency performance as it depends on the base R_w value. For example, an R_w of 59 with a C_{tr} of -9 is $R_w + C_{tr} = 50$, is better than an R_w of 55 with a C_{tr} of -7 which is an $R_w + C_{tr}$ of 48.



Acoustic insulation performance

Acoustic insulation performance of lightweight partitions depends on four key attributes:

1. The mass of plasterboard layer:

- the heavier the mass, the better the sound insulation
- multiple layers of board perform better than single layers

2. Depth of cavity airspace:

- the larger the cavity, the better the sound insulation.

3. Use of cavity insulation (thermal or acoustic):

- the addition of insulation in an empty wall cavity improves sound insulation.

4. Mechanical connection between the two leaves:

- bridging and rigidly connecting the wall linings reduces the sound insulation.

Timber systems tend to have the lowest performance as the two sides of the wall are connected by a relatively large and rigid timber stud. Light gauge steel studs (0.55 mm base metal thickness, bmt) provide better acoustic performance as these are lighter than timber studs and provide a more flexible connection between the two sides of the wall. Heavier gauge steel studs (0.75 mm, 1.15 mm) do not perform as well as light gauge studs. Quiet studs are designed to be even more resilient than standard light gauge studs and these provide the best performance for single studs.

Staggered studs provide even better performance as there is no connection between the wall linings (except at the perimeter of the wall) and the direct path through the wall structure is eliminated.

Twin stud wall systems have the highest acoustic performance since, as with staggered studs, there is no connection between the wall linings, and in addition, the cavities are generally larger and they do not have a common top or bottom track.

The role of cavity insulation in partitions

Cavity insulation provides a useful improvement in acoustic performance. By including insulation in the stud cavity, an increase of up to 10 dB can be achieved, depending on the type of wall system.

The greatest improvement will occur in lightweight systems with no insulation. Where there is insulation in the wall cavity already, adding thicker or more dense insulation will provide a smaller, or marginal, improvement.

Impact sound insulation: $L_{n,w}$

$L_{n,w}$ is the weighted, normalised impact sound pressure level and is the laboratory determined metric used to establish and compare the impact sound insulation performance of floors. Since $L_{n,w}$ is a sound pressure level, the lower the value the better the acoustic performance of the wall.

To determine the $L_{n,w}$ level a standardised tapping machine is used as the noise source. This machine has a number of hammers that are dropped onto the floor to produce the impact noise. The sound pressure levels are then measured in the receiving room below over the frequency range 100 Hz to 3,150 Hz and a reference curve is used to determine the overall $L_{n,w}$ level.

To improve the $L_{n,w}$ performance, resilient ceiling hangers or an acoustic underlay beneath the floor finish can be used to minimise the noise transmission to the ceiling below. These rubber type mounts and underlays are typically applied to concrete slab floors or lightweight timber floor structures in multi-residential construction. These mounts are also used to isolate rain noise in cinema complexes or penetrating noises from appliances or AV equipment from residential or commercial spaces.

The National Construction Code (also known as the Building Code of Australia), mandates minimum acoustic performance of wall and floor partitions in terms of both R_w , $R_w + C_{tr}$ ratings and $L_{n,w}$ levels for different classes of buildings.

Good construction practises for acoustic insulation

Flanking sound is the sound that is transmitted between spaces indirectly, going over or around the main separating element (floor or wall). If the flanking noise path is significant, it can appear as though the wall, or floor, is not performing as well as it should, when in reality it is the flanking path that is the problem.

Sound can be considered similar to water; it will find the path of least resistance, travelling from one space to another. Flanking paths can be via poor joints between the wall and floor, poorly sealed penetrations, open or untreated ceiling spaces, floor spaces, façades, ductwork, etc.

Controlling flanking sounds is critical to ensure that acoustic performance in the field is as close to the laboratory performance as possible. This can be achieved by sealing all air leaks through gaps, cracks, holes, and penetrations. Detailing of junctions and acoustic treatment of penetrations and ventilation systems is also required.

Workmanship

Workmanship plays a clear role in minimising the effects of flanking. It is essential that the partition is airtight. This can be achieved by adequately sealing all floor and wall junctions along the perimeter with flexible fire or acoustic sealant. Skirting alone is not enough to seal gaps.

Square-set ceilings or cornices installed correctly can also provide an acoustic barrier to minimise flanking noise.

Detailing

Additionally, correct detailing is required to minimise structural flanking. Structural flanking can significantly reduce the perceived insulation of a wall, floor or ceiling system and should be given careful consideration.

It is critical to understand potential noise paths and insulate the sound in each room as well as between rooms, for example floor and wall junctions, façade junctions and over ceiling construction.

Sound insulation ratings: Laboratory versus field performance

Verification of acoustic performance for building elements can be conducted in the field; however, they are typically up to 5 dB points lower than laboratory test ratings, and can be as high as 8 dB points lower depending on the construction and noise flanking paths. As a result, building codes and project acoustic specifications provide a 5 dB concession for field performance in recognition that airborne sound and structural flanking may exist.

Results determined in the laboratory may vary to those in the field due to workmanship, presence of airborne and structural flanking paths, background noise in the field, and common testing errors. Identical walls tested on different projects in the field can achieve different results because of different site conditions and normal statistical variability of measurements, particularly at low frequencies.

To achieve acoustic insulation on site, select the correct wall or floor system to meet building codes or project acoustic specifications.

Additionally, to insulate all airborne and impact sound from the structure, it is important to correctly detail the construction at wall and floor intersections. Structural flanking needs to be considered at the design stage, otherwise it will be difficult and costly to rectify after construction.

Conclusion: Identifying and specifying acoustic systems

There are a variety of methods, tools and resources to assist in correctly specifying acoustic systems. On larger projects and those that require compliance with the NCC/BCA, an Acoustic Engineer will be part of the design team to provide advice and will often have their own preferred wall types and products.

While both are good options, it doesn't always guarantee the most cost-effective option for your client or that you are using the most up-to-date information on products' acoustic performances, which are constantly a target for improvement by manufacturers.

Next steps: Continuing Professional Development

Consultants, contractors and relevant authorities need to understand the various acoustic requirements set out in the National Construction Code (NCC) so that they can ensure structures meet the minimum requirements. As requirements, materials, and techniques continue to evolve, it's essential for professionals to stay up to date on the latest information.

Knauf offers a Continuing Professional Development (CPD) webinar presentation on Building Acoustic Fundamentals – Sound Insulation that is certified by the Australian Institute of Architects (AIA).

The webinar is one hour in length and is worth one informal CPD point. On completion of the post-webinar learning outcomes questionnaire, participants can receive one formal CPD point. Participation is free via online registrations and more information can be found at: www.knaufapac.com/au/cpd.

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There are many variables that can influence construction projects, which affect whether a particular construction technique is appropriate. Before proceeding with any project, we recommend you obtain professional advice to ascertain the appropriate construction techniques to suit the particular circumstances of your project. We recommend you use qualified tradespersons to install this system.

The technical information contained in this manual was correct at the time of printing. Building systems, details and product availability are, however, subject to change. To ensure the information you are using is current, Knauf recommends you review the latest building information available on the Knauf website.

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