OPTIMISING ACOUSTICS

IN SPACES WHERE PEOPLE LIVE, LEARN, WORK AND PLAY

Optimising Acoustics in spaces where people Live, Learn, Work and Play.

DR KATE HARTIGAN

Executive Summary

As a leading brand for acoustic product solutions, Lotus knows the importance of getting the acoustic balance correct within adaptable space environments, and the impact acoustics can have on the health and wellbeing of occupants.

With over 50 years of experience in designing, manufacturing and installing acoustic product solutions, Lotus are experts in the field of supplying state of the art adaptable space systems with acoustic benefits to the commercial built environment.

Specifiers and Designers require knowledge of the sound absorption and acoustic requirements of products being used within architectural spaces. To help achieve the desired acoustic environment, collaborating with a qualified acoustic consultant during the design phase is recommended.

In this whitepaper, we look at the impact of acoustics in spaces where people live, learn, work and play and considerations in specifying walls and doors for the acoustic performance required in the design process.

Introduction

The acoustic properties of where we live, learn, work, and play profoundly impact how we experience the space. They can influence how we feel, behave and how efficient or focused we are.

How spaces are designed has changed significantly over time. Offices have moved from the traditional workplace format to large, shared environments. Open-plan living has become the trend, while educational facilities are moving towards more flexible learning environments (FLE's).

This shift in the way people live, learn, work and play means that positive experiences do not only come from functionality and aesthetically pleasing buildings, but must also include acoustically sound solutions. Poor acoustics within an indoor environment can have a significant impact on health, wellbeing and comfort and can impact work and academic performance.

Architects, designers, builders, facility managers and acoustic consultants are now rethinking acoustics to ensure that a building's audibility is fit for purpose, ensuring that there is no rattling, transmission, reverberation, echoes or spaces that are too quiet.

Lotus is a leading supplier of adaptable acoustic space solutions for the commercial built environment, delivering full turn-key solutions to its customers from design, to manufacturing, installation and servicing. Our Architectural Design Consultants understand the importance of good acoustics and what makes an excellent soundscape.

Australian owned and made, with depots in all major capitals of Australia and an office in Auckland, New Zealand, Lotus has become the number one supplier of adaptive space systems for the commercial built environment. Lotus helps create spaces where people can not only perform but thrive.

GLAZED SLIDING DOOR AT HALE SCHOOL. SITE ARCHITECTURE STUDIO

AUSTRALIAN AND NEW ZEALAND STANDARD AS/NZS 2107:2016

The Standard AS/NZS 2107:2016 recommends design criteria conditions for building interiors in Australia and New Zealand. The aim is to ensure that internal spaces (private and public) are healthy, comfortable and productive (AS/NZS 2107:2016).

Building Codes and Australian Standards recommend sound levels and reverberation times for building interiors. Regional standards, such as the Australian Standards AS/NZS 2107:2016 are prepared by a specific geographical region (Australia and New Zealand). There are also detailed international standards that can help guide best practice in acoustics for building environments.

"At Lotus we will always assess what may be required by the building code, as well as what our Architectural Design Team believe would be optimal for each individual project. The recommended product solutions are based on what will be best in terms of the space and its intended use. An Acoustic Consultants project brief is an invaluable start point when determining products and configurations best suited to an application, along with an understanding of the design intent and the end users expected outcomes" Lotus Architectural Design Advice Manager, Gary Wardle.

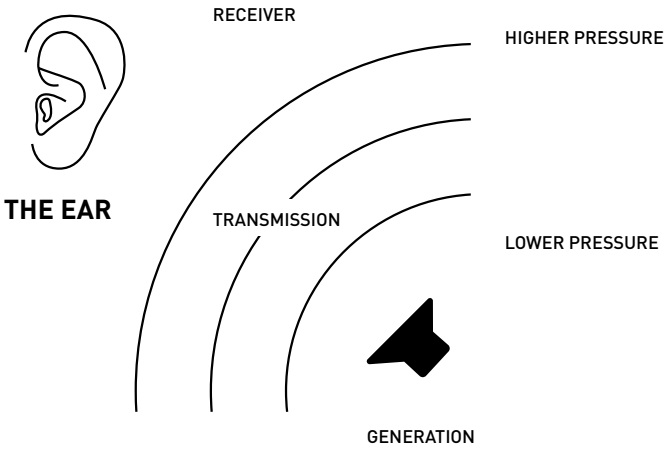
"In the building code, each reference depends on if it is residential, commercial or educational. Contingent on the fitting and the purpose of the space, the standards will specify minimum or base acoustic performance levels to be achieved."

- LOTUS ARCHITECTURAL DESIGN ADVICE MANAGER, GARY WARDLE.

BASIC ACOUSTIC CONSIDERATIONS

SOUND CONTROL

In architectural acoustics, controlling the amplitude and/or the duration of sound is important. As an example, in operable walls, this is done by controlling sound transmission loss and sound absorption.

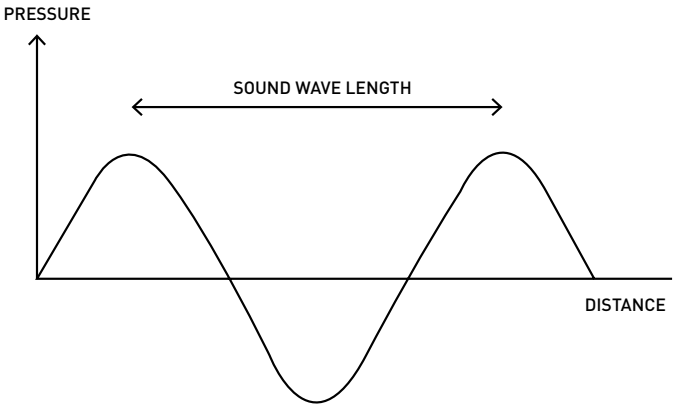


Sound is an energy which is:

- generated by a source
- transmitted through a medium
- received by a receiver.

Sound has several measurable components:

1. frequency
2. amplitude
3. duration.



1. FREQUENCY

The frequency of a sound wave is its rate of vibration (i.e. the number of times the sound wave's basic pattern repeats itself per second).

The frequency determines how high or low the pitch is. At low frequencies the air particles vibrate slowly producing base tones. At high frequency the air particles vibrate quickly giving soprano tones.

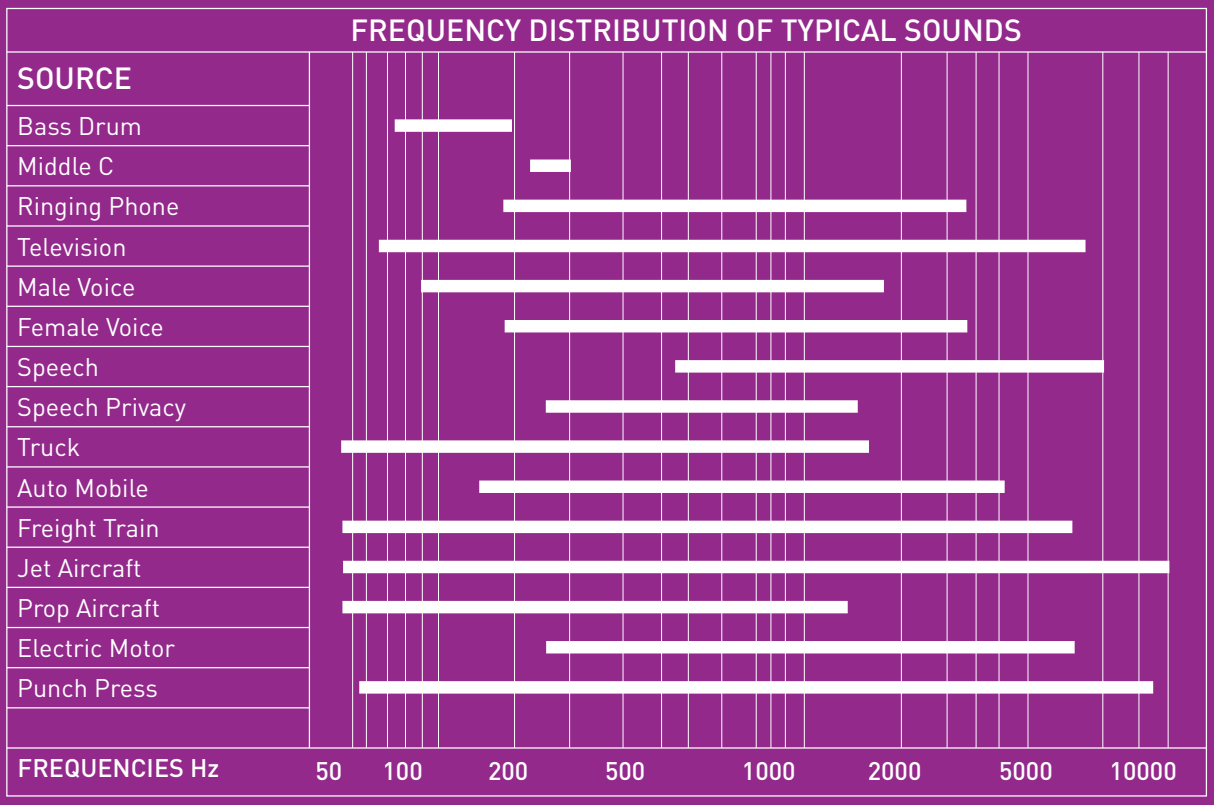
Frequency is measured in cycles per second, expressed as Hertz (Hz). A sound wave with a frequency of 800Hz implies there are 800 vibrations per second generating from the source.

Audible sound for young people lies between 20Hz and 20,000Hz, but the human ear is most sensitive in the range on 100 – 5000Hz.

Operable Walls Require:

1. mass to deflect low frequency
2. good seals for high frequency

→ **Interesting Fact**
Speed of Sound in:
Air 20^0C = 344m/sec
Water = 1500



2. AMPLITUDE

Amplitude is the magnitude of the vibration (pressure change) which determines how loud the sound is. To reduce the very wide range of sound pressures encountered in practice to more manageable numbers, the logarithmic decibel (dB) scale is used.

Sound pressure levels in dB are more easily related to human perceptions. A change in the level of 10dB corresponds approximately to a doubling of perceived loudness, whereas the actual sound intensity or pressure has increased by 10 times.

Under typical conditions, an individual with normal hearing cannot detect a change in sound pressure of 1-2dB. A difference in sound pressure of 3dB is barely perceptible if the change is sustained and no time lapse occurs. A change of 5dB is clearly detectable.

As can be seen in the table, an 80dB sound is not twice as loud as a 40dB sound, it actually has 10,000 times more sound intensity.

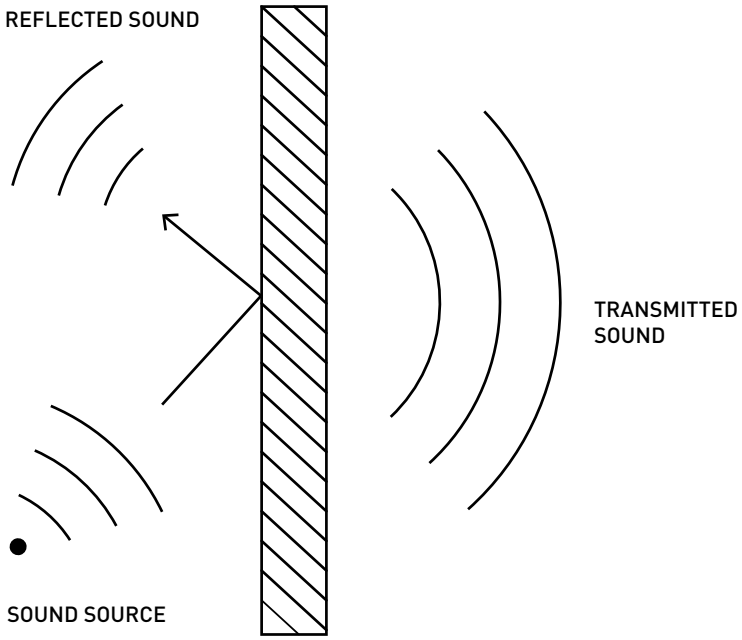
Sound Pressure (Reference Units)	Sound Pressure Level (dB)	Typical source
1,000,000,000,000	120	Thunder Clap
100,000,000,000	110	Nearby Riveter
10,000,000,000	100	Boiler Factory/Subway
1,000,000,000	90	Noisy Factory
100,000,000	80	Noisy Office
10,000,000	70	Average Street Noise
1,000,000	60	Average Office
100,000	50	Average Conversation
10,000	40	Private Office
1,000	30	Average Auditorium
100	20	Whisper
10	10	Soundproof Room
1	0	Threshold Hearing

3. DURATION

Duration is the time the sound lasts, measured in seconds. The duration may indicate how long the source is vibrating or how much the sound is reverberating, or echoing.

Sound Absorption, Reflection and Reverberation

Sound absorption is the effectiveness of a surface or material at preventing the reflection of sound.
It does this by converting sound energy to heat. The more sound absorption, the less echoing will exist.
Hard surfaces like vinyl or veneers are least effective at absorbing sound, whilst thick fabrics like pinboards are more effective at absorbing sound.



THE NEED FOR GOOD ACOUSTICS

Good acoustic performance is considered increasingly important for many reasons. People thrive in optimal soundscapes - experiencing tranquillity and calm at home, clarity and collaboration in educational environments, focus and concentration at work.

A great acoustic solution does not mean creating a room free of reverberations where all the noise is completely absorbed, as people actually do not enjoy experiencing only the noise produced by themselves. Good acoustics are created when all the sound in a room is absorbed equally.

"There are good acoustics that occurs if you're in a room and you're not bothered by the white noise that surrounds you. This might be in a classroom where you can clearly hear the teacher, or in a restaurant where you can comfortably have a conversation with a group of friends without raising your voice or straining to hear what people are saying. It's all about having the right acoustics for that specific situation - to be able to absorb the white noise or reverberation sound to have a really nice clear hearing room," Lotus Architectural Design Advice Manager, Gary Wardle.

When a space has poor acoustics, the sound will bounce and reverberate around the room leading to background noise, echo or flutter, which can be stressful and exhausting (Troldtekt). When speaking with people in smaller rooms, at home or in an office, people want to be able to clearly understand what others are saying, therefore the sound needs to fade more quickly (AS/NZS 2107:2016). If at a concert hall or theatre, the sound must linger a little longer for people to fully enjoy and absorb the music (Riding the Waves: A Life in Sound, Science, and Industry, Leo Beranek). This means that there needs to be different reverberation times depending on the room's size and purpose (Troldtek).

To achieve optimal soundscapes, it is imperative to focus on the design of the space, the intended use and the acoustic solutions. At Lotus, we believe that rooms should always be designed to ensure that people experience good acoustics for their health, wellbeing and comfort.

> "The distribution of acoustic energy, whether originating from a single or multiple sound sources in an enclosure, depends on the room size and geometry and on the combined effects of reflection, diffraction, and absorption."
>
> – LEO BERANEK, MUSIC, ACOUSTICS, AND ARCHITECTURE

WHY DO ACOUSTICS MATTER WHERE PEOPLE...

LIVE

Internal building services, structure borne noise and residential activities all have an effect on how we experience the acoustic environment where we live (Environmental Protection Authority Victoria), and external noises such as sounds from roads, rail and air traffic can trickle in through gaps in your roof, walls, windows, doors and floors.

"Today people want sleek surfaces, concrete floors and stone bench tops. It is not like it used to be back in the 60's where everything was really plush, people had carpets and pillows and soft couches. These soft materials all helped absorb the sound. Now with all beautiful sleek finishes, there is so much sound bouncing around. If the neighbour is also making sound, it gets really loud because the sound doesn't have anywhere to go."
Lotus Architectural Design Advice Manager, Gary Wardle.

To enjoy a healthy and happy life where you live, your home should have comfortable acoustics. Sleep, rest and everyday life can be impacted by noise leading to mental health issues, headaches, stress and irritability (BMC Public Health).

Good acoustics in residential buildings can be achieved through mindful site planning, building layout and design and construction (thermal mass, walls, doors, floors etc.). Guidelines provided by the Building Code of Australia (BCA) have the objective to "safeguard occupants in residential buildings from illness or loss of amenity that may result from excessive noise" (ABBC Handbook).

"It is important to pay close attention to background noise, because it can completely ruin the experience of good acoustics in a room. Therefore, it is necessary to specify requirements for background noise, and to adapt the actual requirements according to what the room is going to be used for."

- TROLDTEKT, AN INTRODUCTION TO GOOD ACOUSTICS.

Thoughtful design process and sound acoustic product solutions can reduce the impact of noise in residential dwellings, improving our lifestyle and wellbeing and providing privacy.

LEARN

It is important not to compromise on the acoustic environment within educational facilities. In fact, it is a critical aspect of a contemporary learning environment. A poor sound environment can negatively affect a student's physical and psychological health (Australian Acoustics Society) and it can even interfere with their speech, language and ability to learn (Noise in the School Environment and Cognitive Performance in Elementary School Children).

"Research shows that poor acoustic standards in school environments can create significant barriers to learning. These barriers include cognitive fatigue, disconnecting and inability to concentrate, and delays in language development. We are seeing the education sector move away from a 'one-size-fits-all' approach where classrooms are uniform, and desks all lined up. Mobility, adaptability and flexibility are central to these new designs, and addressing acoustics with operable walls and acoustic sliding doors is an effective way to minimise acoustic issues and enhance flexible space design." Noise in the School Environment and Cognitive Performance in Elementary School Children, Part B – Cognitive Psychological Studies

Each classroom should be developed to optimise communication between the students and teachers, as learning is improved in flexible dynamic spaces. Ways to optimise acoustics should be at the centre of design to avoid negatively impacting students and their future career prospects (1-3).

"Students who cannot clearly understand speech in a classroom tend to lose concentration and eventually become disconnected with the proceedings. Valuable teaching time is lost and student progress is impaired."Association of Australasian Acoustical Consultants Guideline for Educational Facilities

According to Members of the Association of Australasian Acoustical Consultants (AAAC), modern learning spaces require higher acoustic solutions than what is often provided in Australian schools (Association of Australian Acoustical Consultants). The United Kingdom, United States of America, New Zealand and Sweden have developed specific acoustic criteria for educational facilities, which are now regarded worldwide as one of the main considerations for classroom acoustics.

On average, students spend four to five hours in the classroom per day (AS/NZS 2107:2016), and this is where they are encouraged, motivated and committed to learn. For people with disabilities or special learning needs, there are even greater acoustic requirements as students may have aural sensitivities. Lotus is committed to providing acoustic product solutions that are compliant with the Disability Discrimination Act (DDA), that specifiers can easily incorporate into their building designs to achieve DDA compliance and are safe for all students, teachers and the community.

Traditional classrooms used to be similarly built rooms comprising of four solid walls and a door, where modern classrooms and new educational spaces are now following a new pedagogical model. These open plan environments are built to be flexible and adaptable, where students can collaborate and learn.

It's therefore imperative to carefully consider the sound environment and acoustic performance when designing internal spaces for educational purposes.

Lotus is committed to enhancing the way people learn by creating the right balance between acoustics and flexibility in contemporary learning spaces. We understand the need for good acoustic solutions and the emerging pedagogical changes to education in school. Lotus products are designed to meet the needs of school designs and are the perfect solution to deliver a flexible and innovative learning environment.

WORK

Open-plan offices are great for stimulating discussions, collaborating and creating an engaged workplace culture, while also improving flexibility, efficiency and productivity. It can however, also be distracting and disrupting to work in an open office space due to the amount of noise (Workspace Optimization for Human Resource Management in Project-Based Organizations from a Managerial Perspective, Xiaofeng Yue and Pei Liang).

"Our work environment has changed a lot in recent years with a move to big open spaces, and this has had an impact on acoustics. We now want to be more engaged, collaborate and share office space with our peers. This shift has provided workplace sounds with more room to bounce around. It is therefore important to have acoustic solutions that help absorb some of the sound, but that also keep the sound from breaching the meeting rooms that are available in a workplace." Lotus Architectural Design Advice Manager, Gary Wardle.

We are wired to process sound and it can be near impossible to stop our brains from listening to the noise surrounding us. Although open-plan offices are great for workplace morale and collaboration, people also need access to quieter places for focused activities.

According to the Steelcase/Ipsos study, employees reported not having enough places for focus and mindfulness at work, constantly being disrupted or interrupted.

With workplaces being busy hubs of activity with telephone calls, discussions, meetings, keyboards clicking and chairs shifting, good acoustic product solutions and spaces that adapt to the activities of the moment are key. There is also the exterior noise to consider, with sound 'leaking' in from busy roads, cafés and adjoining office buildings.

"We spend a large amount of our time at work and we all have differing individual needs – personality styles, sensory requirements, behavioural patterns, mental and physical health considerations, wellbeing – and functional workspaces should be designed with these needs in mind. Employers need to think about how the physical environment and acoustics impacts employee's wellbeing, and business productivity and aim to design considered and inclusive workspaces that bring out the best in people." Dr Kate Hartigan, Head of Marketing and Customer Solutions at Lotus.

Considering the design intent and implementing acoustic product solutions like operable walls, sliding doors or agile panels is a way to absorb some of the noise, enhance collaboration and efficiently utilise available floorspace. The use of transparent acoustic walls help maximise the transfer of natural light through a space. Natural light is proven to have a positive effect on people's moods, stress levels and overall wellbeing, which can contribute to healthy, happy and productive work environment.

Lotus acoustic products are designed to meet the needs of open plan designs and have the perfect solutions for flexible and contemporary work environments. We help to create flexible and prosperous work environments so companies can thrive.

"49 percent of workers report not being able to concentrate easily, while the average person loses 86 minutes per day."

- STEELCRAFT 2014

PLAY

Amphitheatres, concert halls, sports stadiums, hotel conference facilities, cafés and restaurants all have different designs and soundscapes. These spaces all require different reverberation times and acoustic solutions.

At the opera or in a classical concert, the audience sits quietly taking in the music - they want the sound to linger to fully enjoy the experience. At a restaurant people want to feel like they are in a lively environment, but still expect to clearly communicate with their friends. Speech intelligibility is therefore of utmost importance in a restaurant or conference venue, as the acoustic performance of a space will influence people's ability to comfortably converse (Troldtekt).

The optimal reverberation times and sound levels recommended for different venues will depend on their intended use, the number of occupants and the activity (AS/NZS 2107:2016).

Along with the workplace and education sector, public areas are moving towards flexible space solutions that require highly functional and flexible features with varied acoustic requirements, that integrate with the other design elements within the space. There is a renewed emphasis on meeting and event spaces to have the flexibility to be configured in a variety of set-ups tailored to the customers' needs. Lotus understands the need for good quality product solutions and the need for the aesthetically pleasing designs to compliment the overall space. Lotus helps to bring public places to life with seamless, flexible and safe space solutions for the way people play.

"Good acoustics play a huge part in making places where we play enjoyable. They have an impact on how we experience a concert or a trip to a stadium."

- LOTUS DOORS ARCHITECTURAL DESIGN ADVICE MANAGER, GARY WARDLE.

A Guide to Specifying Acoustic Operable Walls or Acoustic Solid/Glass Sliders

Acoustic design requires careful deliberation of various design features, all working in combination. In specifying walls and acoustic sliding doors within flexible space environments, noise control is very important.

KEY ACOUSTIC ELEMENTS TO MANAGE

Good acoustic design practices should minimise the noise levels within a space, from adjoining rooms, neighbouring buildings and the outside environment. They will take into account the reverberation times, the sound levels and the Rw Correction values.

According to Lotus Architectural Design Advice Manager, Gary Wardle, the key to developing effective flexible learning spaces is incorporating a mix of products, including traditional high acoustic build-operable walls. These can incorporate practical surfaces, such as pinboards and whiteboards, and be supported by glazed and solid acoustic sliding doors, as well as other acoustic soft furnishings within the educational or workplace environment.

When specifying materials that will have an impact on the soundscape in a room or building, it is important to determine the needs and preferences of those who will be using the space. A sound rating should be chosen to suit the surrounding structure, the sizes of the partitioned areas and use of the space.

There are two primary ways to manage noise levels. The first is to block external noise from entering the space by using materials with a high Rw rating. This prevents airborne noise from entering spaces and provides sound separation. The second method is to reduce reverberation by using soft and absorptive materials that reduce sound bouncing around the room.

Another key element to consider is speech intelligibility, ensuring that a space uses sound absorbing materials to lower the reverberation time. In a classroom, at home or in the office, people shouldn't need to strain to hear. It is important that a room has a suitable amount of sound absorbing material to allow for the right sound to be carried in the room.

"Lotus products are designed to reduce sounds transference between spaces. As an example, if our operable walls and doors are between two classrooms – they will reduce sound from travelling between the two rooms. The higher the Rw rating of the product solution, the better performance you have for reducing sound transfer."

- LOTUS ARCHITECTURAL DESIGN ADVICE MANAGER, GARY WARDLE.

MEASURING ACOUSTIC PERFORMANCE

The performance of an operable wall is measured in a laboratory and expressed by its Weighted Sound Reduction Index (Rw). The single Rw figure is a composite rating of sound reduction at frequencies from 100 Hertz (Hz) to 5000 Hz, when compared to an Australian Standard line. Note that 'Weighted Sound Reduction' (Rw) was known as 'Sound Transmission Class (STC). Numerical values are comparable. Please note that the unit of the Weighted Sound Reduction Index is decibel (dB).

Rw correction values are tested in a lab providing an estimate of the acoustic performance. When considering acoustics, it is important to ensure that test results are reasonably recent and are from reputable laboratories, like the Royal Melbourne Institute of Technology (RMIT) or CSIRO. Laboratories with non-standard testing protocols exist in both Australia and overseas.

Lotus completes testing at CSIRO and RMIT, both leading Australian laboratories, to Australian Standard AS 1191-2002, which makes Lotus walls BCA compliant. In tests up to Rw 53 we use sweep seals at the top and bottom of the panels, demonstrating that retractable seals are not required for acoustic reasons for anything other than the highest rating. Lotus offers Rw 37 to Rw 55, which allows Lotus to meet acoustic requirements from budget to high performance and everything in between. Rw 55 is the highest result achieved for an operable wall in an Australian test.

As a leading brand for acoustic product solutions, Lotus knows the importance of getting the acoustic balance correct in any space. Lotus' comprehensive operable walls and acoustic sliding doors range include a range of Rw products, ensuring that Lotus can cater for rooms that require little acoustic performance; to projects where the maximum acoustic performance and rating is required, so sound doesn't transfer and so that a room is private and not disrupted by surrounding noise.

Acoustic Sliding doors

Recent design trends have led to an increase in the use of large format or multiple unit sliding doors to offer a quick and easy product to open a space. Traditional sliding door systems offer limited acoustic performance, especially as a fully glazed unit. Lotus lead the market in developing some of the highest rated Acoustic Slider systems on the market.

"Rw is a weighted sound reduction. Measured in special university labs to measure the reduction in decibel sound."

- LOTUS ARCHITECTURAL DESIGN ADVICE MANAGER, GARY WARDLE.

"We cater for everything from products with a minimal acoustic requirement through to high at Rw 55. We can also incorporate acoustic products from other companies, such as acoustic glass or fabrics into our systems to help the reverberation sound as well."

- TROLDTEKT, AN INTRODUCTION TO GOOD ACOUSTICS.

To learn more about specifying Lotus products in your projects head to our website or contact our Architectural Design Advice Team.
→ **www.lotusdoors.com.au**

ACOUSTIC GLOSSARY

Dw – Weighted Level Difference: Expressed in decibels, it is the rating of the field measurement of frequency dependent airborne sound insulation between rooms i.e.: it is the measured difference in sound between the two rooms.

DnTw – Weighted Standardized Level Difference: Expressed in decibels, it is the rating of the field measurement of frequency dependent airborne sound insulation between rooms. Uses reverberation time of 0.5sec.

Rw – Weighted Apparent Sound Reduction Index: Expressed in decibels, it is the rating of the laboratory or field frequency dependent measurement of airborne sound insulation between rooms, that may include the influence of flanking paths. Experience has found DnTw is the easiest site performance to achieve, whilst Rw is the most difficult to achieve. Sales will determine the Rw wall to quote, dependent upon the project spec. We typically see a 7-8dB loss from a lab test to a site test. Therefore, the specced 100S/53/SX2 wall could be expected to achieve a 45Dw on site.

Mass Law: As a general rule of thumb, the heavier a panel is, the better it will perform. The mass by law predicts that the sound transmission loss will increase about 6dB per doubling of mass. This rule is primarily for single leaf walls.

Separation of Walls or Panel Faces: Most operable wall panels will consist of a panel with two faces. The greater you can separate the faces, the more you can reduce the effect of the mass-air-mass resonance. The larger the gap the lower the resonance which occurs.

Coincidence Dips: The coincidence dip of a material is the effect where the performance of a material falls rapidly then rises again. It is a function of the wavelength of the sound hitting the substrate and the wavelength of the sound in the substrate. When they coincide the substrate allows the sound to pass through it with reduced attenuation. For any given substrate it will be inversely proportional to the thickness of the material. Ways to reduce the effect of coincidence dips include using an infill between faces and a lamination of a number of different materials and thicknesses for each substrate (face). This is why we have L and D boards.

Flanking Paths: Sound, like water, follows the path of least resistance. If there are leaks in the surrounding construction, even the best operable wall will not provide a good sound barrier. Shoddy construction, customary construction practices or poor installation of the wall can all contribute to the leaks known as flanking paths.

A flanking path of 0.1% of the wall surface area WILL reduce a 55Rw wall to a 30Rw. Flanking paths can be present even though the surrounding construction is of good quality. Direct air conditioning ducts between rooms, common corridors and open plenums above suspended ceilings are all perfect escape routes for sound. The ceiling tiles themselves, whose porous properties help prevent reverberation allow sound to pass through easily.

Uneven floors and out-of-plumb walls also contribute to leaks as do recessed lighting, access panels, projection and lighting booths and other design details.

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