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Association of Australasian Acoustical Consultants
Guideline for
Commercial Building Acoustics

Version 1.0

Association of Australasian Acoustical Consultants

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1.0 INTRODUCTION

Members of the AAAC have been concerned for some time that there are only limited building regulations or standards that address aspects of the acoustical quality of commercial buildings.

This document provides guidelines to rate acoustical aspects to provide a consistent approach across different buildings, states and acoustical consultants. In particular, this document provides guidance for office developments.

The AAAC also has documents providing similar advice in relation to apartments, schools, child care centres, healthcare facilities and advice on the selection of an acoustical consultant.

1.1 The Importance of the Acoustical Environment

In office and open plan working situations, the acoustic environment must support the way people work and interact. The acoustical comfort for occupants and participants in private offices, meeting rooms, board rooms, quiet spaces and huddle spaces are key acoustic deliverables in commercial office projects.

Acoustic comfort relates to the ability to easily and comfortably hold conversations free from intrusive noise with confidence of appropriate privacy. In a similar way to thermal comfort, acoustic comfort is important to achieving successful long-term communication and work-ability of the space.

Offices are a 6 to 12 hour per day working environments, and the acoustic conditions must support and not hinder people's work. Listeners should be able to hear talkers effortlessly, without having to concentrate to understand words easily and not be hampered by excessive colouration in the speech sound. Talkers should feel confident that their voices are heard and understood. When the background noise is uncomfortable, participants have to concentrate harder to understand words, particularly if they are unfamiliar, such as proper nouns or talkers and listeners with unfamiliar accents. The need for listeners to concentrate to discern words detracts from their concentration on the subject matter at hand.

The importance of acoustic design requirements for comfortable speech communication in meeting spaces is usually underestimated. This is often exemplified by complaints from remote parties during audio and video conferencing. If adequate intelligibility and acoustic comfort were provided, concentration would be easier, and participants would be less frustrated and more productive.

To achieve these outcomes, the acoustic design of offices and open-plan work areas should facilitate the following outcomes;

a) Spaces should be comfortable to occupy; occupation and work carried out within each space and environment should not be tiring over long periods.

b) Appropriate privacy should be provided for conversations, as required in each space, with levels of privacy ranging from not distracting to completely confidential.

c) Speech should be comfortable to listen to in each space and should sound natural. Speech should be free of distracting distortions, such as focussing, shrillness and echoes.

d) Spaces should have a suitable level of ambient noise.

e) Spaces should be free from distracting noises, such as hydraulics, lift noise or the clanking of crockery in a kitchen.

f) Speech transmitted to remote participants during video and audio conferencing should be sufficiently natural and free of detrimental acoustic effects to allow easy and comfortable participation by all participants.

To provide the required acoustic environment, the following items must be addressed in the design stage:

- sound insulation between spaces;
- internal room acoustics of spaces;
- building services noise;
- vibration; and
- external noise intrusion from transportation and mechanical services.

2.0 OBJECTIVES

2.1 Building Code of Australia

The *Building Code of Australia* (*BCA*) defines an office as a Class 5 building. Volume 1 of the BCA covers this particular building class; however, Part F5 *Sound Transmission and Insulation* is only applicable to Class 2, 3 or 9c buildings and as such there are no minimum building codes for a Class 5 building that must be satisfied.

The result of this may be that developers/builders construct buildings with poor acoustic qualities. It is noted that where the development is a mixed use combining residential and commercial, Part F5 is applicable in insulating noise from the commercial part to the residential component of the building but is not applicable in reverse or between two commercial tenancies.

2.2 Green Star

The Green Building Council Australia (GBCA) has developed a variety of environmental rating tools, of which acoustics features in the *Indoor Environment Quality* section. A number of points may be awarded for satisfying the acoustic requirements, noting that a total of 45, 60 and 75 points are required to achieve 4 star (Best Practice), 5 star (Australian Excellence) and 6 star (World Leadership) respectively. The acoustic aspects that are considered relate to noise levels from mechanical services and background sources (e.g. road traffic), acceptable reverberation times and appropriate separation of spaces.

The fact that the Green Star system acknowledges acoustics as an important sustainability issue is encouraged by the AAAC. However, the Green Star does not cover all aspects of office building acoustics.

2.3 The AAAC Guideline Objectives

The objectives of the AAAC are:

- To provide guidance for the design process so that all important acoustical attributes are properly addressed;
- To encourage consistency between different developments; and
- To encourage the apparent quality of a development to relate to the underlying acoustical quality of the structure.

The intent of this document is to quantify and communicate the opinions of AAAC members on the design of commercial office buildings. It considers the major issues, including:

- The intrusion of external noise;
- Noise generated by building services;
- Noise transfer between separate tenancies;
- Noise transfer within the same tenancy; and
- Temporal control of sound in meeting rooms.

The document is not intended to compete with Green Star or AS/NZ Standards (particularly AS/NZS 2107:2016 *Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors*) but to complement them.

The guidelines within this document are based on the current experience and opinions of AAAC members. The ratings will be reviewed periodically in order to reflect any changes of thought or tenant expectations. Since the document may change, it is recommended that an intending user check with an AAAC member or www.aaac.org.au.

3.0 DESIGN ASPECTS

The aspects considered in this guide are discussed below.

3.1 External Noise Intrusion

This component of noise is most commonly caused by transportation systems, such as road, rail and air traffic. In some instances, plant noise from adjoining industry, commerce or even an adjoining residential building can also be problematic. In most cases the transmission path will be via airborne noise. In some circumstances, regenerated noise due to vibration may also be an issue. This may be caused by road or rail transport (including tunnels) or sometimes from within the building itself (e.g. mechanical plant).

Intrusive noise can generally be classified as either continuous or intermittent. Continuous noise, even though it might vary from time to time, is measured using a procedure to determine its equivalence over a representative time period. The continuous measurement is normally expressed as L_{Aeq} whereas intermittent noise is often measured as the arithmetic average of the maximum sound level readings expressed as $L_{ASmax,avg}$.

For the $L_{ASmax,avg}$ parameter, it is recommended a minimum of 5 measurements of the maximum type event (i.e. aircraft flyovers, train passes) be measured.

3.2 Speech Privacy

Speech privacy associated with meeting rooms and private offices is dependent on four key factors.

- Sound separation between speaker and listener (i.e. between two offices).
- Ambient noise levels in the room of the listener (generally taken as mechanical services noise level).
- Sound pressure levels of both unamplified and amplified speech in the space.
- The dynamic structure of the speech.

As the sound insulating performance of constructions between adjacent offices is increased, so the level of speech transmitted from the source room to the receiver room is decreased, making it harder for speech to be understood over the various noise-based factors that can mask speech. Similarly, as ambient noise levels increase in the receiving space, the noise masks the speech and the ability for a listener to understand speech is reduced.

Historically, the Articulation Index (AI) has been used to assess speech privacy. However, AI has a fundamental limitation in that under conditions of high privacy, it approaches a value of zero asymptotically. As such, AI values do not differentiate well among cases of high privacy and cannot be used to describe very high privacy.

3.2.1 Speech Privacy Class

A more sophisticated approach based on the likelihood of specific occurrences of intelligible or audible speech occurring was developed by Bradley and Gover[1]. The method, known as Speech Privacy Class (SPC) associates a specific class to a privacy rating and a description of the likely aural experience of the receiver. Table 1 lists SPC ratings with the associated categories and aural privacy risks.

Although the method is based on the speech-to-noise ratio, is derived from long term analysis of the speech levels (160 – 5000Hz).

The Speech Privacy Class = $L_{D(avg)} + L_{n(avg)}$
where:

- LD(avg) is the arithmetic average of the difference between the level within the room and the level at a point 250 mm from the outside of the room, taken over the frequency range of speech.
- Ln(avg) is the arithmetic average of the noise level at a point 250 mm from the outside of the room, taken over the frequency range of speech.

The speech privacy of a closed room will increase as both $L_{D(avg)}$ and $L_{n(avg)}$ increase.

[1] *A new system of speech privacy criteria in terms of Speech Privacy Class (SPC) values.* JS Bradley and BN Gover. Proceedings of 20th International Congress on Acoustics, ICA August 2010

Table 1 – Speech Privacy Class ratings

Category	Speech Privacy Class	Description of Aural Experience and Risk
No speech privacy	<70	Speech clearly audible and intelligible
Minimal speech privacy	>70	Speech clearly audible and frequently* intelligible
Standard speech privacy	>75	Speech occasionally^ intelligible, and frequently* audible
Standard speech security	>80	Rarely^ intelligible, and occasionally+ audible
High speech security	>85	Essentially not~ intelligible, and rarely audible
Very high speech security	>90	Unintelligible and essentially not audible

* *Frequently*: about 1 per 2-minute period.
\+ *Occasionally*: about 1 per 15-minute period.
^ *Rarely*: about 4 per 8-hour period.
~ *Essentially not:* about 1 per 16-hour period

3.2.2 Demands of Amplified Speech

In a meeting or conference situation, participants within the room usually speak at normal or raised voices. At 1 m from a talker, the level of a normal voice is approximately 60 dBA, and a raised voice approximately 66 dBA. However, when speech is amplified, listeners generally prefer the speech to be approximately at 65 to 70 dBA, even when normal vocal effort is used by the talker. Speech from remote parties is therefore likely to be louder in rooms than the actual speech of participants, and this will necessitate a higher SPC rating. An increase of 3 dB is recommended.

Given the ever-increasing use of remote conferencing within meetings, this higher level of amplified speech imposes a need for greater sound isolation, if activities in adjoining spaces are not to be disturbed. In addition, as the sound power level of amplified speech of the remote party will be higher in larger rooms, the required acoustic isolation is higher in these meeting rooms than in smaller rooms.

3.2.3 Open Plan Areas

Open plan spaces are said to encourage teamwork and communication between staff, provide flexibility for a change in office layouts and are cost effective. They do, however, result in compromised acoustics, as a workstation with partitions that are not full height can never provide the acoustic privacy of a private office.

In these areas, the sound absorption performance of the ceiling areas becomes particularly critical in determining sound isolation.

3.3 Internal Noise Intrusion

Internal building services include a range of plant and equipment; all of which have the potential to generate noise within an office. These include air-conditioning and ventilation systems, lifts, hydraulic waste, water supply systems, emergency generators etc. These noises can be continuous as in the case of air-conditioning plant, or intermittent, such as flushing toilets or passing lifts. They can intrude an office via a combination of airborne and structure-borne transmission paths.

Whilst providing a comfortably low background noise level is desirable, a noise level that is too low can present privacy issues as speech sounds are no longer being masked by the background noise. A suitable balance between a comfortable background noise level and speech must therefore be sought.

3.4 Other Activities within the Building

A wide range of different noises can be generated within an office building depending on a particular tenancy's business type. Similarly, many office buildings also comprise other uses, such as residential, retail, cafes and restaurants, gymnasiums etc, and hence the noise from these to the offices should also be given consideration.

3.5 Sound Insulation

The conventional expression for describing sound insulation through a building element, such as a wall, is the Weighted Sound Reduction Index (R_w). This is a single number value in decibels given to an individual element or path through a construction, providing guidance on its sound insulation performance across the spectrum of audible frequencies.

Different building elements may have different R_w values, and a single R_w value may be used to represent the overall 'composite' value. Consider for example a brick wall (R_w 45 dB) with a lightweight door inset (R_w 20 dB) and a gap underneath (R_w ~0 dB). The R_w value representing the overall wall, door and gap will depend on the relative size of each component and real examples typically range from 10 dB to 30 dB.

Note that it is very similar to the previously used STC (Sound Transmission Class) value that some readers may be more familiar with. The only difference being a shift in frequency range and a slight change in calculation where R_w is determined from the transmission loss at each 1/3rd octave band centre frequency between 100 Hz and 3.15 kHz; STC was assessed between 125 Hz and 4 kHz. The two ratings are normally within 1 or 2 dB of each other.

R_w cannot be reliably measured in the field, and some Australian consultants use this as a loophole to mitigate or dilute builders' contractual responsibilities. Refer to Appendix ZZ of AS ISO 140.

D_w is more stable and robust measure of partition performance as a contractual tool, particularly in the commercial building environment. It is better to specify a minimum D_w or D_{nTw} performance than an R_w rating less a debatable margin for site variance. Notes on assessing R_w values post-construction are provided in Appendix A.

3.6 Temporal Behaviour of Sound

To provide high acoustic comfort and effortless intelligibility, rooms must have suitable reverberation times and appropriately control the propagation over time of sound throughout the room at all the frequencies in speech. In technical terms, the total temporal response of the room must be considered.

Providing good temporal behaviour of the sound in the room at all frequencies is a critical component in successful tele-conferencing with remote parties, especially if there are accent differences between talkers and listeners.

Although reverberation time is an important component of the temporal response, there are other equally important components. To address the temporal behaviour of sound in each space, the following items must be addressed:

- control of reverberation times at all frequencies contained in speech;
- control of sound that travels back and forth successively between parallel surfaces, such as walls;
- the spaces should be free of distracting sound effects, such as focussing and shrillness; and
- acoustic reflections from walls and ceiling that contain all the frequencies in speech, rather than only some of those frequencies.

3.6.1 Reverberation Time

Reverberation time is parameter that describes one the fundamental aspects of the temporal behaviour of sound within a space.

Reverberation Time or T_{60}, is measured in seconds is an indication of how quickly sound decays (by 60 dB) within a space. The higher the T_{60}, the more reverberant or acoustically 'live' the space is, whereas a low T_{60} indicates a less reverberant or acoustically 'dead' space.

Although reverberation provides a richness to speech, excessive reverberation actually degrades the clarity of speech, due to the decaying sounds in the space masking the newer speech utterances. Reverberation can be thought of as noise that is self-induced by speech, and therefore there is an associated signal to noise ratio. The primary effect of reverberation on speech occurs in the initial part of the sound decay; i.e. first 10 to 15 dB of decay. The time for the sound to decay by 10 dB (and extrapolated out to 60 dB) is called the Early Decay Time (EDT).

3.6.2 Uniformity of Sound Decay

When reverberation times are calculated, it is commonly thought that the decay of sound is evenly distributed throughout a space; however, this is a common misconception. The decay of sound only occurs evenly in a space when the acoustic absorption is uniformly distributed over all surfaces in the space. Many meeting rooms do not have such uniform distribution, and the sound decay rates are different in the length, width and height dimensions of the space. These differences are most manifest in the EDTs and can be responsible for causing strong colourations to speech in specific frequency ranges.

The Fitzroy equation is a useful tool to assess the reverberation time in a space, as it considers the reverberation times in each of the three dimensions. Experience has shown that when the absorption is not evenly distributed in the three dimensions, the Fitzroy equation can predict excessively high RTs. Therefore, its principal benefit is to indicate to the designer when the absorption is not sufficiently distributed over the three dimensions.

3.6.3 Sound Absorption

The sound absorption coefficient parameter describes a material's ability to absorb sound, whereby a value of 1 is totally absorptive and 0 is totally reflective. An absorber may have a value of 0.6 at a particular frequency, which it can be thought of as absorbing 60% of the sound power that strikes it and reflecting 40% of the power.

The Noise Reduction Coefficient (NRC) value is the average of the mid-frequency sound absorption coefficients (250, 500, 1000 and 2000 Hz) rounded to the nearest 5%. Although the simplicity of the single NRC number is attractive, the averaging process used to form the NRC can hide deficiencies that can lead to strong colourations in speech sound within a space. For example, a material with a NRC of 0.7 is regarded as a good absorber, and could be obtained if the material's absorption coefficients at 1 kHz and 2 kHz are 1, 500 Hz is 0.7 and 250 Hz is 0.1. If this material was used as a primary absorber in a meeting room, the strong lack of sound absorption at 250 Hz will cause speech in the room to sound dull, and strongly coloured with a boomy, unpleasant effect. It would be much more effective to use a material with a lower NRC that had approximately equal sound absorption coefficients over the 250 Hz to 2 kHz range.

It is noted that as speech covers the frequency range of 80 Hz to 12 kHz, the sound absorption coefficients of materials should be also considered for that frequency range.

3.6.4 Situations to Avoid if Possible

Parallel Hard Walls

If two parallel and opposing glazed or untreated plasterboard walls are present in meeting rooms, there is a strong risk of flutter echo occurring between the two walls. Flutter echo is a sequence of successive reflections of sound between the two surfaces and can be audible as series of rapid bursts of sound or an unnatural tonal quality to the sound. This is a temporal problem which can lead to poor acoustic comfort.

Flutter echo can be ameliorated by applying sound absorption panels to untreated plasterboard walls or breaking up the reflective surfaces with full height joinery or furniture; however, this potentially conflicts with the visual appeal of the glazed partitions.

Focussing Effects

Reflections of sound can be concentrated together or focussed by concave surfaces and junctions between walls or between walls and the ceiling.

The right-angle junctions between i) walls and ii) walls and ceiling, can cause a direct echo of an utterance due to the effect often called a cue-ball reflection. This reflection is analogous to a cue-ball shot in billiards which misses the pocket and is returned in the opposite direction to which it was shot. Where possible, cue-ball reflections should be prevented by scattering or absorption.

4.0 CRITERIA

4.1 External Noise Intrusion

The most common source of external noise intrusion is from road traffic. The requirements for measuring road traffic noise are provided in Australian Standard 2702:1984 *Acoustics – Methods for the Measurement of Road Traffic Noise* with recommended façade construction requirements determined in Australian Standard 3671:1989 *Acoustics – Road Traffic Noise Intrusion – Building Siting and Construction*. The latter specifies that the acceptable internal noise levels to be obtained from Australian Standard 2107:2016 *Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors*. This Standard provides guidance on acceptable noise levels within offices and recommended reverberation times – refer to Table 3 below.

Road traffic noise is typically assessed as a L_{Aeq} value. It is recommended that in most circumstances, a 1-hour measurement period be used, coinciding with the highest noise level whilst offices are occupied. Noise from rail traffic is also common with measurement procedures provided in Australian Standard 2377:2002 *Acoustics – Methods for the Measurement of Rail Bound Vehicle Noise*. For rail noise, the $L_{ASmax,avg}$ is typically used and it is recommended that a minimum of 5 train pass-bys be recorded.

No Australian Standard exists that specifies acceptable maximum noise levels from trains. Therefore, the AAAC recommends a value 10 dB higher than the maximum recommended design sound level listed in Table 2 be used. Table 2 summarises the recommended $L_{Aeq,t}$ internal noise levels based on the upper limit of the range listed in AS 2107:2016.

Note: For additional spaces not listed below, see AS 2107:2016.

Table 2 – Internal design levels and reverberation times

Type of Occupancy/Activity	Recommended Design Sound Level, L_{Aeq} dB		Recommended Reverberation Time (T_{60}), secs
	Satisfactory	Maximum	
Board and Conference Rooms	30	40	0.6 to 0.8
Cafeterias	45	50	See Note 1
Call Centres	40	45	0.1 to 0.4
Corridors and Lobbies	45	50	0.4 to 0.6
Design Offices	40	45	0.4 to 0.6
Drafting Offices	40	50	0.4 to 0.6
General Office Areas	40	45	0.4 to 0.6
Private Offices	35	40	0.4 to 0.8
Public Spaces	40	50	0.5 to 1.0
Reception Areas	40	45	See Note 1
Rest Rooms and Tea Rooms	40	45	0.4 to 0.6
Toilets	50	55	-
Undercover Car Parks	55	65	-

Note 1: Reverberation time should be minimised as far as practicable.

Australian Standard 2021:2015 *Acoustics – Aircraft Noise Intrusion – Building Siting and Construction* provides advice in relation to noise from aircraft and the criteria within this Standard are considered to also be relevant for helicopters – refer to Table 3. It is noted that for accuracy, the design should be done a 1/3rd octave basis, and not the simple A weighted method described in that Standard.

Again, it is the $L_{ASmax,avg}$ parameter that is used for assessment and it is recommended a minimum of 5 aircraft flyovers be quantified, including take-off and landing where relevant and to capture the worst-case aircraft type.

Table 3 – Internal design levels for aircraft (From AS 2021:2015)

Type of Occupancy/Activity	Recommended Design Sound Level, $L_{Amax,avg}$ dB
Private Offices, Conference Rooms	55
Drafting, Open Plan Offices	65
Showroom	75

Other external noise may be present from adjoining industry, commercial or residential buildings or even from external plant associated with the building of concern. In the cases where the noise is of a continuous nature (e.g. from mechanical services), the criteria of Table 1 from AS 2107:2000 shall be used.

The measurement procedure would be similar for that of road traffic, although a smaller time period may be more applicable.

4.2 Internal Noise Intrusion

Typically, the noise source of interest will be mechanical services. The applicable criteria are those provided in Table 1 from AS 2107:2000. The equipment shall be operating in its normal design condition sufficient to achieve the required ventilation and the measurement shall be over a minimum of 1-minute.

For hydraulic services, the noise will most likely be intermittent and, as such, it is recommended that the $L_{ASmax,avg}$ again be used with a minimum of 5 samples in critical spaces. Acceptable criteria would be 5 dB higher than the maximum recommended design sound level of Table 1. If the noise is considered to be more of a continuous source, then the design levels of Table 1, measured as a L_{Aeq}, shall be used.

For lift noise, the $L_{ASmax,avg}$ parameter is also applicable and shall capture 5 lift pass-bys, both in the up and down directions of travel. Acceptable criteria would be 5 dB higher than the maximum recommended design sound level of Table 1.

Emergency generators would only operate for significant periods during power failure, however, such equipment must also be tested. Although testing may be for a short duration, it may still cause annoyance in critical areas. Acceptable criteria would be 5 dB higher than the maximum recommended design sound level of Table 1, with the L_{Aeq} being the relevant parameter measured over 1-minute. Other emergency plant would also fall into this category, such as smoke pressurisation fans.

4.3 GBCA

The Green Building Council of Australia (GBCA) provides a Green Star rating system. For commercial buildings, as outlined below, up to three points can be awarded for acoustics:

> *One point is awarded where in the nominated area, ambient sound levels are no more than 5dB(A) above the 'satisfactory' sound levels provided in table 1 of AS/NZ 2107:2000;*
>
> *One point is awarded where the reverberation time in the nominated area is below the maximum stated 'Recommended Reverberation Time' provided in table 1 of AS/NZ 2107:2000; and*
>
> *One point is awarded where the noise transmission between enclosed spaces has been addressed by the installation of partitions that achieve a weighted sound reduction index (Rw) of at least 45 OR noise transmission between enclosed spaces has been addressed by the installation of partitions that comply with $D_w + LA_{eq}T > 75$.*

Note: The rating tools are revised from time to time and when undertaking a Green Star assessment, the consultant should confirm that the above are still the applicable rating point for Acoustics.

4.4 Noise Isolation

The required acoustic separation of spaces depends upon the level of noise within one room and the tolerance of that noise in the adjoining room.

For instance, a plant room adjacent to a private room may have a high noise level and low tolerance and as such the recommended wall performance may be D_w 55 dB. However, the same plant room may also be adjacent to a storeroom, which has a high tolerance for noise and an D_w 45 dB wall may be appropriate.

Performance values in this guideline are based on overall D_w values being the constructed acoustic separation achieved in the field, rather than individual R_w values which is generally for design. It is important that these two terms are not confused.

The conventional expression for describing sound insulation through a building element, such as a wall, is the Weighted Sound Reduction Index (R_w). This is a single number value in decibels given to an individual element or path through a construction, providing guidance on its sound insulation performance across the spectrum of audible frequencies.

Different building elements may have different R_w values, so for simplicity, final performance is recommended to be defined in terms of Weighted Level Difference (D_w) values, which represent the overall 'composite' value and unlike R_w values can be easily measured in-situ following construction.

AAAC members should be consulted to ensure that the appropriate R_w ratings are specified to ensure that the recommended D_w ratings are achieved.

Table 4 below provides guidance on acceptable D_w values depending on a room's noise level and its tolerance. Table 5 below provides a guide as to the source level expected in a particular room and that same room's tolerance to noise.

Table 4 – Sound ratings

Noise Tolerance in Receiving Room	Weighted Sound Reduction Index (D_w) dB for Source Room Activity Noise			
	Low	**Average**	**High**	**Very High**
High	30	35	40	45
Medium	35	40	45	50
Low	40	45	50	55
Very Low	45	50	55	60

Table 5 – Guidance on activity level and tolerance

Type of Occupancy/Activity	Source Activity Level	Noise Tolerance
Board and Conference Rooms	High	Very Low
Cafeterias	Very High	High
Call Centres	Average-High	Low-Medium
Computer (Server) Rooms	High	Medium-High
Corridors and Lobbies	Average	High
Design Offices	Average	Low
Drafting Offices	Average	Low
General Office Areas	Average	Medium
Private Offices	Low	Low
Public Spaces	Average	High
Reception Areas	Average	Medium
Rest Rooms and Tea Rooms	High	High
Toilets	Average	High
Undercover Car Parks	Very High	High

In some circumstances, the use of the spaces on either side of a common wall may not be known and therefore criteria have been provided in terms of acoustic quality – refer to Table 6. As such, the higher the quality of the development, the higher the acoustic performance shall be. If the uses are known, Table 5 can be used as described above.

Table 6 – Performance requirements between separate tenancies

Weighted Sound Reduction Index (D_w) dB				
Poor	**Average**	**Good**	**Very Good**	**Excellent**
35	40	45	50	55

The recommended minimum between tenancies is therefore a 'Low' tolerance and an 'Average' noise level (e.g. D_w 45 dB).

Within the same tenancy, there is likely to be more acceptance of the audibility of noise and therefore the performance requirements can be shifted. Where the use of the spaces is yet to be defined, Table 7 can be used to reflect the quality of the building, however, in most circumstances, Table 3 can be used.

Table 7 – Performance requirements within the same tenancy

Weighted Sound Reduction Index (D_w) dB				
Poor	**Average**	**Good**	**Very Good**	**Excellent**
30	35	40	45	50

To achieve reasonable acoustic separation, it is preferable for walls to extend full height and this would be considered mandatory for separate tenancies. Where this does not occur, achieving the design goals may not be possible.

For office areas where walls do not extend full height, the ceiling tiles selected will also become critical. The performance of ceiling tiles is typically documented as a Ceiling Attenuation Class (CAC) value. Typical tiles would be expected to achieve a CAC of around 30 dB.

For an office that has R_w 40 dB wall construction but only CAC 30 ceiling tiles, the separation between these two spaces would be limited to 30 dB, as the majority of sound transmission will be the ceiling and via the cavity above the wall. In this scenario, significant benefits can be obtained by installing additional barriers in the ceiling space between the top of the partition wall and soffit.

There may be special circumstances where the required ratings would not align with the above. Such an example is security ratings in some Federal Government Departments and these would need to be assessed on a case-by-case basis.

Note: For Tables 4, 6 and 7 a differential of 5 dB has been used for the difference between R_w and D_w.

4.5 Flanking Paths

Flanking paths are paths in which noise will travel around the perimeter of a partition, thereby reducing the effective acoustic performance of that partition. For instance, an internal office is often constructed from a stud wall in combination with window and a door. Most glass manufacturers can provide the D_w ratings of their glass, however, care must also be taken in the selection of the frame as this can downgrade the performance.

Similarly, a door will generally be limited in its performance by the gaps around the perimeter and possibly a door grille. The gap around the perimeter can be sealed with acoustic seals and may achieve a D_w 30 dB (assuming no door grille). It is particularly difficult to obtain higher D_w values for doors. With regard to door grilles, which are typically used as a return air path, these would not be permissible where a reasonable sound rating is required. A door with a grille would likely achieve a maximum performance of D_w 15dB.

Other areas to consider would be the intersection of the internal wall to the external wall/window, as well as penetrations for electrical and mechanical services.

4.6 Vibration

Items such as mechanical plant, passing trains or even footfall on lightweight flooring, can cause vibration. Australian Standard 2670.2:1990 – *Evaluation of Human Exposure to Whole Body Vibration Part 2* provides a series of curves that provide acceptable levels for varying frequencies.

For continuous vibration, such as from mechanical plant, it is recommended that Curve 2 not be exceeded. For intermittent vibration, such as from passing trains, it is recommended that Curve 4 not be exceeded.

4.7 Temporal Behaviour

Table 1 from AS 2107:2000 provides guidance on acceptable reverberation times. It is generally insufficient to just assume that carpet will achieve the desired result. Often, high performance ceiling tiles will also be necessary and in additional treatments to walls to achieve satisfactory reverberation times, particularly when three dimensions are considered.

Care should also be taken in the location of high noise level areas in relation to workstations. Such areas would be plant rooms, tearooms and photocopying areas.

4.8 Environmental Noise

Noise from the development transmitted to neighbouring buildings will need to comply with the regulatory requirements in each jurisdiction. This may require examination of noise from externally-mounted mechanical services, emergency generators or other items of plant. For those developments that also contain restaurants and the like, noise from these would also need to be assessed, although this may be the responsibility of the individual tenant rather than the building developer.

4.9 On Site Testing

Acoustic deficiencies that can arise in commercial buildings are often not obvious in the finished product during a visual inspection. It will be substantially more expensive to rectify any deficiencies after staff have moved in.

It is strongly recommended that the tender documentation, forming part of the building contract, requires that physical testing is undertaken of at least the following acoustic design parameters:

- Sound levels measured in accordance with AS/NZS 2107:2016 at all representative locations of interest;
- Reverberation times measured in accordance with AS 2460:2002 or ISO 3382-1:2009, 3382-2:2008 & 3382-3:2012 of training rooms, board rooms and other areas of presentation or assembly, such as breakout areas or large kitchens;
- Sound insulation of a number of representative samples of each acoustically rated construction.

APPENDIX A NOTES ON R_W & D_W VALUES

The Weighted Sound Reduction (R_w) value is traditionally used as a design value, and it can be measured in a laboratory under controlled conditions using the procedures documented in AS 1191 or the International Standard ISO 140 series, and rated using AS/NZS ISO 717.1.

However, it is not a recommended site commissioning value for an installed building element because the construction is not as controlled as a registered laboratory, and there is inherent risk of 'flanking' noise paths around the element which can and do compromise the result. The International Standard ISO 140.4 acknowledges that results in the field are different to those under laboratory conditions through use of the apparent weighted sound reduction index (R'_w).

It is not possible using current commercially available technology to physically measure R_w values for each individual building element (to the exclusion of other flanking paths and adjacent constructions). Indeed, without comprehensive investigation, the level by which a result is compromised by flanking is often left to opinion, making it difficult to resolve within a building contract.

For this reason, the Australian adaptation of this Standard (AS ISO 140.4-2006) removes the term altogether and instead recommends use of the Weighted Level Difference (D_w) and its variants Weighted Normalised Level Difference ($D_{n,w}$) and Weighted Standardised Level Difference ($D_{nT,w}$). D_w, $D_{n,w}$ and $D_{nT,w}$ values are each suited to slightly different applications, but are all based on the concept of the measured difference in sound level (in the past termed Noise Reduction) between two spaces.

The relationship between R_w and D_w values varies according to site-specific factors, such as room geometry and finishes. Competent acoustical consultants are able to advise and document the necessary design Sound Reduction (R) values and construction methods to meet each overall Level Difference (D) value to be provided. Generally, for assessment of typical interior fitouts, the in-situ performance is judged acceptable where the measured D_w test result is at least the design R_w value less 5 dB. In summary, it is recommended that:

- Weighted Sound Reduction (R_w) values are used for design and procurement purposes of individual building elements; and

- Weighted Level Difference (D_w, $D_{n,w}$ and $D_{nT,w}$) values are used for in-situ verification of construction performance because they provide measure of the 'as-experienced' condition, including the level of degradation from any unwanted flanking paths which can arise from poor design and/or construction.

APPENDIX B NOTES ON FIELD MEASUREMENTS & COMMISSIONING

Compliance should be demonstrated to a 95% confidence interval.

Assessment locations should be representative of the utilisation of the space (e.g. patient head position within wards).

In certain situations, an Authority may request compliance measurements to demonstrate that the noise and vibration levels are in compliance with the criteria upon completion of the development.

Monitoring should be conducted over a sufficient period of time to obtain noise levels from a representative number of events. Any noise levels measured during adverse weather conditions or affected by extraneous noise sources should be discounted.

Compliance vibration monitoring should also be conducted over a sufficient number of events (e.g. train pass-bys), and should be measured at the worst-case location within the nearest sensitive receiver buildings that represents a typical occupancy location.

For more information and other published AAAC Guidelines, go to www.aaac.org.au

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