Association of Australian Acoustical Consultants Guideline for Commercial Building Acoustics

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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 encompass aspects of the acoustical quality of commercial buildings. This document produces guidelines to cover and 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, childcare centres, and advice on the selection of an acoustical consultant.

2.0 OBJECTIVES

2.1 Building Code of Australia

With regard to offices, the *Building Code of Australia* (*BCA*) defines this 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 in a Class 5 building that must be satisfied. The result of this may be that developers/builders construct buildings with poor acoustic qualities. Note 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 vice versa or between two commercial parts.

2.2 Green Star

The Green Building Council Australia (GBCA) has developed an environmental star rating scheme, of which acoustics features in the *Indoor Environment Quality* section. Either 1 or 2 points may be awarded for satisfying the acoustic requirements, noting that a total of 45, 60 and 75 are required to achieve 4 star (Best Practice), 5 star (Australian Excellence) and 6 star (World Leadership) respectively. The acoustic aspects considered relate to noise levels from mechanical services and background sources (e.g. road traffic) with the *Green Star – Office Interiors v1.1* also referring to acceptable reverberation times.

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 Objectives

The objectives of the AAAC are:

- To provide guidance in 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.

The document is not intended to compete with Green Star or AS/NZ Standards (particularly AS/NZS 2107:2000 *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 the AAAC website www.aaac.org.au.

The aspects considered in this guide are discussed below.

2.4 External Noise Intrusion

This 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 a problem. In most cases the transmission path will be via airborne noise. In some circumstances, regenerated noise as a result of 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 $L_{Amax,avg}$.

2.5 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 by a combination of airborne and structure borne transmission paths.

Whilst providing a comfortably low background noise level is desirable, too low a level can present privacy issues, as sounds are no longer being masked by background noise so that a balance must be achieved.

2.6 Commercial Activities

Although the focus of this document is offices, 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.

2.7 Insulation

The expression for effective sound insulation between two adjacent spaces is the weighted sound index (R_w). This is a single number value given to a material providing guidance on its sound insulation performance and measured in a laboratory under controlled conditions. It is determined by using the procedures documented in the International Standard ISO 140.3. 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 one-third-octave band centre frequency between 100 Hz and 3.15 kHz, STC was between 125 Hz and 4 kHz. The two ratings are normally within 1 or 2 dB of each other.

2.8 Reverberation Time

Room acoustics within a space are commonly described by the Reverberation Time, T_{60}, which is measured in seconds and 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.

2.9 Articulation Index

Articulation Index (AI) describes the clarity of speech in a space, which is dependent upon the volume of the speech, the background noise at the listener's ear, the materials and dimensions within a room. As AI approaches 1, speech intelligibility is close to perfect and as AI approaches 0, speech privacy is close to perfect. So different spaces require different values, for instance the design goal for an open plan office may be < 0.30 whereas a lecture theatre or meeting room may require a design goal of > 0.60.

3.0 CRITERIA

3.1 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 2107-2000 *Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors.* This Standard provides guidance on acceptable noise levels within offices and also recommended reverberation times – refer to Table 1 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 $L_{Amax,avg}$ 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 and it is therefore recommended that a value 10 dB higher than the maximum recommended design sound level of Table 1 be used.

Australian Standard 2021-2000 *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 2. Again, it is the $L_{Amax,avg}$ 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.

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 AS2107:2000 shall be used. The measurement procedure will be similar to that of road traffic, although a smaller time period may be more applicable.

Table 1 – 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	-

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

Table 2 – Internal Design Levels for Aircraft

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

3.2 Internal Noise Intrusion

Typically the noise source of interest in this case will be from mechanical services. The applicable criteria are those provided in Table 1 from AS2107:2000. 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 $L_{Amax,avg}$ 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 $L_{Amax,avg}$ 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.

The Green Star Office Interiors V1.1 states the following:

> *One point is awarded where it is demonstrated that ambient internal noise levels are 40-45 dB L_{Aeq} in general offices and 35-40 dB L_{Aeq} in private offices, with the tenancy ready for occupancy but unoccupied as per AS/NZS 2107-2000;*
>
> *AND*
>
> *Where a reverberation time (T60) of 0.4-0.6 seconds for general offices and a T60 of 0.6-0.8 seconds for private offices is achieved.*

The Green Star Office Design v3 & Office As Built v3 states the following:

Up to two points are awarded where 95% of the project's NLA does not exceed the 'Satisfactory' ambient internal noise levels in accordance with AS/NZS 2107:2000, as follows:

> *Building Services Design*
>
> *One point is awarded where, within the entire base building general office space, noise from the building services does not exceed 40 dB L_{Aeq}.*
>
> *Overall Building*
>
> *One point is awarded where within the base building office space, the sound level does not exceed 40 dB L_{Aeq} (assuming open plan offices).*

3.3 Acoustic Separation

Acoustic Separation can be divided into two distinct areas: Speech Privacy and Noise Insulation. Separation between spaces is dependent upon the level of noise within one room and the tolerance of noise in the adjoining room. Determining the appropriate source and tolerance level is therefore critical.

3.4 Speech Privacy

Australian Standard AS 2822-1985 *Acoustics – Methods of predicting speech privacy and speech intelligibility* provides a methodology for determining isolation for speech privacy for private offices and meeting rooms. The variables include required speech privacy, a correction factor to account for source room acoustics, vocal effort in the source room (or amplified audio), and ambient noise in the receiving space. Speech privacy is the inverse of the Articulation Index (AI), so a room with high privacy coincides with a low AI. It is discussed more fully below.

3.5 Noise Isolation

As stated, separation between spaces is dependent upon the level of noise within one room and the tolerance of 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 R_w 60. However, the same plant room may also be adjacent to a store room which has a high tolerance for noise and an R_w 50 wall may be appropriate.

Table 3 below provides guidance on acceptable R_w values depending on a room's noise level and its tolerance. Table 4 below provides a guide as to the source level expected in a particular room and that same room's tolerance to noise.

Table 3 – Sound Ratings R_w

Noise Tolerance in Receiving Room	Source Room Activity Noise			
	Low	Average	High	Very High
High	R_w 35	R_w 40	R_w 45	R_w 50
Medium	R_w 40	R_w 45	R_w 50	R_w 55
Low	R_w 45	R_w 50	R_w 55	R_w 60
Very Low	R_w 50	R_w 55	R_w 60	R_w 65

Table 4 – 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 either side of a common wall may not be known and therefore criteria have been provided in terms of acoustic quality – refer to Table 5. As such, the higher the quality of the development, the higher the acoustic performance shall be. If the uses are known, Table 3 can be used as described above.

Table 5 – Performance Requirements between Separate Tenancies

Weighted Sound Reduction Index (R_w) dB				
Poor	**Average**	**Good**	**Very Good**	**Excellent**
40	45	50	55	60

The recommended minimum between tenancies is therefore a 'Low' tolerance and an 'Average' noise level (e.g. R_w 50).

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 6 can be used to reflect the quality of the building, however in most circumstances Table 3 can be used.

Table 6 – Performance Requirements within the Same Tenancy

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

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 are typically documented as a Ceiling Attenuation Class (CAC) value. Typical tiles would be expected to achieve a CAC of around 30 dB. So for an office that has R_w 40 wall construction but only CAC 30 ceiling tiles, the separation between these two spaces would be limited to 30 dB as noise between the two will be dominated by that over the wall, through the ceiling. 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.

In some projects, 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.

3.6 Flanking Paths

Flanking paths are ways in which noise will travel around the perimeter of a partition and reduce the performance of that partition. For instance, for an internal office, these will often be constructed of a stud wall combined with glass and a door. Most glass manufacturer's can provide the R_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 an R_w 30 value (assuming no door grille). It becomes particularly difficult to obtain higher R_w values for doors. With regards to door grilles, which are typically used as the 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 R_w 20 performance.

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.

3.7 On Site Testing

There is often the case where once a building has been constructed, testing will be required to determine if the partition is providing the required rating. Such testing is to be carried out in accordance with ISO140-4 *Acoustics – Measurement of Sound Insulation in Buildings and of Building Elements: Part 4 – Field Measurements of Airborne Sound Insulation between Rooms*.

It is inevitable that flanking paths will downgrade the overall performance of a partition and as such, a field measurement within 5 dB of the required R_w rating would be considered acceptable.

3.8 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.

3.9 Internal Quality

Reverberation time is often used as a measure of the acoustic quality of an office area. Table 1 from AS2107:2000 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 some cases additional treatments to walls to achieve the recommended levels.

The parameter used to describe a material's ability to absorb sound is the sound absorption coefficient (□). An average ceiling tile may have a value of 0.6 at a particular frequency, which it can be thought of as absorbing 60% of the sound that hits it and reflecting 40% of it or where a value of 1 is totally absorptive and 0 is totally reflective. The Noise Reduction Coefficient (NRC) value is the average of the mid-frequency sound absorption coefficients (250, 500, 1000 and 2000Hz) rounded to the nearest 5%. Some areas within offices may require careful consideration such as atriums, rooms used for video conferencing etc.

The ceiling tile performance becomes particularly critical in open plan areas. These 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.

Where open plan offices are proposed, hotel offices or quiet rooms should be provided, typically at around 1 quiet room per 15 workstations. These offices allow persons to relocate from their workstation intermittently, should the need arise for low background noise levels for concentration or acoustic isolation for private phone calls or conversations.

The Articulation Index (AI) can be used to predict both speech intelligibility and speech privacy as shown below in Table 7.

Table 7 – AI Ratings

Speech Transmission	Very Poor	Poor	Fair	Good	Excellent
Speech Privacy	Excellent	Good	Fair	Poor	Very Poor
AI Value	0.00 – 0.30	0.30 – 0.45	0.45 – 0.60	0.60 – 0.75	0.75 – 1.00

For areas such as boardrooms, teaching spaces or the like, the AI should be > 0.60 so that speech communication is 'good'.

In open plan offices however, the design goal should be an AI < 0.30 aiming for 0.20, so that speech privacy is excellent. Note that to achieve such a level in an open plan office requires all design aspects to be near optimum. Factors that are considered in the AI are:

- Speech level – the higher the speech level, the higher the AI. This can be minimised by utilising meeting rooms where lengthy conversations between staff are necessary and utilising the quiet rooms where privacy/concentration is necessary;
- Background noise level – the higher the background noise level, the lower the AI due to the background noise masking the speech. This is why electronic sound masking systems are sometimes installed in open plan offices;
- Ceiling Absorption – The higher the Noise Reduction Coefficient (NRC) the lower the AI. For open plan, the optimum NRC is around 0.90;
- Screen Height – The higher the screen, the lower the AI. For open plan, the optimum height is around 1.7 metres;
- Screen Absorption – The higher the NRC, the lower the AI.
- Workstation Size – The larger the workstation size, the lower the AI since the distance between workstations becomes greater. Acoustically this is also beneficial as there will be less people per square metre;
- Floor absorption – Only plays a minor role in the AI but again, the higher the NRC, the lower the AI;
- Screen Transmission Loss - Only plays a minor role in the AI but the higher the STC/R_w the lower the AI;
- Ceiling Height - Only plays a minor role in the AI but the higher the ceiling, the lower the AI.

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.

3.10 Environmental Noise

Noise from the development 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 the like. 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.

Other Published AAAC Guidelines:

AAAC Guideline for Apartment and Townhouse Acoustic Rating

AAAC Guideline for Child Care Centre Acoustic Assessment

AAAC Guideline for Educational Facilities Acoustics

AAAC Guideline for Report Writing

AAAC Guideline for Selection of an Acoustical Consultant

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For more information, please visit www.aaac.org.au

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