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Association of Australasian Acoustical Consultants
Guideline for Educational Facilities

Version 2.0

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Association of Australasian Acoustical Consultants

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1.0 INTRODUCTION

1.1 Overview

Members of the Association of Australasian Acoustical Consultants (AAAC) have been concerned for some time that there are no Australia-wide regulations or standards that encompass all aspects of the acoustical qualities of educational and training facilities, including primary and secondary schools. The Association considers that learning spaces in educational facilities require substantially more favourable conditions than are currently provided in many Australian schools.

First released in 2009, the AAAC Guidelines for Educational Facilities has been updated to address the emerging pedagogical changes to education, as well as changes to the Building Code of Australia which impact education environments.

This guideline presents the views of the AAAC and its members in regard to the design of educational facilities. The objectives of the guideline are as follows:

- To provide a consistent Australia-wide approach for the design of appropriate quality standards for acoustics in educational facilities;
- To ensure that sound levels within occupied spaces of educational facilities are such that appropriate discussion, communication, education and comprehension can occur;
- To prevent students suffering from adverse acoustic conditions within their educational environment.

The focus of this document is Australian schools and whilst it may be of some use in New Zealand, the (NZ) Ministry of Education Design of Quality Learning Spaces Acoustics (DQLS v2.0, September 2016) sets out requirements and recommendations for schools in NZ. The DQLS would generally take precedence over the guidance in this document for schools in New Zealand.

1.2 The Need for Good Acoustics

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. Overseas studies have shown that students are at a disadvantage where appropriate acoustic environments are not present. The importance of this situation has resulted in the development of acoustic criteria for educational facilities in the UK, the USA, New Zealand and Sweden.

As the acoustic environment is now regarded internationally as one of the prime considerations in the design of new classroom facilities, the objective of this Guideline is to provide recommendations that will improve the acoustic environment in educational facilities with particular emphasis on classroom acoustics.

1.3 Scope

This guideline deals with the following major acoustic issues:

- the intrusion of external noise;
- noise generated by building services;
- noise transferred between individual spaces including impact noise;
- control of reverberation times to enhance speech intelligibility.

Outdoor teaching and learning activities are often likely to occur at educational facilities. This issue is outside the scope of this document; however, some guidelines will be given to provide assistance.

Advice on hearing augmentation systems is beyond the scope of this document. Any hearing augmentation system provided must consider the specific use and teaching practices at the school, along with appropriate education and professional development for the end users.

1.4 Sources

Preparation of his Guideline has drawn on overseas experience and standards, together with the current experience and opinions of AAAC members. Consideration has been given to the following documents:

- United States of America ANSI 12.60[3].
- New Zealand Ministry of Education DQLS Acoustics [4].
- United Kingdom Department for Education Building Bulletin 93 (BB93)[5].
- Joint Australia/New Zealand Standard AS/NZS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors*[6].
- Building Code of Australia and National Construction Code[7].

This Guideline will be reviewed periodically in order to reflect changing community expectations, educational objectives and new requirements. It is recommended that users of this Guideline check with an AAAC member to confirm that the most recent release of this guide is being used. Current copies of the guideline are available from the AAAC website (www.aaac.org.au); details of the members to contact are provided on the website.

1.5 Changes to the 21st Century Learning Environment

Traditionally, schools and classrooms have been based upon a cellular design with long hallways leading to a series of uniformly-shaped rooms. Most classrooms comprised four walls, a door, and furnished with a desk and chair per thirty students.

This type of classroom design is driven by the older pedagogical model in which children remain predominantly seated whilst the teacher at the front talks and reinforces information via visual and written representations, with an expectation that students will produce a written interpretation as evidence of learning. The design of the traditional style classroom reflects a generally outdated design brief; a teacher-directed and teacher-centric learning space with 'kids-on-grids'.

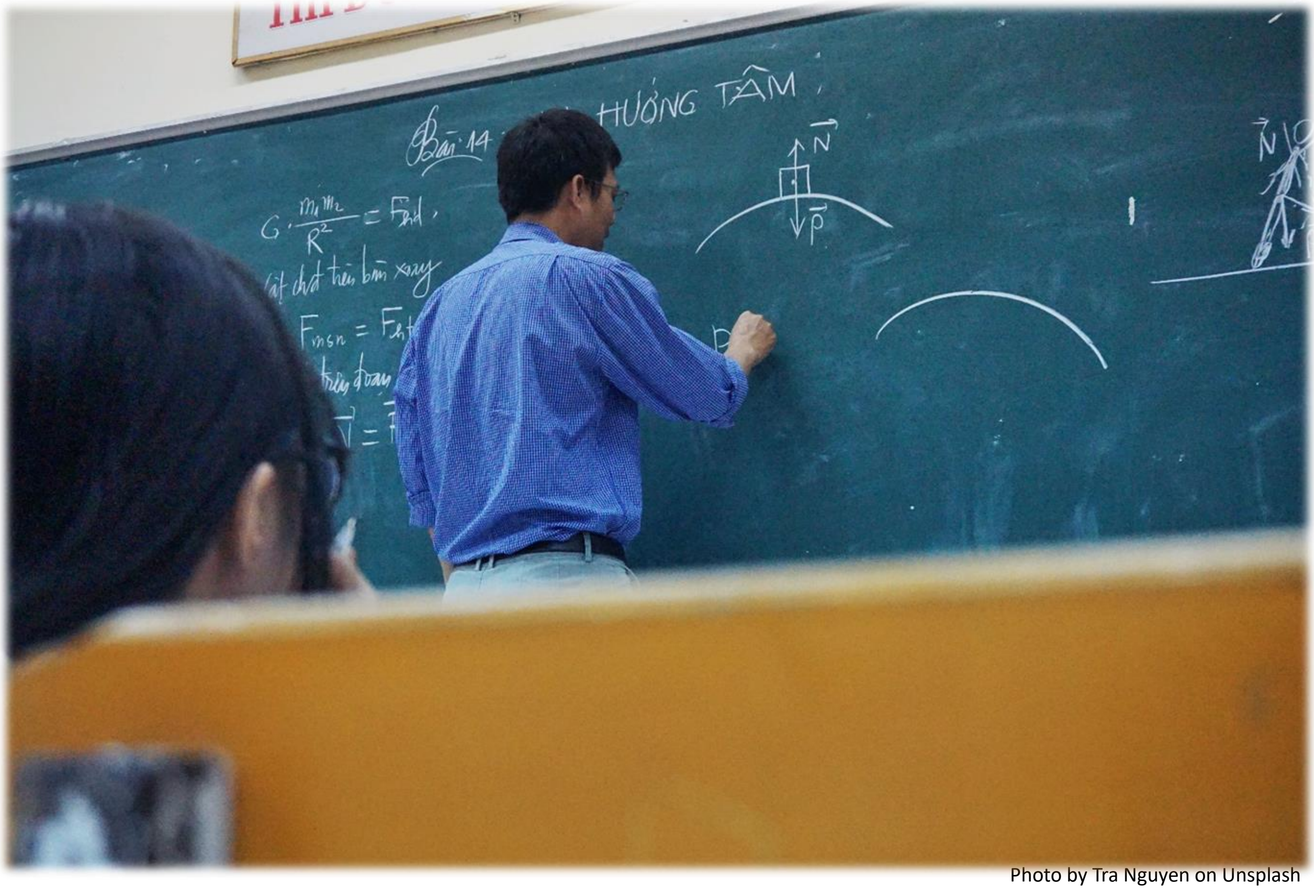
The introduction of new technologies in schools has resulted in a paradigm shift in the way educational spaces are created and used. Today's learning environments are flexible speaking and listening spaces where collaboration, group work, complex problem solving, digital information gathering, and publishing occur. Changes in technology and legislation have highlighted the need for equitable access to learning environments. As these endeavours involve both concentration and speech communication, good acoustic design is essential.

Today, educators are required to teach students using technology in preparation for new and emerging work skills. This has led to learning environments being remodelled into open-plan collaborative spaces to accommodate technology and 21st Century skill development. The new pedagogical model is supported by technology-rich environments with mobile and fixed devices and focuses on student-centred personalised learning. This model requires very different teaching practices, as opposed to the previous generation of teacher-centric methods.

1.6 Codes

This guideline is not intended to compete with established statutory or advisory codes. It is intended to be complementary to, but more comprehensive than, local authority building requirements and individual and state guidelines, where they exist.

Whilst the Building Code of Australia (BCA) details minimum standards for buildings, it does not provide specific recommendations for educational facilities. The development of acoustical standards in education facilities has been left to each individual state, and in past years the (former) Public or Works Departments have produced their own guidelines and criteria. However, with the current reorganisation of government departments, many of these guidelines have fallen into neglect or disuse, using references to acoustic terminology which has been superseded by updated Australian Standards.



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1.7 Changes to Legislation

The Building Code of Australia (BCA) (now known as the National Construction Code (NCC)) is a federally legislated building code that explicitly outlines the minimum standard required to meet building compliance across all states and territories.

The current BCA stipulates all Class 9b buildings must provide hearing augmentation systems, also known as hearing access solutions, which is an inbuilt amplification system. Examples of Class 9b buildings include public spaces such as kindergartens, childcare centres, schools, TAFE colleges, universities. The BCA outlines minimum requirements for hearing augmentation systems that must be met to comply with the code. In interpreting the BCA, the Building Commission of Victoria advised that an inbuilt amplification system in a learning space included the following items:

- A non-portable public-address system (i.e. a fixed or inbuilt public-address system) in a classroom or indoor collaborative open plan learning space.
- A fixed ceiling or wall-mounted data projector or LCD screen or interactive whiteboard within a classroom or indoor collaborative open plan learning space, with a sound source and speakers that amplify sound to the space.

When a definition such as 'inbuilt amplification' is not clarified, the Building Certifier determines a definition, interpretation and subsequent compliance to the BCA. The Australian Institute of Building Surveyors (AIBS) currently has no guidelines for members regarding definition of inbuilt amplification in class 9b buildings or advisory notes on minimum acoustic standards that allow hearing augmentation to be achieved.

2.0 ACOUSTICAL NEEDS FOR LEARNING

Much of children's learning at school is through extended periods of hearing and listening. For example, school children spend an average of four to five hours per day in classrooms.

Acoustically-poor teaching spaces can make hearing and understanding of speech very difficult for children and therefore these spaces are inappropriate for learning situations. Due to their neurological immaturity and inexperience in predicting a message from its context, children are inefficient listeners. Children require optimal acoustic conditions if they are to hear and understand speech[1]. Children who continually miss key words, phrases and concepts in class become significantly disadvantaged.

As a result of the profound changes in teaching style, the traditional lecture style of teaching has been replaced such that, (depending on the class level), about 40% of time in class is spent in group work and for primary students about 30% in mat work. More than 70% of teachers in class act dynamically, walking around and talking to students from numerous positions within the room. This has changed the way information is delivered to, and received by, students.

A New Zealand survey found that 71% of teachers have reported that noise generated within a classroom is a problem. In the UK, where minimum acoustic design standards were introduced in 2003, studies have shown that regulations led to a marked improvement in acoustic conditions in schools.

New classrooms and school facilities must be designed to accommodate these changes in teaching and the need to provide the best possible conditions for learning.

The results of social surveys[2] have shown a clear correlation between noise levels and performance in schools. The need for an appropriate set of consistent Australia-wide acoustical criteria has arisen. Students, in particular young children, require good listening conditions. This is known as having a high signal-to-noise ratio. The teacher's voice needs to be loud and clear above the background noise environment which may include traffic, other school related activities; e.g., on sports fields and in corridors, or even air-conditioning noise.

When the reverberation in a classroom is excessive, it can be regarded as noise; noise that relates to the speech itself; "self-speech noise".

The clear-communication requirement is particularly important for those students with hearing impairments or those from non-English speaking backgrounds; two groups who can make up 25-30% of students in primary school classes[3].

It is important to consider not only activities that occur inside classrooms and teaching spaces, but also activities which occur in adjacent spaces and outside during the day. The ideal classroom should be acoustically "friendly" to all students, not just when the student has normal hearing and is sitting quietly and close to the teacher. The room should also be friendly for hearing-impaired students or students with learning difficulties even when there are high-activity noise levels arising from group discussions.

Acoustical considerations must not restrict teaching styles, but should complement the wide variety of teaching methods used by teachers as well as the ability and age of the students. Further, teachers in class should be able to use a teaching voice, free from vocal stress to minimise long term strain or damage.

In essence, the speech communication process should be comfortable for both teachers and students. Although this would seem obvious, it can only be achieved when proper consideration of the issues has been given to the acoustical issues involved. These issues are discussed in detail below.

3.0 ACOUSTICAL OBJECTIVES

3.1 Acoustical Design Conditions

The AAAC recommends that the following qualities should be achieved in teaching spaces and associated areas in educational facilities:

- Appropriate background noise levels;
- Reverberation times appropriate to the room use and function;
- Good signal-to-noise ratios (S/N);
- Good speech intelligibility (including open plan areas);
- Minimum disturbance or distraction from nearby or adjacent activities, or external noise sources.

For good acoustical design, it is important to achieve a balance of performance across all these design attributes.

3.2 Acoustic Design of Educational Facilities

The design of educational facilities should consider the following aspects that determine the acoustic environment in learning spaces. A more detailed description of acoustic terms is set out in the Appendix.

3.2.1 Internal Ambient Noise Levels

Internal ambient noise levels are generally determined by two different noise sources: noise from building services and external noise:

- Building services noise involves noise from ventilation and air-conditioning services and any other equipment associated with the operation of the facility such as plumbing services;
- External noise intrusion is most commonly caused by transportation systems such as road, rail and air traffic. It may also include noise from nearby industry, commerce and residential buildings. Other school activities such as sport may generate noise intrusion.

Achieving suitable internal noise levels in educational facilities will require the following actions:

- Assessment of noise levels from building services equipment, with control of noise from this equipment being considered at the design stage.
- An assessment of noise levels from external noise sources should be conducted with:
    - the building envelope being designed to provide a defined limit for the ingress of external noise
    - internal walls/ceilings constructed to allow separate school room functions and activities.

Suitable noise levels are measured using the descriptors in AS/NZS 2107-2016.

3.2.2 Floor Impact Isolation

Floor impact noise arises when walking, chair-scraping and other activities on a hard floor surface in one room is transmitting into other rooms that are adjacent and beneath. Control of floor impact noise is required for noise-sensitive areas such as classrooms.

3.2.3 Internal Sound Insulation

In general terms, it is the sound level difference or transmission loss between the two rooms or from outside to inside, which is also adjusted to simulate a typical furnished room. The measure is set out in the Appendix.

3.2.4 Reverberation Time

One of the major descriptors of acoustics within a space is the Reverberation Time, T_{60}, which is measured in seconds and indicates how quickly sound decays within a space.

The higher the T_{60}, the more reverberant or acoustically "live" is the space. A low T_{60} indicates an acoustically "dead" space. A higher T_{60} generally promotes higher noise levels during activity which results in worsening conditions for communication.

3.2.5 Temporal Response

The reverberation time of a classroom is only one of the parameters that affect the overall temporal response of the room. For a classroom to properly support the transmission of speech from a talker to listener, all the components that determine the overall temporal response must be considered in the design; viz. direct field, early-arriving reflections, strong reflections and echoes and reverberation.

3.2.6 Speech Transmission Index

Speech Transmission Index (STI) describes the clarity of speech in a space, and takes account of the space's acoustic characteristics, the background noise level and other noisy activities which may be occurring.

Measurement of STI is relatively complicated process, requiring a combination of measurements and mathematical adjustments to provide a valid result. A special analyser and a good working knowledge of the metric is also required.

In typical classrooms and learning spaces, with less than 400m^3 volume, good speech clarity can be achieved by designing to the reverberation time and noise criteria given, using ceiling and/or wall treatments to achieve required levels of acoustic absorption and diffusion. The use of STI as an objective in these situations can lead to unnecessary work and confusion.

However, for more complicated spaces such as large open-plan teaching areas, auditoria, atria and gymnasiums good speech clarity is not so readily achieved and an STI assessment and compliance measurements is likely to be needed.

4.0 ACOUSTICAL DESIGN CRITERIA

It is important that all acoustical factors be considered holistically in the design and construction of educational facilities. Accordingly, the acoustical performance criteria for background noise (which includes both external noise intrusion and sound insulation) and reverberation time, must both be satisfied to achieve a suitable learning environment in the classroom.

For example, research[1] suggests that reverberation times of 0.4s or less in small and mid-sized classrooms, and 0.6s or less in larger classrooms, will not degrade speech intelligibility excessively, as long as speech levels greater than background noise (signal-to-noise ratio) of 10-15 dB or better are maintained. For a typical talker in a classroom, the requirement for good speech intelligibility will be satisfied when the background noise is sufficiently low, that is around 35 dBA.

Recommended acoustic design criteria for main learning and auxiliary spaces in educational facilities are provided in tables below. Table 1 identifies the particular table holding each type of criterion.

Table 1 – Allocation of acoustic performance to tables

Parameter	Table No	Information provided
Background noise level	Table 2	Design range for L_{Aeq}
Reverberation times	Table 2	Upper limits for T_{60}
Categories of room types for impact and airborne sound insulation	Table 3	Categories for types of source and receiving rooms. Categories relate to the sensitivity to noise in the receiving space and the airborne and impact noise activity generated in the adjacent, source space
Impact noise insulation criteria for each category of source and receiver	Table 4	Upper limits for $L'_{nT,w}$
Sound insulation criteria for each category of source and receiver	Table 5	Lower limits for $D'_{nT,w}$
Speech Transmission Index	Table 6	Lower limits

Table 2 – Recommended internal noise levels and reverberation times

Room	Design level range for internal ambient noise level, L_{Aeq} (dB)	Reverberation time Maximum time, (s) T_{60}
Atria (for circulation, not teaching)	40-50	≤1.5
Art / craft studios	40-45	≤0.8
Assembly halls up to 250 seats	30-40	0.6-0.8
Assembly halls over 250 seats	30-35	*
Audio-visual areas	35-45	0.6-0.8
Cafeterias	45-50	≤1.0
Computer rooms – Teaching	40-45	0.4-0.6
Computer rooms – Laboratories	45-50	0.4-0.6
Conference room	35-40	0.6-0.7
Corridors and lobbies	≤50	≤0.8
Dance Studios	35-40	*
Drama Studios	35-40	*
Engineering workshops – Teaching	≤45	**
Engineering workshops – Non-Teaching	≤60	**
Gymnasia / indoor sports	≤45	*
Weight training / fitness room	≤50	≤1.0
Interview / counselling rooms	40-45	0.3-0.6
Laboratories – Teaching	35-45	0.5-0.8
Laboratories – Working	40-50	0.5-0.8
Lecture rooms – up to 50 seats	30-35	*

Room	Design level range for internal ambient noise level, L_{Aeq} (dB)	Reverberation time Maximum time, (s) T_{60}
Lecture theatres – without speech reinforcement and more than 50 seats	30-35	*
Lecture theatres – with speech reinforcement	30-40	*
Libraries – General areas	40-50	<0.6
Libraries – Reading areas	40-45	<0.6
Manual arts workshops	≤45	*
Medical rooms (First aid)	40-45	0.5-0.7
Music practice rooms	35-45	*
Music studios	30-35	*
Nursery / pre-school – Play rooms	35-40	≤0.6
Nursery / pre-school – Quiet rooms	≤35	≤0.6
Office areas	40-45	0.4-0.7
Professional and administrative offices	35-40	0.6-0.8
Teaching spaces – Open plan	≤40	≤0.6
Teaching spaces – Primary schools	35-40	≤0.6
Teaching spaces – Secondary schools	35-40	≤0.6
Teaching spaces – Hearing impaired	≤30	≤0.4
Staff common rooms	40-45	≤0.6
Staff studies / collegiate	40-45	0.4-0.6
Toile t/ change / showers	≤55	-
Swimming pools	50-60	≤2.0

Notes: * The appropriate reverberation time shall be influenced by the use, volume and geometry of the space. Guidance from an acoustical engineer should be sought.
** Reverberation should be minimised for noise control

Note that rain noise is excluded. For rain noise, the noise level at a rainfall of 25mm/hr should not exceed the upper extent of the noise level range in Table A by more than 5 dBA.

4.1 Room Temporal Response

It should be noted that achieving the required reverberation time on paper will not guarantee that the room acoustics will be conducive for speech intelligibility. The entire temporal response of the space should be considered. The following components are a guide:

Direct field: No obstructions or low height barriers should be present.

Early-arriving reflections: These should be supported wherever possible. Noting that a human voice has little directionality in the vertical plane, the inner sections of ceilings can often provide helpful reinforcement of speech by directing the upward sound from the talker to listeners.

Echoes: Echoes are late-arriving reflections and should be prevented by diffusion or absorption. Rear walls are prime candidates for such treatment. Flutter-echoes between parallel walls should be prevented using diffusion or absorption.

Reverberation: The reverberation time should be constant with frequency. The three-dimensional nature of reverberation must also be considered in addition to the overall reverberation time. A room may have a suitable predicted reverberation time when computed with the Sabine or Eyring equations, and yet sound quite coloured (i.e. unnatural and unbalanced) due to an imbalance in the frequency spectrum, caused by excessive reverberation in one plane at specific frequencies; e.g. floor to ceiling, or wall to wall. The Fitzroy equation provides some insight into the 3D behaviour or the space. To minimise the strength of reverberant build-up in the horizontal plane, absorption should be located on at least two orthogonal walls in rectangular rooms.

In particular with classrooms, the sound absorption should be distributed over the walls and parts of the ceiling and as much acoustic diffusion introduced as possible using furniture, bookcases etc.

Table 3 – Airborne and impact sound insulation requirements

Room	Sound insulation		
	Source room impact generation	**Source room activity airborne noise generation**	**Receiving space noise tolerance**
Atria (for circulation, not teaching)	Medium	Average	High
Art / craft studios	Medium	Average	Medium
Assembly halls up to 250 seats	High	Very High	Low
Assembly halls over 250 seats	High	Very High	Low
Audio-visual areas	Low	High	Low
Cafeterias	High	Very High	High
Computer rooms – Teaching	Low	Average	Medium
Computer rooms – Laboratories	Low	Average	Medium
Conference room	Low	High	Very Low
Corridors and lobbies	Medium	Average	High
Drama Studios	Medium	High	Low
Dance Studios	High	Very High	Medium
Engineering workshops – Teaching	High	High	High
Engineering workshops – Non-teaching	High	High	High
Gymnasia / indoor sports	High	Very High	Medium
Weight training / fitness room	High	High	Medium
Interview / counselling rooms	Low	Low	Medium
Laboratories – Teaching	Low	Average	Medium
Laboratories – Working	Low	Average	Medium
Lecture rooms – up to 50 seats	Low	Average	Medium
Lecture theatres – without speech reinforcement and >50 seats	Low	Average	Low
Lecture theatres – with speech reinforcement	Low	High	Medium
Libraries – General areas	Medium	Average	Medium
Libraries – Reading areas	Low	Low	Low

Room	Sound insulation		
	Source room impact generation	**Source room activity airborne noise generation**	**Receiving space noise tolerance**
Manual arts workshops	Medium	Average	Medium
Medical rooms (First aid)	Low	Low	Medium
Music practice rooms	Low	Very high	Low
Music studios	Low	Very high	Very Low
Nursery school – Play rooms	Medium	Average	Medium
Nursery school - Quiet rooms	Low	Low	Low
Office areas	Low	Average	Medium
Professional and administrative offices	Low	Average	Medium
Teaching spaces – Open plan	Low	Average	Low
Teaching spaces – Primary schools	Low	Average	Low
Teaching spaces – Secondary schools	Low	Average	Low
Teaching spaces – Hearing impaired	Low	Average	Low
Staff common rooms	Low	Low	Medium
Staff studies / collegiate	Low	Low	Low
Toilet / change / showers	Medium	Average	High
Swimming pools	Medium	High	High
Plant rooms	Low	High	High

Table 4 – Impact isolation ratings for floor/ceiling between vertically separated spaces, L'_{nTw} dB

Min L_{nTw}		Impact generation in source room		
		Low	**Medium**	**High**
Noise tolerance in receiving room	**High**	70	65	60
	Medium	65	60	55
	Low	60	55	50*
	Very Low	55	50*	45*

Notes: * Where high impact generating activities are to be located above spaces with low noise tolerance, consideration should be given to the relocating of one of the spaces. Specialist advice should be sought where very high impact activities, such gymnasia, are to occur above a sensitive space.

Table 5 – Sound insulation ratings for interfaces without pass doors*, D_w dB

Min D_w		Activity noise in source room			
		Low	**Average**	**High**	**Very High**
Noise tolerance in receiving room	**High**	30	35	40	45
	Medium	35	40	45	50
	Low	40	45	50	55
	Very Low	45	50	55	60

Notes: * Where doors are proposed between spaces consideration must be given to the placement and performance requirements of the door since ratings for doors with no acoustic treatment are not likely to exceed D_w 20 dB while standard solid core doors with full perimeter acoustic seals could achieve a rating up to D_w 30 dB.

Table 6 – Speech Transmission Index ratings

Space	Lower limit STI*
Open plan teaching spaces	0.7
Auditoria	0.65
Gymnasia (sole use)	0.5
Multipurpose Hall	0.6

Notes: * Measurements of STI must include the effects of reverberation and echo and the equivalent total noise level due to activity and noise ingress measured as L_{eq} in octave frequency bands.

Example of use of impact and sound insulation categories

(see Appendix for detail of technical terms):

Consider a partition between a Dance Studio and a Conference Room. If we consider noise transmission from the Conference Room to the Dance Studio, it can be seen from Table 3 that Conference Rooms have High activity noise generation and Dance Studios have Medium noise tolerance. For this situation, Table 5 shows a partition rating of D_w 45 dB is required.

If we consider noise transmission in the other direction, from Dance Studio to Conference Room, Table 3 shows that Dance Studios have Very High activity noise generation and Conference Rooms have Very Low noise tolerance. From Table 5 a partition rating of D_w 60 dB is required for noise transmission in the reverse direction. The larger D_w value is selected as the criteria for the partition between the Conference Room and the Dance Studio. Accordingly, the partition should achieve a performance rating of D_w 60 dB.

Floor impact insulation ratings are also derived from Tables 3 & 4. For example, a Dance Studio (High impact generation) above a Conference Room (Very Low noise tolerance) should have an $L_{nT,w}$ 45 dB rating, meaning that impact noise generated in overhead or adjacent spaces should not exceed $L_{nT,w}$ 45 dB, when measured in accordance with appropriate standard.

If the Conference Room (Low impact generation) was above the Dance Studio (Medium noise tolerance) the floor/ceiling would require an $L_{nT,w}$ 65 dB rating.

5.0 REFERENCE DOCUMENTS

This document provides the details of criteria recommended by the Association of Australasian Acoustical Consultants (AAAC) covering three main areas namely; recommended noise levels, recommended reverberation times and sound insulation between areas.

The development of this guideline has drawn heavily on the Australian Standard AS 2107-2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors*. Whilst this standard recommends noise levels for certain spaces, it is not comprehensive and as a result, this guideline provides criteria for additional spaces commonly encountered in training and educational facilities.

Other areas of this document such as the recommended reverberation times and the floor impact and sound insulation requirements draw heavily from work conducted by BRANZ as well as from the DFES document BB93 which has been incorporated into Part E of the UK Building Regulations 2003.

6.0 ACOUSTIC TERMS USED

Suitable measured noise levels are set out in AS/NZS 2107:2016, being L_{Aeq} measured over a representative period.

Floor impact transmission may be described using the rating $L'_{n,Tw}$. This represents the measured sound level from a standardised tapping machine used generate noise into the room below. The lower the noise level the better the insulation against floor impact noise.

Transmission lost is the degree of airborne sound insulation between two adjacent spaces and may be quantified with the descriptor D_w. It is an international measure and is described as the weighted sound level difference.

Reverberation time of a room is, for a sound of a given frequency or frequency band, the time that would be required for the reverberantly decaying sound pressure level in the room to decrease by 60 decibels.

Speech transmission index (STI) is a measure for the transmission quality of speech with respect to intelligibility. A value of 0 indicates completely unintelligible speech while a value of 1 indicates perfectly intelligible speech.

Signal-to-noise ratio (SN) is the intelligibility of speech determined by comparing the loudness of the voice (signal) to the loudness of background sound (noise). The difference in decibels between the signal and the noise levels is known as the signal-to-noise ratio. As the signal-to-noise ratio increases, the signal becomes more intelligible.

7.0 BIBLIOGRAPHY

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5. Department for Education Building Bulletin 93 (v17 February 2015), Acoustic design of schools: performance standards
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7. National Construction Code Series Volume 1 Class 2 to Class 9 buildings D3.7 Hearing Augmentation (2016)

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, an R_w rating cannot be measured on site 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.

Additionally, 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) recommends the 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 of between 3 and 5 dB for permanent glazed, plasterboard or masonry walls and anything up to 10 dB for operable walls. 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.

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

Member Firms:

To contact a AAAC member, select a region from the link below:

http://www.aaac.org.au/act
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