Acoustic Services Design Standards

MQU Design Guidelines Review Performance Standards

MACQUARIE University

DOCUMENT HISTORY

Report revision	No. Of Pages	Date	Comments
V1.0	16	Aug 2015	For Review
V1.1	**16**	**Dec 2015**	**For Circulation**

CIRCULATION APPROVAL

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1. GLOSSARY OF TERMS

Unless the context otherwise requires, the following definitions apply:

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	Units of the A-weighted sound level.
D_W	Weighted Level Difference—the noise level difference or reduction between two enclosed spaces. It quantifies the acoustic separation between two spaces. It relates to the R_W rating of the separating building elements (such as walls and doors) and also includes all noise flanking paths (such as ceiling voids, joins and seals) and the acoustic absorption in the receiving space. The higher the D_W rating the better the acoustic separation.
$D_{nC,W}$ / CAC	Weighted Ceiling Noise Reduction Index / Ceiling Attenuation Class—these values represent the ability of a ceiling to prevent the transmission of sound. The $D_{nC,W}$ / CAC is a measure of sound reduction between rooms with a common ceiling plenum (or space). The higher the values the better the acoustic separation provided by the ceiling.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second.
L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
$L_{n,w}$	Weighted Normalised Impact Sound Pressure Level—A measure of the noise impact performance of a floor and ceiling. It is a laboratory tested result and is characterised by how much impact sound reaches the receiving room via the floor and ceiling construction from a standard tapping machine test. The lower the $L_{n,w}$ rating the better the impact isolation.
$L_{n,w} + C_I$	A measure of the noise impact performance of a floor and ceiling with a C_I spectrum adaptation to account for foot fall noise.
$L_{nT,w}$	Weighted Standardised Impact Sound Pressure Level— A measure of the impact noise performance of a floor and ceiling between two enclosed spaces. It is an on-site measured level that relates to the laboratory $L_{n,w}$ value. The lower the $L_{nT,w}$ rating the better the impact isolation.
NR	Noise Rating—a single number evaluation of noise level based on the Noise Rating curve The NR level is normally around 5 dB below the 'A' weighted noise level.
NRC	Noise Reduction Coefficient—A single number that represents the absorption of a material and it is the average of the sound absorption coefficients at 250, 500, 1000 & 2000 Hz for that material. NRC 1.0 represents the highest level of absorption.
R_W	Weighted Sound Reduction Index—A laboratory measured value of the acoustic separation provided by a single building element (such as a partition). The higher the R_W the better the noise isolation provided by a building element.
$R_w + C_{tr}$	A measure of the sound insulation performance of a building element with a C_{tr} spectrum adaptation term placing greater emphasis on the low frequency performance.
Reverberation Time (RT)	Of a room, for a sound of a given frequency or frequency band, the time that would be required for the reverberant decaying sound pressure level in the room to decrease by 60 decibels.

2. INTRODUCTION

This document outlines the acoustic performance standards for the Macquarie University Design Guidelines.

The design of rooms and buildings at Macquarie University facilities should address the following acoustic parameters:

- Internal noise levels
- Noise emission (to the environment)
- Room to room noise control
- Room acoustics (principally reverberation time)
- Vibration control for sensitive equipment

3. INTERNAL NOISE LEVELS

3.1. DESCRIPTION/SCOPE

a. Steady-state noise intrusion from external sources:

   i. Road (and in some cases, rail) traffic noise
   ii. Industry
   iii. General environmental noise including external school activity

b. Intermittent noise intrusion from external sources:

   i. Individual rail pass-bys
   ii. Aircraft flyovers
   iii. Rain noise

c. Steady-state noise contribution of internal sources:

   i. Mechanical ventilation
   ii. Air conditioning

d. Intermittent noise intrusion from internal sources:

   i. Hydraulic services

3.2. BENEFITS OF CONTROL

Control of steady-state internal noise levels is most important in rooms and spaces used for spoken word teaching. It is imperative that noise levels are maintained at a low level in order for a teacher's voice to be clearly audible and intelligible at all locations in the teaching space; for the teacher to not have to use an unacceptably high vocal effort; and to limit the 'Lombard effect' occurring, (being the involuntary use of greater vocal effort to project ones voice over high ambient noise levels, which can result in ever-increasing noise levels within the space whilst in use).

The overall steady-state energy average (L_{Aeq}) noise level in the room or space (being the combination of contributions from all steady-state noise sources) is the primary design and assessment parameter.

Given that steady-state noise levels must be maintained at a low level, it is also necessary to control intermittent noise sources so that they are not unacceptably intrusive.

3.3. INTERNAL NOISE LEVEL ASSESSMENT

3.3.1. Road Noise

For occupied staff spaces, general teaching spaces and laboratories, road traffic noise intrusion shall be assessed generally in accordance with State Environmental Planning Policy (Infrastructure) 2007 - regulation 102.

An assessment shall be undertaken where directed for any site impacted by traffic noise, but it is required for all sites impacted by noise from roads with greater than 20,000 vehicles AADT. The internal noise levels presented in Table 1 shall be used in the assessment (taking into consideration the steady state noise contribution from all sources).

3.3.2. Rail Noise

For occupied staff spaces, general teaching spaces and laboratories, rail noise intrusion shall be assessed generally in accordance with the requirements of State Environmental Planning Policy (Infrastructure) 2007 - regulation 87. The internal noise levels presented in Table 1 shall be used in the assessment (taking into consideration the steady state noise contribution from all sources).

3.3.3. Aircraft Noise

For occupied staff spaces, general teaching spaces and laboratories, aircraft noise intrusion shall be assessed where the school site lies within Australian Noise Exposure Forecast (ANEF) 25 (or higher) as shown on airport planning instruments. The procedures and noise levels in AS 2021 shall be adhered to in the assessment.

3.3.4. Industrial Noise

For occupied staff spaces, general teaching spaces and laboratories, industrial noise intrusion shall be assessed consistent with the requirements of the NSW Industrial Noise Policy.

3.3.5. Rain noise

Rain noise shall be assessed for occupied staff spaces, general teaching spaces and laboratories or as otherwise directed. Rain shall be assessed using the one-year annual recurrence, one-hour event for the region as reported by the Bureau of Meteorology. A recognised rain noise calculation procedure (such as Dubout, 1969 or Griffin, Ballagh, 2012) shall be used.

4. ROOM ACOUSTICS

4.1. DESCRIPTION/SCOPE

- Reverberation time
- Reverberant noise control
- Speech intelligibility (Speech Transmission Index, STI)
- Late acoustic reflections

The extent to room acoustics parameters will have to be considered and the extent of acoustic treatment required will depend upon:

- The use of the room or space and therefore an appropriate reverberation time for the use
- Whether or not noisy activities are expected in the room
- Whether or not speech intelligibility is fundamental to the use of the room, e.g.: general learning areas
- Whether the room or space is a specialist performance or recording or teaching space, or with large dimensions and where late acoustic reflections are considered a risk

4.2. REVERBERATION TIME

In the context of educational rooms and spaces, the principle room acoustic consideration is reverberation time. Reverberation time is defined as the time taken (in seconds) for sound to reduce by 60 dB in a room or space and is hence given the notation RT_{60}. Reverberation time is fundamental to describing the 'acoustical liveliness' of a room.

Reverberation time within a room or space is a function of the room volume and the acoustic absorption coefficients of room internal surface finishes. Where a room volume is defined (elsewhere in the guidelines), the area and absorption coefficient of room internal surface finishes can be selected to provide an appropriate reverberation time and therefore appropriate room acoustics for educational spaces.

For most educational spaces, the performance guideline reverberation time is the average of the predicted or measured octave band values at 500 Hz and 1000 Hz.

In acoustically critical environments it is desirable to define and design for the required reverberation time at all octave band centre frequencies between 63 Hz and 4000 Hz. This is a more onerous requirement and advice must be sought from an acoustic engineer for individual cases.

Controlling reverberation time provides three main benefits:

a. It serves to improve speech intelligibility, and
b. It controls the build up of reverberant noise (i.e. sound levels being sustained by reflecting off multiple surfaces with minimal energy loss)
c. Controlling reverberation time also serves to limit the 'Lombard effect', as described in 'Internal Noise levels'.

Speech intelligibility is an important acoustic consideration in teaching rooms and spaces; control of reverberant noise is important in teaching spaces and other spaces where a build up of noise is undesirable.

5. NOISE EMISSION (TO THE ENVIRONMENT)

5.1. DESCRIPTION/SCOPE

- Noise emission from activity (e.g.: use of a room or space)
- Noise emission from a mechanical services noise source (such as air conditioning unit or fan)

The extent to which noise emission will have to be considered and the extent of acoustic treatment required will depend upon:

- Whether noisy activities take place in a room or space.
- Whether the room or space is naturally ventilated and therefore windows and/or doors are expected to be open whilst noisy activities are taking place.
- Room facade construction and orientation of 'acoustically weak' facades relative to noise-sensitive receivers.
- Distance to noise-sensitive receivers
- Whether mandatory noise emission criteria are required to be satisfied at nearby boundaries and land uses.

5.2. ASSESSMENT OF NOISE EMISSION

5.2.1. Stationary Noise Sources

Generally, noise emission to the environment from mechanical services noise sources (such as air conditioners) will be the subject of a development consent condition. In NSW the development consent condition will refer to the Industrial Noise Policy (INP) or Local Council requirement.

Where no condition regarding stationary noise sources exists for a development, noise emission from such sources should be designed, in-principle, to satisfy the requirements of the Industrial Noise Policy.

5.2.2. Activity noise

Noise associated with student or other similar activity is not a stationary noise source and is not subject to the INP requirements. Where a condition of consent exists for the control of activity related noise, an acoustic engineer shall assess the noise emission.

Generally, such noise emission shall be designed to satisfy an intrusive noise criterion. This would limit the energy average (L_{Aeq}) noise emission to within 5 dB(A) of the prevailing background noise level at the most potentially affected receiver location.

6. ROOM TO ROOM NOISE CONTROL

6.1. DESCRIPTION /SCOPE

a. Consider a room or space as a noise source and determine constructions (predominantly walls) required to control noise emission to an adjacent space
b. Consider a room or space as a noise receiver and determine constructions (predominantly walls) required to control noise intrusion from adjacent spaces.
c. Airborne noise and impact (footfall) noise

The extent to which room to room noise control will have to be considered and the required acoustic rating of constructions between adjacent rooms will depend upon:

a. Whether noisy activities take place in a room or space
b. Whether a room on an upper floor has a hard floor surface (when considering footfall/impact noise)
c. Whether a room is sensitive to noise intrusion
d. The ambient noise level in the receiver room
e. Whether the construction between adjacent rooms includes an operable wall, a door, a glazed section or other 'acoustically weak' construction.

Where a door, glazed element, or other acoustically 'weak' construction component is proposed between rooms, acoustic engineering advice shall be sought.

6.2. AIRBORNE NOISE

For the Macquarie University Design Guidelines, the weighted sound reduction index (notated R_w) is the airborne noise assessment design parameter. When a Post Occupancy Evaluation is conducted for room-to-room noise, the parameter is the Standardised weighted level difference index (notated D_{nTW}). The measured D_{nTW} must be within 5 points of the design $R_{W.}$

The required design value of construction between adjacent rooms can only be defined when the use of both rooms is known. Refer to **Error! Reference source not found.** and Table 3.

6.3. IMPACT (FOOTFALL) NOISE

Refer to the guideline standardised impact sound pressure levels L'_{nTw} values presented in **Error! Reference source not found.**. Design advice shall be sought from an acoustic engineer for multi-storey buildings with noise-sensitive spaces below hard-surfaced floor areas, or with circulation spaces above.

6.4. PRESCRIPTIVE CONSTRUCTIONS

The following elements have prescriptive acoustic performance or construction requirements:

- Partitions to corridors (where a door is present in the partition):
  - Generally: RW 40 or RW 36 if glazed.
  - Teaching spaces and other sensitive spaces: RW 45. Note that it is necessary to upgrade the entry doors (see below) to realise the additional privacy performance provided by the R_W 45 partition. The entry door will strongly influence the acoustic outcome where the door area is greater than 15% of the total partition.
  - Doors and partitions to corridors for Lecture theatres, Theatres and Large Seminar Rooms shall be designed with specialist acoustic advice and may benefit from an airlock (double door) arrangement or be located in an area with low traffic outside while the room is occupied.
- Operable walls:
  - Generally: R_W 45
  - Large volume teaching spaces R_w 50

(It is generally not feasible to realise tangible acoustic privacy or noise control improvements from operable walls rated higher than RW 50). Where higher performance is required, it may be appropriate to reconsider the need for an operable wall. In such cases, specialist acoustic advice shall be sought.

- Entry doors to occupied spaces generally with partition rating no higher than R_W 40: Solid core, minimum 35 mm thick with acoustic seals on all rebated closing faces and at the base to achieve R_W 30.
- Entry doors to more sensitive occupied spaces with partition rating no higher than R_W 45: Solid core, minimum 45 mm thick with acoustic seals on all rebated closing faces and at the base to achieve R_W 33
- Doors in partitions rated higher than R_W 45: seek specialist acoustic advice and consider reconfiguring the architectural arrangement of spaces such that the door is no longer required, or consider an airlock (double door) arrangement or de-rate the total partition acoustic performance.
- Glazed sections in walls and vision panels in or adjacent to doors: Minimum 10.38 mm laminated glass rated at R_W 36.
- Construction separating wastewater pipework from sensitive areas such as teaching spaces: R_W 45
- Construction separating wastewater pipework from highly sensitive areas such as performance spaces: R_W 50
- Where adjacent to an occupied space (and not serving that space), hydraulic supply pipework and wastewater pipework shall be separated from the adjacent occupied space. Construction between the adjacent spaces in this instance shall be discontinuous with a minimum 20 mm offset between two separate leaves of construction.

6.5. ACOUSTIC PERFORMANCE CRITERIA

Table 1 presents:

- Steady-state internal noise level criteria for individual spaces
- Mid-frequency reverberation time criteria for individual spaces

A range from 'low' to 'high' is provided for both noise levels and reverberation times, as it is in Australian/New Zealand Standard AS/NZS 2107:2000 Acoustics – recommended design sound levels and reverberation times for building interiors from which the criteria for the majority of spaces have been based.

A range permits a degree of flexibility to account for the particular activities undertaken in a room or a proportion of time that a room is used for a particular purpose. For example, a staff meeting room may provide a breakout space for staff at certain times, but be more often used as a meeting room. In this case, the meeting room would benefit from a lower design noise level and a value from the lower end of the range may be selected.

Table 1 - Acoustic performance criteria - noise level and reverberation time

Room	Internal Noise Level ($dB\ L_{Aeq\ 1\ hour}$)		Reverberation time, s RT60 (Av 500Hz and 1000Hz)	
	Low	High	Low	High
Staff Spaces				
Executive/Dean/VC	35	40	0.6	0.8
Academic Level	35	40	0.6	0.8
Professional Staff	35	40	0.6	0.8
Staff Meeting Room (Dept.)	35	45	0.4	0.6
Meeting Room	35	45	0.4	0.6
Copy/Print/Resource Room	45	50	Note 2	
Comms Room	Note 1		Note 2	
First Aid	40	45	0.6	0.8

Room	Internal Noise Level (dB $L_{Aeg\ 1\ hour}$)		Reverberation time, s RT60 (Av 500Hz and 1000Hz)	
	Low	High	Low	High
Toilets	45	55	-	
Cleaners Room	N/A		-	
Tea Point	40	45	-	-
Tea Room/Lunchroom	40	45	Note 2	
Seminar Room	35	40	0.4	0.6
General Teaching Spaces				
Tutorial Room	35	40	0.4	0.6
Large Tutorial Room 100	35	40	0.4	0.6
Theatrette	30	35	Note 3	
Theatre (no speech reinforcement)	30	35	Note 3	
Theatre (with speech reinforcement)	35	45	Note 3	
Stage	35	40	Note 3	
Lecture Room	30	35	Note 3	
Tutorial Student Counselling	40	45	0.3	0.6
Meeting /Interview Room	40	45	0.4	0.6
Laboratories				
Teaching Dry Lab	35	45	0.5	0.7
Dry Lab Preparation	40	50	0.6	0.8
Dry Lab Prep Store	45	55	-	
Science / Engineering Comms Room	Note 1		-	
Science / Engineering Robot Test	40	45	Note 2	
Science / Engineering CAD Room	40	45		<0.6
Damp Lab	35	45	0.5	0.7
Damp Lab Prep	40	50	0.6	0.8
Damp Lab Store	45	55	-	
Wet Lab	35	45	0.5	0.7
Wet Lab Prep	40	50	0.6	0.8
Wet Lab Store	45	55	-	
Chemical Store	45	55	-	
Shared Science Laboratory	35	45	0.5	0.7
Wet Lab Science	35	45	0.5	0.7
Preparation - Science	40	50	0.6	0.8
Apparatus Store	45	55	-	

Notes:

a) It is not appropriate to specify a steady state noise level for non-occupied rooms where the room may be inherently noisy due to the operation of mechanical plant or computer equipment located within the room. For each equipment room, it is recommended to undertake a noise-break-out assessment to adjacent occupied spaces and specify partitions, doors and other treatments to control noise break-out. It is recommended that all equipment rooms are lined to the maximum practical extent with acoustic absorption to reduce reverberant noise build up and break-out to adjacent occupied spaces.

b) Reverberation time should be minimised as far as practicable for noise control.

c) An appropriate mid-frequency reverberation time and only be determined once the volume of the space is known. The appropriate reverberation time can then be derived from Curve 1 'spaces for speech' of Appendix A Figure A1 in Australian/New Zealand Standard AS/NZS 2107:2000 Acoustics - recommended design sound levels and reverberation times for building interiors. The figure is reproduced in Figure 1 below

d) Where no value is provided for a space ('-'), the space itself is unlikely to benefit from specification of a design noise level or reverberation time. It is necessary to check that adjacent noise sensitive or occupied spaces are able to satisfy their respective criterion due to noise emission from the adjacent space. (see Note 1, above).

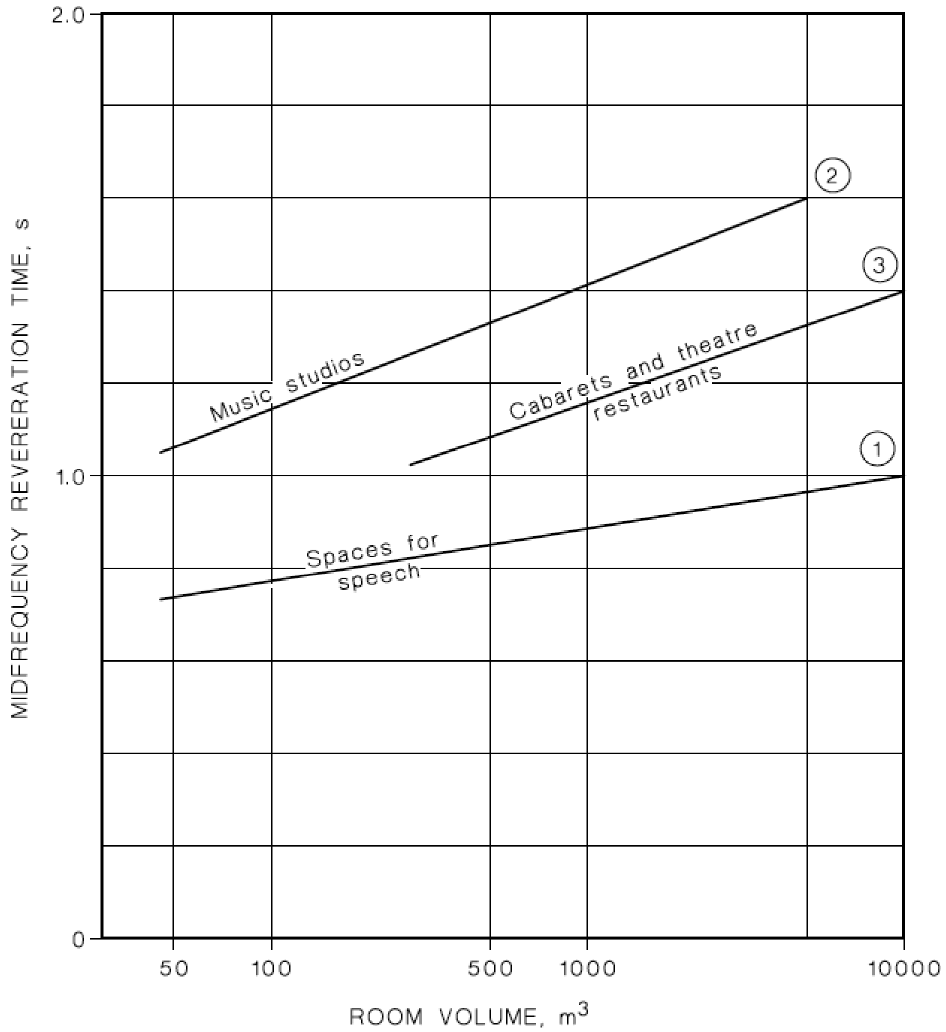

Figure 1 – Reproduction of Figure A1 from Appendix A of AS 2107

Error! Reference source not found. presents acoustic performance criteria for a range of spaces including:

- Source room activity noise and receiving room noise tolerance. The airborne acoustic performance of a partition between two spaces can be determined as follows:

- Determine the source room activity noise from each space (**Error! Reference source not found.**).
- Determine the receiving room tolerance for each space (**Error! Reference source not found.**).
- Read off the corresponding partition designating value (Weighted Sound Reduction Index, R_W) from Table 3.

- These ratings apply where no door or glazing is present in the wall. Where doors and glazing are present, or where a wall is not full height slab to slab the acoustic performance of the total partition will be strongly influenced by the door, glazed element or ceiling path, which for cost, constructability and feasibility reasons will provide a lower level of acoustic separation. Acoustic engineering advice shall be sought for these situations.
- Impact sound insulation rating for each space. This refers to the degree of impact sound insulation from the space or spaces above. A lower value corresponds to a lower level of impact noise (i.e. the room is more sensitive to impact noise). Where a very low value is shown (e.g.: 40) it is often more practical to ensure that no occupied space is located over the noise-sensitive space.

Table 2 - Acoustic performance criteria - source level, tolerance, impact sound rating

Room	***Source room activity noise***	***Receiving room noise tolerance***	***Impact sound insulation rating (L’nTw)***
Staff Spaces			
Executive/Dean/VC	Average	Low	55
Academic Level	Average	Medium	55
Professional Staff	Average	Medium	55
Staff Meeting Room (Dept.)	High	Medium	60
Meeting Room	Average (High if VC)[1]	Low	55
Copy/Print/Resource Room	High	High	65
Comms Room	-	-	-
First Aid	Average	Low	55
Toilets	High	High	-
Corridor/Lobby	Average	High	-
Cleaners Room	-	-	-
Tea Point	High	High	60
Tea Room /Lunchroom	High	High	60
Seminar Room	High	Low	50

General Teaching Spaces			
Tutorial Room	Average	Low	50
Large Tutorial Room 100	High	Low	50
Theatrette	High	Very Low	40
Theatre (350)	High	Very Low	40
Theatre (500+)	High	Very Low	40
Stage	High	Very Low	40
Lecture Room	Average	Low	50
Tutorial Student Counselling	Average	Low	55
Meeting /Interview Room	Average	Low	55
Laboratories			
Teaching Dry Lab	Average	Low	55
Dry Lab Preparation	Average	Medium	60
Dry Lab Prep Store	-	-	-
Science / Engineering Comms Room	-	-	-
Science / Engineering Robot Test	High	Medium	60
Science / Engineering CAD Room	Average	Low	55
Damp Laboratory	Average	Low	55
Damp Laboratory Preparation	Average	Medium	60
Damp Laboratory Store	-	-	-
Wet Laboratory	Average	Medium	55
Wet Laboratory Preparation	Average	Medium	60
Wet Laboratory Store	-	-	-
Chemical Store	-	-	-
Shared Science Laboratory	Average	Low	55
Wet Lab Science	Average	Low	55
Preparation - Science	Average	Medium	60
Apparatus Store	-	-	-

a) Video conferencing

Table 3 provides partition ratings in terms of Weighted Sound Reduction Index (R_W). Table 3 is to be used in conjunction with the source room activity levels and receiving room noise tolerances shown in **Error! Reference source not found.**.

Table 3 - Acoustic performance criteria – partition ratings Rw

		Activity noise in source room			
		Low	**Average**	**High**	**Very high**
Noise tolerance in receiving room	**High**	35	40	45	50
	Medium	40	45	50	55
	Low	45	50	55	60
	Very low	50	55	60	65

Where a space is considered acoustically critical (such as a large lecture theatre or other room provided with speech reinforcement over a public address system), speech intelligibility shall be assessed in terms of Speech Transmission Index.

Lecture theatres and tutorial rooms are to be designed to maximise the use of natural, or unamplified speech, so that reliance on amplified speech is minimised. To this end the rooms are to be designed with passive acoustics in mind and the use and location of absorptive materials, and angled walls be considered to reduce flutter echoes and other acoustic defects in the room. The use of an acoustic ray tracing software program is required in this instance to demonstrate the suitability of the design. The design criterion is presented in Table 4:

Table 4 - Acoustic performance criteria – speech transmission index

Room type	***Speech Transmission Index (STI)***	
	Minimum	**Preferred**
Teaching spaces Study spaces Lecture theatres	> 0.60	> 0.70

7. VIBRATION CONTROL FOR SENSITIVE EQUIPMENT

Where specialist scientific equipment, imaging equipment or other specialist items that are known to be vibration sensitive are proposed as part of a new building or refurbishment, it is necessary to specify vibration criteria for a room or building.

Until the equipment and its location are known, it is not appropriate to specify a criterion. This Section presents general information on a range of vibration criteria that may be considered for application to a particular project. It is recommended that specialist vibration input be sought for every project in which vibration sensitive equipment is proposed.

The VC criteria developed by Colin Gordon and Associates is one of the most commonly used classes of vibration criteria for sensitive equipment. The VC criteria are defined as velocity spectra in one-third octave frequency bands, arriving at a 'curve' of allowable levels for each one-third octave band. VC criteria are named alphabetically and sequentially from VC-A to VC-G in order of increasing sensitivity.

Application of the generic criteria (as derived from Colin Gordon and Associates) to different spaces as outlined in .

Criterion Curve	Amplitude[1] μm/s (μin/s)	Detail size[2] μm	Description of use
Workshop (ISO)	800 (32 000)	N/A	Distinctly perceptible vibration. Appropriate to workshops and nonsensitive areas.
Office (ISO)	400 (16 000)	N/A	Perceptible vibration. Appropriate to offices and nonsensitive areas.
Residential day (ISO)	200 (8 000)	75	Barely perceptible vibration. Appropriate to sleep areas in most instances. Usually adequate for computer equipment, hospital recovery rooms, semiconductor probe test equipment, and microscopes less than 40x.
Operating theatre (ISO)	100 (4 000)	25	Vibration not perceptible. Suitable in most instances for surgical suites, microscopes to 100x and for other equipment of low sensitivity.
VC-A	50 (2 000)	8	Adequate in most instances for optical microscopes to 400x, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25 (1 000)	3	Appropriate for inspection and lithography equipment (including steppers) to 3 μm line widths.
VC-C	12.5 (500)	1 – 3	Appropriate standard for optical microscopes to 1000x, lithography and inspection equipment (including moderately sensitive electron microscopes) to 1 μm detail size, TFT-LCD stepper/scanner processes.
VC-D	6.25 (250)	0.1 – 0.3	Suitable in most instances for demanding equipment, including many electron microscopes (SEMs and TEMs) and E-Beam systems.
VC-E	3.12 (125)	< 0.1	A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems, E-Beam lithography systems working at nanometer scales, and other systems requiring extraordinary dynamic stability.
VC-F	1.56 (62.5)	N/A	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.
VC-G	0.78 (31.3)	N/A	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.

[1]As measured in one-third octave bands of frequency over the frequency range 8 to 80 Hz (VC-A and VC-B) or 1 to 80 Hz (VC-C through VC-G).

[2]The detail size refers to line width in the case of microelectronics fabrication, the particle (cell) size in the case of medical and pharmaceutical research, etc. It is not relevant to imaging associated with probe technologies, AFMs, and nanotechnology.

The information given in this table is for guidance only. In most instances, it is recommended that the advice of someone knowledgeable about applications and vibration requirements of the equipment and processes be sought.

Figure 2 – Reproduction of vibration criteria and description of use (from Colin Gordon and Associates)

8. ACOUSTIC POST-OCCUPANCY EVALUATION

Should the project team or acoustic engineer be directed to do so, a post occupancy evaluation shall be undertaken of selected acoustic parameters only.

The following provides a guide to work that may be undertaken:

8.1. Internal Noise Levels

Generally, post occupancy evaluation of noise levels would involve short-term (typically 15 minutes to one hour) attended measurements of steady state L_{Aeq} noise levels in the centre of a room or space.

Longer, or more detailed measurements of specific sources (e.g.: rail noise) would only generally take place if the subject noise source has been identified as an issue once the building is occupied; if assessment and certification of a particular source (with a defined measurement procedure and duration) has been mandated for a particular project or if certification is required in relation to State Environmental Planning Policies.

Measurements would take place in a room that is not occupied, but ready for occupation.

8.2. Room Acoustics Post-Occupancy Evaluation

Generally, post occupancy evaluation of room acoustics would only take place in spaces with a specified reverberation time. Reverberation time would be reported as the arithmetic average of the measured values at 500 Hz and 1000 Hz, rounded to the nearest 0.1 of a second.

More detailed measurements and reporting (e.g. stating the reverberation time at all octave bands between 63 Hz and 8000 Hz) would only generally take place if reverberation time has been identified as an issue once the building is occupied, or if the room or space has more detailed reverberation time requirements (e.g.: teaching spaces for hearing-impaired students, performance or recording spaces).

8.3. Noise Emission Post-Occupancy Evaluation

Generally, post-occupancy evaluation of noise emission would only occur if mandated by a condition of development consent or where noise emission (from either a stationary noise source or student activity-related noise) is identified as an issue after the room, space or building is occupied.

8.4. Room-to-Room Post-Occupancy Evaluation

Generally, post occupancy evaluation of room-to-room acoustic performance would take place only for airborne noise between occupied teaching spaces such as general learning areas and occupied spaces adjacent to noise producing spaces, or as directed for a particular project.

Airborne noise tests performed according to ISO 140:1998 Part 4 would be performed both ways in the case of two adjacent rooms, and the lowest D_{nTW} value reported according to ISO 717:2013 Part 1 would be reported as the result.

The measured value is deemed compliant if within 5 points of the guideline design value, R_w.

Measurements would take place in a room that is not occupied, but ready for occupation.

9. ACOUSTIC REFERENCES

9.1. Noise Level References and Guidelines

- Australian/New Zealand Standard AS/NZS 2107:2000 Acoustics – recommended design sound levels and reverberation times for building interiors ('AS 2107').
- Association of Australian Acoustical Consultants (AAAC) Guideline for Educational Facilities Acoustics
- NSW Road Noise Policy (RNP, 2011)
- NSW Industrial Noise Policy (INP, 2000)
- Australian Standard AS/NZS 2021:2000 Acoustics – aircraft noise intrusion – Building siting and construction.
- NSW DECC Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects ('IGANRIP')
- Bureau of Meteorology Rainfall Intensity-Frequency-Duration design rainfalls
- NSW RMS Traffic Volume Maps for Noise Assessment for Building on Land Adjacent to Busy Roads.
- State Environmental Planning Policy (Infrastructure) 2007 - regulation 102
- State Environmental Planning Policy (Infrastructure) 2007 - regulation 87

9.2. Room Acoustics References and Guidelines

- Australian/New Zealand Standard AS/NZS 2107:2000 Acoustics – recommended design sound levels and reverberation times for building interiors ('AS 2107').
- Association of Australian Acoustical Consultants (AAAC) Guideline for Educational Facilities Acoustics

9.3. Noise Emission References and Guidelines

- NSW Industrial Noise Policy (INP, 2000)
- Local Council/Authority noise emission requirements

9.4. Room to Room References and Guidelines

- Association of Australian Acoustical Consultants (AAAC) *Guideline for Educational Facilities Acoustics*
- ISO 140:1998 Measurement of sound insulation in buildings and of building elements (Part 4 – Field measurements of airborne sound insulation between rooms; Part 7 Field measurements of impact sound insulation of floors).
- ISO 717:2013 – Rating of sound insulation in buildings and of building elements (Part 1 – Airborne sound insulation; part 2, Impact sound insulation)