0001c Design Checklist - Acoustics

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00 Design principles

0.01 Main Considerations

It is a requirement to undertake the 00 PLANNING AND DESIGN/ 0001R - DESIGN REFERENCE and GLOSSARY OF TERMS information into all aspects of design, detailing and delivery when developing the content here within. Clear demonstration of adherence to these requirements is part of the services and will be called upon at key points in the project and during at the discretion of the Department of Education (DoE).

0.02 Performance parameters

The purpose of this section is to give guidance on the acoustic performance requirements of the various areas and spaces within a school so as to encourage and foster an environment conducive to learning.

Noise refers to the sounds that we would prefer not to hear.

The noise levels within a space can either assist or hamper the ability of both students and teachers to hear each other and work together in the learning environment.

The acoustic design of rooms and spaces should address the following parameters:

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

Generally, the design of all building components, including acoustic components should consider the ‘Whole of Life ‘framework and ensure that the equipment or materials used are of appropriate quality, cost efficient, without compromising the overall efficiency and effectiveness. They should provide longevity, low maintenance and overall Value for Money to the school and its users. For further details refer to the Whole of Life (WoL) section of the Design Guide.

0.03 Internal noise levels

An internal noise level assessment must be carried out for all new buildings to ensure comfortable acoustic conditions for the spaces occupied.

The internal noise levels within the space must meet the limits stipulated in Table 11.06.1 of Section 11.6 Acoustic Performance Guidelines or be within the range stipulated in Table 1 of the Australian and New Zealand Standards (AS/NZS) 2107:2016 standard. The more stringent of the two should be met.

Noise measurements conducted for at least 10% of the spaces will be required to demonstrate compliance with the noise levels criteria. The spaces considered for onsite testing shall be the ones most susceptible to internal and external noise sources as a conservative measure.

Sound Sources Description

- Steady-state(consistent) noise intrusion from external sources:
  - Road (and in some cases, rail) traffic noise
  - Industry
  - General environmental noise including external school activity
- Intermittent (occasional) noise intrusion from external sources:
  - Individual rail pass-bys
  - Aircraft flyovers
  - Rain noise
- Steady-state (consistent) noise contribution of internal sources:
  - Mechanical equipment
  - Air conditioning
- Intermittent (occasional) noise intrusion from internal sources:
  - Hydraulic services

The potential impact of the noise and the extent of acoustic treatment will depend upon:

- Required internal noise levels
- The sensitivity of a room or space to a particular intermittent or intrusive noise source
- The proximity of the room or space to external noise sources and the external noise level incident upon the facade (principally the glazing, ventilation openings or lightweight facade or roof construction)
- Whether mechanical ventilation or air conditioning is present
- Rainfall conditions in the region

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 or student'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 one's voice over high ambient noise levels, which can result in ever-increasing noise levels within the space whilst in use).

The primary design and assessment parameters are the overall steady-state energy average (LAeq) noise level in the room or space (being the combination of contributions from all steady-state noise sources).

To maintain low noise levels, it is also necessary to control intermittent noise sources so that they are not unacceptably intrusive.

Internal Noise Level Assessment

Road Noise for general learning areas, music, drama, movement studios and halls shall be assessed consistent with the requirements of State Environmental Planning Policy (SEPP - Infrastructure) 2007 - regulation 102. An assessment should be undertaken where directed for any site impacted by traffic noise. Generally, it is recommended for all sites impacted by noise from roads with greater than 20,000 vehicles AADT and required for all sites impacted by noise from roads with greater than 40,000 vehicles AADT. The guideline internal noise levels presented in Acoustic Performance Guidelines (section11.06) is to be used in the assessment.

Rail Noise for general learning areas shall be assessed consistent with the requirements of SEPP (Infrastructure) 2007 - regulation 87, The internal noise level requirements for school classrooms presented in NSW DoEC Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects ('IGANRIP') is to be used in the assessment.

Aircraft Noise for general learning areas, music, drama, movement studios and halls are to be assessed where the school site lies within Australian Noise Exposure Forecast (ANEF) 25 (or higher) as shown on airport planning instruments. The procedures in AS 2021 are to be followed in the assessment.

Industrial Noise for general learning areas, music, drama, movement studios and halls are to be assessed consistent with the requirements of the NSW Industrial Noise Policy (School classrooms, internal). The guideline internal noise levels presented in Acoustic Performance Guidelines (Section11.06) is to be used in the assessment.

Rain noise is to be assessed only for general learning areas, music, drama, movement studios and halls or as otherwise directed. Rain is to be assessed using the one-year annual recurrence, one-hour event for the region as reported by the Bureau of Meteorology. A recognized rain noise calculation procedure (such as Dubout, 1969 or Griffin, Ballagh, 2012) shall be used.

0.04 Room Acoustics

Room acoustic design considerations include:

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

The extent to which 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 space with large dimensions and where late acoustic reflections are considered a risk.

The reverberation time within a room must be within the range stipulated in Table 1 of Section 11.6 Acoustic Performance Guidelines or Table 1 of the AS/NZS 2107:2016 standard. The more stringent of the two should be met.

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 RT60. 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 (such as teaching spaces for students who are deaf or hard to hearing), it is desirable to define and design for the required reverberation time at all octave band centre frequencies between 63 Hz and 8000 Hz. This is a more onerous requirement and advice should be sought from an acoustic engineer for individual cases.

Controlling reverberation time provides the following main benefits:

- It serves to improve speech intelligibility, and
- It controls the build-up of reverberant noise (i.e. sound levels being sustained by reflecting off multiple surfaces with minimal energy loss)
- 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 (e.g. practical activity areas, gymnasiums and halls).

0.05 Noise Emission (to the environment)

Noise emission considerations include:

- Noise emission from school activity (e.g.: music performance, sporting activity)
- Noise emission from a mechanical service (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 when 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.

Assessment of Noise Emission

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

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

Noise associated with school activity (such as music or sport within a hall) are 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 is to assess the noise emission. The acoustic engineer should define and state the activity, internal reverberant sound pressure level in the room or space and criteria (including sound pressure level and assessment location) in a report.

Note that an acoustically designed variation on the standard Kit of Parts (KoP) School Hall exists. This incorporates acoustically lined intakes and exhausts on all-natural ventilation openings including rooftop mounted ventilators (‘Whirlybirds’).

0.06 Room to Room Noise Control

Considerations include:

- Ascertain a room or space noise level and determine constructions (both walls and ceilings) required to control noise emission to an adjacent space
- Ascertain a room or space sensitivity as a noise receiver and determine constructions (both walls and ceilings) required to control noise intrusion from adjacent spaces.
- Consider 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:

- Whether noisy activities take place in the room or space
- Whether a room on an upper floor has a hard floor surface (when considering footfall/impact noise)
- Whether a room is sensitive to noise intrusion

- The ambient noise level in the receiver room
- Whether the construction between adjacent rooms includes an operable wall, a door, a glazed section or other potentially ‘acoustically weak’ construction.

Airborne Noise

For the School Facilities Guidelines, the weighted sound reduction index (notated Rw) is the airborne noise assessment parameter.

When a Post Occupancy Evaluation is conducted for room-to-room noise, the parameter is the apparent weighted sound reduction index (notated Rw).

The required design value of construction between adjacent rooms can only be defined when the use of both rooms is known. Refer to Tables 1 and .2.

Impact (Footfall) Noise

Refer to the guideline standardised impact sound pressure levels LnTw values presented in Table 02.

Design advice should be sought from an acoustic engineer for multi-storey buildings with noise-sensitive spaces below hard-surfaced floor areas

Prescriptive Constructions

The following elements have prescriptive acoustic performance or construction requirements:

- Operable walls (between general learning areas, all schools): Rw 45
- Entry doors to occupied teaching, music, drama and sports spaces: Solid core, minimum 35 mm thick with acoustic weather (where external) seals on all rebated closing faces. Gap at floor to be minimized.
- Internal glazed sections in walls and vision panels in or adjacent to internal doors: minimum
- 10.38 mm laminated glass. In some situations, acoustic windows may be needed for satisfactory noise separation.
- Construction separating wastewater pipework from occupied spaces: Rw 40
- 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 a ‘staggered stud’ arrangement or otherwise discontinuous.

Ventilation requirements need consideration when applying acoustic performance requirements.

Refer to 00 PLANNING AND DESIGN/0001C DESIGN CHECKLIST - MECHANICAL and 00 PLANNING AND DESIGN/0001C DESIGN CHECKLIST - SUSTAINABILITY

0.07 Acoustic Performance Standards

Table 01: Internal noise levels and reverberation times

Room	Internal noise level (dB LAeq)	Reverberation time, sRT60 (Av 500Hz and 1000Hz)
Art/craft studios	40	<0.8
Assembly halls up to 250 seats	35	see Note 1
Assembly halls over 250 seats	35	see Note 1
Audio-visual areas	35	<0.8
Computer rooms - Teaching	40	<0.6
Computer rooms - Laboratories	45	<0.6
Conference room	35	<0.7
Corridors and lobbies	45	Minimise
Dance Studios	40	<1.2
Dining rooms	45	<1
Drama Studios	30	<1
Duplicating rooms/stores	50	

Room	Internal noise level (dB LAeq)	Reverberation time, sRT60 (Av 500Hz and 1000Hz)
Engineering workshops	45	Minimise
Gymnasiums	40	<1.5
Interview/counselling rooms	35	<0.6
Kitchens	50	
Laboratories - Teaching	40	<0.7
Laboratories - Working	45	<0.8
Lecture rooms - up to 50 seats	35	see Note 1
Lecture theatres – without speech reinforcement and >50 seats	30	see Note 1
Lecture theatres - with speech reinforcement	35	see Note 1
Libraries - General areas	40	<0.6
Libraries - Reading areas	35	<0.6
Libraries - Stack areas	45	<0.6
Manual arts workshops	40	Minimise
Medical rooms (First aid)	40	<0.8
Music practice rooms	35	see Note 1
Music studios	30	see Note 1

Room	Internal noise level (dB LAeq)	Reverberation time, sRT60 (Av 500Hz and 1000Hz)
Office areas	40	<0.7
Open plan teaching areas	40	<0.8
Professional and Administrative offices	35	<0.8
Staff common rooms	40	<0.6
Study Rooms	35	<0.6
Teaching spaces – students who are deaf or hard of hearing	30	<0.4
Teaching spaces – Primary schools	35	<0.5
Teaching spaces – Secondary schools	35	<0.6
Toilet/change/showers	50	

Note 1: The appropriate reverberation time shall be influenced by the internal volume and intended use of the space. Guidance from an acoustical engineer shall be sought. Also refer to AS/NZS 2107:2000 Figure A1 for guidance values.

Table 02: Airborne and impact sound insulation requirements

Room	Source room activity noise	Receiving room noise tolerance	Impact sound insulation rating (L'nTw)
Art/craft studios	Average	Medium	60
Assembly halls up to 250 seats	High	Low	60
Assembly halls over 250 seats	High	Low	60

Room	Source room activity noise	Receiving room noise tolerance	Impact sound insulation rating (L'nTw)
Audio-visual areas	High	Low	60
Computer rooms - Teaching	Average	Low	60
Computer rooms - Laboratories	Average	Medium	60
Conference room	Average	Low	55
Corridors and lobbies	Average	High	65
Dance Studios	High	Very low	55
Dining rooms	High	Medium	65
Drama Studios	High	Very low	55
Duplicating rooms/stores	High	High	65
Engineering workshops	High	High	65
Gymnasiums	High	Medium	65
Interview/counselling rooms	Average	Low	55
Kitchens	High	High	-
Laboratories - Teaching	Average	Low	60
Laboratories - Working	Average	Medium	65
Lecture rooms - up to 50 seats	Average	Low	55

Room	Source room activity noise	Receiving room noise tolerance	Impact sound insulation rating (L'nTw)
Lecture theatres – without speech reinforcement and >50 seats	Average	Very low	50
Lecture theatres - with speech reinforcement	Average	Low	50
Libraries - General areas	Low	Low	55
Libraries - Reading areas	Low	Low	55
Libraries - Stack areas	Average	Medium	55
Manual arts workshops	Average	Medium	65
Medical rooms (First aid)	Average	Low	60
Music practice rooms	Very high	Low	55
Music studios	Very high	Very low	50
Office areas	Low	Low	55
Open plan teaching areas	Average	Medium	55
Plant Room	High	High	
Professional and administrative offices	Low	Low	60
Staff common rooms	Average	Medium	60
Study Rooms	Low	Low	55
Teaching spaces – Hearing impaired	Average	Very low	50
Teaching spaces – Primary schools	Average	Low	55

Room	Source room activity noise	Receiving room noise tolerance	Impact sound insulation rating (L'nTw)
Teaching spaces – Secondary schools	Average	Low	55
Toilet/change/showers	Average	High	

Table 03: Sound insulation requirements (minimum design Rw) for adjacent rooms without operable walls, entry doors or glazed panels.

Activity noise in source room				
	Low	**Average**	**High**	**Very high**
High	30	35	45	55
Medium	35	40	50	55
Low	40	45	55	55
Very low	45	50	55	60

Table 04: Minimum Speech Transmission Index (Informative)

Room type	Speech Transmission	Index (STI)
Teaching and study spaces		> 0.60
Assembly Halls up to 250 Seats	35	see Note 1
Assembly Halls over 250 seats	35	see Note 1
Audio-visual Areas	35	<0.8
Computer rooms- Teaching	40	<0.6
Computer rooms- Laboratories	45	<0.6
Conference room	35	<0.7
Corridors and lobbies	45	Minimise
Dance Studios	40	<1.2

Room type	Speech Transmission	Index (STI)
Dining rooms	45	<1
Drama Studios	30	<1
Duplicating rooms/stores	50	
Engineering workshops	50	Minimise
Gymnasiums	40	<1.5
Interview/counselling rooms	35	<0.6
Kitchens	50	
Laboratories- Teaching	40	<0.7
Laboratories- Working	45	<0.8
Lecture rooms-up to 50 seats	35	see Note 1
Lecture theatres- without speech reinforcement and >50 seats	30	see Note 1
Lecture theatres- with speech reinforcement	35	see Note 1
Libraries- General areas	40	<0.6
Libraries- Reading areas	35	<0.6
Libraries- Stack areas	45	<0.6
Manual arts workshops	40	<0.8
Medical rooms (First aid)	40	<0.8
Music practice rooms	35	see Note 1
Music studios	30	see Note 1
Office areas	40	<0.8
Open plan teaching areas	40	<0.8
Professional and Administrative offices	35	<0.8
Staff common rooms	40	<0.6
Study Rooms	35	<0.8
Teaching spaces- Hearing impaired	30	<0.4
Teaching spaces- Primary schools	35	<0.5
Teaching spaces- Secondary schools	35	<0.6
Toilet/change/showers	50	-

0.08 Acoustic Post Occupancy Evaluation (POE)

Post Occupancy evaluations are often undertaken to assess the performance of recently completed or existing facilities. Where a Post Occupancy Evaluation is to be undertaken it should be conducted by the project team or acoustic engineer and should be undertaken of selected acoustic parameters only. The following provides a guidance on the extent of work to be undertaken:

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 LAeq 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 be required;

- 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 furnished and ready for occupation, but without people present (unoccupied).

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 be required;

- 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).

Measurements would take place in a room that is furnished and ready for occupation, but without people present (unoccupied).

Noise Emission Post-Occupancy Evaluation

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

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 such as halls, 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 Rw value reported according to ISO 717:2013 Part 1 would be reported as the result. The measured value is considered acceptable if it is within 5 points of the guideline design value, Rw.

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

0.09 Acoustic References

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 DoEC 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

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

Noise Emission References and Guidelines

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

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)