# SECTION 18

# ACOUSTICS

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# 18 Acoustics

Acoustic separation and appropriate room acoustics are important for teaching and office environments. The following principles apply to the acoustic design for JCU projects.

Particular attention shall be paid to acoustics and noise transmission requirements applying to internal spaces.

This section addresses typical spaces in JCU buildings such as teaching spaces, lecture theatres, laboratory and administration spaces, music and media facilities and workshops. Where spaces depart from those listed in this guideline a project specific acoustical brief at the completion of Schematic Design shall be prepared by the acoustical consultant and design team presenting the proposed criteria and basis for submission to JCU for sign-off.

Acoustical Consulting firms engaged by JCU shall be member firms of the Association of Australian Acoustical Consultants and staff of those firms Members of the Australian Acoustical Society.

A glossary is included at the end of this section to assist in the understanding of the subject acoustical parameters.

## 18.1 Regulatory Requirements

The following authority and code requirements are relevant to acoustic considerations for University developments in Queensland:

- Environmental Protection Act 1994
- Environmental Protection (Noise) Policy 2008
- Environmental Protection Regulation 2008
- Council Planning Policies Local to the Campus
- Queensland Work Health and Safety and Other Legislation Amendment Act 2014

## 18.2 Applicable Australian and International Standards and Codes

The following current standards apply to noise and vibration:

- AS 1055 1997 Acoustics - Description and measurement of environmental noise
- AS 1191 2002 Acoustics - Method for laboratory measurement of airborne sound insulation of building elements
- AS NZS 1269 2005 Occupational noise management
- ISO 140.4 1998 Acoustics - Measurement of sound insulation in buildings and of building elements Part 4 - Field measurements of airborne sound insulation between rooms
- ISO 140.5 1998 Acoustics — Measurement of sound insulation in buildings and of building elements - Part 5: Field measurements of airborne sound insulation of façade elements and façades
- AS/NZS ISO 140.7 2006 Acoustics - Measurement of sound insulation in buildings and of building elements - Field measurements of impact sound insulation of floors (ISO140-7:1998, MOD)
- AS NZS 1668.1 1998 The use of ventilation and air-conditioning in buildings Part 1: Fire and smoke control in multi compartment buildings
- AS 1670.4 2004 Fire detection, warning, control and intercom systems - System design, installation and commissioning - Sound systems and intercom systems for emergency purposes

- AS ISO 1999 2003 Acoustics - Determination of occupational noise exposure and estimation of noise-induced hearing impairment
- AS 2021 2000 Acoustics — Aircraft noise intrusion — Building siting and construction
- AS NZS 2107 2000 Acoustics - Recommended design sound levels and reverberation times for building interiors
- AS 2436 2010 Guide to noise and vibration control on construction, demolition and maintenance sites
- AS2670 2001 Evaluation of human exposure to whole-body vibration
- AS 2822 1985 Acoustics---methods of assessing and predicting speech privacy and speech intelligibility
- AS 3671 1989 Acoustics - Road traffic noise intrusion - Building siting and construction
- AS ISO 11654 2002 Acoustics - Rating of sound absorption - Materials and systems
- AS NZS ISO 717.1 2004 Acoustics - Rating of sound insulation in buildings and of building elements Part 1: Airborne sound insulation
- AS NZS ISO 717.2 Acoustics - Rating of sound insulation in buildings and of building elements Part 2: Impact sound insulation
- AS 60849-2004 Sound systems for emergency purposes (IEC 60849:1998 MOD)

### 18.3 Scope of Acoustic Considerations

In the design of new buildings, and the refurbishment of existing facilities, acoustic considerations should include:

- External noise intrusion.
- Noise generated within the building from building services.
- Noise emissions from the building as they affect adjoining buildings or residences.
- Noise interactions between spaces and consequent privacy considerations.
- Acoustic quality of spaces including reverberation and speech intelligibility for teaching / lecturing spaces.
- Special acoustic requirements such as sound or video recording, or music teaching practice or performance.
- The acoustic limitations of the existing building fabric when undertaking refurbishment works.

### 18.4 Unoccupied Internal Noise Levels

Noise within buildings consists of two components:

1. Intrusion from external sources.
2. Building services.

Noise levels in an unoccupied room are a combination of the two sources.

#### 18.4.1 External Noise Intrusion

Typical external noise intrusion sources include:

- Traffic noise (road, rail and/or aircraft sources).
- Mechanical plant and equipment associated with adjacent buildings and industrial activities.
- Local activities such as markets, maintenance, sport and leisure etc.

These types of intrusive noise can be classified as either:

- Steady or pseudo-steady (e.g noise from continuously operating plant or the like) that can be quantified as as the equivalent continuous level : $L_{Aeq}$.
- Transient (e.g. aircraft fly over) that is measured as the level exceeded for 1 percent of the time: $L_{A01}$.

### 18.4.2 Building Services

Building services noise includes noise sources such as fans, air-conditioning, motors and pumps etc. The noise can be transferred to internal useable spaces by two mechanisms:

- Air-borne noise transmission.
- Structure-borne noise transmission.

Both mechanisms of transmission must be considered in the design by the provision of appropriate sound insulation and structural isolation.

Noise from building services can commonly consist of pronounced tonal components which may add to the annoyance. Wherever such tones exist, the measured noise level shall be penalised by and upward adjustment (Adj) in accordance with recommended methods in AS/NZS 2107. The Code recommends adjustments of either 2dB and 5 dB depending on the degree of the tonality.

### 18.4.3 Overall Noise Limits

Limits of acceptable noise in unoccupied buildings are listed below in **Table 18.1.** Unoccupied refers to the area undergoing noise measurements is free from activity from the users of the building. These limits are to be met with contributions from both noise intrusion and building services noise.

**Table 18.1 Recommended Overall Noise Internal Limit (Both Intruding and Building Services Noise)**

| **Room Type** | **dBA** | |
|---|---|---|
| | **$L_{Aeq}$** | **$L_{A01}$** |
| Standard individual offices, or shared offices | 40 | 45 |
| Senior staff (individual) offices | 40 | 45 |
| Interview / Counselling Offices | 40 | 50 |
| Teaching Rooms (including computer-based learning) | 40 | 45 |
| Lecture Theatres <200 persons | 35 | 40 |
| Lecture Theatres >200 persons | 30 | 40 |
| Library (General Areas) | 40 | 50 |
| Video-conferencing Rooms | 35 | 40 |
| Corridors, Lobbies | 45 | 55 |
| Laboratory Spaces | 45 | 50 |
| Laboratory Space used for Teachings | 40 | 45 |
| Tutorial Rooms | 35 | 40 |
| Amenities | 50 | - |
| Workshops | 50 | - |
| Common Rooms | 45 | - |
| Drama Studios | 35 | 40 |
| Cafeterias | 45 | - |
| Museums and Galleries | 35 | 40 |
| Gymnasiums | 45 | 50 |

For **Table 18.1**, the following notes apply:

- For areas not listed in **Table 18.1**, consult satisfactory levels AS/NZS 2107.
- For musical performance spaces, video production, animal houses speech pathology and audiology areas, recommended levels require specific advice from an acoustical consultant.
- Criteria apply over any one hour period during applicable hours (typically 8am to 9pm).
- Where buildings are affected by continuous transportation noise and the building is air-conditioned, the design of the building shall be such that there is an equal contribution between intruding noise and air-conditioning noise. (e.g. 37dBA of intruding noise and 37dBA of air-conditioning noise to give 40 dBA total).
- In a situation where there is no significant intruding noise, then the values in **Table 18.1** can be made up entirely of noise from building services.
- Building services must generate noise levels no less than 5 dB below the criteria. In buildings where silent air-conditioning technologies such as chilled beams are used, Sound conditioning using a speaker array to elevate the background noise level must be installed in all spaces to maintain privacy. The sound conditioning system using a fully adjustable proprietary engineered system adjusted to the satisfaction of JCU.

### 18.5 Rain Noise

Rain noise within noise-sensitive spaces should not exceed the criterion level in **Table 18.1** by more than 5 dBA. Predicted rain noise levels should be based upon rainfall intensity levels of 30 mm/hour for areas of tropical Queensland. In areas other than tropical Queensland, rainfall rates used in design should be stated in reporting.

### 18.6 Building Noise Emissions

Noise emissions can arise from building services or the functional activities of the space. This category includes noise generated by associated activities (e.g. delivery vehicles to a loading dock). Noise of this type may impact on other buildings on or off campus depending on their function.

The acoustic characteristics of potentially affected adjoining buildings should be taken into account to determine acceptable noise emissions from the proposed new building and the associated noise source(s).

**Internal Affected Spaces**

Refer to **Table 18.1** for internal criteria within campus buildings affected by noise from other new buildings.

**External Affected Areas**
The noise limits listed in **Table 18.2**.

**Table 18.2 External Noise Limits for Campus Areas Building for Noise Generation from New Campus Buildings**

| Room Type | dBA |
|---|---|
| Courtyards, outdoor dining and heavily trafficked walkways | 50 |
| Other walkways | 60 |
| Facades of noise sensitive air-conditioned buildings | 60 |
| Facades of noise sensitive naturally ventilated buildings | 50 |
| Facades of other buildings | 65 |
| On and off-site residences and other noise sensitive uses | Refer to applicable statutory requirements |

## 18.7 Acoustic Separation between Spaces

The privacy achieved between two adjoining spaces depends on a number of parameters being the background noise level, the sound reduction of a partition, and the reverberation characteristics of the listening room. These are described in more detail in AS 2822.

For University buildings, the requirements can be simplified to two parameters:

- The sound reduction between the spaces ($D_{nT,w}$)
- The ambient noise level of the receiving space (dBA)

The sound reduction is quantified by the weighted standardised level difference ($D_{nT,w}$). The ambient noise is quantified as the equivalent A-weighted sound pressure level ($L_{Aeq}$).
The summation of the sound reduction and the ambient noise level in the receiving space gives the Privacy Rating (PR):

$$PR = D_{nT,w} + dBA$$

The sound reduction between two spaces primarily depends on the acoustical performance of the dividing partition, generally expressed as the Weighted Sound Reduction Index ($R_w$). Apart from the partition selections, there are numerous other factors which influence noise reduction including:

- Noise flanking paths via common ceiling voids, air-conditioning, ductwork etc.
- Noise leakage at services penetrations and unsealed gaps at window mullions, at partition heads etc.
- Weaker elements incorporated into the partition such as doors, windows, glazed highlights, glass fins etc.
- Poor workmanship and departures from the documented design.
- The amount of sound absorption in the receiving space.

The Designer shall account for these various factors in the selection of particular design detail and in the supervision of the installation. At best, the numerical value of the $D_{ntw}$ could be expected to be 3 dB lower than the $R_w$ rating as tested in a laboratory.

The ambient noise level within a building can vary considerably throughout the day as a result of changing activities inside and external to the building, or resulting from changes in solar load affecting the operation of variable volume air-conditioning systems. Different parts of the building will also affect the ambient noise. For example, locations remote from plant rooms will generally have lower plant noise levels. Some of the new forms of air-conditioning such as chilled-beam systems have inherently low noise generation.

The ambient noise levels specified in **Table 18.1** represent the maximum permissible levels and a shortfall of up to 5 dBA is permissible. Based on the ambient noise levels in Table 18.1, the following $D_{nT,w}$ values are recommended in **Table 18.3**.

**Table 18.3 Recommended Acoustic Separation Between Spaces ($D_{ntw}$)**

| Room Type | Offices | Senior Offices | Open Plan Offices | Counselling | Seminar Room | Lecture Theatre | Library | Video Conference Room | Corridor |
|---|---|---|---|---|---|---|---|---|---|
| **Offices** | 40<br>32* | 45 | 40<br>32* | 50 | 50 | 55 | 40<br>32* | 50 | 25 |
| **Senior Offices** | 45 | 50 | 45** | 50 | 50 | 55 | 50** | 50 | 32 |
| **Open Plan Offices** | 40<br>32* | 45** | - | 50** | 50 | 55 | 45 | 55 | - |
| **Counselling** | 50 | 50 | 50** | 50 | 50 | 60 | 45 | 55 | 32 |
| **Seminar Room** | 50 | 50 | 50 | 50 | 50 | 55 | 45 | 55 | 32 |
| **Lecture Theatre** | 55 | 55 | 55 | 60 | 55 | 55 | 45 | 55 | 32 |
| **Library** | 40<br>32* | 50** | 45 | 45 | 45 | 45 | 45 | 55 | - |
| **Video Conference Room** | 50 | 50 | 55 | 55 | 55 | 55 | 55 | 55 | 32 |
| **Corridor** | 25 | 32 | - | 32 | 32 | 32 | - | 32 | - |

* where doors open directly into another space

** walls containing doors are not recommended.

In addition to the ratings provided in **Table 18.3**, the following recommendations apply to partition construction:

- Details of the intersection of partitions and external windows shall ensure the sound reduction is maintained at the intersection, equivalent to that of the remainder of the partition.

- In the absence of an Australia Standard for the manufacture of polyester insulation, any partition cavities shall be glass wool to achieve the necessary sound transmission loss between spaces.
- All walls separating sensitive spaces from toilets and areas with frequently used joinery and benches attached to walls are required to be resilient to impact noise. Allowance should be made using twin-track, staggered stud or use of resilient mounts depending on the type of impact noise being created and wall construction.
- Where noise from building services and noise intrusion is expected to be lower than the noise levels in **Table 18.1**, and sound conditioning not viable, the partition $D_{nT,w}$ ratings should be increased proportionally to compensate for the lower background noise levels.
- All lecture theatres greater than 200 person shall have sound lock entries unless confirmed by JCU as not required.

Partition details are important to achieve the required $D_{nT,w}$ ratings, particularly for high ratings. The following details should be considered and provided by the acoustical consultant:

- Plasterboard at partition junctions and "T" junctions.
- Recesses above and below services ducts and at wall angles.
- Blinds and blind boxes.
- Mullions.

### 18.8 Acoustic Qualities of a Space

There are a number of acoustical parameters used to define and describe the acoustical qualities of a space. The most common is the measurement of reverberation time: RT60, which is the time in seconds required for a sound to reduce by 60 decibels after the sound is stopped.

The reverberation time should be quoted in terms of the mid-frequency reverberation time, which is the arithmetic average of the reverberation times in the 500 Hz, 1 kHz and 2 kHz octave bands, or the arithmetic average of the reverberation times in the one-third octave bands from 400 Hz to 2.5 kHz.

The RT60 for various spaces are defined in **Table 18.4**:

**Table 18.4 Recommended Reverberation Times**

| Room Type | RT60 (s) |
|---|---|
| Standard individual office, or shared office | ≤0.6 |
| Senior staff (individual) office | ≤0.6 |
| Administrative/clerical office (open space), post graduate student areas | ≤0.6 |
| Counselling Office | ≤0.6 |
| Teaching Room | 0.5 to 0.8 |
| Lecture Theatre | 0.6 to 1.0* |
| Library | ≤0.6** |
| Video-conferencing Room | 0.3 to 0.7 |
| Corridors, Lobbies | 0.6 to 0.8 ** |

* Based on room volumes and recommended Reverberation Times in AS/NZS 2107.

** Longer times are acceptable in larger volumes as recommended by an acoustical consultant.

For any other spaces not listed in **Table 18.4**, AS/NZS 2107.should be used or specific advice from the project acoustical consultant sought

For a quality acoustical environment with good speech intelligibility the following adverse impacts must be avoided:

- Rear wall echoes in lecture theatres.
- Standing wave or room modes in recording or practice studios.
- Flutter echo in performance spaces.

These acoustical issues must be evaluated and addressed on a project specific basis using a specialist acoustic consultant.

### 18.9 Vibration

Vibration isolation of mechanical plant and equipment is to be supplied and installed to limit vibration levels in the building to comply with recommended vibration levels as set out in AS2670 which assessment methods and criteria for vibration.

Where vibration sensitive equipment is to be housed in a building, the manufacturer's data for the equipment shall be obtained and the building should be designed to accommodate the manufacturer's requirements.

### 18.10 Floor Impact Noise

Noise from footsteps and the movement of furniture should not be transmitted into spaces via the floor above. When ceilings are open to the concrete soffit or removed, or if the floor consists of tiles or polished concrete, the performance of the floor-ceiling construction is reduced.

All spaces must be sufficiently insulated against impact noise to provide a maximum impact sound pressure level of no greater than 55 dB $L'_{nT,w}$ in any Teaching, Offices or Meeting Room spaces.

### 18.11 Emergency Fire and Smoke Acoustical Requirements

Emergency smoke and fire systems ventilation systems should comply with the noise requirements specified in Clauses 4.6 and 4.17 of AS NZS 1668.1. Specifically, this states that "The noise level during operation of the smoke control systems (including smoke-spill fans and air pressurization fans) shall not exceed 65 dBA in occupied spaces or 5 dBA above the ambient noise levels to a maximum level of 80 dBA. Noise levels in fire-isolated exits shall not exceed 80 dBA."

The Building Code of Australia (BCA) also requires that a Building Fire Evacuation system complies with: AS 1670.4. There are numerous mandatory requirements associated with this code with the main elements being:

- The ambient noise level at the indicator panel shall be not greater than 70 dBA.
- Warning signals during the 'on' phases shall exceed by a minimum of 10 dB above the ambient sound pressure level averaged over a period of 60 seconds, shall not be less than 65 dB and not more than 105 dB.
- At all places within the zone where ambient noise levels are less than 85 dBA, the speech transmission index (STI) shall be ≥0.5. The rating of speech intelligibility shall be in accordance with the common intelligibility scale (CIS) method of AS 60849, measured in

accordance with Appendix A. The average speech sound pressure level shall not exceed 110 dBA.

- Visual warning devices shall be installed in areas where the background A-weighted ambient noise level exceeds 95 dBA.
- The Warden Intercom Point (WIP) aural call signal shall have a sound pressure level (SPL) of not less than 80 dBA when measured at a distance of 1 m from the WIP.

Where National Code for Construction/Building Code of Australia are updated, the newer requirements supersede the requirements of these documents.

### 18.12 Hydraulics

Noise generated by hydraulics services into occupied spaces should not cause the background noise level to increase by more than 1 dB for typical use.

All fluid-carrying pipes should be isolated at the mounting points to minimize structure-borne noise within the building. Pipes should also be lagged to prevent accidental contact with studs and isolated at both block wall and slab penetration points. Pipes penetrating walls, floors and ceilings, should be isolated from the structure and be sealed airtight with a flexible caulking compound.

Down pipes should be located externally, in public or unoccupied spaces and not within occupied spaces.

Waste and down pipes located in ceiling spaces or adjacent to occupied spaces above critical spaces should be acoustically treated. Waste and down pipes connected to columns require isolation at clamps to minimize the generation of structure borne noise

### 18.13 Electrical Services

Noise generated by electrical services into occupied spaces other than an emergency generator should not cause the background noise level to increase by more than 1 dB for typical use. This includes fluorescent light starters and ballasts, uninterruptible power supplies and other general computer/electronic equipment.

Emergency generators should be designed to be no greater than 5 dB higher than the criteria in **Table 18.1** and 5 dB higher than external recommended noise levels in **Table 18.2**.

### 18.14 Lifts

Noise generated by typical lifts use into occupied spaces should not increase the background noise level by more than 1 dB.

### 18.15 Construction Noise

Construction activities produce noise. The levels of noise and their intrusiveness are typically most significant during the early stages of a new project (e.g. excavation and rock breaking) and diminish as the project advances.

Given the intensive nature of campus development, construction noise can have a significant impact on adjoining university buildings. Designers must consider the potential noise impacts of design

options (e.g. extra basements extend the excavation period and the likely duration of noise impacts). As a minimum, compliance with AS 2436 2010 is required.

Particular considerations include:

- Timing/programming of noisy activities to avoid student teaching hours
- Choice of excavation technologies
- Logical and sensitive site layout and sequence
- Choice of construction equipment
- Use of hoardings and screening.

### 18.16 Commissioning and Acoustic Testing

Three types of acoustic testing should be carried out during the commissioning stage of buildings. These are:

- Measurement of ambient noise levels (including mechanical services).
- Intrusive noise levels.
- Noise isolation between spaces.

Noise levels are to be measured in a representative number of typical rooms. Spaces selected for testing should be chosen in conjunction with JCU and the lead consultant. Periodic inspections should be undertaken during construction to verify that the acoustic design intent is being included in the construction before final closing/sealing of partitions and ceilings.

### 18.17 Glossary

| Parameter or Term | Description |
|---|---|
| dB | The decibel (dB) is the unit measure of sound. Most noises occur in a range of 20 dB (quiet rural area at night) to 120 dB (nightclub dance floor or concert). |
| dBA | Noise levels are most commonly expressed in terms of the 'A' weighted decibel scale, dBA. This scale closely approximates the response of the human ear, thus providing a measure of the subjective loudness of noise and enabling the intensity of noises with different frequency characteristics (e.g. pitch and tone) to be compared. |
| $L_{A01}$ | The noise level exceeded for 1% of the measurement period. |
| $L_{A10}$ | The noise level exceeded for 10% of the measurement period. It is sometimes referred to as the average maximum noise level. |
| $L_{A90}$ | The noise level exceeded for 90% of the measurement period. This is commonly referred to as the background noise level. |
| $L_{Aeq}$ | The equivalent continuous sound level, which is the constant sound level over a given time period, which is equivalent in total sound energy to the time-varying sound level, measured over the same time period. |
| Rw | Refers to the Weighted Sound Reduction Index. The Rw is a single-number quantity which characterises the airborne sound insulation of a material or building element over a range of frequencies tested in a laboratory. |
| $D_{nT,w}$ | Refers to the field measurement of airborne sound transmission. Standardised to a standard 0.5 seconds reverberation time and weighted to provide a single figure value. The results will include flanking transmission so the test is for the total transmission between the rooms, not just the partition. |

| | |
|---|---|
| RT60 | The reverberation time is the time in seconds required for a sound to reduce by 60 decibels after the sound is stopped. Typical desirable reverberation times are 0.3 to 0.5 seconds for an office area, 1 second for a lecture theatre, and 1.5 seconds for a musical auditorium. A longer than desirable reverberation time may adversely affect speech intelligibility. A longer reverberation time results in a 'livelier' room, whereas a shorter reverberation time results in a more 'dead' room. |
| $L'_{nT,w}$ | Weighted standardized impact sound pressure level is a single-number rating system designed to provide a comparison between different floor/ceiling constructions for structure-borne impact transmission between vertically adjoining spaces. It is a field measurement.<br><br>In general, a lower number means better overall impact performance. The rating is derived from data that has been adjusted (standardized) to a receiving room reverberation time of 0.5 seconds.<br><br>It is measured with a standardized tapping machine to generate impact noise, measuring it in the space below at the one-third octave bands between 100 and 3150 Hz. |
| $R_w$ | Weighted Sound Reduction Index is a single number evaluation of the property of a partition to attenuate sounds. The Rw typically equates to the reduction in dBA of speech. |