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Lautaret Pty Ltd

West State Private Hospital

Acoustic Assessment Report

AAc/R01

Rev B | 13 February 2017

PLANS AND DOCUMENTS referred to in the REFERRAL AGENCY RESPONSE

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Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Level 4, 108 Wickham Street
Fortitude Valley
QLD 4006
GPO Box 685 Brisbane QLD 4001
Australia
www.arup.com

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Contents

1 Introduction

Arup has been engaged by Lautaret Pty Ltd to conduct an acoustic assessment for the proposed West State Private Hospital, Townsville.

The development approval has also been referred to the Department of Infrastructure, Local Government and Planning for review, which requires an acoustic report to assess rail noise impacts on the development.

Arup has previously (April 2016) prepared an acoustic report for a previous version of the West State Private Hospital project. The space planning and location of the new-build component on site has subsequently been revised.

This revised report:

- Presents appropriate design criteria based on Townsville City Council and QLD Government policy, relevant Australian Standards and international guidelines (e.g. UK Department of Health)
- Assesses road traffic noise levels impacting the development
- Assesses current and future rail noise levels impacting the development
- Presents façade glazing performance requirements for each façade area to meet appropriate criteria internally within the development
- Presents indicative glazing constructions to meet the performance requirements.
- Provides recommended partition constructions to address internal sound insulation between functional areas of the West State Private Hospital.
- Provides preliminary recommendations for room acoustic treatment.

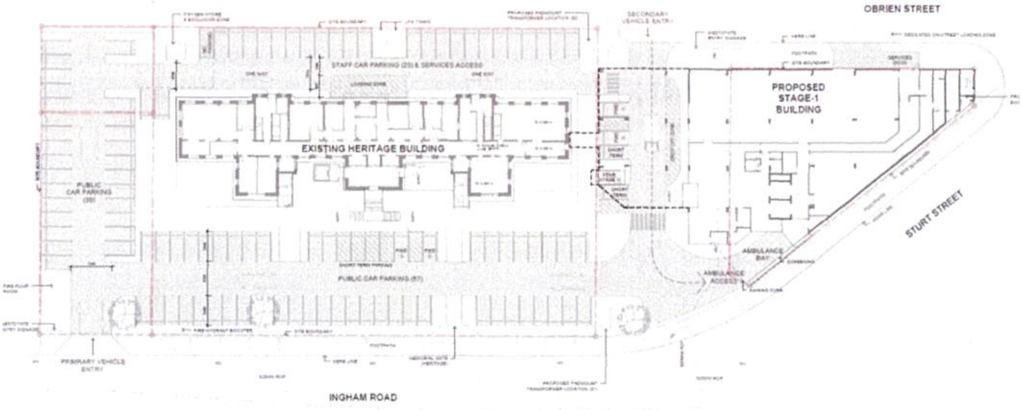
A glossary of acoustic terminology used in this report is presented in Appendix A.

1.1 Proposed Development

Stage 1 of the proposed development consists a mix of a new-build 5-storey hospital building with rooftop plant, and adaptive re-use of the former Townsville West State School main building.

A site plan showing the proposed new-build and refurbishment component of the development is given below in Figure 1.

Figure 1: Site Plan, West State Private Hospital, showing new-build component (right) and heritage refurbishment component (centre)



2 Site Description

The site is located at 39 Ingham Road and 763 Sturt Street, West End, Townsville. The existing site comprises of the former Townsville West State School main building and an undeveloped section of land between Sturt Street and O'Brien Street.

The site is surrounded by the following:

- To the north; new Townsville West State School and O'Brien Street.
- To the south; Ingham Road and the railway line.
- To the west; commercial tenancies fronting Ingham Road.
- To the east; Sturt Street.

2.1 Existing Noise Environment

The existing acoustic environment is a mixture of residential, community (education and places of worship) and commercial land usage, and is dominated by near-constant traffic noise along Ingham Road and Sturt Street, as well as general urban noise from surrounding properties.

Note that at present, it is likely that the total number of railway movements along the line to the south of the site is fewer than 15 movements per day, and rail noise does not significantly contribute to the overall $L_{Aeq,24hr}$ noise level. This would normally trigger treating the Ingham Road + North Coast Railway cumulatively as a 'Type 1' multi-modal corridor (i.e. against the criteria for State-controlled roads); however it must be noted that due to the recent (possibly temporary) closure of the nickel smelter at Townsville, freight movements on the North Coast Line are lower than usual and therefore current conditions are not necessarily representative of the likely maximum rail noise exposure of the site.

Therefore, for the purposes of the noise assessment for West State Private Hospital, it is considered most appropriate to assess against noise criteria for a Type 2 multi-modal corridor (>15 train movements per day) to account for potential future increases in the number of train movements.

Note that Ingham Road and Sturt Street, although significant for consideration of noise intrusion to the development, are not state-controlled roads and hence do not influence the selection of criteria for assessment.

2.2 Noise-Sensitive Receivers

The nearest noise-sensitive receivers to West State Private Hospital developmemt site are:

- residential properties on Lamington Street, to the north-west
- Townsville West State School and residential properties on Wilson Street, to the north
- St Mary's Church and Edmund Rice Education Flexible Learning Centre, located across Ingham Road to the south of the development

2.3 Measured Noise Levels

To quantify the existing noise environment, a noise survey was conducted on the site and surrounding areas. The noise survey consisted of a combination of unattended noise measurements using a noise logger and operator-attended measurements.

A noise logger (ARL Ngara noise logger, serial number 878107) was set up on the proposed development site approximately 5 m north of the Ingham Road footpath, as shown in Figure 2.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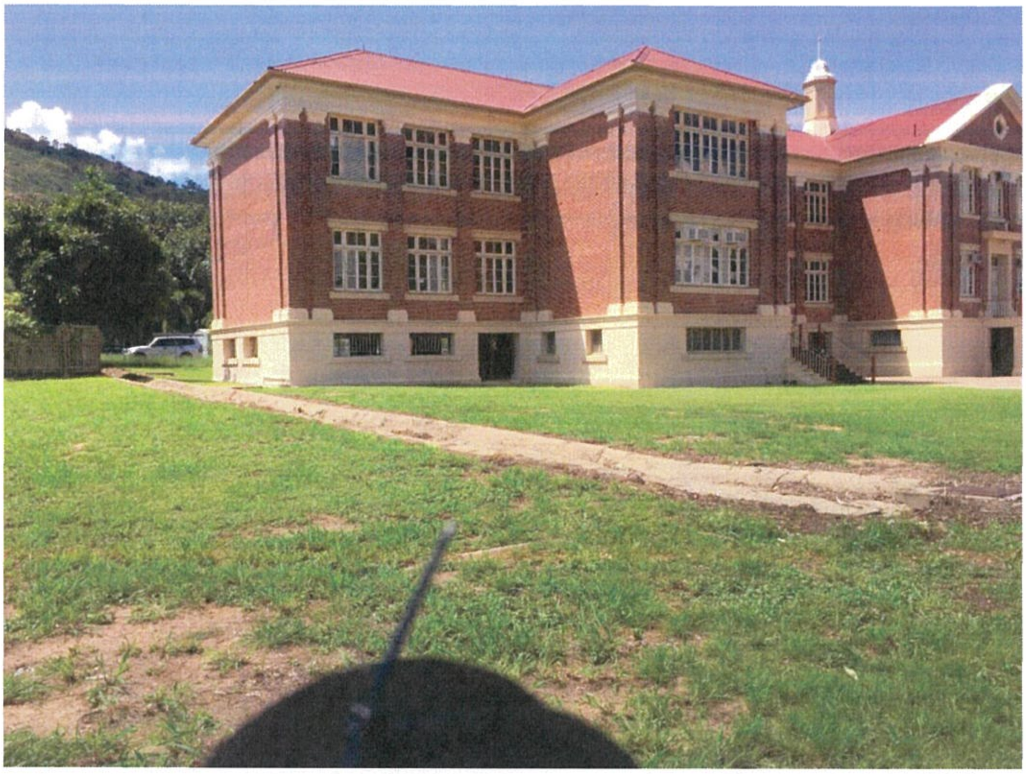


Figure 2 Noise Logger Location at proposed West State Private Hospital

The noise logger measured the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} noise parameters over 15-minute intervals from 22 March 2016 to 24 March 2016.

Averaged noise levels from the noise logger are presented in Figure 3.

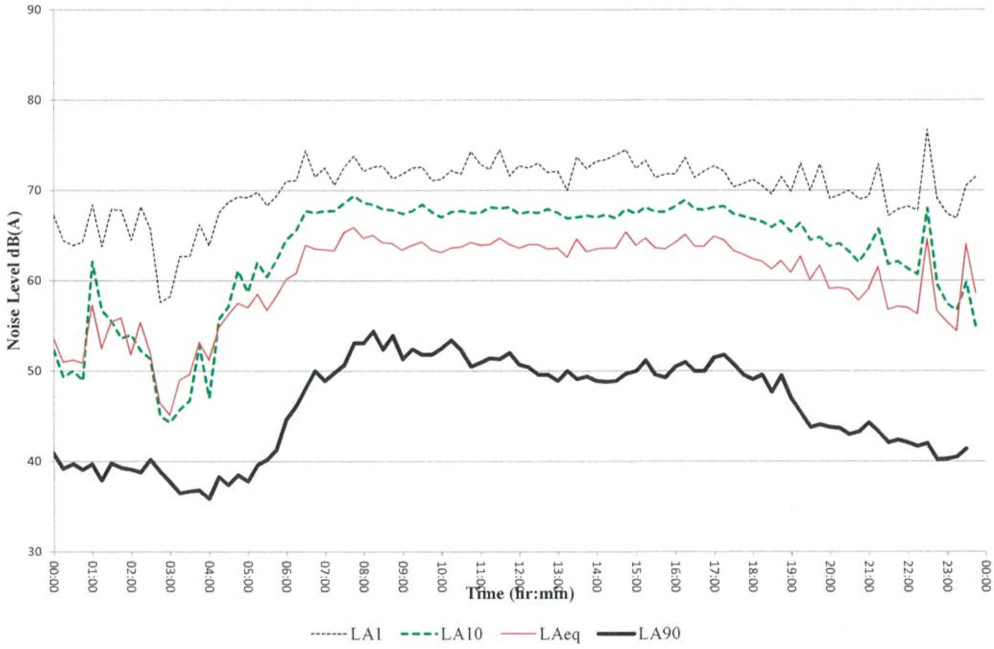


Figure 3 Average Noise Levels, Noise Logger, 22 March to 24 March 2016, dB re 20 μPa

To supplement the noise logger measurements, and to obtain traffic source levels for use in the façade design, attended measurements were taken by Matthew Tripodi of Arup on 22 March, 23 March and 24 March 2016, using a Brüel and Kjær Type 2270 sound level meter (S/N 3008107) and a PCB Piezotronics 393B12 accelerometer (S/N 27441). The accelerometer was mounted on a soil spike and firmly secured in the soil. The sound level meter was checked for calibration using a Brüel and Kjær Type 4231 calibrator before and after each measurement session. No significant drift in calibration occurred.

Simultaneous noise and vibration measurements were taken adjacent to the noise logger location, approximately 3 m away to avoid reflections from the operator affecting the measurements, as shown in Figure 4.

Figure 4 Attended Measurement Location, West State Private Hospital

The attended noise measurements are summarised in Table 1.

Table 1 Attended Measurements, West State Private Hospital, 22-24 March 2016

Comments	**Duration**	**Noise Measurements, dB re 20 µPa**			
		L_{A1}	L_{A10}	L_{Aeq}	L_{A90}
Average AM Peak Traffic Noise	10 mins, average of 12 measurements	73	68	65	53
Average PM Peak Traffic Noise	10 mins, average of 12 measurements	72	68	64	51
Spirit of Queensland Pass-By (northbound)	Pass-by, excluding horn	71	68	65	56
Spirit of Queensland Pass-By (southbound).	Pass-by, excluding horn	77	73	70	58
Diesel Engine pass-by (no wagons)	Pass-by, excluding horn	76	68	65	55
Average Heavy Vehicle Pass-By	Pass-by	73	72	67	60

The loudest single event (which will be used for façade design) is the southbound Spirit of Queensland pass-by, with a maximum noise level (free-field) of 77 dB(A) at the logger location. The southbound Spirit of Queensland is louder than the northbound because the train speed is higher running south compared to northbound where the train is accelerating away from a station stop.

A summary of the measured vibration levels is provided below in Figure 5 (rms vibration spectrum) and Figure 6 (peak vibration spectrum), with the Vibration Criterion (VC) curves overlaid for reference. Most medical equipment will operate satisfactorily with ambient vibration levels at or below the VC-C curve (", although some particularly-sensitive equipment may require VC-D to operate.

Figure 5: Measured RMS Vibration Velocity Spectra, West State Private Hospital

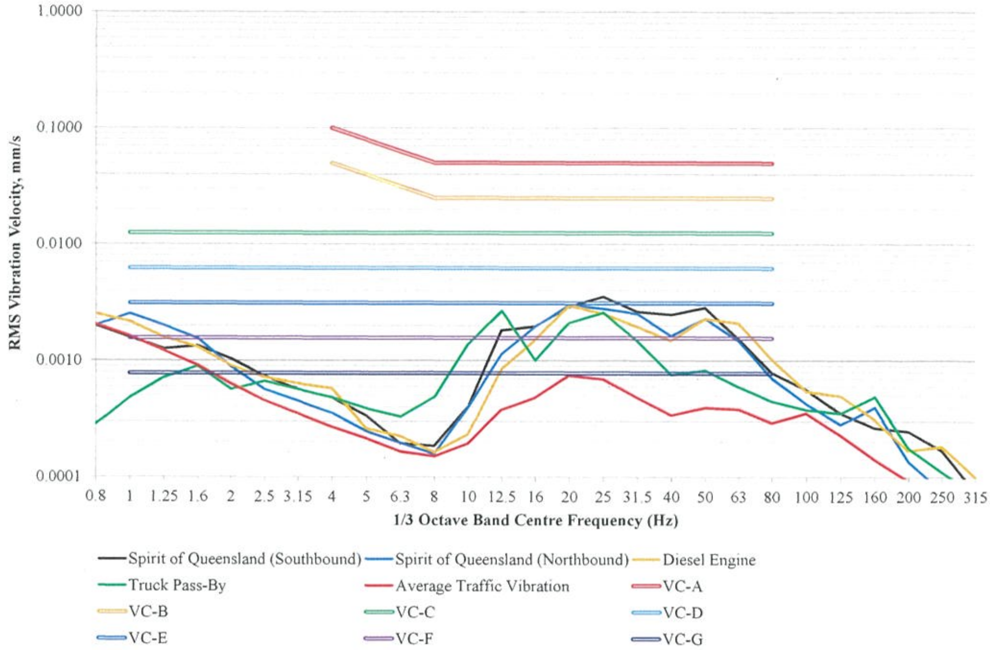
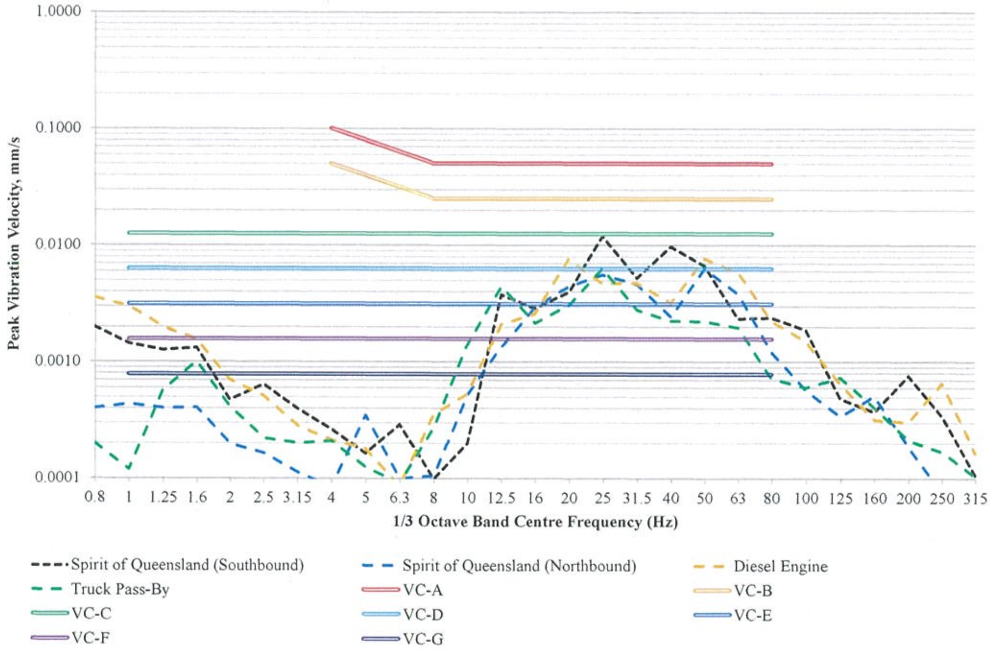


Figure 6: Measured Peak Vibration Velocity Spectra, West State Private Hospital



As can be seen from the measured vibration levels, ambient vibration in ground is likely to be at approximately VC-D, with occasional peaks to VC-C or VC-B. Based on the measured vibration levels, and with careful selection of equipment, appropriate location on site (e.g. away from the railway line at the northern end of site) and appropriate structural design of the building, adverse vibration impacts on medical equipment are not expected.

3 Performance Criteria

Ratings have been proposed for Acoustic Privacy, Noise Sensitivity and Noise Generation for each space in Table 2 below based on Arup's understanding of the client needs and the intended uses of the spaces and good practice guidance from Australian standards (particularly AS 2107 (2000) *Acoustics – Recommended design sound levels and reverberation times for building interiors*) and international guidelines (e.g. the UK Department of Health's *Acoustics: technical design manual 4032* and *Specialist Services Health Technical Memorandum 08-01: Acoustics* (HTM-08-01). Using these ratings and background design levels as provided in Table 3, the required level of sound insulation between functional spaces can be determined.

The ratings are based on the following factors:

- **Acoustic privacy** refers to the degree to which activities in a functional space should be inaudible in adjacent areas.
  E.g. a consultation room used for sensitive medical discussions would require high acoustic privacy to prevent discussions being heard in adjacent rooms.
  - **Confidential** privacy means that raised speech in a room would be just audible but not intelligible in adjacent rooms, while normal speech would is unlikely to be audible
  - **Private** privacy means that normal speech would be audible but not intelligible in adjacent rooms.
  - **Not Private** privacy means that normal speech would be audible and intelligible in adjacent rooms
- **Noise sensitivity** refers to the degree to which a functional space will be disrupted by external noise levels (i.e. the expectation of 'quiet' in a space).
  E.g. a private room is highly sensitive to sleep disturbance from external noise intrusion
  - **Sensitive** means that a room should not normally experience audible noise from adjacent rooms
  - **Medium** sensitivity means that a room should not usually experience audible noise from adjacent rooms, but activities in adjacent rooms will occasionally be audible
  - **Not Sensitive** means that noise from other rooms does not affect the use of the room
- **Noise generation** refers to the likely level of noise associated with activities in a space.
  E.g. a retail/services space can have high noise generation but low/no noise sensitivity

The actual level of sound insulation between two spaces will depend on their adjacency to each other and the acoustic rating system in Table 2. For example, if a high noise generation space is located adjacent to a high noise sensitivity space this will require a higher performing acoustic separation to achieve the desired criteria.

3.1 Acoustic Quality Objectives

Table 2 Proposed Acoustic Privacy, Noise Sensitivity and Noise Generation ratings

Area	Acoustic Privacy	Noise Generation	Noise Sensitivity
Public/Patient Lounges Staff Lounges	Not Private	High	Not Sensitive
Maxillofacial Suite Cardiology Suite Operation/Procedure Rooms Anaesthetic Preparation Rooms Control Rooms	Private	Typical	Sensitive
Radiology	Private	High	Sensitive
Sterilising Supply Department Scrub Rooms Scope Reprocessing Area Pharmacy	Not Private	High	Not Sensitive
Consultation Rooms Interview Rooms	Confidential	Typical	Medium
Staff Support Clinical Support Pathology Services	Moderate	Typical	Medium
Day Unit Recovery Unit Recovery Suite	Moderate	Typical	Medium
Private Bedroom Isolation Room	Confidential	Typical	Medium
Open Plan Office Staff Education/Research	Not Private	Typical	Medium
Private Offices Meeting Rooms Boardroom	Private	Typical	Medium
Reception/Waiting Areas	Not Private	High	Not Sensitive
Retail/Service	Not Private	High	Not Sensitive
Plant	Not Private	Very High	Not Sensitive
Amenities	Moderate	Typical	Not Sensitive

3.2 Building Services Noise Levels

Recommended building services background noise levels are presented in terms of the quasi-steady L_{Aeq} noise level, as well as the Noise Rating (NR) curve is to assist in achieving a neutral background noise spectrum. In cases where the L_{Aeq} and the NR rating conflict, the NR rating should take precedence (i.e. services should be designed to meet a particular NR rating with compliance with the overall L_{Aeq} being secondary).

For spaces where increased acoustic privacy is required (e.g. reception areas where patients may be discussing medical details and multi-bed wards), services are recommended to be designed to the 'maximum' recommended levels from AS2107 in order to provide noise masking.

For other spaces where concentration is required (e.g. operating theatres) or where a quiet environment will assist recovery (private rooms) services should be designed to the 'satisfactory' levels.

Recommended background noise targets are presented in Table 3.

Table 3 Recommended Background Noise Targets, dB re 20 μPa

Area	L_{Aeq}, dB	NR
Staff or Patient Lounges Waiting Areas	45	40
Operation/Procedure Rooms Anaesthetic Induction Rooms Control Rooms	40	35
Diagnostic Imaging Sterilising Supply Department Scrub Rooms Cardiology / Maxillofacial	45	40
Specialist Consultation Rooms Interview Rooms	40	35
CEO Office Private Office Meeting Rooms	40	35
Staff Support Clinical Support	45	40
Private Bedroom	35	30
Day Unit Recovery Intensive Care	40	35
Open Plan Office Reception/Waiting Areas	45	40
Retail/Service	50	45
Amenities	55	50

3.3 Noise Ingress

There are typically three types of noise sources which are considered for noise ingress:

- Continuous noise sources (e.g. near-constant road noise)
- Intermittent noise sources (e.g. railway pass-bys)
- Rain noise on roof

For façade-located spaces, criteria have been developed to address these noise sources considering the recommendations of AS2107 and the UK Department of Health Guidelines, applicable QLD government policy (refer Section 3.3.1) and Townsville City Council development code requirements.

3.3.1 QLD Government Requirements

The QLD Environment Protection (Noise) Policy 2008 provides acoustic quality objectives for noise-sensitive land uses for "health and wellbeing", which are intended as "aspirational" long-term targets.

QLD DTMR's *Policy for Development on Land Affected By Environmental Emissions from Transport and Transport Infrastructure* (TMR Policy) 2013 and the QLD State Development Assessment Provisions Code 1.1 *Managing Noise and Vibration Impacts from Transport Corridors State Code* (SDAP) provides criteria for noise-sensitive developments located adjacent to transport noise corridors to control external noise impacts. These criteria are based in part on the objectives from the EPP(Noise).

Performance Outcome P07 of the SDAP code states *Development involving a hospital achieves acceptable noise levels for workers and patrons by mitigating adverse impacts on the development from noise generated by a railway with 15 or more passing trains per day or a type 2 multi-modal corridor.*

Acceptable Outcomes A07.1, A07.2 and A07.3 of the SDAP code provide performance criteria for healthcare buildings. These are equivalent to the performance criteria in the TMR Policy and therefore meeting the requirements of the TMR Policy will also meet the requirements of Acceptable Outcomes A07.

The TMR Policy sets out primary noise criteria for new sensitive development, which are external criteria, as well as secondary internal criteria. The Policy does not specify whether it is sufficient to just meet the primary criteria or whether both primary and secondary criteria must be met. On previous projects, TMR has clarified that since the external criteria are denoted as "primary" criteria, satisfying the external criteria is sufficient to demonstrate compliance with the Policy, and the secondary criteria are only applicable in cases where the primary criteria cannot be met.

For a development near a railway (or a multi-modal corridor that includes a railway with more than 15 movements per day), the Policy sets out the following primary criteria for healthcare usage:

- External 65 dB $L_{Aeq,1hr}$ (façade-corrected)
- External 87 dB $L_{Amax,single\ event}$ (façade corrected).

The following secondary (internal) criteria would apply:

- Sleeping Areas and Wards 45 dB $L_{Amax,single\ event}$
- Patient Care Areas 50 dB $L_{Amax,single\ event}$

3.3.2 Noise Ingress Criteria

Criteria for steady or quasi-steady noise sources such as road traffic noise have generally been based on not exceeding the recommended 'maximum' noise levels in AS 2107 during the loudest hour ($L_{Aeq,1hr}$), supplemented by the UK Department of Health guidance.

Criteria for maximum noise level have been based on the TMR Policy requirements, extrapolating for other usages based on the relative noise sensitivity of each space in AS2107, as well as the UK Department of Health guidance.

Rain noise criteria are only given for the top floor spaces within the new-build component of West State Private Hospital, since other floors will have a concrete slab above, and it is understood that the existing roof of the former Townsville West Public School building will be retained.

Table 4 Recommended noise ingress targets, dB re 20 μPa

Area	Continuous Noise	Maximum Noise	Rain Noise
	$L_{Aeq,1hr}$	$L_{Amax,fast}$	$L_{Aeq,1hr}$
Private Rooms Intensive Care Day Unit Recovery Area	35 dB	45 dB	40 dB
Operation/Procedure Rooms Anaesthetic Induction Rooms Control Rooms	40 dB	50 dB	-
Consultation Rooms	40 dB	50 dB	-
Office Areas	45 dB	55 dB	-
Diagnostic Imaging	45 dB	55 dB	-
Staff and Clinical Support Areas	45 dB	55 dB	-
Patient Lounges	45 dB	55 dB	-

3.4 Sound Insulation

Sound insulation performance targets for partitions have been specified based on the acoustic performance matrix in Table 2 for each space. Partition constructions to meet the required performance are given in Section 4.2.

The required sound insulation performance for acoustically-rated partitions and acoustically-rated areas of the façade is presented on marked-up drawings in Appendix B.

3.5 Room Acoustics

The reverberation time is a key (although not the only) parameter in quantifying the room acoustic of a space. It quantifies the decay rate of sound in a room and is controlled by the amount of sound absorption and the volume of a space.

Mid-Frequency and low-frequency[1] target reverberation times have been determined with reference to AS 2107 and from previous experience and are presented in Table 5.

These reverberation times apply to furnished but unoccupied spaces.

Note that some spaces have no requirement to control room acoustics and are excluded from Table 5.

Table 5 Recommended Reverberation Time Targets

Area	Low-Frequency Reverberation Time	Mid-Frequency Reverberation Time
Discharge Lounge Patient Lounges	0.6 to 1.0 s	0.6 to 0.8s
Maxillofacial Operation/Procedure Rooms Anaesthetic Induction Rooms Control Rooms	0.4 to 0.7 s	0.4 to 0.7 s
Diagnostic Imaging Sterilising Supply Department Scrub Rooms Scope Reprocessing Area	0.4 to 0.9 s	0.4 to 0.7 s
Consultation Rooms	0.4 to 0.8 s	0.4 to 0.6 s
Staff Support Clinical Support	0.6 to 1.0 s	0.6 to 0.8s
Day Unit Recovery	0.6 to 1.0 s	0.6 to 0.8s
Private Bedroom Isolation Room	0.4 to 0.6 s*	0.4 to 0.6 s*
Open Plan Office	0.6 to 1.0 s	0.6 to 0.8s
CEO Office	0.4 to 0.8 s	0.4 to 0.6 s
Reception/Waiting Areas	0.6 to 1.0 s	0.6 to 1.0 s

* Note that room furnishings in these rooms typically will achieve the acoustic targets without further acoustic treatment

[1] Mid-frequency reverberation times are the average of the 500 and 1k Hz octave band reverberation times. Low-frequency reverberation times are the average of the 125 Hz and 250 Hz octave band reverberation times.

3.6 Noise Egress Requirements

Townsville City Council does not specify noise criteria for environmental noise emission, and refers to the QLD Environmental Protection (Noise) Policy 2008 [EPP(Noise)] assessing environmental noise emission from the development (refer Section SC6.4.3.15 of the Townsville City Plan 2014).

The acoustic quality objectives in the EPP (Noise) are "intended… to be progressively achieved… over the long term". As such, these quality objectives represent aspirational noise targets rather than necessarily absolute noise emission criteria for the project. The objectives in Table 6 are presented for information.

Table 6: Environment Protection (Noise) Policy Acoustic Quality Objectives

Land Use	Time Period	Acoustic Quality Objective		
		$L_{Aeq,1hr}$	$L_{A10,1hr}$	$L_{A1,1hr}$
Residential (Outdoors)	Daytime and Evening	50	55	65
Residential (Indoors)	Daytime and Evening	35	40	45
	Night	30	35	40
Educational institution (indoors)	When in use	35	-	-
Commercial or retail activity (indoors)	When open for business	45	-	-

The EPP(Noise) defines criteria for "background noise creep", set based on whether the noise source in question is continuous or varying:

- For continuous sources, noise from the activity (L_{Aeq}) must not exceed 0 dB(A) above the ambient $L_{A90,T}$
- For varying sources, noise from the activity (L_{Aeq}) must not exceed 5 dB(A) above the ambient $L_{A90,T}$

These criteria apply "to the extent that it is reasonable" to control noise from the activity in question. Table 7 sets out the applicable environmental noise criteria for the development.

Table 7: Environmental Noise Criteria, EPP(Noise)

Noise Source	EPP(Noise) Limits, dB L_{Aeq}		
	Day	Evening	Night
Continuous Sources (e.g. mech plant)	49	42	38
Varying Sources (e.g. loading dock)	54	47	43

4 Acoustic Design

4.1 Building Envelope

Based on the site measurements and logger data, the following building envelope constructions are recommended in order to achieve the acoustic design criteria. In some cases more than one option is provided.

4.1.1 New-Build Roof

The new building roof will need to provide sufficient sound insulation against both external noise sources and rain noise.

The minimum roof slab thickness to control rain noise and vertical noise transfer from rooftop plant is 250 mm concrete, based on a design rainfall rate of 40 mm/h which is typically used for sensitive applications in tropical Australia.

Alternative roofing systems may also be considered however, lightweight roofs typically will all have a requirement to have additional mass layer below the lightweight outer skin to mitigate rain noise and provide sufficient airborne sound insulation.

4.1.2 Required Façade Acoustic Performance

Façade mark-ups showing the required façade performance for West State Private Hospital are provided in Appendix B.

Indicative façade constructions to meet the performance requirements are given below in Table 8. Acoustic performance of glazing can vary by ~1-2 R_w between different manufacturers; the actual façade construction required to meet the acoustic performance should be determined based on manufacturer's test data (i.e. the acoustic rating R_w+C_{tr} takes precedence over the indicative construction in selecting façade glazing).

Table 8 Façade Glazing Constructions

Required Façade Performance	Example Construction
R_w+C_{tr} 25	• 6 mm glazing (operable)
R_w+C_{tr} 30	• 6.38 mm laminated glazing (operable, high-performance seals)
R_w+C_{tr} 32	• 6.76 mm acoustic laminate glazing (operable, high-performance seals) • 10.38 mm laminated glazing (operable, high-performance seals) • 6mm glass |12 mm airgap |6.38mm laminate double glazing (fixed)
R_w+C_{tr} 34	• 10.76 mm laminate glazing (operable, high-performance seals) • 6mm glass |12 mm airgap |10 mm glass double glazing (fixed)

The predicted external and internal noise break-in levels based on these constructions are summarised in Section 4.1.3

4.1.3 Façade Noise Levels

The following noise levels are predicted on the external façades of the West State Private Hospital

Area	Façade-Corrected Noise Levels	SDAP A07.01 / TMR Policy Primary Criteria	Meets Primary Criteria?	Internal Noise Level	SDAP A07.2 / A07.3 / TMR Policy Secondary (Internal) Criteria	Meets Secondary Criteria?
Operating Theatre	63 dB $L_{Aeq,1hr}$ 74 dB $L_{Amax,fast}$	65 dB $L_{Aeq,1hr}$ 87 dB $L_{Amax,fast}$	Yes	37 dB $L_{Aeq,1hr}$ 46 dB $L_{Amax,fazt}$	50 dB $L_{Amax,fast}$	Yes
Recovery Unit (Sturt Street Façade)	**67 dB $L_{Aeq,1hr}$** 73 dB $L_{Amax,fast}$	65 dB $L_{Aeq,1hr}$ 87 dB $L_{Amax,fast}$	No	34 dB $L_{Aeq,1hr}$ 39 dB $L_{Amax,fast}$	50 dB $L_{Amax,fast}$	Yes
Private Bedrooms – Southern Façade (Ingham Road)	62 dB $L_{Aeq,1hr}$ 74 dB $L_{Amax,fast}$	65 dB $L_{Aeq,1hr}$ 87 dB $L_{Amax,fast}$	Yes	35 dB $L_{Aeq,1hr}$ 45 dB $L_{Amax,fast}$	45 dB $L_{Amax,fast}$	Yes
Private Bedrooms– Eastern Façade (Sturt Street)	**66 dB $L_{Aeq,1hr}$** 73 dB $L_{Amax,fast}$	65 dB $L_{Aeq,1hr}$ 87 dB $L_{Amax,fast}$	No	35 dB $L_{Aeq,1hr}$ 42 dB $L_{Amax,fast}$	45 dB $L_{Amax,fast}$	Yes
Consultation Rooms (New Build)	64 dB $L_{Aeq,1hr}$ 71 dB $L_{Amax,fast}$	65 dB $L_{Aeq,1hr}$ 87 dB $L_{Amax,fast}$	Yes	36 dB $L_{Aeq,1hr}$ 45 dB $L_{Amax,fast}$	50 dB $L_{Amax,fast}$	Yes
Consultation Rooms (Refurbishment)	62 dB $L_{Aeq,1hr}$ 74 dB $L_{Amax,fast}$	65 dB $L_{Aeq,1hr}$ 87 dB $L_{Amax,fast}$	Yes	39 dB $L_{Aeq,1hr}$ 49 dB $L_{Amax,fast}$	50 dB $L_{Amax,fast}$	Yes

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The Sturt Street façade of the new-building exceeds the external (primary) criteria of SDAP A07.01 and the TMR Policy. A performance-based solution is required for this façade to meet the internal (secondary) criteria of SDAP A07.02 and A07.03 and the TMR Policy for all areas.

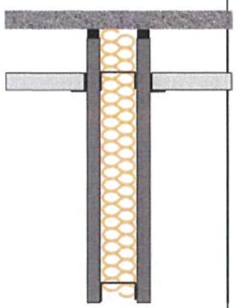
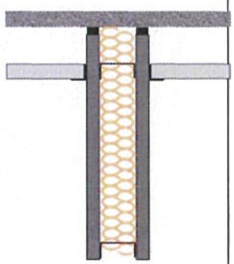
All other façades of the building comply with the external (primary) criteria of the TMR Policy. The façade design for these façades has also been conducted to meet the internal (secondary) criteria of SDAP A07.02 and A07.03 and the TMR Policy for all areas.

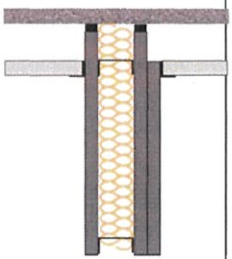
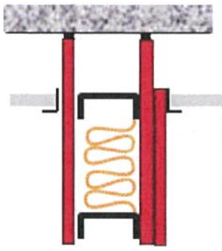
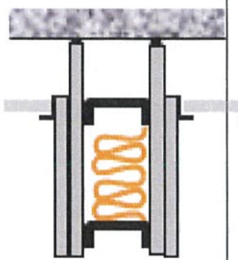
91

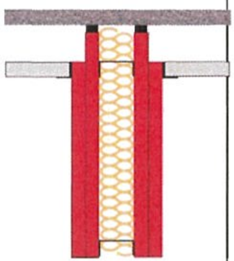
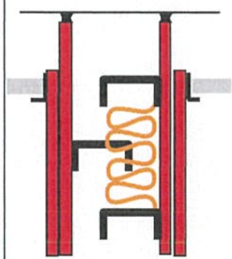
4.2 Internal Partitions

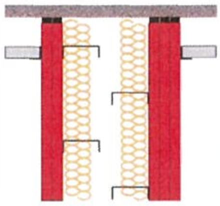
The internal partition constructions presented in Table 9 are designed to meet the acoustic quality objectives presented in Table 2. Refer to Appendix B for marked-up drawings showing partition ratings.

Table 9 Typical internal partition constructions designed to meet sound insulation targets

Sound Insulation Performance	Wall Configurations	Wall Build-up	
D_w 25	Slab-to-ceiling (with unperforated ceiling) Slab-to-slab (with open-format ceiling)		**Lightweight** • 1 x 13 mm plasterboard (≥ 8.5 kg/m² per sheet) ≥ 64 mm stud 50 mm fibreglass (33 kg/m3) in cavity (or equivalent) 1 x 13 mm plasterboard (≥ 8.5 kg/m² per sheet) **Glazed** • 6 mm glazing
D_w 30	Slab-to-ceiling (with unperforated ceiling) Slab-to-slab (with open-format ceiling)		**Lightweight** • 1 x 13 mm plasterboard (≥ 8.5 kg/m² per sheet) ≥ 92 mm stud 50 mm fibreglass (33 kg/m3) in cavity (or equivalent) 1 x 13 mm plasterboard (≥ 8.5 kg/m² per sheet) **Masonry** 75 mm Hebel **Glazing** • 10.38 mm laminate glazing OR • 6.5 mm acoustic laminate

Sound Insulation Performance	Wall Configurations	Wall Build-up	
D_w 35	Slab-to-slab		**Lightweight** • 2 x 13 mm plasterboard (≥ 8.5 kg/m2 per sheet) ≥ 92 mm stud 50 mm fibreglass (33 kg/m3) in cavity (or equivalent) 1 x 13 mm plasterboard (≥ 8.5 kg/m2 per sheet) **Masonry** 100 mm Hebel **Glazing** • 12.5 mm acoustic laminate
D_w 40	Slab-to-slab	 	**Lightweight** • 2 x 16 mm high density plasterboard (≥ 13 kg/m² per sheet) ≥ 92 mm stud 50 mm fibreglass (33 kg/m3) in cavity (or equivalent) 1x 16 mm high density plasterboard (≥ 13 kg/m² per sheet) OR • 2 x 13 mm plasterboard (≥ 8.5 kg/m2 per sheet) ≥ 92 mm stud 50 mm fibreglass (33 kg/m3) in cavity (or equivalent) 2 x 13 mm plasterboard (≥ 8.5 kg/m2 per sheet) **Masonry** • 140 mm hollow concrete block OR 100 mm Hebel ≥ 64 mm stud 50 mm fibreglass (33 kg m^{-3}) in cavity 1 x 13 mm plasterboard (≥ 8.5 kg m^{-2} per sheet) **Glazing** • Not practicable with single glazing

Sound Insulation Performance	Wall Configurations	Wall Build-up	
D_w 45	Slab-to-slab		**Lightweight** • 2 x 16 mm high density plasterboard (≥ 13 kg/m² per sheet) ≥ 92 mm stud (separate stud recommended if plumbing runs through cavity) 50 mm fibreglass (33 kg/m3) in cavity (or equivalent) 2x 16 mm high density plasterboard (≥ 13 kg/m² per sheet) **Masonry** • 140 mm core-filled concrete block OR • 100 mm concrete **Glazing** • Not practicable without large airgap double glazing
D_w 50	Slab-to-slab		**Lightweight** • 2 x 16 mm high density plasterboard (≥ 13 kg/m² per sheet) ≥ 150 mm cavity with staggered stud (separate stud if plumbing runs through wall cavity) 50 mm fibreglass (33 kg/m^3) in cavity (or equivalent) 2x 16 mm high density plasterboard (≥ 13 kg/m² per sheet) **Masonry** • 190 mm core-filled concrete block OR 150 mm concrete **Glazing** • Not practical

Sound Insulation Performance	Wall Configurations	Wall Build-up	
D_w 55	Slab-to-slab		**Lightweight** • 2 x 16 mm high density plasterboard (≥ 13 kg/m² per sheet) ≥ 200 mm cavity with separate studs. Studs to be separated by ≥ 20 mm 50 mm fibreglass (33 kg/m³) in cavity (or equivalent) 3 x 16 mm high density plasterboard (≥ 13 kg/m² per sheet) **Masonry** • 150 mm concrete ≥ 64 mm stud with ≥ 20 mm separation from concrete 50 mm fibreglass (33 kg/m³) in cavity (or equivalent) 1x 13 mm plasterboard (≥ 8.5 kg/m² per sheet)

The following should be observed for the constructions presented in Table 9:

- All plasterboard joins should be taped and sealed.
- Where multiple layers of plasterboard are used joints shall be overlapped between layers, taped and sealed.
- Metal stud framing or furring channels should be installed at minimum 600 mm centres.
- Head and foot channels should be mechanically fixed to the ceiling slab and floor slab, and be fully sealed with a bead of non-hardening sealant beneath the channel.
- Edge joints to masonry walls or columns shall be close fitting, with a gap of maximum width 20 mm. The gaps should be filled with non-hardening sealant such as Selleys ProSeries FireBlock.
- Care with detailing will be required where the partitions meet the façade in order to maintain the sound insulation performance(e.g. cladding/packing of mullions) for higher-rated partitions.
  Acoustic treatment details for partition/façade interfaces will be developed during ongoing design
- Air transfer ducts/grilles should not be located across acoustically-rated constructions unless the transfer ducts are acoustically treated (e.g. lined bends, crosstalk attenuators etc as required to match the acoustic performance of the partitions).
- Service penetrations (such as GPO's, medical gas outlets, switches etc) should be staggered across wall studs. If back-to-back electrical penetrations are unavoidable, an appropriate acoustically rated backing box should be used.
- All building services penetrations through acoustically-rated partitions are to be appropriately sealed. Sealing details for services will be provided during ongoing design.

4.2.1 Doors

Doors will limit the overall sound insulation of a partition since they are generally of much lighter construction than the partition, and they are difficult to effectively seal. While high performance doors can be provided, it should be understood that they are likely to be heavy, more difficult to operate and relatively expensive.

Depending on the arrangement of the door, and the relationship of the room to other adjacent spaces, a door with a sound insulation performance less than the partition itself will typically be appropriate.

Nominal sound insulation performances of typical door constructions in correspondence with partition sound insulation targets are provided in the table below.

These performance requirements are indicative and apply for general situations where the door occupies a small (~20% or less) proportion of the overall partition area. In cases where the door occupies a significant proportion of the partition area, an increased door performance will be required in order to maintain the overall partition acoustic rating.

Note that higher-performance doors require properly-engaging acoustic seals. This may require coordination with infection control requirements and may necessitate a down-rating of the acoustic separation between spaces should infection control take precedence.

Undercuts beneath doors will essentially negate the acoustic performance of the door. The mechanical services design should not rely on air balance via door undercuts for any acoustically-sensitive rooms.

Indicative door constructions to achieve the sound insulation targets are presented in Table 10.

Table 10 Indicative door and framing constructions

Partition Rating	Nominal Door Rating	Typical Construction and Sealing Arrangement
Up to R_w+C_{tr} 30	R_w25	• Solid core (minimum 40 mm) or specialist acoustic glazed door, well fitted to effective frame • Strip seals to head, jambs, meeting stiles and threshold (can be sweep seal) • Vision panel (if required) to comprise 4 mm glass
R_w+ C_{tr} 35	R_w30	• Solid core (minimum 45 mm) or specialist acoustic glazed door, well fitted to effective frame • Compression seals to head, jambs, meeting stiles and threshold (can be drop seal) • Vision panel (if required) to comprise 6 mm glass
R_w+ C_{tr} 40	R_w35	• Solid core (minimum 45 mm), well fitted to effective solid frame • Double high-performance compression seals to head, jambs, meeting stiles and threshold (can be drop seal) • Vision panel (if required) to comprise 10.6 mm laminated glass
R_w+ C_{tr} 45	R_w40	• Proprietary acoustic rated doorset OR • Two back-to-back lobbied R_w25 doors with not less than 200 mm void between.
R_w+ C_{tr} 50	R_w45	• Proprietary acoustically-rated doorset OR • Two back-to-back lobbied R_w35 doors with not less than 200 mm void between.

4.2.2 Ceilings

In cases where partitions do not extend to the slab above, sound transfer between rooms via the ceiling void and along the ceiling tiles will limit the overall sound insulation between rooms. Therefore, floor-to-ceiling constructions are only acceptable for partitions requiring sound insulation ratings up to approximately D_w 30 (subject to the actual acoustic performance of the selected ceiling system; perforated ceiling systems are essentially acoustically transparent and cannot be used with floor-to-ceiling construction).

Even with a <D_w 30 rated partition, care needs to be taken to ensure that a full airtight seal is achieved between the head of the partition and the underside of the ceiling. This will be further reviewed as design develops.

4.2.3 Floor/Ceiling Systems

Minimum slab/ceiling constructions to achieve the required vertical sound insulation performance are summarised in Table 11.

Table 11- Acoustic Slab/Ceiling Constructions

Space A (Upper)	Space B (Lower)	Slab/Ceiling Construction Requirement
Interview Rooms	Radiology	150mm concrete
Day Unit	Kitchen	150mm concrete
Operating Theatres Anaesthetic Preparation Rooms	Interview Rooms	150mm concrete
Recovery Area	Day Unit	200mm concrete
Rehab Suite	Operating Theatre	200mm concrete
Maxillofacial Cardiology	Operating Theatre	200 mm concrete
Private Rooms	Maxillofacial Cardiology	200 mm concrete
Private Rooms	Rehab Suite Recovery Bays	200 mm concrete
Plant	Private Rooms ICU	250 mm concrete

4.3 Room Acoustics

4.3.1 General Considerations

The location of acoustic finishes can have a significant impact on the room acoustic performance of a space.

- Breakout areas and nurse call areas can cause disturbance to surrounding patient areas.
  A highly-absorptive ceiling finish is recommended above these areas in conjunction with partial-height 'screens' (where practicable) to reduce the disturbance to surrounding areas.
- Due to hygiene and infection control requirements, acoustic treatment on walls is unlikely to be possible.
- Acoustic finishes for healthcare applications typically require specialist products.

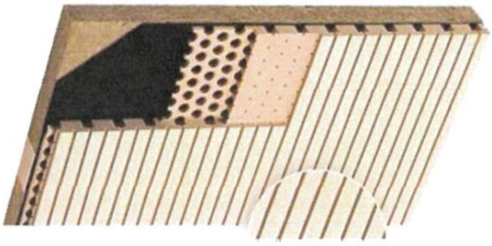
To meet the mid-frequency reverberation time targets presented in Section 3.5 acoustic finishes will be required for most functional spaces. The location and types of acoustic finishes will be determined during ongoing design.

Table 12 presents the minimum random incidence sound absorption co-efficient for typical products in a healthcare environment and Table 13 provides recommendations for suitable products.

Table 12 Minimum random incidence sound absorption coefficients for acoustic finishes

Description		**Minimum Recommended Random Incidence Absorption Coefficients, α Octave Band Centre Frequencies, Hz**					
	NRC	**125**	**250**	**500**	**1k**	**2k**	**4k**
Ceilings							
Acoustic Ceiling Tile	0.85	0.40	0.85	0.90	0.90	0.90	0.90
Perforated/Slotted Ceiling Panel	0.70	0.80	0.80	0.75	0.70	0.50	0.50
Floors							
Carpet Tile	0.20	0.05	0.05	0.10	0.20	0.50	0.50
Walls							
Wall acoustic panel	0.70	0.35	0.80	1.00	1.00	1.00	0.95

Table 13 Recommended types of acoustic finishes

	Descriptions and Minimum Requirements	
Ceilings		
Acoustic Ceiling Tile	Description:	Mineral ceiling tile (≥ 200 mm void behind) such as Ecophon Master A, Armstrong Ultima.
Perforated/ Slotted Ceiling Panel	Description:	Perforated metal, plasterboard, plywood, MDF or equivalent. 50 mm fibreglass backing (30-40 kg/m^3) and 200 mm cavity behind, not less than 15% open area such as Topakustik. 

Locations and extents of acoustic finishes will be developed with the Architect as design progresses.

4.4 Building Services Noise

Noise due to mechanical plant when combined with electrical and hydraulic services should meet the noise targets in Section 3.2.

The following should be considered in the design of the mechanical services systems:

- The selection of quiet equipment. This is the most important factor for achieving in-room noise levels for private rooms since there is very little scope for incorporating noise attenuation into FCU systems serving small rooms.
- Space planning of plant locations to be outside of and away from noise sensitive spaces.
- Careful aerodynamic design so that regenerated noise from bends and take-offs is low enough to ensure that the noise limits are met. This will include:
  a) Arrangement of duct routes for smooth airflow conditions in ductwork (minimising regenerated noise at bends, take-offs and transitions, etc)
  b) Designing the system to be as self-balancing as possible (thereby minimising the need for volume control devices)
  c) Controlling velocities in ducts to be adequately low. The lowest background noise levels for ducted systems in the project are 35 dB L_{Aeq} (for private rooms).
     Typically this would require in-duct air velocities in the order of no more than 3.0 m/s once the ductwork is inside the space.
  d) Selection of terminal units i.e. grilles and diffusers to comply with criteria (taking into account other building services noise sources).
- The need for duct-mounted attenuators on both the supply and extract systems.
- Mechanical services should not undermine the sound insulation. The following should be considered:
  a) Flexible ductwork should not pass through full height partitions.
  b) Cross talk attenuators (or additional acoustic treatment) if ductwork systems serve adjacent noise sensitive spaces.
  c) Avoiding cross talk via flexible ductwork in areas where high levels of sound insulation is required.
  d) Attenuation of air transfer paths in any sound insulating construction.
  e) Effective sealing of all ductwork/ pipework/ cable penetrations.
  f) Avoiding door undercuts or transfer grilles in any acoustically-rated partition
- Acoustic lagging for pipework located in occupied spaces to meet the criteria.
- Plant may need to be provided with appropriate anti-vibration mounts to meet vibration limits. Any plant equipment planned to be located on the roof should incorporate vibration isolation to reduce vibration entering the building structure which can result in structure borne noise

- Tonality and pulsating noise should not be present in any habitable spaces. Tonality is defined as occurring when a one -third octave band value is 5 dB higher than the arithmetic average of the decibel values in the adjoining third octave bands. Pulsing noise refers to any noise characteristic that is evidenced by fluctuations in noise level by more than ± 2 dB.
- The use of an electronic sound masking system should be considered for multi-bed wards or other large areas where services noise may not be even across the floor area, in order to provide noise masking to reduce disturbance from e.g. nurse call stations, patient alarms etc.

4.5 Environmental Noise

4.5.1 Building Services Plant/Equipment

Mechanical or electrical equipment from the development has not been selected at this stage of design.

During ongoing design of the development, mechanical and electrical equipment will be selected and provided with noise attenuation measures as required in order to meet the noise limits given in Table 7.

4.5.2 On-Site Traffic Movements

A screening calculation of noise impacts from the visitor and staff parking areas has been conducted to determine the likely scale of impacts (if any) from parking and pick up/drop off activities at the development.

Note that noise from emergency services vehicles is excluded from assessment under QLD noise criteria.

For vehicle movements within the parking areas, the Calculation of Road Traffic Noise (CoRTN) methodology that is used in QLD for road traffic noise on public roads is not applicable, because vehicle noise emission at very low speeds is dominated by engine noise rather than rolling noise, and CoRTN does not extend to speeds below 30 km/h. A different prediction method was adopted for on-site traffic movements using previous measured pass-by noise levels from cars at low speed (<20 km/h), with a 60-minute equivalent line source sound power level $L'_{w,eq,1hour}$ of 51 dB/m per vehicle.

This was scaled to an absolute "worst case" scenario of 100% turnover of vehicles within a parking area arriving/leaving over a 1-hour period. This scenario is considered unlikely to occur in practice and (if ever) would likely only occur during the Day time period.

The following overall source levels were obtained:

- Southern visitor parking and pick up/drop off areas (100% turnover of 57 spaces) $L'_{w,eq,1hour}$ 68 dB/m.
- Western visitor parking (100% turnover of 30 vehicles) $L'_{w,eq,1hour}$ 66 dB/m.
- Northern staff parking (100% turnover of 23 vehicles) $L'_{w,eq,1hour}$ 65 dB/m.

This sound power was distributed along line sources located within the internal circulation roads within the West State Private Hospital, with the sound power of each source line being weighted according to the number of car spaces along each road. Table 14 presents a summary of the predicted noise levels from traffic flows along the parking areas upon the nearest noise sensitive receivers.

Table 14: Predicted noise level from traffic flows along internal roads, West State Private Hospital, dB re 20 µPa

Receiver	Predicted Level $L_{Aeq,1hr}$	Time Period	Criteria	Meets Criteria?
Residential properties on Lamington Street	44 dB	Day	54 dB	✓
Townsville West State School Residential properties on Wilson Street	42 dB	Day	54 dB	✓
St Mary's Church Edmund Rice Education Learning Centre	40 dB	Day	54 dB	✓

Noise levels at all receivers are predicted to comply with the EPP(Noise) criteria for noise emission from West State Private Hospital.

4.5.3 Traffic Noise on External Roads

Due to the high existing traffic volumes on Ingham Road and Sturt Street, additional traffic noise impacts associated with the West State Private Hospital are anticipated to be negligible.

4.5.4 Loading/Unloading Activities

It is anticipated that loading/unloading activities would only occur during the Day and Evening time periods.

The source location has been assumed to be via the secondary vehicle entry off O'Brien Street.

Two components of noise from vehicle movements on site have been assessed:

- Vehicles accessing the loading dock
- Vehicles unloading within the loading dock.

Noise levels from vehicle movements on site have been predicted using previous Arup measurements of vehicles in loading docks (all noise levels measured at ~4.5 m distance):

- Accessing the loading dock: 56 dB $L_{Aeq(event)}$
- Unloading: 60 dB $L_{Aeq(event)}$

Using these source noise levels, noise levels from operation of the loading docks at the development have been predicted as presented in Table 15

Table 15: Predicted noise level from loading/unloading, West State Private Hospital, dB re 20 µPa

Receiver	Predicted Level $L_{Aeq,1hr}$	Time Period	Criteria	Meets Criteria?
Residential properties on Lamington Street	29-32 dB	Day	54 dB	✓
		Evening	47 dB	✓
		Night	43 dB	✓
Townsville West State School	33-37 dB	Day	54 dB	✓
St Mary's Church Edmund Rice Education Learning Centre	3-7 dB	Day	54 dB	✓

Noise levels at all receivers are predicted to comply with the EPP(Noise) criteria for noise emission from West State Private Hospital.

5 Summary

An acoustic assessment of the predicted noise impacts of the proposed West State Private Hospital has been conducted, assessing against relevant Townsville City Council and QLD Government policy, and deriving performance criteria for the proposed development against applicable Australian Standards and international good practice guidance.

An assessment of railway traffic noise impacts on the development has been conducted in accordance with DTMR's *Policy for Development on Land Affected By Environmental Emissions from Transport and Transport Infrastructure* (TMR Policy) 2013 and the QLD State Development Assessment Provisions Code 1.1 *Managing Noise and Vibration Impacts from Transport Corridors State Code* (SDAP).

The Sturt Street façade of the proposed new-build component of the hospital is predicted to experience traffic noise levels in excess of the primary (external) criteria from the TMR Policy. Accordingly, the building façade has been designed to meet the secondary (internal) criteria.

All other façades of the proposed West State Hospital are predicted to experience noise levels below the primary external criteria.

Internal sound insulation, background noise and room acoustic performance targets have been derived based on the guidance of AS2107 and UK Department of Health technical manuals, which represent international good practice in the design of healthcare facilities.

Noise impacts from operation of the proposed West State Private Hospital are predicted to be negligible compared to applicable impact criteria derived from the QLD Environmental Protection (Noise) Policy.

"A"

Appendix A

Acoustic Terminology

A1 Glossary of Acoustic Terminology

Absorption Coefficient, α

The amount of sound absorbed by a sample is characterised by the absorption coefficient, α. A perfect absorber (e.g. a sufficiently large opening in a room) from which no sound is reflected has an absorption coefficient of 1.00. There are two common methods for measuring sound absorption coefficients of a material.

One, the impedance tube method, is useful for readily obtaining results and only requires a small sample to be tested, but is limited in that it can only measure the *normal-incidence absorption coefficient* – i.e. the absorption coefficient for a single angle with sound propagating perpendicular to the material.

The other method, the reverberation chamber method, requires more extensive tests and a larger (~10 m²) sample size, but obtains the *random-incidence absorption coefficient*- i.e. the effective absorption coefficient of the material averaged over all angles. The random-incidence absorption coefficient is required for detailed room acoustic calculations.
Note that the reverberation chamber method can legitimately measure coefficients greater than 1.0 due to "edge effects" such as diffraction or scattering from the edges of the sample. These edge effects are reduced by using a barrier around the sample or by using a larger sample.

Weighted absorption coefficient (α_w)

The weighted absorption coefficient, defined in ISO 11654 is a frequency-weighted single number absorption coefficient used to categorise the overall absorption effectiveness of a material.
Descriptors are used to indicate if the material absorbs strongly at high ("H"), mid ("M") and/or low ("L") frequencies – e.g. a material may be rated as α_W 0.85(LH), which indicates that it strongly absorbs at both low and high frequencies.
The weighted-absorption coefficient is also used to assign materials into five absorption classes (materials with very low absorption are not assigned a class): Class A has the highest absorption, with Class E having the lowest absorption.

Noise-reduction Coefficient (NRC)

The noise reduction coefficient (NRC) is the (arithmetical) average of the sound-absorption coefficients of a material at 250Hz, 500Hz, 1kHz and 2kHz. It is intended for use a single-number index of the sound absorbing efficiency of a material.

Ambient Noise Level

The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.

Background Noise Level

The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects.

Assessment Background Level (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Rating Background Level (RBL / min$L_{A90,1hour}$)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW, and min$L_{A90,1hour}$ in QLD.

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting ("A-weighting") to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the "average maximum" level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the "average minimum" or "background" level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB L_{Aeq}. Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

L_{max}

The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

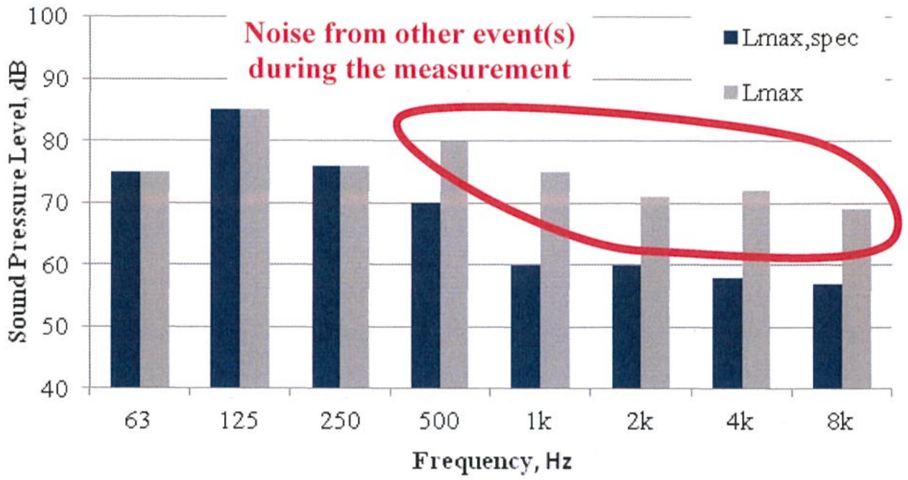
Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

Since L_{max} is often caused by an instantaneous event, L_{max} levels often vary significantly between measurements.

$L_{max\ spec}$

$L_{max\ spec}$ is another representation of the highest noise or vibration levels during the measurement period.

$L_{max\ spec}$ is the spectrum of the event that caused the highest overall sound or vibration level during the measurement period is denoted by dB $L_{max\ spec}$. An example of the relationship between dB L_{max} and dB $L_{max\ spec}$ is shown below.



L_{max} (see definition above), when measured on an octave band or 1/3 octave band meter, is the spectrum obtained by recording the highest measured value in each band. However, the highest measured values in each band may occur at different times.

Hence, $L_{max\ spec}$ represents a real event, while L_{max} is often the mathematical addition of frequency band values from different times and often does not represent a real-world event.

Since $L_{max\ spec}$ is caused by an instantaneous event, $L_{max\ spec}$ levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as "pitch". Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or "low-pitched" and sounds with a higher frequency are perceived as "treble" or "high pitched".

Impact Sound Pressure Level

The technical parameter used to determine impact sound isolation of floors is the impact sound pressure level, L_i.

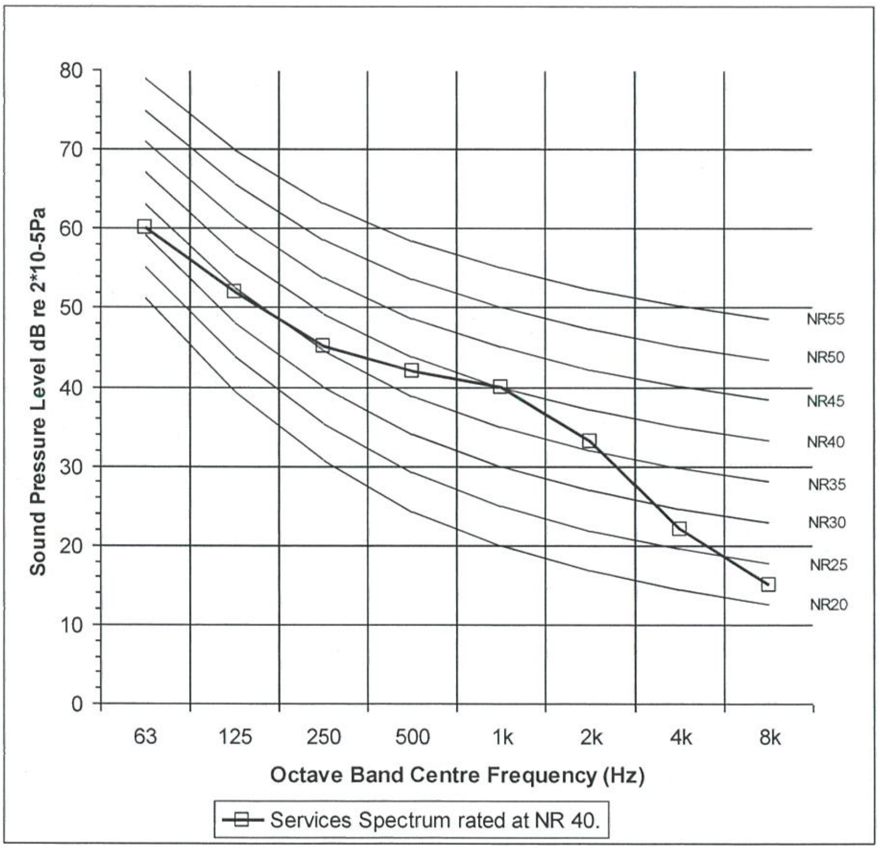
In the laboratory, the weighted normalised impact sound pressure level, $L_{n,w}$, is used to represent the impact sound isolation as a single figure.

On site, the weighted normalised apparent impact sound pressure level, $L'_{n,w}$, and the weighted standardised apparent impact sound pressure level, $L'_{n,Tw}$, are used to represent the impact sound isolation of a floor as a single figure.

These single weighted values are determined by comparing the spectral impact sound pressure levels (as defined in ISO 140-6 & ISO 140-7) with reference values outlined in AS/NZS ISO 717.2.

Noise Rating (NR) Curves

Noise rating (NR) curves are a set of internationally-agreed octave band sound pressure level curves, based on the concept of equal loudness. The curves are commonly used to define building services noise limits. The NR value of a noise is obtained by plotting the octave band spectrum on the set of standard curves. The highest value curve which is reached by the spectrum is the NR value. Shown below is a plant noise spectrum that is equivalent to NR 40.

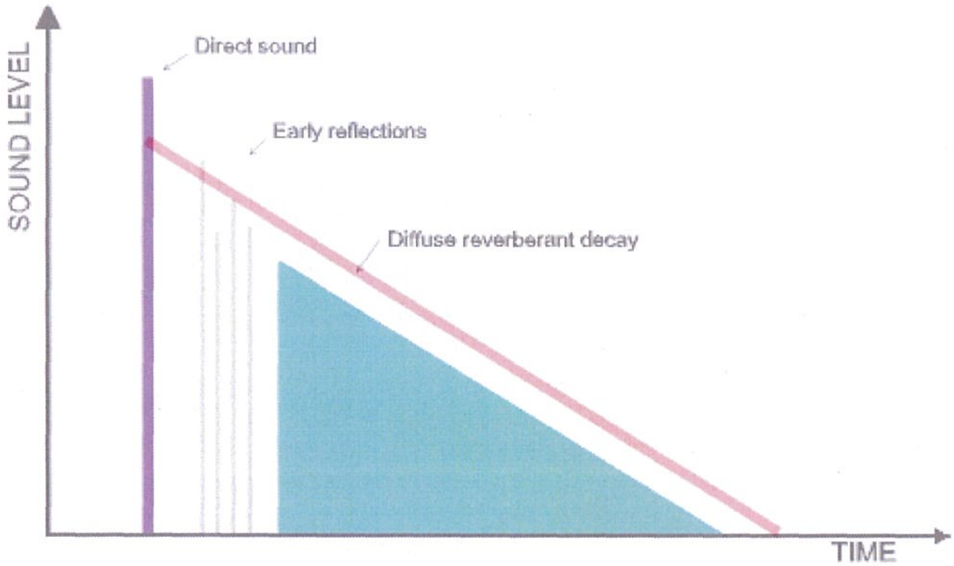


Reverberation Time (T_{60})

The time, in seconds, taken for a sound within a space to decay by 60 dB after the sound source has stopped is denoted at the reverberation time. The RT is an important indicator of the subjective acoustic within an auditorium. A large RT subjectively corresponds to an acoustically 'live' or 'boomy' space, while a small RT subjectively corresponds to an acoustically 'dead' or 'flat' space.

Examples of typical design reverberation times are provided below:

Mid-frequency Reverberation Time, s	Example
< 0.1	Anechoic
0.1 – 0.4	Call centres
0.4 – 0.6	Library
0.6 – 0.8	Offices / board rooms
0.8 – 1.0	Small auditorium for speech
1.0 – 1.2	Music studios
1.2 – 1.5	Chamber music venues
1.5 – 2.0	Orchestral music venues
2.0 – 3.0	Church
3.0 – 8.0	Cathedral



Sound Level Difference (D)

Sound level difference is used to quantify the sound insulation between two spaces, and is equal to the difference in sound level between the two rooms at a particular frequency (e.g. if the sound level in the source room is 100 dB and the sound level in the adjacent room is 75 dB, the sound level difference is 25 dB). The weighted sound level difference, D_w, (as defined in AS/NZS ISO 717.1) is commonly used to provide a single-number descriptor to describe the overall performance of a partition across a wider frequency range.

The terms used to describe the airborne sound insulation rating of a building element when tested on-site are the weighted normalised level difference ($D_{n,w}$), which corrects the measured sound level difference to a reference absorption area in the receiving room, or the weighted standardized level difference ($D_{nT,w}$), which corrects the measurements to a reference reverberation time in the receiving room. These single numbers are determined by comparing the spectral sound insulation test results (as defined in ISO 140-4) with reference values, as outlined in AS/NZS ISO 717.1.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Sound Reduction Index (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, i.e. its sound attenuation properties. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency.

The weighted sound reduction index, R_w, is a single figure description of sound reduction index across a wider frequency range and is defined in BS EN ISO 717-1: 1997. R_w values are calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site measurements (which are invariably lower than the laboratory figures) are referred to as apparent sound reduction index (R'_w) ratings.

Spectrum Adaptation Terms (C and C_{tr})

The terms C and C_{tr} are spectrum adaptation terms (in dB) that are added to the R_w or D_w value of a partition in order to determine the overall sound insulation rating of a partition for various conditions. The overall performance of the partition is quoted as the sum of the Rw value and the spectrum adaptation terms, e.g. $D_w + C$ 55 dB; $R_w + C_{tr}$ 60 dB.

C is a spectrum adaptation term used to measure the performance of a partition for medium to high-frequency noise sources, such as speech.

C_{tr} is a spectrum adaptation term used to measure the performance of a partition for low-frequency noise sources such as traffic noise.

The values of C and C_{tr} are dependent on the construction of the partition. Because C and C_{tr} are (usually) negative quantities, they typically increase the Rw requirement of a partition (eg if C_{tr} is -6 dB, an R_w of 56 dB is required to achieve a rating of $R_w + C_{tr}$ 50 dB).

Vibration

Waves in a solid material are called "vibration", as opposed to similar waves in air, which are called "sound" or "noise". If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.

"A"

Appendix B

Sound Insulation Requirements

Document Set ID: 16730845
Version: 1, Version Date: 10/04/2017

B1 Sound Insulation Mark-Ups

Marked-up drawings showing the internal sound insulation and façade requirements are provided overpage.

Internal partition requirements are shown via a solid line, as per the following legend:

Partition Acoustic Rating	Mark-Up Colour
D_w 25	
D_w 30	
D_w 35	
D_w 40	
D_w 45	
D_w 50	
D_w 55	

Façade sound insulation requirements are indicated by dashed lines, as per the following legend:

Façade Acoustic Rating	Mark-Up Colour
$R_w + C_{tr}$ 25	■ ■ ■ ■
$R_w + C_{tr}$ 30	■ ■ ■ ■
$R_w + C_{tr}$ 32	■ ■ ■ ■
$R_w + C_{tr}$ 37	■ ■ ■ ■