



# Wathaurong Hub

## Construction Design Acoustic report

Wathaurong Aboriginal Co-operative

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# Acoustic terms and acronyms

Acronym	Definition
<b>CAC</b>	Ceiling Attenuation Class is a rating of a ceiling's efficiency as a barrier to airborne sound transmission between adjacent closed rooms.
<b>dB</b>	Unit of measurement for Sound Pressure Level known as a decibel.
<b>dBA</b>	'A-weighted' decibel measurement. Developed in the 1930s as a way to represent the sound frequency sensitivity of the human ear.
<b>D<sub>w</sub></b>	A single figure, weighted level difference covering the 16 third octave bands from 100 Hz to 3150 Hz. Measured on-site in accordance with ISO 16283-1 and rated in accordance with ISO 717-1.. It is a field measurement that indicates the sound insulation between rooms and relates to the R <sub>w</sub> laboratory measurement of a material or building element. The higher the number the better the insulation performance.
<b>HVAC</b>	Heating, Ventilation and Air Conditioning
<b>IIC</b>	Impact Insulation Class – A single number rating derived from measured values of normalized impact sound pressure levels in accordance with Method of ASTM E 492, Annex A1, Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine. It provides an estimate of the impact sound insulating performance of a floor-ceiling assembly.
<b>L<sub>Aeq</sub> (Time)</b>	Equivalent sound pressure level is the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring. This is considered to represent ambient noise.
<b>L<sub>A90</sub> (Time)</b>	The A-weighted sound pressure level that is exceeded for 90 per cent of the time over which a given sound is measured. This is considered to represent the background noise.
<b>L<sub>A10</sub> (Time)</b>	The arithmetic average of the sound pressure level that is exceeded for 10 per cent of the time specified. This is considered representative of the average maximum noise
<b>L<sub>n,w</sub></b>	Weighted Normalised Impact Sound Pressure Lev. A single figure representing of the impact sound insulation of a floor or wall based upon the impact sound pressure level measured in a laboratory
<b>L<sub>nT,w</sub></b>	Weighted Normalised Standardised Field Impact Sound Pressure Level. It is a field measure of the amount of impact sound reaching a space via a floor. The equivalent field measurement to L <sub>n,w</sub> laboratory measurement. The lower the number the better the performance.
<b>NRC</b>	Noise Reduction Coefficient – single number rating which represents the average of sound Absorption Coefficients of a material at specific mid-range frequencies (250, 500, 1,000, and 2,000 Hz octaves)
<b>RC</b>	Room Criteria
<b>R<sub>w</sub></b>	Weighted Sound Reduction Index. A single number descriptor facilitating comparison of the performance of different partitions measured in a laboratory, derived from a curve fitting technique to measure data of calculated 1/3 octave band centre frequency transmission loss (TL) data for the partition between 100 Hz and 3150 Hz

Acronym	Definition
<b>Sound Pressure Level (SPL)</b>	The Sound Pressure level is the change in air pressure above and below the average atmospheric pressure (amplitude) cause by a passing pressure wave; this is then converted to decibels and can be abbreviated as SPL or $L_p$ .
<b>Sound Power Level (SWL)</b>	This is defined as the average rate at which sound energy is radiated from a sound source and is measured in watts (W). The Sound Power Level can be abbreviated as SWL or $L_w$ .
<b>STC</b>	The term is referred to as Sound Transmission Class. A measure of the sound insulation performance of a building element in a laboratory test conditions. A single number rating derived from measured values of transmission loss in accordance with ASTM E 413. It provides an estimate of the performance of a partition in certain common sound insulation situations.

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# 1. Introduction

This Acoustic Report outlines key acoustic requirements for design of the Wathaurong Hub redevelopment Project (the Project). GHD has prepared this Acoustic Report to establish acoustical design criteria to be used for the Project, and to provide key design recommendations to help ensure early coordination with the respective design disciplines.

## 1.1 Purpose of this Report

The purpose of this report is to summarise the outcomes from the review undertaken by GHD for the Wathaurong Hub redevelopment Project in accordance with the outlined scope of works below.

The scope of work involved the following key acoustic considerations:

- Review of Architectural Drawings (Woods Bagot, 40 % CD Issue *dated 26 September 2024 (Rev F)*).
- Determination of internal noise, vibration, reverberation and acoustic separation targets in identified sensitive spaces with reference to applicable acoustic standards and guidelines.
- Identification of key internal noise and vibration sources that may influence the acoustic design of the proposed Project.
- Preparation of an Acoustic Report as part of the Construction Design submission.

## 1.2 Limitations

*This report: has been prepared by GHD for Wathaurong Aboriginal Co-operative and may only be used and relied on by Wathaurong Aboriginal Co-operative for the purpose agreed between GHD and Wathaurong Aboriginal Co-operative as set out in Section 1.1 of this report.*

*GHD otherwise disclaims responsibility to any person other than Wathaurong Aboriginal Co-operative arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.*

*The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.*

*The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.*

*The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section(s) 1.1 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.*

## 1.3 Assumptions

The following assumptions have been considered in completing this Acoustic Design Report:

- This Report is based upon the available information provided by a third party.
- Constraints associated with other factors such as security, safety, ventilation and structural loading may place limitations on the acoustic performance and what can be practically achieved in terms of acoustic performance.
- The Acoustic Design Report is intended to be utilised in conjunction with all other design documentation as a basis of the design parameters, however, it remains the Main Contractor's responsibility to ensure that all aspects of the design and implementation is included in accordance with the relevant standards and statutory requirements whether or not detailed in this document.
- The acoustic treatments provided in this report represent a sample of the potential options available, alternative products may be suitable upon further investigation. Should alternative means of construction system be proposed, it shall be reviewed and approved by the Acoustic Design Team, and it remains the responsibility of the Contractor to ensure that the installed system(s) satisfy the acoustic requirements stipulated in the drawings, specifications and relevant documents.

- The acoustic performance of construction materials is often stated as a single number acoustic descriptor such as Noise Reduction Coefficient (NRC) or Sound Reduction Index (Rw). The NRC or Rw of a material discussed in the report is a single number calculated by averaging the sound absorption coefficients or sound transmission loss over a range of octave bands and as such, it is possible two materials with similar NRC or Rw to have very different acoustic properties. Therefore, the NRC or Rw should be used as an informative quantity only. When making a decision on a product for a particular application, the sound absorption or sound reduction in all octave bands should be taken into account.

## 2. Criteria

The following sections outline the relevant guidelines and standards that are considered for the acoustic design of the Project. It outlines the relevant design basis for each of the project acoustic design elements and brief commentary in relation to applicable standards as detailed below:

- Australia / New Zealand Standard (AS/NZS) 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors*.
- VIC Building Quality Standards Handbook (BQSH, VIC Government, May 2024).
- Association of Australasian Acoustical Consultants (AAAC) *Guideline for Commercial Facilities* Version 2.0 (November 2020) (AAAC Guideline)
- Association of Australasian Acoustical Consultants (AAAC) *Guideline for Healthcare Facilities* Version 2.0 (July 2017) (AAAC Guideline)

For the purpose of this report, sensitive spaces refers to the following types of spaces:

- Function and pre-Function spaces
- Private offices and open plan offices
- Meeting rooms / Boardrooms
- Consult rooms
- Treatment rooms
- Mental health rooms
- Community gathering

### 2.1 Ambient noise and reverberation requirements

Australian Standard AS 2107:2016 *Acoustics – Recommended design sound levels and reverberation times for building interiors* provides recommendations regarding the internal design sound levels for rooms and spaces within buildings based on most relevant space type. AS 2107 recommended internal noise levels are for steady-state or quasi-steady-state-sound and are not specifically intended for transient external noise sources such as road traffic, rail, aircraft and the like.

AS 2107 recommends design criteria for conditions affecting the acoustic environment within occupied spaces. The recommended design sound levels take into account the function of the area and apply to the sound level measured within the space unoccupied, but ready for occupancy. The sound level during occupancy will usually be increased as a result of the activities of the occupants. Conversely, the reverberation time is typically reduced as a result of additional absorption within a room when occupied.

Recommended design sound levels below are expressed as equivalent continuous A-weighted (LAeq) sound pressure levels. In the absence of specific descriptor time-period, the recommended design indoor ambient sound levels below are expressed as equivalent continuous A-weighted (LAeq,1hour) sound pressure levels.

Reverberation time within spaces is a function of internal space volume, room geometry and internal finishes and materials. The presence of acoustically absorptive finishes within certain spaces may be influenced by other discipline design requirements. As such, there may be instances where other discipline design requirements take precedence over acoustic requirements and acoustic finishes may be constrained. Consequently, it may not be possible to achieve the reverberation times presented in Table 1 for all spaces.

Table 2.1 presents the recommended reverberation times as per AS/NZS 2107 for public and health buildings (where appropriate) and the associated requirements from the BQSH. Figure 2.1 presents the curves reference in Table 2.1 for volume specific rooms.

It is understood that interior finishes of the rooms have not been selected at this stage of design. Reverberation times should be verified in subsequent stages of design once internal finishes have been selected.

**Table 2.1** Extract of 'Table 1 – Recommended Design Sound Levels and Reverberation Times for Different Areas of Occupancy in Buildings,' AS/NZS 2107:2016

Type of Occupancy/activity	Design sound levels	Design reverberation time range (seconds)
Art galleries /Craft studios	40-45	Curve 1
Conference rooms without sound reinforcement, up to 50 persons	35-40	Curve 1
Conference rooms without sound reinforcement, 50-250 persons	30-35	Curve 1
Corridors and lobbies	45-50	0.6 to 0.8
Interview/counselling rooms	40-45	0.3 to 0.6
Consulting rooms	40-45	0.4 to 0.6
Office areas	40-45	0.4 to 0.7
Professional and administrative offices	35-40	0.6 to 0.8
Library	40-45	< 0.6
Meeting rooms (small)	40-45	< 0.6
Cafeteria, coffee shops	40-50	Minimised as practicable <sup>2</sup>
Bars	<50	Minimised as practicable <sup>2</sup>
Restaurants	40-50	Minimised as practicable <sup>2</sup>
Staff rooms	40-45	0.4 to 0.6
Staff studies/collegiate	40-45	0.4 to 0.6
<p>NOTES:</p> <ol style="list-style-type: none"> <li>1. Refer to Fig.1</li> <li>2. Reverberation time should be minimised for noise control</li> </ol>		

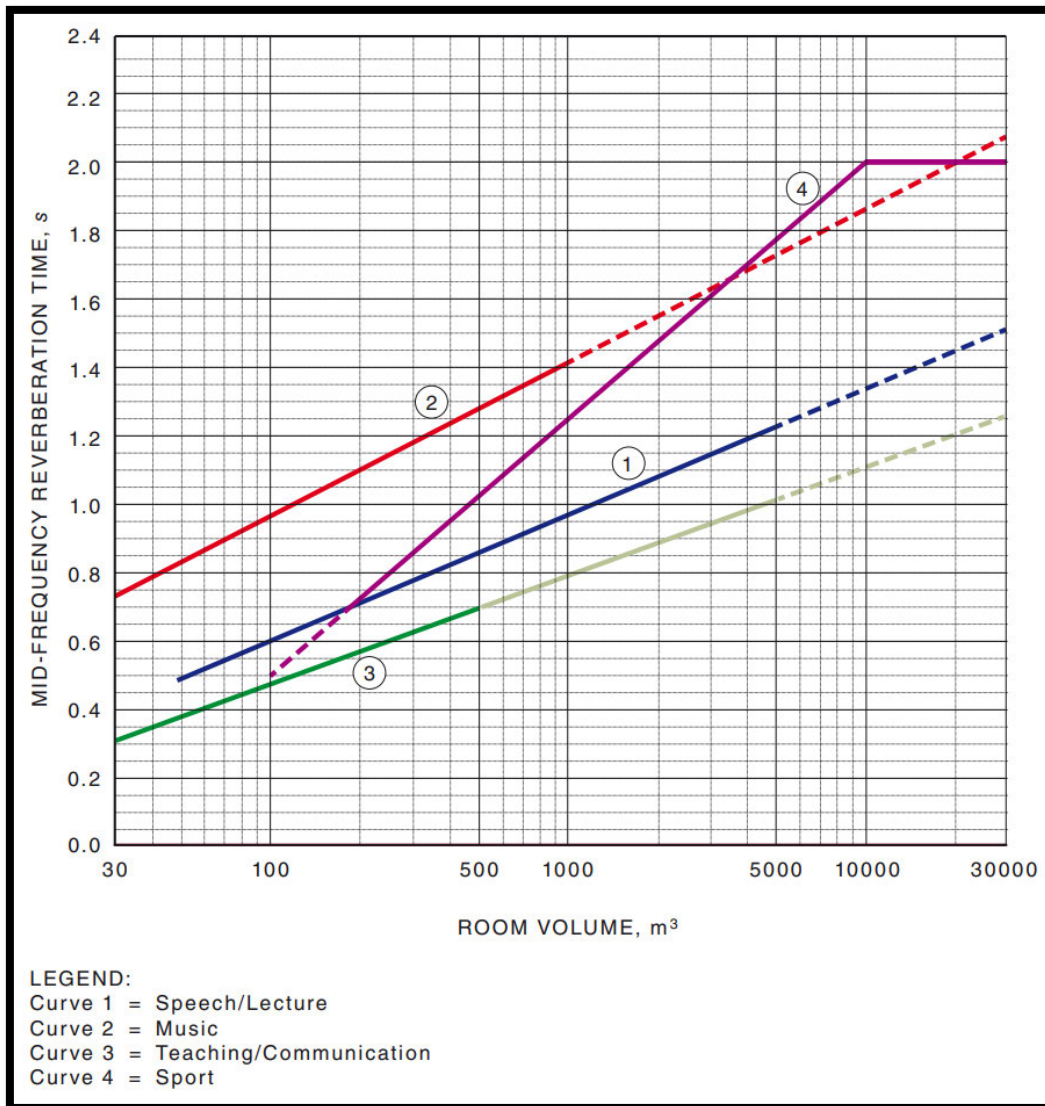


Figure 2.1 Mean reverberation times (Figure A1 from AS/NZS 2107:2016)

## 2.2 Planning Permit

Condition 22 of the Planning Permit states the following regarding noise intrusion:

*22. Concurrently with the submission of amended plans in accordance with condition 2 under this permit, an Acoustic Report must be submitted to and approved by the Responsible Authority. The Acoustic Report must be prepared by a suitably qualified professional and demonstrate:*

*a) That the level of noise which will be emitted from the subject site, including any operation requirements, will not have an unreasonable impact on the surrounding environment, in particular the nearby residential areas; and*

*b) that the future occupant of the building will be protected from noise associated with industrial land uses.*

At this stage, the Acoustic Report and required activities (including noise monitoring) have not been undertaken, therefore specific guidance related to Condition 22 of the Planning Permit is not possible as part of this scope. General advice and discussion regarding each are provided in Section 3.6 (regarding point a) of the Planning Permit) and Section 3.5 (regarding point b) of the Planning Permit).

## 2.3 Acoustic privacy / sound insulation

As there are no specific Australian Standards or government documents or requirements for a facility such as this, recommended sound insulation performances detailed in The Association of Australasian Acoustical Consultants (AAAC) *Guideline for Commercial Building Acoustics* and *Guideline for Healthcare Building Acoustics* can be used as guidance.

AAAC guideline provides more detailed guidance on sound insulation performances for partitions dividing sensitive spaces, depending upon the level of noise within one room and the tolerance of noise in the adjoining room. The recommended AAAC sound insulation performance requirements for each relevant receiving room tolerance and source room activity levels are presented in Table 2.2.

Where adjacent rooms have different speech privacy requirements, the higher requirement is applied to the partition system common to the two rooms. Note that the recommendations in Table 2.2 are applicable to common partitions between two spaces with no doors. Where doors are proposed between spaces, consideration should be given to performance requirement for doors as the performance of the separating partition will be limited by the door. As such, it is often appropriate to downgrade the required sound insulation performance of the wall containing a door to 10 – 15 dB above the sound insulation performance of the door.

Established source room activity levels and tolerance characteristics relevant to the spaces within the proposed Wathaurong Hub redevelopment Project in accordance with the recommendations of AAAC are presented in Table 2.3 (general commercial) and Table 2.4 (clinical areas).

Table 2.2 AAAC recommended sound insulation performance

Minimum $R_w$	Source room activity			
	Low	Average	High	Very High
High	$R_w$ 35	$R_w$ 40	$R_w$ 45	$R_w$ 50
Medium	$R_w$ 40	$R_w$ 45	$R_w$ 50	$R_w$ 55
Low	$R_w$ 45	$R_w$ 50	$R_w$ 55	$R_w$ 60
Very Low	$R_w$ 50	$R_w$ 55	$R_w$ 60	$R_w$ 65

Table 2.3 Established room activity and tolerance level for airborne noise – commercial office areas

Space	Room activity level	Room tolerance level
Meeting Room	High	Low
Professional and administrative offices	Average	Medium
Corridors and lobbies	Average	High
Entrance Foyer	Average	High
General office areas	Average	Medium
Change rooms / Toilets / Showers	Average	High
Store room	Low	Very High

For clinical areas, such as consult rooms, guidance is taken from the AAAC Healthcare Guideline. Relevant information is provided in Table 2.4

Table 2.4 Established room activity and tolerance level for airborne noise – clinical areas

Usage	Indicative acoustic separation	
	Adjacent	Corridor
Consulting, examination, interview, counselling/bereavement	$D_w$ 40	$D_w$ 25
Dental clinics	$D_w$ 45	$D_w$ 25
Family and parents' lounges	$D_w$ 40	$D_w$ 20

The above ratings for corridor walls is lower than what GHD would typically recommend. As such, the markups in Appendix A provide higher ratings for corridor walls.

## 2.4 Impact sound isolation

The proposed development contains scenarios where hard surfaced areas (such as toilets) are located directly above sensitive spaces, such as the Function Space.

Sources of impact noise should be controlled at the source wherever possible e.g. vinyl floor or carpet tile floor coverings with a suitable (e.g. foam or rubber) underlay are generally sufficient to control impact noise through concrete floor structures. Sources of impact noise must be separated from sensitive spaces. Impact isolation treatments must be provided where noise sensitive spaces are located below or adjacent to corridors which have high foot traffic.

The Association of Australasian Acoustical Consultants (AAAC) *Guideline for Healthcare Facilities* Version 2.0 (July 2017) (AAAC Guideline) provides recommended design impact noise levels for floors situated above sensitive areas.

Table 2.5 Recommended floor impact noise levels (Table 7 from AAAC Guideline)

Usage	Impact sound isolation $L_{n,w}$ determined according to AS ISO 717.2, dB
Consulting, examination, interview, counselling, dentistry, bereavement and the like	60
Boardroom/conference, open plan offices, private offices executive offices, cellular offices and the like Treatment, procedures, surgeries, birthing room, laboratories, hydrotherapy and the like	55
Engineering, Workshops, Plantroom	-

Based on the above, where impact isolation is required, an impact sound isolation of  $L_{n,w}$  55 is appropriate.

## 2.5 Rain noise

Whilst it is not a mandatory requirement, rain noise intrusion through any lightweight roof should be considered with a view of ensuring an adequate level of amenity for occupants.

With reference to the advice provided within the AAAC Guideline for Healthcare Facilities, the internal noise level should not exceed the upper extent of the AS 2107 noise level range by more than 5 dBA.

The extent to which rain noise on roofing requires consideration depends on the use of individual spaces. Generally, 'noise sensitive' spaces where speech intelligibility is of importance will require more stringent noise requirements.

Roof and ceiling constructions should be designed to be capable of achieving a noise level within 5 dBA of the adopted criteria under Table 2.1.

## 2.6 Hydraulic noise

Short term noise intrusion from occasional but regular hydraulic sources, such as fluid flow noise from cisterns, waste and supply pipes, will be designed to not exceed the upper range sound level in AS 2107:2016.

# 3. Acoustic design strategy

## 3.1 Internal building elements

The construction of internal building elements will be designed to control noise transfer between internal spaces to the recommended sound insulation performance for the Project. Each element will be designed such that the overall sound insulation integrity of the separation partition is maintained.

It is envisaged that a combination of lightweight and concrete block partitions will be utilised for the internal separating partitions within the Project. Table 3.1 provides a summary of each internal building element, the corresponding standard/guideline that will determine the recommended construction and general comments on the anticipated construction build up.

Markups are provided in the architectural drawing package (Drawing no. A-1500, Acoustic Compliance – Sheet 01).

**Table 3.1** Internal building element construction

Internal building element	Relevant standard/guideline	Comments
Partitions	<ul style="list-style-type: none"> <li>– AAAC Guideline for Commercial/Healthcare Building Acoustics</li> <li>– Consultation with design team, client and end user</li> </ul>	<ul style="list-style-type: none"> <li>– Consists of lightweight constructions which includes fire rated and/or sound rated plasterboard for higher rated partitions or partitions that require impact noise isolation.</li> <li>– Drawing no. A-1500 provides a mark-up of recommended acoustic partition ratings for the facility.</li> <li>– Section 3.1.1 provides a review of the proposed partition constructions for acoustic partitions.</li> </ul>
Glazing		<ul style="list-style-type: none"> <li>– Any internal glazing and/or glazed partitions will be selected such that the overall acoustic performance of the partition is not compromised.</li> <li>– Should internal glazing be proposed for partitions that require a high acoustic performance, double glazed units are likely to be required.</li> <li>– Internal glazing selected for fire and thermal performance will be reviewed at a later stage as the design progresses to ensure acoustic integrity of the glazing is appropriate for its location.</li> </ul>
Doors		<ul style="list-style-type: none"> <li>– Doors in separating partitions will result in a reduction of the performance of the overall partition rating.</li> <li>– Section Table 3.3 provides information and recommendations for door types</li> <li>– Seals will remain an important aspect of the door acoustic performance. Acoustically rated doors will require quality rubber seals to create an airtight seal around the perimeter, door bottom and for double doors at meeting stiles.</li> <li>– Door grilles and undercuts will not be allowed for acoustically rated doors.</li> <li>– Should doors be proposed where a high acoustic performance is required, proprietary acoustic doors may be required.</li> </ul>
Operable wall		<ul style="list-style-type: none"> <li>– An operable wall is to be incorporated in the Function space.</li> <li>– Where operable walls are to be incorporated, it is recommended to have an acoustic rating of not less than <math>R_w</math> 45, which would require proprietary operable walls from manufacturers such as Lotus, Hufcor or Dorma.</li> <li>– It is noted that higher rated operable walls are typically heavier and may provide manual handling constraints if the operable wall is to be used frequently. This will be further discussed and confirmed with the project architect as the design progresses.</li> <li>– Above operable door treatments are provided in Section 3.1.5</li> </ul>

Internal building element	Relevant standard/guideline	Comments
Ceilings		<ul style="list-style-type: none"> <li>For reverberation control purposes, acoustically absorptive mineral fibre tiles or perforated ceiling will be required in majority of spaces, in particular open plan offices.</li> <li>Ceiling with minimum Ceiling Attenuation Class (CAC) of 35 is recommended throughout the facility for acoustically critical spaces. Alternatively, internal partitions may be constructed full height to the slab/roof above.</li> <li>It is noted that perforated plasterboard is proposed in many areas of the development. While this is a good solution for the control of reverberation, this may not be suitable where full height walls are not proposed, or where mechanical services are proposed in the ceiling void above sensitive areas.</li> <li>Additional roof/ceiling acoustic consideration may be required for control of external and rain noise.</li> </ul>
Above partition detailing		<ul style="list-style-type: none"> <li>Walls should be extended full height in acoustically critical spaces with high sound insulation requirement.</li> <li>On level 2, full height walls are not possible due to the large ceiling void below the roof. In this case, the ceilings will need to be treated to reduce noise transfer between spaces, however it is noted that the acoustic separation is more difficult to achieve when walls are not full height.</li> <li>Services related penetrations, air transfer ductwork, electrical cabling tray etc. will be designed to ensure acoustic integrity of the partition is not compromised.</li> <li>Acoustically treated transfer air ducts or cross talk attenuators are expected for high acoustic rated walls.</li> <li>Any pressure relief in acoustic critical spaces will need to be via acoustically treated air transfer as noted above.</li> </ul>
Floors	<ul style="list-style-type: none"> <li>AAAC Guideline for Healthcare Facilities</li> <li>Consultation with design team, client and end user</li> </ul>	<ul style="list-style-type: none"> <li>Carpets or carpet tile would be expected for the majority of the sensitive spaces.</li> <li>Additional treatment may be required for hard flooring, including incorporation of an acoustic underlay, suspended ceiling, insulation within ceiling cavity, additional ceiling/floor linings and/or use of masonry construction</li> </ul>

### 3.1.1 Partition constructions

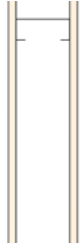


Specific partition construction details have been provided by the architect (Drawing A-6400 Rev C, dated 26 September 2024). A review of these partitions has been undertaken, in conjunction with the Acoustic Compliance Sheet (A-1500 Rev D, dated 26 September 2024) and the Partition Plans (Drawings A-2300, A-2301 and A2303, Rev C dated 26 September 2024).

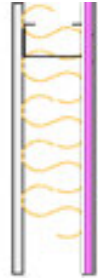

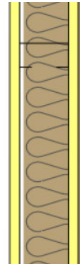
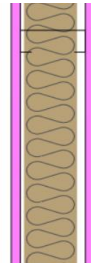
Generally these walls are in accordance with the general advice provided by GHD in Table 3.2 below, however the following is noted:

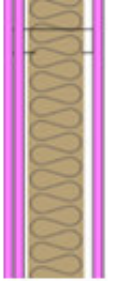
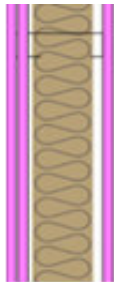
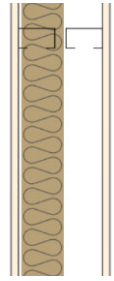
- To achieve the required acoustic rating, the studs must have a BMT of 0.75 mm or less. Any greater than this, the acoustic rating will be reduced and in some cases will not achieve the required performance
- To achieve the required acoustic rating, the studs must be at 600 mm centres. Any less than this, the acoustic rating will be reduced and in some cases will not achieve the required performance
- Acoustic treatment of mullions and the junction with the façade is imperative to maintain the acoustic performance of the separating partition. Details regarding this are provided in Section 3.1.9


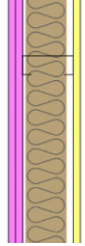


For reference and potential future use, Table 3.2 provides GHD's typical recommended partition constructions and its corresponding sound insulation rating.

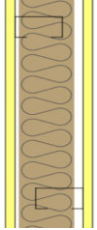
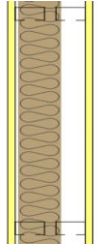
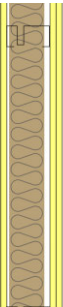
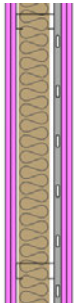
Table 3.2 Recommended acoustically rated wall constructions

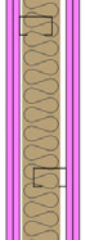
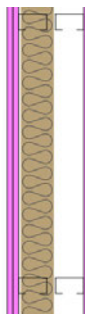
The proposed wall construction	Construction	Comments
<b>D<sub>w</sub> 30 / R<sub>w</sub> 35 rating</b>		
<p><b>Option 1 (Lightweight – Single 92 mm stud – BMT 0.75 @ 450 mm centres)</b>                      1 x 13 mm thick standard plasterboard (minimum density of 8.4 kg/m<sup>2</sup>).                      One row of 92 mm metal studwork with no cavity insulation; OR 64 mm stud with 50 mm thick acoustic insulation.                      1 x 13 mm thick standard plasterboard (minimum density of 8.4 kg/m<sup>2</sup>).</p>		<p>Partition head to meet the ceiling. Seal the joint between partition and ceiling air tight by using two strips of closed cell foam.</p> <p>Ceiling on each side of the partition to be flush plasterboard or have minimum CAC 35.</p> <p>Where perforated ceiling or ceiling with CAC of less than 35 is considered for either side of the wall, extend the wall full height or a higher performing above partition detail would be required to compensate for the resulting degradation in ceiling acoustic performance.</p> <p>Refer to Note 1 for recommendations for wet areas.</p>
<b>D<sub>w</sub> 35 / R<sub>w</sub> 40 rating</b>		
<p><b>Option 1 (Masonry)</b>                      Minimum 90 mm hollow core blockwork (minimum density 1800 kg/m<sup>3</sup>).</p>		<p>Same comments as R<sub>w</sub> 35 applies.</p>
<p><b>Option 2a (Lightweight – Single 64 mm stud – BMT 0.55 @ 600 mm centres)</b>                      1 x 13 mm thick standard plasterboard (minimum density of 8.4 kg/m<sup>2</sup>).                      One row of 64 mm metal studwork.                      1 x 13 mm thick standard plasterboard (minimum density of 8.4 kg/m<sup>2</sup>).                      75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		

<p><b>Option 2b (Lightweight – Single 64 mm stud – BMT 0.75 @ 450 mm centres)</b></p> <p>1 x 13 mm fire rated standard plasterboard (minimum density of 10.5 kg/m<sup>2</sup>).</p> <p>One row of 64 mm metal studwork.</p> <p>1 x 13 mm thick standard plasterboard (minimum density of 8.4 kg/m<sup>2</sup>).</p> <p>75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>D<sub>w</sub> 40 / R<sub>w</sub> 45 rating</b></p>		
<p><b>Option 1 (Masonry)</b></p> <p>Minimum 90 mm core filled blockwork OR</p> <p>Minimum 110 mm hollow core blockwork (minimum density 1800 kg/m<sup>3</sup>).</p>		<p>Where perforated ceiling or ceiling with CAC of less than 35 is considered for either side of the wall, extend the wall full height (slab to slab) or a higher performing above partition detail would be required to compensate for the resulting degradation in ceiling acoustic performance.</p> <p>Refer to Note 1 for recommendations for wet areas.</p>
<p><b>Option 2 (Lightweight – Single 64 mm stud – BMT 0.55 @ 600 mm centres)</b></p> <p>1 x 13 mm sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).</p> <p>One row of 64 mm metal studwork.</p> <p>1 x 13 mm sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).</p> <p>75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>Option 3a (Lightweight – Single 92 mm stud – BMT 0.55 @ 600 mm centres)</b></p> <p>1 x 13 mm thick fire rated plasterboard (minimum density of 10.5 kg/m<sup>2</sup>).</p> <p>One row of 92 mm metal studwork.</p> <p>1 x 13 mm thick fire rated plasterboard (minimum density of 10.5 kg/m<sup>2</sup>).</p> <p>75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		

<p><b>Option 3b (Lightweight – Single 92 mm stud – BMT 0.75 @ 450 mm centres)</b></p> <p>2 x 13 mm thick fire rated plasterboard (minimum density of 10.5 kg/m<sup>2</sup>).  One row of 92 mm metal studwork.  1 x 13 mm thick fire rated plasterboard (minimum density of 10.5 kg/m<sup>2</sup>).  75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>Option 3c (Lightweight – Single 150 mm stud – BMT 0.75 @ 450 mm centres)</b></p> <p>2 x 13 mm thick fire rated plasterboard (minimum density of 10.5 kg/m<sup>2</sup>).  One row of 150 mm metal studwork.  1 x 13 mm thick fire rated plasterboard (minimum density of 10.5 kg/m<sup>2</sup>).  150 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>Option 4 (Light weight – Discontinuous/double stud)</b></p> <p>1 x 13 mm thick standard plasterboard (minimum surface density of 8.4 kg/m<sup>2</sup>).  Two sets of studs separated by minimum 20 mm gap with no mechanical connection between the studs except at periphery.  1 x 13 mm thick standard plasterboard (minimum surface density of 8.4 kg/m<sup>2</sup>).  75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		

<b>D<sub>w</sub> 45 / R<sub>w</sub> 50 rating</b>		
<p>Option 1 (Masonry)            Minimum 140 mm core filled blockwork OR            Minimum 190 mm hollow core blockwork (minimum density 1800 kg/m<sup>3</sup>).</p>		<p>Full height wall (slab to slab).            Refer to Note 1 for recommendations for wet areas.</p>
<p><b>Option 2a (Lightweight – Single 92 mm Stud – BMT 0.55 @ 600 mm centres)</b>            2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>).            One row of 92 mm metal studwork.            1 x 13 mm sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).            75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>Option 2b (Lightweight – Single 92 mm Stud – BMT 0.55 @ 600 mm centres)</b>            2 x 13 mm sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).            One row of 92 mm metal studwork.            2 x 13 mm sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).            75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>Option 2c (Lightweight – Single 150 mm Stud – BMT 0.75 @ 450 mm centres)</b>            2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>).            One row of 150 mm metal studwork.            2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>).            150 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		

<p><b>Option 3 (Light weight – Staggered Stud – BMT 0.75 @ 450 mm centres)</b></p> <p>1 x 13 mm sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).</p> <p>64 mm metal studwork staggered on 92 mm track, with no mechanical connection between the staggered studwork.</p> <p>1 x 13 mm sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).</p> <p>75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>Option 4 (Light weight – Discontinuous/double stud)</b></p> <p>1 x 13 mm thick sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).</p> <p>Two sets of studs separated by minimum 20 mm gap with no mechanical connection between the studs except at periphery.</p> <p>1 x 13 mm thick sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).</p> <p>75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>D<sub>w</sub> 50 / R<sub>w</sub> 55</b></p>		
<p><b>Option 1 (Lightweight – Single Rondo Quiet Stud)</b></p> <p>2 x 13 mm thick sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).</p> <p>92 mm Rondo Quiet Stud 0.55 BMT studwork.</p> <p>2 x 13 mm thick sound rated plasterboard (minimum surface density of 13 kg/m<sup>2</sup>).</p> <p>75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		<p>Full height wall (slab to slab). Refer to Note 1 for recommendations for wet areas.</p>
<p><b>Option 2 (Lightweight – 92 mm Single Steel Stud with resilient mount – BMT 0.75 @ 450 mm centres)</b></p> <p>2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>).</p> <p>92 mm metal studwork with resilient mounts.</p> <p>2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>) on resilient mounts and furring channel.</p> <p>75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		

<p><b>Option 3 (Light weight – Staggered Stud – BMT 0.75 @ 450 mm centres)</b></p> <p>2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>). Two sets of 64 mm steel stud staggered in 92 mm track. Staggered steel studs restrained in track or angle at top and bottom with minimum 20 mm clearance between stud and opposing lining. 2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>). 75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity.</p>		
<p><b>Option 4 (Light weight – Discontinuous/double stud)</b></p> <p>2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>). Two rows of 64 mm steel stud separated by no less than 20 mm. No mechanical connection between studs except at periphery. 75 mm thick 14 kg/m<sup>3</sup> glasswool insulation in stud cavity. 2 x 13 mm thick fire rated plasterboard (minimum surface density of 10.5 kg/m<sup>2</sup>).</p>		
<p><b>Notes:</b></p> <p>13 mm standard, fire or sound rated plasterboard may be replaced with 9 mm fibre cement sheet for wet areas or impact resistance. 13 mm sound rated plasterboard may be replaced with 16 mm fire rated plasterboard where fire rating is required. Unless otherwise stated, the recommended ceiling details are based on a flush plasterboard ceiling or mineral fibre tiles with minimum Ceiling Attenuation Class (CAC) of 35. Where perforated ceiling or ceiling with CAC of less than 35 is considered for either side of the wall, above ceiling will need to be upgraded. Unless otherwise stated, wall constructions are based on 0.55 stud BMTs and 600 centres. Where higher stud BMT or closer spacing is considered, additional lining/treatment to those noted are required.</p>		

### 3.1.2 Single sided walls

In addition to the above, advice has been requested regarding single sided walls, where plasterboard is attached to one side of the stud only.

The acoustic performance of a single sided wall is limited, regardless of the number of plasterboard layers. The following provides a summary of the possible acoustic performance of a single sided wall:

- 1 x 13 mm thick standard plasterboard affixed to stud –  $R_w$  26
- 2 x 13 mm thick standard plasterboard affixed to stud –  $R_w$  32
- 3 x 13 mm thick standard plasterboard affixed to stud –  $R_w$  36
- 1 x 13 mm thick fire rated plasterboard affixed to stud –  $R_w$  28
- 2 x 13 mm thick fire rated plasterboard affixed to stud –  $R_w$  34
- 3 x 13 mm thick fire rated plasterboard affixed to stud –  $R_w$  38

### 3.1.3 Wall/slab junction

Acoustically rated wall systems extended to the underside of a slab above on ground floor and level 1 should be constructed in a manner that it will not compromise the acoustic integrity of the partition system.

All walls with an acoustic rating of  $R_w$  40 and greater should be constructed as per the details in Table 3.2, and shown in Figure 3.1

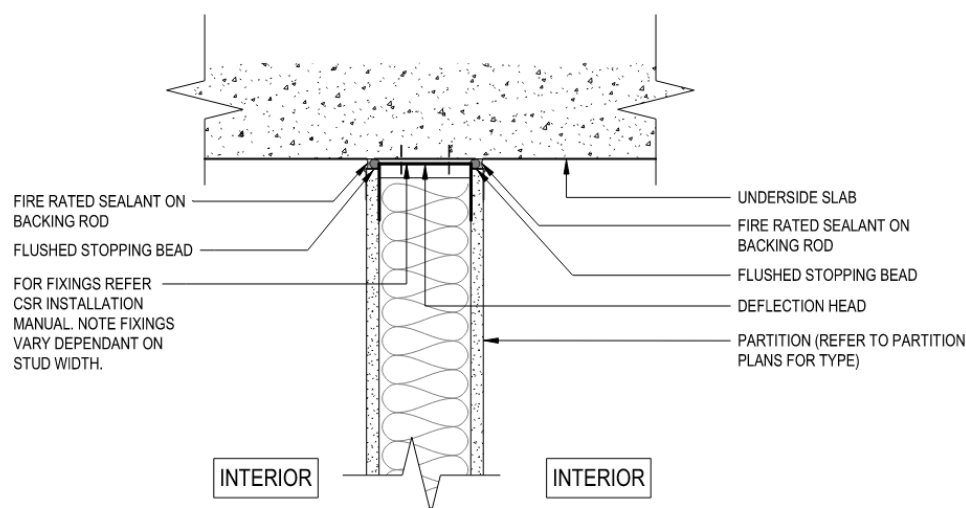


Figure 3.1 Soffit junction acoustic detail for full height walls

### 3.1.4 Non-full height walls

Level 2 walls are not able to be constructed full height due to the large void between the ceiling and the roof structure above. It is recommended that mitigation measures are implemented to reduce noise flanking between spaces via the ceiling and underfloor plenums, in areas where speech privacy is of concern, such as quiet rooms and meeting rooms.

It is noted that where walls are not full height, acoustic privacy is more challenging to achieve. This is due to the flanking path over the wall, in particular when the ceiling does not have the equivalent acoustic performance of the wall. Penetrations and mechanical services can also play a role in the reduction of acoustic separation.

Due to the use of perforated plasterboard in the majority of spaces on Level 2, the acoustic privacy of rooms where walls are not full height will be significantly reduced. As such, the following acoustic design recommendations should be implemented to achieve the acoustic privacy requirements between spaces:

- Ceilings within the offices/meeting rooms should be constructed as follows:

- 2 layers of solid 13 mm thick plasterboard
- Minimum 75 mm thick glasswool insulation (min density 14 kg/m<sup>3</sup>)
- Wall partition to extend minimum 100 mm above ceiling line. It is important that ceilings are not continuous above walls as this will significantly reduce the acoustic performance.
- Penetrations to be minimised as far as practicable
- Ensure services penetrations such as HVAC grilles are spaced apart as much as possible each side of a partition

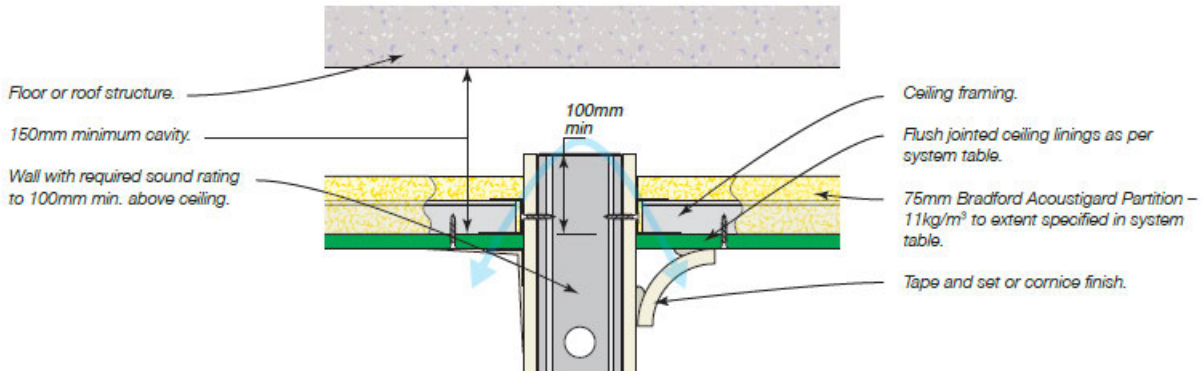


Figure 3.2 Non-full height wall ceiling treatment

It is important to note that the inclusion of a solid plasterboard ceiling will increase the reverberation time in these spaces. As such, additional acoustic treatments will be required. These are discussed in Section 3.3 below.

### 3.1.5 Operable walls

The installed acoustic rating for operable walls is generally lower than that of fixed walls. This is primarily due to flanking of sound from one space to another due to the following:

- Gaps in the ceiling and floor void
- Surrounding wall performance lower than the operable wall, and
- Poor sealing around the perimeter leaving gaps

Where operable walls are to be incorporated, it is recommended to have an acoustic rating of not less than  $R_w$  45, which would require proprietary operable walls from manufacturers such as Lotus, Hufcor or Dorma.

The operable wall perimeter seals should be installed as per manufacturer's specification to achieve the nominated acoustic rating. The operable wall should have a sound absorptive surface finish with a minimum NRC of 0.4 for reverberation control.

The operable wall head track above the ceiling line should be constructed in a manner that it does not compromise the acoustic integrity of the overall partition. Refer to Figure 3.3 below for the recommended construction details.

Any penetrations along the plasterboard panel should be acoustically treated (i.e. cut to size with perimeter seal using 100% polyurethane sealant equal to Bostik Fireban 1).

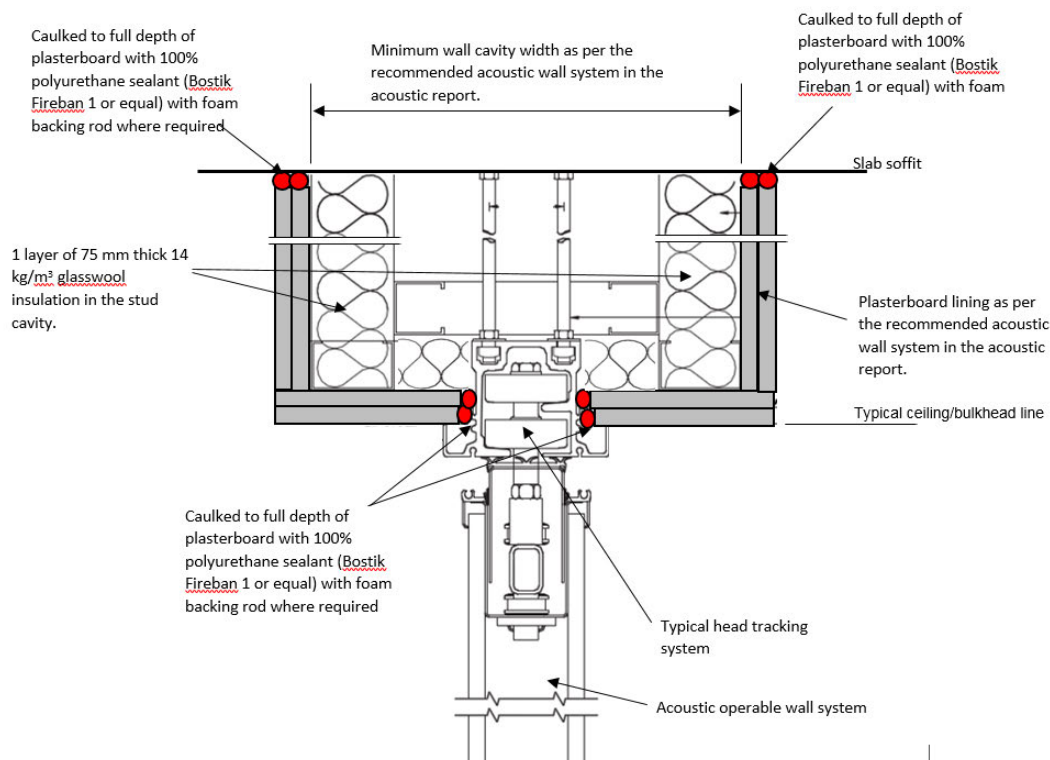


Figure 3.3 Operable wall track to steel structure baffle acoustic treatment details – sectional elevation view

### 3.1.6 Typical recommended door constructions

Doors in separating partitions will result in a reduction of the performance of the overall wall acoustic rating.

Note that mohair/brush/weather pile type seals are **not** acceptable for an acoustically rated door with a rating of  $R_w$  30 and above. All door acoustic seals where required should be compressible bulb or rubber type seals. Ensure that all installed seals are fully engaged around the perimeter of the door frame. Install all sealing joints hard-butted to each other with no gaps. It is also critical that the door provides sufficient compression against the seals to minimise noise leakage around the edges of the seals.

The installation of doors shall be conducted in the following manner:

- All acoustic perimeter seals shall be effective such that there are no gaps along the perimeter when the door is in the closed position.
- Doors shall be installed with gaps minimised along the bottom of the door. Where threshold plates are required, this shall be installed in a levelled floor.
- Perimeter seals, including threshold seals, shall be fully adjusted to ensure acoustically effective seals along the perimeter of the door.
- Gaps along the seal joints are not acceptable. Door seals shall be installed continuously around the perimeter of the door, and any joints shall be hard butted against each other.

Door grilles and undercuts are not allowed for acoustically rated doors. Acoustically treated air transfer ducts should be considered where this is required for ventilation purposes.

Table 3.3 provides GHD’s typical recommended acoustic door construction and typical acoustic performance.

Door markups are provided in Appendix A.

Table 3.3 Recommended acoustic door construction

$R_w$	Door construction	Acoustic seals
25	35 mm solid core timber door (minimum density 25 kg/m <sup>2</sup> ) <b>OR</b>	<u>Perimeter:</u> Lorient IS7025 or Raven RP24

R <sub>w</sub>	Door construction	Acoustic seals
	6 mm thick monolithic glass (framed)	<u>Double doors:</u> Rubber meeting stile recommended seals <u>Bottom seals:</u> Not required Gap to be no more than 3 – 5 mm
30	40 mm solid core timber door (minimum density 28 kg/m <sup>2</sup> ) <b>OR</b> 8 mm thick monolithic glass (framed) <b>OR</b> Acoustic proprietary R <sub>w</sub> 30 doors such as Sontron, Pyropanel or the like	<u>Perimeter:</u> Lorient IS7025 or Raven RP24 <u>Double doors:</u> Raven 16Si or Lorient IS7060si <u>Bottom seals:</u> Lorient IS8090si OR Raven RP38
35	50 mm solid core timber door (minimum density 35 kg/m <sup>2</sup> ); <b>OR</b> 35 mm solid core timber door with 1 mm thick metal sheet faced, equivalent to proprietary Sontron Spence door system <b>OR</b> 12 mm laminated glazing (framed) <b>OR</b> Acoustic proprietary R <sub>w</sub> 35 doors such as Sontron, Pyropanel or the like	<u>Perimeter:</u> Raven RP78Si or Kilargo IS7087si or Kilargo IS6030 <u>Bottom seals:</u> Raven RP38si or RP70 or Kilargo 8090si <u>Corner</u> Raven RP150 or Kilargo 1515 <u>Threshold:</u> Raven RP117si <u>Double doors:</u> Raven 16Si or Lorient IS7060si

### 3.1.7 Room fronts

The behaviour of people using a space tends to change when there is a visual link to adjacent spaces, e.g. between people in a cellular office and those outside. People are less likely to congregate in noisy groups, and the volume of confidential discussions can be managed if others are visibly close by. For these reasons, a lower acoustic rating can normally be tolerated where glazing is used in place of a solid partition for an office front.

Where doors are incorporated in partitions, such as room fronts between circulation and cellular rooms, the sound insulation of the partition will be limited by the performance of the weakest element (usually the door).

The recommended acoustic separation levels for room fronts are provided in Table 3.4. With these measures in place, speech outside the rooms could still be audible. However, it will normally require a concerted effort to be clearly understood, as opposed to the casual passer-by easily hearing conversations taking place. It is considered that this level of acoustic separation will be sufficient for rooms of these uses.

Table 3.4 Acoustic separation levels for room fronts

Wall Element	Low Privacy	Medium Privacy	High Privacy
Doors	35 dB R <sub>w</sub>	37 dB R <sub>w</sub>	>40 dB R <sub>w</sub>
Solid walls	40 dB R <sub>w</sub>	45 dB R <sub>w</sub>	>50 dB R <sub>w</sub>
Vision panels*	33 dB R <sub>w</sub>	35 dB R <sub>w</sub>	>37 dB R <sub>w</sub>
Glazed walls	35 dB R <sub>w</sub>	39 dB R <sub>w</sub>	>40 dB R <sub>w</sub>

Note: \* Vision panels may have reduced performance compared to fully glazed walls due to the limited area of glazing.

Typically, the weakest point in terms of sound insulation for any building partition will be where there are penetrations and flanking/leakage paths. Building elements such as doors or windows are also potential weak points where speech can be transmitted to adjacent areas.

The following sections identify key areas of the architectural design where challenges may exist in terms of acoustic performance and identification of potential design element options to address the challenge.

### 3.1.8 Internal glazing

Internal glazing and/or glazed partitions should be selected such that the overall acoustic performance of the partition is not compromised. Table 3.5 and Table 3.6 present the preliminary internal glazing acoustic rating and construction recommendations and their corresponding sound insulation performance for glazing within solid partitions.

For fully glazed partitions, the acoustic rating of the glazing should match the proposed sound insulation performance of the partition as per the markups provided in the architectural drawing package (Drawing no. A-1500, Acoustic Compliance – Sheet 01).

**Table 3.5** Recommended internal glazing acoustic rating

Partition rating $R_w$	Glazed element area	Recommended glazed element $R_w$
40 or less	Partially glazed	30
	Fully glazed	Same as partition $R_w$ rating
45	Partially glazed – 25% of wall area or less	35
	Partially glazed – more than 25 % of total wall area	40
	Fully glazed	45
50	Partially glazed – 25% of wall area or less	40
	Partially glazed – more than 25 % of total wall area	45
	Fully glazed	50

**Table 3.6** Internal glazing recommendation

Glazed element $R_w$	Recommended fixed glazed partition with acoustic frame and seals
30	6.38 mm laminated glass
35	10.38 mm laminated glass
40	Single glass: – 12.8 mm Pilkington Optiphon; OR – 12.5 mm Viridian VLam Hush; OR Double Glazed Unit (DGU) system comprising of: – 10.38 mm laminated / 16 mm air gap / 12.38 mm laminated – 10 mm annealed glass / 12 mm air gap / 6.38 mm laminated – 6 mm Viridian Float / 16 mm air gap / 8.5 mm Viridian Hush
45	Double glazed unit comprising of: – 10.38 mm laminated / 16 mm air gap / 12.5 mm Viridian VLam Hush; OR – 10.38 mm laminated / 20 mm air gap / 12.8 mm Pilkington Optiphon; OR – 10.38 mm laminated / 40 mm air gap / 10.38 mm laminated; OR – 10.38 mm laminated / 50 mm air gap / 6.38 mm laminated;
50	Double glazed unit comprising of: – 10.38 mm laminated / 100 mm air gap / 10.38 mm laminated; OR – 10.5 mm Pilkington Optiphon / 50 mm airgap / 12.5 mm Pilkington Optiphon; OR – 10.5 mm Viridian VLam Hush / 50 mm airgap / 8.5 mm Viridian VLam Hush

Generally, a lower acoustic rating can be tolerated where glazed partitions are used instead of a solid partition. This is due to a visual link to adjacent spaces, e.g. between people in a cellular office and those outside and as people are less likely to congregate in noisy groups, and the volume of confidential discussions can be managed if others are visibly close by.

Where doors are incorporated in partitions, such as room fronts between circulation and cellular rooms, the sound insulation of the partition will also be limited by the performance of the weakest element (usually the door). Note that for partitions with doors, the acoustic rating of the glazed element may be reduced to that of the door.

The use of doors, vision panels and glazed partitions should generally be avoided where a rating of  $R_w$  50 and above is required as significant glazing constructions will be required. For example, to maintain such high acoustic ratings with a glazed partition with significant area, large air gaps in excess of 200 mm between glass panes would typically be required.

### 3.1.9 Hard flooring treatments

Where hard flooring is proposed above sensitive areas, the following acoustic treatments are required to minimise impact noise transmission.

Installation of acoustic underlay must satisfy the following requirements.

- Underlay should be a minimum 5 mm thick. Example products include:
  - Regupol Sonus Core 5 mm
  - Damtec standard acoustic underlay
- All acoustic underlay shall be hard-butted against each other and that no gaps are visible at matting joints.
- Run acoustic underlay along the edge and ensure no direct contact between the tiles and the wall meeting surface.
- Stop floor hard finishes (tiles, etc.) 2 to 3 mm short of wall edges and caulk with resilient caulking.
- Any waterproof membrane shall be installed below and on top of the underlay, such that it provides sufficient water protection to the underlay.
- Adhesive fallings between the underlay sheets are not acceptable.
- No mechanical fixing through the acoustic underlay.

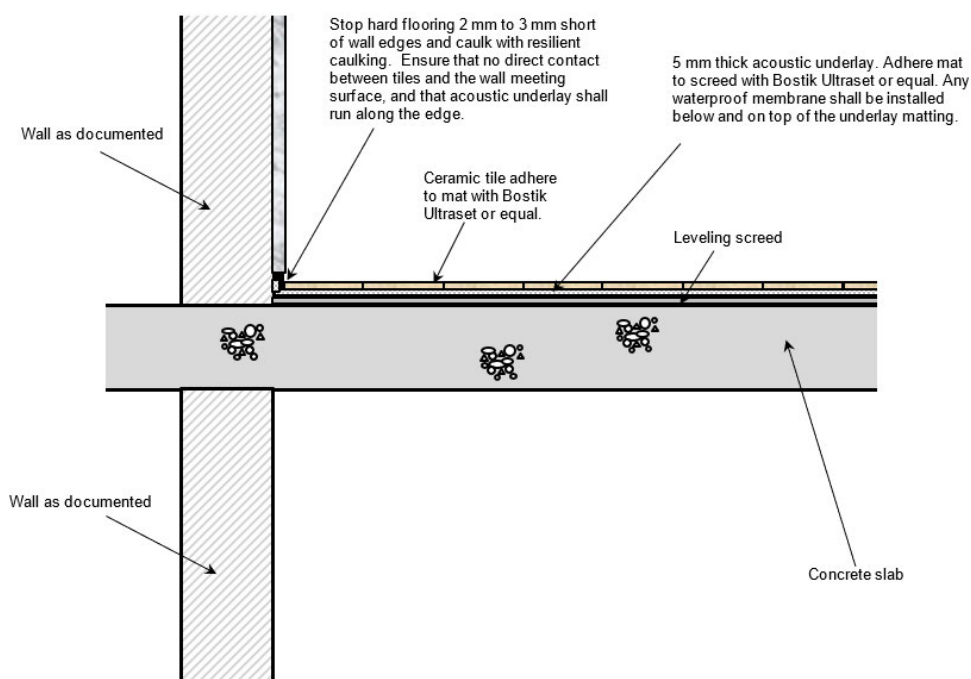


Figure 3.4 Acoustic underlay installation

## 3.2 Flanking at façade

Where there is a gap between the slab and the curtain wall, acoustic measures should be considered to reduce horizontal. The following sections provide examples of acoustic treatment options to minimise flanking along these paths.

Note that all details shown are typical details showing acoustic intent.

### 3.2.1 Mullion treatments

For areas where horizontal acoustic separation is required, the mullion/wall junction should be treated as shown in Figure 3.6 and Figure 3.6.

- For walls  $\leq$  Rw 45, one layer of plasterboard should be used either side.
- For walls  $\geq$  Rw 45, 2 layers of plasterboard should be used either side.

Note the spandrel element is not required as part of the acoustic treatment and is included as part of a typical system. The key element to include is the plasterboard lining on the mullion. The plasterboard can be replaced with an equivalent material (such as 12 mm fibre cement sheet) and can be capped with an aluminium cover.

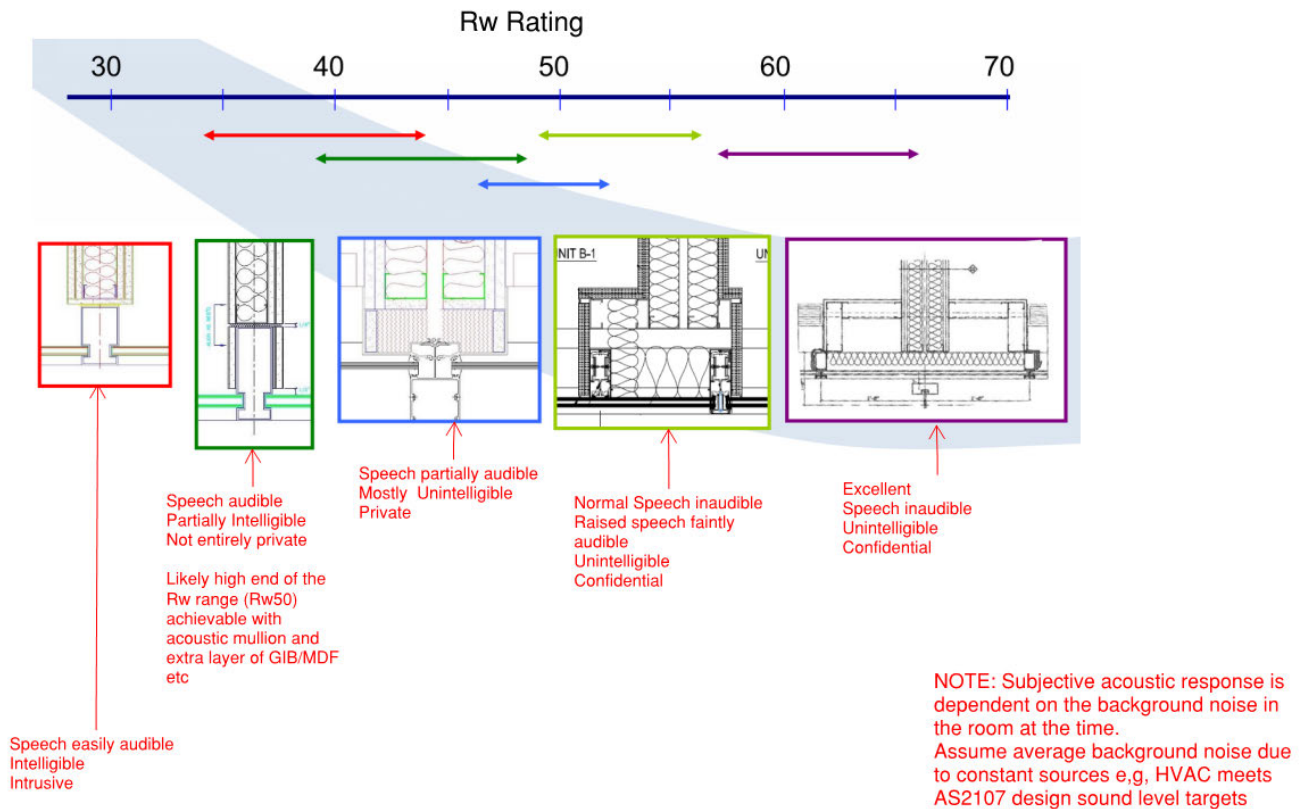


Figure 3.5 Typical horizontal flanking detail mullion acoustic treatment for various Rw (Dw)

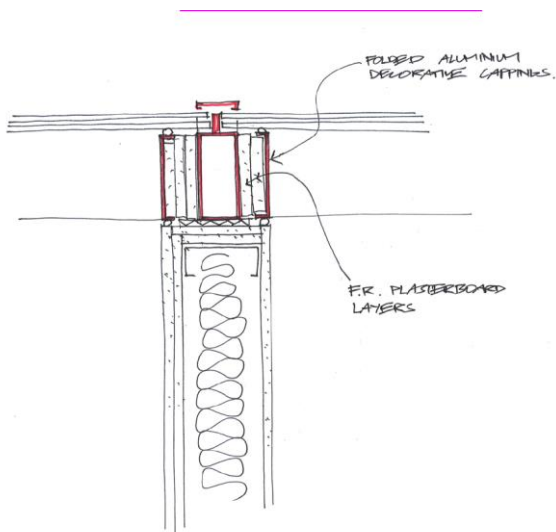


Figure 3.6 Typical mullion acoustic detail

## 3.2.2 Sill treatments

In addition to the mullion treatments, there is potential for flanking through other elements where there is a junction between a wall and the façade. The following advice is provided:

- It is ideal that the horizontal sill element is not a continual element running through the walls between rooms. This may lead to noise flanking between the spaces, reducing the acoustic performance of the partition
- The wall element should be constructed below the sill element as close as possible to the façade. Any remaining gap should be filled with high density insulation (min. 32kg/m<sup>3</sup>).
- The vertical section of the sill should be 13 mm plasterboard with minimal penetrations
- The void separating spaces above the window element should be filled with high density insulation to minimise flanking

## 3.3 Reverberation

### 3.3.1 Introduction

The selection of architectural internal finishes is important in determining the acoustic quality of a building environment. Spaces with predominantly “hard” finishes are typically reverberant and may be perceived as “echoey” which may cause problems with communication and speech intelligibility.

Where practicable reverberation times will be controlled to meet the criteria outlined in Table 2.1. The acoustic requirements have been assessed based on the supplied 50% Developed Design architectural drawings.

Consideration should be given to reverberation time in certain noise sensitive spaces in order to optimise speech intelligibility. The relevant spaces types that fall into this category would be areas where speech is important such as meeting rooms, offices, laboratories and server rooms.

Other spaces such as plant rooms can also benefit from additional sound absorption to minimise the build-up of noise within the space and subsequent reduction in overall noise level transmitted through building elements. Furthermore areas such as collaboration and breakout spaces can also benefit from additional sound absorption to assist with minimising disturbance to adjacent spaces.

The following sections address the reverberation time assessment within the identified sensitive spaces and the recommended acoustic treatment as necessary. Note that it is not the intention to cover every type of internal finish material within the space, but rather to identify materials that would be considered to have significant influence to the reverberation characteristics of the overall space.

### 3.3.2 General discussion of critical spaces

#### 3.3.2.1 Function Space

The Function Space is likely to be used for a range of activities, including sit down functions, music performances and other general activities. As such, a suitable mid-range reverberation time has been established. While this may not be ideal for all situations, it provides a space suitable for a range of typical activities. As such, a reverberation time target of 1.0 seconds has been selected based on guidance provided in AS2107.

Basic reverberation time calculation have been performed using Sabine formulae which is considered appropriate for a space of this nature. Note that detailed computer noise modelling has not been undertaken for this space.

The Function space design includes 3 full walls of floor to ceiling sound absorption treatment, assumed to be direct fix to the wall. The proposed coverings are Autex Cube. Based on the calculations (results below in Section 3.3.3), the following advice is provided regarding the wall treatments:

- The use of 24 mm thick Autex Cube (NRC 0.7) will result in a reverberation time of 0.65 seconds, which will result in a relatively dead space, which may not be appropriate for the range of uses of this space
- The use of 12 mm thick Autex Cube (NRC 0.45) will result in a reverberation time of 0.8 seconds, which is more appropriate for this space

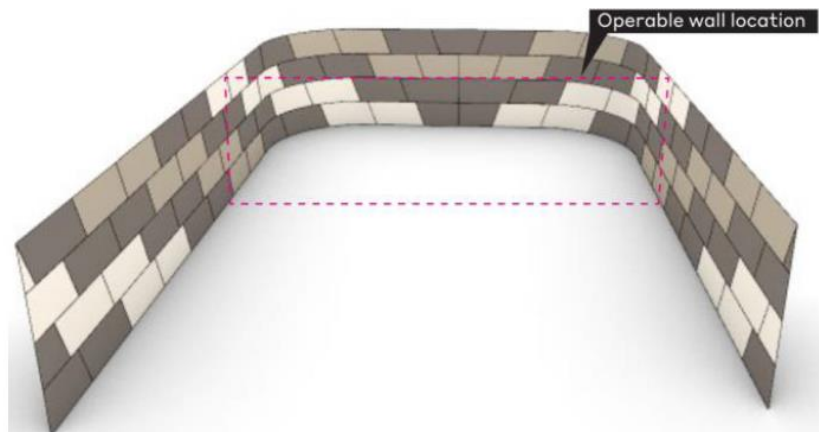


Figure 3.7 Function room wall coverings

### 3.3.2.2 Pre-function space

The pre-function space consists of hard flooring and a significant amount of glazing. As such, soft finishes should be included as much as possible to reduce reverberation time in this area. This includes the proposed perforated plasterboard ceiling, as well as the Sculptform Timber Batten wall lining.

Due to the large number of people that may use this space, the Sculptform Timber Batten should have the following acoustic treatment to reduce reverberation time in the space:

- Acoustic backing (supplied with system)
- Minimum 25 mm air cavity

Based on the manufacturer's specifications, this will achieve an NRC 0.5.

Calculations indicate a reverberation time of 0.8 seconds is predicted using the materials stated above. Based on the predicted results, the pre-function area is expected to be a reasonably live space, which is considered appropriate for the intended usage and meet the adopted AS2107 criteria.

### 3.3.2.3 Community Gathering (Level 1) and FOH Workplace (Level 2)

These spaces consist of the following proposed surface finishes

- Ceiling – perforated plasterboard
- Floors – predominantly paving floor tiles, with the Community Gathering having a section of carpet tiles
- Walls – combination of plasterboard and Sculptform
- Glazing

As the noise buildup in this space is likely to be less than the pre-function space, the Sculptform does not require any acoustic backing in these 2 spaces. This will have an NRC of approximately 0.1, however data is not provided for this.

## 3.3.3 Results of reverberation time calculations

Based on the acoustic analysis, following are the general design recommendations to achieve acceptable Reverberation Time (RT) within the spaces. These recommendations are for general consideration and can be further developed at later stages of the design.

The following NRC values have been assumed for typical surface finishes:

- Carpet tile – 0.1
- Vinyl flooring/Marmoleum – 0.03
- Solid plasterboard – 0.05
- Perforated plasterboard – 0.7
- Glazing – 0.03
- 12 mm thick Autex – 0.45 / 24 mm thick Autex – 0.7

Table 3.7 Reverberation Time and design recommendations

Room	Recommended RT, sec (Based on AS/NZS 2107:2016)	Predicted RT, sec	Proposed surface finishes	Recommendations to achieve design requirements
<b>Ground floor</b>				
Function room	1.0	0.7	Floor – FC:01 (timber look vinyl plank flooring) Ceiling – CL:03 (perforated plasterboard) and exposed concrete beams Walls – combination of: – WC:10 (acoustic panels – 12 mm thick Autex Cube – NRC 0.45) – Glazing	12 mm Autex Cube is recommended due to the large extent of proposed wall coverings.
Pre-function	1.0	0.8	Floor – TL:01 (paving floor tiles) Ceiling – CL:03 (perforated plasterboard) Walls – combination of: – WC:02 (Sculptform timber wall battens with acoustic backing and 25 mm air gap – NRC 0.5) – Plasterboard – Glazing	The Sculptform Timber Batten should have the following acoustic treatment: – Acoustic backing (supplied with system) – Minimum 25 mm air cavity
<b>First floor</b>				
Community gathering (L1.25)	<0.8	0.8	Floor – Combination of TL:01 (paving floor tiles) and FC:02 (carpet tiles) Ceiling – CL:03 (perforated plasterboard) Walls – combination of: – WC:02 (Sculptform timber wall battens with acoustic backing no backing required) – Plasterboard – Glazing	The Sculptform Timber Batten does not require acoustic backing.
Treatment/consult rooms	0.4 – 0.6	1.5	Floor – FC:09 (Marmoleum) Ceiling – CL:01 (plasterboard) Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels

Room	Recommended RT, sec (Based on AS/NZS 2107:2016)	Predicted RT, sec	Proposed surface finishes	Recommendations to achieve design requirements
Mental health rooms	0.4 – 0.6	0.5	Floor – carpet tiles Ceiling – CL:03 (perforated plasterboard) Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels
Medical staff hot desk room (1.65)	< 0.6	0.5	Floor – carpet tiles Ceiling – CL:03 (perforated plasterboard) Walls – combination of: Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels
Family Consult (L1.37)	< 0.6	0.5	Floor – FC:09 (Marmoleum) Ceiling – CL:02 (plasterboard) Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels
Family connection space (L1.09)	<0.8	0.6	Floor – FC:02 (carpet tiles) Ceiling – combination of: – CL:03 (perforated plasterboard) and – CL:01 (solid plasterboard) Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels
Contact room (L1.05)	< 0.6	0.45	Floor – FC:02 (carpet tiles) Ceiling – CL:03 (perforated plasterboard) Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels
Medical workplace (L1.28)	< 0.6	0.5	Floor – FC:04 (carpet tiles) Ceiling – CL:03 (perforated plasterboard) Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels

Room	Recommended RT, sec (Based on AS/NZS 2107:2016)	Predicted RT, sec	Proposed surface finishes	Recommendations to achieve design requirements
Media room (1.23)	< 0.6	0.4	Floor – FC:02 (carpet tiles) Ceiling – CL:03 (perforated plasterboard) Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels
<b>Second floor</b>				
FOH Workplace (L2.00)	<0.8	0.75	Floor – Combination of TL:01 (paving floor tiles) and FC:02 (carpet tiles) Ceiling – CL:03 (perforated plasterboard) Walls – combination of: – WC:02 (Sculptform timber wall battens with acoustic backing no backing required) – Plasterboard – Glazing	The Sculptform Timber Batten does not require acoustic backing.
Open plan offices	<0.6	0.5	Floor – carpet tiles Ceiling – perforated plasterboard Walls – combination of: – Plasterboard – Glazing	NA
Meeting rooms / offices (perforated plasterboard ceilings)	< 0.6	0.4	Floor – carpet tiles Ceiling – perforated plasterboard Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels
Meeting room (plasterboard ceilings)	< 0.6	0.5	Floor – carpet tiles Ceiling –plasterboard Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels
Phone rooms / 1 person rooms	< 0.6	0.4	Floor – carpet tiles Ceiling – perforated plasterboard Walls – combination of: – Plasterboard – Glazing – Autex wall panelling	See discussion in Section 3.3.4 regarding wall panels

### 3.3.4 Discussion regarding wall panels

Enclosed spaces such as meeting rooms, offices, etc, contain a 1200 mm band of acoustic panelling on the solid walls (2 or 3 depending on glazing). Depending on the ceiling in these spaces, the following recommendations are provided:

- Rooms with perforated plasterboard ceilings – as the ceiling provides a large surface area of absorption, the wall panels are not required to control reverberation time. Rather these would be installed only to control flutter echo (see Section 3.3.6). As such, 12 mm thick Autex Cube can be used in this scenario
- Rooms with solid plasterboard ceilings – as the ceiling is reflective and provides no absorption, additional absorption is required on the walls to control the reverberation time. As such, 24 mm Autex Cube should be used in this scenario

### 3.3.5 Ceiling

The overall acoustic performance of a ceiling should consider two primary issues, the ability to absorb sound within a space, and ability to minimise transmission of sound into the space via the ceiling void (typically speech from adjacent rooms where full height walls are not constructed, but also building services related noise).

Generally, the combination of carpet tiles and perforated plasterboard results in acceptable reverberation times.

It is noted that some of the spaces have solid plasterboard ceilings. While this is good to manage noise transmission between rooms where walls are not full height and control noise from services above the ceiling, this is a highly reflective surface which results in long reverberation times in these spaces. Without an absorptive ceiling, significant amounts of absorptive panelling is required to achieve the recommended reverberation time (see Section 3.3.4 above)

Perforated plasterboard should be chosen to achieve a minimum NRC 0.7. The minimum specifications for this would be:

- 16 % open area
- 50 mm thick glasswool insulation (14 kg/m<sup>3</sup>)
- 65 mm air gap

Note that this is one proposed solution to achieve NRC 0.7. Other options may be available. The datasheet for the product should be selected to ensure NRC 0.7 is achieved.

### 3.3.6 Flutter echoes

Reverberation time is particularly important in meeting rooms, offices and areas where speech intelligibility is impacted. Where acoustic wall panelling isn't needed to control reverberation, wall acoustic panels should be installed over two adjacent walls where possible as shown in Figure 3.8.

As a minimum, wall acoustic panels should be installed over two adjacent walls, and they are most effectively installed approximately 1m off the floor in a 1200 mm strip. Where not specified, these should achieve a minimum NRC 0.4.

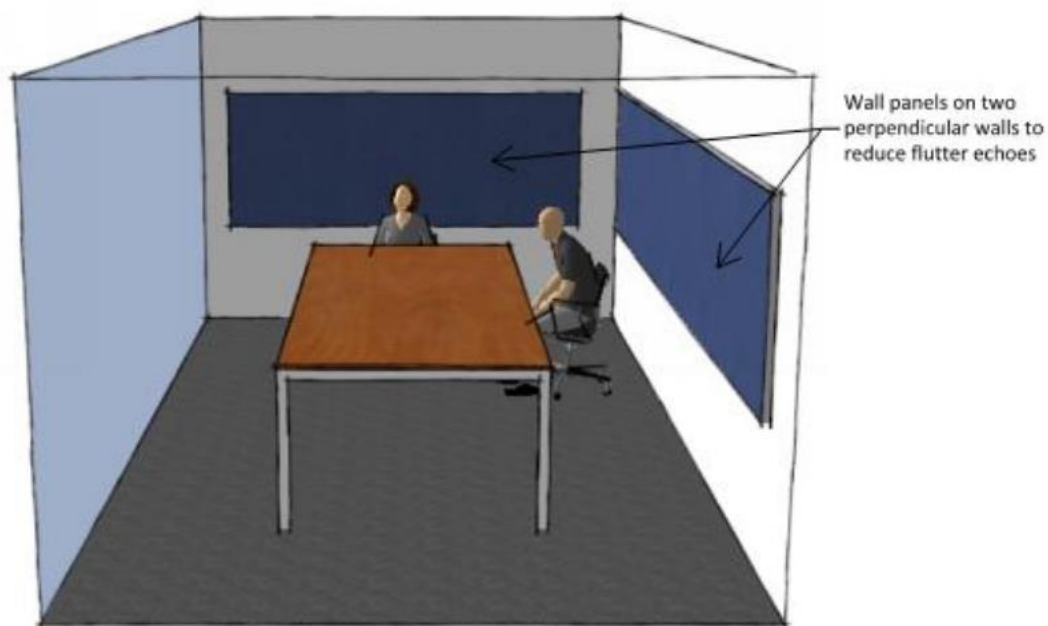


Figure 3.8 Typical acoustic panel locations on wall

### 3.3.7 Recommended acoustic finishes products

Examples of potential acoustic finishes and corresponding NRC and CAC values are provided below in Table 3.8

Table 3.8 Recommended acoustic finishes products

Product	NRC	CAC
<b>Ceiling tiles</b>		
Armstrong Fine Fissued (High Acoustic Lay-in, High Acoustic Fine Guard)	0.7	35 & 40
Armstrong Ultima Health Zone (High CAC/NRC)	0.7	38
Triton Duo 35	0.75	44
USG Boral Mars (High NRC/CAC)	0.7	35 – 39
Mars ClimaPlus High	0.8	35
OWA Singona Baance	0.8	37
Armstrong Ultima High NRC	0.8	35
Armstrong Ultima High CAC	0.85	40+
Armstrong Perla OP dB	0.85	42
Armstrong CALLA	0.85 – 0.9	35
USG Boral Mars High NRC 85/35	0.85	35
OWA Multi Alpha	0.9	32
Ecophon Combison DuoA	0.9	44
<b>Acoustic baffles</b>		
Instyle Ecooustic Baffle 12 mm	0.75	—
Instyle Ecooustic Baffle 24 mm	0.95	—
Sontext Sonofonic acoustic clouds 50 mm	1.06	—
<b>Perforated metal profiles</b>		

Product	NRC	CAC
Stramit perforated panels with 11% open area, or Custom Orb perforated panels with 11% open area, with Minimum 200 mm cavity Minimum 50 mm acoustic insulation with minimum density of 32 kg/m <sup>3</sup> behind the perforated panels	0.8	— — — —
<b>Timber ceiling / wall panels</b>		
Microperforated acoustic timber panelling such as Atkar Au.diMicro, Décorsystems Decorzen Micro, Murano Acoustics, Decustik or acoustically equivalent	0.7+	—
Atkar AudiSlot range with NRC of 0.7 such as AS1125/80 with acoustic insulation backing as per recommendations of the manufacturer	0.7+	—
Supawood decorative timber panels, minimum NRC of 0.7 with acoustic insulation backing as per recommendations of the manufacturer.	0.7+	—
Décorsystems decorative timber panels, minimum NRC of 0.7 with acoustic insulation backing as per recommendations of the manufacturer	0.7+	—
<b>Acoustic wall panels</b>		
Echopanel 7 mm acoustic pinboards	0.25	—
Instyle Ecooustic 9 mm acoustic panels	0.3	—
Echopanel 12 mm acoustic pinboards	0.4	—
Instyle Ecooustic 12 mm acoustic screens	0.4	—
Autex Composition 10 – 12 mm acoustic panels	0.4	—
Autex Cube 12 mm acoustic panels	0.45	—
Baresque Zintra 12 mm acoustic panels	0.45	—
Megasorber 12 mm acoustic panels	0.5	—
Instyle Ecooustic 13.5 mm acoustic panels	0.5	—
Baresque Zintra 24 mm acoustic panels	0.6	—
Echopanel 24 mm acoustic panels	0.65	—
Autex Cube 24 mm acoustic panels	0.7	—
Megasorber 25 mm acoustic panels	0.8	—
Autex Quietspace 25 mm acoustic panels	0.85	—
Instyle Ecooustic 25 mm acoustic panels	0.85	—
Sontex Serenity 25 mm acoustic panels	0.85	—
<b>Acoustic carpet tiles</b>		
Acoufelt carpet tiles	0.35 – 0.4	—
Shaw Ecologic carpet tile	0.35	—
Carpet tiles with EcoSoft™ acoustic backing	0.4	—

Alternative products may be utilised, as long as the required NRC and CAC (for ceilings) for the particular space is achieved.

## 3.4 Open plan office design advice

### 3.4.1 ISO 22955:2021 - Acoustics — Acoustic quality of open office spaces

#### 3.4.1.1 Typology, acoustic challenges and requirements

The acoustic design of open plan offices areas shall take into account the guidance and recommendations given in ISO 22955:2021.

This section outlines the guidance and recommendations given in ISO 22955:2021 for consideration into the design. Based on the proposed usage of the office spaces, the office would be considered Space Type 3 *activity mainly based on collaboration between people at nearest workstation*, as per ISO 22955:2021.

The noise environment characteristics of this space are as follows:

- Simultaneous sources can be relatively numerous and, above all, vocal behaviour fluctuate, giving a lively atmosphere involving multiple interactions.
- The general acoustic environment shall support oral collaborative work between persons from the same team. On the other hand, acoustic discretion between teams should be optimized.

The acoustic challenges of this type of space are:

- A high level of intelligibility between workstations within a single team is required. Acceptable intelligibility with respect to telephone conversations is also required.
- On the assumption that the teams perform independent activities, they shall not interfere with each other. A high level of acoustic discretion between two teams operating close to each other should therefore be achieved.

Table 3.9 provides acoustic indicators and values for activity mainly based on collaboration between people at the nearest workstation.

**Table 3.9** Acoustic indicators and values — Activity mainly based on collaboration between people at the nearest workstation (Table 2 of ISO 22955:2021)

Interaction	Acoustic challenges	Description criterion	Target values	Required values
At workstation	Ability to communicate without raising voice	Good to excellent intelligibility at workstation when speaking normally	$L_{Aeq,T} \leq 52$ dB a	
Between workstations	Communicating between team members Satisfactory intelligibility Within team when speaking normally	Moderate attenuation between same team workstations		Attenuation $D_{A,S} \leq 4$ dB
On floorplate	Reducing disturbance between teams	Attenuating amplification inherent to room as much as possible by reducing reverberation Reducing noise in room by doubling distance		$T_r \leq 0,5$ s <sup>b</sup> $T_r \leq 0,8$ s at 125 Hz $D_{2,S} \geq 8$ dB $L_{p,A,S,4 m} \leq 48$ dB

a During activity (see Annex E).  
b Arithmetic mean of times for octave bands centred on 250 Hz to 4 000 Hz.

### 3.4.1.2 Workspace layout and room acoustics

The following general recommendations are provided for workspace layout and work organisation:

- all cooperating workstations should be grouped together (teams, projects).
- different teams or services should be separate, even if occasional cooperation is possible.
- movements between workstations and supporting spaces such as a photocopying area, meeting rooms, etc. should be optimized. Distinction should be made between supporting spaces directly available to open-plan space users (nearby supporting areas including break areas and meeting rooms) and supporting spaces that do not need to be directly associated or on the same floor as the relevant open-plan space (e.g. cafeterias or training rooms).
- adjacent supporting spaces should be used as much as possible to structure the open-plan space. Separations may be used, if distance is lacking.
- movement areas should be delimited visually (marked) to separate the workspaces from movement flows through the open-plan space.
- doors should be used to isolate supporting areas from the open-plan space are designed not to cause disturbance (clearance or acoustic insulation).

Dimension and geometry of open plan work spaces is a critical factor for ambient noise levels and acoustic environment. Some national standards recommend between 10 m<sup>2</sup> and 15 m<sup>2</sup> per occupant. Geometry is also a key factor in the acoustic environment of the open plan offices. Where possible, cooperating workstations should be located near to each other, with independent workstations as far away as practically possible.

### 3.4.1.3 Acoustic treatment

The acoustic treatment of a room involves covering its surfaces (ceiling, floor and walls) with absorptive acoustic material to limit sound reflection. The more efficient the material (i.e. high absorption coefficient) and the larger and more uniform the treated surface, the more effective the acoustic treatment.

#### Ceiling treatment

The ceiling is the most important reflecting surface in the open plan office. Therefore, it should be as absorptive as possible (absorption coefficient close to 1) and full coverage is preferred.

#### Wall treatment

Although the proportion of wall surfaces to ceiling is low, the use of absorptive panels on walls can limit reflections for workstations close to walls and corners. This may also reduce reverberation time in areas with less furniture.

#### Floor treatment

The absorption performance of flooring is generally limited, however, carpet can assist in reducing reflections, and reduce impact noises associated with movement of people and furniture. Where reverberation control is required, special floor coverings with acoustic layers should be considered.

### 3.4.1.4 Other general treatment / management recommendations

The use of workspace dividing screens are a good option to allow for speech privacy. The following table provides attenuation values for different screen heights.

Table 3.10 Workspace dividing screen attenuation

Separating screen height, cm	Attenuation between workstations without absorptive treatment (plaster ceiling), dB	Attenuation between workstations with ceiling treatment where Alpha w = 1, dB
110 (35 cm above the table)	1.1	3.6
120 (45 cm above the table)	1.7	4.5

Separating screen height, cm	Attenuation between workstations without absorptive treatment (plaster ceiling), dB	Attenuation between workstations with ceiling treatment where Alpha w = 1, dB
130 (55 cm above the table)	2.4	5.4
140 (65 cm above the table)	2.9	6.3
150 (75 cm above the table)	3.4	6.5

The following list is taken from Annex C of ISO 22955:2021 related to etiquette in open plan offices:

- avoid long discussions in the area.
- speak quietly on the phone and with colleagues.
- avoid talking when walking.
- hold conference calls and meetings in a closed office or dedicated space.
- avoid discussions with distant workstations, favour instant messaging or meeting rooms.
- adjust sound level on headset (microphone and headphones).
- reduce level of landline ringtone, favour light indicators.
- do not use the telephone loudspeaker.
- set mobile phones to vibrate mode.
- prefer collaborative and adjacent areas for meeting visitors entering the area.
- avoid individual briefings or training at a workstation.
- do not affix documents to low dividers or acoustic wall panels.

## 3.5 External sound insulation

### 3.5.1 Building envelope

The Project site is located within a Public Park and Recreation Zone (PPRZ), with surrounding lots mainly located within an Industrial 1 Zone.

At this stage, the Planning Permit Acoustic Report has not been undertaken. This includes noise monitoring to determine existing noise levels in the area. Therefore, a review of the area and potential noise sources has been undertaken to understand the level of noise intrusion into sensitive areas of the Project (consult rooms, meeting rooms etc). The potential noise sources in the surrounding area that has the potential to impact the Project are:

- Morgan Street – Department of Transport and Planning (DTP) controlled arterial road, located approximately 50 metres to the north of the site and runs generally east-west between Tarkin Court in the west and The Boulevard in the east.
  - Traffic counts were undertaken between 18 June and 25 June 22, with an average of 9,221 vehicle per day at an average speed of 50.6 km/h.
  - Based on the above, the predicted noise level at the nearest facade from traffic noise is estimated to be less than 60 dBA.
- Industrial sites surrounding the development – nearest industrial site is approximately 30 meters from the Project, with next nearest industrial sites being 125 metres to 150 meters from the Project.
- Rooftop plant on the subject building

Table 3.11 provides a summary of each external building element, the corresponding standard/guideline that will determine the acoustic requirements and general comments on the anticipated construction build up.

Table 3.11 External building element construction

External building element	Relevant standard/guideline	Comments
Façade walls	<ul style="list-style-type: none"> <li>– AS/NZS 2107:2016</li> <li>– AAAC Guideline for Commercial/Healthcare Building Acoustics</li> </ul>	<ul style="list-style-type: none"> <li>– The building façade walls should be designed such that internal noise levels within the building comply with the relevant standard/guideline.</li> <li>– It is expected that the building would be construction using a combination of concrete/masonry, and lightweight steel cladding walls.</li> <li>– The concrete element would likely be sufficient to control external noise intrusion.</li> <li>– The lightweight steel cladding walls should be designed to suitably control noise intrusion. At this stage, it is recommended that a preliminary allowance is made for a wall construction with an approximate acoustic performance of <math>R_w</math> 40. It is unclear what the construction intent is for this element of the façade, however would consist of the following: <ul style="list-style-type: none"> <li>• 0.6 metal steel</li> <li>• 92 metal stud with min 75 mm insulation (min density 14 kg/m<sup>3</sup>)</li> <li>• 1 x 13 mm fire rated plasterboard</li> </ul> </li> </ul>
Façade glazing		<ul style="list-style-type: none"> <li>– The building façade glazing will be designed such that internal noise levels within the building comply with the relevant standard/guideline.</li> <li>– Depending on the location of the glazing, existing ambient noise levels, proposed layout and proposed external mechanical plant, acoustic single glazing (thick laminated glass) or double glazing may be required.</li> <li>– Given the surrounding areas, which includes road traffic noise and general noise from surrounding industrial sites, noise levels may be relatively high.</li> <li>– Noise monitoring should be undertaken at the next phase of the design to help determine the specific external façade design requirements for the site. At this stage, it is recommended that a preliminary allowance is made for double glazing with an approximate acoustic performance of <math>R_w</math> 40. This would be confirmed following noise monitoring.</li> <li>– There are many options to achieve this rating, however the glazing outlined for internal glazing can also be assumed here (see Section 3.1.8). Note that the glazing units should be a tested system (glazing and frame), with certification of the acoustic performance.</li> </ul>
Roof	<ul style="list-style-type: none"> <li>– AS/NZS 2107:2016</li> <li>– AAAC Guideline for Healthcare Facilities</li> </ul>	<ul style="list-style-type: none"> <li>– The building roof construction will be designed such that internal noise levels within the building comply with the relevant standard/guideline, in particular rain noise.</li> <li>– The following roof construction is recommended to control rain noise impacts and noise impacts from the rooftop plant. <ul style="list-style-type: none"> <li>• 0.6 mm thick Metal deck rook sheeting</li> <li>• Cavity with thermal insulation</li> <li>• 12 mm thick fibre cement sheeting</li> </ul> </li> </ul>

## 3.6 Mechanical services noise

The mechanical services design has progressed to a stage where internal noise levels and general treatments can be quantified. Coordination with the mechanical services team has been undertaken, and will continue throughout the later stages of the project.

Consideration will be given to the design of the internal mechanical ventilation system to address internal noise related issues including:

- Transfer of noise where ductwork penetrates acoustically rated partitions;
- Transfer of noise between acoustically rated rooms via air conditioning grilles/openings; and

- Noise generated through air movement, moving parts (e.g. fans) and vibration associated with the mechanical services system.

Noise generated from services should be sufficiently controlled such that the total noise from all services combined does not exceed the recommended maximum design sound level defined as per the AS2107. Plant rooms and external areas are to be designed to minimise noise breakout through the building structure to adjacent spaces.

### 3.6.1 Specific mechanical services noise treatments

Mechanical services noise for sensitive areas in the building have been calculated to determine whether any additional specific measures are required. Where no specific advice is provided, the internal HVAC noise levels are predicted to achieve compliance with AS2107.

A potential issue identified with the mechanical design is the fan coil units located above the perforated ceiling. In particular, this configuration is considered to represent an acoustic risk in terms of:

- Radiated noise from the units themselves
- Noise via the return air path

Advice regarding this risk is provided in Table 3.12, along with other specific advice.

Note that some of the advice has not been included in the mechanical drawings and will be updated as the project progresses.

Table 3.12 Mechanical services noise recommendations

HVAC element	Recommended mitigation
All fan coil units above sensitive spaces (all spaces excluding corridors)	It is recommended: <ul style="list-style-type: none"> <li>– All solid ductwork to be internally lined with 50 mm thick insulation</li> <li>– Ductwork located above perforated plasterboard ceiling to use heavier supply and return air ducts with density of the duct walls 12.2 kg/m<sup>2</sup> or greater to reduce breakout noise</li> <li>– 1 metre of lined duct (min. 50mm internal lining) should be installed on the return air path of each of the FCUs. This should also include at least 1 x 90 degree lined bend</li> <li>– Return air path should be open to plenum rather than ducted to grills in ceiling (assuming perforated plasterboard)</li> <li>– Acoustic rated flexible duct to be used in all sensitive areas</li> <li>– FCUs located above perforated ceilings (not in corridors) to be externally lagged with loaded vinyl (min. 5 kg/m<sup>2</sup>) or enclosed in plasterboard enclosure</li> </ul>
Cassette units	All cassette units have been selected to have low noise levels, which are below the AS2107 requirements. Should these be changed, the noise level should be verified by an acoustic engineer
Cross talk attenuators (CTA)	CTAs should be located above doors (to the corridor) where possible, as this is the weakest element in the partition. CTAs should be avoided between sensitive spaces with high acoustic requirement.  CTAs should include should be a minimum of 1.5 metres with 2 bends. Where possible, these should be open to the ceiling plenum rather than to a grill in the ceiling

<sup>1</sup>Sound reinforcement is assumed in the room

### 3.6.2 General mechanical services noise treatments

Typical mechanical services treatments are outlined in Table 3.13.

Table 3.13 Typical acoustic treatments for mechanical services – internal noise levels

Design Item	System	Typical treatments
Mechanical plant	Evaporative units	Select units with lowest noise emissions where practical and design fans to run at low speeds where practical.

Design Item	System	Typical treatments
	Fan coil units (FCU)	Design fans to run at low speed where practical.
	Packaged units	<p>Locate ceiling space units over non-sensitive spaces such as corridors and toilets with solid ceilings. Where units are located above the ceiling of acoustically sensitive spaces consideration should be given in upgrade of ceiling or lagging of the unit itself. Treatments may include insulation, thicker or more layers of plasterboard, backing mineral fibre ceiling tiles with plasterboard.</p> <p>Timers should be installed on plant items correlating with the operational times of the facility.</p> <p>Plant items should be configured to operate only when required and not operate continuously.</p> <p>Well maintained and regularly serviced machines run more quietly and efficiently.</p> <p>Acoustic lagging may be required to minimise radiated noise breakout from the units.</p>
	Cassette/wall units	The noise from cassette and wall split units cannot be acoustically attenuated. However, the noise from units when operated on medium or low fan speeds is typically lower and may be within the recommended criterion. For very low noise spaces, quieter units or a duct system should be considered
	Heat Recovery Ventilation (HRV)	<p>Ceiling treatment may be required to control breakout noise. Treatments may include insulation, thicker or more layers of plasterboard, backing mineral fibre ceiling tiles with plasterboard.</p> <p>Induct noise may be treated with the use of rigid acoustically lined duct (rather than flexible duct) if required</p>
	External units	<p>Noise break-in from external units can be controlled by treatment to the roof and ceiling structure. Given the project is located at basement level, this is not expected to be an issue.</p> <p>To control noise emissions to the environment (to within the relevant environmental noise criteria), the larger and noisier units may require acoustic louvres or a solid barrier to block line of sight from equipment to outdoor areas and to adjacent receptors.</p>
Air distribution	All	<p>Design the air distribution system to minimise flow resistance and turbulence.</p> <p>Systems shall be balanced with minimum throttling and fans shall run at the lowest speed consistent with obtaining specified air flows at terminals.</p> <p>Minimise flow-generated noise from elbows and take-offs by separating them by at least 4 to 5 duct diameters from each other (10 duct diameters for critical noise areas).</p> <p>For critical noise areas the use of metering plates in the necks of short-length take-offs leading directly to grilles, registers and diffusers, is preferred to volume extractors which protrude into the main duct.</p> <p>Place grilles, diffusers and registers as far as possible from elbows and branch take-offs.</p> <p>Where aspect ratios in main and branch rectangular duct runs exceed 3:1, stiffeners shall be employed.</p> <p>Transitions are to be as gradual as possible (1 in 7 are preferred, with 1 in 4 permitted where air velocities are below 10 m/s) within the physical limitations, and it is preferred that one pair of sides remains parallel.</p> <p>Use turning vanes in large 90-degree rectangular elbows and branch take-offs.</p> <p>Radius bends which have an inside radius smaller than the duct width shall have full arc splitters such that the inside radius of any air channel is not less than the width of that channel (minimum radius of 150 mm permitted).</p>
Ducting	All	<p>It is recommended that any mechanical transfer/ventilation ductwork above ceiling serving separate spaces be treated acoustically through internal duct lining and specific duct arrangement such that noise attenuation path could be maximised.</p> <p>Ensure that there is sufficient rigid lined duct on the supply path, this is typically in the order of 4 to 5 duct diameters for general spaces and 8 to 10 duct diameters for critical spaces (criteria <math>\leq 35\text{dB(A)}</math>).</p> <p>Use acoustic flexible duct where flexible duct is required.</p> <p>All flexible duct shall be acoustically insulated flexible duct, comprised of minimum 25 mm thick insulated "four zero" rated (tested to AS1530.3) acoustic duct with outer aluminium wrapping and inner aluminium fabric core construction;</p> <p>No flexible duct should be allowed to penetrate full height walls. Consideration should be given to incorporation of internally lined rigid rectangular duct of relevant size and length to</p>

Design Item	System	Typical treatments
		<p>maintain the acoustic integrity of the separating wall and flexible duct connection to each end of the treated rigid transfer duct;</p> <p>Line rigid duct with acoustic insulation (minimum 25mm for general spaces and minimum 50mm for critical spaces).</p> <p>Supply and return air should be supplied via lined cushion head boxes.</p> <p>Critical spaces meeting rooms or where duct lengths are limited may require in-duct attenuators to control in-duct noise levels.</p> <p>Ductwork penetrations through any walls, ceilings or floors should be adequately treated so as to maintain the sound isolation capabilities of the building component. Perimeter gaps between the duct and the clearance hole cavity should be loosely packed with acoustically absorbent material, exterior wall junctures should be sealed with angle and gaps caulk with a mastic sealant ensuring no air gaps.</p> <p>It is generally recommended that any ductwork above ceiling of an acoustic secure room, and penetrating to the full-height wall, to be externally wrapped/lagged with 1 layer of 5 kg/m<sup>2</sup> loaded polymer barrier-foil faced with 25 mm convoluted acoustic foam backing (overall system acoustically equal to Soundlag 4525C). All lagging joints are to be overlapped by 50 mm and taped with aluminium tape with no gaps.</p>
Vibration isolation	All	<p>Vibrating plant and equipment shall be acoustically treated and isolated to prevent transfer of vibration to connecting structure.</p> <p>Effective vibration isolators such as elastomeric or spring mounts, or other means of appropriately fastening, must be tailored to match expected loads and frequencies.</p> <p>For items in contact with the floor, a layer of elastomeric neoprene padding should be inserted between supports and the floor. The inserted spacing pad must be of an area greater than the footing area supported. Furthermore any piping and conduit that are connected to vibrating equipment must also be isolated with flexible connections.</p> <p>For items directly fixed to the roof such as the duct support channels, the items should be re-hung from Isolation Hangers that will reduce the transmission of vibration and regenerated noise from suspended equipment and systems.</p> <p>Vibrating plant items should not be directly mechanically affixed to the walls of the surrounding structure.</p>

### 3.6.3 Duct lining

Duct lining material shall be made of fiberglass insulation board, having minimum material density of 48 kg/m<sup>3</sup>. The sound absorption coefficients of the selected duct internal lining material shall have minimum values, as detailed in Table 3.14.

Table 3.14 Minimum duct lining absorption coefficients (α)

Duct Lining Thickness	Octave Midband Frequency (Hz)					
	125	250	500	1000	2000	4000
25 mm (48 kg/m <sup>3</sup> )	0.11	0.28	0.68	0.90	0.93	0.96
50 mm (48 kg/m <sup>3</sup> )	0.21	0.75	1.00	1.00	1.00	1.00
75 mm (48 kg/m <sup>3</sup> )	0.36	1.00	1.00	1.00	1.00	0.93
100 mm (32 kg/m <sup>3</sup> )	0.60	1.00	1.00	1.00	1.00	0.99

For lined ductwork subject to grease build-up, install polyethylene terephthalate (PET) sheet (equivalent to Mylar or Melinex) between the absorptive infill and the perforated metal facings, as per the manufacturer's recommendation and specification. The Contractor shall ensure that the additional PET layer be installed in a manner that it will not reduce the absorption performance of the ductwork and will not compromise the fire safety of the project.

For lined ductwork subject to moisture environment, install hydrophobic Rockwool type insulation as the absorbent infill. The Contractor should ensure that the selected and installed lined ductwork should be in a manner that it will not reduce the overall acoustic performance.

Where induct air velocity exceed 10 m/s, perforated steel sheet covering the lining material should be used.

### 3.7 Electrical services

Noise from electrical services plant and equipment will be designed to meet the AS2107 recommended limits (in occupied spaces). Electrical equipment prone to the generation of tonal noise will be appropriately controlled.

A number of acoustic design considerations in relation to electrical services includes but is not limited to:

- Individual electrical cable penetrating acoustically rated partition shall be acoustically treated using a steel collar or a 5 mm thick, 600 mm long PVC conduit drawn through the penetration. Pack PVC conduit with fibreglass or Rockwool insulation and fully seal around the conduit with 100% polyurethane sealant, equal to Bostik Fireban 1.
- No back-to-back GPOs in acoustically rated walls. GPOs in acoustically rated walls to have minimum 600 mm offset.
- If GPO's cannot be offset, an electrical box required for GPOs along the acoustically rated partition shall be acoustically equivalent to HPM 430 acoustic/fire rated box.
- Install acoustic electrical box or penetrations in a manner that they will not compromise the acoustic performance of the partition.
- Where cable trays run through full height walls, the penetration should be tightly packed with acoustic insulation with minimum density of 32 kg/m<sup>3</sup> and sealed airtight on each side by incorporation of backing rods and creating airtight seal using flexible caulking compound.
- All downlight light fittings shall be acoustic downlight with enclosure at the back. Light fitting using gimbaled downlights shall be acoustically treated with acoustic box, or alternatively using acoustically rated downlight system.

### 3.8 Hydraulic noise

Consideration will be given to the design of the hydraulic services system to address noise related issues, including:

- Structure-borne noise through the connection of the pipe work to the building structure;
- Noise from water movement in pipes; and
- Transfer of noise where pipe work penetrates acoustically rated partitions/baffles.

Appropriate attenuation will be considered as required.

It is recommended that all riser/ceiling construction have an Rw of not less than 35. General recommendations include the following:

- Limit soil and waste fluid velocities to no greater than 5 m/s. However it is not advisable to install elbows to reduce the velocity;
- Use simple design pipe layouts (i.e. long straight runs with minimum of elbows and T-connections); and
- Risers – Rw 35 between pipes and office areas can be achieved by either one of the following options. Note, that the 75 mm polyester insulation between pipes and interior surface of box is not to be closer than 75 mm.

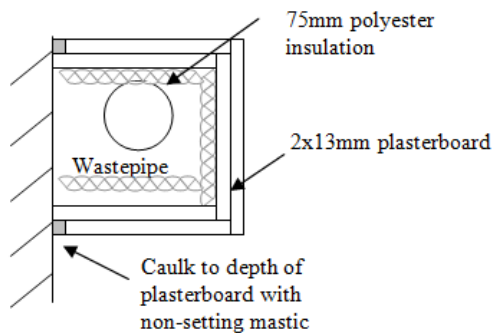


Figure 3.9 Rw 35 riser treatment to pipes in office spaces

**Above plasterboard ceilings** – the following should be implemented above sensitive spaces

- Minimum 1 layer of 13 mm plasterboard ceiling
- 50 mm thick glasswool insulation (14 kg/m<sup>3</sup>)
- Acoustic Lagging (5 kg/m<sup>2</sup> loaded vinyl with 25 mm thick convoluted open cell foam)

**Above perforated plasterboard ceiling** – as the ceiling doesn't provide any acoustic benefit, the following should be implemented above sensitive spaces:

- Sound insulated pipework, such as Raupiano Plus
- Acoustic Lagging (5 kg/m<sup>2</sup> loaded vinyl with 25 mm thick convoluted open cell foam)

Where the above Raupiano Plus can't be used, the pipes will need to be boxed in using the same construction as the plasterboard ceiling detail above.

The following acoustic design consideration in relation to the hydraulic services noise control are recommended:

- Where pipework or hydraulic services exist within a partition to an occupied space, an isolated partition construction should be used to minimise structure borne noise
- Where hydraulic services are required within the acoustically rated wall, they shall be surface mounted or otherwise externally lagged using the specified Acoustic Lagging (5 kg/m<sup>2</sup> loaded vinyl with 25 mm thick convoluted open cell foam)
- Where isolated partition is not practical, a staggered wall arrangement with no mechanical connection between the separate studs could be considered plus incorporation of hydraulic noise isolation system acoustically equivalent to Gyprock 'Silencer
- Pipework should be supported from the wet side of the isolated/staggered partition
- Pipework should not have any mechanical connection to the wall lining
- Penetration should be minimised and sealed airtight with flexible caulking compound
- Pipework should be isolated at supporting points and at penetrations
- Use resilient pipe isolators between all pipes and mounting points
- Limit water flow velocities to 2.5 m/s where appropriate by increasing pipe size.

## 3.9 Vibration

Vibrational energy generated by mechanical plant can be transmitted through the building structure and radiated as regenerated noise from the walls, floors and ceilings and other building elements.

Vibrating plant and equipment shall be acoustically treated as per the following:

- All vibrating plant and equipment to have vibration isolation mounts/hangers installed at the structural support with sufficient static deflection;
- All pipework/ductwork subject to vibration due to connection with vibrating plant and equipment shall be vibration isolated using isolation hangers or mounts, or alternatively provide flexible connections between the pipework and vibrating equipment. It is recommended that vibration isolator selection be determined as per Table 47 of 2018 ASHRAE Handbook's Chapter 48 Sound and Vibration Control;
- Note that all rotating mechanical plant and equipment shall be qualitatively balanced and certified in accordance with ISO 21940-11:2016;
- Additional control may be required for particularly sensitive equipment;
- Note that it remains the responsibility of the contractor to ensure that the installed mechanical plant and equipment be vibration isolated from the building structure such that the noise levels due to the equipment vibration do not exceed the applicable criteria and that the isolators are not bridged by contact between any part of the machine and the structure; and
- If the noise levels due to equipment vibration exceed those specified, carry out rectification work and noise measurement to demonstrate compliance with the specification.

## 3.10 General treatments

### 3.10.1 Sealant

Unless stated otherwise, all recommended acoustic sealant to walls and floors shall be 100% polyurethane flexible mastic type sealant equal to Bostik Fireban 1. Other type of sealant may be used subject to approval from a suitably qualified Acoustic Consultant.

Acrylic type sealants are **not** acceptable.

### 3.10.2 Installation requirements

The installation of the acoustically rated wall must generally satisfy the following:

- Plasterboard linings to have a gap (minimum 10 mm, max 15 mm) at the top and bottom of the wall and caulk gap to full depth of plasterboard with 100% polyurethane sealant equal to Bostik Fireban 1.
- No back to back GPOs in acoustically rated walls. GPOs in acoustically rated walls to minimum 300 mm offset.
- Any penetration along the acoustically rated wall shall be acoustically treated to maintain the acoustic integrity of the wall.
- Where hydraulic services are required within the acoustically rated wall, they shall be surface mounted or otherwise externally lagged using the specified Acoustic Lagging (5 kg/m<sup>2</sup> loaded vinyl with 25 mm thick convoluted open cell foam).
- The base of the first layer of plasterboard in wall constructions shall be bedded in a continuous bead of non-hardening mastic to acoustically seal the sheet to the floor. The contractor shall ensure that any undulations in floor finish do not result in a gap beneath the sheeting material or stud frame.

### 3.10.3 Plasterboard joints

When applicable, joints in plasterboard sheeting in dry wall systems should be staggered where multiple layers of material are used on walls so that the joints should not overlap. All joints shall be installed hard-butted against each other.

### 3.10.4 Door seals

The installation of the doors shall be conducted in the following manner:

- All acoustic perimeter seals shall be effective such that there are no gaps along the perimeter when the door is in closed position.
- Doors shall be installed with gaps minimised along the bottom of the door. Where threshold plate is required, this shall be installed in a levelled floor.
- Perimeter seals, including threshold seals, shall be fully adjusted to ensure acoustically effective seals along the perimeter of the door.
- Gaps along the seals joints are not acceptable. Door seals shall be installed continuously around the perimeter of the door, and that any joints shall be hard-butted against each other.

### 3.10.5 Continuous elements

Lightweight ceiling linings shall not run continuously across two spaces where acoustically rated partitions exist. A saw cut will need to be made at where the continuous element meets the partition line to prevent the noise flanking via the continuous structure.

### 3.10.6 Access panels

Access panels should generally be constructed to match the sound insulation performance of the ceiling.

### 3.10.7 Wall junctions

Where an acoustically rated wall meets a façade or corridor wall junction, the acoustically rated partition wall shall be taken through to the external element of the façade or corridor wall and acoustically sealed at the junction. Tape and set joint may be used at the internal layer of the façade wall element, where required.

Where acoustically rated wall meets at mullion window junction, the wall construction should be built to meet the façade mullion. Wall sheeting to enclose the mullion and caulked is preferable, or alternatively backed mullion from top to bottom with one layer of 16 mm thick plasterboard on both sides of the frame.

Any cable trunking across the acoustically rated wall system to have insulation packing at the partition intersection area with compressed high density Rockwool insulation.

### 3.10.8 Underside of slab junction

Acoustic rated wall systems abutting the ceiling and extended to the underside of slab above should be constructed in a manner that it will not compromise the acoustic integrity of the partition system. It is recommended that the junction details as shown in Figure 3.1 be considered in this case.

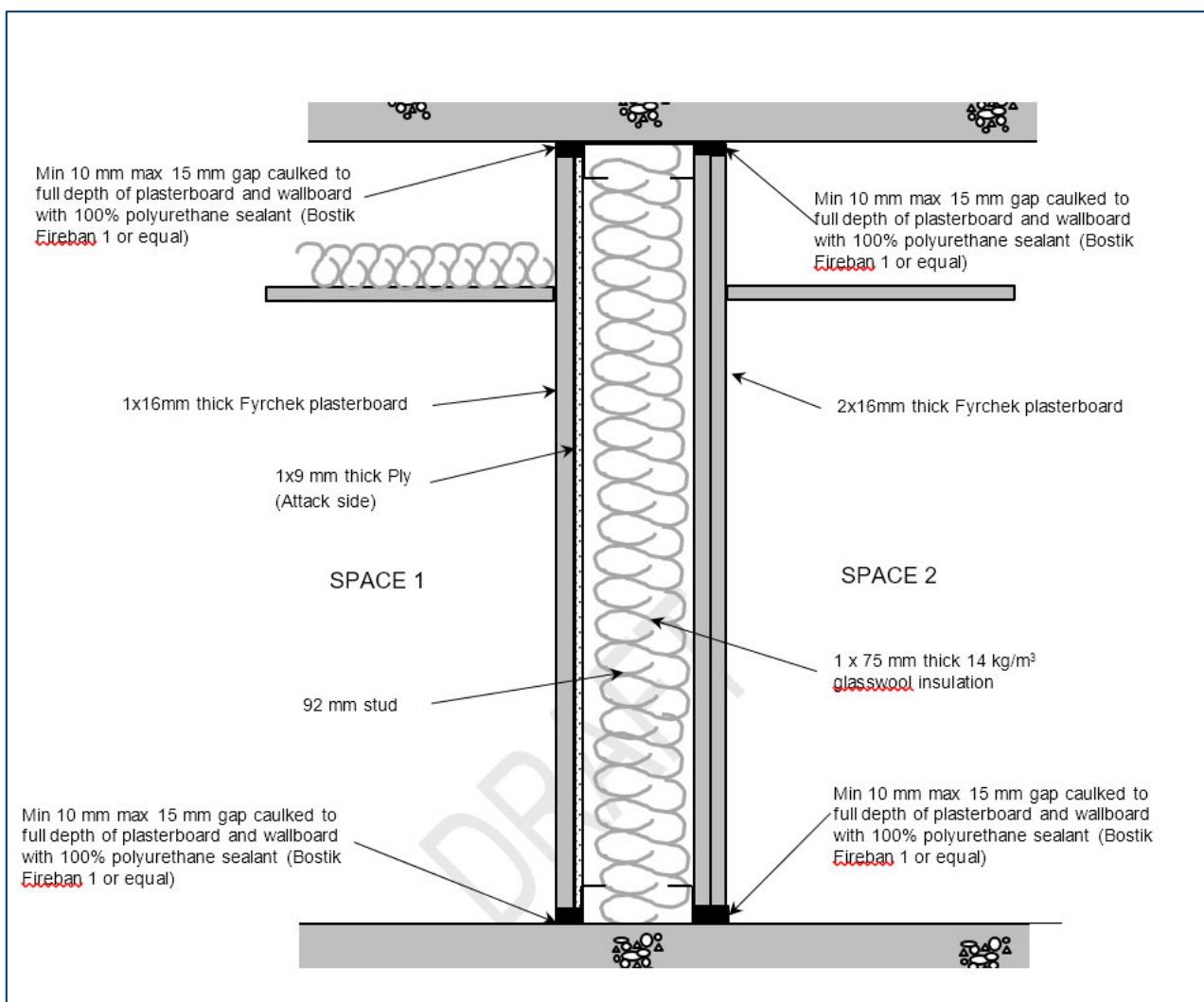
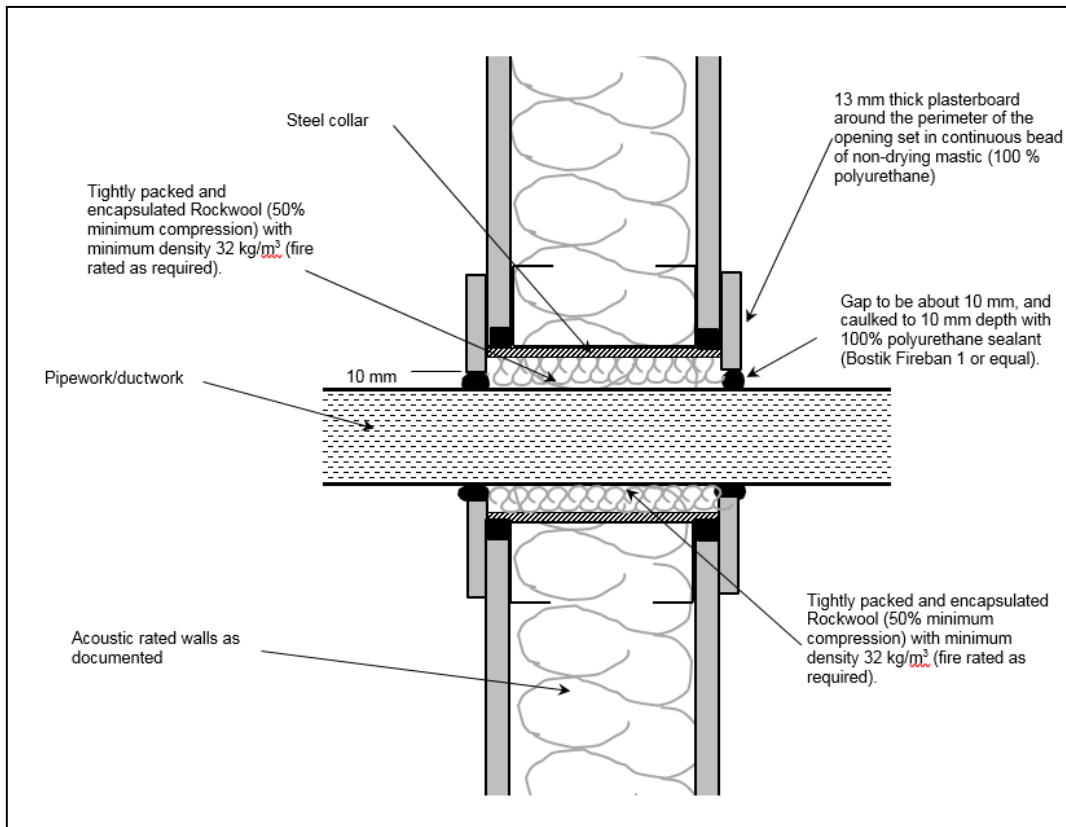


Figure 3.10 Junction acoustic detail for full height walls

### 3.10.9 Penetrations

Mechanical ductwork, cabling and pipework penetrating acoustically rated partitions should be acoustically treated to maintain the acoustic integrity of the partition. Note that oversized penetration hole is not acceptable, use suitably sized acoustic rated sleeve as required with fully sealed gaps using 100% polyurethane sealant such as Bostik Fireban 1.

Where practical, penetrations through full height walls or ceiling barriers should be avoided. Should this be unavoidable, building services penetration should be constructed as per acoustic sealing details in Figure 3.11 to Figure 3.13 and be located above doors where possible.



**Figure 3.11** Sectional elevation view – Pipework/ductwork penetration acoustic sealing details through full height wall with  $D_w$  40 rating or less

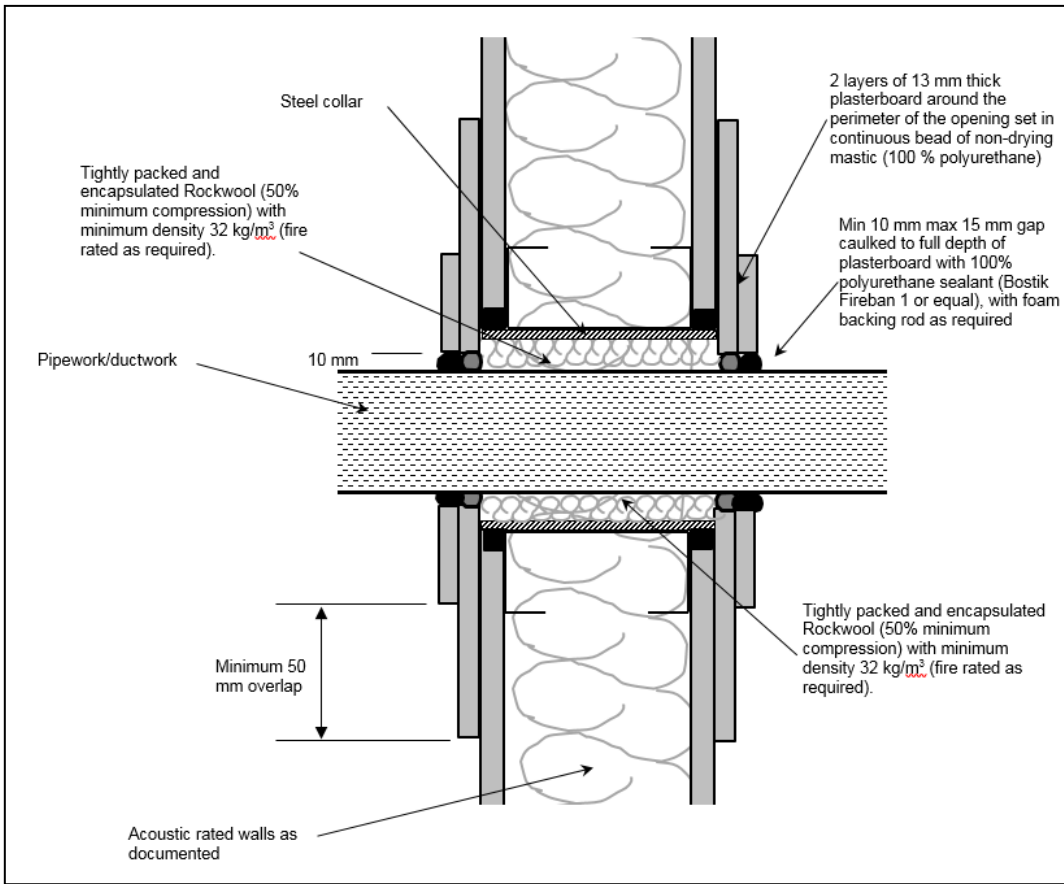


Figure 3.12 Sectional elevation view – Pipework/ductwork penetration acoustic sealing details through full height walls with Dw 45

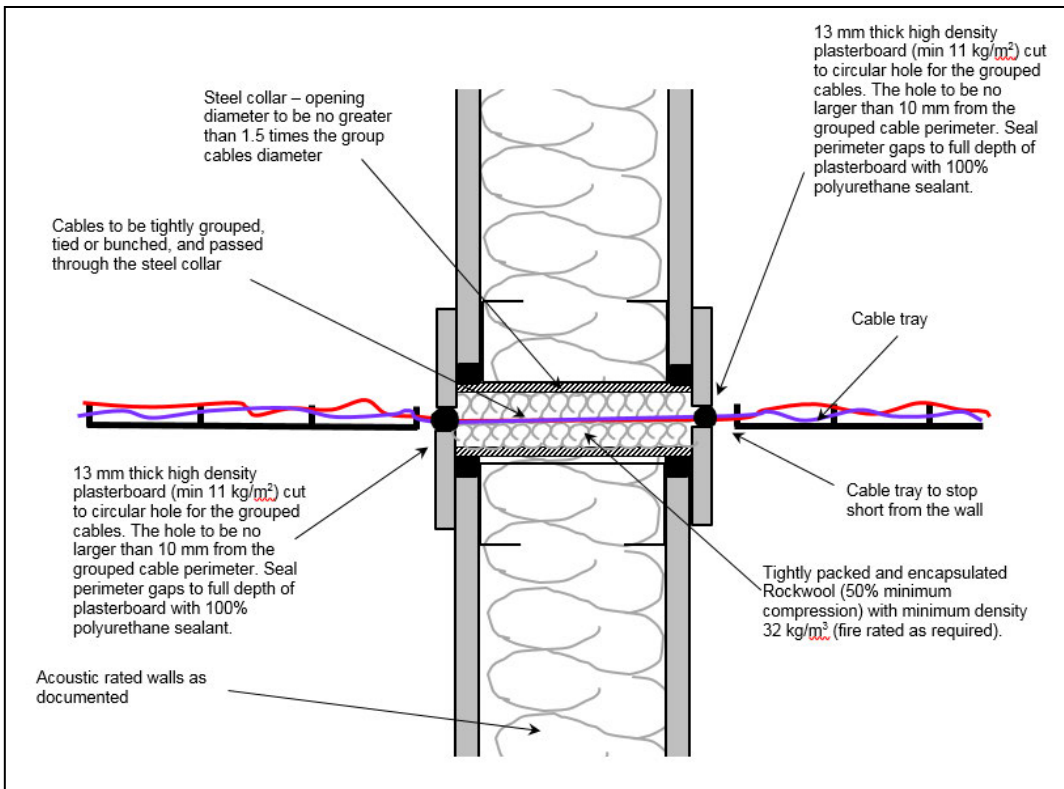


Figure 3.13 Sectional elevation view – Cable tray penetration acoustic sealing details

Noise flanking paths due to weak points such as penetrations can be also compounded by the presence of gaps due to workmanship tolerance as discussed below.

### 3.10.10 Workmanship tolerance

If noise is transmitting in a number of places, upgrading only one of them, however effective, will not solve the noise intrusion problem.

A common misconception is that 'heavier' elements are the primary solution to noise mitigation, but in most cases it is not effective because of other contributing factors. This is due to the overall sound reduction of a partition or façade is significantly influenced by its weakest elements. Sound can also enter a building in unexpected ways, such as through ventilation openings as well as gaps and cracks around the edges of building elements. Below is a list of common causes for noise leaks:

- Holes cut for pipes, conduits, etc.
- Timber jambs around doorways
- Window frames
- Bedding gaskets for doors and operable windows
- Gaps under doors
- Ventilation opening in floor, walls, eaves, and roof spaces
- Junctions between structural elements (e.g. wall and ceiling)

These noise paths are commonly referred to as flanking paths and are often a cause of poor sound reduction in an enclosed space. To reduce noise ingress into an enclosed space, in the first instance, it is necessary to ensure that all penetrations, joints and junctions are sealed airtight where feasible or acoustically treated. If windows do require treatment, achieving effective seals is usually more important than the glazing configuration. Rather than upgrading one area to a very high standard, it may be more sensible to upgrade all affected elements to a reasonable standard. Typically, mitigation is provided with the aim of ensuring continuity of construction between contiguous spaces.



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