CUNDALL

LAHC Seniors Housing Units - Belfield

Acoustic design report

NSW Department of Planning Industry & Environment

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A	07 July 2021	Updated external noise intrusion elements
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E	09 June 2022	Included assessment against I-SEPP (2021); amendments to text and general arrangement plan

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Contents

1.0

Introduction

1.0 Introduction

Cundall has been engaged by the NSW Department of Planning Industry & Environment to provide an acoustic design report for the LAHC Seniors housing units located in Belfield.

This report summarises the results of our noise surveys at the site as well as proposing appropriate acoustics design criteria and our design advice for the various elements of the project.

Appendix A details acoustic terminology used in this report.

1.1 Site location

The proposed location for the project is located on two existing addresses, 97-99 Punchbowl Road, Belfield NSW.

The surrounding environment of the site is all residential housing with the main road being Punchbowl Road.

1.2 Design reference

In this report, acoustic design targets are established for:

- Noise impact of the surrounding community on the development
- External noise intrusion
- Internal sound insulation
- Reverberation control
- Building services noise.

This document will also incorporate acoustics requirements, the design targets and guidance derived from relevant Australian codes, standards, and guidelines. These will include the following:

- NSW EPA 2017, *Noise Policy for Industry* (NPFI)
- Australian Standard AS2107 'Acoustics – Recommended design sound levels and reverberation times for building interiors' (2016);
- National Construction Code (2019) (NCC)
- NSW Apartment Design Guide 2015 (ADG)
- NSW State Environmental Planning Policy (Transport and Infrastructure) 2021 (I-SEPP)
- NSW State Environment Planning Policy (Infrastructure) 2007 [superseded]
- Development near Rail Corridors and Busy Roads – Interim Guide (NSW Department of Planning and Environment).

1.3 Development description

The new development consists of a single building comprising 8 dwellings. An extract of the architectural plans showing the site general arrangement is provided in Figure 1.1 below.

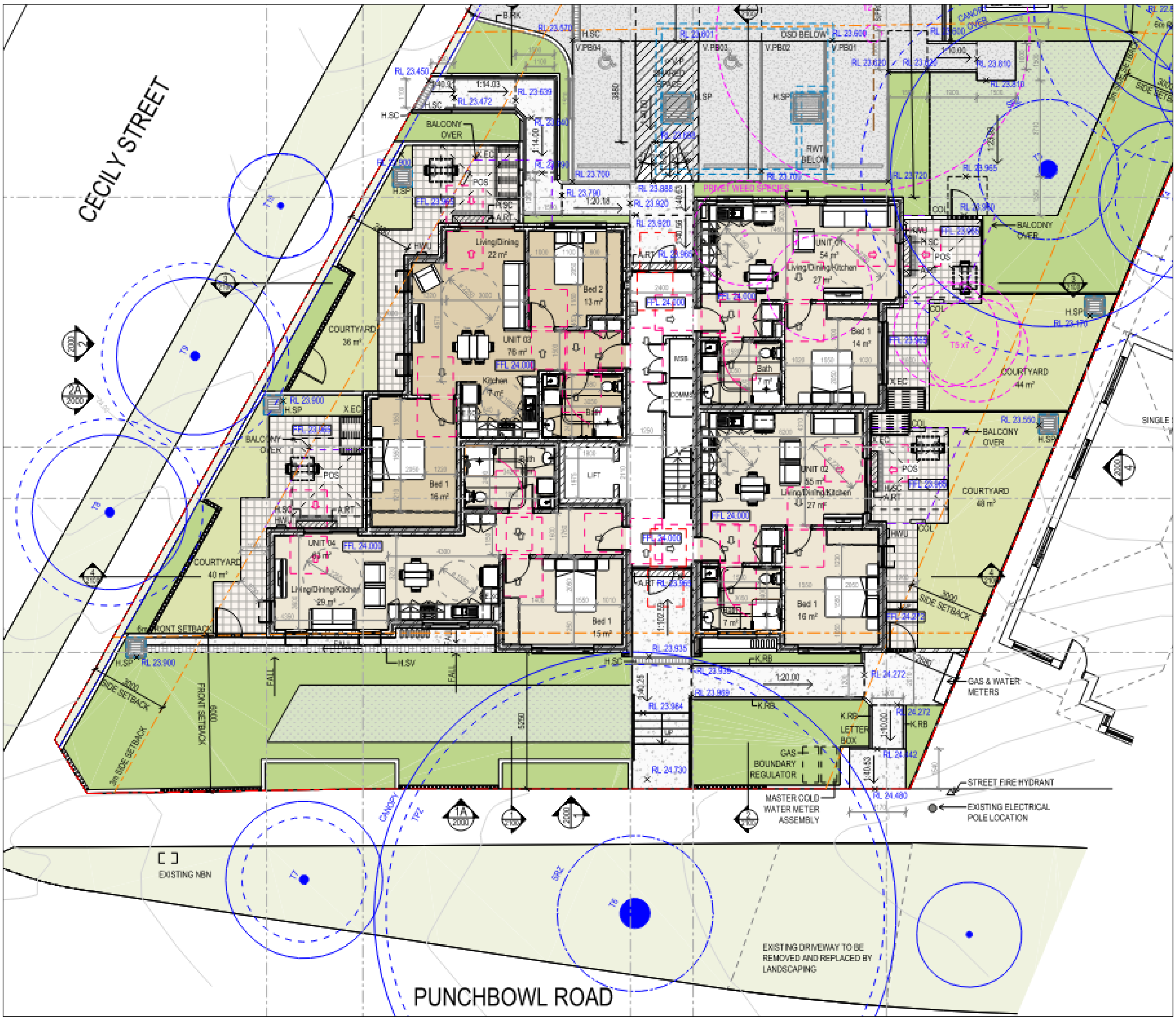


Figure 1.1 General arrangement – Ground level (dated 1 June 2022)

2.0

Environmental noise survey

2.0 Environmental noise survey

2.1 Noise Survey

The purpose of the noise survey was primarily to:

- identify sources of noise that are likely to affect the development and their expected levels;
- quantify existing ambient noise levels, to assist in setting appropriate noise criteria to assess the impact of the proposed development on the surroundings;
- identify potential noise sensitive receivers in the vicinity;
- quantify the existing road traffic noise levels impacting the proposed development.

2.2 Unattended survey

Long-term unattended noise monitoring was conducted between 7 June 2021 and 17 June 2021.

Two unattended noise monitors were placed on the property of 97 Punchbowl Road, Bellfield. Noise monitor 1 (NM01) was placed in the front of the property, its exposure to Punchbowl Road captures the road traffic noise which is considered to have the greatest impact on the site. Noise monitor 2 (NM02) was placed within the backyard of 97 Punchbowl Road to monitor the background noise of the site. Refer to Figure 2.1.

Figure 2.1 Unattended noise monitoring locations

The following Table 2.1 presents a summary of the ambient and background noise levels measured in accordance with *the NSW NPfI*.

Weather during the measurement period provided appropriate noise levels, not inhibiting the background levels for the majority of the time.

Table 2.1 Summary of ambient noise levels

Noise monitor	Measured Ambient Noise Level (dB, L_{Aeq})			Measured Background Noise Level (dB, L_{A90})		
	Daytime	Evening	Night-time	Daytime	Evening	Night-time
NM01 (Traffic)	61	61	57	-	-	-
NM02	53	51	48	46	45	39

3.0

Environmental noise criteria

3.0 Environmental noise criteria

3.1 NSW EPA Noise Policy for Industry

Any environmental noise emissions from the proposed development should be designed to comply with the requirements of the NPfI.

The objective of the NPfI is to ensure noise impacts from the proposed developments are assessed and managed in a consistent and transparent manner. If it is predicted that the development is likely to cause the project noise trigger level to be exceeded at noise-sensitive receivers, management measures need to be considered to seek to reduce the potential noise level.

The project noise trigger level provides an objective for assessing a proposal or site. It is not intended for use as a mandatory requirement. The project noise trigger level is a level that, if exceeded, would indicate a potential noise impact on the community, and so 'trigger' a management response; for example, further investigation of mitigation measures. The project noise trigger level, feasible and reasonable mitigation measures, and consideration of residual noise impacts are used together to assess noise impact and manage the potential noise from a proposal or site.

The project noise trigger level is the lower (that is, the more stringent) value of the project intrusiveness noise level and project amenity noise level.

Applying the most stringent requirement as the project noise trigger level ensures that both intrusive noise is limited, and amenity is protected, and that no single development can unacceptably affect the noise level of an area.

The NPfI separates the day into three different time periods – daytime, evening and night-time. These time periods are detailed below.

Table 3.1 NPfI time periods

Period	Day of week	Time period
Day	Monday-Saturday Sunday, Public Holiday	07:00 – 18:00 hours 08:00 – 18:00 hours
Evening	Monday-Sunday	18:00 – 22:00 hours
Night	Monday-Saturday Sunday, Public Holiday	22:00 – 07:00 hours 22:00 – 08:00 hours

3.2 Operational noise design criteria

The following sub-sections outline the project specific design criteria for environmental noise emission of the Project.

Mechanical services for the project should be designed such that the overall noise emission complies with the following criteria, assessed at the nearest noise sensitive premises.

Punchbowl Road is a high traffic road as traffic noise was observed to be the dominant noise source. NPfI criteria will be calculated accordingly.

3.2.1 Project intrusiveness level

The intrusiveness noise level aims to protect against significant changes in noise levels source and it is generally considered acceptable if the equivalent continuous noise level ($L_{Aeq,15minute}$) does not exceed the background noise level (RBL) by more than 5 dB.

The applicable intrusiveness criteria for the development based on site background noise measurement results[1] are provided in Table 3.2.

Table 3.2 NPfI - Intrusive criteria

Location	Reference monitoring location	Time period	RBL (Measured)	Intrusive criteria RBL + 5 dB
			dBA	dB, $L_{Aeq,15min}$
Nearest residential properties	NM02	Daytime	46	51
		Evening	45	50
		Night-time	39	44

3.2.2 Project amenity level

The amenity noise level is based on noise criteria specific to land use and associated activities. The amenity noise level aims to limit continuing increases in noise levels which may occur if the intrusiveness level alone is applied to multiple and successive developments within an area.

The protection of noise amenity applies to noise from industrial noise sources including noise emitted from the mechanical plants within the proposed development. Criteria consider the type of receiver, the area classification and the time of day the noise is proposed to occur.

It is noted that the dB L_{Aeq} noise level is determined over a 15-minute period for the project intrusiveness noise level and over an assessment period (day, evening and night) for the project amenity noise level. This leads to the situation where, because of the different averaging periods, the same numerical value does not necessarily represent the same amount of noise heard by a person for different time periods.

The NPfI provides the guidance on the adjustment to be made to the $L_{Aeq,period}$ to a representative $L_{Aeq,15minute}$ level in order to standardise the time periods. The following relationship applies:

$$L_{Aeq,15min} = L_{Aeq,\ period} + 3\ \text{dB.}$$

A summary of the amenity criteria using data from the noise logger is presented in Table 3.3.

Table 3.3 NPfI – Amenity criteria

Classification	Time period	Measured noise level dB $L_{Aeq,15min}$	ANL[1,2] dB $L_{Aeq,\ period}$	Amenity criteria dB $L_{Aeq,15min}$
Suburban	Daytime	53	55	53 (55-5+3)
	Evening	51	45	43 (45-5+3)
	Night-time	48	40	38 (40-5+3)

1) Acceptable Noise Level for suburban residences, according to Table 2.2 of NSW NPfI, 2017.
2) To standardise the assessment period for the intrusiveness and amenity noise levels, the policy assumes $L_{Aeq,15min} = L_{Aeq,\ period} + 3$ dB.

[1] Because of the variable nature of background noise levels, the NPfI specifies single number background noise levels for use in setting the intrusiveness noise criterion. The Assessment Background Level [ABL] for each time period is the level exceeded by 90% of the $L_{A90,15min}$ measurements. The Rating Background Level [RBL] for a particular time period is the median of the ABL values for that time period for each day of the measurement period.

3.2.3 Applicable project-specific trigger levels

The most stringent of the intrusiveness and the amenity criteria should be set as the project-specific trigger level to be met by the development. Table 3.4 compares the intrusiveness and the amenity criteria and identifies the project-specific trigger levels adopted.

Table 3.4 NPfI – Project-specific noise trigger levels

Location	Classification	Time period	Intrusive criteria dB $L_{Aeq,15min}$	Amenity criteria dB $L_{Aeq,15min}$	Project -specific trigger level dB $L_{Aeq,15min}$
Nearest residential properties	Suburban	Day	51	53	51
		Evening	50	43	43
		Night	44	38	38

3.3 Noise from busy roads

The NSW Apartment Design Guide 2015 ADG (Section 4J) states that developments near busy roads are required to be assessed in accordance with Development near Rail Corridors and Busy Roads – Interim Guide (NSW Department of Planning and Environment), which in turn refers to Clause 102 of the NSW State Environment Planning Policy (Infrastructure) 2007 (I-SEPP).

Starting from March 2022 the NSW State Environmental Planning Policy (Transport and Infrastructure) 2021 has replaced the NSW State Environment Planning Policy (Infrastructure) 2007. As presented below, there is no significant change in relation to the requirements of road noise impact on non-road development.

Section 2.119 of the I-SEPP (2021) states:

2.119 Impact of road noise or vibration on non-road development

(1) This section applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 20,000 vehicles (based on the traffic volume data published on the website of TfNSW) and that the consent authority considers is likely to be adversely affected by road noise or vibration—

(a) residential accommodation,

(b) a place of public worship,

(c) a hospital,

(d) an educational establishment or centre-based child care facility.

…

(3) If the development is for the purposes of residential accommodation, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded—

(a) in any bedroom in the residential accommodation—35 dB(A) at any time between 10 pm and 7 am,

(b) anywhere else in the residential accommodation (other than a garage, kitchen, bathroom or hallway)—40 dB(A) at any time.

The most recent RTA traffic data for this section of Punchbowl Road is taken from the permanent monitoring position located as shown in Figure 3.1

Figure 3.1 Traffic monitoring location (2018)

This monitor was removed in 2018, but based on typical data, traffic volumes would not have significantly increased in the last 3 years. Data from this location indicates that this section of Punchbowl Road carries 34,153 vehicles a day, meaning that it is classified as a "Busy Road" and therefore it requires an assessment under I-SEPP (2021) Section 2.119.

4.0

Internal noise levels

4.0 Internal noise levels

4.1 General

It is assumed that external noise break-in can be adequately controlled by the building envelope such that the design targets can be achieved.

It is important that ambient noise levels are not reduced too low, as a degree of constant background noise, such as provided by mechanical ventilation systems, helps to mask activity noise intrusion and provides appropriate privacy between areas.

Mechanical services strategies will be reviewed, and ducts should not cross partitions between noise-sensitive spaces wherever possible. Appropriate attenuation will be required to common ductwork serving multiple areas.

4.1.1 Internal noise level design targets

Table 4.1 outlines internal noise levels and reverberation times design targets for typical spaces within the proposed development in line with the I-SEPP (2021) requirements and compliant with the Australian Standard AS2107-2016 '*Acoustics – Recommended design sound levels and reverberation times for building interiors*' (2016).

Table 4.1 Summary of recommended room acoustics design targets

Room type	$L_{Aeq,15hr}$ Day (7am-10pm)	$L_{Aeq,9hr}$ Night (10pm-7am)
Bedrooms	≤ 40	≤ 35
Anywhere else in the residential accommodation	≤ 40	≤ 40

All mechanical services equipment must be designed to achieve the internal ambient levels in Table 4.1.

A detailed review of mechanical services noise is not part of our scope of work for this stage of the project. It is the responsibility of the services contractor to achieve the above noise criteria.

4.1.2 Sleep disturbance

In addition to maintaining acceptable average internal noise levels (AS/NZS 2107), the incidence of sleep disturbance from intermittent noise sources (such as truck pass-bys) should be considered.

The NSW Road Noise Policy 2011, produced by the NSW EPA, provides guidance on potential for sleep disturbance.

The NSW Policy notes that, from the research on sleep disturbance to date, it can be concluded that:

- *maximum internal noise levels below 50–55 dB L_{Amax} are unlikely to awaken people from sleep*
- *one or two noise events per night, with maximum internal noise levels of 65–70 dB L_{Amax}, are not likely to affect health and wellbeing significantly.*

The maximum night-time noise levels have been monitored to reach up to 90 L_{Amax} dB at the proposed facade.

Our glazing recommendations are based on achieving the nominated internal design noise level targets (dB L_{Aeq}). The maximum noise levels (dB L_{Amax}) has also been considered as part of the assessment to minimise risk of sleep disturbance.

4.2 Vibration control

Vibration levels arising from the operations of the building (plant, car stackers, car park doors and lifts) must be limited to prevent undue disturbance to building occupants.

Based on the requirements of AS2670.2-1990 *Evaluation of human exposure to whole-body vibration – Continuous and shock-induced vibration in buildings (1 to 80 Hz),* surface vibration velocity levels in occupied areas must not exceed 0.14 mm/s Root Mean Squared (RMS) (taken to be Curve 1.4 of the combined-direction vibration velocity limit). These vibration levels are unlikely to cause adverse comment in residential apartments.

All equipment must be resiliently isolated from the building structure and flexible connections used between all mechanical plant and duct/pipework. Table 47 of the ASHRAE Handbook, provided in Appendix C, details the recommended isolation systems.

5.0

Building envelope

5.0 Building envelope

5.1 Internal ambient noise levels

With reference to the above internal design noise levels (Table 4.1), it is recommended that the building envelope (including glazed elements) and ventilation strategies (including any openings) be designed such that an internal noise level of ≤ 40 dB $L_{Aeq,15hrs}$ can be achieved within all spaces except for bedrooms where an internal noise level of ≤ 35 dB $L_{Aeq,9hrs}$ is preferred.

5.2 Glazing and façade constructions

The building façade should be designed such that the maximum ambient noise level criteria detailed in Table 4.1 would be achieved with doors and windows closed. Attention should be given to provide the necessary sound insulation performance of the façade and glazing and the selection of suitable ventilation systems. The acoustic performance of glazing systems should not be compromised by the framing system or seals.

Following our review on the building elevation draings provided (dated 17.12.21), our recommendations for façade glazing are provided in Appendix B.

The following table lists the minimum transmission loss performance of the nominated glazing types for achieving the internal noise level design targets outlined in Table 4.1.

Table 5.1 Facade transmission loss specification

Glazing type	Glazing type	Octave band Centre Frequency							
		63	125	250	500	1000	2000	4000	Hz
1	10 mm / 16 mm air gap / 12.5 mm vlam hush	26	29	33	44	44	46	60	dB
2	6 mm / 12 mm air gap / 6.38 mm	18	21	20	31	39	37	45	dB
3	10 mm / 12 mm air gap / 6 mm	23	26	27	34	40	38	44	dB
4	6 mm / 12 mm air gap / 6 mm	17	20	19	29	38	36	43	dB

The non-glazed elements of the façade must also be designed to control external noise intrusion. Based upon the results of our noise surveys, we anticipate that his will be achieved using standard lightweight and masonry constructions. The final constructions will be reviewed as the design progresses.

5.3 Ventilation paths

Any mechanical or passive ventilation paths serving the development must be treated acoustically to ensure that they do not compromise the sound insulation performance of the façade. These will be assessed as the design progresses.

5.4 Rain noise

The internal design noise level during a moderate rain event (up to 25 mm/hr rate) should be controlled to not exceeded the nominated internal noise levels of the respective spaces as detailed in Table 4.1 by more than 5 dB.

5.4.1 Roof constriction for rain noise

The lightweight roofs above occupied spaces providing a nominal Sound Intensity Level of 45 dB L_{iA} are recommended to minimise the impact of rain noise to the spaces below.

The following construction is recommended for the development:

- Minimum 0.48 mm thick metal deck roof
- 50 mm thick, minimum 10 kg/m³ acoustic cavity insulation sandwiched between roof metal and purlins
- Minimum 100 mm airgap (purling/joist depth), with additional layer of 50 mm thick minimum 10 kg/m³ acoustic cavity insulation
- 10 mm thick plasterboard, or equivalent

Alternative roofing systems can be assessed if required.

6.0

Partitions and doors

6.0 Partitions and doors

6.1 NCC Requirements

The project is considered as a Class 2 buildings according the NCC. As a result, the acoustic criteria in Table 6.1 apply to partitions and floors within the proposed Punchbowl Road development.

Table 6.1 NCC minimum sound insulation requirements

Partition/Floor	NCC minimum sound insulation criteria		Comments
	Laboratory	In-situ	
Wall separating habitable rooms	$R_w + C_{tr} \geq 50$	$D_{nT,w} + C_{tr} \geq 45$	Discontinuous construction not required
Wall separating wet areas	$R_w + C_{tr} \geq 50$	$D_{nT,w} + C_{tr} \geq 45$	Discontinuous construction not required
Wall separating a wet area or kitchen and a habitable room	$R_w + C_{tr} \geq 50$	$D_{nT,w} + C_{tr} \geq 45$	Discontinuous construction required
Wall separating a sole-occupancy unit from a stairway, public corridor, public lobby, etc.	$R_w \geq 50$	$D_{nT,w} \geq 45$	Discontinuous construction not required
Wall separating a sole-occupancy unit from a plant room or lift shaft	$R_w \geq 50$	$D_{nT,w} \geq 45$	Discontinuous construction required
Floor separating sole-occupancy units	$R_w + C_{tr} \geq 50$ $L_{n,w} + C_I \leq 55$*	$D_{nT,w} + C_{tr} \geq 45$ $L_{nT,w} + C_I \leq 55$*	Floor impact isolation required
Floor separating a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like	$R_w + C_{tr} \geq 50$ $L_{n,w} + C_I \leq 62$	$D_{nT,w} + C_{tr} \geq 45$ $L_{nT,w} + C_I \leq 62$	Floor impact isolation required
Door separating a sole-occupancy unit from a public corridor, public lobby, etc.	$R_w \geq 30$	$D_{nT,w} \geq 25$	

In instances where discontinuous construction is not required by the NCC, i.e. between sole-occupancy units and; wet areas, plant rooms and lift shafts, we strongly recommend that discontinuous construction is provided to achieve a generally accepted level of acoustic amenity.

Clause F5.5 (e) of the NCC states:

> *Where a wall required to have sound insulation has a floor above, the wall must continue to –*
>
> *(i) The underside of the floor above; or*
>
> *(ii) A ceiling that provides the sound insulation required for the wall.*

Clause F5.5 (f) of the NCC states:

> *Where a wall required to have sound insulation has a roof above, the wall must continue to –*
>
> *(iii) The underside of the roof above; or*
>
> *(iv) A ceiling that provides the sound insulation required for the wall.*

6.2 Typical constructions and detailing

6.2.1 Partitions

We have reviewed the proposed internal partitions for the development as detailedin drawing AR-4000 Wall Type Schedule Rev A dated 26 November 2021 and Table 6.2 comments on their compliance with the minimum NCC sound insulation criteria.

Table 6.2 Partition constructions

Wall type	Construction	Predicted acoustic performance	Discontinuous	NCC compliant
Masonry				
Inter-tenancy walls				
W.M.BR07	▪ 13 mm plasterboard ▪ 28 mm furring channel ▪ 110 mm thick brick ▪ 50 mm cavity with 50 mm, minimum 9 kg/m^3 acoustic cavity insulation ▪ 110 mm thick brick ▪ 28 mm furring channel ▪ 13 mm plasterboard	$R_w+C_{tr} \geq 50$	Yes	Yes
W.M.BR08	▪ 10 mm tile ▪ 6 mm thick compressed fibre cement sheet ▪ 28 mm furring channel ▪ 110 mm thick brick ▪ 50 mm cavity with 50 mm, minimum 9 kg/m^3 acoustic cavity insulation ▪ 110 mm thick brick ▪ 28 mm furring channel ▪ 13 mm plasterboard	$R_w+C_{tr} \geq 50$	Yes	Yes
W.M.BR09	▪ 10 mm tile ▪ 6 mm thick compressed fibre cement sheet ▪ 28 mm furring channel ▪ 110 mm thick brick ▪ 50 mm cavity with 50 mm, minimum 9 kg/m^3 acoustic cavity insulation ▪ 110 mm thick brick ▪ 28 mm furring channel ▪ 6 mm thick compressed fibre cement sheet ▪ 10 mm tile	$R_w+C_{tr} \geq 50$	Yes	Yes

Wall type	Construction	Predicted acoustic performance	Discontinuous	NCC compliant
Wall to stair/lobby/corridor				
W.M.BR10	▪ 13 mm cementitious render ▪ 110 mm thick brick ▪ 50 mm cavity ▪ 110 mm thick brick ▪ 28 mm furring channel ▪ 13 mm plasterboard	$R_w \geq 50$	Yes	Yes
W.M.BR11	▪ 13 mm cementitious render ▪ 110 mm thick brick ▪ 50 mm cavity ▪ 110 mm thick brick ▪ 28 mm furring channel ▪ 6 mm thick fibre cement sheet ▪ 10 mm tile	$R_w \geq 50$	Yes	Yes
Walls to lift shaft				
W.M.BR12	▪ 190 mm hollow concrete block ▪ 50 mm cavity with 50 mm, minimum 9 kg/m^3 acoustic cavity insulation ▪ 110 mm thick brick ▪ 28 mm furring channel ▪ 13 mm plasterboard	Rw ≥ 50	Yes	Yes
W.M.BR13	▪ 190 mm hollow concrete block ▪ 50 mm cavity with 50 mm, minimum 9 kg/m^3 acoustic cavity insulation ▪ 110 mm thick brick ▪ 28 mm furring channel ▪ 6 mm thick fibre cement sheet ▪ 10 mm tile	Rw ≥ 50	Yes	Yes

6.2.2 Floor-ceiling constructions

To achieve the acoustic criteria detailed in Table 6.1 for impact sound insulation, the following minimum construction is recommended:

- Floor finish (carpet, timber or tiles);
- Acoustic underlay below <u>all</u> hard floor finishes;
- Minimum 150 mm concrete floor slab;
- Minimum 100 mm deep cavity with metal suspension system;
- 75 mm thick, 20 kg/m^3 cavity insulation (recommended);
- 13 mm standard plasterboard.

Acceptable acoustic underlay products include 3 mm Damtec Standard or 4.5 mm Regupol 4515.

6.3 General partition construction guidance

In order to see that acoustic integrity and performance of partitions is maintained and controlled, the following general guidance is suggested:

- wall perimeters to be fully stopped and sealed;
- walls are not to be degraded by penetrations for electrical or plumbing fixings or fixtures;
- wherever possible, services should not pass through partitions dividing adjacent sensitive spaces but be routed via an adjoining corridor. Where there is no other option but to pass services through sound-resisting partitions, care must be taken to see that the acoustic integrity of the partition is not compromised.
- air conditioning or ventilation openings in ceilings must not compromise the sound insulation between rooms and should be treated/modified accordingly;
- walls dividing the ceiling cavity are to be sealed at the head, sides and at any and all services penetrations;
- all partitions should ideally be full height, from the structural floor to soffit, well-sealed, and with suitable deflection heads to see no loss of performance;
- partitions that are not constructed from structural floor to soffit will require suitable cavity void barriers (above and below as necessary), in conjunction with an acoustic ceiling system;
- penetrations for services should be avoided within dividing partitions. Ideally, services should be routed via corridors and taken into each cellular room above the door. Suitable details will need to be developed to seal penetrations;
- where double layers of board are used, joints should be staggered. Facing boards should be well sealed with skim finish.

6.4 Partition junctions

When butting internal partitions to external wall linings, care should be taken to see that flanking does not occur either through the junction detail, or via the wall lining and cavity behind.

Partitions that fall on mullions must extend across the sill to the mullion, or a construction equivalent to the partition's sound insulation performance provided to the gap.

For partitions with a sound insulation rating of > 40 dB R_w, additional acoustic treatment may be required to mullions.

Suggested deflection head details are provided in Figure 6.1.

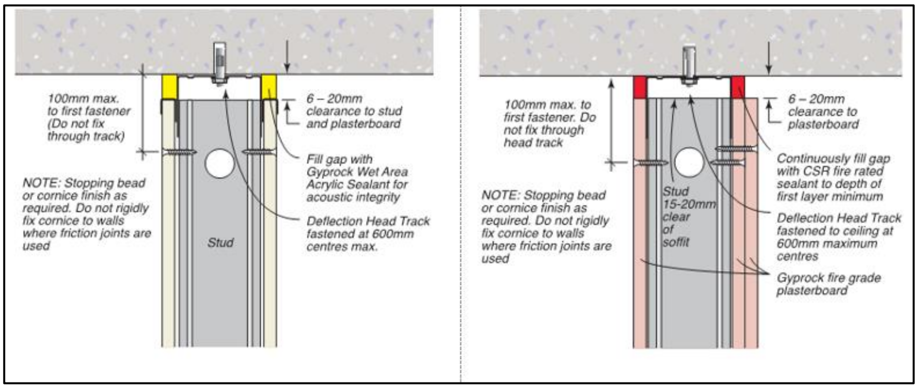


Figure 6.1 Partition head detail example

Where a dividing partition meets with a corridor partition it should be taken through the lining of the corridor partition, as detailed in Figure 6.2.

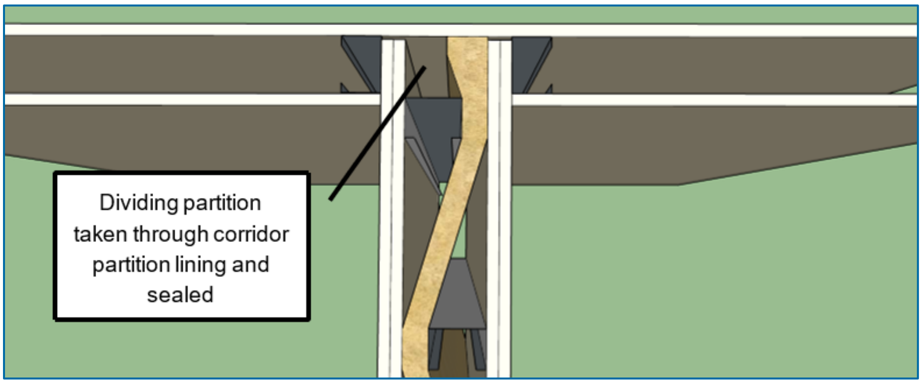


Figure 6.2 Partition junction detail 1

Similarly, masonry constructions should be configured so that cavities between leaves are not continuous across an intenancy wall.

6.5 GPOs

Electrical sockets located in partitions having a sound insulation performance requirement of $R_w \geq 45$ dB should be specified with appropriate proprietary socket box covers/infills. An example of this is shown in Figure 6.3.

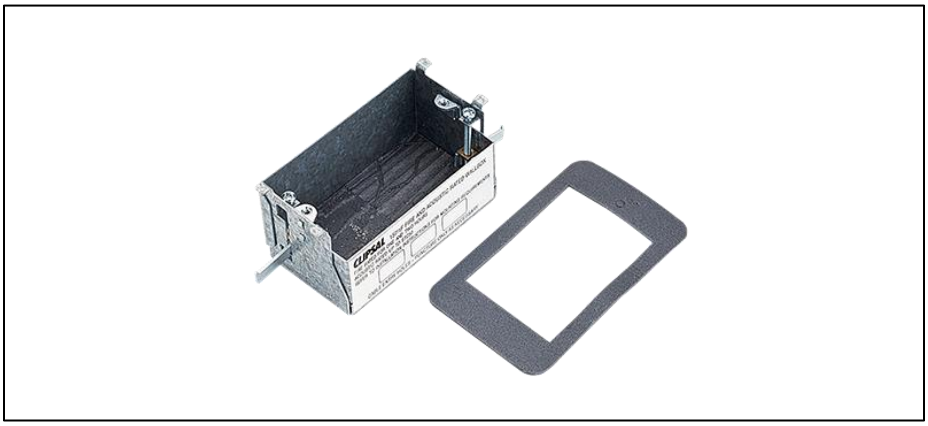


Figure 6.3 Example GPO back box

Electrical sockets should not be placed back-to-back in such cases, but spaced a minimum 150 mm; Penetrations must be sealed with a non-setting acoustic sealant such as mastic.

6.6 Doors

The NCC requires Class 2 buildings where doors that “separates a sole-occupancy unit from a stairway, public corridor, public lobby or the like” be not less than 30 dB R_w.

7.0

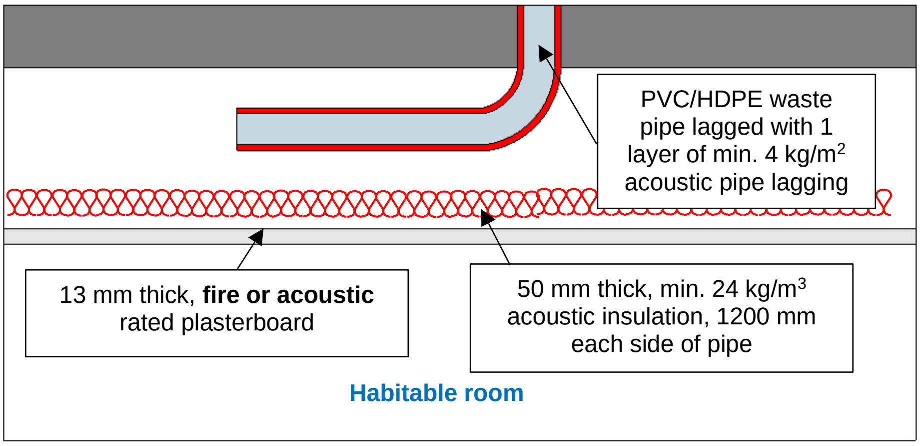
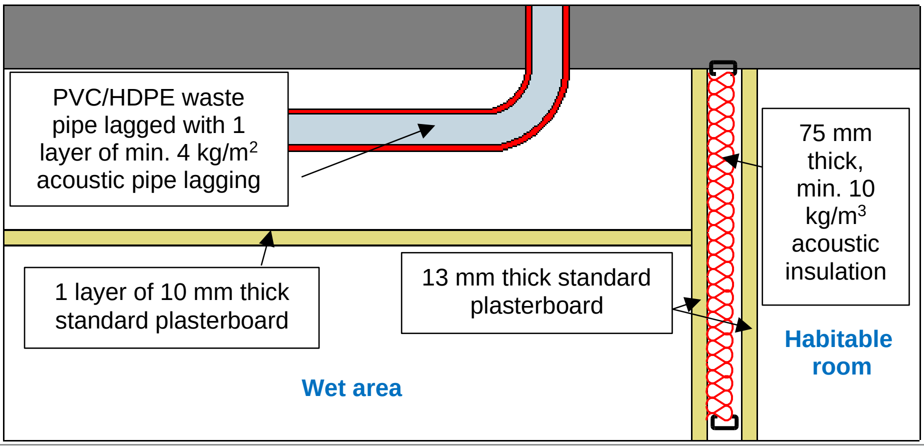
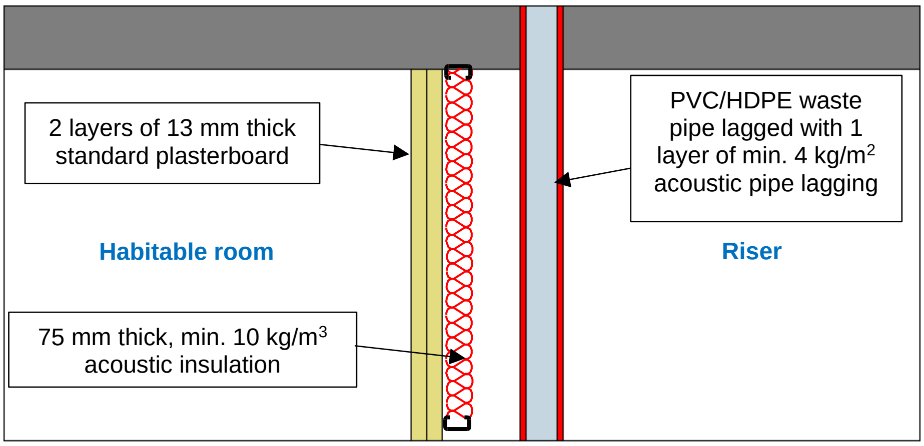
Hydraulic services

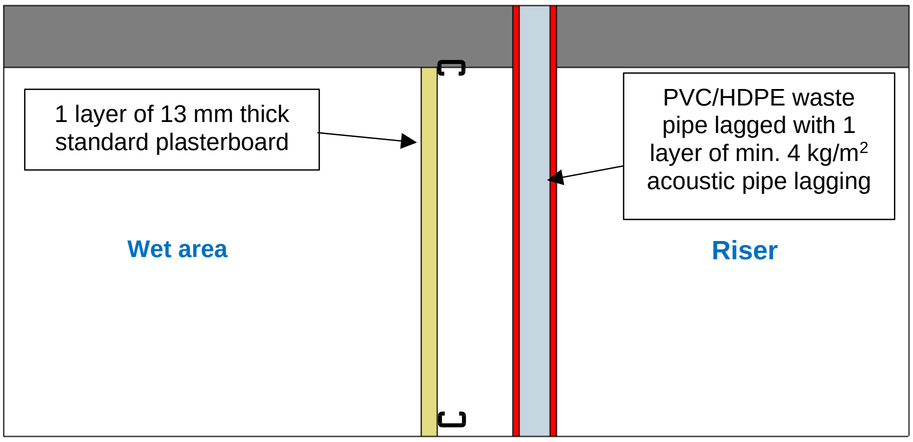
7.0 Hydraulic services

7.1 Services treatment in walls and ceilings

To achieve the minimum requirements of the NCC, the acoustic treatment detailed in Table 7.1 is required.

Table 7.1 Hydraulic services - Acoustic treatment recommendations

Condition and NCC requirement	Minimum acoustic treatment
Pipework above habitable spaces $R_w + C_{tr}$ 40 dB	
Pipework above wet areas $R_w + C_{tr}$ 25 dB	
Pipework in riser adjacent to habitable room $R_w + C_{tr}$ 40 dB	

Condition and NCC requirement	Minimum acoustic treatment
Pipework in riser adjacent to wet area $R_w + C_{tr}$ 25 dB	

7.2 Water supply pipes

Copper and steel pipework should be avoided, and flexible plastic pipework be used to reduce the likelihood of flow generated noise being audible in adjacent spaces.

7.3 Support and fixing of pipework

There must be no physical contact between pipework and lightweight elements of the building structure, including studwork walls and suspended ceilings. Pipework must be suspended and fixed only to the concrete slab above.

Where pipework is located within discontinuous cavity walls, they must only be tied to the side of the partition served by the pipework and not in contact (or by movement come into contact) with studwork on the opposite side of the wall.

7.4 Penetrations

All pipe penetrations through acoustically rated floors, ceilings, and walls must be acoustically sealed.

Penetrations should be no greater than 10 mm larger than required for the pipework, and sealed with a flexible, non-setting acoustic sealant such as mastic. Where larger penetrations occur, they must be reduced to within 10 mm of the pipe using materials of equivalent acoustic performance of the floor, ceiling or wall penetrated, prior to sealing.

Care must be taken to ensure there is no contact between pipes and the surrounding structure.

8.0

Appendix

Appendix A Acoustic Terminology

'A'-WEIGHTED SOUND LEVEL dBA

The unit generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dBA. An A-weighting network can be built into a sound level measuring instrument such that sound levels in dBA can be read directly from a meter. The weighting is based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. An increase or decrease of approximately 10 dB corresponds to a subjective doubling or halving of the loudness of a noise. A change of 2 to 3 dB is subjectively barely perceptible.

EQUIVALENT CONTINUOUS SOUND LEVEL (L_{Aeq})

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level, which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

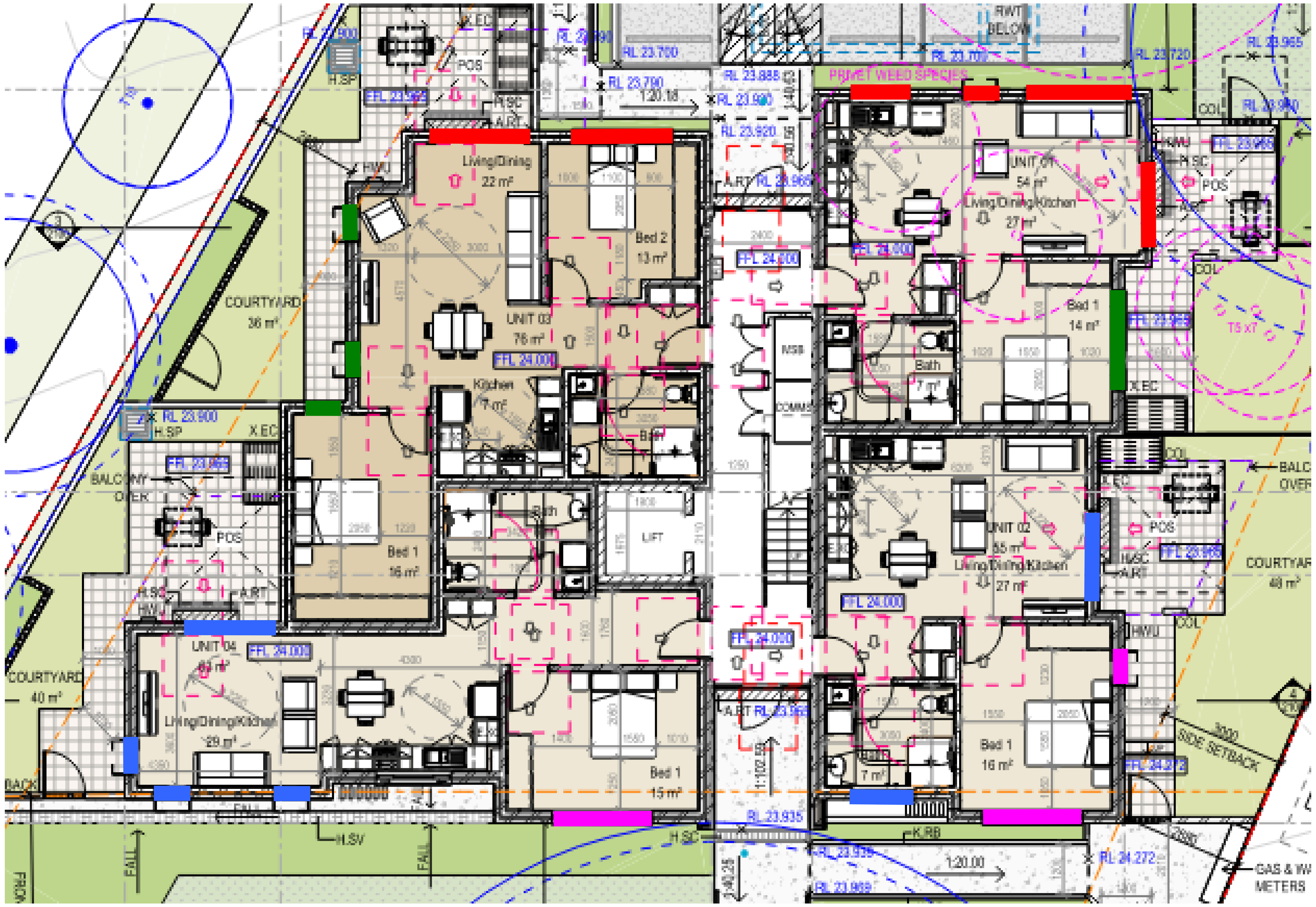
FREQUENCY

The rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted kilohertz (kHz), e.g. 2 kHz = 2000 Hz. Human hearing ranges from approximately 20 Hz to 20 kHz. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For design purposes, the octave bands between 63 Hz to 8 kHz are generally used. For more detailed analysis, each octave band may be split into three one-third octave bands or, in some cases, narrow frequency bands.

L_{A90}

Refers to the sound pressure level measured in dBA, exceeded for 90% of the measured time period i.e. measured noise levels were greater than this value for 90% of the time interval. This is also often referred to the background noise level, or ambient noise level

Appendix B Façade glazing mark up



1031046	A1

DO NOT SCALE FROM THIS DRAWING

Glazing type

- Type 1 10 /16 /10.5
- Type 2 6 /12 /6.38
- Type 3 10 /12 /6
- Type 4 6 /12 /6

Issue	Date	Description	By	Chkd	Verfd
B	9.06.22	Final	DA	ME	DA
A	8.12.21	For 90% submission	PC	LH	PC
-	18.11.21	For DD	PC	LH	PC

Project
LAHC Belfield

Client
Mode Architecture

Architect
Mode Architecture

Title
Glazing mark up for acoustics

Drawing No.	Drawing Status
-	-
Job No. 1031046	Scale Do not scale

Originator	Checker	Verified	Issue
DA	ME	DA	B

CUNDALL

1 Carter Lane
London
EC4V 5ER
Telephone: +44 20 7438 1600

Website: www.cundall.com

Note: As layout on both floors is the same, this mark up applies to both floors

True scale at 1:1

Appendix C ASHRAE Table 47

vibrating piece of equipment and the floor on which it is placed. If a piece of equipment is aligned and balanced within acceptable tolerances and excessive vibration levels still exist, the equipment and installation should be checked for possible resonant conditions Table 46 gives maximum allowable rms velocity levels for selected pieces of equipment.

Vibration levels measured on equipment structures should be in or below the "good" region in Figure 43. Machine vibration levels in the "fair" or "slightly rough" regions may indicate potential problems requiring maintenance. Machines with vibration levels in these regions should be monitored to ensure problems do not arise. Machine vibration levels in the "rough" and "very rough" regions indicate a potentially serious problem; immediate action should be taken to identify and correct the problem.

3.4 SPECIFICATION OF VIBRATION ISOLATORS

Vibration isolators must be selected not only to provide required isolation efficiency but also to ensure that the natural frequency of the isolated system is not close to the natural frequency of the floor. If vibration isolators are not correctly selected, the isolator may actually amplify the force transmitted. Floor spans, equipment operating speeds, equipment power, damping, and other factors are considered in Table 47.

Table 47 Selection Guide for Vibration Isolation

			Equipment Location (Notes for Table 47, Item 1)												
						Floor Span									
			Slab on Grade			Up to 6 m			6 to 9 m			9 to 12 m			
Equipment Type	Shaft Power kW and Other	RPM	Base Type	Isolator Type	Min. Defl., mm	Base Type	Isolator Type	Min. Defl., mm	Base Type	Isolator Type	Min. Defl., mm	Base Type	Isolator Type	Min. Defl., mm	Reference Notes
Refrigeration Machines and Chillers															
Water-cooled reciprocating	All	All	A	2	6.4	A	4	19	A	4	38	A	4	64	2,3,12
Water-cooled centrifugal, scroll	All	All	A	1	6.4	A	4	19	A	4	38	A	4	38	2,3,4,8,12
Water-cooled screw	All	All	A	4	25	A	4	38	A	4	64	A	4	64	2,3,4,12
Absorption	All	All	A	1	6.4	A	4	19	A	4	38	A	4	38	
Air-cooled recip., scroll	All	All	A	1	6.4	A	4	38	A	4	38	A	4	64	2,4,5,12
Air-cooled screw	All	All	A	4	25	A	4	38	B	4	64	B	4	64	2,4,5,8,12
Air Compressors and Vacuum Pumps															
Tank-mounted horiz.	≤7.5	All	A	3	19	A	3	19	A	3	38	A	3	38	3,15
	≥7.5	All	C	3	19	C	3	19	C	3	38	C	3	38	3,15
Tank-mounted vert.	All	All	C	3	19	C	3	19	C	3	38	C	3	38	3,15
Base-mounted	All	All	C	3	19	C	3	19	C	3	38	C	3	38	3,14,15
Large reciprocating	All	All	C	3	19	C	3	19	C	3	38	C	3	38	3,14,15
Pumps															
Close-coupled	≤5.6	All	B	2	6.4	C	3	19	C	3	19	C	3	19	16
	≥5.6	All	C	3	19	C	3	19	C	3	38	C	3	38	16
Large inline	3.7 to 19	All	A	3	19	A	3	38	A	3	38	A	3	38	
	≥19	All	A	3	38	A	3	38	A	3	38	A	3	64	
End suction and split case	≤30	All	C	3	19	C	3	19	C	3	38	C	3	38	16
	30 to 93	All	C	3	19	C	3	19	C	3	38	C	3	64	10,16
	≥93	All	C	3	19	C	3	38	C	3	64	C	3	89	10,16
Packaged pump systems	All	All	A	3	19	A	3	19	A	3	38	C	3	64	
Cooling Towers	All	Up to 300	A	1	6.4	A	4	89	A	4	89	A	4	89	5,8,18
		301 to 500	A	1	6.4	A	4	64	A	4	64	A	4	64	5,18
		501 and up	A	1	6.4	A	4	19	A	4	19	A	4	38	5,18
Boilers															
Fire-tube	All	All	A	1	6.4	B	4	19	B	4	38	B	4	64	4
Water-tube, copper fin	All	All	A	1	3	A	1	3	A	1	3	B	4	6.4	
Axial Fans, Plenum Fans, Cabinet Fans, Fan Sections, Centrifugal Inline Fans															
Up to 560 mm diameter	All	All	A	2	6.4	A	3	19	A	3	19	C	3	19	4,9
610 mm diameter and up	≤500 Pa SP	Up to 300	B	3	64	C	3	89	C	3	89	C	3	89	9,8
		300 to 500	B	3	19	B	3	38	C	3	64	C	3	64	9,8
		501 and up	B	3	19	B	3	38	B	3	38	B	3	38	9,8
	≥501 Pa SP	Up to 300	C	3	64	C	3	89	C	3	89	C	3	89	3,8,9
		300 to 500	C	3	38	C	3	38	C	3	64	C	3	64	3,8,9
		501 and up	C	3	19	C	3	38	C	3	38	C	3	64	3,8,9
Centrifugal Fans															
Up to 560 mm diameter	All	All	B	2	6.4	B	3	19	B	3	19	B	3	38	9,19
610 mm diameter and up	≤30	Up to 300	B	3	64	B	3	89	B	3	89	B	3	89	8,19
		300 to 500	B	3	38	B	3	38	B	3	64	B	3	64	8,19
		501 and up	B	3	19	B	3	19	B	3	19	B	3	38	8,19
	≥37	Up to 300	C	3	64	C	3	89	C	3	89	C	3	89	2,3,8,9,19
		300 to 500	C	3	38	C	3	38	C	3	64	C	3	64	2,3,8,9,19
		501 and up	C	3	25.4	C	3	38	C	3	38	C	3	64	2,3,8,9,19

Table 47 Selection Guide for Vibration Isolation (*Continued*)

			Equipment Location (Notes for Table 47, Item 1)												
						Floor Span									
			Slab on Grade			Up to 6 m			6 to 9 m			9 to 12 m			
Equipment Type	Shaft Power kW and Other	RPM	Base Type	Isolator Type	Min. Defl., mm	Base Type	Isolator Type	Min. Defl., mm	Base Type	Isolator Type	Min. Defl., mm	Base Type	Isolator Type	Min. Defl., mm	Reference Notes
Propeller Fans															
Wall-mounted	All	All	A	1	6.4	A	1	6.4	A	1	6.4	A	1	6.4	
Roof-mounted	All	All	A	1	6.4	A	1	6.4	B	4	38	D	4	38	
Heat Pumps, Fan-Coils, Computer Room Units	All	All	A	3	19	A	3	19	A	3	19	A/D	3	38	
Condensing Units	All	All	A	1	6.4	A	4	19	A	4	38	A/D	4	38	
Packaged AH, AC, H and V Units															
All	7.5	All	A	3	19	A	3	19	A	3	19	A	3	19	19
	7.5 to 11	Up to 300	A	3	19	A	3	89	A	3	89	C	3	89	2,4,8,19
	≤ 1kPa SP	301 to 500	A	3	19	A	3	64	A	3	64	A	3	64	4,19
		501 and up	A	3	19	A	3	38	A	3	38	A	3	38	4,19
	>11,	Up to 300	B	3	19	C	3	89	C	3	89	C	3	89	2,3,4,8,9
	> 1kPa SP	301 to 500	B	3	19	C	3	38	C	3	64	C	3	64	2,3,4,9
		501 and up	B	3	19	C	3	38	C	3	38	C	3	64	2,3,4,9
Packaged Rooftop Equipment	All	All	A/D	1	6.4	D	3	19	See Reference Note 17						5,6,8,17
Ducted Rotating Equipment															
Small fans, fan-powered boxes	≤300 L/s	All	A	3	12.7	A	3	12.7	A	3	12.7	A	3	12.7	7
	≥301 L/s	All	A	3	19	A	3	19	A	3	19	A	3	19	7
Engine-Driven Generators	All	All	A	3	19	C	3	38	C	3	64	C	3	89	2,3,4
Piping and Ducts (See sections on Isolating Vibration and Noise in Piping Systems and Isolating Duct Vibration for isolator selection.)															

Base Types:
A. No base, isolators attached directly to equipment (Note 28)
B. Structural steel rails or base (Notes 29 and 30)
C. Concrete inertia base (Note 30)
D. Curb-mounted base (Note 31)

Isolator Types:
1. Pad, rubber, or glass fiber (Notes 20 and 21)
2. Rubber floor isolator or hanger (Notes 20 and 25)
3. Spring floor isolator or hanger (Notes 22, 23, and 26)
4. Restrained spring isolator (Notes 22 and 24)
5. Thrust restraint (Note 27)
6. Air spring (Note 25)

Notes for Table 47: Selection Guide for Vibration Isolation

These notes are keyed to the column titled *Reference Notes* in Table 47 and to other reference numbers throughout the table. Although the guide is conservative, cases may arise where vibration transmission to the building is still excessive. If the problem persists after all short circuits have been eliminated, it can almost always be corrected by altering the support path (e.g., from ceiling to floor), increasing isolator deflection, using low-frequency air springs, changing operating speed, improving rotating component balancing, or, as a last resort, changing floor frequency by stiffening or adding more mass. Assistance from a qualified vibration consultant can be very useful in resolving these problems.

Note 1. Isolator deflections shown are based on a reasonably expected floor stiffness according to floor span and class of equipment. Certain spaces may dictate higher levels of isolation. For example, bar joist roofs may require a static deflection of 38 mm over factories, but 64 mm over commercial office buildings.

Note 2. For large equipment capable of generating substantial vibratory forces and structureborne noise, increase isolator deflection, if necessary, so isolator stiffness is less than one-tenth the stiffness of the supporting structure, as defined by the deflection due to load at the equipment support.

Note 3. For noisy equipment adjoining or near noise-sensitive areas, see the section on Mechanical Equipment Room Sound Isolation.

Note 4. Certain designs cannot be installed directly on individual isolators (type A), and the equipment manufacturer or a vibration specialist should be consulted on the need for supplemental support (base type).

Note 5. Wind load conditions must be considered. Restraint can be achieved with restrained spring isolators (type 4), supplemental bracing, snubbers, or limit stops. Also see Chapter 55.

Note 6. Certain types of equipment require a curb-mounted base (type D). Airborne noise must be considered.

Note 7. See section on Resilient Pipe Hangers and Supports for hanger locations adjoining equipment and in equipment rooms.

Note 8. To avoid isolator resonance problems, select isolator deflection so that resonance frequency is 40% or less of the lowest normal operating speed of equipment (see Chapter 8 in the 2013 *ASHRAE Handbook—Fundamentals*). Some equipment, such as variable-frequency drives, and high-speed equipment, such as screw chillers and vaneaxial fans, contain very-high-frequency vibration. This equipment creates new technical challenges in the isolation of high-frequency noise and vibration from a building's structure. Structural resonances both internal and external to the isolators can significantly degrade their performance at high frequencies. Unfortunately, at present no test standard exists for measuring the high-frequency dynamic properties of isolators, and commercially available products are not tested to determine their effectiveness for high frequencies. To reduce the chance of high-frequency vibration transmission, add a minimum 20 mm thick elastomeric pad (type 1, Note 20) to the base plate of spring isolators (type 3, Note 22, 23, 24). For some sensitive locations, air springs (Note 25) may be required. If equipment is located near extremely noise-sensitive areas, follow the recommendations of an acoustical consultant.

Note 9. To limit undesirable movement, thrust restraints (type 5) are required for all ceiling-suspended and floor-mounted units operating at 500 Pa or more total static pressure.

Note 10. Pumps over 55 kW may need extra mass and restraints.

Note 11. See text for full discussion.

Isolation for Specific Equipment

Note 12. Refrigeration Machines: Large centrifugal, screw, and reciprocating refrigeration machines may generate very high noise levels; special attention is required when such equipment is installed in upper-story locations or near noise-sensitive areas. If equipment is located near extremely noise-sensitive areas, follow the recommendations of an acoustical consultant.

Note 13. Compressors: The two basic reciprocating compressors are (1) single- and double-cylinder vertical, horizontal or L-head, which are usually air compressors; and (2) Y, W, and multihead or multicylinder air and refrigeration compressors. Single- and double-cylinder compressors generate high vibratory forces requiring large inertia bases (type C) and are generally not suitable for upper-story locations. If this equipment

Notes for Table 47: Selection Guide for Vibration Isolation (*Continued*)

must be installed in an upper-story location or at-grade location near noise-sensitive areas, the expected maximum unbalanced force data must be obtained from the equipment manufacturer and a vibration specialist consulted for design of the isolation system.

Note 14. Compressors: When using Y, W, and multihead and multicylinder compressors, obtain the magnitude of unbalanced forces from the equipment manufacturer so the need for an inertia base can be evaluated.

Note 15. Compressors: Base-mounted compressors through 4 kW and horizontal tank-type air compressors through 8 kW can be installed directly on spring isolators (type 3) with structural bases (type B) if required, and compressors 10 to 75 kW on spring isolators (type 3) with inertia bases (type C) with a mass 1 to 2 times the compressor mass.

Note 16. Pumps: Concrete inertia bases (type C) are preferred for all flexible-coupled pumps and are desirable for most close-coupled pumps, although steel bases (type B) can be used. Close-coupled pumps should not be installed directly on individual isolators (type A) because the impeller usually overhangs the motor support base, causing the rear mounting to be in tension. The primary requirements for type C bases are strength and shape to accommodate base elbow supports. Mass is not usually a factor, except for pumps over 55 kW, where extra mass helps limit excess movement due to starting torque and forces. Concrete bases (type C) should be designed for a thickness of one-tenth the longest dimension with minimum thickness as follows: (1) for up to 20 kW, 150 mm; (2) for 30 to 55 kW, 200 mm; and (3) for 75 kW and up, 300 mm.

Pumps over 55 kW and multistage pumps may exhibit excessive motion at start-up ("heaving"); supplemental restraining devices can be installed if necessary. Pumps over 90 kW may generate high starting forces; consult a vibration specialist.

Note 17. Packaged Rooftop Air-Conditioning Equipment: This equipment is usually installed on low-mass structures that are susceptible to sound and vibration transmission problems. The noise problems are compounded further by curb-mounted equipment, which requires large roof openings for supply and return air.

The table shows type D vibration isolator selections for all spans up to 6 m, but extreme care must be taken for equipment located on spans of over 6 m, especially if construction is open web joists or thin, low-mass slabs. The recommended procedure is to determine the additional deflection caused by equipment in the roof. If additional roof deflection is 6 mm or less, the isolator should be selected for up to 10 times the additional roof deflection. If additional roof deflection is over 6 mm, supplemental roof stiffening should be installed to bring the roof deflection down below 6 mm, or the unit should be relocated to a stiffer roof position.

For mechanical units capable of generating high noise levels, mount the unit on a platform above the roof deck to provide an air gap (buffer zone) and locate the unit away from the associated roof penetration to allow acoustical treatment of ducts before they enter the building.

Some rooftop equipment has compressors, fans, and other equipment isolated internally. This isolation is not always reliable because of internal short-circuiting, inadequate static deflection, or panel resonances. It is recommended that rooftop equipment over 135 kg be isolated externally, as if internal isolation was not used.

Note 18. Cooling Towers: These are normally isolated with restrained spring isolators (type 4) directly under the tower or tower dunnage. High-deflection isolators proposed for use directly under the motor-fan assembly must be used with extreme caution to ensure stability and safety under all weather conditions. See Note 5.

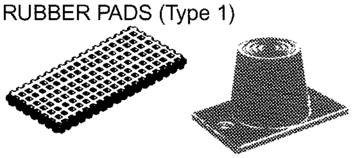
Note 19. Fans and Air-Handling Equipment: Consider the following in selecting isolation systems for fans and air-handling equipment:

1. Fans with wheel diameters of 560 mm and less and all fans operating at speeds up to 300 rpm do not generate large vibratory forces. For fans operating under 300 rpm, select isolator deflection so the isolator natural frequency is 40% or less than the fan speed. For example, for a fan operating at 275 rpm, $0.4 \times 275 = 110$ rpm. Therefore, an isolator natural frequency of 110 rpm or lower is required. This can be accomplished with a 75 mm deflection isolator (type 3).
2. Flexible duct connectors should be installed at the intake and discharge of all fans and air-handling equipment to reduce vibration transmission to air duct structures.
3. Inertia bases (type C) are recommended for all class 2 and 3 fans and air-handling equipment because extra mass allows the use of stiffer springs, which limit heaving movements.
4. Thrust restraints (type 5) that incorporate the same deflection as isolators should be used for all fan heads, all suspended fans, and all base-mounted and suspended air-handling equipment operating at 500 Pa or more total static pressure. Restraint movement adjustment must be made under normal operational static pressures.

Vibration Isolators: Materials, Types, and Configurations

Notes 20 through 32 include figures to assist in evaluating commercially available isolators for HVAC equipment. The isolator selected for a particular application depends on the required deflection, life, cost, and compatibility with associated structures.

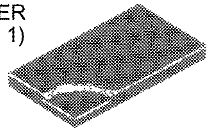
RUBBER PADS (Type 1)



RUBBER MOUNTS (Type 2)

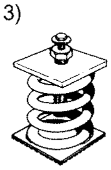
Note 20. Rubber isolators are available in pad (type 1) and molded (type 2) configurations. Pads are used in single or multiple layers. Molded isolators come in a range of 30 to 70 durometer (a measure of stiffness). Material in excess of 70 durometer is usually ineffective because durometers are not a measure of stiffness of an isolator. Isolators are designed for up to 13 mm deflection, but are used where 8 mm or less deflection is required. Solid rubber and composite fabric and rubber pads are also available. They provide high load capacities with small deflection and are used as noise barriers under columns and for pipe supports. These pad types work well only when they are properly loaded and the mass load is evenly distributed over the entire pad surface. Metal loading plates can be used for this purpose.

GLASS FIBER PADS (Type 1)



Note 21. Glass fiber with elastic coating (type 1). This type of isolation pad is precompressed molded fiberglass pads individually coated with a flexible, moisture-impervious elastomeric membrane. Natural frequency of fiberglass vibration isolators should be essentially constant for the operating load range of the supported equipment. Mass load is evenly distributed over the entire pad surface. Metal loading plates can be used for this purpose.

SPRING ISOLATOR (Type 3)

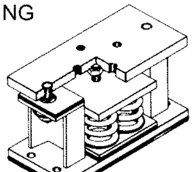


Note 22. Steel springs are the most popular and versatile isolators for HVAC applications because they are available for almost any deflection and have a virtually unlimited life. Spring isolators may have a rubber acoustical barrier to reduce transmission of high-frequency vibration and noise that can migrate down the steel spring coil. They should be corrosion protected if installed outdoors or in a corrosive environment. The basic types include the following:

Note 23. *Open spring isolators* (type 3) consist of top and bottom load plates with adjustment bolts for leveling equipment. Springs should be designed with a horizontal stiffness of at least 80% of the vertical stiffness (k_x/k_y) to ensure stability. Similarly, the springs should have a minimum ratio of 0.8 for the diameter divided by the deflected spring height.

Notes for Table 47: Vibration Isolators: Materials, Types, and Configurations (*Continued*)

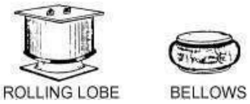
RESTRAINED SPRING ISOLATOR (Type 4)



Note 24. *Restrained spring isolators* (type 4) have hold-down bolts to limit vertical as well as horizontal movement. They are used with (a) equipment with large variations in mass (e.g., boilers, chillers, cooling towers) to restrict movement and prevent strain on piping when water is removed, (b) outdoor equipment, such as condensing units and cooling towers, to prevent excessive movement due to wind loads, and (c) with any equipment subject to seismic forces. Spring criteria should be the same as open spring isolators, and snubbers should have adequate clearance so that they are activated only when a temporary restraint is needed. See Chapter 55 for typical snubber types.

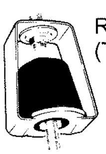
Closed mounts or *housed spring isolators* consist of two telescoping housings separated by a resilient material. These provide lateral snubbing and some vertical damping of equipment movement, but do not limit the vertical movement. Additional vertical snubbers must be used where vertical travel must be limited (see Chapter 55). Care should be taken in selection and installation to minimize binding and short circuiting.

AIR SPRINGS (Type 6)

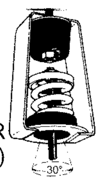


Note 25. Air springs (type 6) can be designed for any frequency, but are economical only in applications with natural frequencies of 1.33 Hz or less (150 mm or greater deflection). They do not transmit high-frequency noise and are often used to replace high-deflection springs on problem jobs (e.g., large transformers on upper-floor installations). A constant air supply (an air compressor with an air dryer) and leveling valves are typically required.

RUBBER HANGER (Type 2)

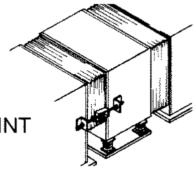


SPRING HANGER (Type 3)



Note 26. Isolation hangers (types 2 and 3) are used for suspended pipe and equipment and have rubber, springs, or a combination of spring and rubber elements. Criteria should be similar to open spring isolators, though lateral stability is less important. Where support rod angular misalignment is a concern, use hangers that have sufficient clearance and/or incorporate rubber bushings to prevent the rod from touching the housing. Swivel or traveler arrangements may be necessary for connections to piping systems subject to large thermal movements.

Precompressed spring hangers incorporate some means of precompression or preloading of the isolator spring to minimize movement of the isolated equipment or system. These are typically used on piping systems that can change mass substantially between installation and operation.



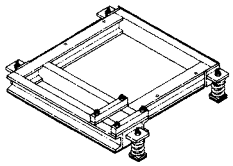
THRUST RESTRAINT (Type 5)

Note 27. Thrust restraints (type 5) are similar to spring hangers or isolators and are installed in pairs to resist the thrust caused by air pressure. These are typically sized to limit lateral movement to 6.4 mm or less.

DIRECT ISOLATION (Type A)

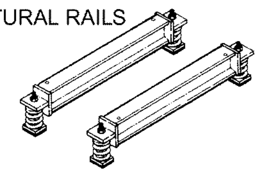
Note 28. Direct isolation (type A) is used when equipment is unitary and rigid and does not require additional support. Direct isolation can be used with large chillers, some fans, packaged air-handling units, and air-cooled condensers. If there is any doubt that the equipment can be supported directly on isolators, use structural bases (type B) or inertia bases (type C), or consult the equipment manufacturer.

STRUCTURAL BASES (Type B)



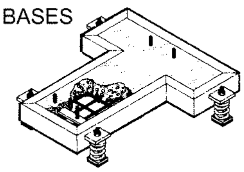
Note 29. Structural bases (type B) are used where equipment cannot be supported at individual locations and/or where some means is necessary to maintain alignment of component parts in equipment. These bases can be used with spring or rubber isolators (types 2 and 3) and should have enough rigidity to resist all starting and operating forces without supplemental hold-down devices. Bases are made in rectangular configurations using structural members with a depth equal to one-tenth the longest span between isolators. Typical base depth is between 100 and 300 mm, except where structural or alignment considerations dictate otherwise.

STRUCTURAL RAILS (Type B)



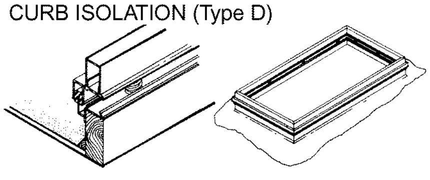
Note 30. Structural rails (type B) are used to support equipment that does not require a unitary base or where the isolators are outside the equipment and the rails act as a cradle. Structural rails can be used with spring or rubber isolators and should be rigid enough to support the equipment without flexing. Usual practice is to use structural members with a depth one-tenth of the longest span between isolators, typically between 100 and 300 mm, except where structural considerations dictate otherwise.

CONCRETE BASES (Type C)



Note 31. Concrete bases (type C) are used where the supported equipment requires a rigid support (e.g., flexible-coupled pumps) or excess heaving motion may occur with spring isolators. They consist of a steel pouring form usually with welded-in reinforcing bars, provision for equipment hold-down, and isolator brackets. Like structural bases, concrete bases should be sized to support piping elbow supports, rectangular or T-shaped, and for rigidity, have a depth equal to one-tenth the longest span between isolators. Base depth is typically between 150 and 300 mm unless additional depth is specifically required for mass, rigidity, or component alignment.

CURB ISOLATION (Type D)



Note 32. Curb isolation systems (type D) are specifically designed for curb-supported rooftop equipment and have spring isolation with a watertight, and sometimes airtight, assembly. *Rooftop rails* consist of upper and lower frames separated by nonadjustable springs and rest on top of architectural roof curbs. *Isolation curbs* incorporate the roof curb into their design as well. Both kinds are designed with springs that have static deflections in the 25 to 75 mm range to meet the design criteria described in type 3. Flexible elastomeric seals are typically most effective for weatherproofing between the upper and lower frames. A continuous sponge gasket around the perimeter of the top frame is typically applied to further weatherproof the installation.

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