3. Mechanical Services – Noise and Vibration

Refer also to acoustic details provided in Part G - Appendix I.

3.1 Noise Criteria

3.1.1 Internal Noise levels

Noise from mechanical plant inside the development shall not exceed the levels given below. Unless stated otherwise, the noise level criteria shall not be exceeded with the plant operating under normal operating conditions, and at start-up for intermittently operating plant items.

Allow for any additional treatment to fully comply with the internal and external noise level requirements, including noise from diffusers, grilles and louvres, ductwork and risers notwithstanding the equipment noise ratings indicated in the mechanical services brief or the acoustic treatments indicated in the mechanical services specification or drawings.

Allowable noise levels are listed in the table below.

Space/Activity Type	Recommended Internal Reverberation Times
Wards	35
Consult Rooms, Meeting, Procedure, Private Office, Interview	40
Operating Theatre, Open plan office, Staff Room, Recovery	45
Lobby / Reception	45
Toilets / Store Rooms	50

Table 5 – Recommended Design Internal Noise Level Criteria for different areas

Noise within rooms shall be free of tones or other undesirable characteristics.

Noise during a Fire Emergency

Noise from all plant during a fire emergency shall comply with the requirements of AS 1668. AS 1668 requires that noise levels during a fire emergency not exceed 80 dB(A) within fire isolated passageways or 65 dB(A) within occupied spaces. Noise levels inside the fire control room shall not exceed 65dB(A) during a fire emergency.

External Noise Levels

Noise levels emitted by the mechanical plant at all property boundaries and nearby buildings on adjacent properties shall meet the requirements of local Authorities. If specific requirements are not available, the following can be considered as the minimum standard.

INP - Intrusiveness Assessment

Intrusiveness criteria permit noise generation to be no more than 5dB(A) above existing background noise levels.

Location	Time of Day	Background noise Level – dB(A)L90	Intrusiveness Noise Objective dB(A)Leq(15min) (Background + 5dB)

Nearby residences	Day Time (7am - 6pm)	38	43
	Evening (6pm - 10pm)	38	43
	Night (10pm - 7am)	31	36

Table 6 – Intrusiveness Assessment

INP - Amenity Assessment

The Amenity criteria set additional criteria based on the land use of the noise sensitive receivers. Amenity criteria are as follows:

Receiver Location	Landy Type	Time of Day	Amenity Noise Objective dB(A) Leq(Period)
All Potentially Affected Residential Properties	Suburban	Day Time (7am - 6pm)	55
		Evening (6pm - 10pm)	45
		Night (10pm - 7am)	40
Commercial	All	When in use	65

Table 7 – Amenity Criteria

3.1.2 Outdoor Areas on the Development Site

Noise emissions to external areas on the site are to comply with the specified levels below:

- Public Spaces (areas where people may sit):<55dB(A)Leq
- Public Spaces (thoroughfares): <60dB(A)Leq

3.2 Noise Generated by Air Distribution Systems

Noise from the air distribution system shall be minimised by:

- Selecting grilles, diffusers, dampers and accessories to meet the specified noise levels.
- Balancing the system using dampers on duct branches, with dampers at grilles being used for minor adjustment of air volumes. Where excessive noise levels are due to noise generated at dampers near grilles, the branch dampers shall be readjusted to eliminate excessive dampering and noise at the grilles.
- Installing ductwork with a minimum number of bends, offsets, etc. Flexible ducts should not be kinked or have excessively bends, particularly near grilles, etc. Ensure there are no protrusions inside the duct that could generate noise. Unless indicated otherwise, install turning vanes in tee's and bends or use long radius bends to minimise turbulence.
- Seal duct joints adequately so there is no noise resulting from air leakage.
- Ensure plenums behind supply and exhaust grilles are correctly sized to ensure even flow over the grille/diffuser.
- Flexible duct diameters shall be selected so as not to exceed the following velocities:

Space Noise Criterion dB(A)	Maximum Velocity (m/s)
35	2.75
40	3.3
45	4.0

Table 8 – Flexible Ducting – Recommended Air Speeds

3.3 Plant Noise Levels

Adjust and balance all systems so that excessive noise is not created, and the scheduled internal and external noise levels are complied with.

3.4 Testing on Completion

Following the installation of mechanical plant and equipment and their subsequent treatments, a qualified Acoustic Consultant is to carry out internal noise level measurements within various rooms of the hospital development and perform external compliance measurements to confirm compliance with the criteria outlined in the sections above.

The locations selected for measurement shall include all critical occupancies close to plant including residences located near plant rooms; balconies; roof terraces; carpark areas, lobbies/corridors and gymnasium.

Noise levels should be measured in the worst affected part of the room/occupancy, at least 1.5m from the grilles located within the room (or the middle of the room, if this is not possible).

3.5 Vibration Criteria

3.5.1 General Areas

Vibration levels caused by activities on the site (including plant) should not exceed the levels specified by the local Authority at any place of different occupancy at and around the site.

When such standard or guidelines is not available, the recommended maximum weighted vibration levels for continuous vibration sources, such as mechanical services plant, and for impulsive vibration sources found in British Standard BS 6472:2008 “Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)” can be referenced. The weighted curves in this BS includes guidance for the assessment of human response to building vibration including continuous vibrations caused by mechanical plant and equipment.

Human response to vibration has been shown to be biased at particular frequencies which are related to the orientation of the person. This standard provides curves of equal annoyance for various orientations. These curves are applied as correction filters such that an overall weighted acceleration level is obtained. As the orientation of the resident is unknown or varying the weighting filter used is based on the combined base curve as given in ISO 2631 & Australian Standard 2670 “Evaluation of Human Exposure to Vibration and Shock in Buildings (1 to 80Hz)” which represents the worst case of the X, Y and Z axes. Filtered measurements are made in all three co-ordinate axes and the highest value axis used.

The standard assesses the annoyance of intermittent vibration (which are generally associated with vibrations induced by trains etc.) by using the Vibration Dose Value (VDV). Alternatively the VDV may be estimated by the eVDV which is derived by a simpler calculation using an empirical factor. The VDV or eVDV is calculated for the two periods of the day being the “Daytime” (7am-10pm) and “Night time” (10pm-7am).

The vibration limits recommended for maintaining human comfort in residences and offices are shown in the table below.

Location	Maximum z-axis weighted RMS vibration acceleration (m/s2)		Vibration Dose Value (m/s1.75)
	Continuous	Impulsive	Intermittent
Inpatient Unit/ ICU/ CCU	0.010	0.30	0.20

Office areas	0.020	0.64	0.40
Workshops	0.040	0.64	0.80

Table 9 – Vibration Limits for different types of occupancy

3.5.2 Critical Areas

- Recommended vibration criteria for critical areas of the hospital development are as follows.
- Theatres – R1 ("Operating Room") curve.

Relevant curves are extracted below.

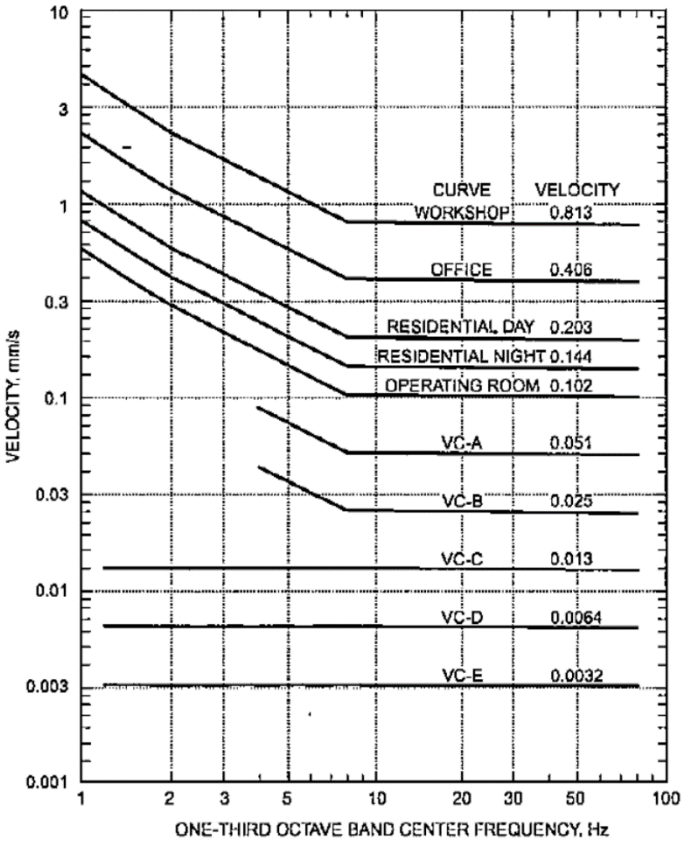

Figure 4 – ASHRAE Equipment Vibration Criteria

Note:

- When the vibration source is constant (as generated by plant), the rms (average) level is to be used.
- When the vibration source is intermittent (as generated by footfall during normal walking), the rms (max 1 second) level is to be used.

These are the proposed test scenarios for any future compliance measurement.

3.6 Ameliorative Treatments to Structure Borne Noise and Vibration

Minimise the transmission of vibration to the building structure to ensure the noise and vibration criteria are achieved by:

- Statically and dynamically balancing rotating plant and equipment. Out of balance not to exceed 0.03mm kg/kg of rotating element after installation. Where specified, provide

balancing test certificates.

- Providing isolation mounts or hangers for vibrating plant and equipment.
- Providing inertia blocks where indicated to limit the vibration amplitude.
- Isolating piping, electrical conduit, etc subject to vibration from the building structure.
- Providing flexible connections where ducts and piping is connected to vibrating plant and machinery.

3.6.1 Anti-Vibration Mounts and Isolators

Selection of Equipment Isolation Mounts

Select isolation mount type and minimum static deflection according to the following table (refer below for isolator types).

Plant	Isolator type	Minimum static deflection
In-line Centrifugal Fans and Small Axial Fans	M3/H1	10 mm
Axial Fans (>450mm diameter), Centrifugal Fans and Pumps	M4	25 mm
Fan/coil and air conditioning units	M1/H1/HE1	2 mm
Cooling Towers	M2	6 mm
Boiler	M1	6 mm
Air-conditioning condenser Units	M1	2 mm
Chillers	M4	25 mm* with 17 mm Super shear flex base pad
Pumps	M4	25 mm*
Air Handling Unit Casing (fan internally spring using 25mm static deflection fan)	M1/H1/HE1	2 mm

Table 10 – Vibration Isolator Schedule

*Plant to be installed on isolators as specified above. Isolators are then to be installed on an isolated plinth (plinth to be separated from structural slab using shear flex pads).

Piping Isolation Mounts

Piping within 20m of the generators (tri-gen or diesel), pumps or chillers shall be vibration isolated using type M4 or H2, 25mm static deflection isolators.

All hangers used to support chiller pipework must incorporate a neoprene pad (as per H2).

Isolate any other small diameter piping runouts to fan coil units within 20m of the pumps or chillers using a flexible 12mm thick foam sleeve between the pipe and the clamp similar to Poron 4701-12- 20250-1604 (2 layers) (suppliers: Mason Grogan 748 3838) fitted between the pipe and the clamp. The clamp should then be tightened just sufficiently to hold the pipe, but not over tightened.

Isolation Mount Types

Type M1 - Waffle Pad Mounts

Waffle pad mounts shall be: minimum 17mm thick neoprene rubber (nitrile rubber where oil contamination is possible); cross ribbed with alternately raised ribs on both faces of the pad; loaded within the load range of the isolator with a minimum static deflection of 1.5mm.

Type M2 - Multiple Layer Waffle Pad Mounts

Multiple layer waffle pad mounts incorporating; specified number of layers of Type M1 Waffle Pad Mount; 1.5mm thick metal shim plate between the pad layers; minimum 1.5mm static deflection per layer.

Type M3 - Neoprene Mounts

Neoprene mounts should be selected to give the static deflections under load nominated for the item of plant and incorporate: separate steel top and base plates completely embedded in elastomer; elastomer colour coded for identification of load rating; non-skid mounting surfaces; bolt holes for bolting down plant.

Type M4 - Spring/Neoprene Mounts

Spring/neoprene mounts should be selected to give the static deflections under load nominated for the item of plant and: be laterally stable without any housing or other lateral support; be capable of an additional travel to solid of at least 50% of the rated static deflection; incorporate a levelling facility; a spring diameter not less than 0.8 of the loaded height; incorporate a 6mm thick neoprene base pad to isolate acoustical frequencies. Isolators exposed to weather should have zinc plated springs and housings coated with a flexible epoxy to prevent corrosion.

Isolation Hanger Types

Type HE1 - Neoprene Hanger Elements

Neoprene hanger elements should be selected to give the static deflections under load nominated for the item of plant and incorporate: separate steel top and base plates completely embedded in elastomer which should interlock in the event of fire or mechanical failure; elastomer colour coded for identification of load rating; hole for locating hanger and a lip to locate the element within in the mounting hole.

Type H1 - Neoprene Hangers

Neoprene hanger elements should be selected to give the static deflections under load nominated for the item of plant and incorporate: Type HE1 - Neoprene Hanger Element located within a galvanised steel cage with provision for threaded hanger rods to screw into the hanger element; provide sufficient clearance around the threaded hanger rod to ensure it cannot touch the hanger cage.

Type H2 - Spring/Neoprene Hangers

Spring/neoprene hangers should be selected to give the static deflections under load nominated for the item of plant and: be laterally stable without any housing or other lateral support; be housed in a galvanised steel cage; be capable of an additional travel to solid of at least 50% of the rated static deflection; incorporate a levelling facility; a spring diameter not less than 0.8 of the loaded height; incorporate a neoprene base pad to isolate acoustical frequencies. Isolators exposed to weather should have zinc plated springs and housings coated with a flexible epoxy to prevent corrosion, and self-draining cups.

3.6.2 Equipment Bases

Generally - Mount equipment on rigid bases. The bases shall be sufficiently rigid not to deform under the weight of the machinery or during operation and reduce the effectiveness of the isolation mounts.

Tri Gen, Diesel generators, Chillers and pumps to be mounted on strip plinths which themselves are isolated from the structural slab using 10mm acoustic matting.

3.6.3 Installation of Vibration Isolation Mounts

Level the mounts once the equipment is fully loaded in its operating condition with a minimum clearance between the machine and the structure of 20mm, and adjusted to ensure that the isolators are loaded correctly. Ensure that the isolators are not bridged by mounting bolts or contact between any part of the machine or an unisolated part of the isolation mounts and the structure.

Select the number and spacing of the mountings to minimise machine rocking. Consider static and dynamic forces during operation and start-up when selecting the mounts.

Where there is a possibility of significant lateral loads occurring use hold down bolts, lateral restraints, or housed mounts to locate equipment.

3.7 Penetrations

3.7.1 General

Duct, pipe and electrical penetrations through walls, floors etc shall not:

- Decrease the required sound rating isolation rating of the wall, floor, ceiling, etc.
- Allow the transmission of vibration from pipes and ducts to the wall, floor, etc.

Do not penetrate full height walls with flexible ducts. Where ducts pass through above ceiling barriers or full height walls, the main sheet metal duct should be taken through the penetration to over the room served by the flexible duct, and the flexible duct runout to the grille connected. Alternatively, the flexible duct may be drawn through a 700mm long sheet metal sleeve that is grouted into the wall. An insulated 4 zero fire rated flexible duct should be used and the outside diameter of the sleeve should be the same as the flexible duct outside diameter.

Treat penetrations in wet area ceilings so as not to decrease the ceiling sound rating performance. This will require, as a minimum, the use of minimum 1m length of 25mm insulated four zero rated acoustic flexible ducting with an inner aluminium fabric core and outer aluminium wrapping to connect the rigid sheet metal ducting to the grille.

3.7.2 Pipe Penetrations

Seal pipes penetrating slabs or walls, as follows:

Project noise criterion in adjacent spaces	Seal type
Within 20m of a pump and condenser water pipes	Type PB seal
Other pipes including hot and cold water	Type PA or PB seal

Table 11 – Pipe Penetration Seal Types

Where the building element penetrated consists of one or more leaves then all leaves shall be acoustically sealed.

3.7.3 Duct Penetrations

Seal ducts penetrating slabs, walls and above ceiling baffles as follows:

Spaces	Wall/floor construction
All	Masonry
All	Plasterboard

Table 12 – Pipe Penetration Seal Types

Where the building element penetrated consists of one or more leaves then all leaves shall be acoustically sealed.

3.8 Silencers and Internally Lined Ducting - General

3.8.1 Lined Ducting

Internal duct insulation should be of a resin bonded mineral wool insulation in a batt or board form having a minimum density of 32kg/m3. Lining acoustic absorption shall exceed the following performance:

Insulation Thickness	Minimum Absorption Coefficient					
	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
25mm	0.08	0.30	0.64	0.90	0.90	0.90
50mm	0.35	0.72	0.95	0.95	0.95	0.95
75mm	0.45	0.8	0.95	0.95	0.95	0.95
100mm	0.5	0.9	0.95	0.95	0.95	0.95

Table 13 – Internal Duct Insulation

Insulation shall be either factory faced with perforated aluminium foil similar to Sisilation 450 or faced with 30% open area perforated zincanneal steel sheet. Perforated steel sheet shall be used whenever airflow velocities in the duct exceed 10m/s, or where specified elsewhere.

3.8.2 Flexible Ducting

All flexible ducting for air-conditioning to be 4 zero fire rated acoustic flexible duct equal to Bradford Acoustiflex with minimum 25mm thick insulation and minimum 1.5m length.

3.8.3 Silencers

Performance

Unless stated otherwise comply with the scheduled minimum silencer performance requirements for insertion loss, airflow pressure drop and regenerated noise.

Construction

General

Acoustic silencers shall be manufactured by a specialist manufacturer approved by the acoustic consultant and shall comprise:

- A minimum 1.6mm thick galvanised outer casing, stiffened as required to ensure that deformation of the silencer does not occur during installation and operation.
- Acoustically absorbent internal splitters constructed of perforated zincanneal steel sheet with acoustically absorbent, heavy density mineral fibre infill. The ends of the splitters shall be shaped to minimise airflow resistance and regenerated noise.

- Heavy gauge flanges where the silencer is to be connected to ducting. Flanges shall be corrosion protected with an approved finish.

Allow for duct transition sections before and after the silencers, if required. Select and install silencers to ensure that airflow generated noise levels do not cause exceedances of the specified levels in Section 3.1. Where silencers are installed in risers, behind louvres, etc seal around the perimeter of the silencer to the building opening with minimum 1.6mm thick sheet metal, fixed and caulked in a similar to that indicated in the "PB" duct penetration detail.

Silencers for Kitchen Exhaust Ducts and Similar

Wherever possible, quiet running kitchen exhaust fans are to be selected for kitchen exhausts to avoid the need for silencer treatment. Where required, silencers used in kitchen exhaust ducts or other ducts carrying contaminated air shall be have a 12µm thick Melinex sheet between the splitter perforated metal facings and the absorptive infill to prevent the ingress of grease, dirt, etc into the infill material. Connect silencers to ductwork and maintain access so that the silencers are easily removable for cleaning.

Silencers and Internally Lined Ductwork Exposed to Moisture

Use hydrophobic grade rockwool absorbent lining faced with perforated zincanneal steel sheet in all silencers and all internally insulated ductwork carrying moisture laden air or that are internally exposed to the weather. Alternatively, use acceptable equivalent insulation with factory applied weatherproof acoustically transparent facing.

3.9 Electrical

3.9.1 Belt Driven Plant

Fit belt driven intermittently operating plant having motors rated at greater than 2.5kW with motor starters that limit the build-up in motor speed at start-up. These are required to eliminate the possibility (especially in the future after belt wear has occurred) of belt squeal being audible in occupied spaces having a noise criterion of 45dB(A) or lower, on adjacent properties and on residential terraces/external spaces.

3.9.2 Electrical Wiring

Individual electrical cables can be sealed with fire-rated intumescent, low modulus, one component and Class A polyurethane sealant. Bunches of cables shall be drawn through a 5mm thick, 600mm long PVC conduit packed with polyester fibre, fibreglass or rockwool insulation. Seal around the conduit by filling with a non-shrinking grout.

3.10 Contactors/Starters/Controllers

Noise from contactors, starters and controllers shall be inaudible inside rooms having a noise of 45dB(A) or lower, on adjacent properties and on residential terraces/external spaces. Provide enclosures around these items and/or vibration isolate the items from building elements where they may give rise to the transmission of structure-borne noise.

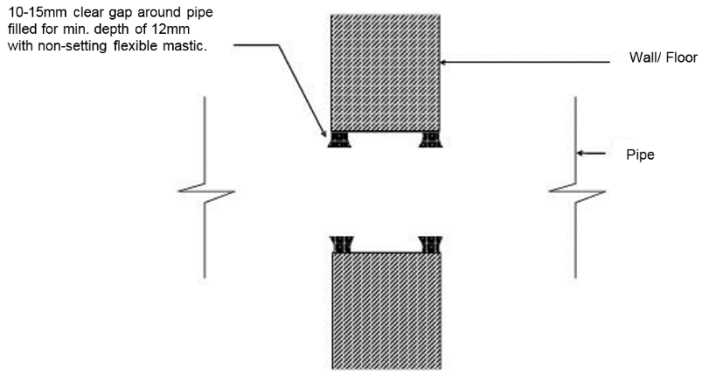

Figure 5 – Type PA Pipe Seal

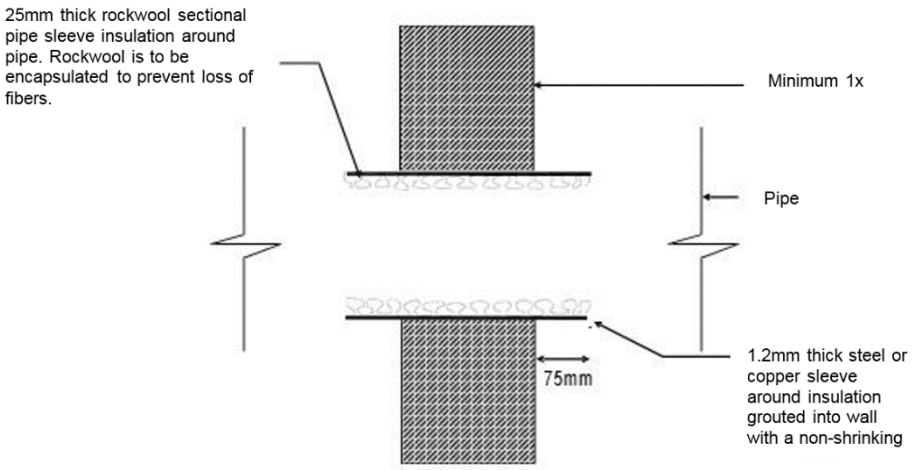

Figure 6 – Type PB Pipe Seal

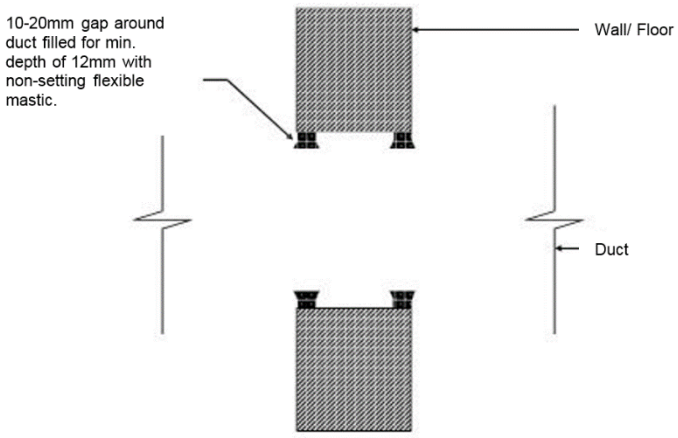

Figure 7 – Type DA Duct Seal

(Note Typical fire damper detail is also adequate provided gaps are sealed with non-setting flexible mastic)

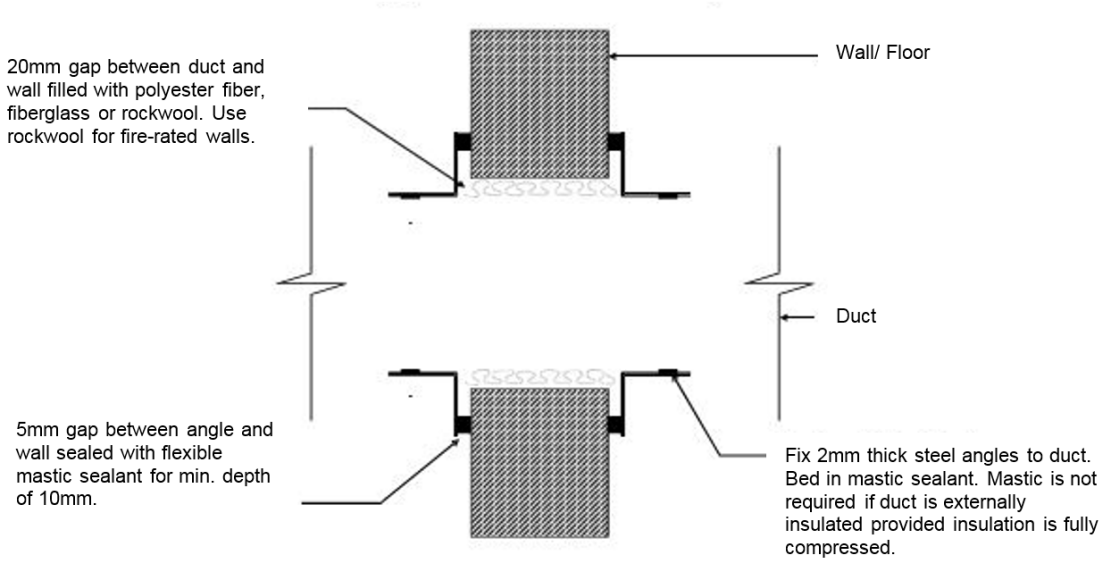

Figure 8 – Type DB Duct Seal

(Note Typical fire damper detail is also adequate provided flange is sealed with non-setting flexible mastic)

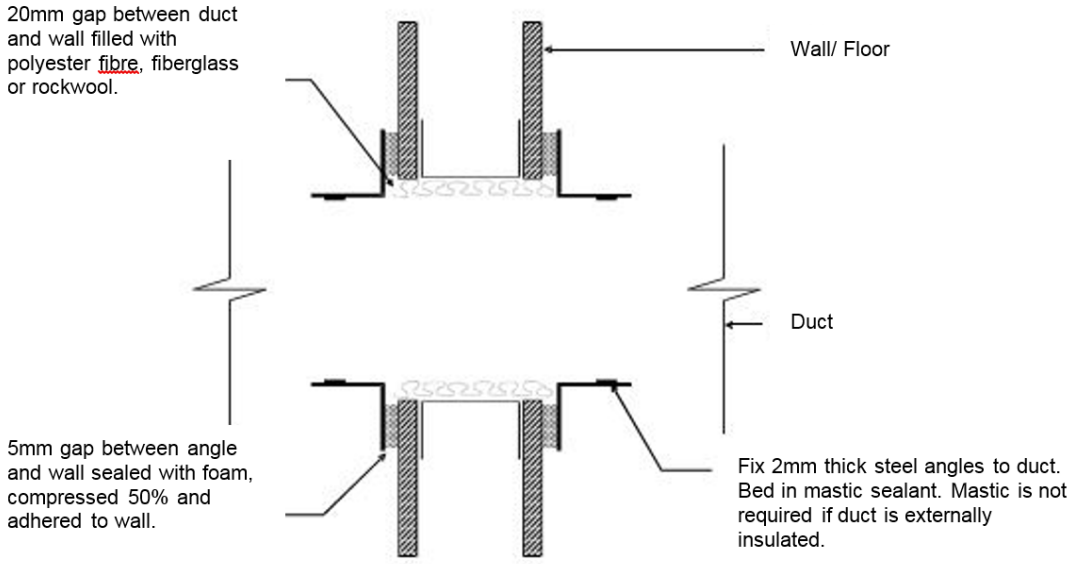

Figure 9 – Type DC Duct Seal

(Note Typical fire damper detail is also adequate for fire-rated walls provided flange is sealed with non-setting flexible mastic)

4. Hydraulic Services – Noise and Vibration

Refer also to acoustic details – Appendix 1

4.1 Application of this specification

The requirements or standards constrained within this acoustic specification are in addition to any other non-acoustic requirements such as structural integrity, fire rating, material, compatibility etc.

Where the acoustic requirements or standards contained in this specification exceed those stated in another specification or drawing then the requirements of this specification shall override the other requirements. Where multiple performance requirements are stated the systems installed shall comply with all requirements.

Install all systems in accordance with the manufacturer's requirements and recommendations unless this specification required a higher standard.

4.2 Noise Criteria

4.2.1 Internal Noise levels

Noise from hydraulics plant inside the development shall not exceed the levels given below. Unless stated otherwise, the noise level criteria shall not be exceeded with the plant operating under normal operating conditions, and at start-up for intermittently operating plant items.

Maximum noise levels in typical areas are listed in the table below:

Space/Activity Type	Noise Level dB(A)Leq
Wards	35
Consult Rooms, Meeting, Procedure, Private Office, Interview	40
Operating Theatre, Open plan office, Staff Room, Recovery	45
Lobby / Reception	45
Toilets / Store Rooms	50

Table 14 – Recommended Design Internal Noise Level Criteria for different areas

Noise within rooms shall be free of tones or other undesirable characteristics.

4.2.2 Noise during a Fire Emergency

Noise from all plant during a fire emergency shall comply with the requirements of the local Standard or requirements. As a guide, noise levels during a fire emergency should not exceed 80 dB(A) within fire isolated passageways or 65 dB(A) within occupied spaces. Noise levels inside the fire control room shall not exceed 65dB(A) during a fire emergency.

4.2.3 External Noise Levels

Intrusiveness criteria permit noise generation to be no more than 5dB(A) above existing background noise levels.

Location	Time of Day	Background noise Level – dB(A)L90	Intrusiveness Noise Objective dB(A)Leq(15min) (Background + 5dB)
	Day Time (7am - 6pm)	38	43
	Evening (6pm - 10pm)	38	43
	Night (10pm - 7am)	31	36

Table 15 – Intrusiveness Assessment

INP - Amenity Assessment

The Amenity criteria set additional criteria based on the land use of the noise sensitive receivers. Amenity criteria are as follows:

Receiver Location	Land Type	Time of Day	Amenity Noise Objective dB(A) Leq(Period)
All Potentially Affected Residential Properties	Suburban	Day Time (7am – 6pm)	55
		Evening (6pm – 10pm)	45
		Night (10pm-7am)	40
Commercial		When in use	65

Table 16 – Amenity Assessment

4.2.4 Outdoor Areas on the Development Site

Noise emissions to external areas on the site are to comply with the specified levels below:

- Public Spaces (areas where people may sit):<55dB(A)Leq
- Public Spaces (thoroughfares): <60dB(A)Leq

4.3 Plant Noise Levels

It should be ensured that systems are installed, adjusted and balanced so that excessive noise is not created, and the scheduled internal and external noise levels are complied with.

4.3.1 Noise Generated by Hydraulic System

Noise from the hydraulics system should be minimised by:

- Limiting pipe velocities in water systems to not more than 1.5m/s.
- Laying out pipes to minimise the number of changes in direction and installing pipes so that the effective cross-sectional area of the pipe is maintained at pipe bends and junctions.
- Selecting valves and fittings that minimise the generation of noise.
- Installing pressure reducing stations as required to eliminate excessive pressure at the terminal valves.
- Controlling structure-borne noise (i.e. plant and pipe vibration transmitted into the building structure) with the use of plant isolation mounts, resilient sleeves, etc
- Routing piping to avoid noise sensitive locations such as meeting rooms.
- Provision of water hammer arrestors in reticulation piping to dishwashers and washing machines.

- Fixing piping and caulking stud penetrations to prevent pipe movement within studwork.
- Locate waste pipes floor penetrations so that they do not fall within or near sound rated walls.
- Do not run piping along the head of walls, or in front of the head of sound rated walls that prevents access to the wall for caulking.

4.4 Vibration Criteria

4.4.1 General Areas

Vibration levels caused by activities on the site (including plant) should not exceed the levels specified in the EPA document "Assessing Vibration Guideline" at any place of different occupancy at and around the site. The Assessing Vibration guideline provides operational vibration criteria for maintaining human comfort within different space uses.

The Assessing Vibration Guideline recommends maximum weighted vibration levels for continuous vibration sources, such as mechanical services plant, and for impulsive vibration sources. The weighted curves outlined in the British Standard BS 6472:2008 "Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)" includes guidance for the assessment of human response to building vibration including continuous vibrations caused by mechanical plant and equipment.

Human response to vibration has been shown to be biased at particular frequencies which are related to the orientation of the person. This standard provides curves of equal annoyance for various orientations. These curves are applied as correction filters such that an overall weighted acceleration level is obtained. As the orientation of the resident is unknown or varying the weighting filter used is based on the combined base curve as given in ISO 2631 & Australian Standard 2670 "Evaluation of Human Exposure to Vibration and Shock in Buildings (1 to 80Hz)" which represents the worst case of the X, Y and Z axes. Filtered measurements are made in all three co-ordinate axes and the highest value axis used.

The standard assesses the annoyance of intermittent vibration (which are generally associated with vibrations induced by trains etc.) by using the Vibration Dose Value (VDV). Alternatively the VDV may be estimated by the eVDV which is derived by a simpler calculation using an empirical factor. The VDV or eVDV is calculated for the two periods of the day being the "Daytime" (7am-10pm) and "Night time" (10pm-7am).

The vibration limits recommended for maintaining human comfort in residences and offices are shown in the table below.

Location	Maximum z-axis weighted RMS vibration acceleration (m/s2		Vibration Dose Value (m/s1.75)
	Continuous	Impulsive	Intermittent
Inpatient Unit/ ICU/ CCU	0.010	0.30	0.20
Office areas	0.020	0.64	0.40
Workshops	0.040	0.64	0.80

Table 17 – Vibration Limits for different types of occupancy

4.4.2 Critical Areas

Recommended vibration criteria for critical areas of the hospital development are as follows.

- Theatres – R1 ("Operating Room") curve.

Relevant curves are extracted below.

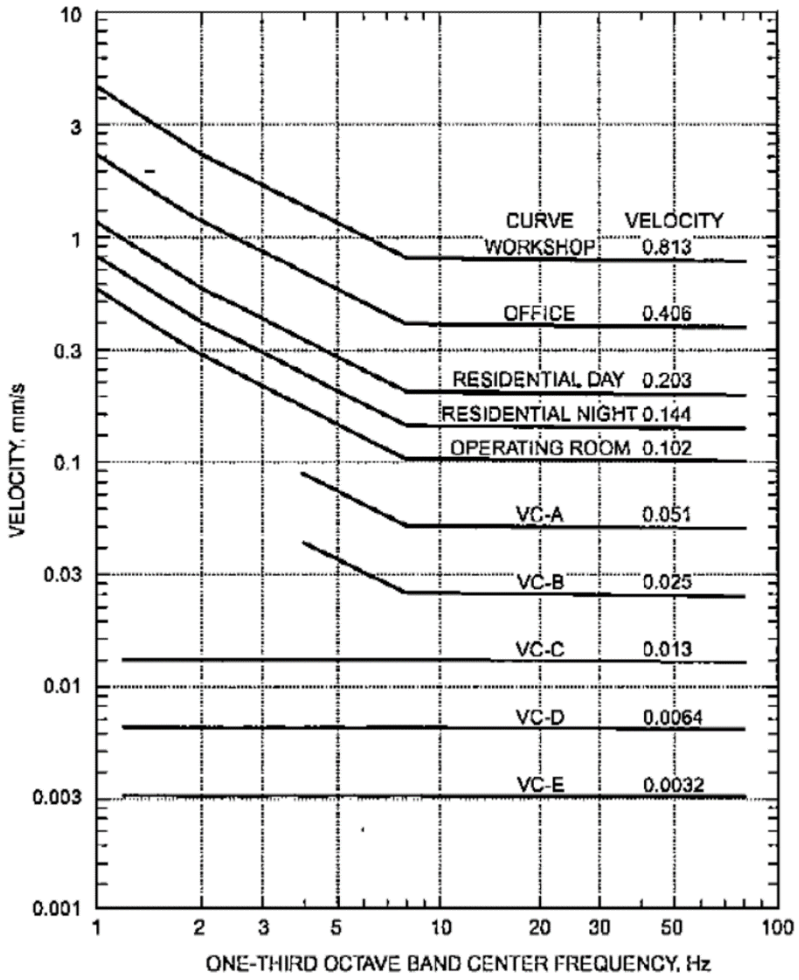

Figure 10 – ASHRAE Equipment Vibration Criteria

Note:

- When the vibration source is constant (as generated by plant), the rms (average) level is to be used.
- When the vibration source is intermittent (as generated by footfall during normal walking), the rms (max 1 second) level is to be used.

4.5 Ameliorative Treatments to Structure Borne Noise and Vibration

Minimise the transmission of vibration to the building structure to ensure the noise and vibration criteria are achieved by:

- Statically and dynamically balancing rotating plant and equipment. Out of balance shall not exceed 0.03mm kg/kg of rotating element after installation. Where specified, provide balancing test certificates.
- Providing isolation mounts or hangers for vibrating plant and equipment.
- Providing inertia blocks where required to limit the vibration amplitude.
- Isolating piping, electrical conduit, etc subject to vibration from the building structure.
- Providing flexible connections where piping is connected to vibrating plant and machinery.
- Where pipes is fixed to stud walls no part of the piping, fixtures and valves or noggings to

support the pipes and valves shall contact or bridge between the stud wall and any other independently supports wall element.

4.5.1 Anti-Vibration Mounts and Isolators

Selection of Equipment Isolation Mounts

Select isolation mount type and minimum static deflection according to the following table (refer above for isolator types).

Plant	Isolator type	Minimum static deflection
Small Vertical and In-line Pumps < 1 kW motor	M3	10 mm
Pumps > 1 kW motor	M4	25 mm
Water tanks	M1/H1/HE1	2 mm
Boilers	M2	6 mm
Hot water units	M2	6 mm
Electric Fire Pumps	M3	10 mm
Diesel Fire Pumps	M4	25 mm

Table 18 – Isolator Schedule

Isolation Mounts

Type M1 - Waffle Pad Mounts

Waffle pad mounts shall be: minimum 17mm thick neoprene rubber (nitrile rubber where oil contamination is possible); cross ribbed with alternately raised ribs on both faces of the pad; loaded within the load range of the isolator with a minimum static deflection of 1.5mm.

Type M2 - Multiple Layer Waffle Pad Mounts

Multiple layer waffle pad mounts incorporating; specified number of layers of Type M1 Waffle Pad Mount; 1.5mm thick metal shim plate between the pad layers; minimum 1.5mm static deflection per layer.

Type M3 - Neoprene Mounts

Neoprene mounts should be selected to give the static deflections under load nominated for the item of plant and incorporate: separate steel top and base plates completely embedded in elastomer; elastomer colour coded for identification of load rating; non-skid mounting surfaces; bolt holes for bolting down plant.

Type M4 - Spring/Neoprene Mounts

Spring/neoprene mounts should be selected to give the static deflections under load nominated for the item of plant and: be laterally stable without any housing or other lateral support; be capable of an additional travel to solid of at least 50% of the rated static deflection; incorporate a levelling facility; a spring diameter not less than 0.8 of the loaded height; incorporate a 6mm thick neoprene base pad to isolate acoustical frequencies. Isolators exposed to weather should have zinc plated springs and housings coated with a flexible epoxy to prevent corrosion.

Isolation Hanger Types

Type HE1 - Neoprene Hanger Elements

Neoprene hanger elements should be selected to give the static deflections under load nominated for the item of plant and incorporate: separate steel top and base plates completely embedded in elastomer which should interlock in the event of fire or mechanical failure; elastomer colour coded for identification of load rating; hole for locating hanger and a lip to locate the element within in the mounting hole.

Type H1 - Neoprene Hangers

Neoprene hanger elements should be selected to give the static deflections under load nominated for the item of plant and incorporate: Type HE1 - Neoprene Hanger Element located within a galvanised steel cage with provision for threaded hanger rods to screw into the hanger element; provide sufficient clearance around the threaded hanger rod to ensure it cannot touch the hanger cage.

Type H2 - Spring/Neoprene Hangers

Spring/neoprene hangers should be selected to give the static deflections under load nominated for the item of plant and: be laterally stable without any housing or other lateral support; be housed in a galvanised steel cage; be capable of an additional travel to solid of at least 50% of the rated static deflection; incorporate a levelling facility; a spring diameter not less than 0.8 of the loaded height; incorporate a neoprene base pad to isolate acoustical frequencies. Isolators exposed to weather should have zinc plated springs and housings coated with a flexible epoxy to prevent corrosion, and self-draining cups.

Piping Isolation Mounts

Piping within 15m of any pump shall be vibration isolated using type M4 or H2, 25mm static deflection isolators; type M3/H1, 10mm static deflection mounts elsewhere within 20m of the pumps or chillers.

Isolate any other small diameter piping runouts to fan coil units further than 20m of the pumps using a flexible 12mm thick foam sleeve between the pipe and the clamp (2 layers) fitted between the pipe and the clamp. The clamp should then be tightened just sufficiently to hold the pipe, but not over tightened.

Resilient Pipe Sleeves

Where required, install resilient pipe sleeves between the pipe and pipe clamps to isolate pipe vibration from the clamps. Sleeves should be 12mm thick foam (2 layers) fitted between the pipe and the clamp. The clamp should then be tightened just sufficiently to hold the pipe, but not over-tightened.

Flexible Pipe Connections

Flexible connections shall be fitted to all pump piping connections. These shall be twin sphere reinforced-rubber elements, be capable of withstanding internal pressure and other forces and be compatible with the fluid in the pipe.

Equipment Bases

Pumps shall be installed on concrete plinth which itself is isolated from the structural slab on a layer of 10mm thick matting. The mass of the plinth shall be at least 1.5 times the mass of the equipment being supported including pipe fittings, etc. Bases shall minimise the height of the centre of gravity of the machine/base.

25mm static deflection spring isolator required between the plinth and the pump base.

Installation of Vibration Isolation Mounts

The mounts shall be levelled once the equipment is fully loaded in its operating condition with a minimum clearance between the machine and the structure of 15mm, and adjusted to ensure that the isolators are loaded correctly. Ensure that the isolators are not bridged by mounting bolts or contact between any part of the machine or an unisolated part of the isolation mounts and the structure.

The number and spacing of the mountings shall be selected to minimise machine rocking. Static and dynamic forces during operation and start-up shall be considered when selecting the mounts.

During construction, pump isolation mounts shall be bridged with a timber block to prevent the possibility of overloading of the mounts during the installation of the piping.

Piping hangers and mounts shall be adjusted so that there is minimum strain on piping with the system operating in its normal condition.

Where there is a possibility of significant lateral loads occurring use hold down bolts, lateral restraints, or housed mounts to locate equipment.

4.6 Penetrations

4.6.1 General

- Decrease the sound rating isolation rating of the wall, floor, etc.
- Allow the transmission of vibration from pipes and ducts to the wall, floor, etc.

4.6.2 Pipe Penetrations

Seal pipes penetrating slabs or walls, as follows:

Project noise criterion in adjacent spaces	Seal type
Domestic water within 25m of Pump	Type PB seal
Elsewhere including waste pipes	Type PA or PB seal

Table 19 – Pipe Penetration Seal Types

Where the building element penetrated consists of one or more leaves then all leaves shall be acoustically sealed.

4.6.3 Location of Penetrations in Acoustically Rated Walls

Where possible where pipes and cables running though ceiling voids enter or pass through an acoustically rated wall (or pass into a wall cavity forming part of an acoustically rated wall) the pipes/cable shall be as close as possible to the head of the wall.

Locate pipe and duct penetrations away from corners and other inaccessible locations that prevent access to seal the penetration.

4.7 Waste and Stormwater Pipes

The following schedule provides the recommended acoustic treatment to piping. Refer also to Part G - Appendix I for detailed drawings.

Service	Location*	Pipe Treatment
Waste Piping / Stormwater Piping (not siphonic)	Meeting Room, Office/Open Plan Office, Consult, Theatre, Interview, Lounge, Staff room, Waiting area	Pipes wrapped with Acoustic Supplies 5 kg/m2.
	Meeting Room, Office/Open Plan Office, Consult, Theatre, Interview, Lounge, Staff, with perforated/slotted ceiling below	Pipes wrapped with 2 layers of Acoustic Supplies 5 kg/m2.
	Lobbies/waiting areas with perforated or slotted ceiling below.	Pipes wrapped with Acoustic Supplies 5 kg/m2.
	Wards/In-patient units.	Pipes wrapped with Acoustic Supplies 5 kg/m2.
Siphonic Drainage	All Areas	Pipes wrapped with Acoustic Supplies 5 kg/m2. Wrap with 2 layers if located over perforated/ slotted ceiling.

Table 20 – Acoustic Treatment to Waste and Stormwater Pipes Generally

*If the walls around the rooms nominated do not run full height – lagging should extend minimum one metre past the line of the wall below.

Pipes required to be externally lagged using 5 kg/m2 loaded vinyl shall have an outer aluminium foil backing. The loaded vinyl shall be separated from the pipe with a layer of minimum 25mm thick open cell foam. Overlap all joints by minimum of 50mm and tape airtight with aluminium tape. In addition all pipes which are required to be lagged which penetrate slab soffits, walls, risers or like shall have the pipe lagging flanged (minimum 50mm lap) to the meeting surface or sealed with a flexible sealant equal to Bostik 2637.

All waste pipes shall be kept a minimum of 20mm clear of any part of the structure including walls, ceilings, ceiling hangers, etc. Waste pipe penetrations shall be sealed as recommended above for pipe penetrations. Mortar or render should be kept clear of the penetrations so as to prevent any bridging between the pipe and the wall.

4.8 Electrical

4.8.1 Belt Driven Plant

Belt driven intermittently operating plant having motors rated at greater than 2.5kW shall be fitted with motor starters that limit the build-up in motor speed at start-up. These are required to eliminate the possibility (especially in the future after belt wear has occurred) of belt squeal being audible in occupied spaces having a noise criterion of 45dB(A) or lower, on adjacent properties and on residential terraces/external spaces.

4.8.2 Electrical Wiring

Individual electrical cables can be sealed with Selleys Proseries Fireblock sealant or equal. Bunches of cables shall be drawn through a 5mm thick, 600mm long PVC conduit packed with polyester fibre, fibreglass or rockwool insulation. Seal around the conduit by filling with a non-shrinking grout or flexible polyurethane sealant

4.8.3 Contactors/Starters/Controllers

Noise from contactors, starters and controllers shall be inaudible inside rooms having a noise of 45dB(A) or lower, on adjacent properties and on residential terraces/external spaces. Provide enclosures around these items and/or vibration isolate the items from building elements where they may give rise to the transmission of structure-borne noise.