NORTHROP

ACOUSTICS SPECIFICATION

Westmead Hospital - Operating Theatres 9-16

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PREPARED FOR
Health Infrastructure (HINSW) ABN 89 600 377 397
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Acoustics Specification

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1. Introduction

Northrop Consulting Engineers (Northrop) Acoustics has been engaged by Health Infrastructure NSW (HINSW) to provide acoustic recommendations for the Westmead Hospital - Operating Theatres 9-16 development, located at Hawkesbury Road, Westmead. This report addresses the relevant criteria and acoustic requirements for the rooms and their specific use, outlines the modelling and calculations and provides recommendations to achieve target acoustic performance criteria.

Recommendations have been provided for reverberation control, airborne acoustic insulation of walls, floors, façade, glazing, doors and seals for compliance with NSW Engineering Services Guidelines criteria.

When the mechanical services equipment noise levels are known, acoustic treatment will be recommended, where required, to ensure interior background noise level criteria are achieved.

1.1 Safety of Building Products

In accordance with the NSW Building Products (Safety) Act 2017, any building products specified or used shall be verified by the contractor as being safe and appropriate for use. Northrop do not take any responsibility for the use of unsafe products.

1.2 Referenced Documents

This assessment has been prepared considering the following documentation:

1.2.1 Project Documents

- Architectural drawings issued by HDR Architects – see Appendix A
- Mechanical drawings issued by Northrop – see Appendix A
- Acoustic wall mark up – issued by Northrop as an appendix to this report (Appendix B)

1.2.2 Consent Authority, Design Guidelines and Standards

- NSW Health Engineering Services Guidelines 12 December 2022

1.3 Project Understanding

As part of the Westmead Redevelopment Project, a section of the Westmead Hospital building is proposed to be demolished and refurbished to accommodate 8 new operating theatres. The proposed works are to be located on Level 3 of the hospital. The fit out will include the 8 new operating rooms with their associated anaesthetic preparation rooms, exit bays and scrub areas; two central sterile stock areas including storage and work areas; a quiet room, workstations and an education space.

Northrop acoustics have been engaged for the Main Works package to provide an assessment of the acoustic performance of the proposed constructions for compliance with the NSW Engineering Services Guidelines in terms of mechanical and building services noise control, reverberation control and internal acoustic separation.

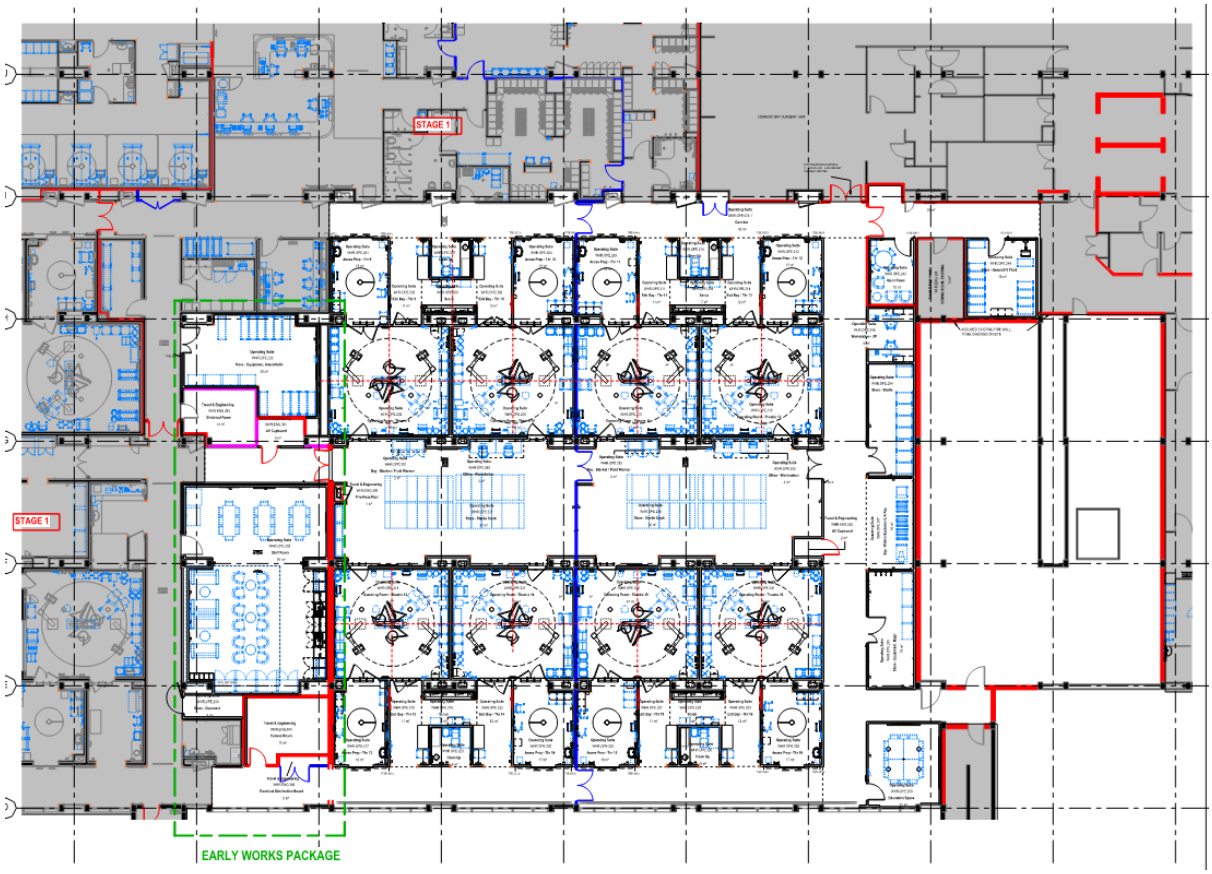


Figure 1: Subject Site within Westmead Hospital

2. Project Acoustic Criteria – Engineering Services Guidelines

2.1 Internal Design Sound Levels and Reverberation Times

Table 1 below summarises the recommended design internal background noise levels and reverberation times ranges in Health NSW Engineering Services Guidelines Section 13.

Table 1: NSW Health Engineering Services Guideline Acoustic Criteria

Area designation	Continuous internal noise levels L_{Aeq} dB		Intermittent internal noise level L_{Amax} dB	Internal noise level helicopter L_{Amax} (slow) dB (7)	Floor impact sound isolation L_{nw} dB	Reverb time (s) (fully furnished) (4)	Emergency generator internal noise level L_{Amax} dB (11)
	Satisfactory	Maximum					
Clinical							
Operating theatre	40	45	55	65	50	Note 12	+5
Birthing room	45	50	65	75	60	Note 12	+5
Intensive care	40	45	60	65	55	Note 12	+5
Single patient bed room	35	40	55 (10)	68	50	0.4 - 0.7 (13)	+5
Multi bed room	35	40	55 (10)	68	55	0.4 - 0.7 (13)	+5
Toilet / ensuite	50	55	–	75	60	–	+10
Patient corridor	40	50	–	80	60	Note 8	
Counselling / interview room	40	45	60	65	55	0.4 - 0.6	
Consultation room	40	45	60	65	55	0.4 - 0.6	+5
Speech therapy	35	40	60 (6)	65	55	0.4 - 0.6	+5
Treatment / medication / examination room	40	45	60	65	60	0.4 - 0.6	+5
Public areas							
Corridors and lobby spaces	40	50	–	80	60	Note 8	+10
Cafeterias / dining	45	50	–	80	60	Note 8	+10
Toilets	45	55	–	70	–	–	+10
Waiting rooms, reception areas	40	50	–	80	60	0.4 - 0.6	+10

Multi faith / chapel	30	35	–	65	50	0.4 - 0.6	+5
Staff / back-of-house							
Meeting room	35	40	–	70	55	0.6 - 0.8	+5
Board / conference room (large)	30	35	–	70	55	0.6 - 0.8	+5
Open plan office space	40	45	–	75	60	0.4 - 0.6	+5
Single person offices	35	40	–	70	55	0.6 - 0.8	+5
Multiple person offices	40	45	–	75	55	0.4 - 0.6	
Change/ locker room	50	55	–	–	–	–	+10
Staff room	40	45	–	75	–	Note 8	+5
Classrooms, training rooms	35	40	–	75	55	0.5 - 0.6	+5
Lecture theatre	30	35	–	75	55	Curve 1 of AS 2107	+5
Library	40	45	–	80	55	0.4 - 0.6	+5
Workshops	45	50	–	–	–	Note 8	+10
Plant rooms	N/a	<85	–	–	–	–	–
Laboratories	45	50	–	75	60	0.4 - 0.7 (12)	+10

Notes:

1. All sound pressure levels referenced to 20 micro-Pascals (dB re 20 µPa).

2. For Column A, Leq noise levels should be measured over a repeatable, worst-case one hour period. A one hour averaging period has been selected to best represent impacts from continuous noise sources, and any frequently occurring intermittent noise sources.

3. The repeatable maximum noise level generated by lift operations should not exceed the maximum Leq noise level specified for that space (excluding lift lobbies).

4. Reverberation times are the arithmetic average of the middle frequencies in the octave bands of 500 Hz and 1 kHz.

5. Where rooms have a "confidential" or "private" speech privacy requirement (Refer to Table 16 of the ESG for speech privacy requirements), the ambient noise levels in adjoining rooms are to be in the range between "satisfactory" and "maximum" in Column A . In other words, the "satisfactory" criterion should be interpreted as a "minimum" value for rooms adjoining those that require a degree of acoustic privacy, unless partition ratings have been otherwise determined using lower background noise levels. In this case the design basis should be nominated.

6. Speech and language therapy excludes audiometric rooms and specialist test and measurement rooms that require more controlled ambient noise conditions.

7. Noise levels apply to Westmead and Royal North Shore hospitals. For new buildings with a rooftop helipad, specific consideration should be given to controlling helicopter noise levels, in agreement with NSW HI on a

case-by-case basis. Direction should be sought from NSW HI on a project-by-project basis as to whether consideration should be given to 'future-proofing' the building against future increases to helicopter movements on the rooftop helipad.

8. Reverberation time should be minimised as much as practicable for noise control. Acoustic treatment should have a minimum acoustic performance equivalent to NRC 0.7 covering at least 80% of the area of the ceiling. If acoustic materials with a higher NRC performance are proposed, the coverage area can be reduced proportionally.

9. The acceptability of any intrusive noise depends on the frequency of occurrence, the intrusive noise level and character, plus the sensitivity of the space. The intermittent internal noise levels shown are intended to apply to any frequently occurring intermittent noise sources including rail, internal and external driveways, loading docks, nearby industry, etc. and where the frequency of occurrence of the noise source is sufficiently high or low that adequate control of the intrusive noise level is not achieved via the Column A, Leq noise levels. The project acoustic engineer is required to apply professional judgement in assessing the frequency of occurrence of the intrusive noise, the intrusive noise level and character, plus the sensitivity of the space to apply the intrusive noise limits in Column B. Justification of the basis of the design needs to be reported for HI review. The intrusive noise limits in Column B do not apply to noise from commercial aircraft (which is to be assessed in accordance with AS2021).

10. Where a significant, intermittent and intrusive noise source is prevalent, a sleep disturbance assessment is required. The outcome of this assessment shall be included with the acoustic design.

11. Noise levels are set relative to the 'maximum' continuous internal noise levels from Column A.

12. For spaces where sound absorptive finishes may have critical implications for infection control, hygiene or sterility requirements, the design team should investigate suitable acoustic treatment options from manufacturers that can satisfy the functional requirements.

13. For mental health units, while good room acoustic design is desired, achieving the reverberation time targets will be challenging given conflicting requirements (e.g. anti-ligature, security, tamper proof, etc.). The design team should justify any instances where sound absorptive finishes may not be possible.

2.2 Acoustic Separation

Table 2 below summarises the acoustic separation requirement in Health NSW Engineering Services Guidelines Section 13.

Table 2: NSW Health Engineering Services Guideline Acoustic Criteria

Area designation	Speech privacy requirement (for walls with no doors)	Door type (1) / adjacency		
		Room to room	Room to reception	Room to corridor / waiting
Clinical				
Operating theatre	Private	Type 1	–	–
Birthing room	Confidential (2)	Type 2	Type 1	–
Intensive care	Moderate	–	–	–
Patient room / single bed room	Minimum R_w 42 partition	–	–	–
Clinical				
Multi bed room	Moderate	–	–	–
Toilet / ensuite	Moderate	–	Type 1	–
Patient corridor	–	–	–	–
Counselling / interview room	Confidential (2)	Type 2	Type 1	Type 1

Consultation room	Confidential (2)	Type 2	Type 1	–
Speech and language therapy (4)	Moderate	Type 1	Type 1	–
Treatment / medication room	Private	Type 2	Type 1	Type 1
Public areas				
Corridors and lobby spaces	–	–	–	–
Cafeterias / dining	–	–	–	–
Toilets	–	–	Type 1	–
Waiting rooms, reception areas	–	–	–	–
Multi faith / chapel	Confidential (2)	Type 2	Type 1	–
Staff / back-of-house areas				
Meeting room	Private	Type 2	Type 1	–
Board / conference room (large)	Private	Type 2	Type 1	Type 1
Open plan offices	Moderate	–	–	–
Private offices	Private	Type 1	Type 1	–
Multi person offices	Moderate	–	–	–
Locker room	Moderate	–	–	–
Rest room	–	–	–	–
Classrooms, training rooms	Private	Type 2	Type 1	–
Lecture theatre	Private	–	Type 1	Type 1
Library	–	–	–	–
Staff / back-of-house areas				
Workshops	–	–	Note 3	Note 3
Plant rooms	–	–	Note 3	Note 3
Laboratories	Moderate	–	–	–

Notes:

1. Door Types

- *o Type 1 – Solid core door with perimeter and threshold acoustic seals*
- *o Type 2 – Specialist acoustic door set (the use of Type 2 doors should be minimised by appropriate planning)*

2. Confidential privacy requirements can be difficult to achieve in practice with cost-effective solutions. These spaces should be reviewed and agreed on a case-by-case basis.

3. As required to control noise break-out from plant, equipment or machinery to adjacent areas.

4. Excluding audiometric rooms and specialist test and measurement rooms that require specific sound insulation and intrusive noise requirements.

5. For lecture theatres, meeting rooms, etc where use of AV, assisted speech or teleconferencing is used extensively, ratings for separating constructions should be increased by five points.

Acoustic separation requirements depend on the level of privacy required and the internal noise level in the subject room. Figure 2 below from the ESG illustrates the required airborne acoustic insulation requirements depending on speech privacy requirements and internal noise levels.

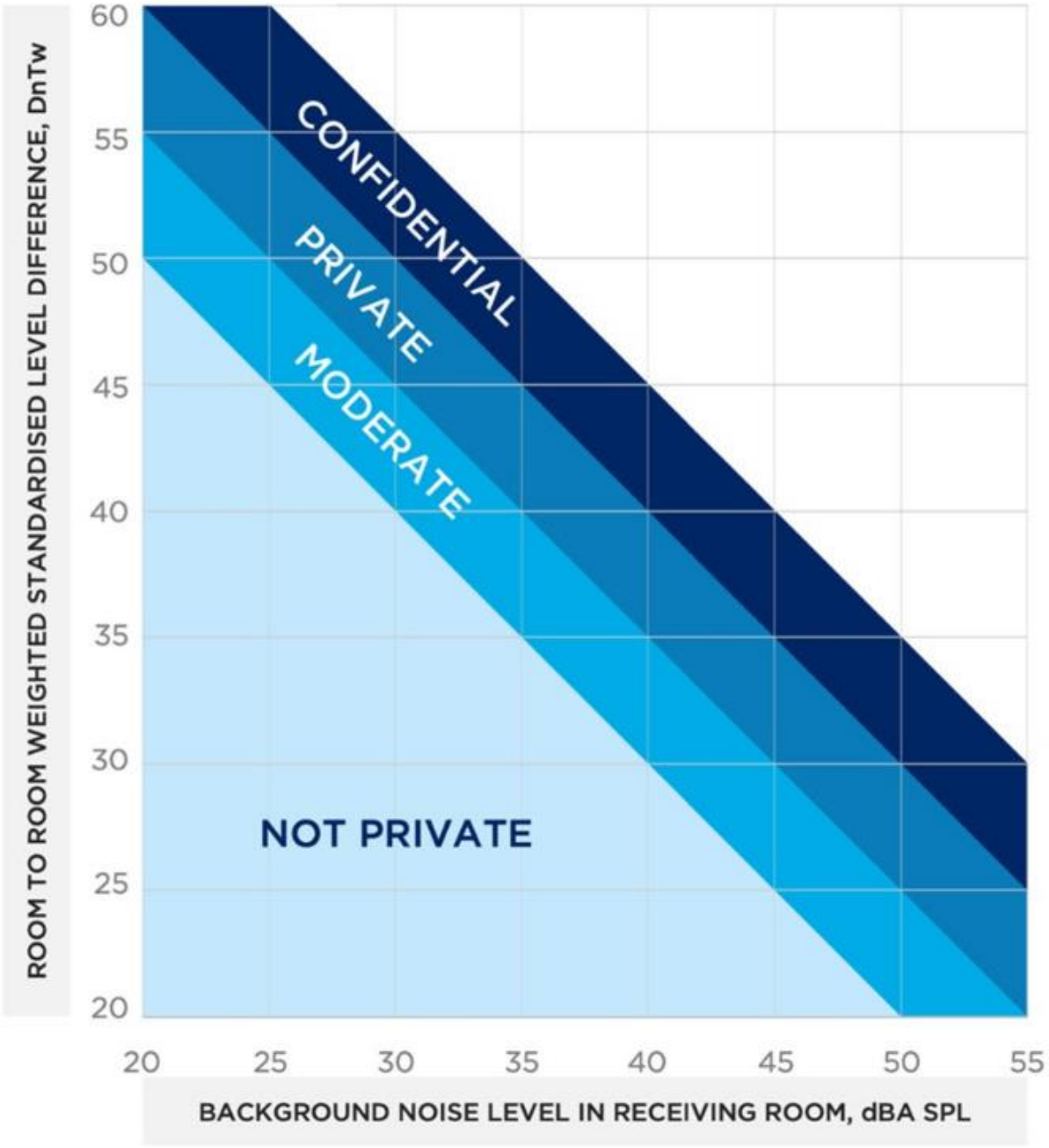


Figure 2: Required airborne acoustic insulation requirements depending on speech privacy requirements and internal noise levels (Source: NSW Engineering Services Guidelines 2022)

The wall mark up in Appendix B provides the recommended/target internal wall acoustic airborne insulation performance for each area given the uses of the space and surrounding space. Airborne sound can propagate through any surface with an open area, regardless of the acoustic performance of the partition. To this end, all doors, windows and operable walls associated with acoustic partitions including the framing and seals are to be designed such that they do not degrade the acoustic performance of the partition as a whole. It is recommended that glazed partitions achieve no less than 5 dB lower than the recommended R_w for the associated wall.

3. Construction Recommendations

The following project specific recommendations have been provided to achieve compliance with the relevant section of the NSW Health Engineering Services Guideline for acoustic separation, noise control and reverberation control.

3.1 Room Acoustics

3.1.1 Reverberation Control Recommendations

Table 3 below summarises the recommended reverberation control treatment. Acoustic panels are recommended to be evenly distributed throughout the space or surfaces specified. Where no minimum area is specified, full area, or an area as large as possible is recommended. The last column provides examples of the required treatment. Other treatment types can be used providing they have an equivalent acoustic performance.

The NSW Health Engineering Services Guideline states the following regarding reverberation control requirements and infection control:

Where it is determined to be impractical to achieve the RT criteria due to conflicting requirements such as cleaning, infection-control, patient-safety, clinical and maintenance requirements, the RT shall be reduced to as far as practicable.

The operating rooms, anaethetic preparation rooms, exit and scrub bays and sterile stock rooms are pressurised, which presents a conflict in requirements for providing sterile and hygienic surfaces and providing acoustically absorptive finishes for reverberation control. To achieve the negative pressure conditions a set and sealed plasterboard ceiling is required, and as such ceiling tiles or perforated plasterboard are not able to be installed. Acoustic wall and ceiling panels present an infection control risk. In this case it is not deemed practical to provide reverberation control in the pressurised rooms.

Acoustic recommendations are subject to compliance with hygiene and infection control requirements which shall be confirmed by the contractor.

Table 3: Recommended reverberation control treatment

Room	Reverberation time criteria (s)	Proposed finishes / acoustic treatment required / minimum NRC of treatment
Quiet room	0.4 – 0.6	Vinyl floor, ceiling tiles minimum NRC 0.7 such as Armstrong Ultima
Workstation	0.4 – 0.6	Vinyl floor, ceiling tiles minimum NRC 0.7 such as Armstrong Ultima
Education space	0.5 – 0.6	Carpet floor, ceiling tiles minimum NRC 0.7 such as Armstrong Ultima
Corridors	Minimised	Acoustic treatment should have a minimum acoustic performance equivalent to NRC 0.7 (such as Armstrong Ultima ceiling tiles) covering at least 80% of the area of the ceiling

3.2 Interior Acoustic Insulation

Acoustic ratings of internal walls shall be specified to consider the worst-case noise levels in the source room and the sensitivity of the receiving room, such that the required background noise levels are not exceeded and the desired level of speech privacy is achieved.

It is recommended that glazed partitions achieve no less than 5 dB lower than the recommended R_w for the associated wall. It is recommended that doors in acoustic walls have acoustic bottom and perimeter seals to achieve R_w not more than 10 dB below the R_w of its associated wall. Pivot doors are not recommended.

Operable walls are recommended to be acoustically rated, with a wall construction of equivalent R_w rating above bulkhead.

3.2.1 Internal Walls

Table 4 shows the calculated airborne acoustic insulation performance of the proposed acoustic internal walls. Calculations have been undertaken using Insul v9.0.23. Calculation margin of error is +/- 3dB. A mark up of the internal wall performance criteria are shown in Appendix B. To minimise flanking paths, it is recommended that acoustic walls extend to full height, with penetrations to be fully sealed to an approved detail and acoustic sealant.

Table 4: Recommended light-weight wall construction for airborne sound insulation

Wall	Build-up	Calculated R_w / $R_w + C_{tr}$	Notes
PT1	13mm plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard. (100mm above FCL)	Part height – performance dependent on ceiling construction	–
PT1.FH	13mm plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard. (Full height)	43 / 32	–
PT1.A35.FH	13mm plasterboard, 92mm steel stud, 13mm plasterboard. (Full height)	37 / 28	Requires R_w 45. Recommended construction: 13mm fire rated plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm fire rated plasterboard. (Full height)
PT1.A40.FH	Wall build-up not provided. Recommended construction: 13mm fire rated plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm fire rated plasterboard. (Full height)	47 / 35	Wall build-up not provided. Requires R_w 45.
PT1.A45	13mm fire rated plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation,	Part height – performance dependent on	Wall should be constructed full height.

	13mm fire rated plasterboard. (part height)	ceiling construction.	
PT1.A45.FH	13mm fire rated plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm fire rated plasterboard. (Full height)	47	–
PT2.FH	Wall build-up not provided. Recommended construction: 25mm CSR Shaft Liner Panel, 92mm steel studs with 75mm 14kg/m^3 glasswool insulation in cavity, 13mm Fyrchek plasterboard.	53 / 41	Wall build-up not provided. Requires $R_w + C_{tr}$ 40
PT2.A45.FH	13mm plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, existing masonry wall	Most masonry construction achieve minimum R_w 45	–
PT2-2.A45.FH	13mm plasterboard, double 92mm steel studs with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard. (Full height)	51	–
PT2-2.A45.FH	Wall build-up not provided. Recommended construction: 13mm fire rated plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm fire rated plasterboard. (Full height)	47 / 35	Wall build-up not provided. Requires R_w 45
PT4	13mm plasterboard, 92mm staggered steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard. (100mm above FCL)	Part height – performance dependent on ceiling construction	–
PT4.FH	13mm plasterboard, 92mm staggered steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard. (Full height)	48 / 37	–
PT14.A50.FH	2 x 13mm fire rated plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm fire rated plasterboard. (Full height)	53 / 42	–
PT20.S.FH	13mm plasterboard, 92mm steel stud with 75mm 11kg/m^3	43 / 32	–

	glasswool insulation, 13mm plasterboard. (Full height)		
PT20.S.A45.FH	13mm fire rated plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm fire rated plasterboard. (Full height)	47 / 35	–
PT22.F1.FH	2 x 13mm fire rated plasterboard, 92mm steel stud, 2 x 13mm plasterboard. (Full height)	52 / 43	–
PT30.F1.A50.FH	78mm speedpanel, 25mm steel top hat with 25mm 32kg/m^3 glasswool insulation, 13mm plasterboard. (Full height)	44 / 35	–
PT35.F1.FH	78mm speedpanel. (Full height)	39 / 34	–
PT2.FH + PT20.S.A45.FH	13mm plasterboard, double 92mm steel studs with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard. (Full height)	51 / 40	–
PT2.FH + PT20.S.FH	13mm plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard. (Full height)	52 / 39	–
PT25 + PT22.F1.FH	13mm plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 2 x 13mm fire rated plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 2 x 13mm fire rated plasterboard. (Full height)	57 / 45	–
PT1A40.FH	13mm plasterboard, 92mm steel stud with 75mm 11kg/m^3 glasswool insulation, 13mm plasterboard. (Full height)	43	–

3.2.2 Internal Glazing

It is recommended that glazing in acoustic walls have acoustic rating no less than 5 dB lower than the required R_w rating. Table 5 below summarises internal glazing acoustic provisions corresponding to the acoustic mark up shown in Appendix B. Glass frames and seals are recommended to be

acoustically rated such that they do not degrade the performance of the partition as a whole. Glazing is not recommended in walls that require R_w 45 or higher.

Table 5: Recommended internal glazing for airborne sound insulation

Grading	Recommended glazing	R_w (dB)
Green	10.38mm laminated glass	36
Yellow	12.5mm VLam Hush glass	40

3.2.3 Doors

The following acoustic door provisions are provided corresponding to the acoustic wall mark up shown in Appendix B. Door framing and seals shall be acoustically rated so they do not degrade the performance of the partition. Pivot doors are not recommended in acoustically rated walls.

Type 1 door (R_w 35):

- Solid core 44mm with acoustic frames,
- Perimeter seal: Raven RP87Si, RP24, Raven RP120 or equivalent
- Bottom seal: Raven RP38, RP99 or Lorient IS 8090 Si seals or equivalent
- Meeting Stile (where applicable): Rebated meeting stile with 2 x Raven RP16Si or equivalent;
- Threshold Plate: RP96 or similar (where practical)

Type 2 door: (not required for this project).

3.2.4 Ceilings

Equipment noise levels for building services within the ceiling are not yet known, however, provisionally recommended construction is 13mm fire rated plasterboard 92mm steel structure with 75mm 11kg/m^3 glasswool insulation in cavity. Final construction pending review of building services noise levels.

Any acoustic absorption treatment recommended in Section 2 shall be built in addition to this ceiling as a secondary ceiling system.

3.2.5 Building Services

Table 6 shows recommended construction for riser walls adjacent to habitable and non-habitable areas.

Table 6: Recommended building services insulation construction and acoustic performance

Area	Criteria (dB)	Riser wall construction
Risers to habitable area	$R_w + C_{tr} > 40$	25mm CSR Shaft Liner Panel, 92mm steel studs with 75mm 14kg/m^3 glasswool insulation in cavity, 13mm Fyrchek plasterboard. Hydraulic pipes should be lagged with Soundlag 4525C or equivalent.
Risers to non-habitable area	$R_w + C_{tr} > 25$	13mm Soundchek plasterboard

3.3 Acoustic Sealing Methodology

Sealing materials fall into three classes – plasterboard setting compound, acoustic sealing (caulking) compound and cement or plaster render.

- Plasterboard Setting Compound shall only be used to seal joints in the exposed sheet of plasterboard in areas where the plasterboard is to be painted (for example, in corridors). It shall not be used for any other purpose. The reason for this is to ensure that cracks do not appear in the plasterboard construction as a result of movement in the structure.
- Acoustic Sealing (caulking) Compound is otherwise used in all other situations but shall only be applied where the gap is less than 5mm wide. In such cases, the compound shall be applied to an equal depth as the width. For example, the gap between plasterboard and soffit slab should be no greater than 5mm.
- Cement or Plaster Render: If the slab is uneven and results in a gap greater than 5mm in parts, the slab shall be faced with cement or plaster render in the area concerned to ensure the gap is made even and is within specification.

Approved acoustic sealing (caulking) compounds are shown in Table 7.

Table 7: Approved acoustic sealing (caulking compounds).

Manufacturer	Product Name	Specific Gravity
Bostik	Fireban 1	1.46 sg
Sika	Firerate	1.5 sg
Promat Fyerguard	Promoseal Mastic	1.6 sg
CSR	Gyprock Fire Mastic	1.6 sg
Ramset	Blaze Brake 201	1.5 sg
Hilti	CP 606 Firestop and Acoustic Sealant	1.5 sg

Alternatively, provided that the acoustic caulking specific gravity is a minimum 1.46 sg, alternative acoustic sealing compound specifications and sample shall be submitted to the acoustic consultant for approval.

The building contractor shall use approved backing rods where necessary to ensure caulking compound is supported from behind.

In the case of A/C duct penetrations through walls and slabs, a tolerance of 5mm gap may not be workable and a larger gap results. In this case, the gap shall be first packed tight with fire rated wool or equivalent. Caulking compound shall then be applied to the whole gap on both sides of the penetration to provide adhesion of metal to slab or wall. Sealing shall be applied over the whole girth of the duct and to a depth equal to the width of the gap. The gap shall then be fully sealed with a 3mm thick steel angle fixed to both duct and slab or wall using caulking sealer along the whole length of the steel angle to ensure that small gaps are sealed closed. The width of the steel angle shall be sized according to the gap width to ensure the gap is fully covered.

Penetrations shall be sized for pipes passing through building slabs or walls to allow a uniform clearance of 10-15mm around the item and this space shall be packed through its depth with fire rated wool or equivalent. The joints on both sides shall be sealed using an approved acoustic sealant 12mm minimum depth.

Render can be plaster or cement based. This material shall be used to reduce uneven gaps to the specified maximum noted above. Specific applications may include the levelling of floor slabs and slab soffits.

The extent of rendering shall extend over an area sufficient to ensure a level base surface.

3.3.1 Services Penetrations

Building services penetrations in acoustic walls are recommended to be acoustically sealed such that they do not degrade the insulation performance of the wall.

1. Electrical cables sealed with acoustic caulk, to ensure removal of all air gaps.
2. All hydraulic pipes sealed with acoustic caulk, to ensure removal of all air gaps.
3. Mechanical transfer ducts are to be acoustically rated to a minimum transfer loss of 28 dB, such as Fantech CTZ or CTU series.
4. Mechanical ducts sealed as per the detail shown in Figure 3, below:

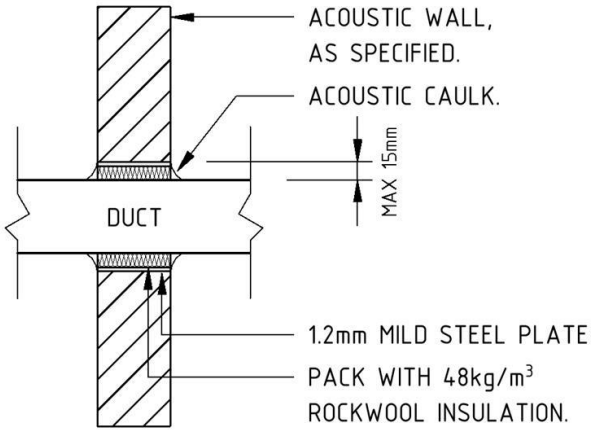


Figure 3: Duct penetration detail

3.4 Mechanical Services Noise Control

An assessment of the mechanical services design and equipment selections has been undertaken based on the drawings and equipment data provided. It is recommended that an assessment of the final mechanical services design and equipment selections is undertaken prior to construction to ensure that the ESG recommended design sound levels in Table 1 are not exceeded.

General recommendations have been provided so that allowance has been made in the design and costing. These recommendations and treatments are indicative and subject to change based on final design.

The mechanical Sub-Contractor shall ensure that generated noise within the air distribution system does not exceed levels shown in Table 1. The Sub-Contractor shall minimise air borne noise generated by air turbulence, air leakage, air moving equipment or by any other mechanical services equipment, through air ducts, clearance holes etc. Internal lining may be polyester or glasswool such as Bradford Supertel or equal approved. All mechanical plant equipment shall be fitted with vibration isolation in accordance with manufacturers specifications.

3.4.1 Mechanical Equipment

3.4.1.1 Fan Coil Units (FCUs)

The assessment has indicated that the following FCUs exceed the ESG criteria significantly:

- FCU-3-SR-P and FCU-3-SR-C (serving the Staff Room)
- FCU-3-EDS (serving the Education Space)

It is recommended that these FCUs are re-selected to reduce the equipment sound power levels, and the duct work is re-designed such that there is more attenuation available through lined ductwork and bends.

In general, allowance should be made for the following:

- Install internal acoustic duct lining to all FCU ducts
- Use acoustic internally lined flexible duct for minimum 1.5m
- Wrap FCUs in 6kg/m^2 mass loaded vinyl such as Pyrotek Wavebar
- Install internally lined return air plenum
- Install internally lined duct with 1 mitred bend to return air

3.4.1.2 Variable Air Volume Units (VAVs)

- Any diffuser/outlet take-offs from main duct runs shall be minimum 3m from VAV
- Install 50mm internal acoustic duct lining to all VAV ducts for minimum 3m from the pressure side of the VAV
- Use acoustic internally lined flexible duct for minimum 1.5m

3.4.1.3 Air Handling Units (AHUs)

- Any diffuser/outlet take-offs from main duct runs shall be minimum 12m from AHU.
- Install 100mm internal acoustic duct lining to minimum 12m of the supply ductwork (pressure side) of air handling units
- Install 100mm internal acoustic duct lining to the return ductwork (suction side) of air handling units
- The lined portion AHU ductwork shall include minimum 1 lined mitred bend for AHUs serving operating theatres and corridors, and minimum 3 lined bends for AHUs serving sterile stock area

3.4.1.4 Fans

The assessment has indicated that the following fans exceed the ESG criteria significantly:

- EAF-4-Scrub-1 (serving scrub area)
- OAF-4-OT (serving OT plant room)
- RAF-4.SS (serving Sterile Stock)
- EAF-3-STR (serving Staff Room)

It is recommended that these fans are re-selected to reduce the equipment sound power levels, and the duct work is re-designed such that there is more attenuation available through lined ductwork and bends.

In general, allowance should be made for the following:

- In-ceiling fans shall be wrapped in mass loaded vinyl
- Allowance for internal duct lining to suction and discharge side of all fans
- Install 100mm internal acoustic duct lining to minimum 12m of the return air ductwork on the suction side of AHU return air fans
- Allowance for attenuators to suction and discharge side of all large fans

3.4.2 System Generated Noise

The following recommendations are provided for the mechanical sub-contractor to ensure that generated noise within the air distribution system does not exceed levels shown in Table 1. The sub-contractor shall ensure that a minimum of air borne noise generated by air turbulence, air leakage, air moving equipment or by any other mechanical services equipment, is transmitted through air ducts, clearance holes etc.

3.4.2.1 Penetrations

The sub-contractor shall seal around pipes, ducts, cables and any other services, which they have provided, where these pass through walls, ceilings and floors. All sealing details utilised shall be designed to maintain the acoustic rating of all walls and ceilings, which they penetrate.

3.4.2.2 Terminal Units

Constant volume and variable volume terminal boxes, induction units etc. shall be selected to ensure that their self-generated down duct and radiated noise, together from noise from the main system which is transmitted through the duct work, does not cause required space noise levels to be exceeded under normal condition of operation.

3.4.2.3 Dampers

Branch dampers shall be used for balancing with only minor adjustments made to diffuser faces. Where damping of diffusers indicates an oversupply of air, the fan speed shall be reduced, or the terminal box, (e.g. mixing box) shall be re-adjusted. Air distribution systems, which are noisy due to excessive damping, shall be re-balanced.

3.4.2.4 Constant Air Flow Regulator Units (CARs)

Constant air flow regulators shall be selected to ensure that their self-generated down duct and radiated noise, together from noise from the main system which is transmitted through the duct work, does not cause required space noise levels to be exceeded under normal condition of operation. Pressure loss and air velocity through CAR units shall be minimized.

3.4.2.5 Grilles, diffusers and HEPA filters

Grilles, diffusers and HEPA filters shall be selected to ensure that their self-generated down duct and radiated noise, together from noise from the main system which is transmitted through the duct work, does not cause required space noise levels to be exceeded under normal condition of operation. Pressure loss and air velocity through CAR units shall be minimized.

3.4.2.6 Duct Air Velocities

Duct air velocities with in ducts and risers shall not exceed those listed in Table 8 below.

Table 8: Maximum duct velocities

Noise criterion dB(A)	Maximum Duct Velocities (m/s)				
	Main riser	Primary branch	Secondary riser	Run outs	Flexible
30	8 – 10	5.8	4.5	2.9	1.9
35	10 – 12	6.9	5.5	3.6	2.5
40	12 – 15	8.4	6.8	4.3	2.9
45	15 – 18	10.2	8.2	5.2	3.6

50	18 – 23	12.5	10.0	6.5	4.3
55	23 – 29	15	12.0	8.0	5.2

3.5 Electrical Services Recommendations

The following is recommended for electrical services so that the installations do not degrade the acoustic performance of acoustic partitions.

3.5.1 Electrical Services in Walls

- Locate electrical outlets on either side of an acoustic wall offset from each other by 300mm.
- Where electrical services penetrate acoustic walls, the penetration shall be acoustically treated so that it does not degrade the sound isolation rating of the subject partition.
- All electrical penetrations shall be sized for cables and conduits passing through building slabs, plasterboard or masonry walls to allow a uniform clearance of 10mm around the item and this gap shall be sealed using an approved acoustic sealant.
- Any alternative sealing details utilised shall be designed to maintain the acoustic rating of the walls, ceilings and floors that they penetrate. Alternative details shall be submitted to the acoustic consultant for approval.

3.5.2 Electrical Services in Ceilings

- Cable penetrations through plasterboard ceiling from surface mounted lights, smoke detectors, etc. shall be sealed using an approved acoustic sealant.
- Any alternative sealing details utilised shall be designed to maintain the acoustic rating of the walls, ceilings and floors that they penetrate. Alternative details shall be submitted to the acoustic consultant for approval.

3.6 Hydraulic Services Recommendations

The following is recommended for hydraulics services so that the interior background noise levels shown in Table 1 are not exceeded.

- All mains hydraulic pipes and mains gas pipes located in acoustic ceilings or walls are to be acoustically lagged with an approved acoustic pipe lagging material (Pyrotek 4525C or equivalent).
- There shall be a minimum of 10mm clearance between any walls, ceilings or risers supporting structure and any hydraulic pipes.
- All downpipes located in the cavity of external walls and internal walls should be installed using appropriate acoustic measures.
- Supply and install all access panels with a minimum acoustic performance of $R_w + C_{tr}$ 25.
- Penetrations shall be sized for pipes passing through building slabs or walls to allow a uniform clearance of 10mm around the pipes and this space shall be packed through its depth with polyester insulation or equivalent. Both side of the penetration shall be sealed with an approved sealant.
- Penetrations made through slabs should be sealed for the full depth of the penetration with a cement grout to achieve an airtight seal around the hydraulic services.
- Supply and install vibration isolation to all pumps in accordance with manufacturers' data.

4. Conclusion

Recommendations have been provided for reverberation control, airborne acoustic insulation of walls, floors, façade, glazing, doors and seals for compliance with NSW Engineering Services Guidelines criteria.

When the mechanical services equipment noise levels are known, acoustic treatment will be recommended where required to ensure interior background noise level criteria are achieved.

Appendix A: Drawings

The following drawings were used in the preparation of this report.

Architectural Drawings

Architectural drawings issued by HDR

Drawing No.	Revision	Title	Date Issued
OAD-WHR-HDR-AR-DG-030304	4	DEMOLITION PLAN - LEVEL 3 - THEATRES 9-16 - ZONE 4	31.03.2023
OAD-WHR-HDR-AR-DG-170310	4	REFLECTED CEILING PLAN - LEVEL 3 - THEATERS 9-16 - ZONE 10	31.03.2023
OAD-WHR-HDR-AR-DG-170311	2	REFLECTED CEILING PLAN - LEVEL 3 - THEATERS 9-16 - ZONE 11	31.03.2023
OAD-WHR-HDR-AR-DG-170312	4	REFLECTED CEILING PLAN - LEVEL 3 - THEATERS 9-16 - ZONE 12	31.03.2023
OAD-WHR-HDR-AR-DG-170313	2	REFLECTED CEILING PLAN - LEVEL 3 - THEATERS 9-16 - ZONE 13	31.03.2023
OAD-WHR-HDR-AR-DG-300310	5	FF&E PLAN - LEVEL 3 - THEATERS 9-16 - ZONE 10	31.03.2023
OAD-WHR-HDR-AR-DG-300311	3	FF&E PLAN - LEVEL 3 -THEATERS 9-16 - ZONE 11	31.03.2023
OAD-WHR-HDR-AR-DG-300312	5	FF&E PLAN - LEVEL 3 -THEATERS 9-16 - ZONE 12	31.03.2023
OAD-WHR-HDR-AR-DG-300313	3	FF&E PLAN - LEVEL 3 -THEATERS 9-16 - ZONE 13	31.03.2023
OAD-WHR-HDR-AR-DG-300350	15	FF&E PLAN - LEVEL 3 - THEATRES 9-16 - OVERALL	31.03.2023
OAD-WHR-HDR-AR-DG-460310	5	PARTITION PLAN - LEVEL 3 -THEATERS 9-16 - ZONE 10 (1)	31.03.2023
OAD-WHR-HDR-AR-DG-460311	3	PARTITION PLAN - LEVEL 3 -THEATERS 9-16 - ZONE 11	31.03.2023
OAD-WHR-HDR-AR-DG-460312	5	PARTITION PLAN - LEVEL 3 -THEATERS 9-16 - ZONE 12	31.03.2023
OAD-WHR-HDR-AR-DG-460313	3	PARTITION PLAN - LEVEL 3 -THEATERS 9-16 - ZONE 13	31.03.2023
OAD-WHR-HDR-AR-DG-630304	2	FINISHES PLANS- LEVEL 3 - THEATERS 9-16 - ZONE 4 (1)	24.03.2023
RPW-WHR-HDR-AR-DG-650000	C	PARTITION PLAN - COVER SHEET	10.11.2021
RPW-WHR-HDR-AR-DG-650001	C	PARTITION SECTION DETAILS - SHEET 1	10.11.2021

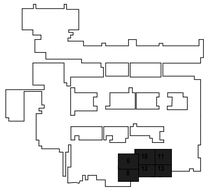
RPW-WHR-HDR-AR-DG-650002	C	PARTITION SECTION DETAILS - SHEET 2	10.11.2021

Mechanical Drawings

Mechanical drawings issued by Northrop

Drawing No.	Revision	Title	Date Issued
OAD-WHR-NOR-ME-DG-00.00	A	COVER SHEET AND DRAWING SCHEDULE	26.05.2023
OAD-WHR-NOR-ME-DG-00.01	A	LEGEND OF SYMBOLS AND NOTES	26.05.2024
OAD-WHR-NOR-ME-DG-30.00	A	LEVEL 3 HVAC LAYOUT	26.05.2025
OAD-WHR-NOR-ME-DG-30.01	A	ROOF HVAC LAYOUT	26.05.2026
OAD-WHR-NOR-ME-DG-30.03	A	LEVEL 3 PIPING LAYOUT	26.05.2027
OAD-WHR-NOR-ME-DG-30.04	A	LEVEL 3 MEDICAL GAS LAYOUT	26.05.2028
OAD-WHR-NOR-ME-DG-30.05	A	PLANTROOM LAYOUT	26.05.2029
OAD-WHR-NOR-ME-DG-60.00	A	PLANTROOM SECTIONS	26.05.2030
OAD-WHR-NOR-ME-DG-70.00	A	DETAILS	26.05.2031
OAD-WHR-NOR-ME-DG-70.06	A	DETAILS	26.05.2032
OAD-WHR-NOR-ME-DG-70.07	A	DETAILS	26.05.2033
OAD-WHR-NOR-ME-DG-80.00	A	CHILLED WATER SCHEMATIC	26.05.2034
OAD-WHR-NOR-ME-DG-80.01	A	HEATING WATER SCHEMATIC	26.05.2035

Appendix B: Acoustic Wall Mark Up



KEY PLAN

TRUE NORTH

0 500 2000 4000
1:100mm

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Acoustic Internal Wall Mark-Up

R_w (dB)	Mark-up
R_w 45	
R_w 40	
Acoustic door	

SY200056-AU04-1
Date: 28/04/2023
NORTHROP

REV	DATE	DESCRIPTION	DWN	CHK
1	29/08/22	ISSUED FOR REVIEW	MT	DJM
2	24/10/22	ISSUED FOR REVIEW	MT	RS
3	01/11/22	ISSUE FOR INFORMATION	SH	RS
4	30/11/22	ISSUE FOR PUG01	SH	DJM
5	01/12/22	ISSUE FOR REVIEW	SH	RS
6	13/12/22	ISSUE FOR REVIEW	SH	RS
7	19/12/22	ISSUE FOR REVIEW	SH	RS
8	21/12/22	ISSUE FOR REVIEW	SH	RS
9	13/01/23	ISSUE FOR REVIEW	SH	RS
10	25/01/23	PRELIMINARY ISSUE FOR BCA REVIEW	RH	RS
11	31/01/23	ISSUE FOR REVIEW	JG	MP
12	13/02/23	ISSUE FOR USER ENDORSEMENT	JG	MP
13	20/02/23	ISSUE FOR ENDORSEMENT	JG	MP
14	27/02/23	ISSUED FOR FINAL ENDORSEMENT	JG	MP
15	31/03/23	ISSUE FOR COORDINATION - OT9-16	SH	DJM

WESTMEAD HOSPITAL
WMH-HDR-AR-EM-MS1_2_3

Hawkesbury Rd, Westmead, NSW, 2145

PROJECT NUMBER
10324179

Sheet Name
FF&E PLAN - LEVEL 3 - THEATRES 9-16 - OVERALL

Scale
1 : 100@ A1

Sheet Number
OAD-WHR-HDR-AR-DG-300350

Revision
15

Project Status
PRELIMINARY-FOR INFORMATION

31/03/2023 5:20:38 PM

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Appendix C: Glossary of Acoustic Terminology

Decibel – dB – relative unit of measurement for acoustic power, pressure and intensity defined by the ratio of square of the sound pressure, power or intensity to a reference sound pressure, power or intensity value (usually the threshold of human hearing at 1kHz). Any value expressed as "level" will use decibels as units. Humans have a large sound-sensitivity range so values are expressed in decibels for a more practical range. Values expressed in decibels such as sound pressure level and sound power level cannot be added arithmetically, as their pressure or power values are expressed as a logarithmic ratio. Two equal sound levels combined will result in sound pressure level of 3dB higher than the sound level of one source (e.g. 60 dB + 60 dB = 63 dB). Levels with 10 or more dB difference will not add (e.g. 50 dB + 60 dB = 60 dB).

A-weighted decibel – dB(A), dBA – frequency weighted sound levels in decibels correlated with perceived human hearing at low and medium levels. dB(A) and dBA are used to express the units; A used as a subscript e.g. L_{Aeq} or L_{A90} denotes an A-weighting applied to that value.

Sound Pressure Level – SPL, L – sound pressure measured in decibels. Logarithmic values relative to a reference value are used to convert the large range of sound pressure (in Pascals) audible to humans to a more practical range. Sound pressure level is a measured value and is dependent on distance from the sound source(s) and acoustic environment.

Sound Power Level – SWL – sound power in decibels. Logarithmic values relative to a reference value are used to convert the large range of sound power (in Watts) audible to humans to a more practical range. Sound power level is a calculated value that is inherent to a sound source and is independent of distance and acoustic environment.

Reverberation – the accumulation of sound energy caused by the reflection of sound on the surfaces in a room.

Reverberation time – RT, RT60, T60 – the time is takes sound in a room to decay 60dB after the sound source has stopped. T60 is often extrapolated from T30 or T20 where the background noise doesn't allow 60dB of decay to be measured. RT is dependent on room volume and amount of acoustically absorptive surfaces. RT is measured in seconds.

Octave band (and centre frequency) – octave bands divide the spectrum of audible sound into equal parts. An octave band is denoted by its "centre frequency", in Hertz, Hz. Each octave or octave band includes a range of frequencies whose upper frequency limit is twice that of its lower frequency limit. For example, the 1000 Hz octave band contains sound energy at all frequencies from 707 Hz to 1414 Hz, rounded to 710 Hz and 1410 Hz for practical reasons. One-third octave bands span one-third of an octave and are often used for more precise applications.

L_{eq} or $L_{eq,T}$ – The equivalent continuous sound level is the energy average of the varying noise over the sample period (often specified in the subscript) and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise. L_{eq} is measured in dB.

L_{Aeq} or $L_{Aeq,T}$ – A-weighted L_{eq} measured in dB(A).

L_{90} or $L_{90,T}$ – The noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{90} level for 10% of the time. This measure is commonly referred to as the background noise level or RBL. L_{90} is measured in dB.

L_{A90} or $L_{A90,T}$ – A-weighted L_{90} measured in dB(A).

L_{max} or $L_{max,T}$ – The Maximum Noise Level over a sample period (often specified in the subscript) is the maximum level, measured on fast response, during the sample period.

L_{Amax} or $L_{Amax,T}$ – A-weighted L_{max} measured in dB(A).

NRC – a single number index from 0 to 1 representing the proportion of sound energy reflected by a surface where 1 equals total absorption and 0 equals zero absorption (total reflection), given by the average value of the absorption coefficients in the 250Hz, 500Hz, 1kHz and 2kHz octave bands. NRC is used to compare sound absorption performance in the midrange of frequencies for building materials.

Acoustic insulation – a general term to describe the ability or effectiveness of a building element such as a wall, window, door or floor to reduce sound transmission depending on its composition and construction. Insulation materials such as fiberglass and polyester – often referred to as "insulation" – can be used in walls, floors, ceilings etc. to reduce interstitial reflections in the cavity which may increase the acoustic insulation performance.

Transmission loss – the reduction in sound pressure level between two designated locations in a sound transmission system.

Sound insulation transmission loss – the difference in decibels between the average sound pressure levels across a partition in the source and receiver rooms.

R_w – Weighted Sound Reduction Index – the design value representing the effective sound reduction of a building element. Each increasing increment in R_w is equivalent to 1 dB of noise reduction. R_w is based on laboratory measurement, where negligible flanking is present. Spectrum adaptation terms C and C_{tr} are often added to the measured R_w result to account for low frequency noise. R_w is measured in (linear) dB.

D_w – Weighted Level Difference – the measured value of the effective sound reduction of a building element. Each increasing increment in D_w is equivalent to 1 dB of noise reduction. D_w is based on field measurement where flanking may be present and has not been "standardized" or adjusted for room volume and reverberation time. Due to the nature of field measurements and inherent flanking paths, typically the measured D_w value is deemed acceptable if within 5 points of the guideline design value, R_w.

$L_{n,w}$ – Weighted Normalised Impact Sound Pressure Level – the design value of the achievable impact noise attenuation of a building element. $L_{n,w}$ quantifies the perceived impact noise in the receiver room, with lower values corresponding to lower levels of theoretical perceived impact noise. Each increasing increment in $L_{n,w}$ is equivalent to 1 dB of impact noise increase. $L_{n,w}$ is based on laboratory measurement, where negligible flanking is present. Spectrum adaptation term C_i is often added to the $L_{n,w}$ result to account for low frequency noise. $L_{n,w}$ is measured in (linear) dB.

Speech privacy – how intelligible an overheard conversation is to a subject given by difference level of intruding sound. This can be in terms of conversations in the same space, or a conversation happening on the opposite side of a partition. Speech privacy depends upon background noise level, the reverberation time of the space and the airborne sound insulation of a partition. Note that even with high quality acoustic privacy and low levels of intelligibility, keen eavesdroppers may still be able to understand speech from adjoining rooms, if they listen from a position close to the adjoining partition (mostly due to the English language containing a significant amount of redundant words).

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