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Association of Australasian Acoustical Consultants
Guideline for Healthcare Facilities

Version 2.0

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Association of Australasian Acoustical Consultants

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1.0 INTRODUCTION

Acoustics is a fundamental quality of modern healthcare. There is a growing body of clinical research that shows that better acoustics leads to improved health outcomes. Well-designed, high quality spaces have been shown to facilitate a reduction in the use of analgesics, improved patient recovery times and increased staff efficiency.

The literature has also identified the potential psychological and physiological effects where it is neglected. These effects include:

- increased sensitivity to pain and sleep disturbance;
- decreased rates of rehabilitation;
- increased risks of myocardial defects and cardiovascular disease, prolonged release of corticosteroids associated with chronic stress as well as temporary and structural changes in mental health, dementia, behaviour and hypertension; and
- increased risks of staff fatigue, error and occupational stress.

Poor acoustic privacy can contribute to poor health outcomes, through increased disturbance and intrusion; but also, particularly through its effects on communication. Patients have been found to withhold important or perhaps crucial health information, or not state their true feelings in confidence where they believe they may be overheard by others and want to avoid any embarrassment.

Although the acoustics of hospitals is acknowledged as very important in the literature, it is not consistently addressed in current national programs affecting procurement and ongoing management. Current hospital design guidance on new developments and refurbishments, such as the Australian Health Facility Guidelines and others do not adequately address the above areas of patient complaint and impact, nor provide objective requirements which can be integrated into future facilities.

Therefore, this document outlines minimum objective noise and vibration standards for the design and commissioning of future hospitals and health care facilities.

1.1 Objectives

The objectives of this document are:

- To provide guidance in the design process so that all important acoustical attributes are properly addressed;
- To encourage consistency in developments; and
- To encourage the apparent quality of a development to relate to the underlying acoustical quality of the structure.

1.2 Scope & Application

The intent of this document is to quantify and communicate the opinions of AAAC members on the design of healthcare facilities. It considers major design issues related to acoustics, such as:

- Management of ambient noise levels from continuous (Section 2.2) and transient noise sources (Section 2.3).
- Reverberation times (Section 3.0).
- Acoustic isolation between spaces and speech privacy (Section 4.0).
- Vibration and structure-borne noise (Section 0).
- Administrative controls (Section 6.0).

The guideline is not applicable to the following, for which specialist design input should be sought:

- Environmental noise emissions – this will be regulated by local and state authorities.
- Detailed design of lecture theatres, videoconferencing, auditoria or other multipurpose spaces where intelligibility of natural speech is important
- Specialist vibration isolation, e.g. hydrotherapy pools, audiometry facilities, helipads, research facilities and precision laboratory or medical equipment.

The document is not intended to compete with other industry guidance such as the National Construction Code, Green Star rating tools or Australian Standards (e.g. AS/NZS 2107:2016 Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors) but to complement them.

It is important to realise that compliance with the noise and vibration criteria presented in this document does not prevent adverse reactions, as sensitivities can vary significantly between people. However, the guideline provides a method of ensuring that the majority of patients will not be unreasonably affected by noise and vibration, as far as is reasonably practicable.

This guideline has been based on a review of social survey research, as well as international and interstate guidelines, in particular from both Western Australia and New South Wales. The guidance within this document represents the current experience and opinions of AAAC members and subject to regular review.

2.0 INTERNAL NOISE

The following section provides information relating to internal noise levels not only from the facilities mechanical services, but noise intrusion from external sources.

2.1 Building Services

The internal noise levels due to mechanical plant should be designed to meet the internal noise level as per Table 1. The noise is to be free of annoying characteristics, such as tonality as outlined in AS/NZS 2107.

In general, noise sensitive spaces should not be located adjacent to, above or below, or in close proximity to main plant rooms. Where plant areas are located directly adjacent to noise sensitive spaces, high levels of acoustic control will be required. Adequate space should be allowed in plant room for attenuators and other control measures, noting that some forms of ductwork may not be appropriate in the context of maintenance and infection control requirements.

The following items should be considered during the design (the list is not exhaustive):

- Plant noise impacts on adjacent areas and maintenance / occupational considerations.
- Down duct noise and aerodynamic noise (regenerated noise).
- Duct break-in and break-out.
- Cross talk: the design sound insulation performance of the wall, ceilings and doors system must not be compromised.
- Mechanical penetrations: the design sound insulation performance of the wall and ceilings must not be compromised.
- Fan coil units to be installed in corridors not inside rooms.
- Internally lined ductwork at the outlet of all VAVs (2m minimum with no spigots in-between).

Technical notes on services and plant

- Care must be taken to ensure that where services passes through a noise sensitive space, the duct or pipe must be separated from the space by a construction with an appropriate sound isolation rating.
- Note that noise requirements specified within AS 1668.1 and 1670.4 may also be applicable for mechanical and fire services.
- The EWIS system must satisfy the requirements of AS 1670.4 for speech intelligibility.

2.2 Steady State / Continuous Noise

When assessing environmental noise intrusion, the following continuous noise sources should be considered, and the facade designed to achieve the aggregate internal noise levels as given in Table 1, using a suitably representative period of at least one hour in duration in each time period of interest:

- Traffic noise from existing roads surrounding the development.
- Traffic noise from internal roads on the healthcare campus.
- Noise emission from adjoining properties.

Staff and patient activity within the space should be excluded. Note that the hours applicable to each day (typically 6am to 10pm) and night (10pm to 6am) time period may be reasonably varied in line with relevant state noise policies.

The recommended noise levels for environmental noise intrusion are listed in Table 1, with criteria for any other usages from application of AS/NZS 2107. These should be considered in *aggregate* with the noise from the buildings own mechanical services. In some cases, a nominal tolerance of 5 dB from the noise levels listed in Table 1 are generally acceptable.

2.3 Transient Noise

Transient noise sources are considered infrequent and short duration and are intended to apply to:

- External vehicle traffic including commercial aircraft, road and rail vehicles; and
- Equipment and appliances of a non-emergency nature located outside the room of interest.

The recommended targets provided exclude:

- Emergency / ambulance vehicles including helicopters (see following subsection).
- Aspects which cannot be practicably managed, e.g. behaviours of individual patients or visitors.
- Emergency alarms.

2.4 Internal Noise Levels for Environmental Noise

Table 1 presents a summary of recommended internal noise criteria.

Table 1 – Recommended internal noise levels (Note [1])

Usage	Continuous Noise Target (Note [2])	Transient Noise Target L_{AmaxS}	Comments
Facility areas			
Single bed ward (including Mental Health, Parent Accommodation)	$L_{Aeq,day}$ 40 dB $L_{Aeq,night}$ 35 dB	L_{AmaxS} 50 dB	Suggest non-squeal Polymer/rubber - based flooring within room and to corridor
Multiple bed ward	$L_{Aeq,T}$ 40 dB	L_{AmaxS} 50 dB	Suggest non-squeal Polymer/rubber - based flooring within room and to corridor
Ward ensuites	$L_{Aeq,T}$ 50 dB	-	
Consulting, examination, interview, counselling/ bereavement	$L_{Aeq,T}$ 45 dB	L_{AmaxS} 55 dB	
Treatment, procedures, surgeries	$L_{Aeq,T}$ 45 dB	L_{AmaxS} 55 dB	
Morgue presentation areas	$L_{Aeq,T}$ 45 dB	L_{AmaxS} 55 dB	
Birthing room/delivery suites	$L_{Aeq,T}$ 50 dB	-	
Laboratories	$L_{Aeq,T}$ 45 dB	L_{AmaxS} 65 dB	
Clean utility/Dirty utility/ drug storage or preparation	$L_{Aeq,T}$ 55 dB	-	Macerator usage/ location/treatment important re adjacent spaces
Speech and language therapy	$L_{Aeq,T}$ 40 dB	L_{AmaxS} 50 dB	
Audiology/audiometry	As per AS 1269.4		Also, AS ISO 8253
Dental clinics	$L_{Aeq,T}$ 45 dB	-	
Rehabilitation areas	$L_{Aeq,T}$ 45 dB	L_{AmaxS} 55 dB	
Hydrotherapy	$L_{Aeq,T}$ 50 dB	-	

[1] All noise targets are recommended on the basis of a Slow (1-second) meter response unless specifically noted otherwise.
[2] Where T refers to a time period that is reasonably representative of each noise source or activity. Refer to Section 2.1 for further information.

Usage	Continuous Noise Target (Note [2])	Transient Noise Target L_{AmaxS}	Comments
General intensive care wards	$L_{Aeq,T}$ 40 dB	L_{AmaxS} 50 dB	Consider non-squeal Polymer/rubber - based flooring within room and to corridor
Neonatal or paediatric ICUs (NICU/PICU)	Specialist design input required (Note [3])	L_{AmaxS} 55 dB	
Pharmacy offices	$L_{Aeq,T}$ 45 dB	-	
Kitchens, sterilisation and service areas	$L_{Aeq,T}$ 50 dB	-	
Operating theatres	$L_{Aeq,T}$ 40 dB	L_{AmaxS} 50 dB	
Public areas			
Corridors and lobby spaces	$L_{Aeq,T}$ 50 dB	L_{AmaxS} 65 dB	
Cafeterias/dining	$L_{Aeq,T}$ 50 dB	-	
Family and parents' lounges	$L_{Aeq,T}$ 45 dB	-	
Toilets, amenities	$L_{Aeq,T}$ 50 dB	-	
Waiting rooms and Reception areas	$L_{Aeq,T}$ 45 dB	L_{AmaxS} 65 dB	
Multi-faith, chapel	$L_{Aeq,T}$ 40 dB	L_{AmaxS} 50 dB	
Atria	$L_{Aeq,T}$ 45 dB	L_{AmaxS} 70 dB	
Outdoor seating or activity areas	$L_{Aeq,T}$ 50 dB	-	Consider annoyance level of any nearby plant
Staff areas			
Enclosed nurse stations	$L_{Aeq,T}$ 45 dB	L_{AmaxS} 55 dB	Open stations as per 'Corridors'
Boardroom/conference	$L_{Aeq,T}$ 40 dB	-	
Open plan office	$L_{Aeq,T}$ 45 dB	-	
Private offices	$L_{Aeq,T}$ 40 dB	-	
Executive offices	$L_{Aeq,T}$ 40 dB	-	
Cellular offices (2-4 desks)	$L_{Aeq,T}$ 45 dB	-	
Utility rooms	$L_{Aeq,T}$ 50 dB	-	

[3] Recommended ambient design background level of Room Criterion Mk 2 (RC2) 30(N) according to ASHRAE guidelines. Including operational noise, $L_{Aeq,1hour}$ 45 dB and $L_{AS10,1hour}$ 50 dB are recommended maxima according to current peer reviewed literature.

Usage	Continuous Noise Target (Note [2])	Transient Noise Target L_{AmaxS}	Comments
Amenities, locker room	$L_{Aeq,T}$ 50 dB	-	
Morgue – Grossing stations, observation areas	$L_{Aeq,T}$ 45 dB	-	
Infrastructure			
Engineering, Workshops	$L_{Aeq,T}$ 55 dB	-	
Plantrooms, generators	As low as reasonably practicable controls, on the basis of daily or weekly noise exposure assessed according to the AS 1269 series.		

Advice should be obtained for specialised spaces, such as lecture theatres, multipurpose halls and radio broadcasting facilities.

2.5 Aircraft Noise

With regards to aircraft noise, Australian Standard 2021:2015 *Acoustics – Aircraft Noise Intrusion – Building Siting and Construction* provides advice in relation to noise from aircraft and the criteria within this Standard are considered to also be relevant for helicopters – refer to Table 2. It is noted that for accuracy, the design should be done a 1/3rd octave basis, and not the simple A weighted method described in that standard.

It is the $L_{ASmax,avg}$ parameter that is used for assessment and it is recommended a minimum of 5 aircraft flyovers be quantified, to capture the worst-case aircraft type.

Table 2 – Internal design levels for aircraft

Type of Occupancy/Activity	Recommended Design Sound Level, $L_{Amax,avg}$ dB
Wards. Theatres, treatment and consulting rooms	50
Laboratories	65
Service areas	75
Private Offices, Conference Rooms	55

2.6 Helicopters

The intrusion of helicopter ambulance noise is not addressed in Australian Standards. AS 2021 is generally intended for commercial facilities located at some distance from an airport, and should not be applied to occasional aircraft. The levels prescribed in AS 2021 are often not practically achievable for a helicopter landing on the roof of a building directly above occupied areas or on adjacent buildings.

Helicopters typically operate infrequently during emergencies and each event is of a short duration; as such they are generally tolerated noise events by staff and patients.

Appropriate helicopter targets are recommended to be developed on the basis of the Transient Noise Target plus an additional 15 dB margin.

2.7 Rain Noise

The noise generated by rain on roofing (particularly metal roofing) and stormwater flow through services such as box gutters and down pipes should be designed so that undue disturbance does not occur – particularly during storm events.

The design is to assume a yearly storm event for a period of 1 hour as given by the Bureau of Meteorology for that location. For example, in Sydney this corresponds to 30 mm of rain in one hour.

The roof and associated hydraulic services should be designed to achieve an internal noise level equal to the Continuous Noise Target + 5 dB.

2.8 Outdoor Areas

Outdoor areas such as courtyards and community gardens are seen as valuable spaces for patient recovery, relaxation and socialisation and should be acoustically screened where practicable.

The amenity of open external areas such as patient or staff courtyards and other existing healthcare buildings surrounding the development should be designed to achieve the values listed in Table 3.

Table 3 – Recommended outdoor noise levels

Period	Indicative Noise Amenity Area	Recommended Noise Level dB	
		Day $L_{Aeq,16hr}$	Night $L_{Aeq,8hr}$
Passive recreation area	All	55	50

Traffic noise as a result of increased traffic volumes due to a development must be assessed in accordance with applicable state guidelines / standards.

3.0 REVERBERATION CONTROL

The control of reverberation is important for speech intelligibility, the control of noise and for desirable subjective qualities.

Traditionally, reverberation times in each space are designed to satisfy AS/NZS 2107, and this approach may generally be applied. However, for simplicity the design management of reverberation is recommended to be similar to the approach provided in the US SVDG (Acoustics Research Council, LLC. 2010), which is around average surface sound absorption rates rather than specific reverberation times. Since ceiling mounted systems represent the best opportunity for introducing sound absorption compared to walls or floors, performance is defined in terms of a minimum average ceiling performance or Sound Absorption Class according to AS ISO 11654.

In many cases, hygiene and infection may still take precedence over reverberation times, as such the targets given listed in Table 4 should be implemented as is practicable.

Areas without a specific minimum rating may still apply reverberation controls where appropriate for the purposes of noise control, e.g. large commercial kitchens or industrial plant rooms.

Table 4 – Internal reverberation controls

Usage	Minimum entire ceiling AS ISO 11654 Sound Absorption Class performance or area equivalent, unfurnished
Facility areas	
Single bed ward (including Mental Health, Parent Accommodation), Multiple bed ward	B
Ward ensuites	-
Consulting, examination, interview, counselling/bereavement, Treatment, procedures, surgeries, Birthing room/ delivery suites	B
Morgue presentation areas	B
Laboratories, Pharmacy offices	B
Clean utility/Dirty utility/drug storage or preparation	-
Speech and language therapy, Audiology /audiometry (general areas, listening spaces subject to AS1269.4)	B
Dental clinics, Rehabilitation areas	B
Hydrotherapy	A
General intensive care wards, Neonatal or paediatric ICUs (NICU/PICU)	A
Kitchens, sterilisation and service areas	-

Usage	Minimum entire ceiling AS ISO 11654 Sound Absorption Class performance or area equivalent, unfurnished
Operating theatres	-
Public areas	
Corridors and lobby spaces	C
Cafeterias/dining, Family and parent lounges	B
Toilets, amenities	-
Waiting rooms and Reception areas	B
Multi-faith, chapel	B
Lecture theatres, cinemas, multipurpose rooms, Radio broadcast, interview or audio editing	Specialist design input required
Atria	C
Outdoor seating or activity areas	-
Staff areas	
Enclosed nurse stations, Boardroom/ conference rooms	B
Open plan office, Private offices, Executive offices, Cellular offices (2-4 desks)	B
Utility rooms	C
Grossing stations (Morgue)	B
Amenities, locker room	-

4.0 ACOUSTIC SEPARATION

Table 4 provides recommended design performance figures for acoustic separation between spaces. These figures are intended as indicative only and serve as a preliminary guide for defining acoustic separation between spaces.

Note: Part F5 of the National Construction Code (NCC) defines specific requirements for reducing the transmission of airborne noise within Class 9c aged care facilities[4]. For these facilities, see Volume One of the National Construction Code.

The adjacency of different room types will influence the sound isolation rating required for a partition. The final sound isolation rating should take into account the adjacency of the different room types.

Performance values are based on overall D_w values in line with relevant Australian standards, rather than individual R_w values. It is important that these two terms are not confused.

The conventional expression for describing sound insulation through a building element, such as a wall, is the Weighted Sound Reduction Index (R_w). This is a single number value in decibels given to an individual element or path through a construction, providing guidance on its sound insulation performance across the spectrum of audible frequencies.

Different building elements may have different R_w values, so for simplicity, final performance is recommended to be defined in terms of Weighted Level Difference (D_w) values, which represent the overall 'composite' value and unlike R_w values can be easily measured in-situ following construction.

The methods outlined in ISO 16283: 2014 may be consulted for further guidance on methodology.

The recommended D_w values are listed below in Table 5.

Table 5 – Recommended acoustic separation requirements

Usage	Indicative Acoustic Separation		Comments
	Adjacent[5]	Corridor[6]	
Single bed ward (including Mental Health, Parent Accommodation)	D_w 40 dB	D_w 25 dB	Suggest non-squeal Polymer/rubber - based flooring within room and to corridor
Multiple bed ward	D_w 40 dB	D_w 25 dB	
Ward ensuites	D_w 40 dB, Discont.	D_w 15 dB	'Corridor' being the ward it serves

[4] NCC Class 9c development is defined as "residential accommodation of aged persons who, due to varying degrees of incapacity associated with the ageing process, are provided with personal care services and 24-hour staff assistance to evacuate the building during an emergency".

[5] Minimum values to nearby noise-sensitive enclosed rooms where no common door exists – where interconnecting doors are proposed, these criteria are very difficult to achieve without effective spatial planning. Discontinuous walls as defined by the National Construction Code are recommended for impact or wall attached noise sources.

[6] To circulation corridor, where the intermediate partition is a solid wall with an operable door or air lock. Subtract 5 dB for listening areas with a visual connection (easily visible to the occupants of the space).
Note that walls without a door onto a corridor would fall into the "Adjacent" category.

Usage	Indicative Acoustic Separation		Comments
	Adjacent[5]	Corridor[6]	
Consulting, examination, interview, counselling/ bereavement	D_w 40 dB	D_w 25 dB	-
Treatment, procedures, surgeries	D_w 40 dB	D_w 25 dB	-
Morgue presentation areas	D_w 45 dB	D_w 25 dB	-
Birthing room/delivery suites	D_w 45 dB	D_w 25 dB	-
Laboratories	D_w 40 dB	D_w 20 dB	-
Clean utility/Dirty utility/ drug storage or preparation	D_w 35 dB	D_w 15 dB	Macerator usage/location/ treatment important re adjacent spaces
Speech and language therapy	D_w 40 dB	D_w 25 dB	-
Audiology/audiometry	As per AS1269.4	-	-
Dental clinics	D_w 45 dB	D_w 25 dB	-
Rehabilitation areas	D_w 40 dB	D_w 25 dB	-
Hydrotherapy	D_w 45 dB	D_w 25 dB	-
General intensive care wards	D_w 45 dB	D_w 25 dB	Consider non-squeal polymer/rubber - based flooring within room and to corridor
Neonatal or paediatric ICUs (NICU/PICU)	D_w 45 dB	D_w 30 dB	
Pharmacy offices	D_w 35 dB	D_w 20 dB	-
Kitchens, sterilisation and service areas	D_w 40 dB	-	-
Operating theatres	D_w 40 dB	D_w 25 dB	-
Public areas			
Corridors and lobby spaces	-	-	-
Cafeterias/ dining	D_w 40 dB	D_w 15 dB	-
Family and parents' lounges	D_w 40 dB	D_w 20 dB	-
Toilets, amenities	D_w 40 dB	D_w 15 dB	-
Waiting rooms and Reception areas	D_w 40 dB	-	-

Usage	Indicative Acoustic Separation		Comments
	Adjacent[5]	Corridor[6]	
Multi-faith, chapel, Lecture theatres, cinemas, multipurpose rooms	Specialist design input required		
Radio broadcast, interview or audio editing	Specialist design input required		
Outdoor seating or activity areas	-	-	Consider annoyance level of nearby plant
Staff areas			
Enclosed nurse stations	D_w 35 dB	-	Open stations as per 'Corridors'
Boardroom/conference	D_w 45 dB	D_w 25 dB	General guide only, refer to AAAC Commercial Building guidelines for further information
Private offices	D_w 35 dB	D_w 20 dB	
Executive offices	D_w 40 dB	D_w 25 dB	
Cellular offices (2-4 desks)	D_w 35 dB	D_w 20 dB	
Utility rooms			-
Amenities, locker rooms	D_w 40 dB	-	For adjacent sensitive areas
Morgue - Grossing stations, observation areas	D_w 55 dB (Discont.)	-	Beware proximity to nearby sensitive areas
Infrastructure			
Engineering, Workshops	D_w 55 dB (Discont.)	-	For adjacent sensitive areas only
Plantrooms, generators	D_w 55 dB (Discont.)	-	

Notes on design using R_w values and assessment post construction are provided in Appendix A. For example, a single bed ward adjacent to a linen / store cupboard will require a different partition to a ward adjacent to a plant room.

Alternative methods for small-scale applications are described in the following subsections.

4.1 Alternative Methods for Assessing Acoustic Separation

There remains a variety of other methods of defining privacy needs between spaces, and the research literature is not conclusive on what minimum level of acoustic separation is appropriate to every type of usage. The following subsections provide alternative methods for specific areas.

ASTM E2638

The Speech Privacy Class (SPC) method defined in ASTM E2638 is a recognised method of objectively defining privacy between closed and open spaces as follows:

Table 6 – Speech Privacy Class SPC goals (FGI 2014 guidelines)

Level (ASTM E2638, AS 2822:1985)	Open plan	Enclosed spaces
Secure	N/A	70 or more
Confidential (Less than or equal to AI 0.05)	52 to 59	60 to 69
Normal (Between AI 0.06 and 0.20)	45 to 51	52 to 59

Whilst the method gives robust estimates of speech intelligibility and can use existing R_w or D_w measures, care should be taken as its guidance on acceptability has origins in commercial offices which may differ to Australian healthcare facilities.

GBCA

The Green Building Council of Australia (GBCA) rating tools provide a similar and simpler speech privacy approach, on the basis of the sum of the partition sound reduction index and background noise level as follows:

- $R_w + L_{Aeq,T} \geq 80$ for solid partitions with no visual connection
- $R_w + L_{Aeq,T} \geq 75$ for partitions with a visual connection

where

- R_w is the weighted sound reduction index of the separating partition.
- $L_{Aeq,T}$ is the background noise level in the adjacent space to that being considered for speech privacy

Rooms with visual connections allow occupants to moderate the volume of their voice if persons can be seen outside the room, so typically less robust constructions are required. This therefore allows for single pane glazing systems where external noise levels are L_{Aeq} 40 dB or greater.

Inspection of these equations suggests a level of privacy which does not suit confidential or highly sensitive areas. It is the AAAC's view that in the context of the above, such provisions are in practice better suited to single tenancy commercial offices and not generally sufficient for healthcare applications.

Specific requirements for each space should be determined with facility users; however, in the first instance, it is suggested to use as a basic guide:

- $D_w + L_{Aeq,T} \geq 80$ for solid partitions with no visual connection.
- $D_w + L_{Aeq,T} \geq 75$ for partitions with a visual connection.

4.2 Design Notes

Within the building, acoustic separation of most individually-occupied spaces can be defined in terms of two measures, the door (and its host wall facing the corridor) and all other internal walls. It is recommended that wall performance provisions be defined in this manner to inform a system which the design team can use themselves, particularly as room arrangements and usages change during development.

Measurement locations should be defined with regard to where listeners might reasonably be anticipated to typically be – not necessarily directly outside a patient room door where they can be seen by the patient. The methods outlined in ISO 16283: 2014 may be consulted for further guidance.

Although the criteria presented in Table 4 are generally practicable, the literature finds that there are some limitations to performance which can arise from other competing requirements such as accessibility, maintenance requirements and safety. Some of these are briefly discussed in the following subsections.

Ceilings

- The ceiling transmission path must not compromise the partition sound isolation rating. All mechanical, electrical and hydraulic services runs and penetrations must be adequately acoustically treated.

- Ceiling tile systems with both relatively high sound isolation and absorption properties (minimum BS EN 20140-9 $D_{n,c,w}$ 35 dB, AS ISO 11654 Class A or B) are commonly available within Australia.

Doors and Internal Glazing

- Many doors must swing both ways (anti-barricade) or use smaller attached leaves ('cat and kitten' for large equipment) which often prevent use of effective seals. Sliding doors more easily accommodate these needs.

- Doors should be considered open for waiting areas, kitchens, and most multiple and single bed wards whereby there is no vision through the wall and staff observation is (increasingly) from the corridor.

- The manual effort required to operate a door by a patient (particularly ensuite doors) is an important design aspect and this often prevents use of heavy solid core doors and/or rubber compression seals.

- Wherever possible, the distance between doors to neighbouring spaces should be maximised, rather than directly side-by-side. Doors along corridors should be offset, to avoid one door being directly opposite another. Pivot doors are not recommended.

- Ensuites should not be difficult or cumbersome to access or reduce the ability for staff to monitor, as patients often require assistance to use or keep the door open for safety, particularly those to single patient rooms.

4.3 Impact Noise

Walls

Where partitions are expected to receive impacts e.g. from moving trolleys / equipment or from machinery and the partition is adjacent to a noise sensitive space, then the partition should be *discontinuous*.

A discontinuous construction is satisfied when two separate leaves of a partition are separated by a minimum of 20 mm. Examples of partition that should be considered for discontinuous construction when adjacent to a noise sensitive space are:

- Bathrooms
- Kitchens
- Laundries
- Workshops
- Lift cores
- High traffic corridors

Floors

Sources of impact noise should be controlled at the source wherever possible e.g. vinyl floor or carpet tile floor coverings with a suitable (e.g. foam or rubber) underlay are generally sufficient to control impact noise through concrete floor structures.

Sources of impact noise must be separated from sensitive spaces, such as wards and operating rooms. Impact isolation treatments must be provided where noise sensitive spaces are located below or adjacent to corridors which have high foot traffic or sudden changes in floor level (steps, gaps).

Table 7 provides recommended design impact noise levels for floors situated above the designated room type.

Table 7 – Recommended floor impact noise levels

Usage	Impact sound isolation $L_{n,w}$ determined according to AS ISO 717.2, dB
Wards (including Mental Health, Parent Accommodation) Intensive care wards, Neonatal or paediatric ICUs (NICU/PICU) or wards considered particularly sensitive to external disturbance Operating theatres [7]	55
Consulting, examination, interview, counselling, dentistry, bereavement and the like	60

[7] Beware soffit / ceiling mounted equipment needs; plant room usually above or in close proximity.

Usage	Impact sound isolation $L_{n,w}$ determined according to AS ISO 717.2, dB
Boardroom/conference, open plan offices, private offices executive offices, cellular offices and the like Treatment, procedures, surgeries, birthing room, laboratories, hydrotherapy and the like	
Engineering, Workshops, Plantrooms	-
Animal house, behaviour (table level) or holding (cage level) rooms, Precision equipment generally	Specialist design input required
Precision equipment generally	Specialist design input required

5.0 VIBRATION & REGENERATED NOISE

5.1 Vibration

Recommended vibration criteria are proposed in the following Table 8, with units defined in BS 6472:2008 and relevant ASHRAE[8] guidelines, measured according to current AS ISO 2631 series.

Table 8 – Recommended hospital vibration design levels

Usage	Continuous Vibration, 1 to 80 Hz, mm/s (ASHRAE)	Vibration dose value (VDV), $m/s^{1.75}$ (BS 6472)		Peak Vibration (all hours), 1 to 80 Hz, mm/s (ASHRAE)
		Day (16 hour)	Night (8 hour)	
Single bed ward (including Mental Health, Parent Accommodation), Multiple bed ward, General intensive care wards, Neonatal or paediatric ICUs, and the like	Curve 0.14	0.20	0.10	2.0
Operating theatres	Curve 0.10	-	-	-

[8] Reference is made to Chapter 48 of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc (ASHRAE) 2011, *2011 ASHRAE Handbook – HVAC Applications – SI Edition*, Atlanta. Reasonable application of more recent versions of this document may be used in lieu of the above.

Usage	Continuous Vibration, 1 to 80 Hz, mm/s (ASHRAE)	Vibration dose value (VDV), $m/s^{1.75}$ (BS 6472)		Peak Vibration (all hours), 1 to 80 Hz, mm/s (ASHRAE)
		Day (16 hour)	Night (8 hour)	
Precision equipment generally, Animal house, behaviour (table level) or holding (cage level) rooms	ASHRAE 'VC' curves	Specialist design input required		
Consulting, examination, treatment, procedures, interview, counselling etc.	Curve 0.4	0.40		3.0
Boardroom/conference, open plan and private offices, etc.	Curve 4	0.80		3.0
Engineering, Workshops, Plantrooms	Curve 8	-		6.0

Technical notes

- Note that AS 2670.2-1990 has been withdrawn by Standards Australia.
- All equipment and associated pipe work or ducts must be vibration isolated from its supporting structure to ensure the vibration criteria are satisfied.
- Medical and optical equipment can be very sensitive to vibration and must be located on sufficiently stiff supporting structures. This type of equipment should be situated away from internal or external vibration sources and preferably on grade. Coordination must be undertaken with the structural consultants to ensure adequate stiffness and control of resonant behaviour.
- Medical equipment can also be a source of vibration that needs to be taken into account when planning of spaces. Scanners and other medical equipment should be located, such that vibration and structure-borne noise achieves the design criteria. Where this is not possible, suitable vibration isolation mounts should be selected and installed.

5.2 Structure-borne noise

Table 9 presents the ground-borne noise criteria for noise sensitive receivers. These criteria should only be applied where the level of ground-borne noise from rail pass-bys is higher than the level of air-borne noise from the pass-by. Refer to the Rail Noise and Vibration Guidelines for further information.

Table 9 – Ground-borne noise criteria for sensitive receivers

Land use	Time period	Ground-borne noise criteria, dB
Wards and sleeping areas	Day, 7 am to 10 pm	40 L_{AmaxS}
	Night, 10 pm to 7 am	35 L_{AmaxS}
Other sensitive hospital areas	When in use	40 – 45 L_{AmaxS}

The L_{AmaxS} criteria outlined in this table refer to the maximum noise level not exceeded for 95% of rail pass-by events, measured using the 'slow' response setting on the sound level meter.

The criteria are intended for the assessment of ground-borne noise from railway traffic only (generally the third octave bands with centre frequencies 8 to 315 Hz) and measurement should exclude contributions from other noise sources.

Ground-borne noise levels should be assessed near, but not at, the centre of the most exposed sensitive room to avoid any undue influence from standing waves. Note that within dedicated quiet areas where listening is important, the lower criterion of 40 L_{AmaxS} would be more applicable.

6.0 ADMINISTRATIVE CONTROLS

The following are administrative controls that should be considered as part of the management of clinical and patient facilities:

1. Staff training and signage to encourage quiet behaviour.
2. Establish and enforce policies around mobile phone use and public visitation hours.
3. Dispersion and location of nurse stations where crowding of staff can occur in wards.
4. Consider anti-microbial polymer and rubber-impregnated flooring over concrete, and avoiding lightweight sprung or raised floor tile systems.
5. Support for rubber lined castors and wheels for all mobile equipment, trolleys and gurneys.
6. Support for recessed sliding glass doors with soft closers and dampers that can't be slammed / closed quickly.
7. Specifications for Smart alarms with distinct features and integration with other communication systems, and silent mobile paging and voicemail systems for staff, e.g. Voalté and similar silent text and smartphone message systems – note that many systems from the major suppliers do not have adjustable volumes and poor audio qualities.
8. Establishment of policies on locating high traffic and utility areas away from patient rooms.
9. Specifications for combined low volume speaker handsets and remote controls for entertainment systems.
10. Selection of ward documentation systems and avoidance of bulky and noisy items such as ring binders.

11. Specification of soft close doors and cabinets, surface bins, trays and trolleys.

12. Avoidance of roller door shutters, latching hardware in close proximity to wards.

13. Specifications for ambient noise sensors within ICU and patient ward areas, particularly those with adaptive limits which light-up when noise levels are exceeded.

7.0 REFERENCES

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APPENDIX A NOTES ON R_w & D_w VALUES

The Weighted Sound Reduction (R_w) value is traditionally used as a design value, and it can be measured in a laboratory under controlled conditions using the procedures documented in AS 1191 or the International Standard ISO 140 series, and rated using AS/NZS ISO 717.1.

However, an R_w rating cannot be measured on site for an installed building element, because the construction is not as controlled as a registered laboratory, and there is inherent risk of 'flanking' noise paths around the element which can and do compromise the result. The International standard ISO 140.4 acknowledges that results in the field are different to those under laboratory conditions.

Additionally, it is not possible using current commercially available technology to physically measure R_w values for each individual building element (to the exclusion of other flanking paths and adjacent constructions). Indeed, without comprehensive investigation, the level by which a result is compromised by flanking is often left to opinion, making it difficult to resolve within a building contract.

For this reason, the Australian adaptation of this standard (AS ISO 140.4-2006) recommends the use of the Weighted Level Difference (D_w) and its variants Weighted Normalised Level Difference ($D_{n,w}$) and Weighted Standardised Level Difference ($D_{nT,w}$). D_w, $D_{n,w}$ and $D_{nT,w}$ values are each suited to slightly different applications, but are all based on the concept of the measured difference in sound level (in the past termed Noise Reduction) between two spaces.

The relationship between R_w and D_w values varies according to site-specific factors, such as room geometry and finishes. Competent acoustical consultants are able to advise and document the necessary design Sound Reduction (R) values and construction methods to meet each overall Level Difference (D) value to be provided. Generally, for assessment of typical interior fitouts, the in-situ performance is judged acceptable where the measured D_w test result is at least the design R_w value of between 3 and 5 dB for permanent glazed, plasterboard or masonry walls and anything up to 10 dB for operable walls. In summary, it is recommended that

- Weighted Sound Reduction (R_w) values are used for design and procurement purposes of individual building elements; and
- Weighted Level Difference (D_w, $D_{n,w}$ and $D_{nT,w}$) values are used for in-situ verification of construction performance, because they provide measure of the 'as-experienced' condition including the level of degradation from any unwanted flanking paths which can arise from poor design and/or construction.

APPENDIX B NOTES ON FIELD MEASUREMENTS & COMMISSIONING

Compliance should be demonstrated to a 95% confidence interval.

Assessment locations should be representative of the utilisation of the space (e.g. patient head position within wards).

In certain situations, an Authority may request compliance measurements to demonstrate that the noise and vibration levels are in compliance with the criteria upon completion of the development.

Monitoring should be conducted over a sufficient period of time to obtain noise levels from a representative number of events. Any noise levels measured during adverse weather conditions or affected by extraneous noise sources should be discounted.

Compliance vibration monitoring should also be conducted over a sufficient number of events (e.g. train pass-bys), and should be measured at the worst-case location within the nearest sensitive receiver buildings that represents a typical occupancy location.

For more information and other published AAAC Guidelines, go to www.aaac.org.au

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Version	Date
1.0	March 2017
2.0	July 2017

Association of Australasian Acoustical Consultants