Review of design approaches to acoustics in Australian hospitals

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ABSTRACT

Surveys of Australian hospital outpatients appear to overlook quietness, one of the lowest areas of satisfaction internationally and an issue which extends beyond individual dissatisfaction to impact actual health outcomes in both current (and soon to be commissioned) hospitals. However, in terms of acoustic design, few Australian hospitals are consistent in their tender requirements and construction provisions, with the exception of reference to several Australian Standards which are arguably due for an update. Consequently, recent research findings challenge the basis of existing guidelines and approaches currently recommended for the acoustical design of these and other healthcare facilities. This paper presents a short review of current guidelines in use and compares these guidelines against the literature state of the art. Recommendations are made as to suitable design positions to be used in the tendering and specification of future healthcare facilities.

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1. Introduction

Australia's state level healthcare facilities have recently undergone a remarkable level of capital investment. At the end of this decade, at least one new major hospital in each mainland Australian state will have been completed – each with unique design requirements and commitments to acoustics provisions. Meanwhile, current surveys of Australian hospital outpatients appear to overlook one of the lowest areas of satisfaction internationally – an issue which extends beyond individual dissatisfaction to impact actual health outcomes in both current (and soon to be commissioned) hospitals.

The United States Consumer Assessment of Healthcare Providers and Systems (CAHPS, also known as HCAHPS) survey is seen as an important annual benchmark in hospital patient satisfaction and is used to distribute government funding between individual healthcare providers. Since the survey started in 2007, the key metric which has consistently scored lowest every year in terms of patient satisfaction is "Quietness of the Hospital Environment".

Noise in hospitals has been identified in the literature as a serious issue that can negatively affect patient physiology and more research is needed [1], there is little objective Australasian guidance on the matter.

In a 2011 review of prominent Australian and international guidance, Clarke [2] noted the various differences of each document and the broad but unspecific nature of various guidelines in Australia, such as the Australian Health Facility Guidelines [3] which notably still does not have a summary chapter on acoustics. He concluded that none should be applied rigidly in an Australian context without considering various 'mitigating factors' such as consultation with users, infection control and medical equipment.

Since this review, there has been an planned update to the Sound and Vibration Design Guidelines for Healthcare facilities (SVDG) [4]. Version 3.0 of the SVDG is expected to be issued this year but was not available at the time of writing.

It is here suggested that the consideration of those additional non-acoustic factors is necessary because the guidelines are outdated, inconsistent, too general and/or incompatible. With a notable lack of research undertaken on noise and vibration in regards to modern Australian hospitals and medical facilities, this presents the design team without clear objective guidance that all parties can agree to.

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In response to recent research and emerging technologies, this paper presents a short discussion on selected design aspects that should be considered for national adoption, and a summary table of recommended administrative design measures for various healthcare spaces.

2. Comments on current Australian guidelines and practices

The following subsections provide comments on current Australian guidelines and practices in the context of research published in the last few years.

2.1 Internal Noise Criteria

Noise levels within hospitals should be considered both in terms of comfort and the significant and evident adverse health impacts that can result if ambient noise is neglected. Traditionally, design around minimum and maximum sound levels has been limited to the configuration of building services and interior wall and ceiling treatments. However the primary complaint issues raised by patients and staff in regards to noise have little to do with these aspects, and more to do with staff activities and conversations, medical equipment, alarms and other short term noise events [5, 6].

Over the last decade, various healthcare facilities in the United States continue to be subjectively assessed in terms of patient noise via the Hospital Consumer Assessment of Healthcare Providers and Systems questionnaire (HCAHPS). Results from this annual questionnaire consistently indicate that of the various qualities experienced in their hospital stay, patients surveyed score noise quality (the question “how often was the area around your room quiet at night?”) as the lowest out of the 10 measures [7, 8].

Internationally, from the literature it is apparent that L_{Aeq} and L_{Amax} noise limits prescribed within WHO guidelines [9, 10] relating to sleep disturbance (and also AS/NZS2107:2000 [11]) are consistently exceeded in current modern hospital wards and ICUs [12, 13, 14]. Perhaps this indicates that current design and management measures are not adequate as internally generated noise events from staff activities and medical equipment are not considered.

Shiers [13] conducted a study of two wards at Bedford Hospital, UK in terms of noise levels and annoyance, including extended measurements of noise levels over periods of generally a week. The fitout and operation of these hospital wards is similar to Australian designs of concrete structure, plasterboard walls and vinyl flooring, with sound absorption primarily through suspended acoustically rated ceiling systems and some additional benefit in privacy curtains and upholstery of easy chairs. Background night time noise levels were around L_{A90} 30-32dB. The study found that:

- More than half of patients surveyed were disturbed by noise at night;
- Night time $L_{Aeq,8hr}$ values for both single and multiple bed wards were typically between 41dB and 51dB; and
- Single bed wards were not necessarily quieter, since the occupants of multiple bed wards tended to moderate their behaviour in consideration of other patients.

2.1.1 Design sound levels

Relevant design guidance within Australia on internal sound levels and reverberation times within typical hospital spaces has already been compared in the literature [2] and are noted here as:

- AS/NZS2107:2000 [11]
- Green Building Council of Australia Green Star Healthcare v1 rating tool [15]
- Sound & Vibration, Design Guidelines for Health Care Facilities, Version 2.0 [4]
- Australian Health Facility Guidelines (AusHFG) v4.0 [3]
- Specialist Engineering Services. Acoustics: Technical Design Manual, 4032:0.6 [16] (previously HTM08-01)
- American Academy of Pediatrics guidelines relating to NICU and PICU wards [17].

However, none of these guidelines provide criteria to specifically address complaints regarding:

1. False or unnecessary equipment alarms
2. Staff and visitor discussions and use of mobile phones
3. Staff paging, fixed internal and mobile phones, broadcast information and communication systems
4. In room patient noise (snoring, cries, laugher, coughing, talking), activities such as

television and other audio entertainment.

5. Squeaks, clattering and knocks from movement of carts and gurneys, ring binders, slamming cabinets and roller shutters.

It's important to put these aspects into the context of continuous noise targets and also the potential for intermittent and occasional external noise intrusion. Universally the attitude in the literature towards short term / sudden noise events in patient areas is to reduce them as far as practicable. However, staff behaviour, lack of awareness and workplace cultures are perhaps the greatest challenges to achieving these goals.

There are also emerging technologies which need to be considered from an acoustic design viewpoint, such as remote patient videoconferencing with medical specialists. As audio from the teleconference is amplified and played into a patient room it introduces potential privacy issues.

The impact and extent of the above complaint issues may be increased where background noise levels are too low. Low level sound masking systems are increasingly important in giving direct control over the background sound environment in wards and critical spaces, particularly where building services are of solid state and/or near-silent in operation (i.e. chilled beam cooling systems).

Intensive care units

Neonatal and paediatric intensive care units (NICUs / PICUs) are commonly 4 to 6 beds in size to allow efficiency in staff monitoring; however, adult ICUs may be single beds where privacy is more paramount. In any case, ICUs are considered among the most acoustically sensitive environments and where the message of a healing environment carries greater currency with both visitors and staff [11].

Similar issues to outpatient ward environments are still prevalent with ICUs. In a review of studies specific to ICU environments, Stafford et al. [12] noted that ICUs noise levels in terms of L_{Aeq} and L_{Amax} were still well above WHO guidelines, and that whilst closing doors decreased average sound levels, it did not significantly decrese peak noise levels.

The 2010 SVDG document recommends an ambient services background level of around L_{Aeq} 35dB. Including for operational noise, noise levels below $L_{AeqS,1hour}$ 45dB and $L_{A10S,1hour}$ 50 dB are also recommended.

Achieving these targets or less within a multiple bed NICU ward appears extremely difficult as sound levels from an infant crying is of the order of L_{Amax} 90dB at one metre. It certainly doesn't help that internal noise levels *within* preterm infant incubators themselves have been measured in excess of L_{Aeq} 53dB and as high as L_{Aeq} 68 dB [18].

Sound levels in critical patient care spaces are recommended to be defined in terms of Room Criterion Mark II (RC2) terms or at least include for consideration of low-frequency and subjective annoyance characteristics, with other general areas using overall A-weighted targets.

2.1.2 Reverberation

Within hospital ward and clinical treatment environments, the apparent rationale for reverberation time targets appears to be historically from a concern of noise control and privacy purposes only, rather than support of speech or any audio-visual system demands. Indeed, various studies have shown the benefit of sound absorptive and diffusive surface treatments in terms of impact to patients [8], with ambient noise reductions in terms of L_{Aeq} of typically 2 to 4dB [5]. The more important aspects of these controls is the reductions in conversational speech effort and behaviour which leads to larger reductions in peak noise levels [13] and subjective annoyance to patients [14].

Reverberation times recommended in AS/NZS2107:2000 are certainly due for review with its origins in the 1980s, and modern hospital activities and processes having significantly advanced since this time. We are not aware of any recent research evidence supporting a *minimum* reverberation time.

Care should be taken to ensure reverberation times are only specified for spaces within a modern hospital where it demonstrates benefit, as it may lead to unnecessary constraints on other factors such as acoustic separation. For some reason, reverberation times are specified in AS/NZS2107:2000 for surgery areas, pharmacies, kitchens and sterilising areas and there appears to be little evidence in the literature to support the approach of reverberation control at the exclusion of direct methods such as equipment selection and staff behaviour.

For simplicity, reverberation could be specified similar to the approach provided in the US SVDG [4], which is around average surface sound absorption rates rather than specific reverberation times. In this way, spaces could be defined in terms of a minimum average ceiling performance or class, noting that ceiling mounted systems represent the bulk performance opportunity (due to infection control issues) besides re-arranging internal walls / layouts.

2.1.3 External noise intrusion

Our review of the literature indicates that whilst external noise intrusion remains an important design parameter in regards to the external fabric of the building, it is not a key area of complaint in established hospitals. This indicates that existing design measures as applicable under environmental or planning legislation are sufficient at this time. Natural ventilation technologies and openings in the facade are often cited as contrary to achieving established ambient noise goals – however careful coordinated design around external conditions and the treatment of openings can effectively mitigate against most forms of transportation and environmental noise intrusion.

Short term maximum design criteria for helicopter operations near hospitals have previously been drawn from application of AS2021:2000 and various state environmental guidelines. Sleep awakening criteria derived from regular scheduled commercial passenger jet aircraft on residences have not been demonstrated as appropriate to the occasional and emergency nature of helicopter transportation upon hospital occupants who have different levels of sensitivity – let alone the practical considerations of noise control of such EMS helicopters in close proximity [19].

The authors' experience is that setting a maximum limit of L_{ASmax} 65dB is appropriate for wards and sensitive spaces where some administrative control of noise from other activities is possible. Design execution will of course vary depending on the design reference helicopter, building arrangement, extent of glazing, facade system etc. A reduced target of L_{ASmax} 55dB in limited circumstances is considered the practicable limit for the most critical ICU individual patient wards where helicopter traffic is anticipated. It is perhaps a reasonable target where the activities and noise sources within can be robustly controlled with certainty to L_{ASmax} 55dB.

Lower values can be aspired to; however, it is important to consider in this context other activities which typically occur throughout each day within hospital wards:

- Typical conversations at one metre distance are generally L_{Amax} 65 to 70dB, depending on background conditions and location (e.g. single or multiple bed ward).
- Medical equipment alarms L_{Amax} 71dB at 2 metres [13].
- Radios and televisions at moderate volume settings up to L_{Amax} 75dB at bed head position.
- Clinical spaces and nurse station environments often exceed L_{Amax} 80-85dB at desk counters due to office machinery (printers, computer keyboards, scanners etc.), equipment handling, and vocal calls for attention from staff.
- Mobile phone ringing, L_{Amax} 75dB at 2 metres [13].
- Patient cries, L_{Amax} 85dB to 91dB at 2 metres [13].
- Patient snoring, L_{Amax} 70dB at 2 metres [13].
- Patient sneezing, L_{Amax} 90dB at 2 metres [13].
- Nurse call systems typically L_{Amax} 76-86dB at 3 metres [13].
- Changing a bin bag, L_{Amax} 93dB at 2 metres [13].
- Snap closing a ring binder, L_{Amax} 83dB to 90dB at 1 metre [13].
- Reverberant noise levels from high pressure cleaning sprays (a bacterial control measure) been measured between L_{Amax} 75 to 95dB [20].

2.2 Internal Acoustic Separation

Poor acoustic privacy can affect health outcomes, particularly through patients withholding important or perhaps crucial health information from staff, or not state their true feelings in confidence where they believe they may be overheard by others.

Provisions for airborne acoustic separation / insulation that must be achieved in practice should be contracted around the Level Difference (D, D_w) parameter, not the partition Sound reduction index (R, R_w). It should be reason enough that R_w values cannot be verified in-situ according to current Australian standards as old as 2006; however, this continues to occur in practice with existing guidelines.

Building contracts with acoustic separation provisions reliant on the R_w parameter are contractually weak, as it allows argument on the proportion of flanking that may excuse a substandard level of overall apparent performance in terms of R'_w. The D_w parameter is also appropriate for in-situ measurement as it represents the level of separation for that space 'as is' and does not need to be normalised (e.g. $D_{nT,w}$) or require measures of reverberation time.

This is not to suggest that the R_w parameter should be abandoned - it is still important for design and comparison/procurement of individual products. Design for speech privacy based on the methods outlined in the standard AS2822:1985 [21] are still relevant despite its age. But any provisions required to be physically measured in-situ should be contracted in terms of D or D_w.

Additionally, the Speech Privacy Class (SPC) method defined in ASTM E2638 [22] is a recognised method of objectively defining privacy between spaces and is likely to be included in the update to the 2014 update to the SVDG. Whilst the method gives robust estimates of speech intelligibility and can use existing R_w or D_w measures, its guidance on acceptability has origins in commercial offices which may differ to Australian healthcare facilities. It is; however, suggested as a way of reviewing intelligibility within clinical spaces, patient consulting rooms and administrative areas.

The Green Building Council of Australia (GBCA) rating tool guidelines 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:

$$R_w + L_{Aeq,T} \geq 80 \quad (1)$$

for solid partitions with no visual connection, or

$$R_w + L_{Aeq,T} \geq 75 \quad (2)$$

for partitions with a visual connection, where

- R_w is the weighted sound reduction index of the separating partition, and
- $L_{Aeq,T}$ is the background noise level in the listening spaces adjacent 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 authors' experience 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

$$D_w + L_{Aeq,T} \geq 80 \quad (4)$$

for solid partitions with no visual connection, or

$$D_w + L_{Aeq,T} \geq 75 \quad (5)$$

for partitions with a visual connection.

There remain 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 each type of usage. However, the literature finds that there are practical limitations which should be addressed:

- 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 [2,13].
- 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.
- 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.
- The manual effort required to operate a door by a patient is an important design aspect and this often prevents use of large solid core doors and/or rubber compression seals.

- Key hospital infrastructure is required to survive significant earthquake loadings, spread of fire and/or external attack, which often requires that internal walls (and heavy in-ceiling services) must be suitably braced and supported by the structure above to avoid risk of sway and collapse. These walls are usually installed first before ceiling systems.
- A variety of ceiling tile systems with both relatively high sound isolation and absorption properties (minimum BS EN 20140-9 $D_{n,c,w}$ 35dB, AS ISO 11654 Class A or B) are now offered within Australia.

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 [23] may be consulted for further guidance on methodology.

2.3 Vibration

Vibration is another area in which there is little design guidance within Australia. Key sensitive facilities are viewed as microscopes, MRIs, precision scanning/diagnostic equipment and animal behavioural and holding rooms. Apart from building plant and freight and passenger rail infrastructure, key vibration sources on floors above ground level are generally footfall and manual handling of hospital equipment and materials. Design guidance from ASHRAE continues to be relevant; however, within Australian healthcare there are some recent changes in technology and standardization to note.

MRI units have always been areas for careful design in terms of vibration. However, ultra-high strength magnetic fields of 7 Tesla (~0.2mm resolution) and above (currently developed as high as 11.7T!) are being introduced, along with increased sensitivity to noise and vibration.

Microscopes for precision surgery such as ophthalmology (eye) and neurology are also becoming lighter and more portable, often on extended and mobile booms. This makes them even more sensitive to building excitation from sources such as footfall vibration, external wind loadings and even traffic speed bumps outside the building.

In 2013 the Standards Australia technical committees for Vibration and Shock Human Effects (AV-010) agreed to withdraw AS 2670.2:1990 [24] perhaps on grounds of its age and lack of progression against other international standards. It’s important to note that although officially withdrawn by Standards Australia, AS 2670.2:1990 may still be used and enforced within building contracts in the absence of superior design guidance. Note that footfall vibration limits specified within ANSI S3.29 [25] and referenced within the 2010 version of the SVDG remain generally consistent with this standard for operating theatres and patient areas.

AV-010’s decision to withdraw AS2670.2-1990 removed objective guidance on acceptable magnitudes of instantaneous and transient vibration (for various occupancies) without providing a similar replacement.

Both BS 6472:2008 [26] and/or ISO 2631 [27] series remain practicable methods of evaluation but require objective limits to be set for the purposes of assessing design compliance. UK design guidance of VDV $0.2\text{m/s}^{1.75}$ in hospital wards and $0.8\text{m/s}^{1.75}$ in offices [16] has been used by the NSW EPA [28] in more broader environmental applications.

2.3.1 Environmental noise criteria

Facilities for outdoor communal activities such as gardening and social games are more common, and therefore the amenity of outdoor patient and staff areas is recognised as very important. Environmental and transportation noise requirements continue to vary between Australian states; however, it is reasonable to expect that ambient noise levels within passive recreational levels can be controlled to L_{Aeq} 55dB or less through siting, screening and control of mechanical services noise emission from the development site .

3. Conclusions and recommendations

Existing hospital design guidelines do not fully address the current areas of patient complaint and future operational trends.

The following sections outline recommended general objective and subjective design provisions for selected usages within healthcare facilities. Strict compliance may not be possible in all instances, and specific requirements should be developed considering individual circumstances [2]. It is hoped that the following table of provisions will be updated from industry feedback as an ongoing basis.

3.1 Objective design provisions

3.1.1 Airborne noise controls

The following table outlines recommended general airborne noise design goals for selected usages within healthcare facilities. Strict compliance may not be possible in all instances, and specific requirements should be developed considering individual circumstances [2].

Table 1 – Indicative hospital design acoustics specifications [3]

Usage	Ambient Noise Level[4]	RT controls[5]	External Transient Noise Intrusion[6]	Indicative Acoustic Separation		Comments
				Adjacent[7]	Corridor[8]	
Single bed ward (including Mental Health, Parent Accommodation)	$L_{Aeq,day}$ 40dB $L_{A90,night}$ 35dB	Class B	L_{AmaxS} 50dB	D_w 40dB	D_w 25dB	Suggest non-squeal Polymer/rubber - based flooring within room and to corridor
Multiple bed ward	L_{Aeq} 40dB	Class B	L_{AmaxS} 50dB	D_w 40dB	D_w 25dB	
Ward ensuites	L_{Aeq} 50dB	-	L_{AmaxS} 65dB	D_w 40dB, Discont.	D_w 15dB	'Corridor' is the associated ward
Consulting, examination, interview, counselling / bereavement	L_{Aeq} 45dB	Class B	L_{AmaxS} 50dB	D_w 40dB	D_w 25dB	
Treatment, procedures, surgeries	L_{Aeq} 45dB	Class B	L_{AmaxS} 50dB	D_w 40dB	D_w 25dB	Specialist input needed for large diagnostic plant (MRI, PET)
Morgue presentation areas	L_{Aeq} 45 dB	Class B	L_{AmaxS} 50dB	D_w 45dB	D_w 25dB	
Birthing room / delivery suites	L_{Aeq} 50dB	Class B	L_{AmaxS} 65dB	D_w 45dB	D_w 25dB	
Laboratories	L_{Aeq} 45dB	Class B	L_{AmaxS} 65dB	D_w 40dB	D_w 20dB	
Clean utility / Dirty utility / drug storage or preparation	L_{Aeq} 50dB	-	-	D_w 35dB	D_w 15dB	Macerator usage / location / treatment important re adjacent spaces
Speech and language therapy	L_{Aeq} 40dB	Class B	L_{AmaxS} 50dB	D_w 40dB	D_w 25dB	
Audiology / audiometry	As per AS1269.4					
Dental clinics	L_{Aeq} 45dB	Class B	L_{AmaxS} 50dB	D_w 45dB	D_w 25dB	
Rehabilitation areas	L_{Aeq} 45dB	Class B	L_{AmaxS} 50dB	D_w 40dB	D_w 25dB	

[3] All sound levels re 20µPa. 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).

[4] Includes external noise ingress in the normal building ventilation mode for a period representative of at least one hour. Excluding staff and patient activity within the space. Nominal +/- 5dB tolerance

[5] Minimum entire ceiling AS ISO 11654 Class performance or area equivalent, unfurnished

[6] Short duration transient / intermittent external events, e.g. aircraft or rail vehicles. For occasional ambulance helicopter operations, increase limit by 15dB.

[7] Minimum values to nearby noise-sensitive enclosed rooms where no common door exists. Discontinuous walls as defined by the National Construction Code are recommended for impact or wall attached noise sources.

[8] To circulation corridor, where the intermediate partition is a solid wall with an operable solid door or air lock. Subtract 5dB for listening areas with a visual connection (easily visible to the occupants of the space)

Usage	Ambient Noise Level[4]	RT controls[5]	External Transient Noise Intrusion[6]	Indicative Acoustic Separation		Comments
				Adjacent[7]	Corridor[8]	
Hydrotherapy	L_{Aeq} 50dB	Class A	L_{AmaxS} 65dB	D_w 45dB	D_w 25dB	
General intensive care wards	L_{Aeq} 40dB	Class A	L_{AmaxS} 50dB	D_w 45dB	D_w 25dB	
Neonatal or pediatric ICUs (NICU / PICU)	Specialist design input required[9]	Class A	L_{AmaxS} 55dB	D_w 45dB	D_w 30dB	Suggest non-squeal Polymer/rubber -based flooring within room and to corridor
Pharmacy offices	L_{Aeq} 45dB	Class B	L_{AmaxS} 50dB	D_w 35dB	D_w 20dB	
Kitchens, sterilisation and service areas	L_{Aeq} 50dB	-	L_{AmaxS} 70dB	D_w 40dB	-	
Triage / emergency	L_{Aeq} 45dB	-	L_{AmaxS} 50dB	-	-	
Operating theatres	L_{Aeq} 40dB	-	L_{AmaxS} 50dB	D_w 40dB	D_w 25dB	
Public areas						
Corridors and lobby spaces	L_{Aeq} 50dB	Class C	L_{AmaxS} 65dB	-	-	
Cafeterias / dining	L_{Aeq} 50dB	Class B	L_{AmaxS} 70dB	D_w 40dB	D_w 15dB	
Family and parents' lounges	L_{Aeq} 45 dB	Class B	L_{AmaxS} 65dB	D_w 40dB	D_w 20dB	
Toilets, amenities	L_{Aeq} 50dB	-	L_{AmaxS} 70dB	D_w 40dB	D_w 15dB	
Waiting rooms and Reception areas	L_{Aeq} 45dB	Class B	L_{AmaxS} 65dB	D_w 40dB	-	
Multi-faith, chapel	L_{Aeq} 40dB	Specialist design input recommended				
Lecture theatres, cinemas, multipurpose rooms	Specialist design input required					
Radio broadcast, interview or audio editing	Specialist design input required					
Atria	L_{Aeq} 45dB	Class C	L_{AmaxS} 70dB	-	-	
Outdoor seating or activity areas	L_{Aeq} 50dB	-	-	-	-	Consider annoyance level of any nearby plant
Staff areas						
Enclosed nurse stations	L_{Aeq} 45dB	Class B	L_{AmaxS} 55 dB			Open stations as per 'Corridors'
Boardroom / conference	L_{Aeq} 40dB	Class B		D_w 45dB		
Open plan office	L_{Aeq} 45dB	Class B			-	
Private offices	L_{Aeq} 40dB	Class B		D_w 35dB	D_w 20dB	
Executive offices	L_{Aeq} 40dB	Class B		D_w 40dB	D_w 25dB	
Cellular offices (2-4 desks)	L_{Aeq} 45dB	Class B		D_w 35dB	D_w 20dB	
Utility rooms	L_{Aeq} 50dB	Class C	-			
Amenities, locker room	L_{Aeq} 50dB	-	L_{AmaxS} 70dB			
Grossing stations (Morgue)	L_{Aeq} 45dB	Class B	L_{AmaxS} 65dB	D_w 55dB Discont.		Beware proximity to nearby sensitive areas
Infrastructure						
Engineering, Workshops	L_{Aeq} 55dB	-	-	D_w 55dB Discont.	-	Separation values for adjacent sensitive areas
Plantrooms, generators	ALARP[10]		-	D_w 55dB Discont.	-	

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

[10] As low as reasonably practicable controls for noisy plant, on the basis of daily or weekly noise exposure under the AS1269 series.

3.1.2 Structural noise and vibration controls

The following table outlines recommended general design goals for structural noise and vibration:

Table 2 – Recommended hospital design structural noise and vibration specifications[11]

Usage	Impact sound isolation	Continuous Vibration limit		Peak Vibration Limit (all hours)	Comments
		Day	Night		
Single bed ward (including Mental Health, Parent Accommodation)	$L_{n,w}$ 50dB	ASHRAE 0.20mm/s, or VDV 0.2m/s$^{1.75}$	ASHRAE 0.14mm/s, or VDV 0.1m/s$^{1.75}$	ASHRAE 2.0mm/s	
Multiple bed ward	$L_{n,w}$ 55dB				
General intensive care wards, Neonatal or pediatric ICUs (NICU / PICU)	$L_{n,w}$ 50dB				
Operating theatres [12]	$L_{n,w}$ 50dB	ASHRAE 0.10mm/s, 1-80Hz vibration curve			
Precision equipment generally	-	ASHRAE 2007 criteria			
Consulting, examination, interview, counselling, dentistry, bereavement and the like	$L_{n,w}$ 55dB	ASHRAE 0.4mm/s or VDV 0.4m/s$^{1.75}$		ASHRAE 3.0mm/s	
Treatment, procedures, surgeries, birthing room, laboratories, hydrotherapy	$L_{n,w}$ 60dB	ASHRAE 0.4mm/s or VDV 0.4m/s$^{1.75}$		ASHRAE 3.0mm/s	
Boardroom / conference, open plan offices, private offices executive offices, cellular offices and the like	$L_{n,w}$ 55dB	ASHRAE 0.4mm/s or VDV 0.8m/s$^{1.75}$		ASHRAE 3.0mm/s	
Engineering, Workshops, Plantrooms	-	ASHRAE 0.8mm/s		ASHRAE 6.0mm/s	
Animal house, behaviour (table level) or holding (cage level) rooms	Specialist design input required	ASHRAE VC-A 0.051mm/s			Specialist design input required

3.2 Subjective improvements to guidelines and specifications

The following are design aspects where future hospital guidelines on acoustics should be updated:

1. Establish and enforce policies around mobile phone use and public visitation hours;
2. Dispersion and location of nurse stations where crowding of staff can occur in wards;
3. Support for anti-microbial polymer and rubber-impregnated flooring over concrete, and avoiding lightweight sprung or raised floor tile systems;
4. Support for rubber lined castors and wheels for all mobile equipment, trolleys and gurneys
5. Support for recessed sliding glass doors with soft closers and dampers that can't be slammed / closed quickly
6. 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;
7. Establish policies on locating high traffic and utility areas away from patient rooms;

[11] Determined at the position of the equipment mounting and/or patient; not necessarily the base building floor structure. Guideline values are nominated subject to final equipment selections. ASHRAE criteria are based on the 1-80Hz vibration curves as defined in the 2007 guidelines as amended, continuous values assessed over one second. VDV values are defined in BS6472:2008 and should be weighted W_g or otherwise reasonably according to BS6472 or BS6471.

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

8. Specifications for combined low volume speaker handsets and remote controls for entertainment systems;
9. Selection of ward documentation systems and avoidance of bulky and noisy items such as ring binders;
10. Specifications for soft close doors and cabinets, surface bins, trays and trolleys;
11. Avoidance of roller door shutters, latching hardware in close proximity to wards, and;
12. Specifications for ambient noise sensors within ICU and patient ward areas, particularly those with adaptive limits which light-up when noise levels are exceeded.

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