Engineering Guidelines for Healthcare Facilities Volume 6 – Specialist Healthcare Engineering and Provisions

Health Technical Guideline HTG-2020-006

Victorian Health and Human Services
BUILDING AUTHORITY

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Engineering guidelines for healthcare facilities: Volume 6 – Specialist healthcare engineering and provisions

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Contents

Introduction

The purpose of engineering systems in healthcare projects is to satisfy internal environmental conditions for infection control, comfort, and safety.

These Engineering guidelines are a guide for the development of design and specification documentation for healthcare facilities. For a glossary of terms and common abbreviations used in the guide refer to Volume 1.

A key objective for delivery of healthcare facility projects is the provision of facilities that provide for:

- achievement of optimal patient care using a model of care for the patient
- contemporary approaches to design
- practical and easy usage
- fitness for purpose
- value for money

It is expected that all projects will be delivered in line with the requirements of all relevant codes and regulations, and all designers are be aware of these obligations.

Any engineered deviations from relevant statutory requirements and other standards due to unique project circumstances need to be thoroughly and holistically assessed, proved, clearly articulated or documented, and signed off by the relevant authority.

All designers will assess the provisions of standards, such as the *Australasian health facility guidelines* (AusHFGs), and determine an appropriate application of these to their project. In new, major hospital developments it is envisaged the requirements of AusHFGs and these guidelines will be closely adhered to, except where deviations are associated with new models of care, operational policies or procedures or innovative approaches to the delivery of health services.

On smaller projects and projects where substantial refurbishment is envisaged, designers will critically evaluate the AusHFGs to determine their applicability and suitability to the project during planning, and deviations will be clearly articulated or documented, and signed off by the relevant authority.

Volume 6 – Specialist healthcare engineering and provisions forms part of a suite of documents in the *Engineering guidelines for healthcare facilities*. The documents in this series are:

- Volume 1 – Fundamentals
- Volume 2 – Electrical and lighting
- Volume 3 – Data, comms and security
- Volume 4 - Heating, ventilation and air-conditioning
- Volume 5 – Fire and hydraulics
- Volume 6 – Specialist healthcare engineering and provisions
- Reference table 1 – Design parameters
- Reference table 2 – Acoustic design parameters
- Reference table 3 – Required noise reductions for room adjacencies

Medical gases

Introduction

6.1. The minimum requirements for the provision of medical gas systems in healthcare facilities will be:

- AS 2473 Valves for compressed gas cylinders – Outlet connections for medical gases (including pin-indexed yoke connections)
- AS 2568 Medical gases – Purity of compressed medical breathing air
- AS 2896 Medical gas systems – Installation and testing of non-flammable medical gases pipeline systems
- AS 2902 Medical gas systems – Low pressure flexible hose assemblies
- AS 3840 Pressure regulators for use with medical gases – Pressure regulators and pressure regulators with flow-metering devices
- AS 4484 Gas cylinders for industrial, scientific, medical and refrigerant use – Labelling and colour coding

6.2. All clauses outlined in the following section are in addition to statutory requirements.

Scope

6.3. Medical gas systems include the following services:

- oxygen
- nitrous oxide
- medical breathing air
- surgical tool gas
- medical gases mixtures
- carbon dioxide
- medical suction – medical suction systems can be:
  - central vacuum
  - venturi ejector operated type

6.4. Medical gases are a critical part of hospitals in their ability to support life and to provide patient care. The design and installation of these systems is governed by Australian Standard AS 2896. Designers and installers must adhere to the requirements of this standard. The critical nature of these services demands a high level of knowledge of the standards by both designers and installers.

Infrastructure

6.5. Each medical gas is recommended to emanate from a central storage or generation point and reticulate to outlets throughout the hospital. The location of medical gas equipment and gas storage as well as the route and size of main pipework runs should account for the future expansion potential of a hospital. Plant layouts should be arranged to account for additional future plant or larger capacity gas storage vessels. Headers used as central distribution points will be arranged to allow for future connections without shutting down the service.

6.6. Medical oxygen, compressed air and nitrous oxide multi-bottle storage manifolds will be arranged in a 'duty' and 'reserve' configuration incorporating automatic change-over facility. It is recommended that each manifold include enough bottle storage to meet two days demand, with additional bottles held in storage to meet three days or holiday period demand. All medical gas

bottle manifolds are recommended to be sited adjacent to each other in a location which facilitates ease of access for bottle delivery and pick-up.

6.7. Pipework will generally be in copper, oxygen cleaned where appropriate in line with AS 2896. Where pipework is installed underground it will be protected against corrosion.

6.8. Underground distribution routes will be recorded. In-ground tracer tape will be installed to identify service routes and above ground markers will be installed at 10 metre intervals and any change of direction.

6.9. Valving will be provided to facilitate isolation of sections of the installation without undue interruption of the supply to the rest of the facility.

6.10. The medical gases installation will incorporate an appropriate low and high pressure audible and visual alarms for each medical gas system and vacuum system respectively. The alarm system will also be hard wired from the essential power supply, if available, with status indication panels sited strategically throughout the hospital on a master and slave arrangement. The master panel will be in a permanently manned location (such as the emergency unit) with slave panels sited in critical areas (such as operating unit and intensive care unit). Alternatively, an independent alarm panel can be provided for operating unit and intensive care unit. These panels will sense pressures in gas pipelines serving each respective area by means of pressure switches located downstream of isolation valves.

Oxygen

6.11. Oxygen will be supplied from gas cylinders or bulk liquid gas storage (vacuum insulated tanks).

6.12. Standby sources in the form of gas cylinders or in the case of a bulk store a second smaller bulk liquid gas storage vessel will also be used.

6.13. Tanker delivery access must be considered and suppliers should be consulted for comment on access for new facilities. Delivery bays should be constructed from a non-bitumen surface, concrete hard standings are recommended.

6.14. Separation distance of liquid oxygen vessels to other plant, structures, boundaries and public roads will comply with the requirements of AS 1894. Storage compounds will be secure and well ventilated. Bulk gas compounds will generally require a water supply, three-phase power outlet and a communication outlet.

6.15. The change over from the duty to the standby source of oxygen must be automatic with a warning raised to indicate that the supply is now operating on the standby source.

Nitrous oxide

6.16. Nitrous oxide is generally provided from gas cylinders arranged to provide a duty and standby source of the gas. The changeover from duty to standby cylinders will be automatic.

6.17. Nitrous oxide is used within specialist areas. The location of the cylinders will be as close as practical to the areas of use, such as perioperative areas, maternity and dental units. The location of the cylinders will be a well-ventilated area and will allow for easy cylinder delivery.

6.18. Scavenging outlets must be provided adjacent to nitrous oxide outlets. These can be provided as part of a venturi suction system or as part of a vacuum pump suction system.

Medical air

6.19. Medical air systems are a life support system and will be used for medical purposes only. Separate compressed air systems will be used for non-medical purposes such as tool air.

6.20. Plant sizing will be in line with AS 2896.

6.21. Medical air will be generated by oil free compressor plant. Medical air compressors will be served from the standby power supply together with any associated plant such as driers and compressor cooling pumps and fans. Medical air receivers will be sized to limit the compressor operation to 10 starts per hour at design flow.

Tool air

6.22. Tool air is used within specialist areas such as perioperative departments. The location of the cylinders will be as close as practical to the areas of use. The location of the cylinders will allow for easy cylinder delivery. Tool air is generally provided from gas cylinders arranged to provide a duty and standby source of the gas. The changeover from duty to standby cylinders will be automatic.

6.23. Where the demand for tool air is extremely high consideration will be given to the use of high-pressure compressor sets to produce the tool air, in which case the designers will size the plant in line with AS 2896.

6.24. Tool air pressure regulator and indicator panels will be provided at the point of use.

6.25. Dental air is required at the dental chairs to drive the pneumatic dental tools. Dental air compressors will be oil free units, the installation will include air driers, a dental air vessel and regulators. The distribution pipework is usually installed beneath the floor slab or in accessible channels to serve the dental chairs. A separately pressure regulated compressed air line may be required to serve such areas as dental laboratories.

Vacuum (suction)

Central plant

6.26. The vacuum pump suction system is the preferred system for new hospitals. This system comprises vacuum pumps mounted on the top of a horizontal vacuum cylinder. Plant will be located within a ventilated plant room and designed in line with AS 2120.

6.27. The discharge from the vacuum pumps will be located away from outside air intakes and open-able windows.

6.28. Vacuum receivers will be sized to limit the pump operation to 10 starts per hour at design flow.

6.29. The siting of the plant will allow for adequate flows of air to cool the pumps. The manufacturers will be consulted over the range of operating temperatures for which the supply system is designed. In extreme cases, refrigerator cooling may be required.

Venturi suction

6.30. This system uses medical breathing air to produce suction. The outlets include an air flow valve that adjusts the suction pressure produced at the outlet. The air flow of medical breathing air is relieved via a pipe to outside. This relief pipe is not filtered and can cause infection control issues. Venturi suction systems will be designed in line with AS 2120.

6.31. It is important that the discharge point for this relief is located away from any outside air intakes and open-able windows.

6.32. Where hospitals are being refurbished consideration will be given to the replacement of venturi suction to vacuum pump suction. Introduction of this system impacts the capacity of the medical air compressor system.

6.33. Vacuum plant will be served with standby power.

6.34. Vacuum plant sizing will be in line with AS 2896 and AS 2120.

Other gas systems

6.35. Where other gases or mixtures of gases are used, medical gas system design concepts will be applied. The design will maintain the elements of gas specificity that are essential requirements together with all other relevant safety considerations.

6.36. Common gases and mixtures are:

- oxygen (O) and nitrous oxide (N_2O) (gas and air)
- helium (He) and oxygen
- oxygen and carbon dioxide (CO_2)
- CO_2

6.37. In the rare instance where nitric oxide (NO) is used or briefed, distribution of the gas by pipeline is not recommended.

6.38. Laboratory systems and non-clinical areas will be served by dedicated plant and reticulation, independent of the clinical services.

Area and room-specific requirements

Valve isolation boxes

6.39. Valve isolation boxes will be mounted at a convenient height between one and 1.8 metres such that they can be operated comfortably by staff without their needing to stoop or overreach. The order of the location of individual valves in an array will follow that for terminal units, for example: O2, N2O or N2O/O2 (or both), MA, SA, VAC, He/O2.

6.40. If the array exceeds one (1) metre in height from top to bottom, it may be preferable to arrange them in two columns. Care must be taken to ensure that valve isolation boxes cannot be obscured by opening doors and the like.

6.41. The placing of local alarm indicators will be such that they are readily visible by staff – notices, partitioning and screens will not obscure them.

6.42. The mounting height will be such that in the event of an audible alarm sounding, staff can activate the ‘mute’ switch without overreaching and be a maximum of 1.8 metres above finished floor level.

6.43. All valve isolation boxes will be labelled to identify the individual rooms or sets of terminal units controlled. They will be provided with flow direction arrows.

6.44. In high dependency areas, such as CCU or ICU, dual circuits or subdivision of circuitry (or both) will occur to ensure that gases are always available to rooms and beds. Terminal units must be identified as associated with the specific valve isolation boxes. Correspondingly, valve isolation boxes will be similarly labelled to identify the terminal units controlled.

Emergency connection point for critical areas

6.45. In critical areas, a connection within the valve box that will allow for emergency connection of gas supplies to the local ward or area is considered advantageous and will be provided where practical. This will allow easy access to the gas pipeline in the area during the installation process for testing and purging procedures. It will also provide flexibility for future use of the

pipeline, should it be necessary to alter or upgrade mains, by allowing local connection of an isolated gas supply when necessary.

Terminal units

6.46. Terminal units will be mounted in positions that result in the shortest practicable routes for flexible connecting assemblies, between the terminal unit and apparatus.

6.47. Terminal units may be surface- or flush-mounted. They may also be incorporated with electrical services, nurse call systems, televisions, radio and audio services, in proprietary fittings such as medical supply units, wall panel systems and pendant fittings. When they are installed within such fittings, it is essential to maintain the concentricity of the terminal unit bezel with the fascia plate aperture. If the installation is highly eccentric, the bezel will bind on the fascia plate and the terminal unit will not function properly.

6.48. The following is **not** allowed:

- floor mounted terminal units
- fixed pipelines carrying body or other fluids from a terminal unit to a remote suction jar

6.49. Concealing medical gas outlets with ‘aesthetic’ doors should be avoided wherever possible.

6.50. Terminal units will be mounted in the following order for horizontal and vertical arrays.

Figure 1: Wall mounted terminal unit mounting order – horizontal array

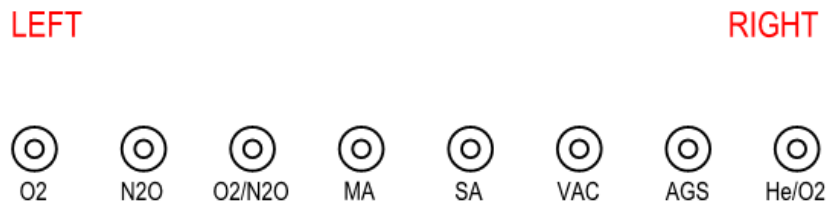
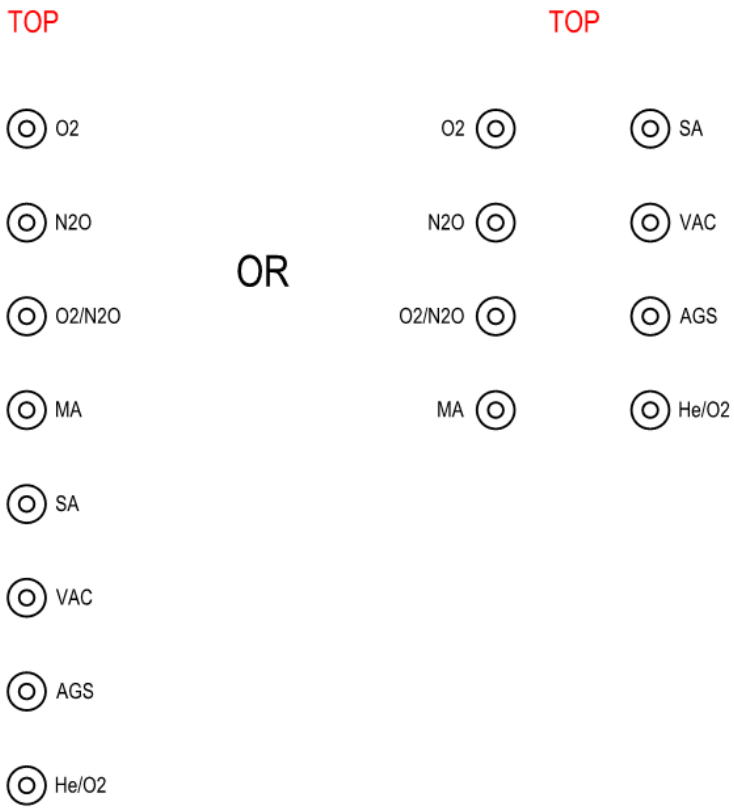


Figure 2: Wall mounted terminal unit mounting order – vertical array



Cross-connection

6.51. All systems must be checked to ensure that there is no cross-connection between pipelines for different gases and vacuum. Tests will not commence until all installations are complete and plant operational. Tests can be performed using ‘test’ gas or ‘working’ gas. Testing and commissioning will be in line with AS 2896.

Vertical transport

Introduction

6.52. The minimum requirements for provision of lifts and escalators in healthcare facilities and listed in this section. This information has been derived from industry best practices and is not to be taken as a design solution for all projects.

6.53. Planning guidance for vertical transportation services are specific to each project and must be assessed and agreed after consultation with relevant stakeholders. Individual requirements for each hospital must be considered and incorporated within the design for each specific site.

6.54. In addition to the minimum requirements and depending upon the type of facility and installed services, the following Australian Standard shall apply:

- AS/NZS 1680.2.5 Interior lighting – Hospital and medical tasks.

6.55. All clauses outlined in this section are in addition to statutory requirements.

Scope

6.56. The scope of this section covers vertical transportation services including:

- bed and passenger lifts
- passenger lifts
- goods lifts
- service lifts
- escalators and moving walks.

6.57. The design will comply with relevant Australian and international standards, the Building Code of Australia and the *Disability Discrimination Act*.

6.58. Preliminary planning for lifts, escalators and moving walks must be based on generic spatial details to assist in providing a design on which competitive tenders can be received from multiple suppliers within the local market.

6.59. Where specialist equipment or products are identified as being required, and such are available from a limited number of suppliers or a sole supplier, these suppliers must be invited to become an active partner in the design development process.

General requirements

Lifts

6.60. Lifts are to be used for transportation of passengers and goods. An assessment of the number, type, speed and size of the lifts must be made based on the agreed site-specific design brief as developed in the design phases.

6.61. Types of lift in healthcare buildings

- public lifts – passenger lift: these lifts carry general passenger traffic including ambulant passengers, semi-ambulant passengers using mobility aids and wheelchair users
- bed lifts – passenger lift: these lifts are intended for the carrying of a patient on a standard extended bed together with the necessary staff and equipment
- goods lifts – goods and passenger lift: these lifts are intended for the movement of conventional goods and dirty items
- service lifts (dumb waiter): these are not designed to carry passengers. They are arranged to be called and despatched externally, normally by a call point adjacent to each hatch or access door. Their size should be selected for each specific purpose.
- helipad lift – passenger lift: designed to accommodate a trauma team and patient
- bariatric lift
- AGV lift.

Escalators and moving walkways

6.62. Careful consideration must be given before incorporating escalators or moving walks into any project, as (although ideal for moving large numbers of people very quickly) they are generally not suitable for use by disabled, elderly or infirm passengers. Use in locations where there is a through site link or link to a transport hub may be appropriate; however, lifts and stairways must also be provided offering a choice for those passengers who are unable or not comfortable using escalators and moving walks.

6.63. A stationary escalator is not safe for use as a stairway as it does not meet stairway code requirements.

6.64. Lift traffic design

6.65. An effective traffic design can only be achieved if the operating requirements of the healthcare facility are understood. The following factors will be considered:

- the number of floors in the building, main entry floors and floors served
- the number of beds in the hospital
- types of departments proposed to be accommodated within the building
- location of theatres, X-ray, CT and MRI scanning equipment and the like
- ward rounds and operating lists
- numbers of staff and shift patterns
- numbers of visitors and visiting hours
- distribution and deliveries of food, beverages, supplies
- waste disposal
- emergency evacuation
- logistics

6.66. The analysis for public lifts will be based on two-way traffic demand for a five-minute interval.

6.67. For calculations, the traffic demand will be in the range of eight to 12.5 per cent of the likely maximum population, where eight per cent will be used for very light use buildings and 12.5 per cent for heavy use buildings. Handling capacity is not usually an issue due to use of large capacity bed and passenger lifts but needs to be assessed with waiting interval.

6.68. The average interval of the lift (waiting interval) will be in the range of 30 to 50 seconds.

6.69. The maximum population can generally be based on between three and five persons per bed. Where peak hours or routes differ between staff and visitors, these populations can be separated into one and two visitors per bed and two and three staff per bed. It will be noted that the maximum building population is measured as the maximum number of persons present in the healthcare building and not the theoretical occupancy of the building based on people per square metre.

6.70. Populations for non-patient ward departments will be determined based on a person per square metre or persons per room basis depending on the type of use.

6.71. Lift car sizes

6.72. The following gives typical equipment and bed sizes and associated minimum lift dimensions.

Table 1: Minimum lift dimensions

Bed or equipment	Width (mm)	Length (mm)
Critical care bed	1100	2400
Standard bed	1080	2370
Bariatric bed	1370	2540
Ambulance stretcher	750	2200
+ electric bed tug		Add 580

6.73. Minimum bed lift size recommended to suit a critical care bed is 1800 mm (width) by 2700 mm (depth), with a minimum clear entrance width of 1400 mm.

6.74. Public and visitor lifts sizes need to consider use by elderly, disabled and users in wheelchairs. A wide and shallow car shape will be employed to intentionally not accommodate a bed and deter staff use of these lifts.

6.75. Goods lifts can be provided as single lifts subject to specific needs, with a recommended minimum capacity of 2000kg. Consideration for lift use and equipment to be transported will be taken into consideration. In larger facilities consideration will be given to grouping two or more goods lifts together to improve performance and efficiency.

Design considerations

6.76. Lifts will be located to limit transfer distances from any point on a floor plate typically less than 50m where practicable for all traffic types.

6.77. Where there is a requirement for high cross traffic of patients across large floor plates, lift nodes should ideally be within 50 metres travel distance from any point on the floor plate.

6.78. Staff, patient and public lifts to be separated where possible. This is essential for larger developments but may not be practical for low rise or smaller developments.

6.79. Where the lifts provide access for critical services, redundancy should be provided by grouping at least two lifts together. The result of an impact assessment to determine the consequences of the failure of a single lift will aid in the decision for redundancy in other areas.

Emergency power

6.80. Consideration should be made for lifts in the event of loss of power. Typical methods used to ensure power to the lifts is maintained include:

- emergency generator power (base building)
- emergency rescue system (incorporated in the lift design).

6.81. Coordination with the lift supplier and electrical design engineer is required to select the most appropriate method of emergency power supply.

Priority control

6.82. In emergency situations lifts may be required to cease normal operation and operate in an exclusive manner to provide priority functions for hospital staff. Planning of these operations with all relevant stakeholders is essential to determine:

- selection of the lifts
- method of activation
- audio and visual communication within the lift
- audio and visual communication on the landing
- operation within the lift car
- operation of other lifts not used in the priority control mode.

6.83. When planning for the use of priority control designers should endeavour to limit the usage of the function to only the highest levels of need. Overuse of priority control will severely degrade the capacity of the lift group to handle other vertical transport needs.

Materials

6.84. Vertical transport systems within health facilities will be designed with finishes that provide the following attributes:

- robustness
- corrosion resistance
- vandal resistance
- infection control
- ease of cleaning.

6.85. Consideration will be made in the joining detail of finishes to reduce gaps and areas where cleaning will be hindered.

6.86. Drive systems

6.87. Electric traction drives will use variable-voltage, variable-frequency (VVVF) technology and the drive will be regenerative.

6.88. Hydraulic drives are only to be considered for low rise (less than 18 metres of travel). Hydraulic lifts are nor recommended when:

- use is greater than 45 up-starts per hour
- the speed exceeds 0.8m/s

Machine-room-less (MRL) lifts

6.89. The design will take into account the potential impact on hospital operations caused by the maintenance access required for MRL lifts.

6.90. The controller cabinets can be located at the top or bottom landings in a small machinery space.

6.91. The designer will consider the following:

- access to the equipment in the well must be carefully managed
- there is less control of the working environment at locations where controller cabinets are installed, often on landings
- additional facilities are required to rescue trapped passengers.

6.92. Machinery cabinets will be fitted with appropriate fire protection, such as smoke detectors connected to the main fire panel, incorporating audio-visual-warning devices.

Pneumatic tube

Introduction

6.93. Pneumatic tube systems are used within hospitals to transport specimens between inpatient units, operating theatres and pathology labs. These systems reduce the manpower and the time taken to get samples to pathology and results back to the medical staff and hence they enhance patient care.

6.94. Departments that commonly use the system are:

- operating theatres
- inpatient units
- pathology
- pharmacy – subject to use of approved spill-secure containers
- emergency departments.

General requirements

6.95. Systems will be designed for the most direct route of tubing runs to keep specimen travel times to a minimum, with care being taken to allow for tubing large turning radius bends that systems demand.

6.96. Hospitals a place high level of reliance on pneumatic tube systems in the delivery of patient care. Systems will therefore be placed on standby power supplies to ensure system operation during power outages.

6.97. Large and complex systems will have an impact on service frequencies. Designers should consult with stakeholders and system suppliers to assess the traffic and resultant system performance.

6.98. Designers will note that the tubes require a minimum bending radius to allow carriers to pass freely. This requires special coordination with services in the ceiling, joinery, walls and fire walls.

6.99. Tube carriers will be leak proof and tamper proof.

Automated guided vehicles (AGV) and autonomous mobile robots (AMR)

Introduction

6.100. Automated guided vehicles (AGVs) are used for handling material in large healthcare facilities to transport supplies, medication, linens, meals, and waste streams throughout a facility. The AGVs navigate defined paths using embedded guide wires or laser guidance systems.

6.101. Autonomous mobile robots (AMRs) are also used for handling material, do not require embedded infrastructure and are suitable in new and existing facilities that have restricted corridors or multiple levels (or both).

Scope

6.102. The use of AGVs is appropriate to reduce staffing demand in the supply chain process for containerised transport of general goods, linen, meals and rubbish. Such systems can provide an automated container transfer service for scheduled transport needs and for specific demands as they arise.

6.103. AGVs are ideally suited to new developments with large logistical volumes, where spatial and services interface can be coordinated during the design phase. Issues for coordination are:

- environment – internal use only
- corridor and walkway width suitable for both pedestrians and AGVs
- corridor and walkway floor covering, gradient, level changes

6.104. AMRs typically handle smaller volumes and are more suited suitable for projects and applications where an embedded guided vehicle system is not practical.

6.105. AMRs are increasingly being used for:

- document courier
- environmental data collection and monitoring
- food and beverage distribution
- linen supply and collection
- laboratory specimen handling
- pharmacy supplies

6.106. An individual needs assessment and business case for AGVs and AMRs must be carried out, and, if carried beyond the preliminary concept planning phase, specialist design input must be sought.

General requirements

6.107. Designers will consider the following when assessing the suitability of AGV and ARM installations:

- AGV parking, storage, recharge area
- electrical services interface
- lift services interface
- automated door interface.

Acoustics

Introduction

6.108. Ongoing clinical research has shown a positive relationship between patient wellbeing and recovery and good acoustic design of healthcare facilities. In the formulation of the design guidance provided in this document, this concept has been at the heart of the decision process.

6.109. In addition to the wellbeing and recovery of the patients, extensive consideration has also been given for the staff who use these facilities daily.

6.110. Sound control is critically important in healthcare facilities. High ambient noise levels can have serious effects ranging from sleep loss, increased blood pressure, heart and respiration rates in patients and can contribute to cognitive impairment for staff.

6.111. Poor acoustically designed environments can pose a risk to patient confidentiality or impede effective communication between patients and staff and between staff members by making speech or auditory signals less intelligible or detectable. The design should prevent the transmission of unwanted sound yet maximize speech intelligibility between people who need to communicate with each other.

6.112. Good acoustic design will:

- improve comfort, privacy and dignity for patients and their visitors
- assist in providing improved sleep patterns which are critical for the healing process
- improve staff comfort, privacy, intelligibility, audibility, efficiency and accuracy

6.113. Acoustic treatments may not be possible in rooms that require extreme levels of infection control (spaces where the primary purpose of the HVAC system is not air conditioning – refer to Reference table 1). In this situation, the acoustic consultant should raise this deviation with project managers.

Scope

6.114. In the development of the acoustic design for a healthcare building, the design team and builder must consider:

- environmental noise emission
- internal design noise and vibration levels
- environmental noise intrusion
- building services noise and vibration
- internal acoustic isolation
- rain noise
- room acoustics and
- vibration and structure borne noise.

6.115. Design guidelines provide advice for the project team to consider while designing to achieve the required performance targets.

General requirements

Environmental noise emission

6.116. Noise emissions from the operation of all healthcare facilities will comply with applicable regulatory requirements. Operational noise may include:

- external mechanical plant.
- back of house operations.
- loading dock areas.
- vehicle noise (carparks and driveways) on the site.
- road noise generated by vehicle traffic associated with the facility
- helicopter noise.

External noise intrusion

6.117. When designing and constructing the fabric of the building, internal noise levels from external sources should not exceed the design levels indicated in the following.

Steady state

6.118. Steady state noise sources (such as traffic or external mechanical plant noise) should not exceed the equivalent A-weighted noise level corresponding to the RC Mark II scale presented in Reference table 2. This A-weighted number should also include the cumulative noise contribution of building engineering services in normal operation.

Intermittent noise

6.119. Noise from intermittent noises (such as aircraft) should not exceed levels as listed in Table 3.3 of Australian Standard AS 2021:2015 Acoustics – Aircraft noise intrusion – Building siting and construction.

Noise from engineering services

6.120. Internal noise levels from the normal operation of all cumulative engineering services should comply with the levels listed in Reference table 2. All measurements should be undertaken using the RC Mark II scale.

6.121. The RC Mark II criteria are provided for noise from engineering services only. In the event the space under consideration is affected by other noise sources (such as external traffic noise intrusion), further considerations should be made by the assessing engineer to ensure adequate allowances are made to ensure the overall cumulative noise level inside the space complies with the A-weighted noise level that corresponds to the RC Mark II criterion level. The equivalent A-weighted noise level corresponding to the RC Mark II criterion will be taken to be equal to the RC Mark II +plus five decibels.

Reverberation time control

6.122. Reverberation time control in healthcare facilities is important in controlling the reverberant build-up of noise within occupied spaces and ensuring adequate speech intelligibility. Spaces that have excessively long reverberation times can be uncomfortable for the end users of the space, including both patients and staff.

6.123. Recommended reverberation times (RT60 values) for fully furnished spaces are in Reference table 2 All reverberation time measurements should be made in both the 500 Hz and 1 kHz

octave bands. If these measurements are made in empty or partially completed rooms, the measured levels should be appropriately adjusted to represent their fully furnished state.

6.124. For critical spaces like audiometric rooms or similar, specialist advice should be sought.

6.125. Acoustic privacy

6.126. Acoustic privacy between some spaces in a healthcare facility is important for patient confidentiality and to promote recovery and wellbeing. Acoustic separation requirements provided in this guideline have been determined on an individual case by case basis of adjacency.

6.127. Three parameters are used to determine required acoustic separation levels,: the source room noise level, the receiving room background noise level and the desired privacy level in the receiving room. Using these three parameters, a minimum sound level difference can be nominated for adequate acoustic privacy (this sound level difference is 'D' in the following formula11).

6.128. With the sound level difference determined for individual room adjacencies, the formula given in ISO 140.4-2006 can be used to determine the apparent sound reduction (R') of the required partition construction. The formula is:

$$R' = D + 10\,Log\left(\frac{S}{A}\right) dB$$

- D is the required level difference (refer to Reference table 3)
- S is the area of the separating element
- A is equivalent sound absorption in the receiving room
- In calculating the apparent sound reduction, reference must be made to Reference table 3.

Rain noise

6.129. Design of the external roof and ceiling constructions should be designed and constructed to meet the overall A-weighted number from the RC ratings in Reference table 2 plus 10 decibels, on the assumption the maximum rainfall intensity for one hour in a single year as given by the Bureau of Meteorology for the project location.

Atrium design

6.130. Acoustic requirements of the atrium will be in line with AS/NZS2107 (refer to Reference table 1).

Helipad

General

6.131. New and existing helipads are to be designed, operated and maintained in line with the Department of Health and Human Services' (the department) 2015 guidelines for helicopter medical transport landing sites.

6.132. New helipads not built in line with these guidelines may not be funded by the department or used by Ambulance Victoria.

6.133. For more information, refer to DHHS' Heliport guidelines 2015 <http://www.capital.health.vic.gov.au/Asset_property_management_and_operations/Helicopter_landing_site_guidelines_2015>

Medical helicopter noise

6.134. Internal noise from medical helicopter operations should comply with the levels listed in the following table.

Table 2: Internal noise levels from medical helicopter operations

Space	Internal noise level – dB $LA_{Max(Slow)}$
Wards and bereavement rooms	65
Office areas	70
Meeting rooms	70
Corridors, public area, reception	70
Operating theatres	65
Consultation, procedure, examination and labourites	65

Ventilation systems

6.135. In hospitals where helicopter operations occur, care will be taken to ensure that outside air inlets are clear of helipads and the rotor air currents with entrained jet exhaust. Where this is unavoidable, considerations should be given to carbon filters or temporary closing of outside air intakes through motorised dampers (or both).

6.136. Where carbon filters are adopted, there will be a bypass for normal operation.

6.137. Where closing of outside intakes is adopted, measures will be taken to ensure that areas with pressure regime controls are maintained. One possible method may be to increase the exhaust quantities in the more negatively pressured areas.

6.138. Designers will consider the use of computer fluid dynamic analysis or wind tunnel analysis of air movement from the helipad to establish the likelihood of air entrainment into ventilation intakes to inform the appropriate design solution.

Fire services

6.139. Helipads will be designed with fire suppression systems to suit the specific hazard, such as Civil aviation advisory publication 92-4 and NFPA 418.

Drainage

6.140. Helipad drainage systems will incorporate appropriate trade waste capture and storage.

Bulk storage cylinders

6.141. Inflammable hospital gases (such as bulk storage LPG and oxygen cylinders or containers) are not to be positioned below the VFR approach and departure paths and will be at least 30 metres beyond the flight path and safety area boundary.

Design and construction advice

6.142. It will be necessary for designers for each helicopter landing site project to work closely with an aviation advisor with sound knowledge of helicopter operations, in particular hospital emergency medical services and helicopter landing site requirements. Close contact with the aviation advisor throughout the project will ensure that costly mistakes do not occur.

Structural

Minimum requirements

6.144. The structure will be designed, as a minimum, to comply with:

- all relevant standards
- all relevant Regulations and legislation
- specific project briefs
- Building Code of Australia
- these Engineering guidelines.

Cost effectiveness

6.145. It is the policy of the department to actively encourage the design and construction of health facilities for the minimum cost and consistent with the minimum requirements set out in benchmark and guidelines reference documents. The following principles have been adopted to achieve this objective:

- various structural systems will be considered and the most cost-effective system adopted
- design contingencies will be approved by the department
- future proofing and planning flexibility that involve additional costs will be approved by the department
- minimum loading requirements may be adopted
- rationalised and repetitive structural systems are most likely to be more cost effective
- standardised structural details and connections are recommended to be adopted
- services integration will be considered
- it is recommended that prefabrication and modularisation be considered
- it is recommended that rigorous commercial approaches and practices be adopted.

6.146. Where possible, it is recommended that the design and construction of the structure offer maximum opportunity to local trades, materials and Australian products.

Competence and certification

6.147. The department has the authority to require an independent review of the structural design if deemed necessary.

6.148. Design calculations and assumptions may be requested by a commissioned independent consultant to verify the structural adequacy and will be made available as required. Copies of legible calculations are acceptable.

Structural design

Design life

6.149. The structure will be designed to provide a projected building life equivalent to either the anticipated useful life of the facility or 50 years, whichever is greater.

Importance level (IL)

6.150. The structure will be designed for an IL3 or IL4, as appropriately determined in line with BCA requirements and confirmed by the relevant building surveyor.

Design loads

6.151. The structure will be designed to be capable of sustaining the greater design load from:

- loading code AS 1170
- actual loads determined by the consultant – appropriate allowances will also be made for access ways, aisles or spaces where heavy equipment loads may be located or moved during construction, installation or commissioning
- the following tables.

Table 3: Live load

Are	Element	Minimum loading condition
Plant rooms, waste holding areas, bulk stores, film stores	Floor	7.5 kPa
Medical records	Floor	10.0 kPa
Stores, kitchens, scullery, catering, dirty utility, CSSD	Floor	5.0 kPa
Dairy, bulk food cool rooms, loading dock, roadways	Floor	15 kPa
Medical imaging, ultrasound unit	Underside of slab over/ceiling structure	One moving load of 10kN anywhere
Operating theatres	Underside of slab over/ceiling structure	Minimum of 8 number of 5kN loads located anywhere

Table 4: Superimposed dead load

Are	Element	Minimum loading condition
General	Floor	1.5 kPa
General	Roof	0.5 kPa

Deflection criteria

6.152. The structure will be designed to avoid excessive deflections that may affect the serviceability of the structure's intended functions.

6.153. Notwithstanding compliance with the following table and relevant standards (including AS 1170.0 Table C1), the consultant will ensure that deflections are visually acceptable and can accommodate equipment and services installed within required tolerances.

Table 5: Deflection table (deflection from horizontal, or from straight line between supports in case of sloping or vertical member)

Structural element	Maximum deflection (Δ/L_{ef})
Members supporting face brick walls	Deflection after wall construction: • For spans: 1/600 • For cantilevers: 1/300
Members supporting rendered brick walls	Deflection after wall construction: • For spans: 1/1000 For cantilevers: 1/500

Structural element	Maximum deflection (Δ/L_{ef})
Members not supporting brittle elements	Total deflection: • For spans: 1/250 or 40 mm absolute value, whichever is less. For the purpose of this requirement, span is the distance between any two immediately adjoining supports (columns or walls) where the deflection is single curvature. The deflection is measured from the line joining the two supports at the structural designed levels. For cantilevers: 1/150 or 30 mm absolute value, whichever is less.
Members supporting brittle finishes	Deflection after installation of finishes: Architect's requirements based on selected finishes • For spans: 1/500 or 20 mm, whichever is less For cantilevers: 1/250 or 20 mm, whichever is less
Stud walls under lateral loading	Total deflection: • For spans: 1/500 For cantilevers: 1/250
Roof members	Total deflection: Due to dead load and factored live loads (G + ψsQ) • For spans: 1/300 • For cantilevers: 1/150 Due to serviceability wind load (W_s) • For spans: 1/250 • For cantilevers: 1/125 Load combinations for serviceability limit states will be as set out in AS 1170.1
Roof members supporting brittle cladding	Total deflection: Due to dead load and factored live loads (G + ψsQ) • For spans: 1/400 • For cantilevers: 1/200 Due to serviceability wind load (W_s) For spans: 1/400 For cantilevers: 1/200 Load combinations for serviceability limit states will be as set out in AS 1170.1

Vibration

6.154. The structure, including lightweight elements (such as the façade) will be designed with due consideration to ensure satisfactory vibration performance.

6.155. The use of localised vibration isolation systems (such as proprietary mounts, vibration isolation benches and floating floor systems) should be considered in conjunction with the building stiffness, where appropriate, to achieve a cost-efficient structure.

6.156. Footfall excitation criteria: The minimum walking frequencies of an 80kg person to be considered for various environments will be:

- generally, unless noted otherwise: 1.5 Hz to 2.5 Hz
- operating theatres: 1.6 Hz to 2.0 Hz
- near-patient environment: 1.5 Hz to 1.8 Hz
- long corridors: 2.0 Hz to 2.5 Hz

6.157. For human perception due to footfall: the vibration acceleration limits will be obtained by multiplying the base vertical acceleration curve in AS 2670.2–1990 by the values in the following table:

Table 6: Multiplying factors for continuous vibrations

Area type	Multiplying factor for continuous vibrations
Operating theatres, precision laboratories, audiometric testing booth	1
Wards	2
General laboratories, treatment areas	4
Offices, consulting rooms	8

6.158. Apart from operating theatres, precision laboratories and other critical environments, the acceleration limits obtained may be reduced by using the vibration dose value (VDV) assessment approach. The maximum VDV values are per the following table:

Table 7: Maximum VDV values

Area type	Maximum VDV value (m/s1.75)
Wards, residential – day	0.2
General laboratories, offices	0.4
Workshops	0.8

6.159. For vibration sensitive equipment, refer to the method set out in *Design Guide 11 Vibration of steel framed structural systems due to human activity – Second Edition*. A similar method could be proposed for consideration.

6.160. The minimum vibration criteria are set out in the following table or per manufacturer's requirements, whichever are more stringent:

Table 8: Maximum RMS velocities

Area type	Maximum RMS velocity (µm/sec) (1 to 80 Hz)
Laboratory robots	100
Bench microscopes at up to 400x magnification, precision balances	50
Microsurgery, bench microscopes at greater than 400x magnification	25
MRI, electron microscopes up to 30,000 magnification	12

6.161. For plant equipment, the guidelines of the UK Department of Health's Technical memorandum 8-01 will apply unless agreed otherwise.

Future proofing and planning flexibility

6.162. Planning considerations will be given to the ability to change floor layouts without undue effect on other parts of the structure. Load bearing walls must be located such that they will not inhibit future planning.

6.163. Allow for future 200mm diameter penetrations around columns unless there are designed penetrations. Place reinforcements or tendons (or both) such that the penetrations can be installed without being clashed.

6.164. If the structure has allowance for future levels, ensure that any plant and services on the roofs do not interfere with the future extension. An appropriate construction loading will be allowed to the roof to minimise disruption to the facility's operation due to extension construction activities.

Radiation bunkers

6.165. Radiation bunkers must be designed to prevent radiation from escaping the bunkers. Appropriate detailing of the reinforcement, high density concrete, steel lining, pour joints and services reticulation will be clearly documented to achieve the intended function and optimum buildability.

Liquid nitrogen base or liquid oxygen base

6.166. Where possible, provide sacrificial and readily replaceable reinforced concrete apron to enable swift replacement in case of damage (such as during filling).

Winch points

6.167. The structural design will allow for reactions from winch points for installation of heavy equipment.

Specialist contractors

6.168. The documentation will specify that all specialist contractors (specialist piling contractor, post-tensioned contractor) will be approved by the department

Roofs

6.169. Complex roof designs, internal box guttering and high maintenance features will be avoided.

6.170. It is recommended **not** to use metal sheet steel roof over critical areas with pendants or radiation equipment, such as operating theatres, MRI's, linear accelerators.

Structural documentation

Structural drawings

6.171. Structural drawings will include, as a minimum, the following:

- general notes, including relevant standards used in the design
- design life
- design parameters for seismic and wind
- geotechnical foundation design criteria
- loading plans will be provided for each level and include:
  - superimposed dead load
  - live load

  - heavy suspended services and heavy equipment including their planned replacement routes, as applicable
- future proofing allowances, as applicable – the description of the future proofing must be clear and sufficient on the structural drawings, to the extent that future works can be relied upon.

Structural specifications

6.172. Structural specifications must be provided and forms part of the contract documents.

As-built structural drawings

6.173. A set of as-built structural drawings will be issued to the department.

Modifications and alterations to existing structures

6.174. The existing structure will be reviewed and a report provided to the department. This report will provide the assessed current structural conditions as well as compliance status with the requirements of these guidelines.

6.175. Projects involving alterations or additions to existing buildings will be designed, programmed and phased to minimise disruption to the on-going operation of the existing facilities.

Site and civil works

6.176. Paved roads will be provided within the boundaries of the site for access to all entrances, parking areas, service, delivery and maintenance points and emergency receiving points (if applicable).

6.177. Paved pathways will be provided for external pedestrian traffic within the site. Movement from bus stops to all accessible on-site locations will be included. Where applicable, it is recommended that council crossovers be considered when designing site roadways, as their impact on public roadways will affect the neighbourhood by impacting local traffic patterns and road design.

6.178. All side entry pits, lintels, kerbs, channels and grated drains will be constructed of reinforced concrete. It is recommended that road surfaces be bitumen paved with appropriate base, sub-base and sub-grades – all formed to provide adequate storm water drainage. It is recommended that aprons to the ambulance bay, the main entry and the loading docks be constructed of reinforced concrete on the appropriate base, sub-base and sub-grades.

6.179. Bulk oxygen vessel foundation slabs and truck loading aprons will be constructed of concrete. Bitumen products will not be used due to the risk of ignition if an oxygen leak occurs during filling.