Engineering Guidelines for Healthcare Facilities Volume 2 – Electrical and Lighting

Health Technical Guideline HTG-2020-002

Victorian Health and Human Services
BUILDING AUTHORITY

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Engineering guidelines for healthcare facilities: Volume 2 – Electrical and lighting

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Contents

Introduction

The purpose of electrical services in healthcare buildings is to provide safe, reliable and flexible power and lighting systems to support the buildings safe operation. It is the designers' responsibility to deliver best practice designs while focusing on cost effective solutions, encourage energy efficiency through innovation and provide a catalyst for future flexibility and improvement.

Significant aspects of the electrical services design are governed by statutory requirements contained principally in the codes and standards including:

- NCC
- AS/ANZ 3000 Electrical installations
- AS/ANZ 3003 Electrical installations – Patient areas
- AS/ANZ 3009 Standby power systems.

Other areas of electrical services systems will be influenced by the following criteria:

- recommendations of Australian standards
- specific project briefing process
- reliability, maintainability, business continuity, redundancy, disaster recovery and
- best engineering practice from similar projects.

These Engineering guidelines are a guide for the development of design and specification documentation for health care facilities.

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 to 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 applicable 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 AusHFG 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 AusHFG to determine their applicability and suitability to the project during planning. Deviations will be clearly articulated or documented, and signed off by the relevant authority.

Volume 2 – Electrical and lighting 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.

Electrical

Scope and objectives

Objectives

2.1 The following services are considered part of electrical systems:

- high voltage and substation services
- renewable energy sources
- incoming mains supply
- metering
- main switchboards
- power factor correction
- active harmonic mitigation
- emergency power generation system
- uninterruptible power supply systems (UPS)
- battery supply
- sub-mains
- sub-circuits
- distribution switchboards
- earthing systems
- electromagnetic interference (EMI)
- lighting and power sub circuit wiring
- cardiac and body protected areas
- socket outlets
- luminaires (internal, external, security), lighting control and functionally specialised lighting
- emergency and exit lighting system
- earthing and lightning protection systems.

2.2 Electrical services provide the systems and infrastructure to support all building and clinical systems requiring all forms of electrical power.

2.3 All projects must consider and document the impacts of the project on existing and future planning on the site, taking into account any master plans that exist for the site. The issues to be highlighted include:

- power utility's network capacity and reliability
- site location in context to existing substations or associated main switch-rooms (or both)
- site location in context to any existing standby generation and associated connectivity
- proposed and existing cabling routes to connect a new or refurbished facility to the substations or main switch-rooms and standby generation
- site wide infrastructure needs are to be balanced with the needs of the project and the needs of future projects, including land divestment opportunities.

Design criteria

2.4 The design criteria will be based on the relevant requirements of the Australian standards, project functional and operational requirements. Consideration needs to be given to location, external conditions and climate change implications.

2.5 Refer to the AusHFGs as a guide for the requirement of services provisions as the initial basis of design criteria. This design criteria will be used for guidance only and must be verified with the project team and user groups to ensure project specific functional requirements are met.

Infrastructure

2.6 Electrical infrastructure in the design of many projects can easily be over-sized due to estimates and conservative allowances for unknowns. Accurate maximum demand and profile calculations will be carried out. This will result in correctly sized systems and optimise the capital and recurrent costs of the project.

2.7 The following needs to be considered:

- capacity of the installation
- capital cost contributions from the supply authority
- the capital cost to the project in terms of built areas
- reliability and redundancy
- impact of ventilation and cooling for accommodation of key plant and equipment
- project program implications
- supply authority requirements and preferences
- future expansion requirements
- appropriate use of land use on site
- flood and water egress and
- maintainability

2.8 The opportunity to source a high voltage (HV) or a low voltage (LV) service by the hospital will be assessed, taking into to consideration:

- tariff arrangement
- cost of HV asset and ownership
- maintenance requirement and contracts
- maintenance and operational costs

2.9 A whole of life assessment on 25-year cycle will be required when the opportunity to become a HV consumer arises.

2.10 Some of the guiding principles include:

- HV selection will be considered when a minimum of 2 feeders are available to the site
- the site capacity is over 3 MVA
- the power supply nodes can be decentralised.
- A number of substations is a cost-effective solution in lieu of lo LV cabling

Electrical supply demand

2.11 Load profiles and maximum demand must be calculated from detailed assessment of the project-specific requirements after adequate investigation by the designers.

2.12 Designers will use best endeavours to design the electrical system to reflect as close as reasonably possible the actual loads that would be realised plus realistic allowance for future

expansion as required. Realistic diversity figures will be used when sizing, substations, switchboards, generators and the like.

2.13 The following is to be taken into account:

- gross area of the new or refurbished building
- power density assessment for the type of facility and benchmarked against similar facilities
- impact to supply demand of the installation if buildings are demolished, decommissioned plant, or for functional changes to the area
- consideration of specific medical and treatment equipment electrical parameters
- demand assessment and application of diversities of the actual connected circuits, systems, plant and equipment
- number, type and use of lifts their individual demand and operational sequence
- essential electrical demand for the facility to operate in an island mode during loss interruption or prolonged failure of Utility's network
- consideration of source of supply to critical equipment, areas or buildings during power failure scenarios
- reference will be made to actual mains, generator and UPS demands from similar existing hospitals as a comparator.

Planned spare capacity

2.14 Allowance for space and capacity for future expansion of the facility taking into consideration masterplan, operational needs and technology growth. Spare capacity will be balanced with the appropriate allocation of available budget and will be agreed to by the design team and client on a project by project basis. Scalable solutions to respond for the site utilisation and masterplan proposals will be adopted.

2.15 Planned spare electrical capacity will be based on predicted future building loads and future equipment loads or the following table:

Table 1: Planned spare electrical capacity

System	Plant strategy	Spare capacity	Spare space allowance
Substations	Transformer to match building load with minimum N+1 connectivity.	50%	minimum 1No transformer
Main switchboards	To match capacity of substation	50%	25%
UPS	To match design load with minimum N+1	25%	n/a
Standby generators	To match design load with minimum N+1	10%	provision for additional generator of same capacity
Low voltage supply (horizontal and risers)	Cabling installed capacity incorporating volt drop provision for light and power, lifts, mechanical and special equipment	25%	15%
Distribution boards	Allow for separate essential/non-essential and UPS	25%	15%
Cable reticulation	To meet AS 3008 requirements	25%	10%

System	Plant strategy	Spare capacity	Spare space allowance
Communication Backbone cabling (for all IP systems)	Primary and redundancy pathways to racks	25%	50%
Communication rooms	Primary and secondary	50%	50%
Communication risers	Primary and secondary	25%	15%
Cable access pathways		25%	50%
Cable support systems		25%	25%
Equipment racks, cubicles, and enclosures		25%	25%

Standby power – generator

Standby power

2.16 Standby electrical power will be provided and guided by the recommendations of AS 3009 and the subsequent paragraphs of this section.

2.17 Standby power will also be provided to all subsidiary mechanical, hydraulic, fire, lifts and medical gas systems (which are dependent on an electrical power source to operate) and are essential in delivering services to the critical care areas. Refer to Volume 1 -Essential Services.

2.18 Standby sub-mains to be provided with standby generator supply will be separate from the normal supply sub-mains.

System capacity

2.19 The capacity of the standby generating plant will be sized to match the diversified maximum demand adjusted to the standby coverage agreed for the project. The need and extent of standby power will be determined on a project by project basis.

2.20 In determining the coverage of standby power provision, the following principles apply:

- all life and safety requirements as required by the NCC
- all ICT communications room active equipment
- pneumatic tube, medical air and suction equipment
- renal Dialysis equipment
- minimum 50 per cent of lighting and power in all areas – this can vary depending on the number of light fittings and power outlets used in any particular room
- full lighting and power in critical areas (normally include peri-operative areas, ICU, CCU, neonatal intensive care, CSSD, emergency department, imaging, and pathology) - full air conditioning will also be provided to these areas. All other areas will have ventilation to meet the ventilation rates indicated in Reference Table 1 and AS1668, environmental temperature control will not necessarily be maintained while under generator power.
- all air handling and exhaust fans serving isolation rooms, central sterile services department (CSSD) and pathology
- imaging areas required for emergency departments only
- critical storage such as -80ºC fridges and blood fridge
- sewage pumping stations if these were used
- domestic water pumps if these were used.

2.21 In addition, assessment of the overall hospital health services operational profile needs to be undertaken for business continuity during prolonged unavailability of utility's main supply network.

2.22 Spare capacity will only be provided from the difference between the actual 'next size' rating of the generator and the calculated standby requirement.

- Generators will be rated for prime use
- Generators will be able to meet the power load on start up without stalling
- Large medical equipment loads need to be considered
- Motor loads will incorporate delay start up where necessary to diversify the start-up currents over time in lieu of a peak current condition to allow the set to reach satisfactory operating conditions without stalling.

Plant configuration

2.23 Generator plant will be sized for the load profile and as close as possible to the actual load. Selection and make-up of generators (farms) will be based on most efficient configuration to allow ease of operation and load control.

2.24 Ventilation, acoustics treatment, exhaust flues, seismic requirements, maintenance and replacement strategy to be considered.

2.25 Plant configuration will be assessed on capital and recurrent cost considerations as well as diversity of range of output. Projects requiring over 1MVA of standby capacity will be provided with a minimum of two generators.

2.26 Control and operation of the standby generator plant will be automatic upon loss of mains.

2.27 Connection of loads to the standby supply system will be designed to allow step or priority loading and to prevent stalling of the generator engines.

Load testing of generators

2.28 The power distribution system will be designed to permit testing of the generators on load without the need for imported load banks.

2.29 The preferred method of load testing generators will be to use the hospital's load as the test load and to connect and disconnect the load. The design of the electrical distribution will consider the types and connectivity of plant and equipment for sufficient test load.

2.30 Major mechanical plant such as chillers and pumps will be considered as part of the load analysis.

2.31 Synchronising the generator with the normal electricity supply (synchronised closed transfer) will be considered subject to approval by the utility.

Fuel storage

2.32 The amount of fuel storage is based upon the category of the hospital (refer to Volume 1 of these guidelines):

- category 1 – 48 hours
- category 2 – 24 hours.

Connection of temporary generator

2.33 All main switchboards will have a temporary generator connection point to allow full connectivity to support the hospital's entire essential demand.

Uninterruptable power supply (UPS)

2.34 Critical equipment and communication systems and those systems supporting critical services and major medical equipment will need to be operational in the event of power interruptions, disturbance or failure.

UPS resilience

2.35 A resilient system will be provided that can withstand sub-system component failures while continuing to operate. This can be achieved by installing additional redundant components and minimising single points of failure. A balanced approach to resilience is essential and must consider the total system, costs, benefits and on-going maintenance.

2.36 A redundancy of N+1 as a minimum for the facility will be provided. This can be achieved through configuring separate UPS units, each loaded at 50 per cent, but both capable of supplying 100 per cent in the event of a single UPS system failure.

2.37 Some of the guiding principles includes:

- UPS shall be online
- single phase UPS will not exceed 10kva in size
- redundancy of critical services will be in a N+1 arrangement
- UPS for medical treatment equipment must be dedicated.
- UPS capacity over 80 kVa must be configured as a N+1
- static UPS technology must be suitable for the load types and ratings
- rotary hybrid UPS will be considered for sizes over 250 kVa
- rotary diesel UPS systems will be considered as part of the site emergency supply system.

2.38 A modular UPS system may be considered if the loads are split between multiple smaller UPS units specified to include N+1 redundant modules in a single cabinet or multiple cabinets.

2.39 Modular UPS units will take into consideration the following:

- on-board intelligence and galvanic isolation of each UPS module such that a fault in one module does not cascade and take out other UPS modules
- hot swappable UPS modules
- N+1 UPS modules installed
- separate UPS power outlet and standby power outlet at each communications rack. Outlets fed from separate distribution boards. Active equipment provided with dual power supplies.
- standby GPOs installed adjacent to UPS GPOs such that critical medical equipment can be moved to standby power in the event of a catastrophic UPS failure
- UPS external wrap around bypass installed
- monitored UPS alarms.

2.40 UPS batteries to be specified in multiple parallel strings such that a single string failure or planned maintenance does not affect the specified UPS system battery autonomy.

2.41 For UPS installations greater than 500 kVA, diesel Rotary uninterruptible power supply systems (DRUPS) will be considered as an alternative to pure battery or kinetic UPS systems.

UPS supply consideration

2.42 The following table is a guide for the UPS supply parameters.

Table 2: UPS supply parameters

Item	Description of requirement
UPS	UPS systems will be sized and UPS power outlets provided in line with AS3009 and AusHFGs to suit facility UPS requirements in N+1 configuration,
Electrical output supply parameters	To match mains voltage and frequency.
System requirements	UPS systems will be provided as follows: • main data centre • medical equipment • floor distributor rooms. UPS systems to support all communication (equipment rack, voice intercom), BMS, security (head end and local devices), and other critical defined UPS loads • technical suite lighting requirements (dedicated UPS or battery backup unit as recommended by manufacturers) • UPS loads requiring higher endurance – separate units each of capacity and endurance as required by AS 3009, and as defined by other relevant standards

Power factor correction

2.43 Power factor correction (PFC) equipment to comply with authority requirements will be incorporated into the design to improve the power factor of the electrical installation to 0.99 to minimise the energy authority demand charge and improve energy efficiency.

2.44 PFC systems will be interfaced to disconnect under generator operation.

2.45 Consideration will be given for the use of a combined PFC and Harmonics mitigation solution.

2.46 Accommodation of the equipment will consider operation risk, cooling and ventilation requirements, segregation and containment.

Harmonics

2.47 The total maximum harmonic distortion of five per cent current (THDi) at point of common coupling for the facility.

Main switchboards and sub-mains

Main switchboards and main distribution boards

2.48 Main switchboard will have a minimum form of separation of at least Form 3b.

2.49 Main switchboards at all new heath care facilities will as a minimum aim to be designed to the following requirements:

- The main switchboard will be housed in a separate, accessible room, suitably ventilated and not subject to flooding.
- Divide the busbar system into separate ‘essential’, 'fire safety' and 'non-essential' circuits, each segregated from the other by fixed and continuous barriers. Clearly label each segregated section of the busbar system.

- 25 per cent spare capacity on all busbar sections, but no need to install spare breakers.
- Provided with complete grading and discrimination of all switchgear throughout the installation with the utility and standby generation system.
- Power factor correction and harmonic mitigation equipment installed.

Distribution boards

2.50 Boards will be minimum form of separation of form 2.

2.51 For light and power sub-mains at least one distribution board will be provided for each fire compartment to minimise the number of small penetrations through fire walls.

2.52 Distribution boards will be fitted with circuit breakers and residual current devices (RCDs) where required for all final sub-circuits.

2.53 Distribution boards will be rated to a minimum of IP5X.

2.54 Unless directed by site specific requirements switchboards will be colour coded:

- electrical main switchboards and distribution board – grey
- mechanical main switchboards and distribution boards – orange

Sub-mains

2.55 The types of sub-mains for distribution of electricity supply from the main switchboard or distribution boards are broadly categorised into the following groups:

- emergency or safety services (defined in AS3000)
- critical care services
- general services (remainder).

Emergency services

2.56 AS/NZS 3000 defines emergency services, some or all of which will be required in the hospital design. Sub-mains for the emergency services require special provisions to ensure integrity of supply in fire and other building emergency situations.

Critical care services

2.57 Standby lighting and power systems to AS/NZS 3009 will be provided in critical care areas.

2.58 AS/NZS 3009 requires that 100 per cent of all power outlets in the ‘surgical suite’ be connected to the emergency supply or a UPS supply which is fed from the emergency supply.

2.59 Light and general purpose power outlets in critical care areas will have dedicated sub-mains originating from the main switchboard, feeding dedicated distribution boards.

2.60 Two dedicated sub-mains circuits and distribution boards will be provided to serve critical care essential lighting and power distribution boards, with as even as possible distribution to both lighting and power from each distribution board.

2.61 On large capital projects, critical areas will be served from a resilient dedicated critical care switchboard rather than the main switchboard.

2.62 Critical care sub-mains cables are not required to be fire rated, however protection against mechanical damage will be provided.

General services

2.63 Sub-mains for non-critical services and equipment will be wired in line with AS3000 and will comprise the following:

- general light and power throughout the buildings
- mechanical services systems
- medical imaging system
- computer (IT servers) system
- hydraulic services system.

Sub-mains capacities

2.64 In addition to the assessed capacity for the present requirement, supply sub-mains will include spare capacities suitable to meet the needs of future expansion outlined for any specific project. Refer to 2.15.

2.65 Sub-mains for fire services and lifts will be sized to match the rated duties of the equipment.

2.66 Neutral conductors will be sized the same as the active conductors or the maximum current generated by harmonics: whichever is greater.

General cable insulation

2.67 Insulation materials for cables will be in line with the relevant codes and standards. The use of low smoke zero halogen (LSZH) is not mandated. Cables will be selected on code requirements and value for money.

Patient electrical protection

Patient electrical protection systems (body and cardiac patient areas)

2.68 Electrical installations will be designed to comply with AS/NZS 3003 ‘Electrical installations – patient areas’ and follow these guiding principles:

- Compliance with AS/NZS 3003 is a statutory requirement for hospitals and healthcare facilities.
- All patient areas in hospitals and healthcare facilities must be wired at least as body-protected electrical areas and protected with 10 mA RCDs.
- Patient safety is not increased by the installation of cardiac-protected electrical areas when performing body-protected procedures.
- Cardiac-type procedures are defined by AS/NZS 2500 and are limited to those that make direct contact with cardiac tissue.
- Patient areas will only be wired as cardiac-protected electrical areas in defined areas according to AS/NZS 3003 or where cardiac-type procedures will be regularly or routinely undertaken.
- Defined areas for cardiac-protected electrical wiring include:
  - cardiac catheter laboratories (CCL) and control rooms
  - cardiac intensive care unit (CICU)
  - coronary care unit (CCU)
  - ICU with regular thermo-dilution Swann-Ganz monitoring
  - neonatal ICU
  - operating theatres used for cardiac or thoracic surgery or interventional radiological procedures

  - accident and emergency resus cubicles and bay
  - cath labs
  - other specialist use areas as briefed.
- All other areas will be wired as body-protected electrical areas to meet AS3003 requirements.

Power outlets

2.69 General power outlets (switched socket outlets) will be colour coded in line with AS 3003 to suit the functional requirements of each of the spaces within the facility. General power outlets must satisfy the following minimum requirements:

- fit out of power outlets for general power circuits not to exceed 60 per cent of the circuit ultimate capacity
- RCD protection to be provided at the local distribution board for all general lighting and power circuits (except for reasons of discrimination where RCD-MCB combination breakers are provided at the outlet as required by AS 3003)
- fault loop impedance not to exceed the limits identified in AS 3000
- accessories to be constructed of polycarbonate resistant to medical cleaning materials, from a suite of commercially available accessories, consistently applied throughout the facility
- all specific power outlets to be provided with isolators
- weatherproof, flameproof or similar requirements due to location in plant rooms, disaster recovery areas, fuel storage, wet areas and the like, comply with the specific requirements of AS 3000
- as a starting point in the design, the scales of provision of socket outlets will be in line with the room data sheets (RDS) in the AusHFGs.

Residual current devices (RCD) and line isolation monitors (LIMS)

2.70 RCDs must meet AS3000 and AS3003 requirements.

2.71 When selecting the LIMs circuit, consider the type, criticality, functional needs and facility standards as set by the Biomedical Department.

2.72 LIMs are to be installed in operating theatres, pendant outlets and dedicated anaesthetic machine outlets, cardiac care, ICU and resuscitation bays.

2.73 LIMs will be placed in dedicated isolated power panels. Supplemental cooling may be required if LIM installations are in confined locations.

labelling and safety shutters

2.74 All RCD protected outlets provided under AS/NZS 3003 will be identified and labelled in line with the Standard. All other outlets and switches will be labelled in line with AS/NZS 3000 and colour coded to AS/NZS 3003.

2.75 Outlets in mental health facilities, nurseries and children’s inpatient units will be fitted with safety shutters.

Electromagnetic radiation

2.76 Diagnostic equipment relies on measuring extremely small bio-signals against a background of large size electromagnetic interference. Electromagnetic interference can arise from low frequency sources such as major cable routes or large transformers, or high frequency sources such as radio, television or paging transmitters.

2.77 Where sensitive electronic equipment is to be installed, an RFI study or site survey (or both) will be undertaken. The study or site survey will indicate a hostile RF environment and whether electromagnetic shielding by way of a Faraday cage is required.

2.78 Location of all LV reticulation will be considered when passing through clinical areas to assess likelihood and mitigate the possibilities of RF interference with sensitive healthcare equipment.

Lightning protection

2.79 Lightning protection will be required for the building. The lightning protection system will be a conventional system compliant with AS/NZS 1768. The air termination network will consist of finials (rods) interconnected with taps or cables. The column reinforcement and footings will generally be used as down conductors and earth electrodes.

Photo voltaic systems

2.80 The opportunity to harness photovoltaic energy using PV cells technology in the project to offset carbon emissions and meet sustainability mandates will be implemented where feasible.

2.81 An assessment for the opportunity will be undertaken in the early planning phases of the project. Refer to VHHSBA's *Guidelines for sustainability in capital works* for further details.

Energy metering

2.82 Subsidiary electrical metering of various areas of the installation can assist in auditing energy use and in troubleshooting system abnormalities.

2.83 Digital multi-function meters will be incorporated at various strategic locations of the electrical network. As a minimum, multi-function meters will be provided to monitor all sub-mains servicing distribution boards, mechanical services switchboards and all other major control cabinets.

2.84 Energy metering will be in line with the latest NCC requirements as a minimum. This is to be interfaced to the mechanical services building management system (BMS).

Vital signs monitoring of boards

2.85 In addition to energy metering, all main switchboards, major distribution boards and critical distribution boards shall be provided with real time monitoring for the following as a minimum:

- operational status
- temperature
- high temperature alarm
- operating capacity percentage
- maintenance status
- age of the switchboard
- fault capacity
- events log
- harmonics.

2.86 The monitoring system will be interfaced with the maintenance department's ICT network for remote access by the maintenance team via the BMS.

Other systems

Building automation

2.87 Switchboards supplying emergency, critical and UPS loads will be provided with switchgear that is monitored at the BMS. The BMS will be able to monitor circuit breaker status, including ‘opened’, ‘closed’, and ‘trip’, and provide alarms. UPS alarms will also be connected to the BMS and security panels.

Mental health areas

2.88 The following measures will be incorporated in mental health areas:

- tamper-proof luminaires including emergency and exit luminaires
- tamper-proof socket outlets and light switches
- extended UPS autonomy for security systems.

Medical services panels (MSPs)

2.89 The different MSP configurations will be documented on room data sheets.

2.90 Attention will be paid to ensure that the provision of MSPs is included in either the electrical or mechanical services, and not lost between the two trades. Careful coordination across disciplines is required to ensure a successful outcome.

2.91 Designers will advise the users on the standardisation of panels as far as possible. This will reduce capital costs and minimise the risk of errors during manufacture and construction.

Lighting

Scope and objectives

Objectives

2.92 The following elements are considered part of lighting systems:

- external lighting
- internal lighting
- feature and architectural lighting
- medical examination, procedure and OT (operating theatre) lighting
- exit and emergency lighting
- security lighting
- associated control systems
- lighting quality
- operational and functional lighting in various spaces to fulfil visual task requirements without glare or discomfort.
- in addition to the functional requirements, one of the key goals of the lighting design is the creation of a healthy and comfortable environment.

Design criteria

2.93 The lighting design needs to take into consideration a number of issues, including functional and medical requirements, the comfort of patients, staff and visitors, the architectural space and design intent, security requirements, access and wayfinding and other considerations such as maintenance, access and coordination.

2.94 The following specific design criteria are to be used as guidance but will need to be verified with the project team and user groups to ensure specific project needs and requirements are met.

2.95 LED luminaires will be installed using smart lighting controls allowing for daylight harvesting, motion detection, dimming and zoning.

Power density- minimum energy performance requirements

2.96 The selection of lighting sources, luminaires and their control gear will comply with the regulatory limits prescribed in J6 – energy efficiency, artificial lighting. Design illumination power density must be calculated in line with Section J 6.2 of the NCC and AS1680 part 2.

General requirements

2.97 Lighting systems are generally required to deliver:

- user comfort
- healthy environments
- task visibility and good visual performance
- orientation and wayfinding
- safety
- energy conservation and efficiency
- comfort control

- reliability
- flexibility and adaptability
- maintainability
- ease of commissioning
- whole of life efficacy

The following issues need to be considered and form part of the design:

Light distribution

2.98 Light distribution of a luminaire determines how the light output is used and distributed into the space or onto an object and plays a key role on the visual results. It is also a determinant in how efficiently the space is illuminated, how the items are enhanced or subdued, as well as in how well glare is reduced or eliminated.

Direction of light and modelling

2.99 Light will be used to define qualities of surfaces (colour, form and texture) and to draw people to particular areas or down certain routes, facilitating orientation and wayfinding.

Visual comfort and sense of wellbeing

2.100 A qualitative lighting approach needs to be aimed at, rather than a quantitative approach which considers illuminance levels on the horizontal surface only. The creation of a healthy environment without visual discomfort will be aimed for.

Architectural lighting and integration

2.101 The lighting approach will also consider the enhancement and reinforcement of the architect's vision and identity of the building and be fully integrated into the architectural design.

Coherence

2.102 Lighting needs to be addressed with a coherent approach that takes the following issues into consideration:

- existing lighting, lighting control systems and emergency lighting control systems in existing buildings or within other parts of the campus
- consistency of architectural lighting concepts within the building
- external and internal lighting and relevant interfaces
- standardisation of lamp types across the project and the campus and
- maintenance access.

2.103 The design will allow for flexibility and future adaptability of the lighting concepts and approaches, considering and allowing for the technology to advance.

External lighting

2.104 External lighting will be provided around the hospital campus to provide a safe and welcoming environment for patients, visitors and staff, with consideration given to:

- safe movement of pedestrians, cyclists and vehicles
- integration with the architectural design intent and overall aesthetics of the buildings and campus
- avoidance of dark areas

- minimisation of obtrusive light spill and glare to surrounding properties
- safe operation of helicopters
- security lighting
- ongoing operational and maintenance costs
- energy efficient lighting.

2.105 LED luminaires will be provided to external areas of the buildings including pedestrian pathways, access roadway and building external surrounds. External luminaires shall be controlled via photoelectric cells (PE cells) and time clock to automatically switch on and off at pre-determine times.

Specific requirements for clinical lighting

Illuminance guidelines for visual tasks

2.106 The Australian Standards, in particular AS/NZS 1680.2.5, will be referred to for general guidelines on illuminance levels.

2.107 The appearance of colour, both in terms of chromaticity (correlated colour temperature) and colour rendition (colour rendering index) are important for the overall comfort and visual performance within the space.

Correlated colour temperature

2.108 Correlated colour temperature of a light source is a measure of the hue of the light output of that source. It is denoted in kelvin degrees (K) and refers to the temperature of a theoretical black body radiator emitting the hue equivalent to that of the light source in question.

2.109 For medical areas, a neutral white colour of about 4000K is recommended; cyanosis lamps and high colour rendering lamps are typically supplied in a 4000K version.

Colour rendering

2.110 The colour rendering index (CRI) describes the effect of a light source on the colour appearance of objects by comparison with their colour appearance under a reference source. Daylight and similarly incandescent light sources have a continuous spectrum and attain a CRI value of 100.

2.111 Australian Standard AS/NZS 1680.2.5 deals with ‘light service colour’ – visual task requiring discrimination of colours. The standard gives three examples:

- examination of patient’s skin condition to detect conditions such as cyanosis and jaundice
- general examination for dermatological conditions
- colour based diagnostic tests.

2.112 For cyanosis observation, based on current lamp technology, requirements of the most current international standards, it is considered that the following will be considered appropriate:

- Install energy efficient high-quality LED type lights of the appropriate colour temperature in all general areas of the hospital to provide a high level of illumination, it ought to be noted that LED is preferred as the cost of LED and T5 lamps are becoming similar
- provide a limited number of mobile LED type Ra 90 lamps for areas that do not have adequate natural lighting or examination or procedure lights
- use oxygen saturation monitoring via fixed or mobile pulse oximeters in all areas for continuous monitoring or for regular observations as required by clinical need.

2.113 For the other areas and usual tasks, the standard recommends a colour measuring index of at least 85 with continuous spectral energy distribution. All patient remedial or diagnostic treatment and accommodation will be illuminated with light source having a high colour rendering index.

Glare limitation

2.114 Glare can occur when the luminance or luminance ratios are too high; both of which occasions can cause a feeling of discomfort and reduced visual performance.

2.115 The following factors which can contribute to glare will be considered as part of the lighting scheme to avoid and minimise glare:

- luminance of the source and size of luminous opening
- position of lighting within the field of view (angle of light)
- background luminance in comparison to light source.

Glare assessment

2.116 For electric lighting systems, the Unified Glare Rating system (UGR), developed by the Commission International de l'Eclairage (CIE), will be used to predict the level of discomfort produced by the applied light sources.

2.117 In day-lit environments, the most cited model for predicting discomfort or reduction in visibility is the daylight glare index (DGI). Day lighting and lighting will be designed to achieve DGI values of less than 22 as glare starts to become uncomfortable above 24.

2.118 High luminance contrasts between the glazing and surrounding surfaces can also cause glare. The luminance contrast ratios will generally not be higher than 20:1.

Glare minimisation

2.119 To minimise glare, designers will consider:

- Assessing luminaires and their positions for glare ratings and cut-off angles
- lighting the room surfaces (vertical surfaces and ceilings) can reduce contrast and possible glare
- investigating window treatments and daylight controls to limit daylight glare
- In-patient units and corridor applications – care has to be taken in designing and placing lighting to minimise glare and disturbance to patients lying on their backs (looking up at the ceiling).

2.120 The following areas may require specific task lighting, in addition to general or architectural lighting. These requirements need to be assessed for each individual project and in collaboration with user groups.

- The beds in the inpatient areas might require a task light which will enable comfortable and glare free reading tasks. The light will be separately controllable with controls easy to reach and operate by the patient.
- Medical procedure lighting in areas where clinical procedures are taking place (such as operating theatres).
- Clinical observation light and examination lighting in areas where clinical observation is required.
- In patient care areas, the lighting used at night-time must allow nursing staff to move around safely and monitor the patients while minimising any light spill and ensuring that the lighting is not interfering with patients' sleep.

- This might require special night-time lighting in some areas that could be achieved with luminaires mounted at low level, directed at the floor in low intensity. To avoid interrupting patients' sleep, warm white lighting or long wavelength lighting (such as amber) are considered most appropriate.
- For staffing stations, operation at night-time might require task lighting within counters or reception desks. Any lighting of this nature will need to provide sufficient task lighting for nursing staff while not causing unwanted spill-light into other areas.
- Consider overhead cupboards and shelves in office or staff areas as part of the lighting scheme. Shadows could be eliminated by means of task lighting to the affected areas.

Space and surface characteristics

2.121 Ensure that the lighting designer understands the room surface characteristics and finishes to enable assessment of brightness and lighting distribution within the space and to ensure compliance with illuminance and colour rendering requirements is maintained.

Light sources

2.122 Generally, lighting will consist of fluorescent or LED fittings (or both). Metal Halide luminaires can be considered where appropriate in areas with high ceilings, directed light and where no dimming or regular switching is required (such as foyer areas). Incandescent or halogen lamps will not be used, unless specifically required for clinical purposes.

2.123 Generally, lamps will have a colour rendering index of 85 or higher.

Luminaires

2.124 The following selection criteria will inform the luminaire selection:

- **performance** (photo-metrics, light output ratio or luminaire efficiency, operating temperatures and heat management, size uniformity of luminous surfaces and openings, glare ratings)
- **quality** (workmanship, quality of manufacture and components, ingress protection ratings, class of material)
- **compliance** with the relevant standards (evidence or certificate to be provided)
- **architectural quality and aesthetics** (including shape, dimensions and finish)
- **track record** of lighting or luminaire company
- **local availability** and representation of supplying company (for future maintenance)
- **environmental impact** of production, transportation and operation.

Maintenance of equipment

2.125 Well maintained lighting equipment is a prerequisite for an effective lighting system.

2.126 Maintenance will be simplified by standardising lamp types and minimising variations throughout a project. Where possible, within the same area or type of area, only one lamp type will be used.

2.127 A luminaire maintenance and bulk lamp replacement schedule will be used for maintenance. This schedule will incorporate information on recommended lamp burning hours prior to lamp replacement.

2.128 Periodic lamp replacements will be targeted at not more than 80 per cent of the total lamp life stated by the lamp manufacturer.

2.129 Education of staff plays an important part in a well-maintained lighting installation not only to fully understand the technical aspects of the lighting system operation, but to be informed of the lighting design principles and objectives.

Location of equipment

2.130 All lighting equipment needs to be in positions that are safely accessible for maintenance. Positioning of lighting and related access will be coordinated with other services:

- to achieve an integrated services approach
- to minimise and share access panels and locations
- to achieve the required offsets and distances.

2.131 Lighting in plant areas and areas with services equipment will be coordinated and positioned to adequately light the equipment and to be accessible for maintenance. Operating theatres incorporating medical imaging technology will need special consideration

2.132 For the placement of luminaires as the support structure for the medical imaging equipment can take up much of the available ceiling area. Designers will need to co-ordinate with medical imaging equipment suppliers as well as the placement of items such as HEPA filters, pendants and access panels.

Daylight

2.133 The use of natural light is encouraged, in particular in-patient care areas, as the perceptual contact with natural light is a key factor of comfort in terms of physiology and psychology.

2.134 Daylight will be also considered regarding its contribution to the illumination of the space which might provide the possibility to reduce the use of electrical power.

2.135 Direct visual contact with daylight may cause disabling and discomfort glare. The amount of daylight, especially direct sunlight entering to staff stations and examination areas will be kept under control by employing appropriate controlling mechanisms to avoid glare and discomfort. The details and level of control may vary depending on the space and its use. Where daylight control is critical, lighting visualisation software packages may need to be used for predicting the distribution of visible radiation in day lit spaces, for assessing effectiveness and suitability of daylight control mechanisms. In addition to appropriate daylight control mechanisms, the internal lighting will be designed to balance daylight and reduce high contrasts.

Internal lighting levels

2.136 Lighting shall generally be selected with a mean time before failure (MTBF) of at least 50,000 hours and five-year warranty. As the reliability of LED luminaires is improving, investigation of using luminaries with 100,000-hour MTBF and a 10-year warranty in some areas shall be investigated.

Localised task lighting to receptions desks, nurse's stations and other similar areas shall be used where possible.

All luminaires shall have a minimum efficacy of 100 lm/W.

Glare from the lighting system shall be in conformance with AS/NZS 1680.2.5 and shall be designed to avoid patient and staff discomfort.

The general lighting type and control methodologies for the building are outlined in Table 3.

Table 3: Internal area luminaire selections

Area	Luminaire type or lighting description	Lighting control	Maintained lighting level (lux)
Plant rooms	Suspended or surface mounted IP65 LED battens with polycarbonate diffusers	Manual control	• 80
Main lobby, café area	Decorative lighting with provision for feature lighting to artwork and other features	Centrally controlled with daylight dimming	• 160
Back of house areas and store rooms	Recessed, suspended or surface-mounted LED luminaires with diffusers	Motion sensor controlled	• 160
Non-patient offices **Co-shared work zone**	Recessed or surface mounted direct/indirect LED luminaires	Manual switch integrated with motion sensors. Manual dimming controls. Daylight dimming to be provided to large rooms with significant daylight penetration	• 320
Patient bedrooms	Overhead LED luminaires to provide ambient, reading and exam lighting LED Night light.	Controls at room entrance and patient bedhead. Possible integration into patient entertainment system. Nightlight to be controlled by integral photoelectric sensor.	• 160 – general • 240 –reading • 320 –examination • 1 – night light
Patient bathrooms	Recessed IP44 rated LED luminaires. Luminaires to provide illumination in the vertical plane at the basin/mirror.	Manual switch integrated with motion sensor	• 160
Fire stairs	Surface mounted LED with diffuser	Reed switch on timer on stair entrance door	• 80
Nurses stations	General overhead LED lighting with task lighting to charting stations	Manual control with dimming to allow multiple scene selection	• 320
Patient imaging	General overhead LED lighting	Dimming controls from 0% to 100% in control room.	• 400
Operating theatres	General overhead LED lighting with minimum CRI 90 Pendant lighting to user requirements	Dimming controls to allow multiple scene selection	• 800 – general

Corridors and patient transit	Recessed or surface mounted LED luminaires	Dimmable lighting via timeclock with override at nurse's station	• 160 – general • 240 – ED to OT
External areas and PECC, ICU, and other shared staff courtyards	Minimum IP65 rated LED luminaires	PE cell and timeclock controlled	• 20
Mental health patient bedrooms	Anti-ligature luminaires and controls Overhead LED luminaires to provide ambient, reading and exam lighting Night Light	Controls at room entrance and patient bedhead. Possible integration into patient entertainment system. Nightlight to be controlled by integral photoelectric sensor. Controls override at nurse's station	• 160 – general • 240 – reading • 320 – examination • 1 – night light
Food services	Sealed LED luminaires	Manual control in food service areas	• 240
Treatment, consult and examination rooms	Recessed LED luminaires with minimum CRI 90	Manual switch with dimming controls	• 400 • 320 – Other
Carpark (indoor)	Recessed or surface mounted LED luminaires	PE cell and timeclock controlled integrated with motion sensor	• 800 – Entrance (during daytime first 15m) • 160 – Entrance (during daytime next 4m) • 160 – Entrance (during night-time) • 40 – Aisles, ramps, circulating roads, normal parking spaces

External lighting levels

2.137 Lighting to external areas shall be designed as per the criteria and levels detailed in Table 4**Error! Reference source not found.**.

Table 4: External area lighting criteria

Area	Lighting criteria	Maintained lighting level (lux)
Areas adjacent to building entries and exits	• AS4485.1 requirements	• 50 average horizontal • 30 minimum horizontal
Passenger set down and drop off areas	• AS4485.1 requirements and • AS1158.3.1 category P2 for high pedestrian activity	• 20 average horizontal • 10 average horizontal • 0.7 point vertical
Public and staff carparks	• AS4485.1 requirements and • AS1158.3.1 category P11b and P12 for medium night time activity	• 20 average horizontal • 10 average horizontal • 1.5 point vertical
Pathways and access ways to carpark areas	• AS4485.1 requirements and • AS1158.3.1 category P2 for high pedestrian activity	• 20 average horizontal • 10 average horizontal • 0.7 point vertical
Back access roads	• AS1158.3.1 category P3 for medium activity, low risk of crime	• 1.75 average horizontal • 0.3 point vertical
Service yards, ambulance bays and other service drop-off areas	• AS4485.1 requirements and • AS1158.3.1 category P11a for high night time vehicle or pedestrian movements	• 20 average horizontal • 14 average horizontal • 3 point vertical
Courtyards and other general groups used for night-time activity	• AS4485.1 requirements	• 20 average horizontal • 10 minimum horizontal
General grounds adjacent to areas used at night	• AS4485.1 requirements	• 5 average horizontal • 3 minimum horizontal
Helipad – flood lights	To satisfy the guidelines of International Civil Aviation Organisation (ICAO) and the Civil Aviation Safety Authority (CASA) requirements	• 32 on the HLS
Helipad – windsock	To satisfy the guidelines of International Civil Aviation Organisation (ICAO) and the Civil Aviation Safety Authority (CASA) requirements	To satisfy the guidelines of International Civil Aviation Organisation (ICAO) and the Civil Aviation Safety Authority (CASA) requirements

Security, exit and emergency lighting

Security lighting

2.138 Security lighting is to be considered for both internal and external areas of the building. The lighting designer is to meet with health security personnel to discuss the security lighting requirements for the building and external areas. Items to consider associated with security lighting are:

- to deter unauthorised entry
- to assist security staff conducting patrols
- provide an increased level of safety to car parks
- to illuminate areas with CCTV coverage to sufficient levels for the effective operation of CCTV cameras
- be considered with crime prevention through environmental design document;
- protecting people and property requirements.

Emergency and exit lighting

2.139 Emergency lighting to health care buildings will be provided in line with the requirements of the National Construction Code and AS2293.1. The emergency and exit lighting system will be designed to considering the following:

- existing health campus emergency system (if in existence)
- integration with architecture and overall lighting design philosophy
- single point or central battery system
- energy efficiency and
- maintenance (monitored or non-monitored system).

2.140 Based on industry trends, the use of single point monitored systems is to be considered.

Lighting control

2.141 The lighting control strategies and systems will be developed in conjunction with the users to suit their operational procedures and requirements.

2.142 The use of daylight harvesting sensors for area adjacent to glazing and daylight access will be considered and is encouraged. This requires a collaborative design approach with the architect and design team.