Minimum Design Standard – Mechanical services

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1 Overview

1.1 General

The purpose of this Minimum Design Standard (MDS) is to set out Northern Territory Government (NTG) minimum requirements for the design of Mechanical Services for non-residential building projects[1].

The Heating, Ventilation and Air Conditioning (HVAC) system must provide proper air flow, heating, and cooling to each area in an efficient and economical manner. When dealing with humidity control and ventilation, occupant health must always take precedence over energy issues.

Any design aspects not specifically addressed by this Minimum Design Standard must be identified by the designer and brought to the attention of the Department's (Department of Logistics and Infrastructure (DLI)) Senior Project Manager Mechanical Engineer for resolution during the design process.

In all instances the Mechanical Services must be designed in consultation with the designated DLI representative.

It is expected that the design and installation of mechanical services and equipment in buildings generally comply with all current statutory requirements and current applicable Australian Standards. These are not specifically referenced in this document.

For the purpose of this Minimum Design Standard, whenever reference is made to NTG or DLI it means the nominated Superintendent or Superintendent's Representative for the project.

All statements made in this document shall be understood to be a minimum requirement, unless specifically noted as otherwise. Guidelines for best-practice are provided over and above the minimum requirements for some design elements and these are clearly described as such, as well as specifying what is required from the design development process with respect to addressing those guidelines (for example a cost-benefit analysis may be required to assess the best-practice guideline, or a qualitative discussion provided in the design development report etc).

1.2 Australian Standards

Table – Referenced Australian Standards – Minimum Design Standard – Mechanical Services	
References to Standards include Australian Standards, and Australian and New Zealand Standards, and other Standards cited in this Specification. Use Standards, and their amendments, current as at the date for the close of tenders except where different editions and/or amendments are required by statutory authorities, including, but not limited to, NATA and the National Construction Code.	
Designation	**Title**
AS 1055	Acoustics – Description and measurement of environmental noise
AS/NZS 1170 (set)	Structural design actions
AS 1170.4	- Earthquake actions in Australia
AS 1324 (series)	Air filters for use in general ventilation and airconditioning
AS 1324.1	- Application, performance and construction

[1] The functional requirements of residential buildings significantly differ to those of non-residential buildings.

Table – Referenced Australian Standards – Minimum Design Standard – Mechanical Services	
References to Standards include Australian Standards, and Australian and New Zealand Standards, and other Standards cited in this Specification. Use Standards, and their amendments, current as at the date for the close of tenders except where different editions and/or amendments are required by statutory authorities, including, but not limited to, NATA and the National Construction Code.	
Designation	**Title**
AS 1366 (series)	Rigid cellular plastics sheets for thermal insulation
AS 1366.3	- Rigid cellular polystyrene – Moulded (RC/PS – M)
AS 1657	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS 1668 (series)	The use of ventilation and air-conditioning in buildings
AS 1668.1	- Fire and smoke control in buildings
AS 1668.2	- Mechanical ventilation in buildings
AS 1768	Lightning protection
AS 2107	Acoustics – Recommended design sound levels and reverberation times for building interiors
AS 2243 (series)	Safety in laboratories
AS 2243.1	- Planning and operational aspects
AS/NZS 2243.8	- Fume cupboards
AS/NZS 3000	Electrical installations – (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3500 (series)	Plumbing and drainage
AS/NZS 3666 (series)	Air-handling and water systems of buildings – Microbial control
AS/NZS 3666.1	- Design, installation and commissioning
AS/NZS 4020	Testing of products for use in contact with drinking water
AS 4254 (series)	Ductwork for air-handling systems in buildings
AS 4254.1	- Flexible duct
AS 4254.2	- Rigid duct

1.3 Definitions and Acronyms

Table – Definitions and Acronyms - Minimum Design Standard – Mechanical Services	
Term	**Meaning**
A	Ampere – a measure of electric current
ACH	Air changes per hour
AHU	Air handling unit
BACnet	Building automation and control network
BCA	Building Code of Australia, part of the NCC
BMS	Building Management System

Table – Definitions and Acronyms - Minimum Design Standard – Mechanical Services	
Term	**Meaning**
CAC	Ceiling attenuation class
CMS	Chiller management system
CO_2	Carbon dioxide
COP	Coefficient of performance
DB	Dry bulb (temperature)
dBA, dB(A)	Decibels, averaged – a measure of sound
Department, the	The Department of Logistics and Infrastructure, DLI
DIA	Diameter
DLI	The Department of Logistics and Infrastructure
Dw	Sound transmission attenuation measure
DX	Direct expansion
FOBOTS	Fibre optic breakout terminal
HDPE	High density polyethylene
HVAC	Heating ventilation and air conditioning
ICT	Information communication technology
kW, kw	Kilo Watts – a measure of electrical power
LAN	Local area network
L/s, L/S	Litres per second
m^2	Square metres - a measure of area
MD	Multiple dwelling
m/s	Metres per second
MSSB	Mechanical service switchboard
MR	Medium density residential
NATA	National Association of Testing Authorities
NCC	National Construction Code – includes the BCA and the PCA
PCA	Plumbing Code of Australia
PLC	Programmable logic controller
PVC	Polyvinylchloride – a plastic material
RH	Relative humidity
rpm	Revolutions per minute
R-value	Thermal resistance rating
SD	Single dwelling
Shall	Is indicative of a mandatory requirement unless the context clearly indicates otherwise.
STAD	Balancing valve

Table – Definitions and Acronyms - Minimum Design Standard – Mechanical Services	
Term	**Meaning**
STAT	Balancing valve (thermostatic)
TDC	Transverse duct connector
TDF	Transverse duct flange
UPS	Un-interruptible power supply
VAV	Variable air volume
VSD	Variable speed drive
W	Watt – a measure of electrical power
WB	Wet bulb (temperature)
Will	Is indicative of a mandatory requirement unless the context clearly indicates otherwise.

2 Design Policy

2.1 Relevant Sections of this Brief

Read this section in conjunction with all other sections of this Minimum Design Standard and the relevant mechanical sections in the Master Specification for Major Building Works.

2.2 General

In all instances the mechanical services must be designed in consultation with the designated DLI representative. The mechanical services design consultant that is undertaking mechanical designs for the NTG must produce their own drawings and specifications to meet the requirements of this MDS. It is unacceptable to use any third party to undertake the design unless clearly stipulated in the tender submission.

The documentation must be prescriptive of all works to be undertaken, and able to be accurately quoted on by contractors, with no ambiguity, no assumptions and/or any design requirement by the contractor. All design requirements and considerations described in this MDS must be addressed to ensure that the installation will provide a fully functional outcome of the final product as specified in the RFT/RFQ.

Design the mechanical services systems in full consultation with DLI to ensure adherence and compliance with policy guidelines on system components and for their ongoing operation and maintenance. This must be achieved by means of a written return brief by the mechanical services designer, which is to be submitted to DLI for verification and acceptance.

On completion of design works, along with all required documentation for tender, submit all supporting heat load calculation reports, program data files, and Safety in Design (SID) reports.

2.3 Design Compliance

The design and installation of mechanical systems must comply with the following:

- Department of Logistics and Infrastructure (DLI) – All sections of the Master Specification for Major Building Works. Copies of these sections must be requested through the DLI Project Manager.
- Department of Logistics and Infrastructure (DLI) - Typical vapour barrier details and specification - available via
  Building design standards | Department of Logistics and Infrastructure
- NTG Data and Voice Cabling Standard – Latest Version - available via
  https://dcdd.nt.gov.au/office-of-digital-government/ict-policies-standards-procedures
- Current applicable Australian Standards.
- National Construction Code (NCC).
- Local Council requirements.
- Northern Territory Government and/or Federal Government requirements.
- Power and Water Corporation requirements.
- NT Work Safe Health and Safety (National Uniform Legislation) Act 2011 and its Regulations
- Environment Protection Authority requirements, and
- Any other relevant Acts or Regulations.

2.4 Mechanical Minimum Capacities and Guarantees

This section of the specification sets out the requirements, minimum capacities and guarantees for the performance of the plant and systems and refers to design criteria affecting such guarantees.

The design of mechanical services for all Northern Territory Government projects must be of a standard sufficient to ensure that high quality indoor environmental comfort and health conditions are provided and maintained in an energy efficient manner.

When designing for humidity control and ventilation, occupant health must always take precedence over any energy initiatives. Hence any dispensation sought to not prioritise occupant health over energy initiatives must be sought from the DLI Senior Project Manager Mechanical Engineer for resolution during the design process.

The mechanical services design consultant must provide mechanical services to the facilities that are:

- Reliable,
- Easy to maintain, repair and with local service support,
- Of optimum capacity and adjustable to suit various load conditions,
- Energy efficient and incorporate sustainable design initiatives,
- Flexible for variable uses and occupancy levels,
- Optimised for minimum life cycle cost over a 25 year life cycle, and
- Which will provide high quality indoor environmental comfort and health conditions.

2.5 Consultant Responsibilities, Requisite Skills and Experience

The primary personnel responsible for mechanical design (hereafter referred to as the 'lead mechanical designer') must have at least 10 years post graduate experience working in the Australian HVAC industry and provide rigorous quality control process of the design documentation throughout the project before submitting to the Superintendent for review. All members of the mechanical design team must have a minimum 5 years post graduate HVAC design experience. If graduates and staff with less than 5 years of design experience are directly assigned to NTG projects, they must be closely supervised by the lead mechanical design engineer who is directly responsible for their work. The quality of all work submitted to the Superintendent is the responsibility of the consultant.

For any tendering clarifications or redesign/construction advice due to ambiguity of the design or lack of co-ordination with other trades or does not achieve a fully functional outcome, the consultant is responsible to rectify and undertake all required works and advice at no additional cost to DLI.

The performance of the consultant will be reflected in the Consultant Performance Scorecard and may be used as a basis of assessment for future NTG tender submissions by the consultant.

For projects with specialist requirements such as:

- Specialist fire suppression systems (gas-based)
- Hospital services design (including medical gas systems)
- Acoustics (mechanical plant-borne noise)
- Laboratories (Physical Containment and/or Biosecurity Containment Level 3 compliant or greater)
- Process cooling (including server rooms)
- Refrigeration systems (for cool rooms and freezers)

The consultant must engage specialist experts to assist in the design of such systems or otherwise provide evidence of their competence and familiarity with the design of such systems if designing it themselves. If the consultant does not have specialist knowledge of these systems and has not made allowances for this in their tender offer, no variation cost will be approved during the design delivery if the design is not approved by the Superintendent. Subsequent costs associated with any additional specialist consultants engaged during design delivery and all additional cost will be borne by the consultant.

2.6 Seismic Design and Restraint

All designs are to be provided with seismic restraints compliant to AS 1170.4.

The mechanical services consultant is required to co-ordinate with the engineer responsible for the design of seismic restraints of all building services elements and the lead designer to ensure the requirements of AS 1170.4 are met.

Where facilities are designated to a particular Importance Level for structural seismic requirements, all structural elements to support, enclose or protect mechanical services are to be structurally designed and certified to the Importance Level.

Note that Importance Levels are distinct from operational requirements for mechanical services during cyclonic events, and must be addressed separately in the design process.

2.7 Technical Specification

The template construction technical specification for the project is DLI's Master Specification for Major Building Works, available via the DLI Project Manager for the contract.

The mechanical services design consultant is required to edit the relevant mechanical work sections in the Master Specification for Major Building Works to make it project specific and to form the construction specification for the building tender. All sections not relevant to the project are to be deleted prior to final issue of the specification.

2.8 Co-ordination of Designs across Disciplines

The mechanical services design consultant must liaise and co-ordinate with all authorities (where applicable) and with people involved in the other disciplines working on the project, including but not limited to, the following:

- Power and Water Corporation (PWC)
- Department of Corporate and Digital Development - responsible for all NTG ICT
- Architectural
- Electrical
- Civil
- Structural
- Hydraulics
- Landscaping

Ensure nominated building services elements e.g. mechanical duct, plant, services switchboards, cable trays/ladder, etc. and their locations are consistent across all discipline documentation and do not conflict. The consultant must rectify any conflicting information at no expense to the Principal.

Co-ordinate with all disciplines to ensure the provision of power (including backup power) and controls are sufficient to provide to the mechanical services plant and all inter-dependent services. The mechanical services design consultant and associated disciplines must agree and confirm that the functionality of the designed and specified systems have been proven and can be practically installed and commissioned by a contractor.

The mechanical services design consultant is the lead designer in respect to co-ordination of designs for metering, monitoring and Building Management Systems, across all 3 disciplines, Mechanical, Electrical, and Hydraulic. Review the designs of the 3 disciplines and ensure the designs are co-ordinated and clashes, or potential clashes, in the designs of the works are eliminated.

2.9 Design of Works Associated With Existing Assets

For designs associated with existing assets, the consultant must attend site and determine the condition of the site infrastructure for all mechanical services and associated services that will affect and/or be affected by the works. The mechanical services design consultant must fully design and document the exact scope of works on all existing site services modifications required to meet the functional design requirements.

Mechanical services investigations are to include measurements of existing air flows, cooling water flows, heating water flows, condensing water flows, maintenance access and electrical loads through the consultant's own measuring instruments or through a sub-contractor at no additional cost to DLI.

Associated services investigations are to include (but not limited to) building structure, power (including main distribution boards and mechanical services switchboards), potable water, building management systems, sewerage/stormwater, fire detection/interface panels and specialist equipment.

Allow for the provision of a condition report detailing the result of the investigation of all of the above affected services. All deficiencies in existing services that will impact on the mechanical design must be referred to the Superintendent prior to commencement of detailed design.

If attending site before submission of a fee offer is not possible, the design consultant will make all necessary allowances required to inspect all services required to meet the minimum design standards set out in this document.

2.10 Design Development Stages

The following design stages are representative of the minimum expected deliverables for each stage of the design project. Where these design stages differ to the design stages of the project specific scope, the same review principle applies as below for the project specific stages.

The stages described below indicate the expected deliverables at each stage as a minimum. Approval must be obtained by the Superintendent to proceed to the next design stage.

2.11 Site Investigation

The design consultant is required to familiarise themselves with the locality of the site via a full site investigation. This includes stakeholder consultation, accessing obscure or hidden structures and services, taking photos, videos and measurements as required to undertake the design. If attending site before

submission of a fee offer is not possible, the design consultant will make all necessary allowances required to inspect all services required meet the minimum design standards set out in this document.

Refer to section 2.9 for sites with existing infrastructure. Failure to allow for the requirements under section 2.9 in the consultant's fee offer does not absolve the consultant of their responsibility to meet this section of the MDS, nor will a cost variation be approved by the Superintendent during the design.

2.12 First Submission (25% Design)

- Written return brief to DLI for verification and acceptance that the design concept is understood and will be adhered to by the consultant. Submissions and correspondence made to authorities are to be included as an appendix.
- Site layout with proposed location and sizes of plant rooms and enclosures.
- **For existing sites only:** Identified existing services for the following;
    - Services to be demolished: to be documented on drawings for contractor's information
    - Services to be retained: to be detailed in a condition report indicating condition, capacity and suitability for reuse, and to be documented on drawings
    - Locations of existing distribution boards, fire indicator panels and mechanical services switchboards
- Concept design report and drawings, including preliminary engineering calculations such as heat loads.

2.13 Second Submission (50% Design)

- Updated drawings from the previous stage with any feedback fully addressed
- Further detailed engineering calculations such as heat loads and hydraulic system calculations.
- Building layout must be finalised or close to finalisation with only minor adjustments required. All floor space allowed for services must be confirmed sufficient by the Mechanical Services consultant, and where applicable, the project design leader.
- Layout plans with detailed services are to be provided and include at minimum:
    - Existing mechanical services to be reused
    - Existing ancillary services such as pipework, switchboards, and power distribution
    - New/proposed general mechanical plant layout
    - Co-ordination with other disciplines.
- Draft mechanical system schematics of proposed systems
    - Water side schematics (for CHW, HW, RHW, CW systems)
        - Where the system is integrating into an existing site water system, capture the schematic for the entire network
    - Air side schematics
    - Specialised system schematics
    - Mechanical-electrical single line diagrams for new/existing mechanical plant

2.14 Third Submission (75% Design)

- All detail from the previous design submissions incorporating previous design feedback
- Finalised engineering calculations including NCC Section J5.4 and J5.7 calculations
- Detailed building service layout plans including demolition and equipment lists
- Detailed mechanical system schematics
- Draft controls functional description.
- Draft submission of project specific updates to the construction tender specification document
- Draft safety in design report
- Draft clause-by clause NCC Section J5 Compliance Report

2.15 Fourth Submission (95% Design)

- Full set of complete design drawings incorporating all comments from previous designs stages
- All mechanical items checked for coordination and clashes with the building structure and other services.
- All design details and schematics must be clear and finalised
- Completed safety in design report
- Completed controls functional description, including final BMS points schedule
- Completed construction tender specification

2.16 Final Submission (100% Design)

- Complete set of design drawings incorporating all previous design stage comments
- Design Section 40 Certificate of Compliance
- Complete controls functional description
- Complete safety in design report
- Complete construction tender specification

3 Key Design Objectives

The following key mechanical design objectives are to be considered the DLI minimum design requirements for any project and must be used in developing design solutions for the project.

3.1 Air Conditioning Systems

During the design phase the design engineer must incorporate energy efficient systems that are in keeping with the Northern Territory Government's policies towards sustainable development.

During the design phase assess all layers of functionality of the air conditioning system and its relationship to other building systems.

The overall concept of system design, based on all relevant standards, DLI requirements and specific user information, must be presented in a detailed return brief for preliminary discussion and approval with DLI.

For multi-stage projects, in addition to the return brief, submit a report detailing the proposed future peak load capacity of the thermal plant including any assumptions, the peak load capacity required at the completion of the current stage of works, and the proposed final thermal plant configuration.

Air handling systems will be required to be contained entirely within the smoke zone and fire zones they are serving. Design methodologies for plant location must ensure the majority of maintenance obligations are kept within plant room spaces, away from the principal functional activities of the building.

3.1.1 General

Design air conditioning systems for ease of maintenance, including good accessibility to all items of plant. External noise levels from plant rooms, cooling towers and condensing units must be assessed with respect to the occupied areas and the site boundary, to ensure sound pressure levels are within that nominated by the Australian Standards and these Guidelines.

Design air conditioning systems to meet the requirements of DLI, AS 1668 Parts 1 and 2, and AS/NZS 3666.

Do not use the natural ventilation provisions of the NCC to achieve a concession regarding the drawing in of outside air for air-conditioned spaces.

Design for minimum energy consumption. The DLI Sustainability Minimum Design Standard requires 2019DLIthat all DLI building designs must comply with Section J of the NCC2019.

3.1.2 Minimum HVAC System Features

Generally, provide air conditioning systems:

- That are effective in delivering the required conditions for optimum comfort to each thermal zone and application.
- That are flexible and capable of cost-effective modification should there be a change in the function of the building or occupied spaces at a later stage.
- That provides ease of maintenance, including adequate accessibility and circulation space to all items of plant. Avoid locating plant on roofs or in ceiling spaces, and allow for plant maintenance to

occur at ground level. Refer clause 4.12 for plant room access for maintenance documentation requirements.

- That provide a healthy internal environment, ensuring optimum air quality and providing safe and comfortable working conditions. Provide a design opportunity for a controlled space environment which manages both dry bulb and absolute humidity upper limits within all functional areas.
- That includes demand-based ventilation such as by CO_2 level sensing and/or minimum fresh air at plant start up.
- That enables an economic after-hours operation for individual areas of the building.
- That provide a minimum of 6 Air Changes per Hour (ACH) for all internal zones and an average of 8.5 ACH across all zones served by a single HVAC system under all load conditions - where ACH is considered to be the volumetric air flow rate through the occupied zone (3m above floor level maximum).
- That provides sub-metering to all major items of plant.
- That interlocks operation of toilet exhaust systems with the HVAC system.
- That provides adequate building pressurisation to minimise infiltration of outside air. Provide 0.5 air changes per hour net positive airflow into the building (account for building exhaust systems such as toilet exhausts, kitchen exhausts, fume cupboards, and the like).
- That allows for complete, unimpeded removal of all mechanical plant components. Design isolation points on connecting pipework and ancillaries to allow disconnection of pipework to permit plant removal and installation.
- That is compliant to NCC Section J clauses J5.0 to J5.9 only when directed by the Superintendent. DLI may choose to comply with specific clauses of Section J.

3.1.3 Cooling Plant Concept

The cooling plant concept (i.e. PAC unit, air-cooled chilled water or water-cooled chilled water) for sites expected to operate business hours or operate 24/7 shall be as prescribed in the tables below, where:

- “PAC” denotes air-cooled PAC unit plant
- “Air” denotes air-cooled chilled water plant
- “Water” denotes water-cooled chilled water plant
- Climate zones refer to NCC climate zones

Table: Default cooling plant concept for sites expected to operate business hours only (typical lowest life cycle cost options listed first where two options given)

		Business hours operation						
Design Cooling Load (kW)	Installed Cooling Capacity (kW)	Darwin	Alice Springs	Katherine	Nhulunbuy	Tennant Creek	Remote – Climate Zone 1	Remote – Climate Zone 3
30	42	PAC	PAC	PAC	PAC	PAC	PAC	PAC
50	70	PAC	PAC	PAC	PAC	PAC	PAC	PAC
100	140	PAC or Air	PAC or Air	PAC or Air	PAC or Air	PAC or Air	PAC or Air	PAC or Air
150	210	Air	PAC or Air	PAC or Air	Air	PAC or Air	PAC or Air	PAC or Air
200	280	Air	PAC or Air	Air	Air	PAC or Air	Air	PAC or Air
250	350	Air	PAC or Air	Air	Air	PAC or Air	Air	PAC or Air
300	420	Air	PAC or Air	Air	Air	PAC or Air	Air	PAC or Air
350	490	Air	PAC or Air	Air	Air	PAC or Air	Air	PAC or Air
400	560	Air	Air	Air	Air	Air	Air	Air
450	630	Air	Air	Air	Air	Air	Air	Air
500	700	Air or Water	Air	Air	Air or Water	Air	Air	Air
550	770	Air or Water	Air	Air	Air or Water	Air	Air	Air
600	840	Air or Water	Air or Water	Air or Water	Air or Water	Air or Water	Air	Air
700	980	Air or Water	Air or Water	Air or Water	Air or Water	Air or Water	Air	Air
800	1120	Air or Water	Air or Water	Air or Water	Air or Water	Air or Water	Air	Air
900	1260	Air or Water	Air or Water	Air or Water	Air or Water	Air or Water	Air	Air
1000	1400	Water	Air or Water	Water	Water	Air or Water	Air	Air
1100	1540	Water	Air or Water	Water	Water	Air or Water	Air	Air
1200	1680	Water	Air or Water	Water	Water	Air or Water	Air	Air
1500	2100	Water	Water	Water	Water	Air or Water	Air	Air
> 2000	> 2800	Water	Water	Water	Water	Water	Air	Air

Default cooling plant concept for sites expected to operate 24/7

		24-7 operation						
Design Cooling Load (kW)	Installed Cooling Capacity (kW)	Darwin	Alice Springs	Katherine	Nhulunbuy	Tennant Creek	Remote – Climate Zone 1	Remote – Climate Zone 3
30	42	PAC	PAC	PAC	PAC	PAC	PAC	PAC
50	70	PAC	PAC	PAC	PAC	PAC	PAC	PAC
100	140	Air	Air	Air	Air	Air	Air	Air
150	210	Air	Air	Air	Air	Air	Air	Air
200	280	Air	Air	Air	Air	Air	Air	Air
250	350	Air	Air	Air	Air	Air	Air	Air
300	420	Air	Air	Air	Air	Air	Air	Air
350	490	Air	Air	Air	Air	Air	Air	Air
400	560	Air	Air	Air	Air	Air	Air	Air
450	630	Air	Air	Air	Air	Air	Air	Air
500	700	Water	Air	Air	Water	Air	Air	Air
550	770	Water	Air	Air	Water	Air	Air	Air
600	840	Water	Water	Water	Water	Water	Air	Air
700	980	Water	Water	Water	Water	Water	Air	Air
800	1120	Water	Water	Water	Water	Water	Air	Air
900	1260	Water	Water	Water	Water	Water	Air	Air
1000	1400	Water	Water	Water	Water	Water	Air	Air
1100	1540	Water	Water	Water	Water	Water	Air	Air
1200	1680	Water	Water	Water	Water	Water	Air	Air
1500	2100	Water	Water	Water	Water	Water	Air	Air
> 2000	> 2800	Water	Water	Water	Water	Water	Air	Air

3.1.4 General Chiller Plant Design Considerations

The chilled water thermal plant system design must have consideration for the following:

- Chilled water plant system design shall be compliant with the following relevant requirements of NCC2019 Section J:
    - Part J5.7 – Pump systems
    - Part J5.8 – Pipework systems
    - Part J5.10 – Refrigerant chillers
    - Part J5.12 – Heat rejection
- If existing thermal plant is to be reused in the proposed design, submit to DLI a dilapidation report of the existing plant. Approval must be obtained from DLI prior to reusing existing plant in new designs.
- Within the design development report, identify the optimum thermal plant configuration (air-cooled or water cooled, primary loop or primary-secondary loop configuration), from practicality, capital cost, and whole-of-life cost perspectives. Approval must be obtained to proceed to design documentation.
- Nominally configure the system with a multiple-chiller base load arrangement. The chillers are to be sized such that in the event of partial or complete failure of any one chiller, the remaining fully operational chillers are to be capable of handling a minimum of 70% of the total site-wide, non-diversity adjusted load. Priority is to be given to deploying chillers of identical make, model and capacity.
- Chilled water circuit design must include an active thermal inertia tank in the return chilled water path.
- The primary pumps in primary loop configurations, and the secondary pumps in primary-secondary loop configurations, must have full n+1 redundancy on all pumping components.
- Where a header arrangement is included for the chilled water supply and/or return path, the header must be arranged such that all flows out of the supply header are evenly mixed together prior to be distributed to the field, and similarly that all flows into the return header are even mixed prior to entering any of the chiller plant (specifically to avoid uneven loading of chillers and uneven supply temperature distribution to the field).
- All common chilled water and condenser water plant (headers, expansion tanks, and the like) must be sized for the full future system capacity and have all future expansion provisions in place. For the condenser water loop, ensure that the future expansion provisions are designed to prevent biological growth whilst not in use.
- Open condenser water circuits must incorporate centrifugal separators, side-stream filtration and chemical treatment for microbial control in the design.
- Allowances are to be made for the collection and discharge of condenser circuit water during system operation and maintenance, in accordance with the requirements of applicable statutory authorities.
- Consideration must be made to material selections, with regards to preventing or mitigating corrosion (i.e. if the site is in close proximity to salt water).

- If the site has significant after-hours usage, use low-load chilled water generation in the form of a low load chiller. The low load chiller may be used to achieve the 70% capacity minimum load failure tolerance criteria.
- Where multiple cooling towers are included in the design, the cooling towers shall be configured on a common header, to enable the common set of cooling towers to serve each individual chiller. Motorised isolation valves shall be installed on the entering and leaving side of each tower so they can each be isolated under command from the control system.
- The location and arrangement of cooling towers must prevent:
    - exhaust air or water vapour drift affecting occupied areas, pedestrian thoroughfares, building openings and air intakes; or,
    - the contamination of cooling towers by exhaust discharges from buildings or other cooling towers (as per AS/NZS 3666.1), or from airborne particulates from disturbed soils.
- Static bypass flows in the field (such as flow through 3-way valves for example) must be minimised as much as possible, so that the static field bypass flow is only as much as required to avoid the formation of dead legs. Where 3-way valves are necessary, the bypass line shall include a dedicated balancing valve so that the bypass flow can be minimised independently of the coil flow.
- The design development report for any proposed design incorporating water-cooled chilled water systems must include a risk assessment in relation to mains water quality in the project location. Of specific concern are the following risks:
    - Corrosive impacts on plant where chlorine content is relatively high.
    - Calcium scaling on plant where calcium content is relatively high.
- Make-up water treatment systems must be included in the design wherever mains water quality poses a risk to water-cooled chiller plant and/or cooling tower plant.
- Air-cooled chillers must comply with the energy efficiency requirements of NCC2019 and, in addition, shall have a minimum IPLV.SI (when determined in accordance with AHRI 551/591) of:
    - For units with cooling capacity ≤ 528 kWr, IPLV.SI ≥ 5.3
    - For units with cooling capacity > 528 kWr, IPLV.SI ≥ 5.4
- Water-cooled chillers must comply with the energy efficiency requirements of NCC2109 and, in addition, shall have a minimum IPLV.SI (when determined in accordance with AHRI 551/591) of:
    - For units with cooling capacity > 264 kWr AND ≤ 528 kWr, IPLV.SI ≥ 9.8
    - For units with cooling capacity > 528 kWr, IPLV.SI ≥ 10.0

3.1.5 General Heating Water Plant Design Considerations

The new heating water thermal plant design must have consideration for the following:

- Heating water plant system design shall be compliant with the following relevant requirements of NCC2019 Section J:
    - Part J5.7 - Pump Systems
    - Part J5.8 - Pipework Insulation
    - Part J5.9 - Space Heating

- If existing thermal plant is to be reused in the proposed design, submit to DLI a dilapidation report of the existing plant. Approval must be given by DLI prior to using existing plant in new designs.
- The preferred heating plant configuration shall be all-electric heat pump. Deviations from the preferred configuration will only be accepted where it can be shown that:
    - Electric heat pump plant would pose a risk to serviceability and operation in the project location and/or;
    - For existing buildings, integration of electric heat pump plant with existing infrastructure would be prohibitively intrusive or expensive.
- Within the design development report:
    - Address deviations from the preferred heating plant configuration (all-electric heat pump) as per the above.
    - Identify the optimum detailed heating water thermal plant configuration (heating only heat pump, reversible heat pump, water-source heat pump, solar collector pre-heaters, reverse cycle chiller, condenser water heat recovery, primary loop or primary-secondary loop configuration), from practicality, capital cost, and whole-of-life cost perspectives.
    - Opportunities for utilising heat recovery should be identified and assessed in the design development process as best-practice options and documented in the design development report. See Section noting opportunities that are expected to be considered.
- Nominally configure the system with a two heat pump base load arrangement, with any one heat pump capable of handling up to 70% of the total site-wide, non-diversity adjusted load.
- Heat pump plant shall meet the following efficiency performance requirements:
    - Minimum full load COP of 3.0 for air-source heat pumps (for supply water temperature of 45°C and ambient dry bulb temperature of 7°C).
    - Variable speed compressor(s) and/or multi-compressor arrangement
    - Capability for stable operation down to 25% of full load capacity
- Reversible heat pumps are encouraged to be considered as a measure for reducing capital costs, plant footprint and maintenance demands.
- Heating water circuit design must implement an active thermal inertia tank in the return heating water path. The primary pumps in primary loop configurations, and the secondary pumps in primary-secondary loop configurations, must have full n+1 redundancy on all pumping components.
- All common heating water plant (headers, expansion tanks and the like) must be sized for the full future system capacity and have all future expansion provisions in place.
- Thermal plant must be installed within and adequately ventilated weatherproof enclosure.
- New heat-pump heaters (or gas-fired boilers where approved) shall be installed with infrastructure required for the system to operate with a variable leaving heating water temperature set point directed by the central control system.
- For any approved fuel combustion plant:
    - Thermal plant must incorporate electronic automatic ignitors and full modulation of fuel and combustion airflow above 20% of the rated capacity.

    - The *plant enclosure* ventilation rate must be designed to satisfy combustion air requirements and dissipation of radiated heat to ensure a safe worker environment. Combustion gas flues must be constructed from non-corroding materials.
- Heating infrastructure for new buildings not incorporating heat pump plant shall be designed for a heating hot water supply water temperature no higher than 50°C, and allocate space for future heat pumps, to allow for the possibility of heat pump conversion at the next lifecycle replacement of the thermal plant.
- Heating hot water coil replacements in existing buildings shall be designed for a heating hot water supply water temperature no higher than 50°C, to allow for the possibility of heat pump conversion at the next lifecycle replacement of the thermal plant.

3.1.6 Chilled Water System Heat Recovery Opportunity Assessment

Projects that include a significant year-round demand for cooling and/or a significant year-round demand for heating must be assessed for heat recovery opportunities during design development. Examples of expected opportunities include:

- Heat recovery from chilled water systems in Climate Zone 1 for hot water pre-heat in buildings such as hospitals and other facilities with high hot water usage.
- Heat recovery from chilled water systems serving humidity-controlled spaces in Climate Zone 3 for space heating and/or hot water pre-heat.

Assessment of heat recovery solutions for space heating applications shall include dynamic energy modelling via thermal simulation software that assesses performance on an hourly basis and is validated through ANSI/ASHRAE Standard 140.

Assessment of heat recovery solutions for hot water applications is also preferred to be conducted via dynamic energy modelling but may otherwise be assessed via manual spreadsheet calculations. Any such calculations must consider the likely operating load profile of the cooling plant, from which can be derived the likely profile of available heat recovery for comparison to the likely demand profile of the heating application.

All heat recovery assessments shall include consideration of and allowance for:

- Expected daily and hourly load profile of recoverable heat.
- Expected daily and hourly load profile of heating demand.
- Energy consumption of ancillary heat recovery equipment such as pumps.
- Energy cost and carbon offset cost savings.
- Incremental capital cost.
- Incremental maintenance costs.
- Risks to operation and maintenance (for each of the heat recovery system, the heating system and the cooling system).

Examples of potential heat recovery systems include (but are not limited to):

- 4-pipe heat recovery chillers (designed for cooling):
    - Chillers designed and controlled primarily for the cooling application with factory-built capability for simultaneous hot water production.
    - Applicable for hot water pre-heat.
    - May be considered for space heating applications where appropriate measures are taken to mitigate against the risk of fluctuating supply temperature of recovered heat (such as de-coupling via a HEX).
- 4-pipe heat recovery chillers (designed for heating):
    - Same unit as per the above but designed and controlled primarily for the heating application with factory-built capability for simultaneous cold water production.
    - Applicable for systems with a seasonal heating demand and a year-round cooling demand.
    - Appropriate measures should be taken to mitigate against the risk of fluctuating supply temperature of recovered cold water (such as de-coupling via a HEX).
- Water-source heat pump connected to condenser water:
    - Built-up system designed to reclaim heat from the condenser water system serving a chiller set, thereby redirecting heat from the cooling towers to a useful heating application.
    - Applicable for hot water pre-heat and space heating hot water generation.

3.1.7 General Air Handling Plant Considerations

The air handling plant must have considerations for the following:

- Air handling system design shall be compliant with the following relevant requirements of NCC2019 Section J:
    - Part J5.4 - Fan Systems
    - Part J5.5 - Ductwork Insulation
    - Part J5.6 - Ductwork Sealing
- All air handlers and fan coil units must have adequate insulation thickness to avoid condensation on the external surfaces at all times. All air handler frames to have a thermal bridging class of TB2 or greater.
- All chilled water air handling units to have minimum 6 row deep main coils, and any of the following pre-cooling options:
    - Dedicated chilled water outside-air pre-cooling dehumidification unit, with a minimum 6 row deep coil, and
    - Run-around coil system with a minimum 6 row deep pre-cooling coil. No row depth restriction to the heat gain/reheat coil.

- Active dehumidification (and associated pre-cooling/run-around systems) is not specifically required for designs in NCC Climate Zone 3 however it remains the responsibility of the designer to ensure that internal design conditions will be achieved with the system they propose.
- If reheat is required at the air handler to offset over-cooling from the dehumidification process, then that heat shall be sourced from a passive and/or recovered source (for example via return air or recovered via a run-around coil or condenser water path). Primary sources of heat such as electric heater banks or heated hot water shall not be used for dehumidification reheat.
- The use of air to air heat exchangers shall be considered in the design development process and addressed in the design development report, noting the following:
    - Air to air heat recovery is encouraged where there is an opportunity for heat exchange with spill air (i.e. conditioned air from a spill air path rather than exhaust air from toilet/kitchen/laboratory exhaust path). The design development report must identify such opportunities and provide a life cycle cost evaluation to support their inclusion/exclusion.
    - Air to air heat exchange with toilet/kitchen/laboratory exhaust air streams is not permitted. However, opportunities for heat recovery from these exhaust paths via run-around coil systems will be welcomed as an optional design inclusion where they can be justified by life-cycle cost evaluation.
    - Latent heat recovery is particularly encouraged in NCC Climate Zone 1 due to the high latent loads and energy saving opportunities in this climate.
- Desiccant-based dehumidification is not permitted.
- All water coils must have a fin density of no greater than 394 fins per metre (10 fins per inch) to assist in coil cleaning.
- All water coils must have a face velocity of no greater than 2.0 metres/second.
- Packaged DX-type units are to have a minimum of two fixed-capacity stages or incorporate variable capacity compressors. Ensure packaged plant designs for NCC Climate Zone 3 are capable of maintaining capacity up to 50°C ambient conditions. Packaged air-conditioning plant is to comply with NCC Section J clause J5.11. Approval must be obtained for use of Packaged DX-type units in any design.
- Filters must be deep-bed type, of a class to suit the minimum effective outdoor air requirements of AS 1668.2, or class F5 to AS 1324.1 (whichever is greater). Use ‘Pyracube’, ‘Four Peak’, or ‘Multipeak’ type filter forms.
- Consideration must be made to coil construction materials and protective coatings, with regards to preventing or mitigating corrosion (i.e. if the site is in close proximity to salt water).
- Air handlers must have fully ducted return and outside air reticulation to all air handling units. Do not use plant rooms as mixing plenums.
- Economy cycle shall be included where required by NCC2019 Part J5.2a (iii) & Table J5.2, with the added criteria that for buildings that are occupied over 4,000 hours per year, the total air flow rate threshold for systems requiring economy cycle in Climate Zone 3 is reduced from 7,500 L/s to 3,500 L/s. Where not specifically required by these conditions, designers are still encouraged to utilise economy cycle in Climate Zone 3 wherever the system design is able to accommodate it without extensive modification.
- Provide tempered air conditions inside all mechanical plant rooms via bleed air from the air handling units. Target design conditions for plant rooms must be no more than 28°C and 60% RH.

- Where reheat coils are deployed, limit the in-duct humidity to no more than 85% RH.
- Nominate stainless steel drip trays with adequate length to catch all airborne condensate or use a low face velocity. Face velocity must not exceed 2.0 m/s for all coils.
- Approved corrosion protection systems must be provided for all condenser coils.
- For air handlers serving kitchen areas, the total room heat load is to allow for the full heat load of permanently active kitchen equipment (such as refrigerators and freezers), and 30% of the total heat load of transient kitchen equipment (such as stoves, ovens and dishwashers).
- For all DX plant, it is essential that discharge air from the condenser(s) is not recirculated back into the suction path of that condenser, any other condenser or any ventilation supply air system. Plant configuration must be designed in accordance with this requirement.
- As per NCC2019 Part J5.2a (v), any chilled water air handler with flow >1,000 L/s must have a variable speed fan when its supply air quantity is capable of being varied (which is expected to be applicable to the majority of systems) and the control strategy should incorporate variable speed control of the fan. (Note that this requirement does not specifically apply to DX systems but variable flow solutions for these systems will be favourably considered where the risks associated with low-flow are appropriately mitigated).

3.1.8 Package (PAC) Plant

- PAC units must comply with NCC2019 requirements in addition to the following requirements:
  - PAC units shall have full load EER of no less than 3.0 at Test Condition T1 of AS/NZS 3823.1.2
  - PAC units shall feature:
    - Inverter-driven compressor(s)
    - Inverter-driven condenser fan(s)
    - Variable-speed supply air fan(s)
- As a risk control measure against excessive moisture in the building, inverter-driven PAC unit installations in Climate Zone 1 shall include an enthalpy sensor in the unit's return air path.
- PAC unit controls must be configured to utilise the variable speed capability of the inverter in response to zone temperature, and in Climate Zone 1, shall also include an override to prioritise dehumidification when the return air relative humidity is >65%.
- For PAC units in Climate Zone 1, or in any other dehumidifying applications, specialist dehumidifying units shall be preferred, incorporating integrated heat reclaim from the refrigerant circuit for any reheat requirements.

3.1.9 Evaporative Air Cooling Systems

The use of evaporative air cooling systems will be subject to approval of the DLI representative, and must only be considered in regions within NCC Climate Zone 3, and only where the ambient operating conditions exist below 23°C wet bulb for sufficient periods of time for evaporative cooling to be economically viable.

Do not use evaporative air cooling systems in areas where water availability is scarce, or where poor water supply quality will lead to excessive mineral and scale build-up.

Optimise the system configuration based on the design requirements of the space:

- Residential installation: Direct evaporative, and
- Commercial or large-scale installation: Indirect or two-stage evaporative, as the primary cooling system or pre-cooling stage to refrigerant-based plant.

Primary evaporative cooling systems must achieve the following internal design conditions:

- Maximum internal conditions 27.4 °C dry bulb, relative humidity (RH) no more than 80%,
- Air change rate of 20 – 40 air changes per hour (ACH), and
- Achieve relief/exhaust air for the space through non-mechanical means.

Use control and water quality systems that are automatic with continuous water quality monitoring. Use robust, low maintenance components for controls and sensors. To reduce water consumption, do not use water quality systems that use continuous water bleed or periodic dumping methods.

Interlock the operation of the unit with ambient enthalpy sensors for:

- Economy cycle – where the water circuit can be disabled and the fan permitted to run to provide ventilation when ambient conditions equal the target internal temperatures, and
- Extreme ambient conditions – where the system can be disabled when it cannot achieve target internal conditions. Set to automatically change over to refrigeration-based plant in this condition.

3.1.10 Split Systems

The use of split systems is to be restricted to supplementary air systems only, and only with the approval of the DLI representative.

Use inverter type condensing units to ensure that the cooling coil is active at low loads. Single occupant office is exempt from this rule.

In regions within NCC Climate Zone 3, ensure split systems are reverse-cycle capable to provide heating during winter, except were used for utility rooms that do not require heating (i.e. IT equipment rooms).

Do not use multi-headed and/or variable refrigerant volume split systems.

The condensers must be selected for continuous operation at peak ambient conditions and peak demand with consideration to specific placement.

Provide interlocks with any outside air system associated with the split system. Interlocks must have delay timers, with adjustable timing (initially set to 10 minutes) to allow for the split system to cool the space before starting the outside air system.

All refrigerant pipe work must be fully insulated and vapour sealed with ends and joints of insulation taped and/or glued. Cover all external pipe work and wiring with metal capping, and supported with saddle clips. Provide fully weatherproof units and electrical controls etc., suitable for outdoor operation under tropical conditions.

For all DX plant, it is essential that discharge air from the condenser(s) is not recirculated back into the suction path of that condenser, any other condenser or any ventilation supply air system. Plant configuration must be designed in accordance with this requirement.

Generally, all equipment must be suitable for operation, without deterioration, in the following conditions:

- High humidity levels,
- Ingress of wind driven rain,
- High ultra violet light levels,
- Termite/ant infestation, and
- Areas prone to property damage and/or vandalism.

Energy performance requirements for split system air-conditioning units are defined with reference to the Australian Energy Rating Label scheme, and shall conform to the following minimum Energy Star rating requirements:

Item	Minimum Seasonal Energy Efficiency Ratio (SEER) Cooling Star rating for Hot Zones	Minimum Annual Energy Efficiency Ratio (AEER)
Non-ducted split system	4.5 Stars	N/A
Ducted split system <= 20 kWr	3.5 Stars	N/A
Ducted split system > 20 kWr	2.0 Stars	3.5

SEERs and AEERs for different models are available in the Australian Government's Energy Rating Product Database. At the time of drafting these values were listed in the 'c_star_hot' and the 'Rated AEER' columns respectively.

3.1.11 Refrigerant Selection

Except for air-cooled package plant, DLI does not allow use of refrigerants with a Global Warming Potential (GWP) greater than 700 (such as R-134a, R-410A or R-407C).

For each application, designers are to:

- Check the availability of the proposed refrigerant; and
- Investigate the availability and potential use of equipment using non-HFO (PFAS containing) refrigerants with a GWP less than 10 - for example R717 (ammonia), R290 (propane) and, for small hot water heat pumps, R744 (carbon dioxide).

Maximum refrigerant GWP requirements are specified in the table below:

System	Capacity (kWr)	Refrigerant maximum GWP requirement
Air-cooled chiller	350 to 1,500	GWP < 10
	All other units	GWP < 700
Water-cooled chiller	300 to 1,500	GWP < 10
	All other units	GWP < 700
Air-source heating hot water heat pump	All units	GWP < 700
Air-cooled PAC unit	All units	GWP < 700 preferred

Exceptions to these requirements will be considered by DLI on a case-by-case basis, where it can be shown that the overall environmental performance of the system would be improved despite refrigerant selection not conforming to these requirements.

DLI is aware that many low-GWP refrigerants (including most HFOs, R-32 and hydrocarbons) are flammable, and designs for DLI projects must include installation risk assessments in accordance with AS/NZS 5149.3 Refrigerating systems and heat pumps - Safety and environmental requirements, Part 3 Installation site and AS/NZS60079.10.1: Classification of areas – Explosive gas atmospheres.

Designers are to complete and submit the refrigerant check list provided on the DLI Technical Specifications website (example checklist template included in Attachment).

3.2 Exhaust Air Systems

Exhausted air presents numerous problems to buildings in terms of energy losses, humidity problems and human comfort issues, and must be designed to be aligned with the Australian Standards, the National Construction Code of Australia, associated air conditioning plant, design briefs, and Northern Territory Government sustainable development policies, to the fullest extent possible.

3.2.1 General

Design exhaust air systems in compliance with AS 1668 Parts 1 and 2. Provide mechanical exhaust ventilation in all circumstances where make-up air is to be sourced from air-conditioned spaces or where natural ventilation will create a public nuisance or hazard.

Select exhaust fans based on expected duty, serviceability, efficiency, and acoustics. Allow for fan selections which will have minimal in-duct and breakout noise to comply with the interior space acoustic levels specified in AS 2107, with minimal additional acoustic insulation required.

For fans capable of 100 litres per second and above, provide speed controllers to allow for exhaust air flow rate balancing.

Where mechanical exhaust fans have make up air sourced from air-conditioned spaces, ensure that the main air handling systems maintain overall building pressurisation when the exhausts are active, particularly when the exhaust system is constantly operating. Generally, provide make up air through transfer ducts.

Any specialist exhaust air systems (e.g. Physical Containment laboratories, negative pressure wards) must be designed strictly in accordance with the Australian Standards, and the requirements of applicable statutory authorities, and commissioned via a specialist NATA accredited agent.

Attempt to locate fans in easily accessible areas and avoid locating access panels and plant in socially and/or culturally sensitive areas.

Do not use air-to-air energy recovery units to recover energy from exhausted air.

3.2.2 Toilet Exhausts

Natural ventilation (Subject to NCC clause F4.6) for ablutions is only permitted where there will be sufficient natural cross-flow ventilation through the building, such as standalone toilet blocks and the like. Coordinate with architects and other services to ensure that any airflow from naturally ventilated toilets cannot permeate adjacent occupied spaces.

Control exhausts with time switch controls or dual technology occupancy sensors and 15 minute run on timers interlocked with ablution area lighting.

For multiple fans attached to a single exhaust stack arrangements, provide backdraft dampers on each fan to prevent exhausted air from pushing back into adjacent spaces. Ensure each fan has enough static pressure to drive exhaust air through the common duct when all fans are active.

3.2.3 Kitchen Exhausts

All commercial kitchen exhaust hoods are to be of the compensating type with filtered outside air make up.

Use of proprietary commercial kitchen hoods is subject to approval by DLI, and, prior to design, supply the manufacturer's letter of compliance to AS 1668.2.

Do not use inline ducted fans for kitchen exhaust. Use roof mounted high temperature vertical discharge fans only.

Use a minimum ratio of 20% air-conditioned spill air, 80% filtered outside air to compensate for exhausted kitchen air. Do not use less than 20% air-conditioned spill air.

For exhaust ductwork, comply with the duct design requirements of AS 1668.1 and AS 1668.2, particularly with respect to duct service hatch and horizontal duct fall requirements. Ensure the duct design does not allow for grease to pool and create a fire hazard.

Do not allow for direct line-of-sight noise emitted from the exhaust fan to enter the kitchen space. Either design for two or more duct bends before the fan, or provide kitchen exhaust specific in-duct attenuators.

For grease filters, use 'Email' Type GW or similar.

3.2.4 Fume Cupboards

Generally comply with AS/NZS 2243.8, and dependant on the facility usage and design brief, the ventilation requirements in AS 2243.1 for Physical Containment level facilities, and/or the Australian Government Department of Agriculture, Fisheries and Forestry – Conditions for Operating Approved Arrangements.

3.3 High Volume Low Speed Fans

High-volume low-speed (HVLS) fans are large diameter fans, typically ceiling mounted, that move large volumes of air at low speed. To be classified as a HVLS fan, the fan must be able to pass through a volume of 500 cubic feet (14.16 cubic meters) in a single revolution, and the fan blade tip speed must not exceed 60 miles per hour (96.6 km/h).

The use of high-volume low-speed ceiling fans in large, open, high-ceiling indoor spaces is encouraged to supplement active air-conditioning systems.

Where employed, high volume low speed fans shall incorporate occupancy sensors for automated on/off control and temperature sensors for automated speed control.

Energy efficient coordination of the air-conditioning system and the ceiling fans should be considered in commissioning and building tuning, with the intent that in operation the air-conditioning set point may be able to be set higher than the design condition, and in hybrid buildings may even be able to be switched off in mild conditions where the fans are able to provide sufficient cooling effect on their own.

3.3.1 External HVLS Installations

For HVLS installations outside of the building fabric or in outdoor areas, the fan designs and selections are to:

- Not exceed 3.7m in diameter
- Be fitted with gripple-locked guy-wires for lateral bracing, or braced as per manufacturer's specifications
- When installed in existing structures, have the structure (and if required, extra required building elements) assessed and certified by a structural engineer.

Where possible, HLVS fans are to be installed in a location where the upper part of the installation structure is cladded, to ensure the fan is not directly subjected to wind gusts.

3.4 Continuously Conditioned Rooms in Business Hours Conditioned Buildings

For rooms, such as health clinic pharmacies and critical ICT equipment rooms, that must be continually air conditioned within facilities that operate for less hours:

- Provide after-hours air conditioning with an energy efficient dedicated air conditioning system inter-locked with the main plant so that it does not operate when the main plant is on;
- Ensure the dedicated/base building air conditioning serving the room does not provide heating unless specified otherwise; and,
- The BMS, if present, is to record and communicate an alarm when room temperature rises above 30° C.

3.5 Mechanical-Electrical Services

Generally comply with the DLI Minimum Design Standard – Electrical Services.

3.5.1 Mechanical Services Switchboards (MSSBs)

Large buildings must be provided with a dedicated Main Mechanical Services Switchboard (MSSB) which supplies power to all mechanical services equipment. The main MSSB must be fed directly from the site Main Switchboard.

Mechanical Services Distribution Boards within each building must be fed from the main MSSB.

For sites with multiple buildings (i.e. campus designs), each buildings main MSSB may be supplied from the buildings Main Distribution Board where connection to the Site Main Switchboard is impractical.

MSSB's serving centralised chilled water/heating water plant must be fed directly from the site main switchboard.

For MSSBs with a rated current equal to or greater than 800 A, the form of separation of the board is to be Form 3b or 4a. Do not use alternative constructions such as Form 3bi, 3bh and 3bih.

All MSSBs must come with 100 kA surge protection devices compliant to AS 1768. Surge protection devices must have clearly distinguishable fail indicators that can be seen without removing covers and exposing other live components.

3.5.2 Control Systems

Air-conditioning system design shall comply with NCC2019 Part J5.2 Air-Conditioning System Control. Exceptions to specific requirements of Part J5.2 will be considered by DLI for facilities in remote locations where it can be shown that the requirement adds a complexity of control that will be a risk to serviceability.

All new mechanical services plant and equipment is to be scheduled and controlled using simple Direct Digital Control (DDC) systems, based on off-the shelf components with fully open protocol BACnet architecture, and is to include basic energy monitoring functions.

As the facility may have infrequent or intermittent usage patterns, provide time-clock control for all systems to include function for set-back control on temperatures and ventilation rates. Manual operation and override of every mechanical system must also be provided.

For all systems with central thermal plant, controllers for all elements of the air-conditioning system are required to communicate on a common Building Management System accessible via a user interface with an on-site operator workstation and a remote web server connection (unless otherwise specified/approved by DLI).

The central BMS shall allow for control of central plant to be based on the live parameters of downstream field equipment (i.e. allowing the chilled water plant control algorithms to consider the chilled water valve position of all downstream AHUs, and allowing AHU control algorithms to consider the damper positions/zone temperatures of all downstream VAVs, for example).

The BMS user interface shall include graphics screens for all plant equipment as required to clearly demonstrate to the user the operation of the plant and key control parameters of control algorithms for the plant. AIRAH Manual DA28 Appendix D: BMCS Graphics Screens should be used as a general reference point for the required detail and layout of BMS graphics screens.

Trend logging and reporting capability shall be available for all key data points via the BMS user interface, with data both displayed graphically on the user interface and exportable for external analysis.

Exceptions to the above requirements will be considered by DLI for works on existing sites where the existing infrastructure is not capable of meeting these requirements.

Where the BMS has been nominated to control multiple building services including mechanical services (i.e. for lighting, security, potable water controls etc.), the Mechanical Services designer is to be the lead designer for the BMS in respect to co-ordination of designs across all 3 disciplines, Mechanical, Electrical, and Hydraulic.

3.5.3 Ownership

All ownership of access accounts, passwords, programming logic, and intellectual property used in the control system must be transferred to the Northern Territory Government. All licenses for proprietary software used in conjunction with the development and/or operation of the control system must be transferrable, and be transferred, to the Northern Territory Government.

3.5.4 Thermal Plant Control

Thermal plant control is to be provided via a proprietary BACnet communication open protocol Chiller Management System (CMS) or similar, complete with graphical user interface front end.

The CMS is to control the chiller plant sequencing, staging, and flows so as to optimise plant operation and maximise the plant's energy efficiency (COP) and reliability.

The Thermal plant is to initialise on receipt from call for cooling signals from independent controls that operate the site air handling units.

Chilled water plant control shall include energy efficient control strategies appropriate to the plant configuration and the serviceability of the facility's location. Efficient control strategies to be considered include:

- Variable chilled water temperature set point
- Variable condenser water temperature set point (based on ambient wet bulb temperature)
- Variable field pressure set point for chilled water pumps
- Variable primary chilled water flow
- Variable condenser water flow
- Cooling tower staging control allowing towers to stage on and off at minimum speed independently, and ramp up speed together in parallel

The chiller plant control strategies shall be detailed in the controls functional description which will undergo iterations of review and approval to ensure the plant is controlled efficiently. Where strategies such as those above are not employed, the exclusion will need to be justified to, and approved by DLI on the grounds of applicability to the plant configuration or the ability to readily service the controls in the facility's location.

3.5.5 Air Handler Control

Air handler controls are to be provided via BACnet open protocol standard DDC/PLC based control systems. The controllers are to receive start signals from the time clock and/or after hours switching functionality, from which a call for cooling will be sent to initialise the thermal plant system.

Where direct valve control is employed, chilled water valve and heating water value opening and positioning will be in response to deviation from space temperature and relative humidity set points via proportional and integral control response. Otherwise, valve position shall be controlled in response to deviation from a variable supply air temperature set point. (Note that supply air temperature sensors are still required where direct-valve control is employed, for maintenance and performance monitoring purposes).

Initiation of the chilled water system will be initiated and terminated by means of chilled water valve opening positioning. An increase and retardation of thermal potential from the chilled water system will be initiated and retarded by means of chilled water valve opening and positioning.

Air handling unit supply air mass flow will be varied in response to thermal load within a minimum to maximum range to conserve electrical energy.

Where VAV terminals are employed downstream of the AHU, the fan speed shall be controlled to achieve a static pressure set point and the set point shall be dynamically varied in response to VAV damper position.

The outdoor air ventilation and pressurization rate will be varied in response to the detection of occupancy within a minimum to maximum range to conserve thermal (and consequentially electrical) energy.

All air handler controls systems are to run independently from the thermal plant system and from other separate air handler controls and field devices.

3.5.6 Controls Network

Unless alternative communications infrastructure is specified by DLI, the controls network between the thermal plant, field devices, and remote operator terminals (if specified), are to be over a dedicated fibre optic network running the BACnet/IP protocol. The fibre optic LAN network to include FOBOTS switches local power supply including 50% redundancy in each building complete with surge protection. The controls network may be shared by other building services but must be completely isolated from the facility ICT network.

3.5.7 Supplementary System Control

Supplementary DX split systems are to be programmed to be inoperable when the main air handlers are operational. Interlocks between auxiliary mechanical plant and other building services (such as booster fans, etc.) must come complete with run-on or delay timers, depending on the expected system usage.

3.5.8 Hours of Operation

Unless specifically requested, it can be assumed that the building will be occupied Monday to Friday from 0800 hours to 1700 hours.

The plant is required to provide comfort conditions for the hours of occupation and shall be programmed with lead times as required to achieve cool-down/warm-up ahead of occupancy.

Where a BMS is included in the design, the plant operating schedule shall be dynamically determined via an optimum start routine targeted at engaging the plant no sooner or later than required to achieve comfort conditions by the specified occupancy start time. Optimum start duration shall be a maximum of one hour prior to occupancy start time.

Public holidays must be scheduled off (unless otherwise specified) through a time switch incorporating a 365 day calendar function. For schools the programming must exclude all school holidays. Unless specifically requested otherwise, after-hours push button time delay must be 2 hours.

Liaise with the other disciplines to ensure the building structure and all services are co-ordinated, including any 24-hour operational requirements of the building, and including full vapour barrier detailing.

3.5.9 Fire Mode

The operation of the air handling plant and the building fire protection and detection system must be fully integrated to meet the prescriptive requirements of the National Construction Code of Australia and AS 1668 where applicable.

Alternatively, performance based solutions are actively encouraged and must be pursued provided they are supported by the Building Certifier and the application of Fire Safety Engineering principles that are further supported by computational modelling techniques.

3.5.10 Metering

The requirements of NCC2019 Part J8 shall apply. The lead responsibility for the metering system shall be under the mechanical design. The mechanical design must be coordinated with other services designs to ensure the following requirements are met using BACnet over IP compatible equipment.

Table – Minimum Design Standard – Electrical Services – Minimum metering requirements	
Incomer check meters	15 minute (minimum) interval data, meter specifications equivalent to Power and Water Corporation smart billing meter requirements (at minimum, must record kWh, kVA, kW, kVAr and power factor and retain data for at least 12 months)
Sub-system meters	15 minute (minimum) data kWh or MJ, smart meter (same specification as incomer check meters preferred)

For buildings that require a sub-metering system under NCC2019 J8.3(b), and for any building with a central plant HVAC configuration, the sub-metering system must have remote access capability and independently capture the following end use categories:

- Incomer check meter(s)
- Chillers
- Chilled water plant ancillaries (i.e. pumps and cooling towers)
- Heating hot water generators
- Heating hot water system pumps and ancillary loads
- Fan coil units and air handler fans
- Artificial lighting
- Appliance power
- Central hot water supply (domestic)
- Lifts and other internal transport devices
- Diesel generator electricity production
- Solar PV electricity generation
- Other ancillary plant

Note that metering requirements for the above categories are to be understood as a requirement to capture the aggregate of all units within the category. It is not the intention to individually sub-meter each individual unit in each category. Exceptions to the above requirements will be considered by DLI for works on existing sites where the existing ICT infrastructure is not capable of meeting these requirements.

The mechanical design shall include provision of meters to cover:

- Chillers
- Chilled water plant ancillaries (i.e. pumps and cooling towers)

- Heating hot water generators (electrical supplies and gas supplies to metered)
- Heating hot water system pumps and ancillary loads
- Fan coil units and air handler fans
- Other ancillary plant

Where the installation incorporates a new or existing BMS system, connect the meters into the BMS system to facilitate the monitoring of the magnitude and pattern of energy consumption.

The mechanical design must include documentation covering the complete energy monitoring system including references to all sub-metering points in the facility using a consistent naming convention. The complete energy monitoring system must be documented with a metering schematic that demonstrates the coverage of all sub-meters in the building on a single document, clearing demonstrating:

- The physical location of meters within the building i.e. which meters are installed in which switchboards / electrical boards etc. and;
- The location of all meters with respect to the electrical reticulation of the site; i.e. which loads are downstream of which meters

Generally, all-sub-meters are to be located at their respective distribution board and not at the main switchboard.

Electrical and hydraulic designers are to provide information required for co-ordination and documentation of the energy monitoring system.

3.6 Indoor Environmental Quality Control

The buildings are designed to accommodate various configurations and occupancy rates, which will determine both the maximum and minimum internal design configurations. The mechanical design will be required to accommodate all occupancy rates and maintain the design internal temperature and humidity set-points.

Outside air preconditioning and run-around coil systems are to be used to satisfy the building design internal conditions, to be used in conjunction with demand controlled ventilation to reduce outdoor air levels where possible, whilst maintaining adequate building pressurisation to reduce infiltration.

3.6.1 Climatic Design Considerations and Weatherproofing

The design and installation of the mechanical services for projects located in the Top End must make allowance for the severe climatic conditions prevalent in the Top End, and must incorporate the following design considerations:

- Cyclone resistant protection for external plant. For facilities with an operational requirement to be operational post-cyclone, all debris screens to be structurally designed and certified to resist airborne debris that can damage mechanical plant. For facilities with an operational requirement to be fully functional *during* a cyclonic event, design debris screens as above in conjunction with maintaining plant ventilation requirements at all cyclonic wind conditions,
- Limit or avoid roof penetrations. Requirement to flash back to the ridge line capping for any unavoidable roof penetrations. If possible, avoid box gutters within the external wall perimeter,
- Limit vapour barrier penetrations, or where unavoidable, design to allow for a mechanically fixed continuous vapour impermeable seal between the vapour barrier and the mechanical service,

- Wall louvres should be shielded from horizontal wind driven rain or employ the use of two/three stage weather louvres with integral rain gutters,
- The effects of a salt laden marine environment is exacerbated by high humidity and temperature, resulting in the need to select appropriate equipment and materials that resist corrosion from the effects of the adjacent marine environment.

Criteria applicable throughout the NT include:

- Prevention of cold tracking, surface condensation, moisture damage, mould and mildew between air conditioned and naturally ventilated spaces through the application of appropriate thermal and vapour barrier construction techniques to wall and roof elements,
- External shading of glazed facades and windows. Naturally, this is of particular importance on east and west facing facades to control the effect of solar glare to internal spaces in the morning and late afternoon,
- Intermittent power surges and power outages from the grid in the build-up and wet seasons, and dirty power sources in remote communities. Provide surge protection to MSSBs, and power filtration and UPS supplies to controls sub-boards,
- Plant located at ground level must be located on a concrete plinth not less than 150 mm above surrounding ground level,
- Provide access panels in ductwork immediately below the roof penetrations to allow inspection for moisture entry,
- Provide steel or aluminium alloy security bars or other effective means to prevent entry to the building via ventilation ductwork,
- Major items of external plant to be grouped and screened where visible from street sight lines and open spaces. Where accessible from public areas, provide a secure lockable enclosure with galvanised wire mesh roof, and
- Acoustically treat external plant as necessary to achieve environmental noise restrictions in accordance with the recommendations of the acoustic consultant.

3.7 Plant Accommodation

All mechanical services plant is to be accommodated within centralised internal plant rooms. Plant may be located in external plant areas only at the direction of the DLI representative.

Refer to the project specific requirements and/or the DLI representative for alternative plant accommodations outside of centralised plant areas.

Air handling plant ductwork is to be reticulated from the plant rooms through the building ceiling spaces, voids and risers.

3.7.1 Internal Plant Rooms

Internal plant rooms are to meet the following requirements:

- Access and maintenance space not less than:
    - that recommended by the equipment manufacturer, and

    - that required for compliance with work health and safety legislation, codes, and regulatory requirements.
- Access doors to plant rooms to be external where possible to minimise the need for maintenance personnel to enter the occupied building spaces,
- Acoustic treatment as necessary for noise control in accordance with recommendations by the acoustic consultant,
- Plant rooms are not part of a room used for other purposes,
- Plant room internal walls and ceilings to be provided with vapour barriers, and
- Provisions for bleed air from the air handling units to provide plant room conditions of no more than 27 °C DB, 60% RH (max).

3.7.2 External Plant Rooms

External plant must generally be located and configured to meet the following requirements:

- Plant to be located in a dedicated external plant enclosure, with the perimeter secured by fencing designed to meet the ventilation requirements of the plant contained within, and designed to conform to the security requirements of the project/site,
- Plant items designed to prevent pooling and ingress of water. Use only weatherproof plant that is specifically designed and recommended by the manufacturer for external use,
- Plant items designed to minimise ingress of dust, particularly in arid regions,
- Sensitive plant items (i.e. switchboards, modulation motors, pumps, BMS controls, etc.) to be located in areas with protection from extreme ambient conditions (particularly from adjacent sources of heat and humidity) and sunlight (ultraviolet light damage),
- No mechanical plant is to be located on the roof, except for exhaust fans,
- All access conforms to the latest work health and safety legislation and requirements,
- Platforms, walkways, stairs and ladders to comply with AS 1657,
- All materials and fasteners used are to be corrosion resistant,
- Platforms must be sized to allow access to all sides of plant for maintenance, and
- Where air handling units are located in walkways, the minimum height to the underside of the platform frame must be 2.4 m.

3.8 Noise Levels

All mechanical services systems must be designed to minimise the transmission of noise and vibration from air conditioning and mechanical ventilation equipment.

Where strict noise requirements are nominated in a project, noise levels for the selected areas of the building will be specified or will be determined by a nominated specialist acoustic consultant. This nominated specialist acoustic consultant will also provide advice in the following areas:

- Architectural acoustics,
- Noise control,
- Sound system design, and

- Structural vibration.

Specific initiatives must be developed in conjunction with the nominated specialist acoustic consultant.

Sound attenuators and/or attenuation-specific internal ductwork insulation must be installed where necessary to minimise the transmission of fan noise.

The requirements of AS 2107 must be strictly adhered to. Specifically comply with the design sound level ranges shown in **Table – Minimum Design Requirements for Noise Attenuation.**

Table – Minimum Design Requirements for Noise Attenuation	
Type of occupancy/activity	**Design sound level ($L_{Aeq,t}$) range**
Executive office	35 – 40
Open plan office	40 – 45
Board / conference rooms	30 – 40
Video/audio conference rooms	30 – 40
Consultation / surgeries / treatment / procedure rooms	40 – 45
Ward bedrooms	35 – 40
Teaching spaces (single classroom)	35 – 40
Lecture theatres	30 – 40
Interview / counselling rooms	40 – 45
Library – general areas	40 – 50
Library – reading areas	40 – 45
Corridors and lobbies	45 – 50

Note: The project specifications and/or room data sheets may require lower design sound levels than those specified in this table and AS 2107. Use the lower of the two specified sound levels, that is, provide the higher level of sound attenuation.

Ensure that the measured background levels are not exceeded at the boundary of any adjacent building or dwelling. Background level must be measured generally in accordance with AS 1055 using the statistically averaged LA_{eq} dB(A) for 90% exceedance level. The level must be determined for a sufficiently long time to be representative of the background at the time of noise impact. The minimum period is 10 minutes.

As an alternative to site measurement, the following "estimated" levels may be used:

- Single Dwelling (SD) /Multiple Dwelling (MD) residential: 50 LA_{eq} dBA from 7am to 10pm and 40 LA_{eq} dBA from 10pm to 7am.
- Medium Density (MR) residential: 55 LA_{eq} dBA from 7am to 10pm and 45 LA_{eq} dBA from 10pm to 7am.

A penalty of 5 decibels applies if there is modulation or tonality in the noise source and 10 decibels if both modulation and tonality are present.

The sound pressure level contribution from HVAC or associated equipment at any specific external activity area within the site such as play areas, sports areas, walkways, designated work areas etc. must not increase the background noise levels by more than 3dB(A).

3.8.1 Speech Privacy

Where speech privacy between rooms of lightweight construction and other spaces is required ensure that the Ceiling Attenuation Class (CAC) is at least 35 and the Dw is at least 45dB. Liaise with the architect, acoustic engineers and other building services designers to select and implement appropriate wall construction types to achieve the target design sound insulation.

3.9 System Ancillaries

All supporting hardware ancillaries to be used in Northern Territory Government projects are to conform to the following:

3.9.1 Piping, Valves & Fittings

Use the Master Specification for Major Building Works.

Specify all pipework to be of Type B Copper except condensate drains, which must be class 12 PVC.

Pipework within the building must be run in service ducts, risers, or ceiling spaces. Pipework must be easily accessible for maintenance or modifications.

For pipework in walkways the minimum height to the underside of the pipework and its support structures must be no less than 2.4m.

External, accessible pipework and other ancillaries must be provided with appropriate mechanical protection to protect against damage.

Unless otherwise directed by DLI, all copper pipework joints are to be silver soldered for permanent joints, or flanged joints for demountable joints.

Specify all underground pipework to have a minimum of 600 mm cover to topmost surface of pipe or pipes, and a minimum 150mm of pipe embedment (bedding, overlay and side support) consisting of washed river sand. Pipes must be laid to the requirements of AS/NZS 3500. Pipes must be laid side by side and not one above the other. Pipes laid in the same trench as electrical or data conduits must be separated in accordance with the requirements of AS/NZS 3000 and AS/NZS 3500. All underground pipework must be identified by laying continuous PVC detectable warning tape not less than 300 mm above the pipe. Specify trenches to be backfilled only with selected fill and compacted in layers not exceeding 200 mm to a relative density of 90%.

Valves must be of approved manufacture to conform to AS/NZS 4020 and must be located in easily accessible positions. Provide ceiling markers to easily identify the location of equipment above ceilings.

All valves must be accessible in concrete pits, which must be drained. All bolts, nuts, washers etc must be 316 stainless steel. Thrust brackets in pits must be hot dipped galvanised. Pipes must be sleeved where they pass through the pit wall. Identify all valve pits on the surface by a pre-cast concrete pillar with recess for reflective ‘V’ marker plate, which must be installed.

Specify ball or resilient seat valves be used throughout except where throttling for flow measurement is required in which case Tour and Anderson STAT and STAD or approved equal valves must be specified. Valves must be butterfly lever action if less than 150 mm DIA, or geared action for 150 mm DIA and above.

All valves must have extended shafts to accommodate complete insulation of the pipework. Valve actuators must have a reserve torque capacity of 25% from that nominated by the valve manufacturer.

Incoming mains and main distribution pipes must be installed of a size adequate to permit connection of future buildings or any expansion. The requirements are to be discussed with the DLI representative and generally follow the site master plan if available.

For pipes that pass through floors or walls specify sleeves filled with appropriate insulation or fire rated material to suit the application.

Specify suitably sized pipework risers within the building to service every building level. Provide dirt legs and drains at the bottom of each riser, fitted with hose cocks. Pipework risers must incorporate dedicated isolating valves at every building level take-off and at all other significant sub branch pipework runs. It must be possible to isolate each building level and sub branch without disrupting the chilled water service to other levels and sub-branches. Provide drains at the lowest points in the chilled water system on each building level. Automatic air bleeds complete with isolation valve and drains to the nearest waste must be provided at the highest point of any piping system.

All screwed valves and fittings must have unions for easy removal without requiring cutting of the pipework.

Fit Binder test plugs to all air-handling units, fan coil units, pumps etc. These must extend a minimum of 15 mm beyond the outside surface of the insulation. Binder test plugs must be located next to all DDC sensors for calibration and test purposes.

Chilled water thermal inertia tanks must allow for stratification and incorporate a well-designed diffuser for charging and discharging. Ensure that the Froude number is less than 0.5. Tanks must be able to withstand the full pump head.

3.9.2 Ductwork & Registers

Use the Master Specification for Major Building Works.

Main supply ducts must be capable of handling an increase of 15% in air quantity. Fans and motors should be selected with this in mind.

Ductwork, solid and flexible, must be constructed an installed in accordance with AS 4254. Flexible ductwork must be supported by packaging straps, buckles, and gutter guard saddles to suit the duct diameter. Gutter guard saddles must be not less than 300 mm long. Provide locking quadrants to all adjustable dampers including spigot and butterfly dampers.

Unless specified by DLI, alternative, non-sheet-metal ductwork materials such as rigid phenolic foam are not permitted.

Insulation to air conditioning ductwork must be applied to the internal surfaces of the duct. External insulation of ductwork may only be applied:

- Where outside air ductwork is located in conditions where the internal air stream humidity may condense on the inside of the duct,
- Where exhaust air ductwork is located in conditions where the ambient air humidity may condense on the exterior surface of the duct, or
- Where directed by the DLI representative.

Where ductwork is exposed to view in occupied spaces, all ductwork whether insulated, or uninsulated, must be spiral wound circular or oval duct. Where ductwork is exposed to weather, it must be profiled to shed water. Ductwork exposed above roofline excluding fume exhausts must be constructed from Colorbond sheet steel to match the roof colour. External ducts must be graded to prevent ponding and all joints must be sealed with a sealant.

Special consideration must be made to ductwork exclusively serving evaporative cooling plant. Subject to the approval of the DLI representative, ductwork hidden from view may be externally insulated, and ductwork exposed to view may be uninsulated. Acoustics and noise transfer from evaporative plant through ductwork must be carefully assessed where evaporative plant is used.

Specify all longitudinal joints to be the Pittsburgh type with a smooth interior finish.

Use TDF/ TDC (Transverse Duct flanges or Transverse Duct Connectors) for joining ductwork. Do not use slip joints.

Duct supports must not be used to support piping, ceiling, or any other loads additional to the ductwork.

The Installation of Duct Liners must comply with the requirements of AS 4254.2 and the NCC and:

- The insulating performance of the duct liner must comply with the requirements of the NCC.
- The liner surface designated to be exposed must face the airstream.
- The liner must be adequately retained within the duct by use of pins.
- The liner must be neatly butted without gaps at all joints.
- The liner must be folded and compressed in the corners of rectangular duct sections or must be cut and fitted to ensure butted edge overlapping.
- Longitudinal joints in duct liners must not occur except at the corners of ducts, unless the size of the duct and the standard liner's product dimensions make them necessary.

Provide duct access panels in the risers at each floor and in each branch or sub-branch for cleaning purposes. Duct access panels must not be more than 10 metres apart. Duct access panels minimum size 300 x 200 mm may be 'Bullock' brand and the location of access panels above ceilings must be coordinated with the ceiling grid, light fittings and equipment layout.

Ceiling registers must be of the square louvers-faced type of 'Air Diffusion', 'Holyoake' or other approved manufacture, with removable cores. The interior of ductwork behind registers should be painted black.

Wall registers must be of the adjustable blade type with the front set of blades horizontal. Maximum blade spacing is 20 mm.

Ceiling-mounted exhaust and return air grilles are to be eggcrate-type.

Wall-mounted exhaust and return air grilles that are inaccessible by occupants are to be square or rectangular half chevrons with removable cores.

Wall-mounted exhaust and return air grilles that are accessible by occupants are to be linear bar grille type.

Ensure the ductwork behind wall grilles are accessible for cleaning while ensuring that grilles accessible by occupants remain tamper-proof.

Exhaust and return air grilles may have alternative selections for aesthetic and/or performance reasons; Consult the project brief and/or refer to the Superintendent to obtain the specific design requirements.

Ductwork penetrations to walls and floors must be packed with an approved insulation (fire rated in a fire rated wall, ceiling, or floor) and must be flanged on both sides of the penetrations. Flexible ducts must be sleeved where they penetrate full height walls.

Where required, provide details for all duct penetrations and cushion heads passing through walls and ceilings with special requirements (such as fire rated security walls and ceilings).

Outside air intakes must be provided with easily removable media filters to pre-filter the air before it enters the unit(s). Outside air grilles must be anodised aluminium, coating thickness minimum 20 microns, colour to match the exterior colour scheme of the building. Do not use Colorbond for outside air grilles. Provide removable vermin mesh behind all external louvers. Outside air ductwork located in conditioned space must be insulated externally to avoid condensation.

Secure areas may require the use of anti-ligature grilles and/or reinforced perforated diffusers. Ensure that noise and pressure drop objectives are met, and installation requirements are allowed for during system design. Consult the project brief and/or refer to the Superintendent to obtain the specific design requirements.

3.9.3 Insulation to Pipework

Use Master Specification for Major Building Works.

Factory pre-insulated pipework systems are preferred to ensure uniform thickness of insulation and to avoid voids within. All site-applied insulation used in conjunction with pre-insulated systems must utilise pressure-injected foam application methods.

Where factory pre-insulated pipework systems are unavailable, chilled water pipework must be insulated with preformed, polystyrene insulation in accordance with AS 1366 Part 3, complete with vapour seal. Insulation must be factory faced with ‘Sisalation 450’ (extra heavy duty grade) and must be glued to the pipework and between all mating surfaces using ‘Fosters 252WB’ adhesive and further secured with nylon straps. Oversized sections must not be used. All joints must be overlapped and sealed using ‘Precision 493’ (or approved equal) foil tape. Insulation valves, flanges and fittings must be arranged for easy removal for maintenance purposes and must have hinged and clipped (not screw fixed) casings.

Insulation R-Value to chilled water pipework generally to conform to NCC Section J Table J5.8a.

Chilled water pipes which are run underground can be direct buried but must have a ‘HDPE’ outer layer. Pipework exposed to the weather must be clad with galvanised steel sheathing and painted where exposed to view.

The sealing of joints must not be over compressed as this reduces the R-value of the insulation and can lead to points where mould-causing condensation can form.

Condensate drains must be continuously insulated with approved elastomeric closed cell insulation, minimum 19 mm wall thickness equivalent to ‘Armaflex’. All joints must be glued with approved adhesive in accordance with the manufacturer’s recommendation.

Where future buildings are planned, provide valved take-offs located in service pits for future connection. Service pits must be located adjacent future building sites. Pipework must be sized to accommodate future buildings as indicated on the site master plan and anticipated natural expansion.

3.9.4 Pumps

Pumps must be close-coupled, Back-End-Pull-Out type wherever possible, 'Ajax 2000 Series' or 'Southern Cross'. Impellers must be bronze, casings gunmetal and shafts etc stainless steel. Chilled water pump selection must be based on suitability to the duty. The pump casing and electric motor must be sized to accommodate an impeller two standard sizes larger than selected. Stainless steel drip trays are to be mounted on concrete inertia bases complete with spring mounts.

In all cases, dual pumps must be provided complete with variable speed drives (VSD) for balancing or controlling purposes. Each secondary/tertiary chilled water pump must be sized to accommodate 100% of the required design water flow.

When pumps are arranged in a parallel configuration for staged operation, ensure that a minimum of 70% of total design flow can be sustained with the loss of any one pump.

3.9.5 Motors

Motors must be totally enclosed fan cooled and normally be limited to 1450 rpm maximum. Motors must have an IP56 rating. Belts, pulleys, and couplings must be protected by the use of easily removable and replaceable guards. Motors rated at more that 10kW must be provided with a lifting eye. All motors rated at 5.5 kw and above must be of the Premium Efficiency type ('TECO Max-E2' or equivalent).

3.9.6 Heater Banks

Do not use electric heater banks. Where reheat is required for humidity control, consider the use of heat recovery from chillers and other cogeneration options.

4 Design Criteria

Design conditions for the project heat load calculations must be based on the data set out below:

4.1 Design Conditions

In general terms, the system will need to perform to achieve the imperatives of design consistent with the following:

Summer Conditions (Darwin):

- Outside: 35.0 °C DB, 28.0 °C WB
- Inside: 24 °C (set point) DB, 60% RH (max)

Summer Conditions (Katherine):

- Outside: 39.3°C DB, 27.9°C WB
- Inside: 24 °C (set point) DB, 60% RH (max)

Summer Conditions (Alice Springs):

- Outside: 40.7°C DB, 22.9 °C WB
- Inside: 24 °C (set point) DB, 60% RH (max)

Winter Conditions (Alice Springs):

- Outside: 1.1°C DB
- Inside: 22°C DB, 50% RH (max)

The above set points apply to offices, laboratories, classrooms, patient care areas, lecture theatres etc unless other specific conditions are stipulated in the Brief. All set points for temperature control are to be adjustable over the range of 18°C to 28°C. Set point minimum temperature for cooling must be 22°C. The set point is to be determined by DLI. An adjustable dead band of at least 2°C must be provided across the set point.

Preliminary design reports must state what consideration has been given, in the design, to the consequences of abnormal ambient conditions for extremes, separately of dry bulb temperature and absolute humidity, with consideration to recent trends in frequency of occurrence of abnormal extremes and projected future abnormal extremes.

Katherine and its surrounds have no requirements for winter heating for items of plant operating for 10 hours or less daily.

It is a requirement to specifically assess and provide options for upper limit humidity control in the design development report.

The selected heat exchangers for air handling systems must be able to achieve peak load cooling capacity at elevated chilled water temperatures to improve chiller energy efficiency.

4.2 Internal Heat Gains

Design to the furniture, fixture and equipment list, and room lighting specifications in the room data sheets. For mechanical projects not involving internal fitouts and/or new internal equipment, conduct a site survey of all electrical and heat emitting equipment.

In the absence of detailed equipment layouts and heat rejection quantities, the cooling load calculation must include a 15 W/m^2 allowance.

4.3 Population Densities

Where no specific occupancy rates have been nominated, use the greater of the density levels listed in Table D1.1 of the NCC, or the density levels of Minimum Effective Outdoor Airflow Rates Table of AS 1668.2, in the Minimum Effective Outdoor Airflow Requirements Based on Occupancy appendix.

4.4 Hours of Operation

Unless specifically requested, it can be assumed that the plant will operate Monday to Friday from 0800 hours to 1700 hours, excluding public holidays, through a time switch incorporating a 365 day calendar function. For schools the programming must exclude all school holidays. Unless specifically requested otherwise, after-hours push button time delay must be 2 hours.

Liaise with the other disciplines to ensure the building structure and all services co-ordinated, including any 24-hour operational requirements of the building, and including full vapour barrier detailing.

4.5 Outside Air

Design generally in accordance with AS 1668.2, including the multiple enclosure rule, and incorporating the following:

- 7.5 L/s/person in occupied areas to determine area maximum, when used in conjunction with the filter performance rating conditions described below.
- The greater of 0.35 l/s/m2 or 0.5 air changes per hour (ACH) to determine area minimum, to satisfy AS1668.2, minimum requirements and building pressurisation. This rate is to be net positive airflow, taking into account make up air for exhaust systems.
- Outside air must be filtered with deep-bed filters of minimum performance rating of F5 in accordance with section 2.8.2(b) of AS 1668.2, to allow the above reduction in design outdoor air rates.

  Note: This reduction does not apply to 100% outside air supply systems.
- Apply demand controlled ventilation techniques to air conditioning systems. Modulate outside air to maintain a CO2 concentration of 800 ppm.

4.6 Exhaust ventilation

Design to AS1668.2 requirements of 10 L/s/m^2 or 25 L/s/fixture (whichever is greater) for all ablution areas.

Designers are required to assess whether excessive heat, steam and odour levels will be generated (ref. AS1668.2 clause C3.2.1): design to 30 ACH for steam/water vapour issues; and 20 ACH for odour issues.

4.7 Chilled Water Temperatures

For design purposes, unless specified by DLI, the following chilled water temperatures may be assumed as the general design criteria:

- Supply Water Temperature 7°C
- Return Water Temperature 13°C

4.8 Cooling Loads

Cooling loads must be calculated using proprietary software such as ACADS-BSG CAMEL or Carrier HAP. The calculations must assess the internal cooling loads and ventilation requirements and other relevant heat gains for each space.

A safety factor of 10% to the cooling loads must be applied.

5 Scope of Deliverables

5.1 General

Provide the mechanical services design documentation consistent with the following description.

5.2 Preliminary details

Submit preliminary concept documentation consistent with the requirements listed under the First Submission (25% Design) section.

Approval must be obtained to proceed to design documentation stage.

Review comments must be taken into account by the consultant designer. The review comments may constitute an indication that the design is to be adjusted and resubmitted.

If the consultant designer considers incorporation of changes indicated in the review comments will be inconsistent with the objectives of the specification the consultant designer must provide details of the perceived inconsistencies to the Superintendent.

If the consultant designer considers incorporation of the changes indicated in the review comments will fall outside the scope of works the consultant designer must provide details of the perceived changes to the scope of works to the Superintendent.

The consultant may submit a request for variation to the contract where the reviewers' comments indicate changes to the scope of works/objectives of the specification. Any request for variation to the contract is to be negotiated with the Superintendent.

5.3 Review Submissions

Unless otherwise indicated by the Superintendent or the project scope documentation, submit documentation consistent with the requirements listed under the Second Submission (50% Design), Third Submission (75% Design), Fourth Submission (95% Design) and Final submission (100% Design) for review.

Approval must be obtained by the Superintendent to proceed to each subsequent design stage.

5.4 Mechanical Tender Specification

Modify the default mechanical NATSPEC tender documentation to suit the project scope of work:

- Refer to the NATSPEC guide notes for information on clauses that require specific conditions for completion or deletion (use the Show Formatting Marks function in Microsoft Word to view the guide notes)
- Delete clauses and sections that are not applicable to the works
- Complete/delete the information where *[enter value]* or *[complete/delete]* appears
- The MECHANICAL SYSTEMS work section is intended for design and construct and early contractor involvement projects only. Delete the work section for design and document projects.

5.5 Workshopping

Where documented or requested by any of the Superintendent, client, or consultants, convene a workshop to resolve any issues of query, concern or conflict.

5.6 CAD Drawing Requirements

All Mechanical CAD Drawings are to conform to the following:

- Must adhere to the DLI Documentation manuals - NTG technical drawings - Part 1 - Requirements for technical records management and Part 3 – Documentation manual for buildings

  (available from https://DLI.nt.gov.au/industry/technical-standards-guidelines-and-specifications/technical-records)
- Must contain part 1 of the DLI Mechanical Standard Notes (to be supplied by DLI Mechanical)
- Must contain the DLI standard mechanical details, where applicable to the project
- May contain the supplementary Standard Notes, to be used when applicable

5.6.1 Drawings in Colour

This section is to take precedence over section 4.3 – Coloured on Drawings in the DLI Documentation manuals - NTG technical drawings - Part 3 – Documentation manual for buildings

The use of colour in mechanical drawings is discouraged and is subject to the restrictions set out below.

Where colour is used, ensure that the colour used can be clearly reproduced in black and white and the intended information on the drawings is not lost through the process.

The following is a list of accepted applications for colour on drawings without restriction:

- 3D Perspective render for illustrative purposes
- Site Plan
- Photographs (where required)

For all other applications, the conditions for using colour in drawings is as follows:

- The content of drawings, when plotted from AutoCAD/Revit in black and white, or when printed in greyscale from a PDF generated in colour:
  - Must be legible and easily distinguishable; and
  - Must not result in large areas of solid black/grey when plotted in black and white/greyscale.
- The instruction to print drawings in colour is not to be compulsory. Do not place “Print in Colour” stamps or insert instructions to print in colour on the drawings or in the tender documentation.
- Where transparency filters are used, all lines and hatches shall be clearly visible when printed and where applicable reduced from A1 to A3.

5.6.2 Drawing Sizes

All mechanical drawings are to be plotted in A3, unless:

- The mechanical drawing set is a component of a multidisciplinary project, and the project lead documentation is A1; or
- As directed by the Superintendent.

The legibility of text in drawings at A1 must be maintained when the drawings are plotted/reproduced in A3. Refer to Table 1 in NTG Technical Drawings – Part 3.

5.7 Design and Construct – Preliminary Submissions and As-Constructed Submissions

Conform to the requirements in this work section and the requirements in the Master Specification for Major Building Works. As-Constructed CAD Drawings must comply with the CAD Drawing Requirements section.

5.8 Other Submissions

Unless directed by DLI, the following are the minimum required details to be described in the design submissions:

- Calculations
- Electrical Loading Information for Mechanical Services
- Mechanical Services Detail Drawings
- Technical Data
- Control Functional Descriptions

5.9 Calculations

Submit calculations as documented including:

- Building heat loads, conforming to ACADS-BSG CAMEL or similar and approved
- Fan and ducting system head losses
- Water pipework system pressure losses
- Radiated sound pressure levels
- Plant room sound transmission
- Electricity and chilled water maximum demand calculation, calculation consistent with peak thermal delivery demand.

5.10 Certification

Submit certification that the proposed plant and equipment meets the statutory and design requirements of the contract documents.

5.11 Electrical Loading Information for Mechanical Services

Submit electrical loading information for all proposed equipment.

5.11.1 Loading and connection

Submit the information for items not supplied from the services switchboards.

5.11.2 Starting characteristics

Submit details for motors with reduced current starting. Make sure starting characteristics are within the characteristics of the respective submain protection devices.

5.11.3 Switchboards

Submit the following information for each building services switchboard:

- Board location and designation.
- Single line diagrams
- For each submain connected to the board, submit the following for each item connected to it:
    - Submain designation.
    - Item designation and name.
    - Power rating in kW.
    - Number of phases.
    - Full load amps per phase.
    - Power factor.
    - Total amps on each phase for respective submain.

5.12 Mechanical Services Detail Drawings

Submit the following detail drawings at minimum 1:100 scale, showing:

- Fire and smoke dampers.
- Floor wastes.
- Ductwork, plinths, pipework, and equipment layouts and sections. Show the location of fire-resisting building elements.
- Diffuser, grille, terminal, and reference numbers corresponding to identification and design values. Key performance data include, but are not limited to, capacity (L/S) master power, and speed.
- Riser layouts, and sections.
- Plant room layouts, and sections including maintenance clearances, door swing clearances, and end-of-life plant replacement clearances and pathways.
- Locations of automatic control sensors, motors, and valves.
- Acoustic details.

- Plant construction details.
- Seismic restraint details.
- Provisions for access for maintenance and removal of components
- Lifting provisions for heavy items.
- Piping and other schematic drawings
- Underground pipe trenching details
- Submission drawings required by authorities.
- Connections to other services.
- Switchboard details.
- Single line diagrams of all mechanical-electrical services.

5.13 Technical data

5.13.1 General

Documented fan pressures and pump heads are to be based on provisional equipment selections and estimated pressure drops.

5.13.2 Equipment

Calculate the respective system pressure losses based on the equipment proposed and layouts shown on the design drawings and submit the proposed selections.

5.13.3 Submissions

Submit technical data for all items of plant and equipment.

5.13.4 Data to be Submitted

As a minimum provide schedules giving information about all proposed items of plant and equipment.

For each item proposed the information provided must include, but not be limited to:

- Make
- Model name, designation, and number
- Size, including required clearances for installation
- Capacity of all system elements
- Performance characteristics related to all inputs, all outputs, and all the functions of the item
- AHRI full load and Integrated Part Load Value energy efficiency characteristics of proposed item and/or system
- Refrigerant type, Global Warming Potential and kilograms of charge
- Proposed location
- Country of origin and manufacture

- Materials used in the construction
- Certification of conformance to the applicable code or standard
- Assumptions
- Calculations
- Technical data schedules
- Manufacturers' technical literature
- Type-test reports
- Other information listed in this Minimum Design Standard as being required

5.13.5 Control Functional Descriptions

Submit descriptions of control sequences. Maintain as a working document with current sequences throughout the course of design.

ATTACHMENT – EXAMPLE REFRIGERANT CHECKLIST TEMPLATE

	Refrigerant checklist			Info to be completed
1	Project number			
2	Project name			
3	Project location			
4	Installation indoors or outdoors			
5	Equipment type			
6	Equipment manufacturer			
7	Equipment model number			
8	Equipment refrigerant	R-???		
9	Refrigerant type (HFO/HFC/HC/Inorganic)			
10	Refrigerant class - toxicity (A/B)			
11	Refrigerant class - flammability (1/2/2L/3)			
12	Refrigerant Global Warming Potential (GWP)			
13	Does refrigerant contain PFAS?		Y or N	
14	Refrigerant charge		kg	
15	Does equipment comply to relevant Australian standards?	AS/NZS5149.2 AS/NZS60335.1 AS/NZS60335.2.40 AS/NZS60335.2.89 Other relevant AS/NZS		
16	Does charge exceed permitted charge limit?	AS/NZS5149.1	Y or N	
17	If 16 = Y, has additional ventilation been provided?		Y or N	
18	Are refrigerant leak detectors required?	AS/NZS5149.3 AS/NZS60079.10.1	Y or N	
19	If 18 = Y, have these been included?		Y or N	
20	If installed indoors, is adequate ventilation provide	AS/NZS5149.3	Y or N	
21	Has a risk assessment been prepared for the site, covering			
22	- toxicity / asphyxiation risk	AS/NZS5149.3	Y or N	
23	- flammability risk	AS/NZS60079.10.1	Y or N	
24	What is availability of 100% refrigerant charge replacement in NT?		days	
25				
26	Checklist completed by			
27	Name (print/type)			
28	Company			
29	Signature			
30	Date			