

LAS GROUP / QUALITAS

ONE WELLINGTON

8-12 PUNT RD & 3-7 WELLINGTON ST

ST KILDA VIC 3182

MECHANICAL SPECIFICATION

NOVEMBER 2018



Question today *Imagine tomorrow* Create for the future

One Wellington
8-12 Punt Rd & 3-7 Wellington St
St Kilda VIC 3182
Mechanical Specification
LAS Group / QUALITAS

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1 PROJECT INFORMATION

1.1 GENERAL

The project is a new residential development, named ONE WELLINGTON, located at 8-12 Punt Road, St Kilda, Victoria.

The project delivery being *design and construct* has been adopted for this project.

This Technical specification is to be read in conjunction with other tender documents issued by the (Project Manager) including:

- Conditions of Tender
- Conditions of Contract
- Contract Preliminaries
- This Specification is a technical specification and for the purpose of this Technical Specification, Works shall mean all works or work as described in this Specification and/or associated drawings

1.2 PROJECT TEAM

The Project Team includes the following team members:

PRINCIPAL/CLIENT	LAS Group / QUALITAS
PROJECT MANAGER	PDS Group
CONTRACTOR	The company who undertakes the Works
ARCHITECT	Plus Architecture
CONSULTANT ENGINEER (MECHANICAL, ELECTRICAL, VERTICAL TRANSPORTATION, FIRE PROTECTION, HYDRAULICS)	WSP Australia Pty Ltd
STRUCTURAL ENGINEER	Webber Design
FIRE SAFETY ENGINEER	RED Fire Engineers
BUILDING SURVEYOR	Philip Chun Building Surveyors
SUSTAINABILITY CONSULTANT	WSP Australia Pty Ltd
ACOUSTIC ENGINEER	Renzo Tonin & Associates

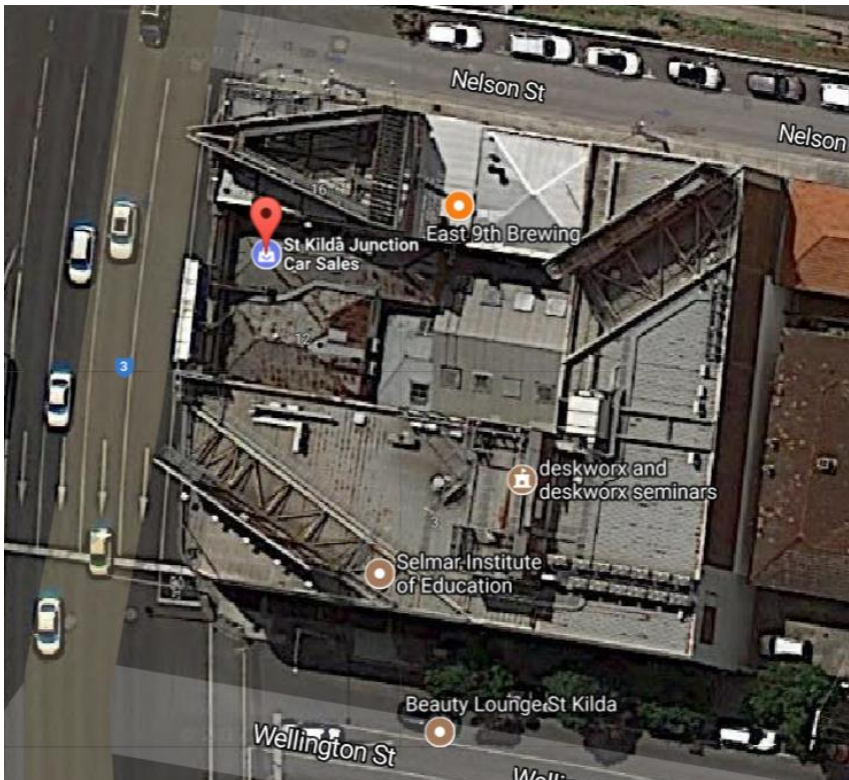
1.3 THE PROJECT DESCRIPTION

1.3.1.1 GENERAL DESCRIPTION

The project site currently consists of a low-rise office development and a car sales retail business. The existing site will be cleared to make way for the new development. The site is bounded to the North West and East by existing buildings. To the North a pedestrian laneway connects Nelson Street St and Punt Road. To the South is the Wellington Road frontage. New development is expected to contain the following attributes:

- a. Two 12 and 26 story residential towers.
- b. Approximately 252 residential units between the two buildings
- c. Three levels (B1 to B3) basement car parks.
- d. 2Nos food and beverage type tenancies in the Ground floor.
- e. Communal areas (Gym, Pool, Lounge, Dining spaces, Yoga room, Study room etc).

1.3.1.1 LOCATION



1.3.1.2 UTILITIES

The following utilities are relevant for this project;

- Electricity - Citipower
- Gas – Multinet / Origin
- Water – South East Water
- Sewer – South East Water

- Telecommunications – NBNCO or equivalent
- Fire Authority (name) - MFB

2 GENERAL REQUIREMENTS

2.1 GENERAL

2.1.1 DEFINITIONS

Unless the context otherwise requires, the following definitions apply:

Supply: 'Supply', 'furnish' and similar expressions mean 'supply only'.

Provide: 'Provide' and similar expressions mean 'supply, deliver and install' and include all testing, commissioning, tuning, interfaces etc.

Proprietary: 'Proprietary' means identifiable by naming manufacturer, supplier, installer, trade name, brand name, and catalogue or reference number.

Samples: Includes samples and prototypes.

Zinc-coated steel: Includes zinc-coated steel, zinc/iron alloy-coated steel and aluminium/zinc-coated steel.

2.1.2 SPECIFICATION OBJECTIVES

The intent of this Specification is to:

- 1 Provide a basis for competitive tendering for suitably qualified tenderers.
- 2 Allow competent Contractors to price the works.
- 3 Provide a clear statement of technical and performance requirements against which compliance can be assessed.
- 4 Provide documentation required by Authorities to demonstrate design compliance with statutory requirements for the purpose of building permit application.
- 5 Provide documentation detailing the scope and quality of the project for the purpose of Client's confirmation of compliance to the Client's project brief.
- 6 Define the requirements of the Contractor with respect to Quality Assurance.
- 7 Define the scope of services including project management, installation engineering, testing commissioning, maintenance and documentation to be provided.
- 8 Specify the technical requirements of the Installation.
- 9 The Specification relies upon the Contractor having the necessary specialist services resources to complete the detailed design, testing and commissioning of the installation in accordance with the design intent and the requirements of the specification and drawings.

2.1.3 DESIGN INTENT

- 1 Intent: The Contract documents are intended to call for complete, operational systems. Provide all items (major and minor), equipment, accessories and incidental work required for the completion of the installation and to ensure full integration.
- 2 Diagrammatic layouts: Layouts of service lines, plant and equipment shown on the drawings are diagrammatic only, except where figured dimensions are provided or calculable. Before commencing work, inspect the site, obtain all necessary measurements and information.

2.1.4 DISCREPANCIES IN DOCUMENTS

Give immediate notice in case of any ambiguity, discrepancy or inconsistency in the Contract document. Should conflict arise between the requirements of specification, drawings, mandatory requirements, standards including Standards Australia Codes, then the higher standard or most stringent requirements shall prevail and shall be deemed to have been included in the Contract. The Contract's order of documents precedence is not intended and shall not be applicable in this case

2.1.5 REFERENCED DOCUMENTS/STANDARDS

Use referenced documents/standards which are editions, with amendments, current 3 months before the closing date for tenders, except where other editions or amendments are required by Statutory Authorities.

2.2 QUALITY ASSURANCE

- 1 Provide a Quality Assurance plan in order to propose, establish, maintain, monitor and document a quality assurance system covering all aspects of the design, purchase, fabrication, installation and completion of the works. The plan shall be in accordance with ISO 9001/.2 (as appropriate).
- 2 Designate a Project Quality Inspector to discharge the quality plan, which must include the following minimum:
- 3 Inspect the installation works regularly and provide installation defects reports on regular basis in order to systematically reduce the incidences of installation defects. Submit copy of such defects lists to the Consultant Engineer upon request. This task can be delegated to qualified site foreman if applicable.
- 4 Check and sign off all shop drawings (including all third-party shop drawings) for conformance to requirements prior to submission. All such documents shall list all non-conformances with the Specification and Drawings.
- 5 Check and sign off equipment compliance schedule against the particular Specification requirements and equipment schedules prior to submission. All such documents shall list all non-conformances with the Specification and Drawings.
- 6 Check and sign off all samples for conformance to requirements prior to submission. All such documents shall list all non-conformances with the Specification and Drawings.
- 7 Check all tests required for proper manufacturing of the equipment.
- 8 Check and sign off all manufactured items for compliance prior to dispatch to site.
- 9 Check and sign off installation of all items under this Specification and Drawings. Provide signed off installation ITPs for every elements of installation (minimum floor by floor and/or for every individual area up to 1000sqm whichever is smaller).
- 10 Check all materials, welding, joining, terminations, fixing and finishes.
- 11 Check and sign off all associated ITPs for all on-site tests required to commission the works.
- 12 Check and sign off operating and maintenance manuals to ensure they contain adequate information to permit systems to be operated by the Client at the end of defects liability period. (Including adequate training and tuition of the nominated Client's representative).
- 13 Check and sign off all associated integrated ITPs for all integrated on-site tests required to commission the works and to be carried out by various systems.
- 14 All trades works including sub trades works shall form part of overall QA and required to have their ITPs, Shop drawings, technical submissions signed off also by the Project Quality Inspector. This sign off represent all required checking that these works are consistent and compliant with the rest of the works.

15 Submit the following documentation:

- a** Quality System third party certification, if any, to the Standards specified by the Joint Accreditation System of Australia and New Zealand.
- b** Quality manual detailing, corporate Q.A. policy statement, system element description, register of procedures and project specific ITPs.

16 Notice:

- a** Inspect witness points: If notice for inspection is to be given in respect of parts of the works, advise if and when those parts are to be concealed. Inspect and provide signed off installation ITPs indicating appropriate methods of installation been carried out.
- b** Inspection hold points: If notice of inspection is to be given in respect of parts of the works, do not conceal those parts without approval.
- c** Minimum notice for inspections to be made: 4 hours for inspections full time on-site, otherwise 2 working days for on-site inspections, and 5 working days for local pre-delivery inspections.
- d** Concealed services: Give notice so that inspection may be made of services to be concealed. Irrespective of Consultant Engineer inspection, inspect the works, sign off relevant ITPs and highlight any noncompliance and/or defects.

17 Witness tests: Give sufficient notice so that designated tests may be witnessed.

- a** Minimum notice for tests to be witnessed is 5 working days for site tests; and 10 working days for local pre-delivery tests.
- b** Test hold points: Do not carry out designated tests without approval.

18 Testing Authorities:

- a** General: Except for Site Tests, have type tests carried out by authorities accredited by NATA to test in the relevant field, or an approved organisation outside Australia recognised by NATA through a mutual recognition agreement. Co-operate as required with testing authorities.
- b** Site tests: Use instruments calibrated by authorities accredited by NATA.

19 Reports:

- a** General: Submit copies of test reports, including certificates for type tests, showing the observations and results of tests and compliance or non-compliance with requirements.
- b** Submit Installation Defects Reports carried out on regular basis to the Consultant Engineer upon request.

20 Concealment:

- a** If tests are to be carried out on parts of the work, do not conceal those parts and do not commence further work on those parts until the tests have been satisfactorily completed and compliance verified.

2.3 ELECTROMAGNETIC COMPATIBILITY

1 Comply with Australian Communications Authority requirements for electrical and electronics products to limit electromagnetic interference (EMI).

2 Emissions:

- a Passive products with C-tick or Regulatory Compliance Mark (RCM) to AS/NZS 4417.3, marking of electrical products to indicate compliance with regulations – Specific requirements for electromagnetic compatibility regulatory applications.
- 3 Immunity:
- a Electrical and electronic apparatus: To AS/NZS 4252.1, Electromagnetic compatibility – Generic immunity standard – Residential, commercial and light industry (EN 50082-1), or
 - b EN 5008-2, Electromagnetic compatibility – Generic immunity standard – Industrial environment.
- 4 Harmonics:
- a Levels of emissions shall be in accordance with the electricity Distribution Code. Keep the THDI current to 5% Maximum for all individual components/equipment and at least to that level at the first supplying control panel for all components/equipment connected to the switchboard. Provide active harmonic filters within the component, or respective control panel. Do not rely on the external harmonic filters to be installed on the Main Switchboard(s). Refer to the remaining sections for more specific requirements. Chillers and large motor >10kW with VSDs requires dedicated harmonic mitigation measures to be effective at all operating levels (i.e. from no load to full load range)

2.4 BUILDING PENETRATIONS

2.4.1 FIRE RESISTING BUILDING ELEMENTS

- 1 Seal penetrations to comply with NCC using a system to AS 4072.1, Components for the protection of openings in fire-resistant separating elements – Services penetrations and control joints.
- 2 Comply with Section 3 of AS/NZS 1668:1, Fire and Smoke control in Multi Compartment Buildings.

AS4072.1 inter-alia Appendix B and AS1851 inter-alia Clause 17.2.3.1 shall be complied with in as-built documentation to identify all fire and smoke containment compartment walls and barriers. To satisfy specific identification requirements to AS4072.1 Appendix B4 and AS1851 Clause 17.2.4, permanently fixed labelling, tagging and signage of all passive fire and smoke containment systems must be provided for on-site identification. Fire stopping barriers and penetrations shall comply in particular with reference to a service label affixed adjacent to each fire stop barrier and service penetration (or close proximity group) as detailed on page 25 of AS4072.1 and page 165 of AS1851. This as-built provision amongst other as-built documentation and manuals is essential as part of handing over process of the project.

2.4.2 NON-FIRE RESISTING BUILDING ELEMENTS

- 1 Seal penetrations around conduits and sleeves. Seal around cables within sleeves. If the building element is weatherproof, acoustic rated or subject to pressure, maintain the rating. Acoustically seal penetrations through plantroom walls and floors.

2.4.3 CHASES

- 1 Cut, drill and chase as necessary, where possible avoiding finished work. Where chasing of finished work is essential, make good all damage to the original standards of the finishes.

2.4.4 LIMITATIONS

- 1 General: Do not penetrate, or chase the following without approval:
- 2 Structural building elements including external walls, core walls, fire walls, floor slabs, beams or columns.
- 3 Acoustic barriers.

- 4 Other building services.
 - 5 Membrane elements including damp-proof courses, waterproofing membranes and roof coverings.
 - 6 Membranes: If approval is given to penetrate membranes, provide a waterproof seal between the membrane and the penetrating compound.
-

2.5 REQUIRED SUBMISSIONS

- 1 Provide in good time to allow review without impediment to the programme, including possible amendment and resubmission: -
 - a Copies of correspondence and notes of meetings with Authorities.
 - b Documents showing approval of the Authorities whose requirements may apply to the work.
 - c Certified schedule of compliance for all plant and equipment, prior to placing orders.
 - d Factory test results where applicable.
 - e All product data, performance test and commissioning results required by this Specification.
 - f Shop drawings for fabrication and installation of all equipment and items supplied.
 - g Manufacturer's product data for equipment, materials, components and systems including:
 - i Technical specifications and drawings.
 - ii Size, arrangement, operating and maintenance clearances.
 - iii Operating weight.
 - iv Type test reports.
 - v Performance and rating curves or tables marked with each selection showing for both duty point and for part load conditions the capacity; the energy consumption and power factor; and the sound power level.
 - vi Motor power requirements (both full load and starting).
 - vii Control details.
 - viii Recommendations for installation and maintenance.
 - ix Evidence of compliance with specified product certification schemes.
 - h Inspection, test and commissioning plans for every section of the works. Detail:
 - i The procedure of how to complete the task.
 - ii The skill or competency of the person undertaking the works.
 - iii The review or testing procedure to assure satisfactory completion of the task.
 - iv The person within the Works Package's organisation authorised to sign-off the task as accepted.
 - i Client handover/training proposals.
 - j Record and installation drawings: Record all changes to equipment and services layouts, wiring and any other items during the construction period, which may have been incorporated into these works.
 - k Operating and Maintenance manuals.
 - l Maintenance/service records during the defects liability period.

- 2 Give notice before commencing work affected by the submissions, unless the submissions have been reviewed with no exception taken.
- 3 Do not commence production of equipment, materials, components of equipment, components or systems until submission has been reviewed with no exception taken.
- 4 Maintain and submit monthly a schedule of shop drawings and submissions to identify all proposed drawings and submissions designated in the following categories:
 - a Accepted.
 - b Submitted, awaiting acceptance (with submission date and revision number).
 - c Not yet submitted.
- 5 Submit electronically (PDF or alternative agreed format).
- 6 Identify the project, Works Package, supplier/manufacturer, applicable product name, product number, included product options, and relevant specification references.
- 7 Where selected equipment or systems do not fully comply with this Specification and associated documents, submit details of proposed deviations for acceptance. Where such deviations require any changes to the structure, building works or services, these shall be provided by the Contractor without variation to the Contract. Apart from deviations listed, it will be taken that the materials and equipment proposed meets with all other specified requirements. Review of equipment and materials is undertaken on this basis, and that non-complying equipment/materials may be rejected at any time – even if already installed.
- 8 Submit amended documents as appropriate, highlighting changes since the previous submission.

2.5.1 SAMPLES

2.5.1.1 TIMING

- 1 Co-ordinate submissions of samples as listed in the Schedules. Do not cause delays by making late submissions or submitting inadequate samples.

2.5.1.2 QUANTITY

- 1 Submit a sample of each designated item and 2 copies of supporting documentation. Include ancillary items such as fasteners and mounting brackets. Amend and resubmit samples which are not accepted.

2.5.1.3 IDENTIFICATION

- 1 Identify the project, Contractor, their agents or supplier, manufacturer, applicable product, model number and options, as appropriate and include pertinent Specification references.
- 2 Include service connection requirements and product certification.
- 3 Identify non-compliances with project requirements, and characteristics that may be detrimental to successful performance of the completed work.

2.5.1.4 SAMPLE ACCEPTANCE AND RETENTION

- 1 Do not commence work affected by samples until the samples have been accepted. Submit further samples as necessary.
- 2 Keep approved samples in good condition on site, until Practical Completion.
- 3 Incorporate in the works samples, which have been approved for incorporation. Do not incorporate other samples.

- 4 Installed items will match accepted samples throughout the works.
-

2.6 MATERIALS, EQUIPMENT AND COMPONENTS

2.6.1 GENERAL

- 1 Provide new materials, equipment and components shall be new, of good quality and fit for purpose, selected for a reasonable service life. Do not provide without approval products that are obsolete, discontinued or about to be discontinued.
- 2 Identification of a proprietary item does not necessarily imply exclusive preference for the item so identified, but indicates a deemed to comply item.
- 3 Manufacturers: Provide equipment and associated accessories which are the products of established manufacturers regularly engaged in the manufacture of such equipment, who issue comprehensive rating data and certified test data on their products.
- 4 Consistency: For the whole quantity of each material or product use the same manufacturer or source and provide consistent type, size, quality and appearance.
- 5 Safety: Provide all necessary safety devices for the protection of personnel against injury and the protection of plant and equipment against damage including relief valves, belt guards, safety railing, and effective earthing of electrical components, electrical interlocks, warning lights, and signs, alarms and local lighting. Provide permanent lifting eyes for equipment exceeding 40kg.
- 6 General: Select, if no selection is given, and transport, deliver, store, handle, protect, finish, adjust, prepare for use, and use manufactured items in accordance with the current written recommendations and instructions of the manufacturer or supplier.
- 7 Instructions: Submit the recommendations and instructions, and advise of conflicts with other requirements.
- 8 Project modifications: Advise of activities that supplement, or are contrary to, manufacturers or suppliers' written recommendations and instructions.
- 9 Product certification: If products must comply with product certification schemes, use them in accordance with the certification requirements.
- 10 Provide permanently fixed plates indicating manufacturer, model, serial number, capacity and electrical data for all equipment. Lettering height: 5mm maximum, 1.5mm minimum.
- 11 Provide materials or products are supplied by the manufacturer in closed or sealed containers

2.6.2 FINISHES AND VISUAL ELEMENTS

- 1 Surfaces shall be flat and free of noticeable distortion, warping and twisting.
- 2 Edges and corners accessible to users dressed to avoid cutting if touched.
- 3 Pressings shall be accurate in dimension and profile to ensure consistent mating and clearance gaps and pressing shape.
- 4 Mating surfaces between adjacent pressings - flush and accurate to produce smooth distortion free joint.
- 5 Provide protection against damage until Practical Completion.
- 6 Surface shall be clean, undamaged and free of stains

2.6.3 *MANUFACTURERS' OR SUPPLIERS' RECOMMENDATIONS*

- 1 General: Select, if no selection is given, and transport, deliver, store, handle, protect, finish, adjust, prepare for use, and use manufactured items in accordance with the current written recommendations and instructions of the manufacturer or supplier.
- 2 Instructions: Submit the recommendations and instructions, and advise of conflicts with other requirements.
- 3 Project modifications: Advise of activities that supplement, or are contrary to, manufacturers or suppliers' written recommendations and instructions.
- 4 Product certification: If products must comply with product certification schemes, use them in accordance with the certification requirements.

2.6.4 *CLEANING AND PROTECTION OF FINISHED WORK*

During handling and installation of work at the site, clean and protect work in progress and adjoining work. Apply suitable protective covering on newly installed work where required to ensure freedom from damage or deterioration at a time of Completion; otherwise, clean and perform maintenance on newly installed work as frequently as necessary throughout remainder of construction period. Adjust and lubricate operable components to ensure operation without damaging effects.

2.6.5 *PROHIBITED MATERIALS*

- 1 Do not use any of the following materials:
 - a Lead where the metal or its corrosion products may be directly ingested, inhaled or absorbed, or any lead-based paints or primers.
 - b Chromate paint pigment or chromate water treatment.
 - c Urea formaldehyde foam or materials which may release formaldehyde in quantities which may be hazardous or irritant.
 - d Synthetic mineral fibres except in accordance with Worksafe Australia National Standard and National Code of Practice.
 - e Materials in which chlorofluorocarbons, hydrochlorofluorocarbons or hexa-fluoroacetones have been used as a blowing agent.
 - f Chlorofluorocarbons.
 - g Polychlorinated biphenyls.
 - h Other substances generally known to be deleterious to health or safety or which would adversely affect the works.
 - i Any that would be contrary to achievement of a required project Green Star or other sustainability rating.

2.7 *INSTALLATION*

2.7.1 *GENERAL*

- 1 General: Carry out the work in a proper and workmanlike manner.
- 2 Arrangement: Install equipment and services parallel or perpendicular to building elements. Organise reticulated services neatly. Provide for movement in both structure and service. Under suspended ground floors, keep services at least 150mm clear above ground surface, additional to insulation.

- 3 Movement and expansion: Provide expansion facilities in ductwork, piping, cables, cable trays and supports to accommodate thermal expansion and movement at structural expansion joints.
- 4 Protection: Protect equipment from weather and the ingress of dirt, moisture, vandalism and tampering.
- 5 Access: Provide access to all components requiring entry, inspection or maintenance.
- 6 If interruptions to supply of any service are required co-ordinate the shutdowns to the satisfaction of the Superintendent, advise the occupants, minimise inconvenience, and advise when supply is reinstated. Arrange shutdowns out of hours.

2.7.2 SERVICES/UTILITIES CONNECTIONS

- 1 If the utility provider elects to perform or supply part of the works, make the necessary arrangements. Install equipment supplied, but not installed, by the utility provider.
- 2 Connect to utility provider services or service points. Excavate to locate and expose connection points. On completion reinstate the surfaces and facilities which have been disturbed. Pay connection charges.

2.7.3 SYSTEM INTEGRATION

- 1 Interconnect system elements so that the installations perform their designated functions.

2.7.4 SETTING OUT OPENINGS AND MAKING GOOD

- 1 The Specification Drawings are diagrammatic only and unless otherwise stated shall not be used for determining the precise positions of equipment outlets and like features. The exact location of these shall be determined on site and/or from shop drawings.
- 2 All chases, ducts, recesses and penetrations in structural elements not shown on the building and structural drawings shall be subject to approval.
- 3 Provide the precise location of all openings, fixings and similar items of work required for these works.
- 4 Determine requirements at such times as not to cause delay to the work.
- 5 Check all items to ensure correct positioning.
- 6 Wrongly located or omitted openings, fixings and similar items of work resulting from incorrect or lack of inter trade coordination shall be remedied and paid for under these works.

2.7.5 WORKS PROGRAMME AND TIME CHART

- 1 Sufficient information of construction phase activities shall be provided to enable preparation of a detailed construction programme incorporating activities of every trades.
- 2 The programme of work shall be arranged in consultation with all Trades and the installation shall be completed according to the agreed programme.
- 3 The Works programme shall clearly show the start and completion dates with the typical activities listed below. The list is indicative.
- 4 Submission of shop drawings and major technical submissions.
- 5 Shop fabrication
- 6 Ordering of plant and materials.
- 7 Delivery of plant and materials.
- 8 Erection, testing and painting/identification of pipework/cable trays/ conduits/ducts in false ceilings.

- 9 Erection of duct and pipe risers and installation of electrical wiring in vertical building risers before building riser walls are completed and closed.
- 10 Permanent power connection.
- 11 Commencement of fitting offs and final terminations.
- 12 Authorities acceptance tests.
- 13 Commencement of testing.
- 14 Commencement and Completion of plant commissioning.

2.7.6 METALWORK

- 1 General: Use metalwork capable of transmitting the loads imposed, and sufficient to ensure the rigidity of the assembly without causing deflection or distortion of finished surfaces. Construct to prevent rattle and nuisance.
- 2 Metal separation: Prevent contact between electrolytically dissimilar metals, by using concealed insertion layers.
- 3 Edges and surfaces: Keep clean, neat and free from burrs and indentations. Remove sharp edges.

2.7.7 FIXING

- 1 Fix all plant to structure in approved manner, either directly or via secondary structure as required. Submit details of types of fixings, locations and loads for approval.
- 2 Fix only light weight items to non-structural building elements.
- 3 Do not pierce waterproof roofs, floors or walls with fixings.
- 4 Fasteners to comply with appropriate Australian / New Zealand Standards.
- 5 Use proprietary corrosion resistant fasteners capable of transmitting the loads imposed, and sufficient to ensure the rigidity of the assembly. Use metal expansion bolts for concrete and masonry. Do not use explosive charge fixings without approval.
- 6 Corrosion protection: Use corrosion resistant, chemically and electrolytically compatible fasteners. Provide insulating spacers where necessary.

2.8 CO-ORDINATION

Comprehensive co-ordination of all services and associated building work form part of the Works.

These responsibilities shall include:

- 1 Co-ordination of the works as required.
- 2 Management of the advance procurement of equipment to meet programme.
- 3 Co-ordination of in-ground and in-ceiling services routes, including trenching, trays and pipework.
- 4 Management of the preparation and approval of fully co-ordinated drawings including penetration drawings.
- 5 Management of services testing and commissioning
- 6 Ensuring provision of all test results and required certifications to obtain Certificate of Occupancy from the relevant Building Surveyor.

During the construction period the works require that a competent supervisor is provided on site responsible for the comprehensive co-ordination of all engineering services, including civil, structural, electrical, mechanical, hydraulics, fire and lift services.

Responsibility for the proper direction, supervision, control and co-ordination of the work forms part of the works and shall assist all other trades in every way possible in meeting this responsibility.

All services shall be thoroughly co-ordinated prior to installation. Should work proceed without co-ordination being undertaken and authorisation by those with such responsibility and should other trades subsequently not be able to effectively proceed with their respective installation, the work initially undertaken shall be removed and reinstalled at the expense of the Contractor.

Any claims for additional costs or delays due to the lack of effective co-ordination by the various trades will be rejected.

Arrange and co-ordinate all interconnection testing with other services systems, e.g. fire mode tests, power failure testing, etc.

2.8.1 CO-ORDINATION OF INSTALLATION WITH CEILING TILES AND FINISHES

Co-ordination shall be carried out to ensure that all building and services elements such as air ducts, outlets and light fittings, sprinklers, speakers and other ceiling elements are installed in a co-ordinated manner, such that all services can be connected and maintained as indicated on the Architectural Reflected Ceiling Plans.

2.9 SAFETY IN DESIGN

Safety in Design risk management shall form an integral part of these works and shall conform to the requirements of the Workplace Health and Safety (WHS) Act 2011 & WHS Regulations 2011.

The Safety in Design process shall conform to the State-relevant Compliance and Guidance documentation.

General principles of risk management to be followed shall be as AS/NZS ISO 31000 (2009) Risk Management – Principles and Guidelines.

The National Standard for Construction Work (NOHSC:1016) shall be used to align design risk management practice with construction risk management practice.

The Safety in Design Risk Assessment shall include but not be limited to:

- 1 Understand the range of work activities associated with the intended use of the building / structure as a work place.
- 2 Identify hazards, assess risks (quantify and rank), identify control measures, implement control measures, review and prepare risk register prior to construction of work. Monitor and review throughout construction and operation. The process includes review and acknowledgement of residual risks identified and communicated by the designer as defined by the WHS Act and Regulations.
- 3 Elimination or where this is not reasonable practicable, minimisation of any risk to health and safety of any person. The process includes, recommendation of design alternatives that will eliminate / reduce risks, recommendation of control measures for residual risks; organising participate and facilitating Safety in Design workshops as required.
- 4 Report in writing, on health and safety aspects and risks of the design identified. Implementation of control measures which shall be monitored and reviewed throughout construction and operation.
- 5 Provide at the conclusion of the project all residual risk information, in the form of a Safety in Design File and the related instruction and training as required to ensure an understanding of the safety aspects of the installation.

Where local regulatory practice differs from the above the more onerous shall be used as the basis for compliance.

3 PROJECT REQUIREMENTS & DESCRIPTION OF WORKS

3.1 GENERAL

Unless varied by Specification Addenda, the requirements set out below in this section are mandatory and no deviation is permitted.

List and allow in your tender form all of the items called in and listed in this section. No deviation from requirements of this section is permitted unless approved by Superintendent in writings during the tender process.

3.2 ROLES AND RESPONSIBILITIES

3.2.1 CONSULTANT ENGINEER

During the construction phase the Consultant Engineer's role is:

- 1 Analysis of schedule of technical data and alternatives offered.
- 2 Review of shop drawings for the purpose of establishing compliance with design intent.
- 3 Review of samples for the purpose of establishing compliance with the Specification.
- 4 Review of Contractor's Services trade inspection and test plans (ITPs) for each section of the works.
- 5 Periodic review of the progress of the works on the site, noting any observations with respect to quality of the installation or materials used.
- 6 Issue of any clarification (Consultants Advice) required to interpret the Specification and Drawings.
- 7 Prepare and issue Consultants Advice if required to amend the Specification and or Drawings
- 8 Accompanied by the Contractor's representative, randomly inspect and verify test records achieved by witnessing Contractor's test demonstrations.
- 9 Review and with attendance by the Contractor's representative, random commissioning data achieved by witnessing Contractor's test demonstrations.
- 10 Review Contractor's Services trade Q.A. records including ITPs.
- 11 Inspect the works at Practical Completion
- 12 Review Client training proposals.
- 13 Review 'As Installed', and operating and maintenance documents.
- 14 Review maintenance records during the defects liability period.
- 15 Inspect the works at the end of defects liability period.

3.2.2 OBLIGATIONS OF THE CONTRACTOR

- 1 In writing this Technical Specification the Client expects and relies upon the Contractor to provide its own personnel and its trades possessing specialist trade expertise necessary to complete the works in accordance with this Technical Specification and Drawings which form part of the overall Contract documentation.

- 2 In addition, the Contractor has the following obligations:
- a To raise in good time, issues requiring design input or clarification from the Consultant Engineer, particularly in respect to:
 - i interpretation of the Specification or drawings;
 - ii problems in complying with the Specification together with suggested alternative/substitutions;
 - iii matters in the Contractor's opinion, are omissions not discovered during the tender process, together with suggested alternatives/substitutions
 - b To allow the design verification costs of the Consultant Engineer when suggesting alternatives and departures from this Technical Specification and accompanying Drawings.
 - c To certify compliance with Authority requirements.
 - d To pay all fees applicable to the works.
 - e To obtain all Authority permits and certificates to allow the progress of the work.
 - f To provide manufacturer's and construction drawings of sufficient detail to allow proper fabrication, co-ordination and installation and a scale not less than 1:50; incorporating all post-tender changes to architectural and structural drawings.
 - g To provide samples and prototypes where specified.
 - h To provide manufacturer's factory test records (type tests and witnessed tests) and site installation inspection and sign-off certifying that the completed installation comply with the manufacturer's installation guidelines and requirements
 - i To provide the completed Services installation that is fully and correctly commissioned and fine-tuned and, that is functional and operable efficiently in compliance with all requirements of this Technical Specification.
 - j To provide copies of all monthly/ quarterly maintenance and servicing reports required to the Consultant Engineer.
 - k To certify compliance with Contract documents, including all variation instructions, at Practical Completion

3.2.3 *CONTRACTOR'S DESIGN RESPONSIBILITIES*

- 1 Specifically, for specialist services trades, the Contractor shall be responsible for the detailed design activities listed below, as these activities are considered to be normally undertaken through the custom and practice of the industry.
- 2 The Contractor shall be responsible for ensuring that the detailed design undertaken is fully co-ordinated and compatible with the remainder of the project design.
- 3 Check space requirements of equipment and services which are indicated diagrammatically in the Contract documents. Select equipment with dimensions to suit the available space.
- 4 Lay out equipment and services to be accessible for operation, maintenance and replacement and so as not to interfere with access to other installations. Make offsets as necessary.
- 5 Set out access ways 2.1m high and 1.0m wide (minimum) to all major plant clear of all obstructions, unless otherwise approved.
- 6 Co-ordinate the layout of plant and services with the building layout and structure, and with other plant and services.
- 7 Neatly group services, with separate layers for crossing services.
- 8 Interface details with other trades.

- 9 Size and location of penetrations in walls and floors.
- 10 Physical co-ordination of installation with other trades.
- 11 Provision of electrical loads to electrical trade and compare with design loads cable sizes and circuit protection devices, seeking design direction where discrepancies occur.
- 12 Co-ordination of the construction of the installation.
- 13 Details of electrical wiring and control diagrams of all equipment supplied showing all interconnections between equipment to enable the necessary wiring to be undertaken.
- 14 Thermal expansion accommodation and anchorage, including provision of bellows or bends, taking into account final installation details and consistent with specified requirements.
- 15 Mounting, support and fixing details, and fasteners, including any secondary structure which may be required.
- 16 Cable installation details and derating factors.
- 17 Settings for protection equipment, time delays, time switches etc.
- 18 Capacity, location, design and sizing of cable support, trunking and conduit systems.
- 19 Acoustic design or modification of actual selected equipment that may require change, to meet with the noise levels specified. Such change to approval of the Consultant Engineer. Specified levels to be achieved with all plant operating.
- 20 Selection of all anti-vibration mountings to suit the particular application of the mounts
- 21 Valve, damper and access locations.
- 22 System water capacities and chemical additives.
- 23 Final locations of control sensors, detectors, thermostats, switches, outlets.
- 24 Calculate system resistances to fluid flow based upon the actual plant layout and selected equipment. Allow for dirty filters and diversified flows. Allow for standby plant and future demand as shown.
- 25 Amend piping, fans, pumps, motors and electrical power supplies to suit the requirements of the actual installation. Submit amended selections for review. Comply with the stricter of the NCC Section J maximum power ratings and those in the Schedules.
- 26 Calculate cable rating and voltage drops based upon actual cable lengths and selected make of cables. Allow for standby plant and future demand as shown. Take into consideration installation conditions, and external influences short-circuit fault levels and ratings of protection equipment.

3.2.4 *ALTERNATIVE PRODUCTS*

Should the part of the work be proposed to be done quicker, better or more effectively by substitution of materials or methods other than those specified, the details of such substitutions or alternatives shall be included in the Tender, including a comprehensive Report including any performance and life cycle analysis in support of the proposals.

Where the words 'equal or approved' are used in this Technical Specification, permission may be requested to use a substitute for what is specified, provided it and the relevant manufacturer of the item certify in writing that the substitute is of equal, or better quality and effectiveness to that specified.

Submit for approval full details to allow verification that the alternative products comply with the Contract Documents. Provide a certificate for each alternate product confirming that the proposed alternative product complies with the contract documents. Include all compliance and non-compliance items related to Project Brief, Specifications and

Contract Drawings. State if use of proposed alternatives will necessitate alteration to other parts of the works and include consequential costs.

- 1 Allow for additional work resulting from the utilisation of an approved alternative product, including additional or revised statutory approvals, changes to adjacent work, re-submission of shop drawings and any costs incurred by the Consultant Engineer in assessing such alternative products. Allow for Consultant Engineer Review cost based on agreed Market hourly rates. These sums are to be paid irrespective of the alternatives being selected or not.

Proposals for substitution must include details of:

- 1 Changes to adjacent work, if any.
- 2 Cost differences.
- 3 Life cycle cost differences
- 4 Quality differences and advantage to the Client.
- 5 Lead time and program changes.
- 6 Certificate of compliance.

3.3 DESCRIPTION OF WORKS

Whether or not particular works are described in the Technical Specification all items and materials needed for the complete works are required and shall be installed unless clearly excluded.

The project includes the detailed design, supply, delivery, installation, commissioning, tuning, testing, placing into service, maintenance, warranty and defects liability of materials, labour and plant of the services systems in accordance with this Technical Specification. All components and systems shall be complete in every respect and tested and commissioned unless otherwise noted specifically.

3.3.1 GENERAL

- 1 Site visit and familiarization with the site conditions and scope of work required under this contract and making required allowances to complete the works.
- 2 All necessary negotiations including formal submissions as required with all Authorities/utilities having jurisdiction including obtaining of design approval and final certification of the installed systems by an independent certifier approved by the Authority. Payment of all fees associated with the authorities/utilities connections and permits for the installation
- 3 Provision of detailed safety in design analysis and ensure the installation is in compliance with the Site's safety in design proposal including all regulatory requirements.
- 4 Engagement and Coordination with the Green Star / Sustainability Consultant and the Independent Commissioning Agent, including timely preparation of documents as required by them
- 5 Allow for all requirements in relation to alternatives proposed for the project. Allow for Consultant Engineer review cost based on agreed market hourly rates. These sums are to be paid irrespective of the alternatives being selected or not.
- 6 Collaboration and working with Mechanical Trade who is responsible for the management and coordination of overall services shop drawing process including providing timely input into the process to allow fully coordinated shop drawing production for all services Active engagement and provision of nominated staff for input into the multidisciplinary coordination workshops in relation to shop drawing production as well as onsite installation methodology and integrated commissioning of multi-disciplinary interfaces

- 7 Coordinate with the Electrical trade and advise final equipment selections and their power requirements prior to their ordering and installation of submains to respective switchboard to ensure correct submain cable selections- Submains cabling from the MSB is provided to the mechanical switchboards. Provide all lugs, cable glands and gland plates for the Electrical trades so they can terminate the cabling and do the final connection to your respective switchboard. Any submains/sub-circuit to secondary switchboards/control panels shall be included in the respective services Works Packages
- 8 Provision of QA plan including inspection, testing, commissioning ITPs for all systems installed
- 9 Preparation of “For Construction” and “Shop Drawings” coordinated with other services prior to commencement of works including services layouts at the same scale as the design drawings.
- 10 Detailed design and preparation and submission of design schematics and calculations prior to shop drawing.
- 11 Preparation and submission of shop drawings and equipment schedules prior to construction. Refer to Section 3 for additional Information.
- 12 Provision of all samples and technical submissions.
- 13 Identification and coordination of penetrations, provision of fire/smoke sleeves and sealing of all wall, floor, ceiling penetrations to the required fire/smoke/acoustic rating.
- 14 Provision of vibration isolation for all rotating equipment.
- 15 Provision of seismic restraints, including design.
- 16 Provision of all painting and finishes including identification and labelling schedules,
- 17 Provision of As-Built drawings and O&M Manuals in compliance with a uniform overall Site Services Documentation System.
- 18 Preparation and supply of complete and detailed Operating and Maintenance Manuals which include all commissioning data in both hard and soft copy format. Ensure Operation and Maintenance Manuals clearly indicate on an individual equipment basis a schedule of maintenance routines, inspections, preventative maintenance procedures, test surveys and records conducted on the fire and smoke protections systems installed as outlined in AS1851. Generic type procedures / inspections are not acceptable.
- 19 Provision of all training for staff in the operation and preventative maintenance of the systems. Training of the nominated building facility management staff to the level of understanding of day by day operation of the services systems
- 20 Twelve (12) months statutory testing, servicing, maintenance, defect liability and warranty of all services systems/equipment installed under this contract from the date of Practical Completion
- 21 Fine tuning commissioning of all systems during the defects liability period as per Green Star/NABERS requirements. The tuning shall involve inspection, check and all adjustments of all systems and controls every three (3) months after the date of Practical Completion. Detailed final recommissioning of all systems shall be carried out at the end of the defect liability period.
- 22 Prepare detailed heat load calculations using CAMEL heat load software for all apartments and air conditioned spaces and submit them to the Engineer for review and agreement. All input values shall be agreed prior to performing calculations. On completion and agreement of heat load calculations, shall the Mechanical Contractor complete his design and selection for all air conditioning and ventilation plant.

3.3.2 *INTER SERVICES WORKS*

- 1 Provision of ventilation to substation rooms (subject to confirmation from the Authority), including ducts, grilles, louvers, fire dampers and the like, unless where the provisions are agreed to be separately provided under a managed contract or by a third party (such as a Contractor or by the network authority)
- 2 Provision of all mechanical services cabling and control wiring from mechanical services switchboards to all mechanical plant including secondary mechanical switchboards and any integrated mechanical devices requiring control such as automated louvres.
- 3 Provision of valved condenser water connections located in the diesel generator room for standby diesel generators
- 4 Provision of ventilation to Fire Pump Room
- 5 Provision of access panels in ducts requiring sprinklers and smoke detectors to be fitted
- 6 Provision of valved natural gas line for extension and connection to central domestic gas fired hot water plant in roof plant room
- 7 Connection of mechanical drains from equipment to tundishes
- 8 Final connection and extension of water supplies to mechanical equipment e.g. cooling towers, boilers etc.
- 9 Coordination and Connection of BMS/BAS controls and monitoring for all services.
- 10 Provision of ventilation/cooling to lift machine rooms and lift shafts.
- 11 Provision of vermin proof and weather proof ventilation grille and fire damper on the outside of the lift well to suit the ventilation opening at the top of lift well. MRL lifts only
- 12 Provision of vermin proof and weather proof ventilation louvres as located on the drawings, unless where the provisions are agreed to be separately provided under a managed contract or by a third party (such as a Contractor or by the network authority)

3.3.3 *MECHANICAL WORKS SYSTEMS*

- 1 Thermal Plant
 - a Boilers
 - b Cooling Towers
 - c Heat Exchangers
 - d Pumps
 - e Valves
- 2 Air Handling Plant
 - a Air Handling Units
 - b Coils
 - c Heat Recovery Units
- 3 Air Conditioning Systems
 - a VRF air cooled
 - b Split and Packaged Systems
 - c Heat Recovery Units

- d Computer Room Air Conditioning Systems
 - e Refrigeration Systems
- 4 Mechanical, Smoke and Natural Ventilation Systems
 - a Stair Pressurisation
 - b General Pressurisation and Air Relief Fans
 - c Smoke Spill
 - d Carpark Supply and Exhaust Systems
 - e Kitchen Exhaust
- 5 Control Systems
 - a Building Management System
 - b Energy Management System
 - c Sensors and Air Monitoring
 - d Metering
- 6 Mechanical Electrical Systems
 - a Switchboards
 - b Sub-Metering
- 7 All control valves, isolating valves, test pressure/temperature points and any other equipment subject to condensation shall be provided with stainless steel safety trays under, separately trapped and drained. All pressure/temperature test points, valves, etc., shall be insulated.
- 8 Provision of required balancing valves, throttling valves as required to facilitate balancing of chilled water system whether or not specially indicated on the drawings. Reduction of chilled water pipework sizing will not be considered to absorb system pressure for the operation of FCU/AHU control valves.
- 9 Direct expansion air conditioning units comprising but not limited to; centrifugal supply air fans, aluminium finned, copper tube cooling coils with in-built condensate trays, insulated refrigerant pipework, air filters, controls, internal lighting, motorised outside air and motorised return dampers where required for CO2 control, PIR or smoke mode operation. All FCU's/AHU's located outside plant rooms shall be provided with insulated stainless steel safety tray under separately trapped and drained to tundish/floor waste.
- 10 Water Cooled Units (WCU's) comprising but not limited to; centrifugal supply air fans, aluminium finned, copper tube cooling coils with in-built condensate trays, air filters, controls, pipework, head pressure control option (to selected WCU's) and the like. All water-cooled units shall be provided with insulated stainless steel safety tray under separately trapped and drained to tundish/floor waste. Provide motorised outside air and motorised return dampers where required for CO2 control / economy cycle.
- 11 Supply and installation of air diffusion equipment (e.g. swirl type supply air diffusers, linear slot diffusers) as shown on drawings complete with insulated low profile (where required) manufacturer approved cushion head boxes, flexible ductwork and balancing dampers.
- 12 Air conditioning air distribution systems comprising but not limited to; low pressure, low velocity, sheet metal ductwork, ductwork insulation (internal or external as scheduled), attenuators, grilles, motorised dampers, filters, spigots, flexible ductwork and diffusers. Heating of supply air shall be by hot water heating coils.

- 13 Heat recovery system comprising but not limited to; outside air and extract air backward curved centrifugal fans, built up insulated casings, access doors, internal lighting, filters, controls and motorised dampers.
- 14 Kitchen exhaust systems comprising but not limited to; stainless steel kitchen exhaust hoods, lighting, ductwork, attenuators, filters, fan, controls and accessories. Exhaust ductwork shall be provided with ductwork access panels to meet AS1668.1.
- 15 Stair Pressurisation and Relief systems comprising but not limited to; ductwork, variable speed drives, attenuators, grilles, fan, dampers (including motorized dampers), hard wired controls. All systems shall be in accordance with AS1668.1.
- 16 Car park exhaust systems comprising but not limited to; fan, variable speed drive, low pressure, low velocity sheet metal ductwork, grilles, dampers, CO and NO2 control system.
- 17 Ventilation and exhaust systems comprising but not limited to; fans, low pressure, low velocity sheet metal ductwork, attenuators, grilles, filters, spigots, flexible ductwork, diffusers, dampers (including motorized dampers) and control systems.
- 18 Fire rated ductwork as shown on drawings.
- 19 Provision of dampers (splitter, butterfly, opposed blade volume control, etc.) as required to facilitate balancing whether or not specifically indicated on the drawings.
- 20 Hot water heating system comprising but not limited to; gas fired non-condensing / condensing hot water heaters, pumps, insulated water pipe work, control valves and fittings. All hot water systems located in roof plant rooms shall be provided with stainless steel safety tray under, separately trapped and drained. All internal hot water systems shall be provided with flue discharging above roof to comply with AS 5601.
- 21 Natural gas reticulation systems as per AS/NZS 5601.1, Energy Safe Victoria (ESV) and the relevant Authority requirements comprising but not limited to; filters, relief valves, solenoid valves, regulators, isolation valves, pipework, gas proving devices, alarm devices, safety cut off controls, controls and electric work and as further specified. Application for supply of natural gas and payment of all Authority charges for the installation of incoming gas, meter and associated assemblies. Acquisition of gas supply, including ventilation of gas meter room (natural Ventilation) and reticulation of gas. Prepare and submit Gas Meter / Connection Forms to the relevant Authority / Retailer for the provision of gas to the site and allow for all necessary co-ordination and liaison. Allow for Cost Option to provide gas boosters as described in section 3.4.1.3 and in Tender Form section of this specification.
- 22 Mechanical services switchboards comprising but not limited to all electrical power and control wiring from the mechanical services switchboards to mechanical equipment. Perform maximum demand calculations as noted in Schedules Section. Provide separate non-essential/essential/fire essential switchboards as scheduled. Termination of sub mains provided by the Electrical Works Package.
- 23 Complete commissioning of the mechanical systems including but not limited to: air conditioning systems, ventilation systems, smoke exhaust systems, hot water systems, heating hot water systems, chilled water systems, L.P gas systems, compressed air and hot smoke tests for smoke exhaust systems. Mechanical Works Package shall adhere to the requirements of Section 13 Testing, Commissioning and Handover, in particular, requirement for NEBB certified commissioning personnel, Testing and Commissioning Program, Inspection and Test Plans, and Testing and Commissioning Procedures. Mechanical Works Package shall note the requirement to allow for the engineer to witness 25% of final commissioned data. Where witness testing reveals commissioned data is not within allowable specified values and requires re-balance, re-commissioning and re-witness, the Mechanical Works Package shall be charged for the Consultant Engineer's time-cost at standard hourly rates to re-witness any final commissioned data previously witnessed as not satisfactory.
- 24 Building Management System (BMS) to all equipment including but not limited to; controllers, software, hardware, operator interface, input devices, sensors, actuator, control valves, training, testing and commissioning.

- 25 Items as specified and shown to provide enhanced sustainability to the project.
 - 26 Provision of vibration isolation for all rotating equipment.
 - 27 Provision of seismic restraints, including design.
 - 28 Painting, labelling and identification of all mechanical systems including but not limited to: air conditioning systems, ventilation systems, smoke exhaust systems, hot water systems, industrial gases, chilled water systems, L.P gas systems, compressed air and vacuum systems including hot smoke tests for smoke exhaust systems.
 - 29 Provision of minor core holes and penetrations. Placing, casting in and protection of pipe sleeves and conduits. Chasing is not acceptable.
 - 30 Provision of support systems, structure and framework to support mechanical systems (e.g. ductwork, fans, fan coil units, compressed air, refrigerant pipework, cable trays and the like) comprising but not limited to hot dipped galvanised uni-strut, square hollow section, rolled steel angle or similar (to span structural roof members / roof purlins), metal strap, wires, support saddles, clamps, clips and fasteners. Mechanical support systems shall include but not limited to internal and external guy wire system (including roof and structural steel fixing systems) to support flues located internally (below roof from equipment) and externally (above roof).
 - 31 Packing and sealing around duct penetrations to provide fire rated/acoustic sealing as required.
 - 32 Hoisting or lowering of equipment where not provided by the building trade. All necessary scaffolding and access ladders for placing of mechanical plant during installation, commissioning and services during defect liability period
 - 33 Metal plinth surrounds for mechanical plant including but not limited to: chillers, cooling towers, chemical dosing pot, water heaters, pumps, storage tanks, side stream filtration, packaged air conditioners, air handling units, condensing units, switchboards and fan coil units where applicable.
 - 34 Provision of insulated condensate drain pipework to tundishes.
 - 35 Submissions Schedule in accordance with Section 3.
 - 36 Provision of 12 months defects liability period from the date of practical completion.
 - 37 Provision of complete service and maintenance of all systems during the defects liability period.
 - 38 Provision of all ongoing commissioning and tuning as required by Greenstar
-

3.4 SYSTEM DESCRIPTIONS

The following system description is based on the Design Development /Schematic Design report and is reproduced for Information Only. Refer to the Description of Works and other Scoping Clauses for scope of works.

3.4.1.1 GENERAL VENTILATION

CAR PARK VENTILATION

The car park levels shall be mechanically ventilated. Exhaust air rates are based on a performance solution to comply with AS1668.2-2012. Therefore, any alterations are to be confirmed by both the building surveyor and consultant engineer.

The exhaust air ducting shall be reticulated on each level of carpark along the length of one boundary of the site, and shall be connected to an exhaust riser and discharge exhaust air horizontally at Level 4 through signage. Exhaust grilles shall be fitted into the sheet metal ducting with dampers for balancing. All car park levels shall be served by the exhaust fan located in the Carpark Exhaust Fan Room on Level 3, and the system is to operate via means of CO sensor control located at various locations throughout the car park.

The carpark exhaust fan shall discharge exhausted air to atmosphere horizontally, min. 3m above trafficable space and 6m from the nearest boundary.

Make-up air for the carpark shall be drawn from both the Ground & Level 3 Carpark Supply Air Fan Room and ducted to levels B3-B1 of the car park via two supply air risers. The supply air system is to run in tandem with the exhaust system. The ductwork take-off on each level shall be provided with volume control dampers for balancing. Supply grilles shall be fitted into the sheet metal ducting with dampers for balancing and run parallel to the boundary opposite the exhaust system.

APARTMENTS

I. Kitchen Exhaust System

A kitchen exhaust system shall be provided for each apartment. The kitchen range hoods shall be ducted and locally discharged to outside. The kitchen rangehood shall be supplied complete with its own exhaust fan, and integral back draft damper to reduce uncontrolled infiltration. The exhaust louver is proposed to discharge towards the outer facades of the building.

A booster fan, interlocked with the range hood fan, shall be provided in the design for kitchen hood exhaust systems where:

- (i) The kitchen hood fan selected for the apartments is inadequate to provide the required exhaust rate, OR;
- (i) Where the kitchen exhaust ducting is excessively long, OR
- (ii) The expected wind pressure against the building (especially at high levels) will limit the effectiveness of a range hood fan. (This will be based on the facade engineers design ratings for building facade air pressure resulting from wind.)

The kitchen exhaust rate shall be 120L/s (minimum) for apartment kitchen exhaust systems.

II. Toilet / Laundry Exhaust System

A toilet exhaust system shall be provided for each toilet/bathroom for odour control. These systems shall be complete with a back-draft damper to reduce uncontrolled infiltration. The toilet exhaust fans shall operate via the local light switch within the wet areas.

The exhausted air shall be discharged via a horizontal louver/s on the facade of each apartment depending on the layout of the apartment.

The exhaust rates shall be as follows:

- (i) 70L/s where shower, toilet and bathtub areas are located in the same wet area.
- (ii) 40L/s where shower and toilet areas are located in the same wet area.
- (iii) 40L/s per laundry area.

The doors to wet areas shall be undercut by **25mm** for make-up air, where door louvers are not fitted. *This shall be detailed on the Architects door schedules / joinery schedules.*

III. Make-up air to apartments

The makeup air is to be provided via operable windows. It would be expected that the occupants would “crack open” a window when exhaust systems are in operation.

RETAIL TENANCY VENTILATION

- a. Blanked outside air and general exhaust louvres for the Ground Level tenancies, for future fitout works by the tenants, as part of the 'cold shell' approach for the tenancies. Intake louvres shall be sized to cater for make-up air to kitchen exhaust (where applicable) and outdoor air requirements to meet AS1668.2 occupant density or as modified by the Building Surveyor or retail tenancy Leasing Agent.
- b. Exhaust louvres shall be sized to cater for a nominal toilet exhaust quantity dependent on the floor area of the tenancy or as advised by the Building Surveyor or retail tenancy Leasing Agent. In addition each retail tenancy shall have a 200L/s general exhaust louvre provision to cater for store rooms and the like.
- c. Provision of commercial kitchen exhaust risers for Ground Level food & beverage tenancy. Fans and filtration equipment shall be supplied and installed by the future tenant within the tenancy kitchen space

It is noted that due to the constraints of the architecture and limitations for points of discharge, dispensation will be sought from the Building Surveyor to not comply with certain elements of the NCC and the relevant Australian Standards. This will include an alternate solution to incorporate filtration equipment to allow a non-compliant discharge location to be utilised. Where dispensation is not provided, alternative Deemed to satisfy applications will have to be applied.

VERTICAL FIRE ISOLATED EGRESS PRESSURISATION SYSTEM

The fire stair shall be pressurized using separate stair pressurization systems designed in accordance with AS1668.1 requirements for a Residential building, and as specified by the Fire Engineer. The stair pressurization fans, one per riser, shall be located on the roof plant and supply air to the fire isolated stairs via wall mounted grilles at every 2 levels throughout the building, from Level 24 on the high-rise tower and Level 9 on the low-rise tower down to Level 1.

Corridor relief air system shall be provided as part of the stair pressurization system to relieve air from the apartment corridors via a wall mounted grille on each level. The relief air system shall be provided with sub-ducts in accordance with AS1668.1.

System status is to be monitored on the BMS.

REFUSE/BIN ROOM

The bin rooms located on ground level shall be mechanically ventilated via the bin chute riser. The exhaust fan shall be located on roof level where the exhaust air will discharge.

Make-up air shall be introduced to the refuse rooms via a wall mounted transfer air grille at low level. The room shall always remain under negative pressure.

This system shall also serve the apartment bin rooms on each floor.

Each grille and duct penetration through fire rated walls shall be fitted with fire dampers.

The bin room ventilation system shall be rated for continuous operation.

The ventilation system shall be complete with control, fault alarms, etc.

System status is to be monitored on the BMS.

LOADING BAY VENTILATION

The Loading Bay shall be mechanically ventilated (exhaust only) in accordance with AS1668.2-2012 requirements for a Loading Bay.

The exhaust air ducting shall be reticulated at high level within the loading bay area, and shall be connected to the carpark exhaust air riser, operated by means of CO/NOx sensors and adjustable timer. The loading bay exhaust system shall discharge exhausted air horizontally at level 4. Exhaust grilles shall be fitted into the sheet metal ducting with dampers for balancing.

Make-up air for the carpark shall be drawn in naturally via the Ground level driveway.

The ventilation system shall be complete with control, fault alarms, etc.

System status is to be monitored on the BMS.

SUB-STATION

The sub-station shall be mechanically ventilated via intake louvres and discharge louvers at ground level. The mechanical ventilation fan shall be fitted with a thermostatically controlled variable speed drive. The ventilation system shall be designed to meet the requirements of the power authority and shall be connected to a separate power supply provided by the power authority.

MSB ROOM

The room housing the Main Electrical Switchboard shall be temperature controlled using mechanical ventilation. A ducted, two speed, in-line fan shall be installed in the room and exhaust air from the room at high level, discharging through a fire damper and wall louver.

Make-up air shall be introduced at low level via a wall mounted louver and fire damper complete with panel filter.

The ventilation system shall be complete with fan, controls, temperature control, temperature sensors, fault alarms, etc.

The MSB ventilation system shall be rated for continuous operation.

System status is to be monitored on the BMS.

GAS METER ROOM

The gas meter room shall be naturally ventilated.

FIRE PUMP ROOM

The fire pump room shall be mechanically ventilated. The exhaust air quantity shall be sufficient to remove radiant heat from the diesel motors and the makeup air shall be sufficient for engine combustion.

The exhaust air shall be ducted into the room. Makeup air shall be provided via high level acoustic louvers on the opposite side of the room to encourage 'cross-flow' of air through the room.

The ventilation system shall be complete with fan, controls, temperature control, temperature sensors, fault alarms, etc.

The mechanical contractor shall coordinate with the fire protection services contractor to complete the installation.

System status is to be monitored on the BMS.

FIRE CONTROL ROOM

The fire control room shall be mechanically ventilated in accordance with the National Construction Code (NCC).

A ducted in-line fan shall be installed to exhaust air outside. A makeup air louver shall also be provided.

System status is to be monitored on the BMS.

GREASE INTERCEPTOR TRAP

The grease interceptor trap shall be mechanically ventilated.

The exhaust fan shall be located on L12 roof where the exhaust air will discharge.

System status is to be monitored on the BMS.

3.4.1.2 AIR CONDITIONING

THERMAL PLANT

Public spaces & L1-L13 West Tower apartments shall be air conditioned using condenser water to reject heat from water cooled in ceiling void mounted reverse cycle air conditioning units complete with filter plenum with 25mm V form panel filters, supply and return (insulated) ductwork with outside air duct connections where required (not required in apartments), supply and return air grilles. Grilles to be of the linear bar type in apartments. All controls and power terminals, filters and valves shall be located at one side of the packaged units accessible through one access panel only.

Two cooling towers along with two heat exchangers with 2 pumps on the primary side and 2 pumps on the secondary side reticulate water over the entire height of the building. It is important to note that the pipes and all filtering shall be sized for the pressures associated with this set and tested to 1.5 times the operating pressures. Equipment listed above is located on the roof of the West Tower.

The primary side of the loop shall be treated with biocide by a specialist water treatment company. The cooling tower setup shall also be provided with side stream filtration. The secondary side is to be treated by a slug dosing system.

Six condensing boilers shall be used to inject heat into the condenser water loop to offer the heating required for the reverse cycle operation of all water cooled packaged air conditioning units. The water heaters are located on the roof of the west tower. A feed and expansion tank shall be provided to cater for the requirements of the closed condenser water loop.

Each boiler shall be supported by a pump. The boilers shall operate in parallel to maintain condenser water temperature to the field of 29.5°C (adjustable). In addition the boilers shall serve a heating coil for the west tower corridor ventilation system.

WEST TOWER L1-L13 APARTMENT AIR CONDITIONING

Ceiling concealed reverse-cycle water sourced packaged unit with proprietary controls to the designated living areas and bedrooms of each individual apartment. Both cooling and heating shall be provided to the living areas and all bedrooms. The water shall be provided from Cooling Towers located on the high-rise tower roof with heating provided by condensing boilers via a heat injection loop. Watercooled units are to operate on a day/night cycle.

WEST TOWER L14-L26 / EAST TOWER APARTMENT AIR CONDITIONING

Ceiling concealed reverse-cycle air-cooled VRF conditioning units with proprietary controls to the designated living areas and bedrooms of each individual apartment. Both cooling and heating shall be provided to the living areas and all bedrooms. The outdoor condenser units shall be located on the roof level in common plant areas. The refrigerant shall be R410A or an equivalent refrigerant that has minimal impact on the environment.

SWIMMING POOL VENTILATION

Swimming Pool shall be ventilated via dedicated water cooled packaged unit providing dehumidification and heat recovery. The PAC unit is situated in the Level 3 plant room and is served via the condenser water loop. Both supply and return ductwork shall reticulate through risers to the pool on level 4. Outside air & exhaust air is via nearby louvres.

The system shall operate 24/7 through the BMS and shall be rated for continuous operation.

~~GROUND FLOOR LOBBY, GYM, AMENITIES, ETC., AIR CONDITIONING~~

~~These spaces shall be provided with local water sourced packaged units. Outdoor air and relief air shall be sourced from local façade louvres. Supply air shall be reticulated via insulated ductwork to linear slot diffusers or circular diffusers as required.~~

~~The system shall operate 24/7 through the BMS and shall be rated for continuous operation.~~

APARTMENT FLOOR COMMON CORRIDORS

The Apartment corridors/ passages and lift lobbies from Ground Level to Level 26 shall be provided with 100% outdoor air at all times (24/7). The outdoor ventilation system shall provide outdoor air for each corridor level via wall mounted grilles and will supply not less than 1L/s/m² outdoor air ventilation rate. The supply air to the corridors shall be relieved via building leakage/lift shafts. The west tower system shall also include a heating coil to provide supply air at 20°C.

The system shall operate 24/7 through the BMS and shall be rated for continuous operation.

COMMS ROOM

The Comms room shall be air conditioned via an air cooled, cooling only wall mounted split system.

The system shall be rated for continuous operation and the local temperature shall be independently monitored and alarmed on the BMS.

3.4.1.3 NATURAL GAS

Provide natural gas services as shown on the drawings including blanked off connection to café & retail for future tenant utilisation.

3.4.1.4 BUILDING AUTOMATION SYSTEM (BAS)

Building Automation System (BAS) of open communication protocol (fully BACnet compatible end to end) shall be provided. The BAS will be configured through a local area network to form a dedicated communication backbone. The system shall be capable of supporting 20% increase in capacity without requiring upgrade to BAS infrastructure. The BAS shall be responsible for the monitoring and control functions associated with the following services:

- Mechanical Services

The BAS will include the following minimum facilities:

- Alarm monitoring, trending and reporting
- After Hours Operation
- Gathering, monitoring, recording, trending and management of energy (thermal and electrical) and water usage to suit Green Star.
- Central time clock control
- Manual operator override control
- Trend logging and archival storage of data
- Detailed fault alarms monitored on major items of plant such as chillers, generators, boilers, critical plant and specific plant
- Remote Stop/Start function
- Separate monitoring of all tenant installed meters, including retail areas.
- Load shedding of mechanical services plant and equipment during emergency power supply. Sequential start-up of mechanical services plant and equipment upon normal power restoration.

Provide Open Protocol Native Bacnet / TCP/IP gateway adjacent each floor BAS controller c/w patch cable to terminate at the nearest wall cabinet within the communication riser.

3.4.1.5 GENERAL

MECHANICAL SERVICES SWITCHBOARD

Mechanical Services Switchboard (MSSB) shall be supplied to provide power to and to control all mechanical HVAC plant.

Switchboards shall comprise but not be limited to all electrical power and control wiring from the mechanical services switchboards to mechanical equipment. Provide separate non-essential/essential/fire essential switchboards as scheduled.

3.5 SHOP DRAWING AND CONSTRUCTION DRAWING REQUIREMENTS

Prepare and submit dimensioned drawings showing details of the fabrication, layout and installation of all plant and equipment, including relationship to building structure and other services.

Prepare and submit drawings of penetrations and “built-in” components in the same form and manner as described for the processing of shop drawings. All penetration measures shall relate to grid lines, co-ordinates or relative levels.

Submit co-ordinated penetration drawings in sufficient time for review. Any failure to submit requirements within sufficient time for revision of structural drawings, resulting in re-working of the structure or re-ordering of structural components shall be responsibility of Contractor and shall not constitute any claim for variation or delay. All penetration measures shall relate to grid lines, co-ordinates or relative levels.

Provide drawings generally in accordance with the design drawings supplied with this specification.

Sheet sizes: Standard metric series, all sheets the same size. Plant room layout plans 1:50 scale, with sections and details at 1:20 scale. All services Floor plans at 1:100 scale, with detailed sections.

Drawings:

- 1 Access to and removal of all plant including locations and sizes of access doors to be installed in finished building surfaces.
- 2 Schematic and layout drawings of piping, tray and conduits, electrical and controls.
- 3 Switchboard and control panel layouts and schematics with terminal numbering.
- 4 Locations of all control sensors, valves and actuators.
- 5 Detail of all interfaces with other services and utilities.
- 6 Services co-ordination drawings for spatial co-ordination with building structure and other services with details for restricted locations.
- 7 Control logic diagrams with settings.
- 8 Foundations, plinths, chases, ducts, pits and penetrations through structure.
- 9 Layout and details of services cast in concrete. (for co-ordination and review by structural engineer /architect)
- 10 Structural support details and methods of fixing to structure.
- 11 Construction loadings (for structural engineer review).
- 12 Lifting point loads. (for structural engineer review)

- 13 Maintain current sets of drawings on site and progressively record variations which lead to creation of as-built drawings.

Please note when shop drawings review comments states “satisfactory subject to comments”, resubmit the revised drawings with comments incorporated within a period of no longer than 2 weeks. However, this should not stop the installation works.

3.6 BIM/REVIT REQUIREMENTS

The project is documented in a 3D authoring tool to produce the Consultant Engineers Model(s). The Consultant Engineers Model(s) forms the basis of the creation of Consultant Engineers Drawings (2D) which will be considered the main form of contract documentation together with this Specifications for Tendering purposes. Where considered appropriate, the communication of design intent via the Consultant Engineers Drawings have been prioritised over the detailed modelling of some elements in 3D in accordance with agreement made via a BIM Management Plan.

Co-ordination of model elements in the Consultant Engineers Model(s) has been completed to a degree adequate for proof of design content feasibility and shall allow for finalisation of locations, selections, support and constructability considerations to be incorporated as part of a shop drawing process.

Where implemented, the design team BIM Management Plan has determined the project specific extent of modelling required to achieve project objectives. This may have included documenting aspirational Level of Development (LOD) targets for specific element types. The Consultant Engineer’s model elements allow for a competitive Tender process (multiple equipment suppliers) and as such have not been nominated as specific elements.

No information contained within the Consultant Engineers Model(s) shall be used by any party for any purpose unless specifically referenced and agreed to in the BIM Management Plan.

The Consultant Engineers Model shall under no circumstances be used for any construction purposes.

In the absence of a design team BIM Management Plan, only the Consultant Engineers 2D Drawings in lieu of the Model shall be used for Tender Documentation or project design communication.

Where, in agreement via the BIM Management Plan, the Consultant Engineers Model(s) is provided to the Contractor, it will be done so for information purposes only, in order to assist in gaining general understanding of extent of services elements when combined with the Architectural and Structural federated model. Accordingly, it shall be used as a guide together with the Consultant Engineers Drawings and Specifications for the production of shop drawings after;

- 1 Determination of each trades installation methodology
- 2 Safety in Design analysis
- 3 Sequence of works considerations
- 4 Final Selection of Equipment and specific manufacturer recommended installation method plus maintenance, servicing and access needs
- 5 Final arrangement of equipment
- 6 Inter-trades coordination

Consultant Engineer’s coordination activities of services during the design phase was focused on the following;

- 1 Spatial sizing of major plant to provide spatial allowance only - Contractor shop drawing process and final equipment selection will determine the final equipment set out.
- 2 Spatial sizing of the services risers - Contractor shop drawing process and final equipment selection will determine the final riser size, installation method and set out.

- 3 General determination of ceiling zone for allocation of services - Contractor shop drawing process and final equipment selection will determine the final in-ceiling services installation and equipment set out based on site conditions

Allow in the tender for all costs in related activities to produce coordinated shop drawings for all trades based on the Contract documents, including, but not limited to any requirements listed in a project or construction BIM Management Plan.

3.7 SITE PROVISIONS AND BUILDING WORKS IN CONNECTION

- 1 This clause is provided to highlight the project requirements in relation to the Site provisions as well as Building Works in Connection BWIC and to ensure that they have been allowed for part of the Contractor Tender submission. Contractor is responsible for demarcation of tasks and responsibilities between various trades in relation to these items to suit his/her delivery methodology.
- 2 Site Provision include but not limited to;
 - a Hoisting and Lowering:
 - b Scaffolding:
 - c Temporary Services – Water, Electricity:
 - d Site facilities including Sheds.
 - e Power and Fuel for Testing and Commissioning

3.7.1 BUILDING WORKS IN CONNECTION

Allow for the following;

- 1 Demolition:
 - a Services decommissioning, disconnection from supply, capping and sealing.
 - b Services demolition and removal.
- 2 Ground Works: Services trenches; excavation and backfilling.
- 3 Concrete:
 - a Chasing, coring, cutting and making good.
 - b Placing, casting in and protection of pipe sleeves and conduits.
 - c Bases and plinths for equipment (excluding galvanised steel edge surround to be provided as part of the Mechanical Services Works Package).
 - d Piers and beams under cooling towers, fluid coolers and adiabatic coolers.
 - e Water-proof curbs round floor penetration in plant rooms.
 - f Sealed air rise shafts for supply and exhaust systems where shown on the mechanical drawings, including fire rating where required.
- 4 Masonry:
 - a Chasing, coring, cutting and making good.

- b Plant enclosures, masonry air ducts and service risers.
- 5 Structural Steel:
 - a Lifting beams.
 - b Platforms and walkways for maintenance to equipment.
- 6 Roofing:
 - a Openings and under flashings including over flashings
 - b Services works.
 - c Roof access walkways.
- 7 External Walls:
 - a Metal louvre grilles complete with bird mesh for air intakes and exhausts.
- 8 Internal walls
 - a Setout of cut-outs including cut-out and trimming of openings
- 9 Doors:
 - a Cut-outs in doors and trimming of openings
 - b Undercutting of doors for ventilation purposes.
 - c Access doors and hatches for maintenance of Services equipment.
- 10 Ceilings:
 - a Removal and replacement of ceiling tiles.
 - b Co-ordination of penetrations.
 - c Ceiling access panels to equipment, valves, dampers and duct access panels above solid ceilings.
 - d Sealed air Plenums for smoke exhaust systems.
- 11 Dry wall/ Plenum Construction
 - a Sealed air plenums for supply and exhaust systems where show on the drawings, including fire rating and thermal insulation where required.
 - b Co-ordination of penetrations.
 - c Vapour barriers within walls where required.

3.8 SERVICES INTERFACE WORKS

Contractor is responsible to carry out the works outlined under all contract documents including this Specification to achieve a fully operational installation including all required interfaces between various systems. Whilst the responsibilities for interface works and division of works is solely with Contractor the following information is provided for guidance only. Contractor has full control to alter and modify the trade allocation/demarcation of interface works to suit the Contractor's overall programme and delivery methodology in order to achieve a fully integrated, interfaced and operational whole services installations, systems and sub-systems.

Table below indicate key areas where different work packages will interface with each other. Column 1 indicate the disciplines/work packages identified and column 2 and 3 outline the key interface works between these two work packages.

	DISCIPLINE 1	DISCIPLINE 2
Elec 1 / Mech 2	<ul style="list-style-type: none"> — Coordinate for final mechanical equipment selections the maximum demand for each MSSB to ensure correct submain cable and circuit breaker selections for the respective MSSB prior to installation of submains. — Coordinate for final apartment mechanical equipment selections for the maximum demand of each equipment to ensure correct final sub-circuit and circuit breaker prior to the installation. — The Electrical Installer shall provide earthing conductors with sufficient rating for Mechanical Services — Electrical installer shall provide information on heat rejection of electrical equipment to the Mechanical Installer to enable sizing on cooling/ventilation plant. — Electrical installer shall provide power supply terminating in weatherproof isolator adjacent to all air-cooled condensers and isolators adjacent to water cooled packaged air conditioner units/fan coil units. The mechanical installer shall connect the outdoor unit to the isolator, and reticulate cabling for the indoor unit. — Electrical installer shall provide power supply terminating in a GPO in the ceiling void to each Apartment Bathroom/Toilet/Shower fan. Mechanical installer shall connect from the GPO to the fan. The electrical installer shall provide a current sensing relay (CSR) on the dryer power outlet and a junction box from the switched active of each bathroom lighting circuit. The mechanical installer shall wire from the CSR and junction boxes to the mechanical fan controller — Provision of submains to MSSB's complete with sufficient tail length to allow termination to the MSSB's 	<ul style="list-style-type: none"> — Coordinate and advise after final equipment selections the maximum demand for each MSSB to ensure correct submain cable selections for the respective MSSB — Coordinate and advise after final apartment equipment selections the maximum demand for to ensure correct final sub-circuit cable and circuit breaker selections. — Provision of all lugs, cable glands and gland plates for submain terminations and provision of final connections of submains to all MSSBs — Confirm final electrical loads to the Electrical Installer. — Confirm location of Mechanical Services Switchboards, both essential and non-essential. — Mechanical installer to provide mechanical ventilation for the Main Switchboard Room. Controls by mechanical installer. — Mechanical installer to provide mechanical ventilation for Substation to Citipower requirements. Power supply to fan switchboard by Citipower. Controls by mechanical installer. — The mechanical installer shall connect the outdoor unit to the isolator, and reticulate power for the indoor unit. — Mechanical installer shall connect from the GPO to the fan. The mechanical installer shall wire from the CSR and junction boxes to the mechanical fan controller. Mechanical installer shall coordinate with the electrical installer to nominate the final location of the condenser.
Fire 1 /Mech2	<ul style="list-style-type: none"> — Provision of cabling to transmit General Fire Alarm (GFA) and Zone Fire Alarm (ZFA) signals from FIP to the relevant Mechanical switchboards to initiate shut down and reset of the respective Mechanical Plants. 	<ul style="list-style-type: none"> — Provision of all controls and relays for control of air handling plants in fire mode operation, including cabling from equipment to FFCP module in the FIP.

	DISCIPLINE 1	DISCIPLINE 2
	<ul style="list-style-type: none"> — Provision of cabling from FIP to MDB associated with natural gas services for natural gas shutdown upon receipt of GFA. — Provision of sprinkler protection and fire detection systems in all plant rooms, in air plenums and in ducts — Provision of cabling to transmit Zone Fire Alarm (ZFA) signals from FFCP module in FIP to the terminal strip of the respective zone mechanical services switchboard (MSSB) — Sprinkler protection and smoke detection in air plenums and ducts. — Provision, installation & commissioning of in-duct smoke detectors in the air chambers downstream of the Fresh Air Supply Fans. — Provision of low level interface between the Sprinkler Water tanks electric level indicators and FIP. Provide two level signals per tank. — Provision of High Level Interface (BACnet protocol) cabling from the FIP to the terminal strip at BAS panel. <p>Allow for thirty (30) individual signals</p> <ul style="list-style-type: none"> — Termination of cabling for control of Mechanical plant & equipment at FFCP module in FIP. — Provision of a Fire Fan Control Panel (FFCP) incorporated in the Fire Indicator Panel. The FFCP shall have the following facilities: <ul style="list-style-type: none"> — Provision of Zone Fire Alarm (ZFA) signal transmission to the terminal strip of the respective zone mechanical services switchboard (MSSB) from the FFCP. — Provision of Zone Supply Air Detector Alarm signal transmission to the terminal strip of the respective zone mechanical services switchboard (MSSB) from the FFCP. — Auto/Off/Manual switch for each mechanical services fan operating in fire mode. Grouping can be provided in accordance with AS1668. — Red pilot light for each fan indicating the fan is operating. 	<ul style="list-style-type: none"> — Termination of fire control cabling in MDBs for mechanical system shut down on GFA & ZFA and reset signal (as required). — Termination of fire control cabling in MDBs for natural gas shut down in the event of sprinkler activation only. — Termination of HLI (BACnet Protocol) cabling from the FIP inside BAS panel. — Provision of access panels in ducts requiring sprinklers and smoke detectors to be fitted. — Provision of Mechanical ventilation to Fire Pumproom. — Provision of matrix of mechanical equipment operation in fire mode.

	DISCIPLINE 1	DISCIPLINE 2
	<ul style="list-style-type: none"> — Green pilot light for each fan indicating the fan has been shut down and power supply is available. — Amber pilot light for each fan indicating the fan fault. <p>Note: Switches and lights are for Fire Brigade personnel operation only – install appropriate labels and advice of restriction of the use.</p> <ul style="list-style-type: none"> — Provision of Close/Open/Manual switch for each mechanical damper operating in fire mode. Grouping can be provided in accordance with AS1668. 	
Hyd1/ Mech2	<ul style="list-style-type: none"> — Coordinate location and provision of open end tundishes for all mechanical equipment — Provision of water supply to mechanical plant. Terminate with valved branch. — Extension of gas pipes to each domestic hot water plant on the roof for each tower. 	<ul style="list-style-type: none"> — Connection of mechanical drains from equipment to tundishes. — Extension from valved branches and final connections of water supplies to mechanical equipment e.g. cooling towers, boilers — Provision of gas pipe with isolation valve for domestic hot water plants on the roof for each tower.
VT1 /Mech2	<ul style="list-style-type: none"> — Supply and installation of wire mesh screens to meet the requirements of AS1735.2 (clause 5.3) on the inside face of the lift well to suit ventilation opening at the top of lift well. MRL Lifts only. 	<ul style="list-style-type: none"> — Provision of vermin proof and weather proof ventilation grille and fire damper on the outside of the lift well to suit the ventilation opening at the top of lift well. MRL lifts only

4 DESIGN & PERFORMANCE CRITERIA

4.1 GENERAL

- 1 The following standards are applicable throughout the project.
- 2 National Construction Code 2016 (Referred throughout this specification as NCC) including all relevant Australian Standards called in the NCC
- 3 Relevant Occupation/Workplace Health and Safety legislation
- 4 The Environmental Protection Authority
- 5 WorkCover
- 6 Any other Authority having jurisdiction over all or part of the installation to ensure that the equipment and installation, when manufactured and installed, will comply with the rules and regulations.

The following standards are applicable throughout the project as a minimum. Where items of equipment are required the relevant Australian Standard to the equipment will apply. If clarification required, the Contractor shall seek clarification at the time of tender.

Where Australian Standards and Codes do not exist, the appropriate British Standard or Code shall apply.

Details of documents applicable to this:

4.2 AUSTRALIAN/NEW ZEALAND STANDARDS AND CODE (MECHANICAL SERVICES)

STANDARD / CODE	TITLE
AHRI 410	Forced-circulation air-cooling and air-heating coils
AHRI 450	Water-cooled refrigerant condensers, remote type
AHRI 460	Performance rating of remote mechanical-draft air-cooled refrigerant condensers
AHRI 480	Refrigerant-cooled liquid coolers, remote type
AHRI 540	Performance rating of positive displacement refrigerant compressors and compressor units
AS ISO 7.1	Dimensions, tolerances and designation
AS ISO 1000	The international system of units (SI) and its application
AS 1045	Acoustics - Measurement of sound absorption in a reverberation room
AS 1074	Steel tubes and tubulars for ordinary service
AS/NZS 1125	Conductors in insulated electric cables and flexible cords
AS/NZS 1163	Cold-formed structural steel hollow sections
AS/NZS 1167.1	Welding and brazing - Filler metals - Filler metal for brazing and braze welding
AS/NZS 1167.2	Welding and brazing - Filler metals – Filler metal for welding

STANDARD / CODE	TITLE
AS 1170.4	Structural Design actions – Earthquake actions in Australia
AS/NZS 1200	Pressure equipment
AS 1210	Pressure vessels
AS 1228	Pressure equipment – Boilers
AS 1271	Safety valves, other valves, liquid level gauges and other fittings for boilers and unfired pressure vessels
AS 1284.1	Electricity metering - General purpose induction watthour meters
AS 1318	Use of colour for the marking of physical hazards and the identification of certain equipment in industry (known as the SAA Industrial Safety Colour Code)
AS 1319	Safety signs for the occupational environment
AS 1324.1	Air filters for use in general ventilation and air-conditioning - Application, performance and construction
AS 1324.2	Air filters for use in general ventilation and air-conditioning - Methods of test
AS 1345	Identification of the contents of pipes, conduits and ducts
AS 1349	Bourdon tube pressure and vacuum gauges
AS 1359.0	Rotating electrical machines - General requirements - Introduction and list of Parts
AS/NZS 1359.5	Rotating electrical machines - General requirements - Three-phase cage induction motors – High efficiency and minimum energy performance standards requirements
AS 1359.30	Rotating electrical machines - General requirements - Preferred outputs and frame sizes
AS 1359.31	Rotating electrical machines - General requirements - Three-phase induction motors - Operation on unbalanced voltages
AS 1359-101	Rotating electrical machines - General requirements - Rating and performance
AS 1359.114	Rotating electrical machines - General requirements - Vibration measurements and limits
AS 1366.1	Rigid cellular plastics sheets for thermal insulation - Rigid cellular polyurethane (RC/PUR)
AS 1366.3	Rigid cellular plastics sheets for thermal insulation - Rigid cellular polystyrene - Moulded (RC/PS - M)
AS 1397	Continuous hot-dip metallic coated steel sheet and strip – coatings of zinc and zinc alloyed with aluminium and magnesium
AS 1428.1	Design for access and mobility – General requirements for access – New building work
AS 1428.2	Design for access and mobility – Enhanced and additional requirements – Buildings and facilities
AS 1428.3	Design for access and mobility – Requirements for children and adolescents with physical disabilities
AS 1432	Copper tubes for plumbing, gas fitting and drainage applications

STANDARD / CODE	TITLE
AS/NZS 1477	PVC pipes and fittings for pressure applications
AS 1530.1	Methods for fire tests on building materials, components and structures – Combustibility test for materials
AS 1530.2	Methods for fire tests on building materials, components and structures – Test for flammability of materials
AS/NZS 1530.3	Methods for fire tests on building materials, components and structures - Simultaneous determination of ignitability, flame propagation, heat release and smoke release
AS 1530.7	Methods for fire tests on building materials, components and structures – Smoke control assemblies – Ambient and medium temperature leakage test procedure
AS 1548	Fine grained, weldable steel plates for pressure equipment
AS/NZS 1554.1	Structural steel welding - Welding of steel structures
AS/NZS 1554.6	Structural steel welding - Welding stainless steels for structural purposes
AS 1569	Copper and copper alloys - Seamless tubes for heat exchangers
AS/NZS 1571	Copper - Seamless tubes for air-conditioning and refrigeration
AS 1572	Copper and copper alloys - Seamless tubes for engineering purposes
AS 1604.1	Specification for preservative treatment – sawn and round timber
AS 1628	Water supply - Metallic gate, globe and non-return valves
AS 1657	Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS/NZS 1665	Welding of aluminium structures
AS/NZS 1668.1	The use of ventilation and air-conditioning in buildings - Fire and smoke control in buildings
AS 1668.2	The use of ventilation and air-conditioning in buildings – Mechanical ventilation in buildings
AS 1674.1	Safety in welding and allied processes - Fire precautions
AS 1674.2	Safety in welding and allied processes - Electrical
AS 1682.1	Fire, smoke and air dampers - Specification
AS 1682.2	Fire, smoke and air dampers - Installation
AS/NZS 1716	Respiratory protective devices
AS 1722.2	Pipe threads of Whitworth form – Fastening pipe threads
AS 1796	Certification of welders and welding supervisors
AS 1851	Routine service of fire protection systems and equipment
AS 1852.441	International electrotechnical vocabulary – Switchgear, control gear and fuses
AS 1910	Water supply - Float control valves for use in hot and cold water

STANDARD / CODE	TITLE
AS 1939 Supplement 1	Degrees of protection provided by enclosures for electrical equipment (IP Code) - Wallchart 1 (Supplement 1 to AS 1939-1990)
AS 1939 Supplement 2	Degrees of protection provided by enclosures for electrical equipment (IP Code) - Wallchart 2 (Supplement 2 to AS 1939-1990)
AS/NZS 2053.1	Conduits and fittings for electrical installations - General requirements
AS/NZS 2053.2	Conduits and fittings for electrical installations – Rigid plain conduits and fittings of insulating material
AS/NZS 2053.3	Conduits and fittings for electrical installations - Rigid plain conduits and fittings of fibre-reinforced concrete material
AS/NZS 2053.4	Conduits and fittings for electrical installations – Flexible plain conduits and fittings of insulating material (IEC 60614-2-5 Ed. 1.0 (Bilingual 1992))
AS/NZS 2053.5	Conduits and fittings for electrical installations – Corrugated conduits and fittings of insulating material
AS/NZS 2053.7	Conduits and fittings for electrical installations - Rigid metal conduits and fittings
AS/NZS 2053.8	Conduits and fittings for electrical installations – Flexible conduits and fittings of metal or composite material (IEC 60614-2-5 Ed. 1.0 (Bilingual 1992))
AS 2239	Galvanic (sacrificial) anodes for cathodic protection
AS/NZS 2243.3	Safety in laboratories – Microbiological safety and containment
AS/NZS 2243.6	Safety in laboratories – Plant and equipment aspects
AS/NZS 2243.8	Safety in laboratories - Fume cupboards
AS/NZS 2243.9	Safety in laboratories – Recirculating fume cupboards
AS/NZS 2280	Ductile iron pipes and fittings
AS/NZS 2310	Glossary of paint and painting terms
AS 2467	Maintenance of electrical switchgear
AS 2528	Bolts, stud bolts and nuts for flanges and other high and low temperature applications
AS 2625.1	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - General guidelines
AS 2670.1	Evaluation of human exposure to whole-body vibration – General requirements
AS 2700	Colour standards for general purposes
AS 2738	Copper and copper alloys - Compositions and designations of refinery products, wrought products, ingots and castings
AS 2784	Endless wedge belt and V-belt drives

STANDARD / CODE	TITLE
AS 2832.1	Cathodic protection of metals – Pipes and cables
AS 2832.4	Cathodic protection of metals – Internal surfaces
AS 2848.1	Aluminium and aluminium alloys - Compositions and designations - Wrought products
AS 2971	Serially produced pressure vessels
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3003	Electrical installations – Patient areas
AS/NZS 3008.1.1	Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV - Typical Australian installation conditions
AS/NZS 3013	Electrical installations – Classification of the fire and mechanical performance of wiring system elements
AS/NZS 3100	Approval and test specification - General requirements for electrical equipment
AS 3111	Approval and test specification - Miniature overcurrent circuit-breakers
AS/NZS 3191	Electric flexible cords
AS/NZS 3200.1.1	Approval and test specification – Medical electrical equipment – General requirements for safety – Collateral Standard: Safety requirements for medical electrical systems
AS/NZS 3200.1.2	Approval and test specification – Medical electrical equipment – General requirements for safety – Collateral Standard: Electromagnetic compatibility – Requirements and tests
AS/NZS 3200.1.4	Approval and test specification – Medical electrical equipment – General requirements for safety – Collateral Standard: Programmable electrical medical systems
AS/NZS 3200.1.8	Approval and test specification – Medical electrical equipment – General requirements for safety – Collateral Standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems
AS/NZS 3200.2.41	Approval and test specification – Medical electrical equipment – Particular requirements for safety – Surgical luminaires and luminaires for diagnosis
AS/NZS 3439.1	Low-voltage switchgear and control gear assemblies - Type-tested and partially type-tested assemblies
AS/NZS 3439.2	Low-voltage switchgear and control gear assemblies - Particular requirements for busbar trunking systems (busways)
AS/NZS 3439.3	Low-voltage switchgear and control gear assemblies - Particular requirements for low-voltage switchgear and control gear assemblies intended to be installed in places where unskilled persons have access for their use – Distribution boards
AS/NZS 3439.4	Low-voltage switchgear and control gear assemblies - Particular requirements for assemblies for construction sites (ACS)
AS/NZS 3500.0	Plumbing and drainage – Glossary of terms
AS/NZS 3500.1	Plumbing and drainage – Water services

STANDARD / CODE	TITLE
AS/NZS 3500.1.1	Plumbing and drainage – Water supply – Performance requirements
AS/NZS 3500.2	Plumbing and drainage – Sanitary plumbing and drainage
AS/NZS 3500.2.1	Plumbing and drainage – Sanitary plumbing and drainage - Performance requirements
AS/NZS 3518	Acrylonitrile butadiene styrene (ABS) compounds, pipes and fittings for pressure applications
AS 3645	Essential requirements for gas equipment
AS/NZS 3666.1	Air-handling and water systems of buildings - Microbial control - Design, installation and commissioning
AS/NZS 3666.2	Air-handling and water systems of buildings – Microbial control – Operation and maintenance
AS/NZS 3666.3	Air-handling and water systems of buildings – Microbial control – Performance-based maintenance of cooling water systems
AS/NZS 3666.4	Air-handling and water systems of buildings – Microbial control – Performance-based maintenance of air handling systems (ducts and components)
AS 3688	Water supply – Metallic fittings and end connectors
AS 3690	Installation of ABS pipe systems
AS 3715	Metal finishing - Thermoset powder coating for architectural applications of aluminium and aluminium alloys
AS/NZS 3750	Paints for steel structures
AS 3768	Guide to the effects of temperature on electrical equipment
AS 3865	Calculation of the effects of short-circuit currents
AS/NZS 3879	Solvent Cements and Priming Fluids for PVC (PVC-U and PVC-M) and ABS Pipes and Fittings
AS/NZS 3947.3	Low-voltage switchgear and control gear - General rules
AS/NZS 3992	Pressure equipment - Welding and brazing qualification
AS 3996	Access covers and grates
AS 4041	Pressure piping
AS 4072.1	Components for the protection of openings in fire-resistant separating elements - Service penetrations and control joints
AS 4180.1	Measurement of drift loss from cooling towers - Chloride balance method
AS 4180.2	Measurement of drift loss from cooling towers – Lost chlorine method
AS/NZS 4200.1	Pliable building membranes and underlays - Materials
AS/NZS 4200.2	Pliable building membranes and underlays – Installation requirements
AS/NZS 4251.1	Electromagnetic compatibility - Generic immunity standard - Residential, commercial and light industry
AS 4254.1	Ductwork for air-handling systems in buildings - Flexible duct

STANDARD / CODE	TITLE
AS 4254.2	Ductwork for air-handling systems in buildings - Rigid duct
AS 4260	High efficiency particulate air (HEPA) filters - Classification, construction and performance
AS/NZS 4417.3	Regulatory compliance mark for electrical and electronic equipment - Specific requirements for electromagnetic compatibility regulatory applications
AS 4506	Metal finishing - Thermoset powder coatings
AS/NZS 4680	Hot-dipped galvanized (zinc) coatings on fabricated ferrous articles
AS 4702	Polymeric cable protection covers
AS/NZS 4766	Polyethylene storage tanks for water and chemicals
AS/NZS 4776.1.1	Liquid-chilling packages using the vapour compression cycle – Method of rating and testing for performance – Rating
AS/NZS 4776.1.2	Liquid-chilling packages using the vapour compression cycle – Method of rating and testing for performance – Testing
AS/NZS 4776.2	Liquid-chilling packages using the vapour compression cycle – Minimum energy performance standard (MEPS) and compliance requirements
AS/NZS 4791	Hot-dip galvanized (zinc) coatings on ferrous open sections, applied by an in-line process
AS/NZS 4792	Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialized process
AS/NZS 4859.1	Mineral wool thermal insulation – General criteria and technical provisions
AS/NZS 5149.1	Refrigerating systems and heat pumps—Safety and environmental requirements - Part 1: Definitions, classification and selection criteria
AS/NZS 5149.2	Refrigerating systems and heat pumps—Safety and environmental requirements - Part 2: Design, construction, testing, marking and documentation
AS/NZS 5149.3	Refrigerating systems and heat pumps—Safety and environmental requirements - Part 3: Installation site
AS/NZS 5149.4	Refrigerating systems and heat pumps—Safety and environmental requirements - Part 4: Operation, maintenance, repair and recovery
AS/NZS 5601.1	Gas installation – General installations
AS ISO 8601	Data elements and interchange formats - Information interchange - Representation of dates and times
CIBSE	Commissioning Codes
IEC 60085	Electrical insulation – Thermal evaluation and designation
NCC	Section J

4.3 SEISMIC RESTRAINTS

4.3.1 DESIGN STANDARD

- 1 NCC - Building Code of Australia.
- 2 AS 1170.4 - Structural design actions - Earthquake actions in Australia

4.3.2 DESIGN PARAMETERS

The following design parameters shall be used to design the Engineering Services equipment and fastenings as per AS1170.4:

Importance Level	To be confirmed with Structural Engineer
Site Sub-Soil Class	To be confirmed with Structural Engineer

Design and install the scope of works to withstand the earthquake forces determined from the above design criteria in accordance with the requirements of the NCC and AS1170.4.

4.4 DESIGN CRITERIA

PARAMETER	DESIGN CRITERIA
External Ambient Conditions (for air conditioning plant full load performance)	Summer — 35°C dry bulb maximum — 21°C wet bulb maximum Winter — 3.5°C dry bulb minimum
Internal Conditions (for air conditioning plant full load performance)	Apartments/General Conditioned Spaces: Summer — 24°C dry bulb maximum at point of control Winter — 21°C dry bulb at the point of control Apartment corridors and lift lobbies: Winter — 20°C dry bulb at the point of control (West Tower only) Entry Lobbies and Common Areas: Summer — 25°C dry bulb maximum at point of control Winter

	<p>— 19°C dry bulb at the point of control</p> <p>Relative humidity to be a maximum of 70% but noting that no humidity controls are specified</p>
Air Conditioning System Controls Tolerance	±1.5°C dry bulb at point of control
Ventilation	<p>Outside Air: AS 1668.2</p> <p>Outdoor air to Apartments will be supplied by natural means. I.e: occupants will open a window / door to achieve ventilation and as such all opening will be required to comply with the NCC, eg: 5% of the flow areas shall have equivalent openable free area of the window.</p> <p>Main Switchroom:</p> <p>Max Internal Temp : 35 °C DB</p> <p>Continues operation</p> <p>Fire Pump room:</p> <p>Max Internal Temp : 35 °C DB</p> <p>And sufficient ventilation to supply diesel engine with sufficient air for combustion and maintain positive pressurisation of the room (operates only when diesel pump in operation)</p> <p>Ground Floor Lobby & Service Corridor: 1L/s/m²</p> <p>Gas Meter Room: Naturally Ventilated as per relevant authority requirements</p> <p>All internal and equipment heat loads shall be verified by the mechanical contractor with the various installers / suppliers before he/she prepares detailed heat load and ventilation calculations</p>
Exhaust Air	<p>General Requirements: AS 1668.2</p> <p>Male, Female & Disabled Toilets: AS 1668.2</p> <p>Switch Room: To suit equipment heat rejection at dT=10°C</p> <p>Substation: As per relevant authority requirements</p> <p>Fire Pump Room: To suit equipment heat rejection at dT=10°C</p> <p>Lift Motor Rooms: AS 1735.1</p>
Hours of Operation	24 hours / 7 days

Internal Heat Gains

PARAMETER		DESIGN CRITERIA
Occupancy		<p>Apartments: 24/7</p> <p>Reception: 24/7</p> <p>Retail: TBC</p>
Infiltration	Perimeter Façade:	0.25 air changes per hour

	Main Entry Lobby:	1.0 air change per hour
People		70 Watts/person sensible 70 Watts/person latent
Lighting		5W/m ²
Equipment		Living Area (1 bedroom): 400 Watts Living Area (2 bedrooms): 600 Watts Living Area (3 bedrooms): 800 Watts Kitchen Area: 350 Watts Sensible + 750 Watts Latent (as per NATHERS @ 7pm)* Bedroom Area: 400 Watts

System Velocity / Pressure Drop

PARAMETER	DESIGN CRITERIA
General	6m/s & 0.8Pa/m & in accordance with Acoustic Design Report
Carpark supply duct to masonry plenums	3.5m/s
Toilet exhaust with grilles	3m/s
Exhaust/Relief Air Riser	6m/s
FCU/WCU Main Supply Air	6m/s
FCU/WCU Branch Supply Air with grille	3m/s
FCU/WCU Return Air Duct with grilles	3m/s
Kitchen Exhaust Riser	8m/s
Louvres	1.25 m/s face velocity at 50% free open area.

Building Parameters

PARAMETER	DESIGN CRITERIA
Roof	Refer Architectural Documentation
Walls	Refer Architectural Documentation
Glazing	Refer Architectural Documentation
Blinds/Drapes	Closed when sun on façade, open when sun off façade
Partition Loads	Adjacent non-air conditioned spaces included

Tenancy Provisions

PARAMETER	DESIGN CRITERIA
Provisional Kitchen Exhaust System	In addition to Base Building general exhaust facilities, Ground floor kitchens are to be exhausted at 2500 L/s & 1000L/s capacity each which will share the same exhaust fan however will be complete with an in duct partition (see mechanical drawings for more details). Maximum PD for any kitchen 150 Pa.

Acoustic

PARAMETER	DESIGN CRITERIA
Maximum Noise Levels	Refer to Schedules

Vibration

PARAMETER	DESIGN CRITERIA
Maximum Vibration Levels	Tactile structure vibration levels due to plant not to exceed the lower end of the range specified in AS 2670.2.

5 PAINTING, PROTECTION & IDENTIFICATION

5.1 GENERAL REQUIREMENTS

- 1 Select painting and finishes in accordance with the area environmental conditions.
- 2 Review the risk assessment and statutory and authority requirements completed as part of the system testing, commissioning and handover requirements and provide labelling and signage as determined.
- 3 Where exposed to view paint exposed equipment, cable trays, ductwork and pipework
- 4 Where ductwork, pipework, cable trays exposed to view is not specified to be painted, all factory and installation markings shall be removed.
- 5 All black steel surfaces and surfaces subject to corrosion shall be primed with at least two coats of primer and protected.
- 6 Protect all items of work during dispatch and whilst on site during progress of installation.
- 7 Fabricated pipe and steelwork shall be delivered to site prime coated
- 8 Concealed pipe work to be prime coated
- 9 If exposed to view, paint new services and equipment including in plant rooms, except chromium, anodised aluminium, GRP, UPVC, stainless steel, non-metallic flexible materials and normally lubricated machined surfaces. Repaint proprietary items only if damaged.
- 10 Do not combine paints from different manufacturers in a paint system.
- 11 Remove or protect fixtures, equipment, surfaces and labels before starting to paint, and re-instate after completion of painting.
- 12 All internal surfaces of air outlets and openings exposed to view shall be painted matt black
- 13 Repair factory finishes if damaged with identical finishes.
- 14 Finish visible joints made by welding, brazing or soldering using methods appropriate to the class of work (including grinding or buffing) before further treatment such as filling, painting, galvanising or electroplating.
- 15 If galvanised surfaces have been cut or welded after galvanising, prime the affected area using zinc rich organic binder AS/NZS 2312.
- 16 Before applying coatings to metalwork, complete cutting, drilling and other fabrication, remove all grease, oil and other contaminants and prepare surfaces to AS 1627.0
- 17 Use relevant Australian Standards for the following finishes; Galvanising, Electroplating, Anodising, Thermoset powder coating, Two-pack liquid coating, Air-drying enamel, Stoving enamel

5.2 SUBMISSIONS

- 1 Provide the following submissions or samples:
 - a Proposed Labelling Systems.

- b Schedule of statutory, maintenance and operating signage.
- c Valve Identification

5.3 CORROSION PROTECTION

5.3.1 GENERAL

- 1 Apply corrosion protection measures to all metallic surfaces.
- 2 Select an appropriate protective coating system to suit atmospheric corrosivity category as defined in referenced Standards/Codes.
- 3 Fastenings are to be protected to have a corrosion resistance equivalent to the parts fastened.
- 4 All welding is to be completed before any corrosion protection treatment is applied.

ATMOSPHERIC CORROSIVITY CATEGORY	TYPICAL EXTERIOR ENVIRONMENTS	TYPICAL INTERIOR ENVIRONMENT
C1: Very Low	Few alpine regions	Heated or air conditioned buildings, such as most of commercial buildings. Unheated or non-air conditioned buildings in semi-sheltered locations remote from marine or industrial influence
C2: Low	Dry, rural areas as well as other regions remote from the coast or sources of pollution. Typical areas occur in arid and rural inland regions, most inland cities and suburbs of cities on sheltered bays.	Unheated or non-air conditioned buildings, where some condensation may occur, such as warehouses and sports halls, can be in this category. Proximity to the coast is an important factor.
C3: Medium	Coastal areas with low salinity	Food processing plants, laundries, breweries, printing works, dairies
C4: High	Sea-shore (calm)	Swimming pools, dye works, paper manufacturers, foundries, smelters and chemical processing plants, livestock buildings
C5-I: Very High (Industrial)	Sea-shore /offshore	-
C5-M: Very High (Marine)	Shoreline (severe surf)	Adjacent to acidic processes
T: Inland Tropical	Non-coastal tropics	-

5.3.2 PROTECTION FOR STEEL SURFACES

- 1 Apply corrosion protection to meet the performance criteria scheduled in the table below.
- 2 Standards of surface preparation procedures and of corrosion treatments are to meet the specified criteria and the referenced Standards/Codes for the relevant application.

- 3 Surface preparation procedures and coating systems for corrosion protection are to meet all relevant requirements of the referenced Standards/Codes.

ATMOSPHERIC CORROSIVITY CATEGORY	SURFACE PREPARATION	COATING SYSTEM
C1: Very Low	Class Sa 2½ Blast Cleaning 'Very thorough' (commonly called 'near white') blast cleaning which removes millscale, rust and foreign particles to the extent that only traces remain.	1 st Coat – zinc phosphate alkyd primer, 75 microns thick 2 nd Coat – full gloss alkyd finish, 50 microns thick 3 rd Coat – full gloss alkyd finish, 50 microns thick Or Factory applied zinc primer and thermoset powder coated finish
C2: Low	Class Sa 2½ Blast Cleaning	1 st Coat – zinc phosphate alkyd primer, 75 microns thick 2 nd Coat – full gloss alkyd finish, 50 microns thick 3 rd Coat – full gloss alkyd finish, 50 microns thick Or Factory applied zinc primer and thermoset powder coated finish
C3: Medium	Class Sa 2½ Blast Cleaning	1 st Coat – Organic zinc primer, 75 microns thick 2 nd Coat – polyurethane, 100 microns thick Or Factory applied zinc primer and thermoset powder coated finish
C4: High	Class Sa 2½ Blast Cleaning	1 st Coat – Organic zinc primer, 75 microns thick 2 nd Coat – polyurethane, 100 microns thick Or Factory applied zinc primer and thermoset powder coated finish
C5-I Very High Industrial	Manufacturer's recommendation	To approval
C5-M Very High Marine	Class Sa 2½ Blast Cleaning	1 st Coat – Organic zinc primer, 75 microns thick 2 nd Coat – polyurethane, 100 microns thick Or Factory applied zinc primer and thermoset powder coated finish
T Inland Tropical	Class Sa 2½ Blast Cleaning	One coat inorganic zinc coating, 75 microns thick Or zinc or aluminium thermal spray metallic coating.

5.3.3 PROTECTION FOR NON-FERROUS METALLIC SURFACES

- Standards of surface preparation procedures and of corrosion treatments are to meet the specified criteria and the referenced Standards/Codes for the relevant application.

- 2 Surface preparation procedures and coating systems for corrosion protection are to meet all relevant requirements of the referenced Standards/Codes.

5.4 PAINTING

5.4.1 LOW VOC

The following additional requirements are to be met if required by the Green Star Schedule in Schedules.

- 1 All painted surfaces to use low-VOC paints.
- 2 VOCs are to be in accordance with The Australian Environmental Labelling Association, Inc. Standard No: AELA 23-2005 'Australian Voluntary Environmental Labelling Standard Architectural and Protective Coatings'.
Conformance with VOC levels listed in this standard (refer to table below) shall be demonstrated by providing test reports from laboratories accredited to carry out the relevant tests and/or calculations and appropriate documentation of production methods and quality controls.

PRODUCT TYPE	MAXIMUM VOC CONTENT (G/LITRE)
Latex Primer for galvanised iron and zincalume	60
Exterior latex undercoat	55
Interior latex undercoat	65
Interior gloss	75
Interior semi-gloss	16
Exterior gloss	75

- 3 VOC limits on architectural coatings covered. Allowable levels include water content in the formulation.
- 4 For solvent-based coatings the paint shall not contain VOCs in excess of 200g/litre. For recycled paints the VOC level (averaged across batches) in the paint must not exceed 100g/litre.
- 5 The VOC content of the paint shall either be calculated from the VOC data for each of the raw materials or, experimentally by ASTM D3960, as qualified the Australian Environmental Labelling Association, Inc. Standard No: AELA 23-2005 'Australian Voluntary Environmental Labelling Standard Architectural and Protective Coatings'.
- 6 Where the raw material is a mixture of compounds, some of which contain VOCs, the VOC content of the mixture may in turn be calculated from the VOC content of the individual components. Where this is not known, it must be determined by the methodology detailed in AELA 23-2005.

5.4.2 PREPARATION OF SURFACES

- 1 Preparation: all surfaces shall be prepared by thorough cleaning of all dirt, grease, scale, welding flux and corrosion in accordance with AS/NZS 2312.
- 2 For galvanised surfaces that have been subsequently cut or welded, prime the affected area with organic zinc rich coating for protection of steel to AS/NZS2312, two pack or accepted alternative.
- 3 Prime/undercoat all surfaces. Galvanised and non-ferrous surfaces must be etch primed.

5.4.3 APPLICATION

- 1 First coat: apply the first coat immediately after the substrate preparation and before contamination of the substrate can occur.
- 2 Apply all paint systems in strict accordance with manufacturer's recommendations.
- 3 Finish: each coat of paint or finish shall be uniform in colour, gloss, thickness and texture and free of runs, sags or blisters.

5.4.4 FINISHING

- 1 Concrete Bases: 2 coats synthetic emulsion paint
- 2 Equipment Panels/Switchboards: 2 final coats full gloss enamel
- 3 Equipment: Factory spray application
- 4 Other surfaces: 2 final coats full gloss enamel

5.5 COLOURS

Paint colours nominated are to be in accordance with AS 2700 and AS 1345.

5.6 IDENTIFICATION AND LABELLING

5.6.1 GENERAL

- 1 Mark all systems and equipment including wiring, piping, control panels, switchboards, ductwork, equipment cabinets, conduits, controls, gauges, valves and fittings to that they are readily identifiable.
- 2 Equipment requiring special maintenance procedures or presenting occupational health and safety hazards: provide permanent labels complying with statutory requirements.
- 3 Locate labels so that they are easily seen and either attached to, below or next to item referred.
- 4 Labelling to match installation documentation schedules.
- 5 For systems containing hazardous materials provide labelling in accordance with AS 1318.
- 6 Where a pipe or duct passes through a wall, slab or partition provide labelling each side.
- 7 Equipment and Service labels shall be in accordance with the Legend of Symbols nomenclature for the respective service. Provide appropriate Emergency and Operating Instructions to every equipment and system.
- 8 Provide text and simple diagrams where practicable. Locate at a fixed point and point of operation.
- 9 Affix hazardous equipment with warning signs.
- 10 Labels shall be permanent.
- 11 Type: select from the following:
 - a Engraved and black filled lettering on stainless steel or brass plate, minimum 1mm thick mechanically fixed.
 - b Stencil with black or white lettering contrasting with background.
 - c Engraved two-colour laminated plastic mechanically fixed.
 - d Adhesive labelling.

e Painted.

12 Adhesive labels and laminated plastic labels shall not be used where exposed to the environment.

13 Painted labels shall be in the same finish paint type as the installation.

5.6.2 LABELLING REQUIREMENTS

ITEMS	REQUIREMENTS
Pipework	Labelling and lettering to AS 1345 and AS1318
Conduits	Labelling and lettering to AS 1345
Exposed Conduits	Labelling and lettering to AS 1345
Valves	Labels shall be colour coded laminated labels indicating service, function and normal position, and attached to hand wheels or spindles using a vandal resistant permanent chain/ring
Switchboards(general)	<ol style="list-style-type: none"> 1 Main switches: 10mm. 2 Outgoing electrical functional units: 8mm. 3 Automatic controls electrical equipment and instruments: 5mm. 4 Rear covers of switchboards: 5mm. 5 Components inside electrical enclosures and control panels: 3.5mm 6 Locate labels so that they are easily seen from normal access adjacent to the item being marked. Do not install labels on components normally removed or replaced.
All equipment such as chillers, pumps, fans, air handling units, generators including controls, gauges and fittings to that they are readily identifiable	<ol style="list-style-type: none"> 1 Label in accordance with the specification abbreviations, symbols and acronyms scheduled or otherwise approved. 2 Locate labels so that they are easily seen from normal access adjacent to the item being marked. Do not install labels on components normally removed or replaced. 3 Major equipment nameplates: 40mm. 4 Minor equipment nameplates: 20mm. 5 Danger, warning and caution notices: 10mm for heading, 5mm for text. 6 Warning notices: 7mm. 7 Minor lettering: 3mm. 8 Lettering Style: Helvetica Medium. 9 Fixing: Use mechanical fixings. Do not penetrate isolation vapour barriers. 10 Equipment requiring special maintenance procedures or presenting occupational health and safety hazards: provide permanent labels complying with statutory requirements. 11 Equipment requiring consumables including replacement belts, oils, filters and strainers: provide labels indicating consumable component details and quantities and corrective maintenance trigger point such as filter pressure drop.
Fire services in ceiling identifications	<ol style="list-style-type: none"> 1 Provide identification to ceiling tile or access panel for servicing to test drain valves, flow switches, concealed detectors or similar.

ITEMS	REQUIREMENTS
	<p>2 Use colour markers of 'black' for general servicing and 'red' for Code required identification e.g. concealed detectors.</p> <p>3 Use self-adhesive 'dot' type markers on ceiling suspension or plastic headed pins for insertion in ceiling material.</p>

6 INSPECTION, TESTING, COMMISSIONING, HANDOVER & DEFECTS LIABILITY PERIOD

6.1 GENERAL

- 1 This section sets out the engineering and quality assurance requirements for the completion of the installation, inspection regime, testing, commissioning, handover and defects liability period.

6.1.1 DESIGN

Complete the detail engineering of the testing commissioning and handover of the works to the specified requirements.

Comply with applicable authority design guidelines and codes of practice and requirements.

Commissioning guidelines as detailed by CIBSE Commissioning Codes shall be used as a minimum to undertake the commissioning of services listed in this section.

6.1.2 PRACTICAL COMPLETION REQUIREMENTS

- 1 Notwithstanding any other provisions of the Contract with regard to the granting of Practical Completion, the following requirements, listed in order of importance / priority, shall be completed and completion submissions made prior the date of Practical Completion:
- 2 Minimum submissions required for application for Occupancy Permit:
- 3 Submission of signed off testing and commissioning schedules to confirm that Testing and Commissioning has been finalised and that all plants and systems operate in a safe, stable and automatic manner under all conditions of full and partial load - full commissioning data.
- 4 Submission of Authority approvals including Statutory Authority approvals and Certification of Compliance with the NCC
- 5 Submission of Certification that works comply with the Contract Documents
- 6 Operating Instruction and Maintenance manual sections covering all Safety Services as required by regulations
- 7 Other submissions:
- 8 Submission of correctly and completely executed ITPs including test results completed in accordance with the Contractors Quality Plan and the satisfaction of the Consultant Engineer
- 9 Adequate training and instruction of the Principal's representatives in safe operation of the plant
- 10 Official Equipment manufacturer's acceptance certification for the installation
- 11 Completed Operating and Maintenance manuals and 'as built' drawings
- 12 The Defects Liability period may be extended in the event:
 - a Specific systems fail to achieve the desired outcomes after two attempts are made to rectify the drawback. These specific systems include those that are fire and life safety or business / mission critical to the Principal.

- b** If there have been more than three (3) attempts to rectify the defect, in which instance a further 12 months of monitoring will be required after the defect is rectified to monitor that the desired outcomes are achieved without further shortfalls.
-

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 - 5** Submission of Certification that works comply with the Contract Documents
 - 6** Operating Instruction and Maintenance manual sections covering all Safety Services as required by regulations
 - 7** Other submissions:
 - 8** Submission of correctly and completely executed ITPs including test results completed in accordance with the Contractor Quality Plan and the satisfaction of the Consultant Engineer
 - 9** Adequate training and instruction of the Principal's representatives in safe operation of the plant
 - 10** Official Equipment manufacturer's acceptance certification for the installation
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 - b** If there have been more than three (3) attempts to rectify the defect, in which instance a further 12 months of monitoring will be required after the defect is rectified to monitor that the desired outcomes are achieved without further shortfalls.
-

6.3 MANAGEMENT OF INSPECTION, TESTING, COMMISSIONING, HANDOVER AND DEFECTS LIABILITY PERIOD COMMITMENTS

6.3.1 GENERAL

- 1** Manage the whole process so as to
 - a** Ensure complete execution of Project Specific Quality Plan and specifically Installation and Commissioning ITPs are completed progressively from commencement of the project.

- b** Test and verify the operation of individual items of plant and equipment, sub-systems, systems and the overall installation including the interfaces with other building services systems forming part of the project.
- c** Create and record accurately and verify all “As Built “drawings progressively prior to services being concealed by construction of ceilings, wall cavities and shafts.
- d** Ensure completed Operating and Maintenance manuals inclusive of comprehensive system descriptions, operating modes and associated control functionality, tailored and project specific manufacturers literature.
- e** Responsive defects rectification process during the construction phase as well as post Practical Completion during Defects Liability Period.
- f** Ensure Responsive approach towards maintenance and operational fine tuning during the Defects Liability Period

6.3.2 SEQUENCE OF ACTIVITIES

Generally, follow the sequence of activities listed below. Modify to suit specific requirements of the project however no reduction of scope is allowed.

- 1** Submission of Project specific Project Quality Plan including generic and project Specific ITPs within the first quarter of the project programme after site possession.
- 2** Ongoing inspection of installation works by relevant Quality Manager and/or his nominated staff for meeting project quality requirements including preparing Inspection reports (listing all observed installation defects) not longer than fortnightly and also checking that all Installation ITPs are signed off.
- 3** Initiate Safety in Design process and documentation where applicable
- 4** Evidence of adequate commissioning programme allowance in construction programme.
- 5** Production and submission of commissioning Inspection and Test Plan (ITP) 12 weeks after site possession
- 6** Amendment to ITP as necessary and re-submission at least 1-2 weeks after the original submission.
- 7** Submission of controls manufacturer’s functional descriptions elaborating on the methodology proposed to implement the requirements of the control strategies the manufacturer’s controls functional descriptions shall be prepared and submitted at least 12 weeks prior to start of installation and commissioning of controls systems.
- 8** Nomination of those to be involved in commissioning including individuals with responsibility for management, engineering and field testing and commissioning.
- 9** Liaison with and briefing of Authorities to ensure that the connection to their assets and commissioning procedures and resultant data provided for their approval is consistent with their requirements and records.
- 10** Preparation of periodic (minimum monthly) progress reports on testing and commissioning.
- 11** Early and active engagement of Independent Commissioning Agent ICA where applicable.
- 12** Early (within the first quarter of the project construction programme) submissions of Operating and Maintenance Manual (for Safety Services and, for preliminary draft of the overall manual). Confirmation of acceptance of proposed Electronic Operating and Maintenance Manual software/platform.
- 13** Submission of detailed commissioning procedures for review by the Consultant Engineer. Submission shall be made early, at least 12 weeks prior to the commencement of commissioning when the project construction period greater than 12 months, or 6 weeks when the project construction period is less than 12 months’ duration.
- 14** Rectification of all defects likely to interfere with testing and commissioning.
- 15** Commencement of “As Built” drawing production

- 16 Carryout preliminary commissioning including pre-commissioning procedures until achievement of correct operation and performance. Providing statement that the pre-commissioning activities for each system are completed.
 - 17 Testing and commissioning of major plant and equipment, complete systems, interfaces between systems and finally all systems which interact together under normal or emergency conditions.
 - 18 Integrated testing and commissioning of multi systems (including multi-disciplinary systems) and their associated interfaces
 - 19 Inclusion of all completed Commissioning ITPs in the Operating and Maintenance Manual.
 - 20 Rectification of any further defects and deficiencies found during testing and commissioning.
 - 21 Provide notification of completion of remedial work in sufficient time to permit re-inspection as necessary before the intended date for re-testing.
 - 22 Repetition of sequence of activities as necessary until works comply with acceptance criteria as set out in the ITPs.
 - 23 Final handover of Final Operating and Maintenance Manuals
 - 24 Certification that works comply with the Contract Documents and with the NCC and Statutory Authorities and are ready for granting of Practical Completion.
-

6.3.3 SUBMISSIONS

Required submissions include but not limited to the following;

- 1 Installation and commissioning Inspection and Test Plans ITPs. 4 Copies of ITPs to be supplied, 3 bound into Installation Manuals and 1 bound separately
- 2 Evidence of periodic (weekly) Quality Inspection/defects reports
- 3 Testing and commissioning procedures including integrated commissioning procedures.
- 4 Evidence of Safety in Design process during the construction phase is completed where applicable
- 5 Evidence of currency of calibration of equipment to be used in commissioning procedures.
- 6 Records of all pre-commissioning checks and final commissioning data. All records/data to be certified as being conducted in accordance with agreed and approved procedures.
- 7 Manufacturers' certificates for all proprietary items, to confirm that the installation complies with their installation and maintenance requirements prior to start-up of equipment. Certificates shall also be provided at commencement of equipment installation to confirm their requirements with respect to installation are being provided for.
- 8 Manufacturers' test certificates of all capacity/performance verification checks carried out at factory prior to dispatch to site.
- 9 Accurate and verified (by QA manager) "As Built" drawings
- 10 Complete Operating and Maintenance Manuals (Electronic system/package and, unless instructed otherwise, hard copies)
- 11 Warranties
- 12 Maintenance Plan and Schedules following acceptance of technical submission and installation minimum 4-8 weeks prior to Practical Completion with priority with respect to timely completion given to plan and schedules covering Safety Services.

6.3.4 INSPECTION AND TEST PLANS

- 1 Inspection and test plans are to be prepared specifically for the project but may be based on or customised from generic ITPs. All commissioning result forms shall be completed, including the following:

Tested By: Please print	Witnessed By:
Signed:	Signed:
Date:	Date:
Test Device used:	
Serial Number:	
Date of Calibration:	
Method of Testing:	

- 2 List acceptance criteria for each element and sub-element of the installation in ITPs. Acceptance criteria to include:
- Specification details in regard to materials, construction methods, physical requirements, performance and operational requirements.
 - Schedule of Technical Data in respect of make, model and performance details of equipment.
 - Shop drawings.
 - Control logic and diagrams.
 - Authority inspection and testing requirements.
 - References to specific clauses of this Specification for acceptance criteria

6.3.5 COMMISSIONING INSTRUMENTATION

- All instrumentation used in the commissioning of the installation shall be managed in accordance with the requirements of AS 3912 or NEBB.
- Reference instruments are to be NATA certified.
- All commissioning results to include instrument calibration documentation.

6.3.6 COMMISSIONING PERSONNEL

- Provide only qualified registered / licensed personnel specific to the trades as required by local regulations, and where regulatory requirements do not apply, personnel certified by appropriate industry bodies.
- Submit a schedule of key commissioning personnel together with their qualifications prior to undertaking commissioning activities on site.
- All personnel used in the commissioning of the installation shall be managed in accordance with the requirements of NEBB and shall be NEBB certified.

6.4 TESTING AND COMMISSIONING

6.4.1 TESTS

Site testing shall include but not limited to the following:

- 1 Pre-energisation tests.
- 2 All ductwork systems pressure tests
- 3 All pipework systems pressure tests
- 4 Preliminary commissioning
 - a Air systems
 - b Water and condensate systems
 - c Controls and electrical
- 5 Final commissioning
 - a Major items of plant and equipment and components
 - b Systems and sub-systems
 - c Inter-system operation and interfaces
- 6 Additional tests as required by relevant Authorities
- 7 Performance tests
 - a Summer
 - b Winter

6.4.2 PRE-ENERGISATION TESTS

Prior to energisation of any system with electrical connections, conduct the following tests:

- 1 Tightness of screwed and bolted connections.
- 2 Physical integrity.
- 3 Correct phasing. Check phase rotation is consistent throughout the project and is the same as the supply.
- 4 Motor rotation.
- 5 Insulation resistance tests.
- 6 Test operation of all trips, interlocks, motor driven devices, contactors and control circuits and devices by instigating or simulating inputs.
- 7 Checks: Before starting, verify that each piece of equipment has been checked for proper lubrication, drive rotation, belt tension, control sequence, circuit protection or for other conditions which may cause damage.
- 8 Tests: Verify that tests, meter readings and specified electrical characteristics agree with those required by the manufacturer.
- 9 Load tests: Carry out simulated and on-line load tests for any standby generators or UPSs.

- 10 Wiring: Verify wiring and support components for equipment are complete and tested.
 - 11 Starting up: Execute starting up under supervision of manufacturer's representative in accordance with manufacturers' instructions.
 - 12 Electrical load balance: Measure phase currents and balance electrical loads.
 - 13 Insulation resistance: Check that the insulation resistance values are within limits.
 - 14 Report: Submit a report demonstrating that equipment has been properly installed and checked and is functioning correctly.
-

6.4.3 PRELIMINARY COMMISSIONING

6.4.4 AIR SYSTEMS

- 1 Check all dampers for correct operation.
 - 2 Clean air handling unit interiors and clean or replace air filters as necessary.
 - 3 Check and adjust air diffusers and grilles for direction and throw.
 - 4 Balance and adjust air flows for each system and sub-system so as to achieve air flows within 0% to +10% of specified rates allowing for filters partly obstructed to simulate 50% loaded.
 - 5 Check index run is not provided with any dampers. If any dampers are provided, these shall be fully open and demonstrated as part of the witness tests.
 - 6 Make sure velocities through filters and coils do not exceed the design limits.
-

6.4.5 WATER AND CONDENSATE SYSTEMS

- 1 Follow the procedures set out in 'Water Treatment' clauses of this specification prior to commencing balancing.
 - 2 Balance and adjust water flows for each system and sub-system so as to achieve 0% to +5% of the specified flow rates.
 - 3 Check and verify pressure and flow activated controls, relief devices, bleeds, vents, drains, etc.
 - 4 Check index run is not provided with any valves. If any valves are provided, these shall be fully open and demonstrated as part of the witness tests.
-

6.4.6 CONTROLS AND ELECTRICAL

- 1 Check and verify the correct operation of each item of control equipment and of each control system.
 - 2 Check and verify correct performance of all instrumentation, lights, timers, relays and safeties under all working conditions.
 - 3 Calibrate, set and adjust control instruments, control systems and safety controls.
-

6.4.7 FINAL COMMISSIONING

- 1 Undertake final commissioning in 3 stages:
 - a Major items of plant and equipment and components.
 - b Systems and sub-systems.

- c Inter-system operation and interfaces.
- 2 Final commissioning to include:
- a Testing of performance of individual plant items and components.
 - b Testing of operating sequences, interlocks and safeties.
 - c Final air and water balancing.
 - d Electrical testing and verification to AS/NZS 3000.
 - e Final controls calibration.
 - f System operation under all operating modes and under all conditions of load.
 - g Inter-system operation and correct interfacing connections under all operating conditions and under simulated fire conditions.
 - h Noise and vibration tests.
 - i Thermographic survey of mechanical switchboards.
 - j Water treatment tests and water analysis.
 - k Environmental audit (if required).
 - l Rectification and correction of any defects and deficiencies.
 - m Cleaning of plant room, switchboards and all mechanical services equipment and devices.
-

6.4.8 PERFORMANCE TESTS

- 1 Conduct air conditioning performance tests over 2 periods of up to 5 consecutive days each period in Summer and Winter. During each testing period, log the following at hourly intervals:
- a Ambient dry and wet bulb temperatures in a shaded location.
 - b Internal dry and wet bulb temperatures in representative locations.
 - c Estimated number of persons in each area.
 - d Estimated kW of lighting and heat producing appliances.
 - e Any other factors effecting cooling loads.
 - f Velocities through each cooling and heating coil on each air handling unit.
 - g Velocity through each set of filters on each unit.
- 2 Calculate the plant thermal capacity at peak operating conditions obtained from the test results.
- 3 Undertake any adjustments to controls or to air and water quantities as may be required to correct any deficiencies found during the performance testing.
-

6.4.9 COMMISSIONING

Operate the installation to prove the performance, capacities and ability to provide the required service.

Undertake commissioning in 4 stages:

- 1 Individual component functionality testing including verification of defects free installation
- 2 Major items of plant and equipment and components.

- 3 Systems and sub-systems.
- 4 Inter-system operation and interfaces.

Commissioning to include:

- 1 Performance of individual plant items and components.
- 2 Operating sequences, interlocks and safeties.
- 3 Final controls calibration.
- 4 System operation under all operating modes and under all conditions of load.
- 5 Inter-system operation and correct interfacing connections under all operating conditions and under simulated fire conditions.
- 6 Noise and vibration tests.
- 7 Thermoscan survey of switchboards.
- 8 Environmental audit as required by Authorities.
- 9 Rectification and correction of any defects and deficiencies.
- 10 Continue commissioning until achievement of correct performance and operation.
- 11 Final air and water balancing.
- 12 Electrical testing and verification to AS/NZS 3000.
- 13 Water treatment tests and water analysis.
- 14 Cleaning of plant room, switchboards and all equipment and devices.

6.5 FINAL CONTRACT AND HANDOVER DOCUMENTATION

6.5.1 GENERAL REQUIREMENTS

- 1 Documentation is required in electronic and hard copy format. Electronic documentation shall be supplied on the latest Microsoft and AutoCAD Software versions at the time of Practical Completion.
- 2 Scope of the documentation and format requirements comprise:

Document	Format	Sets
Operating and Maintenance Manuals, including Final commissioning data	Electronic installed on BAS File Server	1
	CD ROM – Microsoft Office Latest Version	3
	Hardcopy	3
As Built Drawings	CD ROM – AutoCAD	3
	Hardcopy – Full Size with hanging strips	1
	A3 Size	2
Control Software	CD ROM	1
OH&S Safety Signage	Permanent	1

6.5.2 AS BUILT DRAWINGS

- 1 All as Built/As Installed documents submitted shall have a stamp with similar words to the following and be signed prior to submission for review.

AS INSTALLED DRAWING	
We certify that this drawing is an accurate record of the work installed by our company under the terms of our contract.	
Contractor's Name	
Contractor's Address	
Signed	Date
Printed	

- 2 Progressively record changes to form a record of work as installed.
- 3 Prepare and submit for approval as-built drawings covering all aspects of the work.
- 4 Show dimensions, types and locations of equipment, cables, piping, ductwork pits and markers in relation to permanent site features and other underground services.
- 5 Show the 'as-installed' locations of building elements, plant and equipment with particular emphasis on items requiring maintenance or clearing.
- 6 Show off-the-grid dimensions where applicable. Include relationship to building structure street features and other services and changes made during commissioning.
- 7 Show inverts of drainage and relative locations of gully and boundary traps
- 8 Provide as Built documentation as per Schedule of Required as Builts:

6.5.3 OPERATING AND MAINTENANCE MANUALS

- 1 Provide comprehensive Operating and Maintenance documentation to cover all installations in order to provide a detailed understanding of the plant and its operation, an aid for training of operators, a reference for fault diagnosis and a framework for preventative and breakdown maintenance.
- 2 Submit manuals in two stages. Stage 1 include all of the sections (generally sections 1-5) of manuals excluding final testing and commissioning records and As Built drawings. This manual shall be submitted well in advance of the Practical Completion and should be signed off by the Consultant Engineer at least 4-6 weeks before programme Practical Completion Date.
- 3 First draft manuals Stage 1: Submit a first draft manual 8-10 weeks before the date for practical completion for review.
- 4 Second drafts Stage 1: Following receipt of comment on the first draft and not later than 2 weeks after submit a completed second draft for review. Incorporate comments.
- 5 Third Draft Stage 1&2: Include all remaining sections and submit 2-3 weeks before Practical Completion. Incorporate all changes and resubmit until all comments are addressed to the satisfaction of the Consultant Engineer.
- 6 Final copies Stage 1&2: Submit 3 sets of final volumes within 2 weeks after practical completion. Incorporate feedback from review and from training of Principal's staff, including preparation and insertion of additional data. Include a section containing commissioning test reports.

- 7 Revisions: Prior to final completion, submit 3 sections sets of loose leaf amendments for insertion in the manuals, incorporating feedback from the maintenance period.
- 8 Warning and Cautions: Include to emphasise conditions hazardous to personnel or equipment, giving instructions to avoid the hazard. Format to be:
- 9 **WARNING:** An examining or testing procedure or practice which must be observed or risk loss of life or injury to personnel.
- 10 **CAUTION:** An examining or testing procedure or practice which must be followed or risk damage to equipment.
- 11 The manual shall be neatly prepared and bound in one, or a series of, vinyl hard-back folder with lettering on the front and the spine including the following information:

OPERATION AND MAINTENANCE MANUAL

VOLUME NUMBER

PROJECT NAME

DATE OF ISSUE

XX SERVICES

CONTRACTOR











CONSULTANT ENGINEERS – WSP

SUB CONTRACTOR

- 12 Pagination: Number pages consecutively. Double sided on A4 size (minimum 50%) recycled white (minimum CIE whiteness of 140) paper, with reinforced binder perforations.
- 13 Ring size: 50mm maximum, with compressor bars.
- 14 Dividers: Durable divider for each separate element, with typed description of system and major equipment components. Clearly print short titles under laminated plastic tabs.
- 15 Drawings: Fold illustrative drawings to A4 size and accommodate them in plastic pockets in the binder. Title block to be visible without removal of drawing
- 16 All aspects of the style and quality of the manual, including folders and contents shall be submitted for approval prior to completion.
- 17 After the draft copy, has been approved, supply 3 copies of the manuals for issue to the Principal and the Consultant Engineer.
- 18 Allow for loading the manual onto the Building BAS systems (where available) and arrange to provide the manual including commissioning results.

ELECTRONIC/DIGITAL FORMAT

- 1 Documents shall be stored in DVD Disc or Potable USB Flash Drive Storage Drive. Provide labelling to the storage media.
- 2 Electronic Storage device shall not be “copy protected”.
- 3 Manual shall be contained within **a single searchable PDF** accessible via Adobe or similar PDF reader. PDF shall be indexed, divided in to folders and titled. Each folder shall contain relevant electronic/digital format documentation in line with the contents specified below. Refer below of a screen print of Adobe Reader for a typical arrangement.

File Edit View Document Tools Window Help				
     				
	Name	Modified	Created	Order
	1 Index	14/06/2011 5:47:51 PM	14/06/2011 5:47:51 PM	0
	2 General Description & Capacities of Installation	14/06/2011 5:41:58 PM	14/06/2011 5:41:57 PM	1
	3 Equipment Schedule & Technical Data	14/06/2011 5:42:20 PM	14/06/2011 5:42:08 PM	2
	4 Installation, Maintenance & Operating Instructions	14/06/2011 5:42:34 PM	14/06/2011 5:42:33 PM	3

“Screen Shot” for Reference

- 4 Avoid submitting manually scanned Manufacturers’ data, where possible include only searchable PDF documentation.
- 5 Include only relevant diagrams, equipment data in clear concise English. Avoid jargon and esoteric pseudonyms.
- 6 Provide each document included in the PDF with the following naming convention:
- 7 Section “X” – “Document Description”.pdf
- 8 Provide clear scanned copies of Statutory Certificates of Compliance
 - a Accessible Dwg format CAD drawings of the as-built documentation shall be contained within the PDF.

INSTALLATION MANUAL FORMAT

- 1 Section 1 – Index
 - a Index all sub-divisions of each section including lists of drawings, equipment, etc. for quick reference.
 - b Include index in every volume of the manuals.
- 2 Section 2 - General Description and Capacities of Installations:
 - a Divide into sub-sections for general items and for each individual system as appropriate and include full details
 - b Include a directory: Names, addresses and telephone, email and facsimile numbers of Principal, Consultant Engineer, Sub-Consultants, Contractor, Sub-Contractors and names of responsible parties.
 - c Include a scope of works: Statement of scope of services and interfacing with other Contracts.
 - d Include an installation description: General description of installation.
 - e Systems description: Technical description of the systems installed, written to ensure that the Principal’s staff fully understand the scope and facilities provided. Identify function, normal operating characteristics and limiting conditions. Include schematic diagrams.
 - f System performance: Technical description of the modes of operation of the systems installed.
- 3 Section 3 – Equipment:
 - a Sub-divide as for Section 2 and list all major items of equipment installed complete with manufacturer's name, agent's name, contact details, model and/or type No., serial No., size, design ratings and including all relevant data necessary for re-ordering or replacing the equipment or components of same. As far as practicable, all equipment should be broken down to individually identifiable items.

- b** Provide manufacturers' technical literature for equipment installed, assembled specifically for the project, excluding irrelevant matter. Mark each product data sheet to clearly identify specific products and component parts used in the installation and data applicable to the installation. Do not include advertising literature. Cross out any section of literature which is not applicable to the project.

4 Section 4 – Installation, Maintenance and Operating Instructions:

- a** Sub-divide as for Section 2 and include manufacturer's installation, maintenance and operating instructions for each item of equipment.
- b** Emergency maintenance procedures, including telephone numbers for emergency services and after hour's contact for suppliers and Contractors and procedures for fault finding.
- c** Manufacturer's technical literature as appropriate. Register with manufacturer as necessary. Retain copies delivered with equipment.
- d** Detailed recommendations for preventative maintenance frequency and procedures which should be adopted by the Principal to ensure the most efficient operation of the systems installed. Include inspection, testing and maintenance programme in tabular form showing frequency and level of routine checks for each item.
- e** Safe trouble shooting, disassembly, repair and reassembly, cleaning, alignment and adjustment, balancing and checking procedures. Provide logical step-by-step sequence of instructions for each procedure. Include calibration and recommissioning of controls.
- f** Schedule of spares recommended to be held on site, being those items subject to wear or deterioration and which may involve the Principal in extended deliveries when replacements are required. Include complete nomenclature and model numbers, and local sources of supply. Include sectionalised diagrams of machines identifying component parts.
- g** Schedule of normal consumable items, local sources of supply and expected replacement intervals up to a running time of 40,000 hours. Include lubricant and lubrication schedules for equipment where applicable.
- h** Add to the manufacturer's technical literature, for assembly, operating, maintenance and disassembly, safety information for all plant, systems or structures installed within the project or for existing plant, systems or structures where assembly, operating, maintenance and disassembly are altered or amended by the installation of plant, systems or structures within the project.
- i** The added safety information shall be included at relevant sections of the manufacturer's literature and not as a separate part and shall be made clear and obvious to the user of the manual.

5 Section 5 – Plant Operating Instructions:

- a** Sub-divide as for Section 2 and provide a complete description and correct sequence of all actions necessary to start-up, operate and shut-down all plant including procedures for seasonal changeovers where applicable. These instructions shall include full information on such items as normal and abnormal gauge readings, instrument settings and control points, differentials, time delays, oil levels, water temperatures, and all similar relevant variable and adjustable items, to permit checking and adjustments where practicable and identification of hazardous conditions or malfunction of plant. In addition, the instructions shall include information on the immediate action to be taken in the event of hazardous conditions arising.
- b** Add to the manufacturer's technical literature, for assembly, operating, maintenance and disassembly, safety information for all plant, systems or structures installed within the project or for existing plant, systems or structures where assembly, operating, maintenance and disassembly are altered or amended by the installation of plant, systems or structures within the project.
- c** The added safety information shall be included at relevant sections of the manufacturer's literature and not as a separate part and shall be made clear and obvious to the user of the manual.

6 Section 6 – Performance Test Results:

- a** This section shall be sub-divided as for Section 2 and shall include all performance test results as outlined in previous Clauses.

7 Section 7 – Certificates and Warranties

- a** Statutory Certificates of Compliance for:
- b** Electrical work.
- c** Plumbing drainage or gas-fitting work.
- d** Refrigeration or air conditioning and ventilation work.
- e** Copies of manufacturers' warranties.
- f** Certificates from authorities and utilities.
- g** Production certification.
- h** Copies of test certificates for the installation and equipment used in the installation.

8 Section 8 – Drawings

- a** Drawings and technical data: As necessary for the efficient operation and maintenance of the installation.

6.5.4 WARRANTIES

Warranty periods are deemed to end at expiry of defects liability period unless specified otherwise.

Name the Principal as warrantee. Register with manufacturers as necessary. Retain copies delivered with components and equipment.

Commence warranty periods at practical completion or at acceptance of installation, if acceptance is not concurrent with Practical Completion.

If installation is not being manufactured and product warranty is conditional on the manufacturer's approval of the Contractor, submit the manufacturer's written approval of the installing firm.

6.5.5 REQUIRED OPERATING INSTRUCTIONS

- 1** Provide operating instructions and schematic diagrams mounted alongside equipment to meet statutory requirements, e.g. Fire Brigade. Diagrams to be colour-coded, colour-fast, laminated and mounted.

6.5.6 TRAINING OF PRINCIPAL'S NOMINATED PERSONNEL

- 1** The service of a fully knowledgeable Commissioning Engineer shall be required for a period of 2 full working weeks to instruct the Owner's nominated representatives in all details of the plant operation.
- 2** Conduct training at agreed time, at system or equipment location.
- 3** Immediately after Practical Completion, explain and demonstrate to the building users or nominated representative, the purpose, function and maintenance of the installations.
- 4** Use qualified personnel who are knowledgeable about the installations.
- 5** Prior to Practical Completion, explain and demonstrate to the Principal's nominated personnel the purpose, function, operating and maintenance of the installations.

- 6 Use items and procedures listed in the Operation and Maintenance manuals as the basis for detailed instruction of Principal's nominated personnel.
 - 7 Conduct training at agreed time, at each system of equipment location.
 - 8 Upon completion, submit certificates of training, signed by trainer and trainees.
 - 9 Provide qualified manufacturer's training representatives who are knowledgeable about the installations
 - 10 The services of the Contractor's Commissioning Engineer and BAS controls commissioning engineer shall be required for a period of 8 weeks after Practical Completion to assist the operator in the operation of the Facility.
 - 11 During the warranty period, provide technical assistance and advice to the Principal's nominated personnel regarding the operation and maintenance of the plant.
 - 12 For equipment requiring seasonal operation, demonstrate during the appropriate season and within 6 months of Practical Completion.
 - 13 Include copy of training material within the O&M Manual
-

6.5.7 SPARE PARTS SCHEDULE

At least 8 weeks before the date for Practical Completion, submit a schedule of spare parts necessary for maintenance of the installation. State against each item the recommended quantity, and the manufacturer's current price, including for

- 1 Packaging and delivery to site;
 - 2 Checking receipt, marking and numbering in accordance with the spare parts schedule;
 - 3 Referencing equipment schedules in the operation and maintenance manual; and
 - 4 Painting, greasing and packing to prevent deterioration during storage.
-

6.6 POST PRACTICAL COMPLETION AND DEFECTS LIABILITY PERIOD

6.6.1 WARRANTY AND DEFECTS LIABILITY

Warrant the whole of the Contract Works, for the Defects Liability Period (DLP), against defective workmanship and materials and against non-compliance of equipment and/or complete system with specified performance and operation.

The Defects Liability Period shall continue for a period of **12 months** after the date of issue of Practical Completion and during this period, the Contractor shall be responsible for making good on a timely manner, defects arising from the defective design materials, premature component failures, or workmanship or from any act of the Contractor that may develop in the work.

Perform maintenance during the warranty period to maintain warranty conditions. Maintenance shall comply with the current regulatory requirements.

In the event of inclusion of equipment normally covered by a lesser time warranty, or whose warranty would otherwise normally expire during the warranty period, allow for and include the costs of extending such warranty to that covering up to the end of the Defect Liability Period.

Where warranted work or equipment has failed, the warranty shall recommence on the date of acceptance of the rectified work for an additional period of time, extended by the period during which the Principal was without the use of the work

or equipment. For rectified work involving new replaced equipment, the warranty for the new component shall be from date of replacement for the 12 months or longer as required by this specification

6.6.2 GENERAL DLP MAINTENANCE SCOPE

Maintenance services shall include:

- 1 Preparation of a maintenance management plan which includes a detailed maintenance programme, equipment schedules, statutory and preventative maintenance schedules, OH&S risk assessment, inspection and testing schedules, breakdown rectification management and reporting systems. Submit maintenance plan and schedules prior to Practical Completion
- 2 Preventative and corrective maintenance and testing services to assure specified system reliability and availability.
- 3 Statutory maintenance and testing required by the Building Regulations and other authorities.
- 4 Breakdown and system fault responses. Attend site, ascertain cause of alarm and rectify where possible. Make system alterations at own cost to prevent future system faults. Pay any Authority charges resulting from callout on system faults.
- 5 Statutory regular system fire and life safety system control and performance verification test to be carried out after hours.
- 6 Comply with Building and Occupational Health and Safety Regulations. Comply with manufacturer's recommended maintenance programme and schedules.
- 7 Monthly maintenance and servicing in accordance with maintenance schedules recommended by equipment manufacturers.
- 8 Rectification of defects at Contractors cost.
- 9 Replacement of consumables at Contractors cost during the maintenance period.
- 10 Submission of monthly reports to Principal and Consultant Engineer on maintenance activities performed.
- 11 Provision and filling out log book which must be kept on site, detailing all visits.
- 12 Service personnel to be available for call out on a 24 hour per day, 7 day per week basis. Response time for emergency and corrective maintenance must not exceed 2 hours.
- 13 Comply with AS/NZS 3666.2. AS/NZS 3666.3 and AS/NZS 1677.2.
- 14 Maintenance, testing and inspections in accordance with regulatory requirements and relevant Australian Standards industry guidelines. (such as AIRAH DA19 HVAC&R Maintenance Manual).
- 15 Operation and verification in conjunction with other services trades, of all fire and life safety systems. Such testing to be undertaken at 6 monthly intervals.

6.6.3 FINAL COMPLETION

Final Completion will not be granted until maintenance records are complete and signed off and until all defects have been rectified and inspected.

The Maintenance and Defects Liability Period may be extended unless maintenance and servicing visits have been made and reported as specified.

6.6.4 SUBMISSIONS

- 1 Provide;
- 2 Maintenance management plan.
- 3 Monthly Maintenance reports.
- 4 Completed maintenance records

Mandatory maintenance records to include monthly maintenance and service reports, including water treatment reports, reports on all defects and their rectification, certification of the correct operation of essential services, a maintenance log book and any other records which must be kept in order to comply with legislative or OH&S requirements.

Monthly Maintenance and Service Reports to include:

- 1 Check list of all items serviced and inspected.
- 2 Description of maintenance performed.
- 3 Notes on supplementary maintenance required.
- 4 Comprehensive water treatment report.

Maintenance Log Book to include:

- 1 Schedule of all equipment.
- 2 Schedule of all control sensors and control set point values.
- 3 Register of maintenance visits and cross reference to service reports.
- 4 Register of work performed under headings of preventive maintenance, corrective and emergency maintenance and defects rectification.

The Maintenance Log Book is to be kept in a locked cabinet provided for the purpose in an agreed location on site.

At the conclusion of each maintenance visit the log book is to be duly completed and signed off by an authorised representative of the Principal /Building Owner and service records are to be forwarded to the Principal /Building Owner or his representative within 3 days of each visit.

6.6.5 DLP PREVENTATIVE MAINTENANCE AND TESTING

GENERAL

As a minimum, carry out all maintenance and servicing recommended by the manufacturer of each piece of equipment at the recommended intervals

MECHANICAL SERVICES REQUIREMENTS

The following minimum items shall be carried out for applicable equipment, as well as those required by Codes, Standards and the manufacturers. As a minimum requirement or where in doubt as to the applicability of any particular maintenance regime, the maintenance schedules as identified in Appendix A of the AIRAH DA19 HVAC&R Maintenance Manual shall take precedence and form part of the maintenance management plan.

Monthly

- 1 Check and adjust all belt drives and couplings.

- 2 Check and clean all washable filters.
- 3 Check and report on necessity for replacement of removable filter media and disposable filters.
- 4 Oil and grease all bearings.
- 5 Clean as necessary drip trays, strainers and other sediment collecting items, which may become fouled.
- 6 Adjust and repack as appropriate, glands of all pumps and valves.
- 7 Check refrigerant system for leaks and supply replacement refrigerant as necessary to leave the plant tight and fully charged at all times. Drier cores to be replaced as necessary.
- 8 Test cooling towers for Legionella and carry out tower clean in accordance with AS/NZS 3666.1.
- 9 Check, test and report on chemical treatment and dose as required.
- 10 All manufacturers recommended maintenance items.

Quarterly

- 1 Monthly items, plus the following:
- 2 Check operation, setting and calibration of all controls.
- 3 Check all motors for temperature rise, operating current and leakage.
- 4 Check and record compressor head pressures and operation of HP, LP and oil pressure cut outs.
- 5 Check and adjust boilers and burners.

Six monthly

- 1 Quarterly items, plus the following:
- 2 Check internal and external vibration isolation.
- 3 Check, test and report on all fire detection and protection systems including smoke spill systems, stairwell pressurisation systems and fire shut down controls.
- 4 Check operation of all electrical switchgear including setting and operation of motor overloads.

Last maintenance visit at 12 months

- 1 Six-monthly items, plus the following:
- 2 Complete clean of cooling towers and condenser water systems.
- 3 Removal of end covers from condensers and evaporators and cleaning of tubes and all internal surfaces.
- 4 Removal of oil and drier cartridges on compressors and refrigeration systems and replacement of same with new cartridges.
- 5 Arranging for a testing authority to analyse refrigerant and oil samples for impurities and to submit a thorough report.
- 6 Check all motor starters and relay controls.
- 7 Check and megger all electric motors and check overloads.
- 8 Undertake thermal scanning of switchboards and report thereon.
- 9 Check all system safeties.
- 10 Replace all air filter media and disposable filters.
- 11 Thoroughly check chiller cathodic protection systems.

- 12** Thoroughly check cooling tower side stream filtration equipment.
- 13** Check, test and report on a building fire safety control test including testing of fire detection systems, smoke control systems, electric duct heaters, fire dampers and smoke and heat vents; Certify the correct operation of essential services in accordance with the requirements of the BCA.
- 14** The date for the final maintenance visit to be advised 7 days prior to the proposed visit so that a Principal's representative may be present to inspect the equipment when end covers are removed.

7 MECHANICAL PLANT & EQUIPMENT

7.1 GENERAL

- 1 This section sets out the engineering and quality assurance requirements for the design, materials components, fabrication, installation and testing of the Mechanical Services equipment.
- 2 Plant and equipment shall be suitable for the application and comply with the requirements of this Specification and the relevant Statutory Authorities:
 - a Meet structural and architectural conditions.
 - b All equipment to achieve a workmanlike appearance with adequate provision for maintenance and replacement.
 - c Be of service proven design and shall operate satisfactorily within the standard ranges of capacities.
 - d Provide a lead time in the replacement of parts agreed with the owner/operator
 - e Include safety devices for the protection of both construction and operational personnel against injury and the protection of plant and equipment against damage and comply with occupational health and safety requirements.
 - f All equipment to be provided with adequate provision for lifting, installation maintenance and replacement of heavy parts.
 - g Include all equipment safety devices and signage required to protect the equipment against damage.
 - h Carry visible manufacturer's nameplates permanently fitted to each and every item of equipment and showing the manufacturer's name, type and/or model number, serial number, and all essential operating data such as speed, capacity, voltage, current draw, etc.
 - i Additional nameplates shall be provided where required to provide permanent details of equipment performance details as scheduled in the equipment schedules such as pump duty and capacity, etc.

7.2 MOTORS

7.2.1 GENERAL

- 1 Where available, all motors shall be the MEPS High Efficiency type to AS/NZS 1359.5.
- 2 Unless specified otherwise select all motors continuously rated squirrel cage metric induction type to be non-overloading at all operating conditions.
- 3 Comply with AS 1359.0 and AS 1360.11. Where this is not possible, submit full details of variations to these requirements with the tender.
- 4 Design specifically to operate on either 400Volts 3 phase or 230 Volts single phase supply 50Hz and of high efficiency performance.
- 5 Select enclosures suitable for the conditions of operation and adequately protected against corrosion.
- 6 In plant room areas and for open drive compressors use the drip proof or totally enclosed fan cooled type.
- 7 Use totally enclosed fan cooled fan motors in conditioned air streams.
- 8 Use totally enclosed air cooled axial flow fan motors.

- 9 Use totally enclosed fan cooled motors exposed to weather. Fully weather-proof using additional seals, shrouds, etc., as required and fitted with porous drain plugs.
 - 10 Select motors suitable for direct on line starting having minimum Class B insulation and rated for Class B temperature rise, with the exception of smoke exhaust fans associated with fire and smoke control.
 - 11 Provide motors with insulated motor bearings where motors are to be operated by variable speed drives.
 - 12 Provide motors used for smoke control with totally enclosed fan cooled enclosures with insulation in accordance with AS/NZS 1668.1.
 - 13 Select fan motors for air cooled condensers having minimum Class F insulation and rated for Class F temperature rise.
 - 14 Provide Class F and Class H insulated motors with high temperature leads and terminals. Bearings packed with high temperature grease and guaranteed for operation at the specified duty.
 - 15 Motors required to operate within Hazardous Zones shall be suitable for the Hazard Zone within which it is to operate and as a minimum shall be of the specific scheduled requirements.
 - 16 Install motors in dynamic and electrical balance free from vibration during starting and running.
 - 17 Ensure the torque characteristics are suitable for the load characteristics.
 - 18 Design synchronous speed: Not exceeding 24 rps unless otherwise specified.
 - 19 Power output ratings: Not less than those shown in the 'Schedule of Equipment'.
 - 20 Ensure the locked rotor torque is adequate to provide satisfactory starting of the load being driven considering the load inertia and all other relevant factors but in any case, not less than 150% full load torque.
 - 21 Locked rotor current: Not exceeding the limitations specified in AS 1359 for Design B Motors.
 - 22 Fitted with thermal overloads.
 - 23 Carefully match motors driving high inertia loads such as centrifugal fans to the load, bearing in mind the starting method, in order to accelerate the load to full speed well within the maximum start time specified by the motor manufacturer, without overheating of the motor or its associated starting equipment.
 - 24 End shield mount bearings wherever possible and having a minimum service life of 100,000 hours' continuous operation at the installed duty where possible.
 - 25 On small motors, up to and including 15kW incorporate permanently lubricated 'sealed for life' bearings.
 - 26 Lubricate by means of readily accessible lubrication points, capable of greasing with the motor in operation.
 - 27 Fit pressure relief devices such that grease cannot enter the motor for motors over 15kW.
 - 28 Provide captive dust caps on lubrication points.
-

7.2.2 MOTOR PROTECTION AND CONTROL

- 1 Accept responsibility for selection of correct types of starting equipment.
- 2 Ensure starter selected gives proper overload protection during starting.
- 3 Overloads: In circuit at all times except for smoke spill fans to AS/NZS 1668.1.
- 4 Starting equipment and/or the drive motor will be rejected if tripping during starting occurs.
- 5 Set overloads to the full name plate current of the motor.
- 6 Provide positive temperature co-efficient thermistors for motors rated at 11kW and above.

- 7 Do not provide thermistor protection for motors that operate only on fire conditions and are essential for fire and smoke control as defined in AS 1668.2. Such items include smoke exhaust air fans and stairwell pressurising fans.
-

7.2.3 VARIABLE SPEED OPERATION

- 1 Ensure each speed controlled motor is compatible with the associated variable frequency speed controller to provide smooth operation over the entire speed range, without objectionable noise.
 - 2 Select the electric motor capable of continuous operation at any constant speed setting throughout the speed range, without overheating.
 - 3 Provide supplementary cooling of the motor as required to prevent overheating at sustained low speed where so recommended by the manufacturer.
-

7.3 BELTS, PULLEYS AND DRIVES

7.3.1 GENERAL

- 1 Select all belts, pulleys, couplings and drives as the products of one manufacturer, and to be dynamically balanced and aligned in accordance with the drive manufacturer's recommendation.
-

7.3.2 PULLEYS

- 1 'Fenner Dodge' or approved equivalent fixed with keyed taper lock bushes to shafts.
-

7.3.3 BELTS

- 1 A minimum two belts are required on each pulley.
 - 2 Belt drives: 'V' belt type and the drive assembly incorporating belt tension adjustment.
 - 3 Belt drives: Size for $\geq 125\%$ of motor power and capable of transmitting the full starting torque without slip.
 - 4 Belts: Wedge belts to AS 2784, consisting of matched sets of at least 2 belts.
 - 5 Mark belt size in a prominent location on the fan casing.
-

7.3.4 FLEXIBLE COUPLINGS.

- 1 Rubber pin shear spacer type of 'Thomas' or approved equivalent.
- 2 Guards for belt drives shall completely enclose the drive, be adequately ventilated, readily removable, allow for adjustment of belts and components and permit speed measurements to be taken with a tachometer at pulley shafts without guard removal.
- 3 Use guards for couplings of rigid construction and permitting ventilation of the enclosed components.
- 4 Align all belts.
- 5 Align flexible couplings by a firm specialising in the work.

7.3.5 DRIVE SHAFTS

- 1 Designed so that the first critical resonant speed of the shaft is $\geq 130\%$ of design maximum operating speed.
- 2 Double width fans with shaft diameter > 60 mm: Filleted stepped type to permit easy impeller removal.
- 3 Keyed with taper-lock fixing devices for fixing of pulleys.
- 4 Countersunk ends for tachometer application or, where the end of the shaft is not accessible, make provision for use of stroboscope or optical tachometer.
- 5 Material: Mild steel or high tensile steel, as appropriate for the duty. Provide corrosion protection by solvent removable petroleum based protective coating formulated for machinery shafts and parts.

DRIVE GUARDS

Provide rigid, removable belt guards on all fans where drive is accessible while motor is running. Provide the following:

- 1 Tachometer opening.
- 2 Perforated sides on double width, double inlet fans.
- 3 Weatherproof construction, ventilated and drained where exposed to weather.
- 4 Material: Open mesh or perforated metallic-coated sheet steel.

7.4 COOLING TOWER – STAINLESS STEEL

7.4.1 GENERAL

- 5 Comply with requirements of AS/NZS 3666.1, recommendations of SAA/SNZ HB 32 and relevant local Statutory Authority Technical Directives.
- 6 Demonstrate correct performance selection by reference to type test results and calculations allowing for actual site enclosure conditions.
- 7 Verify performance by field performance using Cooling Tower Institute Acceptance and Test Code ATC-105 conducted within the warranty period.
- 8 Should test prove tower as installed is deficient, meet all costs for correcting the deficiency and re-test.
- 9 Provide sump balancing pipe to at least 1.5 diameter of water outlet if more than one tower is used in the system.

7.4.2 TYPE

- 10 Factory assembled of rectangular cross flow type of approved manufacturer, constructed generally of stainless steel 316 complete with fan, water distributing system, fill, tower basin, sump, drift eliminators, valves and fittings.
- 11 Select capacity of tower rated to suit location indicated on Drawings, with adequate clearances for installation, operation and maintenance.
- 12 Install externally to the building designed to withstand maximum stress imposed by winds equivalent to 1.5kPa of projected surface.

7.4.3 *STRUCTURE, ACCESS DOORS AND HARDWARE*

13 Stainless Steel 316.

7.4.4 *WATER BASIN AND DISTRIBUTION*

- 14** Floor sloped to an integral sump fitted with a removable screened suction outlet connection, overflow, valved drain and float controlled make-up connection.
- 15** Water distribution system designed for 140 percent of the specified capacity without causing overflow or splashing.
- 16** Arrange the cooling towers and piping so that all parts can be drained and flushed. Provide additional full way drain valves and flushing facilities so that balance/equalising lines between towers can be drained and flushed.
- 17** Install drift eliminators.
-

7.4.5 *TOWER FILL*

- 18** Corrugated honeycomb packs for tower fill, removable or otherwise made accessible for cleaning.
-

7.4.6 *FANS, MOTORS AND DRIVES*

- 19** Slow speed direct or belt driven, quiet in operation and statically and dynamically balanced.
- 20** Impeller: Aluminium alloy or glass reinforced nylon attached to a stainless-steel shaft.
- 21** Centrifugal units: glass fibre reinforced fan scroll, hot dip galvanised and epoxy painted impeller, stainless steel shaft, cast iron taper lock pulley motors.
- 22** Motors and drives to comply with 'Motors' and 'Belts, Pulleys and Drives' Clauses in this Section of the Specification and incorporate the following additional features: stainless steel 316 motor shaft, stainless steel pulley shaft, epoxy paint finish to motor, epoxy finish to pulleys (where steel or cast iron), motor degree of protection: IP 56 and removable stainless steel 316 belt guard to complete enclose the drive and exposed shaft. Allow for tachometer insertion. Make provision for grease relief and extend lubrication lines to outside of tower.
-

7.4.7 *ACCESS LADDERS*

- 23** Provide hot dipped galvanised or stainless steel 316 fixed access ladders and platforms to AS1657 and Workplace Health and Safety Regulations for all equipment requiring service and maintenance located 2400mm above floor level. Equipment requiring routine service and maintenance shall include but not be limited to, drift eliminators, fill, fans, motors, bearings, belts, hot decks, control equipment, float valves, basins, strainers, float valves and valves for flow adjustment.
-

7.5 *COOLING TOWER – SIDE STREAM FILTRATION*

7.5.1 *GENERAL*

- 24** Refer to Water Treatment section of this specification.

7.6 HOT WATER HEATER – ATMOSPHERIC TYPE

7.6.1 GENERAL

- 1 Select instantaneous hot water boilers of approved manufacture.
- 2 Comply with AS 5601- Gas Installations, and AS4552- Gas water heaters
- 3 Gas trains and safety devices to AS5601 requirements
- 4 Corrosion resistant outer casing
- 5 Steel or Cast Iron heat exchangers
- 6 Minimum efficiency of 80% or as required by NCC Section J.
- 7 Suitable for use with natural gas or dual fuel, where indicated.
- 8 Manufacture and install to the requirements of relevant statutory authority.
- 9 Provide capacity certification.
- 10 Install boilers for efficient combustion independent of flue draught.
- 11 Design to operate on the naturally aspirated firing system.
- 12 Line as necessary with layers of refractory insulating panels.
- 13 Select all refractory materials to suit the specified operating conditions.
- 14 Supply and install flues, complete with AGA approved 'Jaks' cowls, with sufficient height to satisfy the relevant Authorities. Alternatively provide an approved dual flue.
- 15 Fabricate the flue from minimum 2mm 316L stainless steel adequately supported and with provision for thermal expansion.
- 16 Flue insulation: 50mm thick high temperature mineral wool and sheathed with 0.8mm thick metal cladding where exposed to view.
- 17 Flue above the roof: Sheathed with 0.8mm thick type 316L stainless steel fitted with welded weatherproof stainless steel overskirt.

7.6.2 HEAT EXCHANGER

- 1 Single bank, vee baffled multi-pass arrangement constructed of 25mm minimum diameter integral copper fin tubes with fin spacing of not less than 275 fins per metre.
- 2 Use fire box steel for tube sheet.
- 3 Use high pressure cast bronze for headers.
- 4 To be cleanable from either the right or left sides of the boiler by removing the headers or external piping.
- 5 Construct waterways of copper and bronze to prevent galvanic action within the boiler by positively sealing off water contact between ferrous and non-ferrous metals.

7.6.3 BURNERS

- 1 Provide gas train and burner, capable of quiet ignition and extinction and equipped with fixed primary air ports.
- 2 Provide control system for automatic ignition and extinction, modulating (100% to 20% capacity) firing.
- 3 Include control system with main flame control through pilot flame sequence, flame failure device, safety thermostat and a flow switch installed in the flow pipe to the boiler.
- 4 Provide a solenoid shut-off valve for the burner and wire it in parallel with the shut-off valve supplied with the burner (double block and bleed arrangement).
- 5 Incorporate modulating inlet dampers to control air flow to ensure maximum operating efficiency at all operating load conditions.

7.6.4 FLUE

- 1 Supply and install the flue with sufficient height above the roof to satisfy the requirements of the relevant Authorities.
- 2 Supply and install separate flue for each boiler to the point of termination outside the building. If a common flue is used, provide a back-draft damper and a spectacle blind on each flue from each heater. Fabricate each flue from a minimum 2mm 316L stainless steel all welded and adequately supported and with provision for thermal expansion.
- 3 Ensure that the modulating boilers operating at reduced capacity do not result in low flue exit velocity, below the requirements of AS5601.
- 4 Where necessary, drain the flues to waste via minimum 32 diameter pipework.
- 5 Flue insulation: 50mm thick high temperature mineral wool and sheathed with 0.8mm thick metal cladding where exposed to view above the roof with 0.8mm thick Type 316L stainless steel fitted with welded weatherproof stainless steel overskirt.

7.6.5 ELECTRICAL SYSTEMS

- 1 Provide dustproof totally enclosed control panel of steel construction factory finished.
- 2 Within the panel, include power supply isolators, starter for pump motor, burner controls, test and control switches, indicating instruments, fuses and any other necessary apparatus.
- 3 Ensure all electrical equipment and controls supplied integrally with the boiler are factory wired to the control panels.

7.6.6 SAFETY AND OPERATING CONTROLS

- 1 Furnish each boiler with the following operating and safety control components in addition to the integral control components detailed in the 'Controls' Section of this Specification:
 - a Hot water operating limit thermostat. (Adjustable range for each burner.)
 - b Hot water high temperature cut out thermostat. (Manual re-set.)
 - c Low water cut out controls connected to burner control circuit to prevent operation when boiler water falls below the safe level.
 - d Pressure relief valve or valves.
 - e Flow and return water thermometer pockets.
 - f Flow and return water temperature gauges.

7.7 WATER HEAT EXCHANGERS – PLATE

7.7.1 GENERAL

- 1 Use sandwiched plate type of approved manufacture consisting of gasketed heat exchange plates, fixed end plate, removable pressure plate, upper carrying bar, lower guide bar, end support column, clamping rods, lifting lugs, mounting feet and screwed drain connections.

7.7.2 CONSTRUCTION

- 1 Fabricate heat exchanger plates from Type 316 stainless steel with a press-formed corrugated finish.
- 2 Align adjoining plate corrugations in orthogonal directions to produce a herringbone flow pattern.
- 3 Arrange flow and return apertures between plates to provide a single pass of each water circuit with full counter flow conditions maintained throughout.
- 4 Fully gasket flow passages between adjoining plates to prevent intermixing or external leakage.
- 5 Use gaskets of nitrile rubber manufacture of grade suitable for the working temperatures and pressures, thermally bonded to the heat exchange plates.
- 6 End plates and pressure plates: Machined carbon steel.
- 7 Make all external flow and return pipe connections solely to the end plate.
- 8 Provide the end plate with flanged and gasketed nozzles.
- 9 Mate the pressure plate to the upper carrying bar and lower guide bar.
- 10 Fit the pressure plate with rollers to permit ease of withdrawal by a single tradesperson.
- 11 Fabricate carrying bars, guide bars and end support columns from rolled steel sections.
- 12 Use machined roller surfaces for carrying and guide bars of sufficient size to permit an additional 40% accommodation of heat exchange plates if required, without restriction to the serviceability of individual plates.
- 13 Fabricate clamping rods and nuts of high tensile steel and ensure they are readily removable for access to heat exchange plates.
- 14 Except for heat exchanger plates and roller surfaces, factory descale all exposed steelwork, prime coated with a rust and corrosion inhibitor, and epoxy painted.

7.7.3 THERMAL INSULATION

- 1 Refer to Thermal Insulation Section.

7.8 WATER PUMP – BACK PULL OUT

7.8.1 GENERAL

- 1 Centrifugal of one manufacturer, non-overloading, volute type, at not more than 48rps.

- 2 Impeller diameters do not exceed 98% of the maximum size impeller pump casing can accommodate. Full size impellers may be used on VSD pumps subject to the pump operating under 50 Hz at maximum design capacity.
 - 3 Motors and drives to comply with 'Motors' and 'Belts, Pulleys and Drives' Clauses in this Section of the Specification.
 - 4 Spacer coupled, direct drive.
 - 5 All pumps to be selected to operate within 5% of the Best Efficiency Point on the pump curve. The final commissioned system shall operate within a range of 2% of the duty point submitted for review with all valves fully open. No throttling of pump discharge or index circuit to achieve desired head is acceptable; only throttling via VSD.
-

7.8.2 PUMP CASING

- 1 Close grained cast iron AS 1830 grade T200 or equal for chilled, condenser and heating water services.
 - 2 For fluid temperatures $\geq 90^{\circ}\text{C}$: Bronze, grade 836B.
 - 3 For open systems including cooling tower water and for pumping aggressive water: Bronze, grade 836B.
 - 4 Domestic cold/hot water duties use bronze to AS 1565 grade 922C or 316 stainless steel. Pressure Rating: For systems with a design pressure ≤ 500 kPa: Minimum static test pressure of 1.6 MPa. For systems with a design pressure > 500 kPa: Minimum static test pressure of 1.6 MPa or 1.5 times the total of the pump shut-off head plus the static and system pressures, whichever is the greater.
 - 5 Chilled water pumps assemblies to be mounted on drained 316 stainless steel drip trays designed and installed to collect all condensate forming and dripping from the pump. Extend drip tray not less than 100mm beyond the pump suction and insulated pump flanges.
 - 6 Insulate the pump (heating or chilled) as per the appropriate pipe insulation.
-

7.8.3 IMPELLERS AND SHAFTS

- 1 Shrouded type with replaceable wearing collars manufactured from bronze Alloy 922C or equal.
 - 2 Balance impellers statically and dynamically.
 - 3 Shafts type 420 stainless steel.
 - 4 Casing and shaft wear rings in bronze or cast iron suitable for the application.
-

7.8.4 BEARINGS AND SEALS

- 1 Greaseable self-aligning ball or roller type positively located on shafts.
 - 2 Bearings operating life of not less than 100,000 hours.
 - 3 Fit bearings with lubricant retaining and dust excluding seals and grease relief.
 - 4 'John Crane' or equal for unbalanced mechanical seals.
 - 5 'Chesterton' or equal for balanced mechanical seals.
-

7.8.5 PUMP MOTOR BASE

- 1 Hot dip galvanised, rigid, fully welded steel base fabricated from rolled steel sections.
- 2 Provide concrete inertia base.

- 3 Inertia base to be cast concrete with fabricated steel base with reinforcing bars welded between base sections, and with a combined weight at least that of the pump and motor.
-

7.9 EXPANSION TANK – CLOSED

7.9.1 GENERAL

- 1 Sealed membrane pressure tank with internal rubber membrane.
 - 2 Welded steel construction in accordance with requirements of local Statutory Authority.
 - 3 Complete with make-up pump and valves including isolating valve, check and pressure reducing valves, pressure gauge and relief valves, automatic air vents and drain cock.
 - 4 Approved backflow preventer device to be fitted on incoming water supply side.
-

7.10 COIL – HEATING WATER

7.10.1 CONSTRUCTION

- 1 Counter flow circuit of copper tube.
- 2 Mechanically bond aluminium fins to the tubes.
- 3 Not to exceed 400 fins per metre.
- 4 Pressure test to the greater of 2000kPa or 1.5 times the working pressure for at least 1 hour by either submerging in warm water and applying air (or other gas under pressure) or hydrostatic test.
- 5 Guaranteed for 1050kPa working pressure.
- 6 Face velocities: Not to exceed 3.0m/s.
- 7 Water velocity: Not to exceed 1.5m/s.
- 8 Headers of seamless copper tube complete with vents and drains.
- 9 Flanged brass connection for inlet and outlet connections over 50mm diameter.
- 10 Braze core joints and brass adaptor connections with approved copper brazing alloys.
- 11 Use heavy gauge aluminium for top and bottom support frames and tube end plates.
- 12 Mount banks on common support fabricated from minimum 50mm x 50mm x 5mm steel angle framework hot dipped galvanised after fabrication.
- 13 Prevent contact between dissimilar metals using neoprene gaskets or equal.
- 14 Minimise air leakage through gaps between the fin ends and frames. Recess fin ends into the top and bottom channels, close gaps with sealing strips, or gaps to a maximum clearance of 1.5 mm.
- 15 Provide factory applied coating resistant to dilute acids, dilute alkalis, solvents, inorganic salts and salt laden air after foil fabrication to achieve no sign of attack after 3000 hours in salt spray when tested to ASTM B117 for atmospheric corrosivity category of C or D.

7.10.2 PROTECTION DURING TRANSPORT AND ERECTION

- 1 Protect coil faces by factory fitted sheets of 'Masonite' or sheet metal to prevent fin and tube damage.
 - 2 Fit this protection prior to coils being shipped from the factory.
 - 3 Do not remove protection until shortly before commissioning.
 - 4 Comb damaged fins straight.
 - 5 Prevent ingress of foreign matter and moisture during transport and storage via plastic end caps.
-

7.11 AIR FILTERS

7.11.1 GENERAL

- 1 Comply with AS1324.1, AS1324.2 and AS4260 (HEPA filters). Where this is not possible submit full details of variations to these requirements with the tender.
- 2 Install filters with sufficient provision for maintenance and the replacement of media. Allow for service access from the dirty air side of filters.
- 3 The bottom of plenums and housings to be trafficable without damage by service personnel.
- 4 Include mezzanine access catwalk on filter banks higher than 2400mm for service access without the use of ladders.
- 5 Install mounting frames with a continuous airtight silicone seal between each frame. Seal airtight filter frames and adjoining casings. Provide adequate structural support to the frames against air pressure forces and mechanical action during filter replacement.
- 6 Base all filter modules and mounting frames on the standard universal size of 610mm/610mm.
- 7 Manufacture mounting frames from folded Galva bond or stainless steel. Mounting frames to be open and free from integral wire supports or mechanisms.
- 8 Fit mounting frames with spring retaining clips and a continuous neoprene gasket at the filter to frame contact surface. Clips must not insert under gaskets but fix to tags on front of frame. Do not use self-adhesive foam strip gaskets or 'P' type clips.
- 9 Do not use slide type housings unless specified. Slide housings where used shall comprise 'Farr' Glide pack or equal approved with tested bypass leakage at less than 1% at 375 Pa pressure differential and comprise side removable universal filter holding frames.
- 10 Provide gauges across filters where scheduled.
 - a Non DDC projects – Dial type, graduated 0 – 500 Pa, Connect the gauge to the filter chamber with copper or aluminium tubes. Level, adjust and permanently mark gauges at the appropriate pressure – 'Filter Dirty – Replace'.
 - b DDC Projects – Provide DDC analogue static pressure transducers on each unit, Connect the transducers to the filter chamber with copper or aluminium tubes. Pressure switches may be acceptable subject to approval.
- 11 Full test reports shall be submitted for all filters offered.
- 12 No system shall be operated without filters in place.
- 13 Provide engraved labels to filter chamber access doors clearly identifying the installed filter combination and F ratings.
e.g.

- a Filtration:
 - i Primary Filter: F5
 - ii Secondary Filter: F8

14 Select filters at maximum 2m/s face velocity unless otherwise noted.

7.11.2 TEMPORARY PRE-FILTERS

- 1 Install to protect all filters prior to fan start up on all units.
- 2 Do not remove from the installed permanent filters until just before practical completion is achieved.
- 3 Renew temporary filters when combined pressure drop of dirty pre-filters and the installed filters exceeds the dirty pressure drop allowance of the installed permanent final filters alone.
- 4 When tested to AS1324.2 the average arrestance of the temporary filter media shall not be less than 90%. (G4)
- 5 For pre-filters, use either disposable panel filters or media fitted across the front of permanent filters.

7.11.3 LINT SCREENS

- 1 Lint screens shall be of the removable flat panel type with woven polypropylene washable media complete with aluminium frames and stainless steel wire support.
- 2 At the design maximum air flow the effective face velocity shall not exceed 2.5 m/s and the initial (clean) resistance shall not exceed 50 Pa.
- 3 When tested to AS1324.2 the screen shall have an average arrestance of not less than 30%.
- 4 Each panel shall comprise a fabricated 12mm thick aluminium frame containing the media. Provide clips to hold the panels tightly in position and to ensure a positive seal between the panels and the holding frames or final filters.

7.11.4 FILTERS – DISPOSABLE DRY MEDIA PANEL

- 1 Filters shall be of the disposable extended surface cardboard frame type with a 595/595mm panel type 100mm thick and of dry, fire resistant construction. The non-woven media shall be supported on an expanded metal backing grid integrally adhered into a die cut, rigid, beverage board housing. Pleat separators as part of the cardboard frame shall maintain Media pleats.
- 2 The prefilters shall achieve the following performance criteria when tested to AS 1324.2:

CLASSIFICATION TO AS 1324.2		F4	F5
For Rating face velocity	m/s	2.5	2.5
Maximum final resistance	Pa	250	450
Minimum efficiency	%	20	25
Average efficiency	%	20-40	40-60
Average arrestance	%	>90	>95%
Dust holding capacity @ 250 Pa resistance	gram	250	200

- 3 Each filter shall include a permanent identification label stating the make, model and F rating.

7.11.5 FILTERS – DISPOSABLE DRY MEDIA EXTENDED SURFACE

- 1 Filters shall be of the disposable, modular extended surface type, with 595/595mm frame and dry fire resistant construction.
- 2 The filter module shall be corrosion resistant, and rigid to provide an airtight seal with mounting frame gasket and permanently retain and support the filter media in a leak free manner. Media shall be adhesive sealed or mechanically fixed into the module to eliminate air bypass leakage.
- 3 Filter media shall be constructed of dry unbreakable fibres. Media shall be fully sealed and supported against air flow induced movement and bypass and arranged for even air flow across the full area of the media.
- 4 Filters with adhesive coatings or of media that sags or of arrangements requiring permanent installed wire supports to the mounting frames shall be rejected. Where sewn seams are employed they shall be sealed against ‘pin hole’ leakage of air or dust via the stitching.
- 5 Filter modules achieving the following performance criteria when tested to AS 1324.2.

CLASSIFICATION TO 1324.2		F6	F7	F8	F9
For Rating face velocity	m/s	2.5	2.5	2.5	2.5
Maximum final resistance	Pa	450	450	450	450
Minimum efficiency	%	30	60	80	85
Average efficiency	%	60-80	80-90	90-95	95-98
Average a life arrestance	%	>98	>99	>99	>99
Dust holding capacity @ 375 Pa resistance	gram	400	300	200	180

- 6 Each filter shall include a permanent identification label stating the make, model and F rating.

7.12 AIR HANDLING UNIT – PANEL CONSTRUCTION

7.12.1 GENERAL

- 1 Complete with air filters holding frames, inlet plenum, coils, insulated drain tray, centrifugal fan, volume control and/or mixing dampers, enclosed in insulated galvanised steel casing.

7.12.2 CASING

- 1 1.55mm thick Galva bond or zincanneal sheet folded to form panels to accommodate the thickness of acoustic insulation.
- 2 Outside surface flush without external framing, internal stiffening may be used.
- 3 Panels structurally sound and vibration free and with gasketed joints.
- 4 Provide access panels to allow easy access to all necessary areas.
- 5 Fit access panels with steel sash clamps for ease of removal.

7.12.3 *CONDITIONER DOORS*

- 1 For access to all sections of the conditioners.
 - 2 Adequate size to enable removal of items of equipment requiring maintenance, such as electric motors, filters media, etc.
 - 3 Construct similar to the skin panels.
 - 4 Fit neoprene type gaskets to form seal between panel and frame surfaces.
 - 5 Fit approved type chrome plated wedge catches suitable for opening from both sides, and heavy duty chrome plated hinges.
 - 6 Frame to form a door stop and sealing surface.
 - 7 Be neat in appearance and fresh faced.
-

7.12.4 *FAN*

- 1 Sized to provide air flow rates of 10% more than specified against the corresponding increased system resistance.
 - 2 Mount on a common frame with motor, independently sprung within the unit.
 - 3 Suitable for variable volume applications.
 - 4 Select for efficient operation at design flow.
 - 5 To operate from 40 to 110% of design capacity without going into surge condition.
 - 6 Discharge velocity: Not exceeding 9 m/s. at design air flow.
 - 7 Motors and drive to comply with 'Motors' and 'Belts, Pulleys and Drives' Clauses in this Section of Specification.
 - 8 Noise spectra to be provided for all proposed fans in terms of Sound Power Levels measured in accordance with ISO 5136:2003 (BS 848-2.5:2003) in 1/1 Octave Bands Centre Frequencies 63 Hz – 8 kHz.
-

7.12.5 *BEARINGS*

- 1 Self-aligning ball or roller type bearings with lubricant retaining and dust excluding seals.
 - 2 Operating life of not less than 30,000 hours.
 - 3 Grease relief housings.
 - 4 Lubricate through grease nipples situated in readily accessible positions.
-

7.12.6 *COILS AND CONDENSATE TRAYS*

- 1 Comply with Coils Clauses in this Section of Specification.
-

7.12.7 *AIR FILTERS*

- 1 Comply with 'Air Filters' Clause in this Section of Specification.

7.12.8 LIGHTING

- 1 Provide each separate compartment of the air handling unit with ceiling mounted light fittings.
 - 2 Light fittings of the weather proof type, with not less than 1 x 18 Watt fluorescent tube.
-

7.12.9 INSULATION

- 1 Acoustically insulate entire casing with not less than 50mm thickness mineral wool or fibreglass, density not less than 48kg/m³.
 - 2 Face with perforated foil laminate sheet, retained by flush fitting caps.
 - 3 Install access panels and separate joints with not less than 25mm edge return of surface material. NO RAW edges.
-

7.13 FAN CENTRIFUGAL

7.13.1 GENERAL

- 1 Centrifugal fans: Backward curved, aerofoil blade, limit load type with V-belt drives, drive guards, motors and steel bases.
 - 2 Select fans and motors to provide air flow rates of 5% more than specified against corresponding increased system resistance without unstable operation.
 - 3 Able to be used for variable volume applications for maximum efficiency at 70% to 80% of design air flow and operate from 40% to 110% of design capacity without going into a surge condition.
 - 4 Discharge velocity at design air flow: Not to exceed 9 m/s.
 - 5 Comply motor and drive with the 'Motors' and 'Belts, Pulleys and Drives' Clauses in this Section of Specification.
 - 6 Provide fan operating status/interlock by flow switch mounted in the discharge side of the fan, conditioner, casing or duct.
 - 7 Alternatively, differential pressure sensor or current sensor as part of the control system may be used.
 - 8 Fan contactors and auxiliary relays fed from the fan power supply are not to be used for fan status or interlock signals unless in series with a remote sensor such as differential pressure switch or flow switch.
 - 9 Noise spectra to be provided for all proposed fans in terms of Sound Power Levels measured in accordance with ISO 5136:2003 (BS 848-2.5:2003) in 1/1 Octave Bands Centre Frequencies 63 Hz – 8 kHz.
-

7.13.2 CASING

- 1 Mild steel plate braced as necessary depending on duty.
- 2 Incorporate angle flanged outlets, curved inlet rings, sealed access panels and 40 diameter screwed and plugged drain connections.
- 3 Fit lifting lugs on fans over 500mm diameter. Access panels to casings of fans with impellers \geq 650 mm diameter to provide full access to the fan interior. Seal panels airtight with neoprene gaskets
- 4 Fit access panels with wedge type clamps to provide airtight sealing.

-
- 5 Use removable curved inlet rings to allow removal of impeller.
-

7.13.3 IMPELLERS

- 1 Mild steel all welded construction, die-formed aerofoil blades and front plates, balanced both statically and dynamically.
 - 2 Securely key hub to the drive shaft.
-

7.13.4 DRIVE SHAFT

- 1 Machined high tensile steel and stepped to facilitate easy impeller removal.
 - 2 Countersink shaft ends at the shaft centres to take a tachometer.
-

7.13.5 BEARINGS

- 1 Self-aligning ball or roller type fitted with lubricant retaining and dust excluding seals.
 - 2 Select for an operating life of not less than 100,000 hours.
 - 3 Accommodate in grease relief housings, lubricate through grease nipples situated in readily accessible positions.
 - 4 For single width fans with impellers < 1250 mm diameter and double width fans with impellers < 950 mm diameter provide pillow-block mounted, self-aligning ball bearings, sealed for life, with a minimum rating fatigue life of 40 000 hours.
 - 5 For single width fans with impellers \geq 1250 mm diameter and double width fans with impellers \geq 950 mm diameter: Provide plummer-block mounted roller bearings to, with seals and grease relief, with a minimum rating fatigue life of 20 000 hours. Extend grease nipples for ready access.
-

7.13.6 KITCHEN EXHAUST FANS

In addition to the requirements above provide the following:

- 1 Access for cleaning: Provide a large gasketed access panel.
 - 2 Drain: Provide trapped drain from lowest point in casing. Provide unions at connection and arrange drain to be easily cleaned. Pipe drain to waste.
 - 3 Finish: Internally zinc sprayed.
 - 4 Fire rating: If installed in a fire rated duct system and not installed in a separate fire rated room or enclosure, fire rate fan to the same standard as duct. Make sure that fire rating provisions permit easy access for inspection, cleaning and maintenance.
-

7.14 FAN – AEROFOIL AXIAL FLOW

7.14.1 GENERAL

- 1 Non-overloading aerofoil type of approved manufacture, minimum efficiency of 65% at the design air flow rate.
- 2 Select to provide air flow rates of 10% more than that specified against the corresponding increase in system resistance.

- 3 Delete, cover in controls section.
 - 4 Noise spectra to be provided for all proposed fans in terms of Sound Power Levels measured in accordance with ISO 5136:2003 (BS 848-2.5:2003) in 1/1 Octave Bands Centre Frequencies 63 Hz – 8 kHz.
-

7.14.2 CASING

- 1 Flanged hot dipped galvanised tubular extending over the length of the fan and motor (unless specified otherwise).
 - 2 Provide an airtight access door suitably placed for fan inspection, on units above 450mm diameter.
 - 3 Use matching flanges for mounting fans within the ductwork. Do not connect flexible connections directly to fan inlet or discharge flanges. Fit flexible connections at first duct connection.
 - 4 On open systems fit inlet cones complete with heavy gauge galvanised steel mesh guards and provide manufacturer's standard 15deg. conical diffuser on outlet to convert velocity head to static pressure.
-

7.14.3 IMPELLER

- 1 Adjustable pitch, injection moulded, glass reinforced polypropylene on fans up to 1000mm diameter; aluminium alloy on larger sizes, car park exhaust and kitchen exhaust.
 - 2 Balance statically and dynamically.
-

7.14.4 FAN MOTOR

- 1 Comply with the 'Motors' Clause in this Section of Specification.
 - 2 Ball or roller type bearings, sealed for life on fans up to 1200mm diameter, grease packed fitted with lubricant retaining and dust excluding seals extended through the casing on larger sizes. All selected for an operating life of not less than 100,000 hours.
-

7.14.5 CONSTRUCTION – SMOKE EXHAUST

- 1 To fully comply with AS/NZS 1668.1.
 - 2 To continue operating when handling spill air at 200°C for a period of not less than two hours.
 - 3 To continue operating when handling spill air at 300°C for a period of not less than thirty minutes in a non-sprinkle red building.
 - 4 Do not fit motors mounted in the air stream with integral high temperature cut-outs.
-

7.14.6 ACCESS:

- 1 < 1000 mm diameter: Sight hole in casing plugged with an airtight removable closure.
- 2 ≥ 1000 mm diameter: Provide access panels, securely bolted to casings and sealed with neoprene gaskets, for maintenance.

7.15 FAN – ROOF MOUNTED

7.15.1 GENERAL

- 1 Totally weatherproof centrifugal, mixed flow or axial flow housed in a compact base fitted with weathering skirt surmounted by a bird-proof cowl with a curved contour.
- 2 Select fans and motors to provide air flow rates of 10% more than specified against corresponding increase in system resistance.
- 3 Comply with the 'Motors' and 'Belts, Pulleys and Drives' Clauses in this Section of Specification.
- 4 Provide fan operating status/interlock by flow switch mounted in the discharge side of the fan, conditioner, casing or duct.
- 5 Alternatively, differential pressure sensor or current sensor as part of the control system may be used.
- 6 Fan contactors and auxiliary relays fed from the fan power supply are not to be used for fan status or interlock signals unless in series with a remote sensor such as differential pressure switch or flow switch.
- 7 Noise spectra to be provided for all proposed fans in terms of Sound Power Levels measured in accordance with ISO 5136:2003 (BS 848-2.5:2003) in 1/1 Octave Bands Centre Frequencies 63 Hz – 8 kHz.

7.15.2 CONSTRUCTION

- 1 All welded and hot dipped galvanised after fabrication or fibreglass suitably stiffened and braced.
- 2 Isolate all rotating parts from casings by approved resilient mountings.

7.15.3 FAN/MOTOR ASSEMBLY

- 1 Comply with the 'Motors' Clause.
- 2 Motor bearings: Ball or roller type, sealed for life selected for an operating life of not less than 30,000 hours.
- 3 Allow access to motor and fan via a hinged cowl or a service door in the cowl.
- 4 Position motors and impellers to allow servicing from above the roof.

7.15.4 CONSTRUCTION – SMOKE EXHAUST

- 1 To fully comply with AS/NZS 1668.1.
- 2 To continue operating when handling spill air at 200°C for a period of not less than two hours.
- 3 To continue operating when handling spill air at 300°C for a period of not less than thirty minutes in a non-sprinkle red building.
- 4 Do not fit motors mounted in the air stream with integral high temperature cut-outs.

7.16 FAN – IN LINE CENTRIFUGAL

7.16.1 GENERAL

- 1 In-duct mounted type of approved manufacture with the motor located in the air stream.
 - 2 Select fans and motors for air flow rates of 10% more than specified against corresponding increase in system resistance.
 - 3 Provide fan operating status/interlock by flow switch mounted in the discharge side of the fan, conditioner, casing or duct.
 - 4 Alternatively, differential pressure sensor or current sensor as part of the control system may be used.
 - 5 Fan contactors and auxiliary relays fed from the fan power supply are not to be used for fan status or interlock signals unless in series with a remote sensor such as differential pressure switch or flow switch.
 - 6 Noise spectra to be provided for all proposed fans in terms of Sound Power Levels measured in accordance with ISO 5136:2003 (BS 848-2.5:2003) in 1/1 Octave Bands Centre Frequencies 63 Hz – 8 kHz.
-

7.16.2 CONSTRUCTION

- 1 Fan casing: Galvanised sheet steel or rigid PVC, with facility for removal of impeller/motor assembly without disconnecting the fan assembly from the ductwork.
 - 2 Fan impeller, Aluminium, GRP, galvanised steel or rigid PVC with backward inclined blades.
-

7.16.3 FAN/MOTOR ASSEMBLY

- 1 Comply with the 'Motors' Clause, in this Section of the Specification.
 - 2 Motor bearings: Ball or roller type, sealed for life selected for an operating life of not less than 30,000 hours.
-

7.17 FAN – PROPELLER

7.17.1 GENERAL

- 1 In-duct diaphragm, wall or roof cowl mounting type and approved manufacture.
- 2 Select fans and motors for air flow rates of 10% more than specified against corresponding increase in system resistance.
- 3 Provide fan operating status/interlock by flow switch mounted in the discharge side of the fan, conditioner, casing or duct.
- 4 Alternatively, differential pressure sensor or current sensor as part of the control system may be used.
- 5 Fan contactors and auxiliary relays fed from the fan power supply are not to be used for fan status or interlock signals unless in series with a remote sensor such as differential pressure switch or flow switch.
- 6 Noise spectra to be provided for all proposed fans in terms of Sound Power Levels measured in accordance with ISO 5136:2003 (BS 848-2.5:2003) in 1/1 Octave Bands Centre Frequencies 63 Hz – 8 kHz.

7.17.2 CONSTRUCTION

- 1 Fans: Cast aluminium or pressed mild steel blades mounted in hubs and complete with brackets.
- 2 Mount wall fans using ring mounted type of the complete with hot dip galvanised ring mountings, wire mesh guards and aluminium louvre shutters.
- 3 Provide hot dip galvanised external wall cowls on externally located fans.

7.17.3 FAN/MOTOR ASSEMBLY

- 1 Comply with the 'Motors' Clause.
- 2 Motor bearings of the ball or roller type, sealed for life selected for an operating life of not less than 30,000 hours.

7.18 AIR CONDITIONING UNIT – WATER COOLED

7.18.1 GENERAL

- 1 Units approved manufacture with local factory support.
- 2 Units to be quiet running and free from vibration to the building structure.
- 3 Operate on refrigerant, R410A, R-134a or other approved non-CFC/HCFC refrigerant.
- 4 Units to be complete with flexible connections, anti-vibration mountings or hangers as applicable, air filters, refrigeration system, pipework and drain pans and connections.

7.18.2 CASINGS

- 1 Unit casings fabricated from not less than 1.15mm zinc coated steel sheet factory finished.
- 2 Casings to be fitted with removable panels to provide full access for maintenance.
- 3 Casings and access panels to be internally thermally insulated with not less than 25mm of aluminium foil faced mineral wool or 12mm of foil faced polyethylene foam.
- 4 One piece fully welded drip tray fabricated from minimum 1.55mm zinc coated steel sheet suitably painted to avoid corrosion or use 1.15mm stainless or fibreglass and insulated to suit application.
- 5 25mm drain connections.

7.18.3 FANS AND MOTORS

- 1 All fans to be double inlet double width forward curved type, fully balanced both statically and dynamically.
- 2 Fan bearings to be of self-aligning ball bearing packed for life type.
- 3 Motors to be of drip proof type with a speed of not more than 24 rps and a power capacity to handle at least 110% of design air capacity without overloading and under 24-hour continuous operation if required.
- 4 Motors to be fitted with thermal overloads and manual reset.
- 5 Fan discharge velocity to not exceed 9m/s.

- 6 Fan drives may be direct or multiple matched V-belts.
-

7.18.4 CONDENSERS

- 1 Condensers to be mechanically cleanable type and to be suitable for 1350kPa working pressure on the water side and 2000kPa on the refrigerant side.
 - 2 Water connections to be arranged to permit easy removal of the condenser and maybe flanged, have unions or rolled groove connections.
 - 3 Each condenser to be fitted with a water regulating valve directly controlled by the condensing pressure of the respective refrigeration system. Pressure drop at maximum design flow through these regulating valves not to exceed 7kPa.
-

7.18.5 COOLING COILS

- 1 Copper tube aluminium fins mechanically bonded.
 - 2 Face velocity to be maximum 2.0m/s.
-

7.18.6 COMPRESSORS

- 1 Hermetic or accessible hermetic type.
 - 2 Helical rotor or reciprocating type operating at not greater than 48rps.
 - 3 Protect compressors from electrical short-circuit. Also, provide manual reset thermal cut-out on motor windings.
 - 4 Compressors to be fitted with:
 - a Fully automatic splash or pressure feed lubrication system designed to maintain positive lubrication of all moving parts at any operating condition.
 - b Crankcase heaters; on when the compressors not running; served by separately fused circuits.
 - c Discharge mufflers.
 - d Anti-vibration mounts.
 - e Filter dryer.
 - f Controls:
 - i Automatic reset low pressure switch.
 - ii Manual reset high pressure switch.
 - iii Start limiting timer.
-

7.19 AIR CONDITIONING UNIT – SPLIT AND PACKAGE

7.19.1 GENERAL

- 1 Operate on refrigerant, R410A, R-134a or other approved non-CFC/HCFC refrigerant.

7.19.2 QUALITY

PRE-COMPLETION TESTS

1 The relevant Standards for pre-completion testing of air conditioners are as follows:

- a Packaged air conditioners: To AS 3823.1.1.

7.19.3 AIR CONDITIONING EQUIPMENT

GENERAL

1 Equipment enclosures:

- a Outdoor location: Provide enclosures, materials and finishes that are corrosion resistant and weatherproof.
- b Construction: Assembled and reinforced to prevent flexing and drumming. Provide for removal of major components.
- c Access: Provide access for inspection and maintenance.
- d Access panels: Readily removable with positive reusable fasteners and soft gaskets that provide an airtight seal.
- e Insulation: Insulate enclosures to prevent condensation on external surfaces under operational conditions.

2 Condensate trays:

- a Provide a tray under each cooling coil section, extending downstream to collect water carry over, and under components on which condensation can occur.
- b Material: Stainless steel.
- c Insulation: Insulate trays to prevent condensation internally and on external surfaces of the unit enclosure under operational conditions.
- d Reverse cycle units: If reverse cycle outdoor units do not have drain connections, locate the condensate trays below the units.
- e Condensate drains: Connect condensate trays to the nearest drain points with trapped drain lines, minimum DN 20.

3 Hermetic compressors:

- a Refrigeration service: Provide facilities for access to suction and discharge sides of refrigeration circuits.

4 Installation of condensers:

- a Provide clearance around units for condenser air flow and maintenance access.

5 Internal refrigeration system:

- a Standard: To AS/NZS 1677.1.
- b Piping: Copper pipe to AS/NZS 1571.
- c Insulation: Elastomeric foam.
- d For reverse cycle units, provide the following:
 - i Effective outdoor facility for coil defrost; and
 - ii Refrigerant reversing valve.

SPLIT AIR CONDITIONING UNITS

1 General:

- a Provide split type packaged air conditioning units, including indoor supply air units, complete with replaceable filters, outdoor condensing sections, interconnecting refrigeration piping, insulation sufficient to prevent condensation, and operating and safety controls.

2 Condensing Units:

- a General: Provide packaged condensing units consisting of refrigerant condensers, compressors and associated piping and electrical connections, mounted within the condenser enclosure.
- b Multiple compressor units: Provide separate control and electrical circuits for each refrigerant circuit.
- c Pressure cut-outs: Provide each compressor with a manual reset high pressure cut-out and an automatic reset low pressure cut-out.
- d Motor protection: Provide short circuit protection using high rupture coefficient (HRC) fuses or circuit breakers and a contactor (with manual reset thermal overload) for each compressor and each three-phase motor.
- e Short cycle timer function: To limit compressor starts.
- f Condenser fans: Two speed type controlled by refrigerant pressure.
- g Passivate coils post assembly with corrosion inhibitor to provide maximum coil corrosion protection.

3 Fan Coil Units:

- a General: Provide units consisting of coils, refrigeration, piping, supply air fan, accessories and electrical connections, mounted within an insulated enclosure.
- b Configuration: Blow through coil or draw through coil.
- c Fan: Double inlet forward curve centrifugal type, belt driven with variable speed motor.
- d Condensate line: Provide air break external to unit. Insulate to prevent condensation.

4 Enclosures:

- a Duct connections: Provide spigots or flanged connections.
- b Insulation: Provide foil faced acoustic insulation. Minimum 50mm thick.

5 Unit Safe Tray:

- a Provide galvanised tray under evaporator unit and condenser unit. Run drain line separately to unit drain line to nearest waste.

6 Cooling Coils:

- a Maximum 480 fins/m.
- b 2.5m/s maximum face velocity.
- c At least 3°C superheat, for refrigerant coils.

7 Controls:

- a Provide controls and safeties required for safe, efficient and reliable operation, including the following:
 - i Terminal strip for connection of all incoming and outgoing control signals. Refer to 'Controls' Section for description of controls requirements;
 - ii Variable speed controller to control evaporator fan speed;

- iii Independent reverse cycle defrost for multiple compressor units; and
- iv Reverse cycle defrost with shutdown of evaporator fan for single compressor units.

PACKAGED AIR CONDITIONING UNITS

1 General:

- a Provide complete packaged units consisting of cooling coil, supply air fan, compressors, condensers, filters and electrical components, mounted in an enclosure.

2 Condensing Section:

- a General: Provide packaged condensing section consisting of refrigerant condensers, compressors and associated piping and electrical connections, mounted within the enclosure.
- b Multiple compressor units: Provide separate control and electrical circuits for each refrigerant circuit.
- c Pressure cut-outs: Provide each compressor with a manual reset high pressure cut-out and an automatic reset low pressure cut-out.
- d Motor protection: Provide short-circuit protection using high rupture coefficient (HRC) fuses or circuit breakers and a contactor (with manual reset thermal overload) for each compressor and each three-phase motor.
- e Short cycle timer function: To limit compressor starts.
- f Condenser fans: Two speed type controlled by refrigerant pressure.
- g Passivate coils post assembly with corrosion inhibitor to provide maximum coil corrosion protection.

3 Fan Coil Section:

- a General: Provide section consisting of coils, refrigeration, piping, supply air fan, accessories and electrical connections, mounted within the enclosure.
- b Configuration: Blow through coil or draw through coil.
- c Fan: Double inlet forward curve centrifugal type, with variable speed motor.
- d Condensate line: Provide air break external to unit. Insulate to prevent condensation.

4 Enclosures:

- a Duct connections: Provide spigots or flanged connections.
- b Insulation: Provide foil faced acoustic insulation. Minimum 50mm thick.

5 Cooling Coils:

- i Maximum 480 fins/m.
- ii 2.5m/s maximum face velocity.
- iii At least 3°C superheat, for refrigerant coils.

6 Controls:

- a Provide controls and safeties required for safe, efficient and reliable operation, including the following:
 - i Terminal strip for connection of all incoming and outgoing control signals. Refer to 'Controls' Section for description of controls requirements;
 - ii Variable speed controller to control evaporator fan speed;
 - iii Independent reverse cycle defrost for multiple compressor units; and

7.20 ROOF COWLS

- 1 Totally weatherproof type.
 - 2 Compact base fitted with weathering skirt surmounted by a bird-proof cowl with a curved contour.
 - 3 Fibreglass construction.
 - 4 Maximum design pressure drop of 15Pa.
-

7.21 AIR CONDITIONING UNIT – VARIABLE REFRIGERANT VOLUME

7.21.1 GENERAL

- 1 Provide variable refrigerant volume (VRV) split type multi air conditioning system consisting of one outdoor unit and multiple indoor units, each having the capacity to cool and heat independently to meet individual requirements.
 - 2 Operate on refrigerant, R410A, R134a or other approved non-CFC/HCFC refrigerant.
-

7.21.2 CONDENSING UNITS

- 1 Compressor:
 - a The compressor shall be a highly efficient scroll type, equipped with inverter controls capable of changing the speed in accordance to the cooling or heating load requirements.
 - b Units having multiple compressors shall be able to operate even in the case that one of the compressors is out of order.
 - 2 Heat Exchanger:
 - a The heat exchanger shall be constructed with copper tubes mechanically bonded to aluminium fins to form a cross fin coil. Aluminium fins shall be treated with anti-corrosion resin film.
 - 3 Refrigerant Circuit:
 - a The refrigerant circuit shall include liquid and gas shut off valves and solenoid valves. All necessary safety devices shall be provided to ensure the safety operation of the system.
 - 4 Safety Devices:
 - a Each outdoor unit shall be provided with high pressure switch, overload relay, inverter overload protector and fusible plugs.
 - 5 Oil Recovery System:
 - a Units shall be equipped with an oil recovery system to ensure stable operation with long refrigerant piping.
-

7.21.3 FAN COIL UNITS

- 1 General:

- a** Provide units consisting of coils, control valves and refrigeration pipework, supply air fan, controls, accessories and electrical connections, mounted within an insulated enclosure.
- 2** Enclosures:
 - a** Duct connections: Provide spigots or flanged connections.
 - b** Insulation: Provide foil faced acoustic insulation. Minimum 50mm thick.
- 3** Unit Safe Tray:
 - a** Provide galvanised tray under evaporator unit and condenser unit. Run drain line separately to unit drain line to nearest waste.
- 4** Cooling Coils:
 - a** Maximum 480 fins/m.
 - b** 2.25m/s maximum face velocity.
- 5** Controls:
 - a** Provide controls and safeties required for safe, efficient and reliable operation, including the following:
 - i** Centralised multi-functional controller able to control each indoor unit individually or grouped in zones.
 - ii** Local controllers for individual indoor units.
 - iii** Unit shall be equipped with self-diagnostic for easy and quick maintenance and service.
 - iv** Control system to be integrated with BMS (see Control Section).

8 PIPING, VALVES & FITTINGS

8.1 GENERAL

8.1.1 SCOPE

- 1 This section sets out the engineering and quality assurance requirements for the completion of the installation design, materials, components, general installation and testing of the Mechanical Services piping systems.
 - 2 Piping systems shall be complete with all valves, fittings, vents, drains, expansion facilities, anchors, supports and other items necessary for their safe, reliable and efficient testing, commissioning, operation and maintenance.
 - 3 Piping systems, permitted material selections, design pressure, temperature ranges and testing criteria and procedures are specified in the Schedules.
-

8.2 DESIGN

8.2.1 GENERAL

- 1 Complete the detail design and engineering of the piping installation to the specified requirements.
-

8.2.2 DESIGN PRESSURE

- 1 Design pressure shall be not less than the sum of the following:
 - a Maximum hydrostatic pressure taking account of closed system pressurisation or head tank height.
 - b Pump shut-off head with maximum size impeller – pump selections to be confirmed following selection of equipment and controls.
-

8.2.3 PIPE ANCHORS, EXPANSION JOINTS AND SUPPORTS

- 1 Pipework anchors, supports and expansion joints shall be specifically designed and selected to accommodate weight of full piping, pressure thrust forces (including those generated by test pressures), thermal expansion and contraction, seismic restraint requirements, and building dynamic and time-dependent movement and plant movement. All anchors, supports and expansion joints shall be to the pipe manufacturers' recommendations.
- 2 Report to be provided by the Contractors specialist supplier according to the Contractors final equipment selections and system layout.
- 3 Proprietary type tested pipework anchors may be used for light duty anchor installations.
- 4 For systems operating above 750kPa design pressure, pipework anchor design shall be carried out by qualified structural engineer to comply with relevant structural codes. Submit structural reaction forces and installation details for acceptance.
- 5 Pipework installation and jointing systems to be designed in accordance with supplier design manuals for systems with specific requirements.

- 6 All pipework anchors and expansion joints shall have permanent access arrangements for inspection and maintenance.
 - 7 Provide hot dip galvanised external pipework structural steel supports.
 - 8 For water systems, Victaulic flexible couplings may be used to accommodate thermal growth and contraction, and for the elimination of expansion loops; where approved by the Consultant Engineer. Where loops are required, use flexible couplings on the loops.
 - 9 All materials for anchors, expansion joints and supports shall be compatible with pipe materials and not result in dissimilar metal corrosion or fatigue/cracking in plastic or metal pipes.
-

8.2.4 REFRIGERATION SYSTEMS

- 1 Piping design shall be generally in accordance with AS/NZS 1677.1 and, where applicable, equipment manufacturer's guidelines.
 - 2 Refrigerant piping shall be sized and designed so as to achieve proper oil return, freedom from slugging and trapping of refrigerant and oil.
 - 3 System design shall include oil traps, reservoirs, oil stills and suction separators necessary to provide satisfactory operation of the system.
-

8.3 QUALITY ASSURANCE

- 1 Refer to the Mechanical Services Specification *General Requirements* for requirements in relation to quality assurance.
- 2 The following details additional submissions, requirements and approvals in relation to the design, materials, components, fabrication, installation and testing of the Mechanical Services piping systems:
 - a Design Submissions
 - i System pipe schematics confirming system design, materials selection, expansion and contraction design, anchors, jointing, valves and fitting selections, gauges and DDC service points, testing and commissioning information.
 - ii System operating pressures incorporating final equipment selections and installation layout noting closed loop system pressurisation or make-up tank head.
 - iii Pipe selection and jointing method schedule including quality assurance procedures.
 - iv Pipe expansion/contraction device support and pipe anchor thrust and weight forces at test pressure conditions.
 - v Structural design for pipe riser supports and anchors indicating structural loads and building contraction and expansion provisions.
 - b Material and Equipment Submissions
 - i Valve Schedule: schedule of valve types indicating application, manufacturer, figure number, materials, pressure rating.
 - ii All grooved joint couplings and fittings shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - iii All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability
 - c Shop Drawings

- i Pipework support, expansion and anchor details.
 - ii Grooved joint couplings and fittings shall be shown on drawings and product submittals, and shall be specifically identified by the manufacturer's style or series designation.
- d Installation
 - i Qualification and training records for welders, pipe joiners and supervisors.
 - ii The grooved joint coupling manufacturer's factory trained representative shall provide on-site training for the Contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the project site to ensure best practices in grooved installation are being followed. (A distributor's representative is not considered qualified to conduct the training or field visits.)
- e Testing and Inspection
 - i Allow for non-destructive testing or cutting out up to three welded joints and for opening up at least three other types of joints in each system for inspection. Make good joints cut out or opened up after inspection.
 - ii Records of hydrostatic and pressure testing.
- f Completion
 - i Compliance statement with respect to the NCC Clause C3.15 fire resistance requirements for services openings including submission of type test reports in accordance with AS 4072.1 and AS 1530.4.

8.4 PIPING SYSTEMS

8.4.1 GENERAL

- 1 Supply piping in clean, full standard, straight lengths, free from any defects, mill scale, rust, burns, dents and kinks and protected against mechanical damage.

8.4.2 STEEL

- 1 Pipes:
 - a Closed Water Systems: AS 4041, API 5L Grade B to specified design pressure and temperature ranges. Minimum wall thickness: 4.8mm for pipes less than DN150, 6.4mm for pipes ND150 and over.
 - b Open Water Systems: AS 4041, API 5L Grade B to specified design pressure and temperature ranges.
 - c Minimum wall thickness: Standard Grade B.
 - d All pipes to be supplied with black lacquer finish.
 - e Pipes to be used with weld joints and flanges to be supplied with factory bevelled ends to AS 1163.
 - f Pipes to be used with rolled groove couplings shall be supplied with factory roll grooves by Victaulic certified supplier. Pipes under DN150 may be supplied with bevelled ends to AS 1163; DN150 be supplied with plain ends.
 - g AS/NZS 2280: Ductile iron pipes and fittings.
 - h Pipes specified to be galvanised shall comply with AS/NZ 4792 with a minimum coating of 300g/m².
- 2 Joints:

- a** Weld Joints: Full penetration welded. Comply with AS 4041 welding requirements and welder certification. For systems with a design pressure greater than 1400 kPa all welds are to be carried out by qualified welders with the appropriate AS 1796 certificate.
- b** Flanged Joints: to AS 2129 and AS 2528. Gasket material shall be performed proprietary type at least 0.8mm thick selected for application.
- c** Screwed joints: to AS 1074 and AS 1722.1. Screw threads to be sealed with degreased PTFE tape or an approved thread sealing compound, hemp and paste similar to 'HAWKINS'. Hemp shall not be used for systems with a design temperature above 60°C.
- d** Rolled groove couplings: Victaulic supplied only. Rolled grooves to be factory rolled by Victaulic registered supplier. Site rolled grooves to be undertaken by factory-trained personnel, stamped, and recorded to factory approved quality control system. All Victaulic couplings shall use flush type seals. Design and install in accordance with Victaulic Design and Installation Manual.
- e** Couplings shall consist of two ductile iron housing segments, pressure responsive gasket, and zinc electroplated steel bolts and nuts conforming.
 - i** Rigid Type, sizes through 300mm: Coupling housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging similar to a welded system (consult the manufacturer's latest published information).
 - ii** Victaulic Style 107H. Installation-Ready, for direct stab installation without field disassembly. Complete with grade EHP gasket rated for water service to +120 deg C or Nitrile gasket.
 - iii** Victaulic Zero-Flex Style 07.
 - iv** Flexible Type, sizes though 300mm: For use in locations where vibration attenuation and stress relief are required, and in lieu of flexible connectors. Victaulic Installation-Ready Style 177 and Style 77.
 - v** 350mm and Larger sizes: Victaulic AGS Series, with lead-in chamfer on housing key and wide width FlushSeal gaskets. Victaulic Style W07 (rigid) and W77 (flexible).
- f** Brazed joints to copper pipe and fittings are not permitted.

3 Connections:

- a** Connections to equipment up to and including DN50 to be ground joint, steel socket welded unions to AS 1074.
- b** Connections to equipment over DN50 to be rolled groove Victaulic type arranged to permit removal without cutting pipework or breaking any structure.
- c** Connections to copper piping and dissimilar metal components to incorporate flange isolation kits, bronze coupling or Victaulic Style 47 coupling.

4 Bends:

- a** Centreline radius not less than 1.5 times the pipe diameter. Pipe bends with centre line radius of 1.0-time pipe diameter shall not be accepted.
- b** Victaulic Style 10/W10 and 11/W11 are acceptable.

5 Branches:

- a** Branches to be welded swept tee type with a minimum centreline radius of not less than one and a half times the diameter of the pipe.

6 Reducers:

- a** Use concentric reducers or Victaulic Style 50/W50 type on all vertical lines.

- b** Use eccentric reducers or Victaulic Style 51/W51 on all horizontal line connections \geq DN50 to pump suction with installed flat on top and to other items of equipment with the flat of the eccentric arranged on the top or bottom of the pipe to allow venting and drainage as required.

8.4.3 COPPER

1 Pipes:

- a** Pipes: AS 1432: Type A or Type B for specified design pressure and temperature ranges. Copper Alloy: AS 2738 Designation 122.
- b** All pipe to be Hard Drawn.

2 Joints:

- a** Brazed: Use either capillary fittings to AS 3688, or expand one pipe over the other leaving minimum clearance and an effective overlap not less than:

PIPE SIZE DN	OVERLAP MM
< 20	12
≥ 20 to < 32	15
≥ 32 to < 50	25
≥ 50 to < 80	30
≥ 80 to < 125	35
≥ 125	40

- b** Brazing alloys to AS 1167 and comprise a minimum of 5% silver.
- c** Flanged: Copper alloy flanges to AS 2129 selected for design pressure and temperature, minimum Table E, brazed to pipe or alternatively may be floating type connected to pipe via a silver soldered copper Van Stone socket with inbuilt tube stops. Backing flanges polyester resin coated steel or composite material, Cop-a-Mate or equal.
- d** Nuts, bolts and washers used in flanges to AS 2129 Appendix C and AS 2528; stainless steel, galvanised or zinc plated after manufacture with non-conductive bushes.
- e** Roll Grooved: Victaulic Style 607H, Installation-Ready, for direct stab installation without field disassembly. Housings shall be cast with offsetting angle pattern bolt pads for joint rigidity. Manufactured to copper-tubing dimensions. (Flaring tube or fitting ends to accommodate alternate sized couplings is not permitted.)
- f** Victaulic Style 641 flange adaptor.
- g** Brazed joints to steel pipe and fittings not permitted.

3 Connections:

- a** Use flanged, screwed, compression or roll grooved connections to valves, equipment and fittings arranged to permit removal of any item of equipment without cutting pipework or without breaking any structure.
- b** Screwed connections to be silver soldered bronze socket unions.

4 Bends:

- a** Smooth finish without any discernible flattening or corrugation.
- b** Minimum centreline radius of not less than one and a half times the diameter.

- c Victaulic Style 610 or 611 are acceptable.
 - d Standard proprietary bends may be used subject to compliance with above conditions.
- 5 Branches:
- a Branches from main pipelines to be of swept tee type fabricated from abovementioned bends.
- 6 Reducers:
- a Use concentric reducers or Victaulic Style 650 type on all vertical lines.
 - b Use eccentric reducers or Victaulic Style 651 on all horizontal lines, connections to pump suction to have flat on top and to other items of equipment with the flat of the eccentric arranged on the top or bottom of the pipe to allow venting and drainage as required.

8.4.4 STAINLESS STEEL

- 1 Pipes:
- a AS 4041, ASTM A 312M Grade 316 L.
 - b Minimum Wall Thickness:

Piping up to DN 150: 1.6mm
Piping from DN 150 to DN 300: 2mm.
- 2 Joints:
- a Use stainless steel of the same grade and wall thickness as the pipe.
 - b Weld Joints: Full penetration welded. Comply with AS 4041 Welding Requirements and AS/NZS 3992. Provide details of qualified welding procedure to be carried out by qualified welding personnel with appropriate AS 1796 certificate.
 - c Flanged Joints: to AS 2129 and AS 2528. Use flange jointing material similar to Bestobell J2100 preformed proprietary type at least 0.8mm thick.
 - d Screwed joints: to AS 1722.1. Screw threads to be sealed with degreased PTFE tape or an approved thread sealing compound, hemp and paste similar to 'HAWKINS'.
 - e Rolled groove couplings: Victaulic supplied only. Rolled grooves to be factory rolled by Victaulic registered supplier. Site rolled grooves to be undertaken by factory trained personnel. Schedule 5S and 10S pipe shall be grooved using Victaulic RX roll sets, specifically designed for stainless steel pipe. Use only flush type seals. Design and install in accordance with Victaulic Design and Installation Manual. Couplings shall be provided with coated ductile iron or stainless steel housings as required. Victaulic Style 89 / W89 (DI) and Style 489 (SS) rigid type, or Style 77 (DI) and 77S (SS) flexible type. For sizes through 100mm, Victaulic Style 107H and Series 177, Installation-Ready couplings, for direct stub installation without field disassembly. Complete with grade EHP gasket rated for water service to +120 deg C or Nitrile gasket
 - f In stainless steel pipe systems use only stainless steel nuts, bolts and washers of same grade as piping.
- 3 Connections:
- a Victaulic rolled groove couplings or flanged joints for connections over 50mm to all equipment to permit their removal without cutting pipework or breaking any structure.
 - b Connections up to and including 50mm to be ground joint, steel socket welded unions to AS 1074.
 - c All connections between copper piping and dissimilar metals to incorporate flange isolation kits, bronze coupling or Victaulic Style 47 coupling.

- 4 Bends:
 - a Centreline radius not less than one and a half times the diameter of the pipe.
 - b Victaulic Style 100SS and 410 and 110SS and 411 are acceptable.
 - 5 Branches:
 - a Branches from main pipelines to be welded swept tee type with a minimum centreline radius of not less than one and a half times the diameter of the pipe.
 - 6 Reducers:
 - a Use concentric reducers or Victaulic Style 50-SSLT type on all vertical lines.
 - b Use eccentric reducers or Victaulic Style 51-SSLT on all horizontal lines. Connections to pump suction to have flat on top and to other items of equipment with the flat of the eccentric arranged on the top or bottom of the pipe to allow venting and drainage as required.
-

8.4.5 ABS AND UPVC

- 1 Pipes:
 - a ABS: AS 3518.
UPVC: AS/NZ 1477.
 - b Min Wall thickness ABS: class 9, UPVC PN9 or higher to suit selected pressure and temperature rating.
- 2 Joints:
 - a Socket formed solvent cement welded type to piping manufacturers recommendations and instructions for applications where pipework is located in plant rooms, with allowances for changes in direction via bends and offsets and is not subject to excessive thermal expansion.
 - b When subject to expansion and contraction and long lengths of piping above 200mm are involved, use Durapipe post formed expansion units with lipped neoprene 'O' ring or alternatively use rubber bellows type.
- 3 Connections:
 - a Flanged joints for connections to valves, fittings and equipment to consist of ABS/UPVC flanges, galvanised backing rings drilled to match flanges and neoprene gaskets.
- 4 Bends:
 - a Plain radius type.
 - b Fabricate large bends from mitred standard type having at least five sections per bend and with sections welded with hot gas filler rod technique or other approved.
 - c Cover all fabricated fittings with an applied layer of 60g CMS fibreglass, consolidated with polyester resin type RP161 at the rate of 1.2 to 1.9kg per m².
- 5 Branches:
 - a Use standard tee type branch connections for smaller pipes.
 - b Use telescopic branch connections for larger pipes to ensure a smooth entry of water to the reduced port.
 - c Use preformed saddles fully welded to the pipe for branch connections for flow switches, sensors and other fittings.
- 6 Reducers:

- a Use concentric reducers on all vertical lines.
- b Use eccentric reducers on all horizontal lines. Connections to pump suctions to have flat on top and to other items of equipment with the flat of the eccentric arranged on the top or bottom of the pipe to allow venting and drainage as required.

8.4.6 REFRIGERANT COPPER

1 Pipes:

- a Pipes: AS/NZS 1571. Type A or Type B for specified design pressure and temperature ranges.
- b Use refrigerant grade copper to suit application.
- c All pipe to be Hard Drawn.
- d Deliver to the site in clean moisture free coils and straight lengths with sealed ends and keep it clean and free of moisture at all times during construction.
- e Comply with all applicable Australian Standards, Codes, Statutory Requirements and Regulations.
- f Neatly install true and square and with the minimum number of bends with all necessary brackets and supports to provide firm fixings and obviate sagging.
- g Tape uninsulated lines for isolation from direct contact with ferrous materials.
- h Provide insulated lines with timber saddles or galvanised sheet metal sleeves to obviate compression of the insulation at points of support.
- i Provide suction risers with traps at all low points and the line sizes shall be such that they will ensure adequate gas velocities for the return of oil up the risers.

2 Joints:

- a Silver soldered to AS 4041, AS 3688, AS/NZS 1677.1.
- b Use demountable connections to valves, equipment and fittings arranged to permit removal of any item of equipment without cutting pipework and without breaking any structure.
- c Flared compression fittings may be used up to 20mm. Use compression fittings to AS/NZS 1677.1.
- d Flanges to be Table E copper alloy flanges to AS 2129, of silver soldered type with recessed gaskets.
- e Use flange bolts, nuts and washers complying with AS 2129 and AS 2528, of stainless steel, or galvanised or zinc plated after manufacture and with non-conductive bushes.
- f Use flange gaskets of Klingerit 400 Universal type.
- g Brazed: Use either capillary fittings to AS 3688, or expand one pipe over the other leaving minimum clearance and an effective overlap not less than:

PIPE SIZE DN	OVERLAP MM
< 20	12
≥ 20 to < 32	15
≥32 to < 50	25
≥50 to < 80	30
≥80 to <125	35
≥125	40

h Brazing alloys to AS 1167.1 and comprises a minimum of 5% silver.

3 Connections:

a Use fittings such as couplings of forged and wrought copper type of Heldon manufacture or offered equal.

4 Bends:

a Use fittings such as elbows and return bends of forged and wrought copper type of Heldon manufacture or offered equal.

5 Branches:

a Use fittings such as tees, stop ends and Y pieces of forged and wrought copper type of Heldon manufacture or offered equal.

6 Reducers:

a Use fittings such as reducing bushes of forged and wrought copper type of Heldon manufacture or offered equal.

b Use concentric reducers on vertical lines.

c Use eccentric reducers on horizontal lines and connections to equipment with the flat of the eccentric arranged at the top or bottom as appropriate for gas venting or oil and liquid return as appropriate.

8.4.7 POLYETHYLENE (PE)

1 Pipes:

a To AS/NZS 4130.

2 Fitting and Components:

a To AS/NZS 4129 and 4131.

3 Installation:

a To AS/NZS 2033.

4 Jointing:

a Permanent joints: Solvent cement

b Demountable joints: Piping ≤ DN 50: Threaded fittings. Piping > DN 50: Flanges with backing rings.

8.5 VALVES AND FITTINGS

8.5.1 GENERAL REQUIREMENTS

- 1 Use valves suitably sized for the application and at least line size unless used for control when a smaller size may be necessary.
- 2 Select valves and fittings to meet the operating pressures and operating characteristics of the relevant systems and to meet higher test pressures where applicable.
- 3 Design pressure of valves and fittings not less than the system design pressure.
- 4 All isolating valves and throttling valves shall be rated for full shut-off pressure.
- 5 All valves and fittings shall be installed in accordance with manufacturer's recommendations and with valve shafts installed on or above the horizontal plane and with all tapping points a minimum of 45 degrees off the vertical downwards plane.
- 6 Provide extended shafts or bodies for insulated valves to allow full thickness of insulation.
- 7 Valves up to 50mm diameter; screwed connections to AS 1722.1, or with Victaulic Vic-Press connections.
- 8 Valves over 50mm diameter; flanged connections to AS 2129 Type E minimum or Victaulic rolled groove.
- 9 Handwheels and handles to be removable with the direction of closing to be marked clearly.
- 10 Select valves to water supply authority approval where applicable; valves to be stamped with approval details.
- 11 For each type of valve and fitting, valves and fittings to be supplied from one manufacturer throughout the project.
- 12 Where copper alloy valves used, select valves of dezincification resistant type.
- 13 Tag all valves and flow measuring devices for identification purposes. Valves with Handwheels: Provide a circular brass disc attached to the valve by a stainless-steel wire drawn through the holes in the disc on each valve provided with operating handwheel or lever stamp the valve identification mark on the disc in characters 10 mm high. Valves without handwheel: Mark by aluminium or brass strap 20 mm wide by 90 mm long stamped in the same manner as the valve identification discs. Attach by wire to the body of the valves.

8.5.2 WATER SERVICES VALVES AND FITTINGS

8.5.2.1 THROTTLING VALVES (UP TO AND INCLUDING 50MM)

- 1 Double Regulating Valves:
 - a Continuously adjustable graduated limit stop for precise setting of maximum valve opening.
 - b Numeric indication of valve opening.
 - c Pressure tappings across variable orifice or across fixed orifice flow measuring device.
 - d Copper alloy body and copper alloy trim.
 - e Screwed connections.
 - f PTFE seat.
 - g Tour and Anderson STAD or approved equal.

8.5.2.2 THROTTLING VALVES (OVER 50MM)

1 Butterfly Valves:

- a Lug type to BS5155.
- b High tensile cast iron body, stainless steel shaft, bronze disc and keyed replaceable EDPM seat.
- c Suitable for installation between flanges with spool piece or retaining flanges to facilitate removal of downstream pipework with valve remaining in place for isolation.
- d Butterfly valves shall have a stainless-steel stem that is offset from the disc centreline to provide complete 360-degree circumferential seating. Victaulic Master Seal and AGS-Vic300. (For stainless steel piping, Victaulic Series 763.)
- e Valves used in copper-tubing systems shall be Victaulic Series 608, with stem integrally cast with the disc.
- f Lever operated with adjustable infinitely variable memory stops.
- g For valves over 150mm diameter, geared or motorised operators with adjustable travel stops.
- h Provide chain wheels and chain with handwheel with memory stops or permanently marked at low level for manually operated valves over 150mm in size, when located above 2 metres above finished floor level.

2 Double Regulating Valves:

- a Continuously adjustable graduated limit stop for precise setting of maximum valve opening position.
- b Pressure tapings across variable orifice.
- c Flanged bronze body type and stainless steel trim.
- d PTFE seat.
- e Tour and Anderson STA-F or STA-G approved equal.

8.5.2.3 AUTOMATIC/DYNAMIC BALANCING VALVES (UP TO AND INCLUDING 40MM)

- 1 Valves shall be of DZR brass with BSP union connections.
- 2 Flow control cartridges shall be adjustable, rolling diaphragm style of composite construction.
- 3 Valves shall include 2 P/T Hyflo plugs and an integral isolating ball valve.
- 4 Body style will ensure that cartridge is accessible while valve remains in line.
- 5 Flow control accuracy as a minimum will be +5% within cartridge control range.
- 6 Manufacturer's warranty shall be for 5 years from date of system start-up.
- 7 FlowCon ABV or equal approved.

8.5.2.4 AUTOMATIC/DYNAMIC BALANCING VALVES (OVER 40MM)

- 1 Valves shall be of ductile iron in wafer body configuration.
- 2 Flow control cartridges shall be of stainless steel.
- 3 Valves shall include 2 P/T Hyflo plugs and extensions.
- 4 Flow control accuracy as a minimum will be +5% within cartridge control range.
- 5 Manufacturer's warranty shall be for 5 years from date of system start-up.
- 6 FlowCon AHU wafer, class 150 wafer or equal approved.

8.5.2.5 ISOLATING VALVES (UP TO AND INCLUDING 50MM)

1 Gate Valves:

- a Straight through flow, solid wedge type.
- b Bronze bodied to AS 1628 with zinc free inside screw of non-rising spindle type.
- c Medium pattern.
- d Integral bronze seat.
- e Screwed connections.

2 Ball Valves:

- a Full bore pattern with handle parallel to direction of flow when fully open.
- b Bronze bodied with hard chromed brass or stainless steel ball, stainless steel stem and PTFE seat.
- c Screwed connections.
- d John 350 or equal approved.

8.5.3 ISOLATING VALVES (OVER 50MM)

1 Gate Valves:

- a Straight through flow, solid wedge type.
- b Bronze bodied to AS 1628 or cast iron to AS 2638 or cast steel with zinc free, non-rising inside screw type spindles.
- c Medium pattern.
- d Replaceable bronze seat.
- e Flanged connections.
- f John 59M or equal approved.

2 Ball Valves:

- a Full bore pattern with handle parallel to direction of flow when fully open.
- b Bronze bodied with stainless steel ball, stem and PTFE seat.
- c Watermark (as defined in SAA MPS2 Section 012) and AGA approved.
- d Flanged or rolled groove connection.
- e John 360 or equal approved.
- f Victaulic style 721 / 726 are acceptable.

3 Butterfly Valves:

- a Lug type to BS 5155.
- b High tensile cast iron body, stainless steel shaft, bronze disc and bonded EDPM seat.
- c Rated for dead end and bi-directional service.
- d Suitable for installing between flanges with spool piece or retaining flanges to facilitate removal of downstream pipework with valve remaining in place for isolation.

- e Butterfly valves shall have a stainless-steel stem that is offset from the disc centreline to provide complete 360-degree circumferential seating. Victaulic Master Seal and AGS-Vic300. (For stainless steel piping, Victaulic Series 763.)
- f Valves used in copper-tubing systems shall be Victaulic Series 608, with stem integrally cast with the disc.
- g Memory stop for throttling, metering or balancing service.
- h For valves over 150mm, geared or motorised operators.
- i Provide chain wheels and chain with chain at low level for manually operated valves over 150mm in size when located above 2 metres above finished floor level.

8.5.3.1 NON-RETURN VALVES (UP TO 50MM)

- 1 Bronze body swing check type to AS 1628 with stainless steel trim.
- 2 Screwed connections.
- 3 To be completely free of hammering under all operating conditions.
- 4 John Figure 4B or equal approved.

8.5.3.2 NON-RETURN VALVES (OVER 50MM)

- 1 Cast iron spring loaded dual flap type with stainless steel spring and pin, stainless steel plates, integral nitrile rubber seat.
- 2 Flanged connections or rolled groove connections.
- 3 Hyflo, Stock ham or approved equal.
- 4 Victaulic Style 716 / W715 are acceptable.

8.5.3.3 CONTROL VALVES

- 1 General Control Valves:
 - a Modified linear or equal percentage type.
 - b Valve bodies bronze or cast iron with stainless steel trim and renewable discs and seats.
 - c Visible position indicators for valve actuators connected to valves above 32mm diameter.
 - d Arranged as normally closed valves with 100% close off to items controlled except for bypass valves which are to be normally open.
 - e Select for demand authority of items served and for minimum fully open resistance (identified by KV or CV Valves) of not less than 1.5 times the combined pressure drop of the branch pipe and item served.
- 2 Dynamic Modulating Control Valves (up to 40mm):
 - a Valves shall be DZR brass body with stainless steel and brass components and BSP union connections.
 - b Valves will be fitted with pressure tapping points.
 - c Valve authority to be 100% with flow variation for each valve position not to exceed $\pm 5\%$ across the working pressure drop range of the valve.
 - d Valve actuator will be adjustable to any one of 50 different maximum flow rate limits.
 - e Control input and position output signals will be 2-10 Volts dc, 4-20 mA or 3-point floating.
 - f Manufacturer's warranty shall be 3 years from date of system start-up.

- g FlowCon Model SM100 or equal approved.

8.5.3.4 PRESSURE RELIEF VALVES

- 1 Direct acting, spring loaded, side outlet type with adjustable setting to AS 1271.
- 2 Designed to discharge at full capacity at a pressure not greater than 10% higher than set point pressure.
- 3 Bronze bodied with renewable stainless steel disc and seat with springs protected from working fluid.
- 4 Provide easing gear.
- 5 Lockable shield to prevent unauthorised alteration to setting.
- 6 Valve drained to waste.

8.5.3.5 BALL FLOAT VALVES

- 1 Copper alloy or bronze bodied to AS 1910 or cast iron.
- 2 Bronze needle and pins.
- 3 Copper or plastic float with brass or stainless steel linkage.

8.5.3.6 COLD WATER STOP TAPS

- 1 Select stop taps of brass to the requirements of the Local Water Supply Authority.

8.5.3.7 STRAINERS

- 1 Y type or Victaulic Style 731 / W732 suction diffusers complete with pre-filter 16 mesh for pressures up to 2065kPa.
- 2 Screwed bronze body on all lines up to and including 50mm and flanged cast iron body above 50mm with easily removed perforated stainless steel or brass strainer basket.
- 3 Select mesh for 15kPa maximum pressure drop.
- 4 Fit ball valve and drain line to waste for strainers over 50mm as follows:
 - a 65, 80 and 100mm strainer – 25mm drain; 125mm – 32mm drain; 150 and 200mm – 40mm drain; 250, 300 and 350 – 50mm drain.

8.5.3.8 AUTOMATIC AIR VENTS

- 1 Float operated with cast iron or copper alloy body and stainless steel or solid plastic floats and mechanisms.
- 2 Air vents are to be fully rated for the system operating conditions; minimum acceptable is 1,000kPa and 120°C.
- 3 All vents are to be fitted with separate isolation valve on the inlet to allow servicing of the vent without draining the system.
- 4 Combined air vent discharge capacity of any section of the system being filled must exceed the flow rate at the fast fill system.
- 5 Flamco Flex vent, Flex vent Super or equal.

8.5.3.9 EXPANSION JOINTS

- 1 Non Metallic:
 - a Flanged type of high grade neoprene.
 - b Powersorb type REJ or equal.

2 Metallic Braided:

- a** Stainless steel braided flexible connection.
- b** Flanged type of high grade EPDM and spirally wound wire and reinforcing having a nominal max length of 300mm.

8.5.3.10 FLEXIBLE PIPEWORK CONNECTIONS

- 1** Flanged type of high grade EPDM and spirally wound wire and reinforcing having a nominal length of 6 times nominal pipe diameter.
- 2** Hyflo C-Flex or equal approved.
- 3** Three Victaulic flexible couplings may be used in lieu of a flexible connector for vibration attenuation and stress relief at equipment connections. The couplings shall be placed in close proximity to the vibration source.

8.5.4 REFRIGERANT SYSTEMS VALVES AND FITTINGS

1 Refrigerant Valves:

- a** Forged steel, brass or bronze, packed cap, back seating type of F. L. Hudson manufacture or equal.
- b** Alternatively, a packed, capped ball valve of low loss type of Apollo manufacture.
- c** Use brass packed valves with brass caps or packless valves of Heldon manufacture.
- d** Suitable for operation on 240V \pm 10%, 50Hz supply within an ambient temperature range of 0°C to 40°C and a maximum operating pressure differential of up to 850kPa.
- e** Check valves of lifting type with manual lifting provisions.
- f** Supply and install individual gauge valves as close to equipment and main lines as possible.

2 Thermometer Pockets:

- a** Supply and install thermometer pockets on each compressor suction and discharge line.

3 Refrigerant Pressure Gauges:

- a** 100mm chrome plated flanged pressure gauges with dials marked with combined pressure temperature scales.
- b** Supply and install gauges for each compressor to measure suction pressure, discharge pressure and oil pressure.

4 Refrigerant Sight Glass and Dryness Indicator:

- a** Heldon or equal.
- b** Install prior to each expansion valve and at least 500mm downstream of solenoid valve.
- c** Provide 'bulls-eye' type of brass or bronze construction, designed to minimise sediment deposits, clearly show inadequate refrigerant flows and indicate the presence of moisture in the refrigerant by means of a colour change.

5 Refrigerant Solenoid Valve:

- a** Supply and install a solenoid valve of Danfoss or Sporlan make at least 600mm upstream of sight glass.
- b** Size valve for minimum pressure drop.

6 Refrigerant Expansion Valve:

- a** Pilot operated of Sporlan, Danfoss or equal manufacture.
- b** Brass or bronze with stainless steel trim and having copper capillaries and sensor bulbs.

- c Provide thermostatic expansion type with external equalisers and adjustable super-heat controls.
 - d Provide correctly sized orifices for the loads and pressure drops involved and capillaries of adequate length to permit correct location of the sensor bulbs on the suction lines.
 - e Incorporate all valves with integral fine mesh filters fitted to the inlet connections.
- 7 Refrigerant Dryer:**
- a Supply and install a refrigerant dryer in a valved bypass in the liquid line from the liquid receiver or condenser to the evaporator.
 - b Brass or copper construction with brass or stainless steel mesh screens and charged with silica-gel or activated alumina desiccant.
- 8 Refrigerant Strainer:**
- a Supply a strainer of YK or equal manufacture in the main liquid line with isolating valves to permit maintenance.
- 9 Pressure Relief Valve:**
- a Supply and fit pressure relief valves, bursting disc or fusible plug set to operate at a test pressure at least 175kPa below the test pressure specified and sized to ensure that system pressure cannot exceed test pressure. The pressure relieve valve shall be vented in accordance with authority requirements.

8.5.5 NATURAL GAS TOWNS GAS AND LPG VALVES

- 1 Isolating Valves:**
- a Full bore, dezincification resistant.
 - b Ball valves operable by one quarter turn.
 - c Permanently fixed handle indicating direction of gas flow.
 - d Comply with Gas Supply Authority requirements and AGA / ALGA Standards as appropriate.
 - e John 360 or equal approved.
- 2 Pressure Reducing Valves:**
- a Reliance or Jeavons J48 type.

8.6 GAUGES AND INSTRUMENT FITTINGS

- 1 Universal Test Points:**
- a Binder Twin lock type or approved alternative.
 - b Test points to be installed a minimum of 45° above the vertical downwards plane and as required to provide access.
- 2 Thermometers:**
- a 100mm dial type mercury in steel thermometers matching pressure gauges and calibrated in Deg. C.
 - b Dial range twice operating temperature range.
 - c Accuracy $\pm 1\%$ of scale range.
 - d Bulb type 316 stainless steel.
- 3 Thermometer Pockets:**

- a Locate thermometer pockets in positions where no adverse flow conditions exist.
 - b Use thermometer pockets of removable screwed stainless steel type in steel lines, inserted through screwed type boss welded to the pipe.
 - c Use thermometer pockets of fixed copper tube type brazed into copper piping lines.
 - d Length of pockets and depth of insertion in pipe adequate to ensure accurate readings.
 - e Fill pockets with heat conducting fluid to a minimum depth of 50mm and fit caps to each pocket.
 - f Enlarge pipes smaller than 65mm so as to retain free area.
 - g Install pockets vertically or at an angle to retain heat conducting fluid.
- 4 Pressure Gauges:
- a Oil filled 100mm dial Bourdon pipe type to AS 1349.
 - b Fit with ball valve.
 - c Manually adjustable set point needle incorporated on face of gauge.
 - d Chrome plated escutcheon and suitable for recessed mounting.
 - e Select compound type gauges for pump suction graduated in mm of mercury on vacuum side and kPa on the pressure side.
 - f Bourdon pipe material stainless steel for hot water and steam, phosphor bronze for other services.
 - g Bosses for pressure gauges, standard internally screwed type welded or brazed to side of piping.
- 5 Gauge Panels:
- a Folded sheet metal of adequate stiffness, painted or powder coated with gauges logically grouped and mounted to approval.
-

8.7 INSTALLATION

8.7.1 ARRANGEMENT

- 1 Layout piping with adequate provision for expansion, contraction, grading, alignment and access for maintenance with not less than 25mm clearance in addition to insulation between pipes and all other surfaces and services.
 - 2 Co-ordinate and detail offsets and bends required for co-ordination between trades and integration with building structure and architectural finishes.
-

8.7.2 ACCESSIBILITY

- 1 Provide access and clearance at fittings which require maintenance or servicing, including control valves and joints intended to permit pipe removal. Arrange piping so that it does not interfere with the removal or servicing of associated equipment or valves or block access or ventilation openings.
- 2 Locate thermometers, pressure gauges and similar instruments so that they are easily read after installation.

8.7.3 PIPEWORK SUPPORTS AND ANCHORS

1 General Requirements:

- a Design supports for all static and dynamic load and reactions.
- b Install seismic bracing to all pipework as required by AS 1170.4. Refer to General Requirements for AS 1170.4 Design parameters.
- c Comply with all Statutory and Code requirements.
- d Locate valves and fittings as close as possible to points of support and separately support valves in line sizes 200mm and larger.
- e Supports and anchors to be in accordance with pipe manufacturers' recommendations.

2 Support Spacing:

- a Steel pipe to AS 4041 Table 3.28.2.
- b Copper pipes to AS 4809 Table 6.2.
- c Other non-ferrous pipe to AS 3500.1 Table 5.2.
- d ABS to manufacturer's recommendations.

3 Pipe Clamps, Spacers and Saddles:

- a Individually hung pipes - bolted, two-piece type clamps with clevis or welded yokes of 'Millstrut' PC7 or PC10 series or equivalent. One-piece type clamps with clevis similar to 'Millstrut' PC2 series may be used for pipe sizes DN65 or less. Clamps rated for the full load of pipe plus its fluid contents, insulation and fittings.
- b Spacers - Low temperature insulated pipes - fully vapour sealed hardwood spacers located between clamps and pipes. Spacers wedge shaped hardwood blocks arranged to form circular collars of the same thickness as the insulation and projecting a minimum of 10mm on either side of the clamps.
- c Spacers - Chilled Water Pipework Alternative: - fully vapour sealed spacers manufactured from cellular glass insulating material equivalent to Pittsburgh Corning Foamglas. Install using galvanised sheet metal saddles between the spacers and the pipe supports. Design of the system including lengths of spacer, shape and thickness of saddle, adhesives and vapour barriers to be in accordance with manufacturer's recommendations.
- d Spacers - High temperature insulated pipes operating over 60°C - sectional high density fibreglass or mineral wool spacers having a minimum density of 80kg/m³.
- e Spacers – ABS – to manufacturers recommendations.
- f Firmly attach clamps and collars to pipework and/or insulating spacers without applying undue pressure to the pipe walls.

4 Hanger Rods:

- a Fabricate hanger rods and associated fittings from hot dip galvanised or zinc plated mild steel bar of not less than the following diameters:

NOMINAL PIPE SIZE MM	ROD DIAMETER MM
Up to 20 (inclusive)	6
25 & 32	10
40 to 100	12

125 to 250	16
300 to 450	20
500 & above	24

5 Fixed Supports:

- a Fix hanger rods direct to structure unless moving supports required to cater for expansion, contraction and vibration.
- b Support two or more pipes on common channel section bracket or trapeze type support:

Pipe sizes up to 100mm	Millstrut P1000 Series.
Pipe sizes over 1000mm	Standard rolled sections.

6 Moving Supports:

- a Where hanger rods used to take up movement ratio of effective length to pipe movement to be not less than 6:1.
- b Provide 'V' shaped brackets with oversize holes for rods. Similarly, clevis or welded yokes on pipe clamps to have oversize holes for rods. Secure rods at each end using spherical washers and locknuts and do not use any nuts between brackets and clevis or welded yoke.
- c Use spring and double deflection hangers similar to Mason PC 30N-400 and 30N-400 when movement is too great to be accommodated by the previous method and when movement is less than 25°.
- d Use rigid channel section support brackets or trapeze type supports with roller or sliding supports when pipe movement extensive. Roller supports similar to Millstrut types P2119, P2474 or P2475.
- e Protect insulation on sliding supports with heavy gauge galvanised steel sheet forming a sleeve and provide rigid insulation for at least four pipe diameters on either side of support.

7 Anti-Vibration Hangers:

- a Supply and install spring and neoprene high deflection anti-vibration hangers to all pipework within 10m of equipment which is supported on similar high deflection mounts.
- b Deflection to be selected according to the load and to comply with hanger manufacturer's recommendations.
- c Anti-vibration hangers to be Mason Industries Pty Ltd or equivalent.

8 Anchors:

- a Design, supply and install anchors where shown on drawings and where required to accommodate pipework weight, thrust forces and expansion and contraction.
- b Submit detailed design and installation details for the project structural engineer's approval and confirmation that the building structure can resist the anchor forces imposed by the system design.
- c Anchor connections to the pipework shall be:

Steel pipe:	Fully welded to pipe.
Copper pipe:	Anchors comprising bronze flanges fully brazed to pipe and bolted to galvanised steel anchor plates. Use non-conductive bushes and washers.
ABS pipe	To manufacturer's recommendations.

- d Anchor shall comprise steel plates and/or rolled steel sections designed to transfer the weight of pipework, pipe and thrust forces exerted by the system to the structure.

8.7.4 PIPELINE GRADIENTS, AIR VENTS AND DRAINS

1 Water Services:

- a Install piping with continuous upwards gradient of not less than 1:500 in the direction of flow.
- b Fit air vents in any section of pipework where air may collect with outlet drained to waste via a visible tundish in a readily accessible position. Fabricate air bottles 25mm smaller than the pipework for pipes above 80mm diameter and equal to the pipe sizes for pipework below 80mm in diameter.
- c Drain all low parts of pipework not less than 20mm for pipes up to 100mm diameter, 25mm for pipes up to 150mm and 32mm for pipes above 150mm.
- d Fit draining facilities to all items of equipment, ancillary items and fittings such as expansion tanks, strainers, dirt legs. Run drain points to the nearest floor waste or tundish.
- e Install full size dirt legs with valves and hose nipples at the bottom of risers and vertical piping. Valves not less than 32mm for pipes above 50mm and not less than 20mm for pipes less than 50mm.
- f All water coil connections are to have drains and vents at coil headers.

2 Gas Services:

- a The entire installation, including draining and cleaning requirements in accordance with AS 5601.

3 Compressed Air Services:

- a Install piping graded in a downward direction in the direction of flow with a grade of not less than 1:500 and arrange for a minimum of low points.
- b Fit automatic water eliminators (traps) at after coolers, receivers and low sections of piping.
- c All branches to be taken off the top of supply lines.

4 Refrigerant Services:

- a Piping systems to be installed in accordance with practices detailed in ASHRAE Handbook 'Refrigeration' or Carrier System Design Manual 'Refrigeration Piping Design'.
- b Liquid line. Pressure drop not to exceed the equivalent of 1°C change in saturation temperature.
- c Suction line. Pressure drop not to exceed the equivalent of 1°C change in saturated temperature. Double suction risers may be needed for oil entertainment up vertical pipes. Trap size should be as small as possible. Main vertical pipe should enter horizontal pipe from above. Horizontal runs should be level.
- d Discharge line. Pressure drop not to exceed the equivalent of 1°C change in saturation temperature.

8.7.5 VIBRATION ISOLATORS

- 1 Rubber bellows are not to be used to absorb piping movement due to expansion in the system.
- 2 Rubber bellows should NOT be installed extended, compressed or offset to make up for deficiencies in pipe length or alignment.
- 3 Pipework must be properly anchored around the unit, to avoid the bellows bearing the weight of the piping system.
- 4 Units must be rated for the system operation pressure and temperature.
- 5 The Works Package should note the allowable bellows movement in their submission of products.

- 6 Construction to include flanged connections bellows to be nylon cord and wire reinforced EPDM rubber suitable for a working temperature of up to 95°C.
 - 7 Hyflo C-Flex or equal approved.
-

8.7.6 PIPE EXPANSION AND CONTRACTION

- 1 Provide means to accommodate piping expansion and contraction in pipe runs longer than 30m from anchor points which may be a series of full radius bends and diversions, expansion loops or bellows.
 - 2 Expansion and contraction joints using Victaulic style 150 or style 155 joints shall be designed and installed in accordance with the Manufacturer's recommendations.
 - 3 For water systems, Victaulic flexible couplings may be used to accommodate thermal growth and contraction, and for the elimination of expansion loops. (As approved by the Consultant Engineer.) Where loops are required, use flexible couplings on the loops.
-

8.7.7 PIPE PENETRATIONS

- 1 Supply 1.6mm galvanised steel sleeves for placement and casting in penetrations. Sleeves to extend a minimum of 100mm above floors.
 - 2 Pipe penetrations in fire rated structures to comply with NCC Clause C3.15 where applicable – refer to architectural and structural drawings for required fire ratings.
 - 3 Pipe penetration fire rating system to comply with approved type tested installation.
 - 4 Where required provide 100mm guard around fire rated penetrations to ensure no combustible material comes within 100mm of pipe penetration and pipe.
 - 5 Non fire rated wall penetrations to be sealed with mineral fibre insulation to maintain acoustic and pressure differential rating.
 - 6 Where packing material is mineral fibre material enclose in isolation.
 - 7 Where exposed to view provide galvanised sheet metal collar.
-

8.8 TESTING OF PIPEWORK

- 1 Pressure test all sections of pipework prior to lagging or painting using calibrated pressure gauges. Provide signed test reports for each pressure test.
- 2 Isolate any equipment that will not withstand test pressures prior to testing.
- 3 Provide detailed water treatment and pipework passivation proposal for approval prior to filling any part of the system. Water which is not chemically treated shall not enter any part of any system. Introduce corrosion inhibiting chemicals in water used for hydrostatic testing in strict accordance with the recommendations of a water treatment specialist. If chemically treated water is left in piping after testing the water must be circulated and monitored to assure protection is maintained.
- 4 Circulate test water to ensure continuity and effectiveness of corrosion inhibition providing temporary circulation facility if required.
- 5 Remake any leaking joint and retest.

9 WATER TREATMENT

9.1 GENERAL

9.1.1 SCOPE

- 1 This section sets out the engineering and quality assurance requirements for the completion of the installation design, materials, components, general installation and testing of the Mechanical Services water treatment systems.
-

9.2 DESIGN

9.2.1 GENERAL

- 1 Complete the detail design and engineering of the water treatment system and installation to the specified requirements.
-

9.3 SUBMISSIONS

Provide the following submissions:

- 1 System conditions report.
 - 2 System volume and dosing rate calculations.
 - 3 Commissioning and maintenance monthly site reports.
 - 4 Equipment selection submittals.
-

9.4 GENERAL REQUIREMENTS

- 1 Engage a specialist water treatment company to provide a water treatment programme, to comply with AS/NZS 3666 and local Authority requirements and control corrosion, scale and biological activity of the water circuits, both during construction and thereafter during the Maintenance and Defects Liability Period.
- 2 Prior to the commencement of the water treatment programme, the specialist water treatment company is to assess and submit a written report on the entire system conditions likely to affect the programme, including design issues such as selection of piping materials, dirt legs, flow rates under maximum and minimum operating conditions and construction issues such as jointing methods and separation of dissimilar metals, system dead legs and means to ensure circulation, valves and bypasses for maintenance, etc. Review piping specification and schematic drawings to ensure understanding of system configuration, materials and water velocities. Submit calculations used to determine system volumes and chemical dosing rates to achieve the required concentrations for review by the Consultant Engineer, prior to commencing treatment.
- 3 Indemnify the Proprietor for all liabilities and damages as a result of the use of Water Treatment processes, chemical / cleaning agents or methods of disposal which are not approved by relevant Authorities or which violate relevant legislation.

- 4 Guarantee the effectiveness of the entire water treatment programme commencing with the pre-cleaning of piping, hydrostatic pressure testing, further pre-cleaning and passivation of pipework and ongoing water treatment until Final Completion.
- 5 Select chemicals to suit the application and to meet the requirements of the appropriate authority responsible for discharge of effluent to waste.
- 6 Commission the water treatment plant, inspect and test systems as required but at least monthly until the completion of the maintenance period. Provide written site reports of all activities during commissioning and maintenance.
- 7 Acceptance program criteria will be:
 - a General Corrosion rate of metals not to exceed 0.08mm/year (approx. 3mpy) for carbon steel, 0.005mm/year (approx. 0.2mpy) for stainless steel with no pitting and 0.005mm/year (approx. 0.2mpy) for copper based on corrosion coupons tested in accordance with ASTM D 2688.
 - b Maximum pit corrosion rate of metals not to exceed 0.02mm/year (approx. 0.8mpy) for carbon steel, zero mm/year for stainless steel and 0.02mm/year (approx. 0.8mpy) for copper based on coupons tested for long term corrosion rates in accordance with ASTM D 2688.
 - c System to be clean and free of corrosion products, deposits, sludge and other foulants.
 - d Total plate count to not exceed 100,000cfu/ml as measured by an independent certified laboratory when measured in accordance with AS/NZS 3666.3 requirements.
 - e Legionella count not to exceed 10cfu/ml as measured by an independent certified laboratory when measured in accordance with AS/NZS 3666.3 requirements.
- 8 Following each visit to site, submit a comprehensive report stating the condition of each water system, giving details of chemicals added, commenting on the results of the water analysis and commenting on general operation and maintenance of systems particularly relating to the minimisation of corrosion and prevention of Legionnaires Disease. Water treatment reports to include but not be limited to water analysis covering make up water and system water to be tested comparing targeted values with recorded values.
- 9 Minimum test requirements:

OPEN CIRCUITS	CLOSED CIRCUITS
Conductivity/Total Dissolved Solids	Conductivity/Total Dissolved Solids
Chlorides	PH
Hardness Calcium and Total	Iron
PH	Copper if present in the circuit
Iron	
Copper if present in the circuit	Inhibitor Level
Cycles of Concentration	
M Alkalinity	
Total Plate Count (cfu/ml)	
Legionella Count (cfu/ml)	

- 10 Note: The water treatment specialist is to set out target values for each of the above parameters together with actual measured values with an explanation or comment on any variance.

- 11 Supply and install corrosion coupons on the open condenser water circuits and monitor and report on corrosion rates both general and pitting.
 - 12 Provide test kits for analysis of water systems together with log sheets, product bulletins, MSDS sheets and dosing instructions for all work to be carried out on site. In summary provide an operating manual for the systems treated.
 - 13 Instruct plant personnel in the correct procedure for chemical handling dosing and testing of the various systems and record routine test results in a log book, which will form part of the operating manual.
 - 14 At the conclusion of the Maintenance and Defects Liability period submit a comprehensive report which summarises all of the previous reports and gives a detailed overview of the condition of all systems with recommendations for future treatment.
-

9.5 PRESSURE TESTING OF SYSTEMS

- 1 Systems are to be filled in the presence of the specialist water treatment company to assure provision of required water treatment guarantees.
 - 2 At no time is the system to be filled without the addition of a corrosion inhibitor and passive chemicals.
 - 3 Install temporary circulation and dosing pumps together with interconnections as required to assure circulation of treated water and protection of the entire installation. Treated water shall not be left in the systems for extended periods of time without means of circulation.
-

9.6 PRECOMMISSION CLEANING AND PASSIVATION OF ALL WATER SYSTEMS

- 1 Thoroughly clean and flush out all water systems with non-foaming precleaner to remove swarf, superficial dirt, oil and corrosion products. This precleaner needs to be disposed of correctly. Leave the pipe internals clean and passive.
 - 2 Ensure biological treatment is maintained at all times.
 - 3 Remove and clean strainers where necessary following pre-cleaning.
 - 4 Install temporary pumps as necessary to assist in flushing when normal circulating velocities may be insufficient to remove undissolved solids.
 - 5 Review effectiveness of pre-cleaning and if necessary redo until the pipework including butt welds are free of oil and grease, corrosion products, swarf and deposits.
 - 6 Immediately following cleaning, add high dosage of suitable corrosion inhibitors and circulate for some days until residuals show the system has stabilised and that internal surfaces have become passivated.
 - 7 Following passivating commission the water treatment programme and monitor weekly until stability is reached.
 - 8 At no time is the system to be filled or operated without the addition of a suitable applicable corrosion inhibitor and biocide.
-

9.7 CLOSED WATER SYSTEMS

- 1 After completing the pre-clean, protect each water system with a corrosion inhibitor introduced into the system via a dosing by-pass pot connected across the supply and return water pipes. After dosing and recirculating check final inhibitor concentration is correct to ensure continued pipe line protection. Adjust if necessary.

9.8 CONDENSER WATER SYSTEMS

- 1 After completing the pre-treatment involving pre-cleaning and passivation, protect the system by implementing an automated Water Treatment program, to include:
 - a A Water Treatment control centre.
 - b At least two types of biocides. One an oxidising agent to be either slug dosed on a timer basis or metered using Oxygen Reducing Potential (ORP) control and introduced to an area of turbulence (typically the tower basin). The second biocide a Legionella effective non-oxidising biocide also dosed to an area of turbulence, on a timer basis.
 - c The auto dosing system shall have the provision to shut off the tower bleed during and for a variable time after biocide additions to maximise biocide retention in the water system.
 - d Bio dispersants and dispersants are to be included as part of the operating program, and shall be batch dosed, or dosed continually via the Water Treatment control centre.
- 2 The automatic dosing equipment (Control Centre) shall include appropriately sized chemical storage tanks with lids and chemical injection pumps with adjustable output to provide proportional addition of chemicals. Chemical storage capacity shall be at least 1.5 times service frequency time.
- 3 The condenser water bleed rate shall be controlled from an automatic conductivity or total dissolved solids meter, with manual bleed, all part of the Control Centre. The system bleed shall be discharged to sewer.
- 4 The location of the bleed and meter is to be carefully considered with respect to the entire system configuration and is to be at a point where the 'worst case' conditions are likely to occur.
- 5 The Water Treatment Control Centre shall be electrically interlocked with the system recirculation pumps such that chemicals are only dosed when the condenser water system is operative. A Water Meter on the tower make up line may be used in conjunction with the Control Centre to initiate dosage of corrosion inhibitors or dispersants.
- 6 The Control Centre shall provide all interfacing requirements for electrical and water connections.
- 7 Unless otherwise specified or instructed, supply a side stream filtration system.
- 8 Provide six or better cycles of concentration. Include water softening and other plant as necessary to achieve this without excessive scaling and corrosion.

9.9 SIDE STREAM FILTRATION SYSTEM

- 1 Provide side stream filtration system(s) complete with automatic self-cleaning screen filters, eductors, ABS piping, pumps, automatic backwash facility and strainer and all necessary valves, fittings, controls, drains and vents to provide continuous filtration and agitation of the cooling tower basins. Backwashing shall be carried out using system pressure to automatically back-flush the screen effectively with low water use over a maximum of 10 seconds.
- 2 Provide manufacturer's written acceptance of the installation following completion.
- 3 Utilise the BAS to operate all main condenser water circulating pumps on a time schedule at full capacity and to open the control valves to achieve cleaning.
- 4 Backwash provisions shall be automatic based on pressure differential across the strainer. Provide visible backwash discharge to allow manual checks for leakage of the unit backwash system.
- 5 Amiad or Triangle make units to be considered for the project, subject to the systems proposed meeting all the specified requirements.
- 6 Type of screen mesh used to be confirmed at the time of selection of the unit, allow for range of 80 to 200 microns.

9.10 BOILER FEED WATER, BOILER WATER STEAM SYSTEMS AND BLOWDOWN SYSTEMS

- 1 Boiler feeds lines, boiler internals, and steam pipe work shall be protected by an automatic chemical dosing plant and automatic blowdown facility.
- 2 Boiler feed water quality shall be matched to steam pressure and boiler pre-treatment equipment such as softeners and demineralises, supplied as part of the boiler package, to ensure correct feed water quality.
- 3 The boiler chemical package shall include:
 - a Scale inhibitor introduced on the positive side of the boiler feed pump/s.
 - b Alkalinity Builder, pumped directly into the boiler feed tank to maintain pH level between 8.5 and 9.0.
 - c Oxygen scavenger, pumped into the feed water tank below the water level such that all lines forward of the feed tank are protected.
 - d Filming amine or neutralising amine introduced directly into the steam supply pipes or into the boiler feed tank or lines. The choice of amine program, chemicals used and location of injection point will depend on the steam application (e.g. if steam is likely to contact food or be used into autoclaves).
- 4 The boiler needs to be blown down regularly, either automatically or continually or both to ensure the boiler conductivity stays within set limits, which are directly proportional to boiler steam pressure and boiler feed water quality.
- 5 The boiler feed water temperature shall be maintained at 90°C by steam injection or by collecting waste heat from the blowdown or both.
- 6 Automatic chemical injection plant shall include suitable sized mix tanks and lids for chemical storage. Incorporate manual stirrers on all mix and dilution tanks.
- 7 Pumps for injections of chemicals into the boiler drum and feed water tanks shall be of the duplex type.
- 8 All pumps shall be suitable for the application and have adjustable output to provide proportional addition of chemicals.
- 9 Electrically interlock the pumps with boiler feed water pumps to ensure that chemicals are only dosed when the boiler is operative.

10 DUCTWORK, SHEET METAL ITEMS, AIR OUTLETS

10.1 GENERAL

10.1.1 SCOPE

- 1 This section sets out the engineering and quality assurance requirements for the completion of the installation design, materials, components, general installation and testing of the Mechanical Services ductwork, sheet metal items, air outlets, grilles and fittings.
-

10.2 DESIGN

10.2.1 GENERAL

- 1 Complete the detail design and engineering of the ductwork installation to the specified requirements.
-

10.3 SUBMISSIONS

- 1 Duct system pressure drop calculation.
 - 2 Fire resistant sprayed coatings
 - 3 Air dampers.
 - 4 Air outlets and grilles.
-

10.4 GENERAL REQUIREMENTS

- 1 Supply and install ductwork systems complete with transitions, bends, tees, supports, dampers, offsets, flexible connections, take offs, air outlets, grilles and fittings necessary for the satisfactory operation of the air handling system.
 - 2 Drawings show routes and sizes of ducts but do not detail all offsets and bends required for co-ordination between trades and for integration with building structure and finishes.
 - 3 Sizes are clear internal dimensions of the air passage and, in the case of rectangular ductwork, the first dimension quoted is the dimension of the side in view on the particular plan or elevation.
 - 4 Install seismic bracing to all ductwork as required by AS 1170.
-

10.5 INFORMATION REQUIRED

- 1 Provide the following:
 - a Shop drawings.

- b** Evidence of Local Authority approval for method of fire rating ductwork.
 - c** Test certificates for fire dampers.
 - d** Evidence of Local Authority approval for fire stop collars for UPVC ductwork
 - e** Certification of early fire hazard properties for acoustic lining.
 - f** Records of NATA approved laboratory tests for air outlets and grilles.
-

10.6 DUCTWORK MATERIALS

10.6.1 SHEET METAL

- 1** Zinc coated steel:
 - a** To AS 1397 galvanised steel sheet to coating.
 - b** Class G2/Z275.
 - 2** Stainless steel:
 - a** To ASTM A240/A240M Type 304 or as specified.
 - 3** Fasteners:
 - a** Rivets: aluminium expanding solid end type.
 - b** Self-tapping screws: bright zinc plated for galvanised duct, stainless steel for stainless steel duct.
 - c** Bolts, nuts and washers: Zinc plated steel, service condition No. 2 for galvanised duct, stainless steel for stainless steel duct.
-

10.6.2 UPVC

- 1** Material:
 - a** Sheet:
 - i** External use – pressed grey UPVC sheet with UV inhibitors; painted with two coats Taubmans Sunproof Acrylic Gloss or accepted alternative when exposed to UV radiation.
 - ii** Internal use - extruded grey UPVC sheet.
 - b** Pipe:
 - i** Stormwater pipe to AS/NZS 1254, minimum wall thickness 6mm, UV stabilised and painted with two coats of Taubmans Sunproof Acrylic Gloss or accepted alternative when exposed to UV radiation.
-

10.6.3 FLEXIBLE CIRCULAR DUCTING

- 1** Performance in accordance with NCC and AS 4254.
- 2** Submit test results for compliance with AS/NZS 1530.3 and UL181.
- 3** Mechanically locked seams.
- 4** Where insulated comply with AS 4508 and provide a minimum R-value as noted in Schedules.

10.6.4 FLEXIBLE CONNECTIONS

- 1 Neoprene coated glass fabric with density not less than 1 kg/m² for temperatures up to 90°C.
- 2 Non-combustible coated woven glass fabric in compliance with AS/NZS 1668.1:1998 for temperatures above 90°C and smoke spill applications.
- 3 Where exposed to weather, protect by galvanised steel covers.

10.6.5 FIRE RATED DUCTWORK

- 1 Fire resistant sprayed coating to achieve the required FRL when tested to AS 1530.4.
- 2 Fire resistant sprayed coating shall be installed by a professional specialist installer who is licensed to install passive fire protection system by the BSA and who has current professional indemnity insurance.
- 3 Alternatively, provide duct wraps or other duct enclosure system assembled from proprietary products to achieve the required FRL.
- 4 Provide easily removable FRL rated panels where access is required for access (fire dampers, dampers, motors, etc.). Panels to be sufficiently sized for the equipment to be accessed.
- 5 The professional specialist installer shall provide all materials, accessories, spray equipment, tools, inspection services and labour to satisfactorily carry out the works in best trade practice. All workmanship and installation techniques shall comply with manufacturer's instructions, relevant Building Code Statutory requirements and applicable ASTM, BS or AS.
- 6 Fire rated ductwork and plenums shall be certified to the required FRL when tested to AS1530.4 before the date for practical completion. Certification to be provided in Operation and Maintenance Manuals.
- 7 Provide fire rating to Local Authority and NCC requirements.

10.7 DUCT CONSTRUCTION

10.7.1 RECTANGULAR SHEET METAL DUCTWORK

- 1 Fabrication:
 - a Machine bent, free from waves and buckles.
 - b Galvanising unbroken after fabrication.
 - c Adequately stiffened to avoid drumming.
 - d Free of sharp burrs, edges and protrusions into air stream.
 - e Where exposed to view in occupied spaces use sheet metal two gauges heavier than required for pressure rating with no cross breaking, no beading, no exposed fasteners, free from damage, dents, blemishes and suitable for high quality finish painting.
- 2 Bends:
 - a All bends and elbows with maximum air velocities exceeding 4 m/s shall be fitted with turning vanes.
 - b All square bends shall have single skin turning vanes.

c All radius bends shall have turning vanes based on their throat radius-to width (R/W) ratio:

- | | | | |
|-----|-----|-------------|---------|
| i | R/W | >0.5 to 1.0 | 1 vane |
| ii | R/W | 0.3 to 0.5 | 2 vanes |
| iii | R/W | <0.3 | 3 vanes |

3 Joints:

- a In accordance with SMACNA, AS 4254.
- b Use a proprietary system such as Duct Mate, TDF, METU.
- c Seal as per AS 4254, except that ALL transverse joints shall be sealed for all duct work, not just for Pressure Class 500 and above.
- d Allow to air leak test three ductwork systems before any required external insulation is applied, and before any riser shafts are sealed. Failure of a system will require both retesting of the system when repaired, as well as testing of a further ductwork system. Testing to be carried out with equipment calibrated in the last 12 months, and in compliance with SMACNA HVAC Air Duct Leakage Test Manual and ASHRAE Handbook – HVAC Systems and Equipment. In addition, all systems with a pressure classification of 1000Pa or above shall be air leakage tested.

10.7.2 CIRCULAR AND OVAL SHEET METAL DUCTWORK

1 Fabrication:

- a Galvanising unbroken after fabrication.
- b Manufactured from full size sheets roll formed on heavy ribbed spiral wound such as Spiroduct, Spiroloc and Duraduct.
- c Free of sharp burrs, edges and protrusions into air stream.
- d Where exposed to view in occupied spaces, use 1mm thick duct with spigot joints and backing ring, no exposed fastenings, free from damage, dents, blemishes and suitable for high quality finish painting.
- e Bends: lobster back with at least 5 segments, with centreline radius minimum 1.5 times duct diameter. Alternatively use proprietary smooth swept bends of minimum wall thickness specified above.

10.7.3 UPVC DUCTWORK

1 Fabrication:

- a Ductwork thickness, stiffening and other details as follows:

LONGEST SIDE MM	MATERIAL THICKNESS MM	FRAME MM	REINFORCING MM		
600	4.5	Butt Joint	Nil		
800	6.0	60x60x6 Angle	60x10	Rib	1200 ctr
800	6.0	60x60x10 Angle	60x10	Rib	800 ctr

- b Joints: continuously welded including seams, stiffeners, flanges and corners of fabricated bends, tees and fittings; stiffeners to be welded both sides; butt welds 60° chamfered; less than or equal to 4mm thickness one run of 3mm welding rod; over 4mm thickness triple run of 3mm welding rod.

- c Cross joints flanged: weld flanges to ductwork and connect with 6mm diameter bolts at 25mm centres.
- d Cross joints, socket type: weld UPVC backing ring to one duct, tack weld overlapping surfaces and finish with fully welded joint.
- e Bends: lobster back with at least 5 segments, butt welded, with centreline radius minimum 1.5 times duct diameter. Alternatively use proprietary smooth swept bends of minimum wall thickness specified above.
- f Note that solvent “welded” joints are not acceptable as they do not comply with AS 4254.

10.7.4 KITCHEN EXHAUST DUCTWORK

- 1 Fabrication and installation to AS 4254 and AS/NZS 1668.1 and AS 1668.2.
- 2 In addition to liquid tight cleanout to AS4254, provide liquid tight cleanouts at bottom of kitchen exhaust riser and at sprinkler locations.
- 3 Provide a grease gutter and DN 25 drain socket and plug at the bottom of vertical risers.

10.7.5 STAINLESS STEEL DUCTWORK

- 1 For use, in particular applications where ductwork is exposed to moisture or corrosion.
- 2 Fabrications and installation to AS 4254 and clause Rectangular Sheet Metal Ductwork.

10.8 DUCTWORK INSTALLATION

10.8.1 REQUIREMENTS

- 1 In accordance with AS 4254 and AS/NZS 1668.1:
 - a Neat tidy appearance with duct runs adjacent and parallel to each other and building elements.
 - b Designed and arranged with all necessary anchoring and flexible connections to prevent damage to ducts and building structure due to expansion and/or contraction or building shrinkage and to prevent transmission of noise and vibration from equipment.
- 2 Spacing (in each case the minimum permitted):
 - a 25mm between ducts (and external insulation).
 - b 25mm between duct flanges or upper surfaces of ducts and soffit of building structure.
 - c 50mm between ducts and electric cables.
 - d 150mm between ducts and ground below suspended slabs.
- 3 Hangers and supports:
 - a To AS 4254.
 - b Locking washers for nuts to all hangers and supports for suspended equipment.
 - c UPVC ductwork to be supported at maximum 2400mm centres.
- 4 Ducts exposed to weather to be constructed with graded top surface or provided with a separate cover to prevent pooling of water.

- 5 Kitchen exhaust ducts to have 1:200 minimum rise in direction of air flow and to be 300mm clear of both any combustible material and all other services. If this clearance is not possible, insulate the kitchen exhaust duct in compliance with AS/NZS 1668.1.
 - 6 Prior to and during installation, progressively clean interior of ducts to remove dust and building debris and maintain cover over open ends.
 - 7 Install approved bracing to ductwork for seismic restraint, where required by AS 1170.4.
-

10.8.2 FLEXIBLE DUCTWORK

- 1 In accordance with AS 4254.
 - 2 Maximum length 5m.
 - 3 Minimise unnecessary bends; bend radii to be not less than the requirements of AS 4254; minimum 3 – diameters of straight duct attached to each supply diffuser/grille.
 - 4 Fittings galvanised sheet metal.
 - 5 Connect to ducting, cushion head boxes or other devices using a galvanised sheet metal spigot which incorporates a convex swage at least 3mm high. Air seal, inner duct onto spigot over swage with duct tape, then secure with a non-metallic mechanical fastener.
 - 6 Where the duct is insulated, band the external insulation behind the swage then tape the whole joint at least 75mm each side of the clamping band.
 - 7 Screws or rivets shall not be used.
-

10.9 DAMPERS

10.9.1 GENERAL REQUIREMENTS

- 1 This clause applies to dampers in rigid ductwork and at air handling and fan coil units
 - 2 Free of rattles, fluttering and slack movement.
 - 3 Locate where required for correct and proper air balancing and commissioning and as shown on drawings accompanying this specification.
 - 4 Suitable for operating pressures of ductwork.
 - 5 Capable of adjustment over normal operating range without excessive self-generated noise.
 - 6 Volume control dampers in ducts up to 250mm deep may be single blade butterfly type. Dampers in ducts over 250mm deep shall be opposed blade dampers.
 - 7 Dampers in UPVC and stainless ducts shall be manufactured from material matching the properties of the duct.
 - 8 Locate dampers and actuators in readily accessible positions.
-

10.9.2 SPLITTER DAMPERS

- 1 Zinc coated steel construction comprising single blade and adjusting rod.
- 2 Blade thickness 0.8mm minimum and double folded.

- 3 Adjusting rod galvanised steel with external screw locking mechanism. Provide rod(s) at maximum 600mm spacing.
-

10.9.3 OPPOSED BLADE DAMPERS (MANUAL)

1 Galvanised or stainless sheet steel construction:

- a Blades: Minimum 1.15mm thick with 12mm wide edge breaks; max. blade length 1200mm; maximum blade width 225mm.
- b Spindles: Minimum 12mm diameter, cadmium plated steel.
- c Bearings: Replaceable oil impregnated sintered bronze or ball bearings.
- d Frames: Minimum 1.6mm thick folded sheet to form channels approximately 150mm wide; corners of frames spot welded, cleaned (and coated with one coat of cold galvanising paint (for galvanised damper frames).
- e Linkages: Zinc coated or stainless steel fixed securely to blades so that blades rotate equally and without slip.
- f Control: Dampers controlled by use of quadrants, control lever and locking device.

2 Aluminium construction:

- a Blades: Extruded aluminium with edge breaks; maximum blade length 1200mm; max. blade width 175mm; or air foil type similar to Holyoake HBD, Bullock 6700 and Bradflo AVCD types.
 - b Spindles: Minimum 12mm diameter. zinc plated steel or cast alloy.
 - c Bearings: Replaceable oil impregnated sintered bronze, ball bearings, Teflon or Acetyl.
 - d Frames: Extruded aluminium, with corners either welded or robustly screwed.
 - e Linkages: Aluminium or cast alloy fixed securely so that blades rotate equally without slip.
 - f Control: Dampers controlled by use of quadrants, control lever and locking device.
-

10.9.4 MOTORISED DAMPERS

1 General requirements:

- a Comply with requirements for opposed blade dampers except as noted below.
 - b Aluminium dampers similar to Holyoake HCD-150, Bradflo AVCDP or Unique UVAD types, and suitable for minimum 20,000 operations maintenance free.
 - c Side seals and blade tip seals of aluminium, vinyl, neoprene or silicon rubber to be mechanically fastened in position. Where damper may be exposed to smoke spill air, seals are to be minimum 225 °C rated. Air leakage to be less than 25, 40 and 50 L/s m² when closed against static pressures of 250, 500 and 1000 Pa respectively.
 - d Drive shafts square, keyed or hexagonal and run full length of the blade and extended for motor connection.
 - e For motorised dampers, exceeding 1m² face area fit ball bearings throughout.
 - f Dampers required to control areas greater than 1.2m² to be divided into multiple sections each of 1.2m² maximum face area with an individual drive motor for each section.
 - g Free from distortion or flexing of frame during operation.
-

10.9.5 NON-RETURN DAMPERS

1 General Requirements:

- a Aluminium construction with blades 0.7mm minimum thickness and frames 2.5mm extruded aluminium with corners either welded or robustly screwed.
 - b Damper blades parallel action type.
 - c Spindles type 316 stainless steel with acetyl or nylon bushes.
 - d Arrange counterweight of calibrated adjustable type to allow opening to air flow with minimum resistance and closure by gravity, or adjustable spring tensioner.
 - e Free from fluttering.
-

10.9.6 FIRE AND SMOKE DAMPERS

1 General Requirements:

- a To NCC, AS1668.1, AS1530 series and AS1682.1 and 2.
- b Tested and approved by Local Authority.
- c Any fasteners used for connection of duct to fire damper to be of material having fusion temperature below 700°C.

2 Curtain and Blade Type Fire Dampers:

- a Free cross section area of at least 85% of face area.
- b Fusible link or frangible bulb approved by Local Authority.

3 Intumescent Type Fire Dampers:

- a Aerodynamic aluminium foil sheathed intumescent material slats mounted in a steel frame.
- b Comply with AS1668.1 closure time.
- c Air pressure drop equal to or less than 30 Pa at 6 m/s for sizes greater than 200 x 200 or 200 nominal dia.
- d Similar to Kilargo IFD series.

4 Motorised Fire and Smoke Dampers:

- a As per blade type fire dampers and motorised dampers except for the following to comply with AS/NZS 1668.1.
 - b Complete with motorised actuator to allow closure from a fire alarm signal, approved by the Local Authority.
 - c High temperature damper blade tip seals.
 - d Smoke dampers similar to Holyoake HFS, Bullock Prefco, Ruskin IB.
-

10.10 ACCESS PANELS AND DOORS

10.10.1 GENERAL REQUIREMENTS

- 1 Locate access panels where shown on drawings and where access is required for duct cleaning and maintenance and to permit resetting or inspection of dampers, duct heaters, filters and other items of equipment.
- 2 Access panels and doors to be rigidly constructed to avoid distortion and for suitability for operating pressure range.
- 3 Doors to open against air pressure and have clear opening of not less than 1.35m high by 600mm wide.
- 4 Construction of panels and doors to avoid cold bridging.

- 5 Door hardware to permit opening from both sides.
 - 6 Panel fastenings to be quick release patented type not screw fixings.
 - 7 Seals to suit duty; woven ceramic fibre for fire rated seals; neoprene or silicone rubber for normal duty.
-

10.11 PITOT TUBE OPENINGS

10.11.1 GENERAL REQUIREMENTS

- 1 Provide pitot opening in accordance with CIBSE Code A and BSRAI AG3/89.3 for accurate balancing and commissioning purposes and in all main ducts and branches.
 - 2 Pitot openings in low pressure ductwork to be 15mm diameter sealed with rubber grommet.
 - 3 Pitot openings in medium and high pressure ductwork to be proprietary fittings similar to Duro-Dyne Instrument Test Port type.
-

10.12 INTERNAL DUCTWORK INSULATION

10.12.1 GENERAL

- 1 Comply with AS 4254 and NCC Section J.
-

10.12.2 INSULATION MATERIAL

- 1 Thermally bonded polyester or resin bonded mineral wool or fibreglass to AS/NZS 4859.1 and maximum thermal conductivity 0.036 W/mK at 23°C.
 - 2 Internal insulation including facing to NFPA 90A UL181 Class 1 requirements and early fire hazard properties as follows: Ignitability 0; Spread of Flame, 0; Heat Evolved 0 and Smoke Developed 3.
-

10.12.3 ADHESIVES

- 1 Suitable for bonding facing to insulation and insulation to ductwork with early fire hazard indices as follows: Ignitability 0; Spread of Flame, 0; Heat Evolved 0 and Smoke Developed 0.
-

10.12.4 ALUMINIUM FOIL FACING

- 1 Perforated foil laminate such as Sisalation 450 having free area of 10%.
-

10.12.5 PERFORATED SHEET METAL FACING

- 1 0.55mm thick perforated zincanneal sheet having a free area of 11%.
- 2 Use in, areas subject to mechanical damage, trafficable/maintenance areas, smoke spill ducts and plenums to AS1668 and as otherwise specified.

10.12.6 MECHANICAL FIXING

- 1 Ductwork (Perforated Foil Faced Insulation).
 - a Fix with adhesive, weld pins and speed clips located not more than 75mm from the edges of ducts and spaced at not more than 300mm centres.
 - b Joints to have 50mm wide overlap of facing glued and then taped with aluminium foil top.
 - c Extend insulation by 5mm at ends of ducts to enable adjacent sections to butt together without a cold bridge.
-

10.12.7 CONDITIONER CASINGS AND PLENUMS

- 1 Fix with adhesive, weld pins and speed clips or mechanical type fixings such as Hilti IN or ID for masonry as appropriate located at not more than 300mm centres.
 - 2 Fit protective PVC caps to weld pins within 2100mm of floor level and adjacent to access openings, valves and similar equipment where access above the 2100mm height is required.
 - 3 Joints in facing to be overlapped and pop riveted.
 - 4 For masonry ducts, conditioner casings and plenums, fit galvanised end sections fixed with Dynabolts or Loxins at 450mm centres to support the full weight of the insulation and use adhesive fixed pins in lieu of welded type.
-

10.12.8 ACOUSTIC PERFORMANCE

- 1 As per the following table:

10.12.8.1 MINIMUM ABSORPTION COEFFICIENTS TABLE

INSULATION	ABSORPTION CO-EFFICIENTS (NOMINAL) TO AS 1045-1988 AT				
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz
Perforated foil faced					
-25mm thick	0.08	0.24	0.68	0.96	1.01
-50mm thick	0.26	0.66	1.09	1.09	1.05
Perforated metal faced: -50mm thick	0.20	0.73	1.00	0.99	0.89

10.13 SITE BUILT CONDITIONER CASINGS AND PLENUMS

10.13.1 GENERAL REQUIREMENTS

- 1 Includes all supply, return, relief and filter air plenum chambers and enclosures for and air passages between air inlets, heating and cooling coils and fans.
- 2 Not applicable to factory assembled units.
- 3 Install on concrete plinths.
- 4 Provide air tight seals at all openings.

- 5 It is mandatory to submit construction details to demonstrate that cold tracking or sweating will not occur.
 - 6 Eliminate rattling, excess deflection, or flexibility.
-

10.13.2 SHEET METAL CONSTRUCTION

- 1 Zinc coated steel sheet of 1.55mm minimum thickness machine folded to form 450mm dished panels with 50mm deep stand up edges and 15mm deep returns with corners welded and cold galvanised.
 - 2 50x50x5 thick galvanised steel bracing angles.
 - 3 All joints airtight and bolted at 150mm centres using galvanised nuts, bolts and washers and gaskets or silicone sealant.
 - 4 Fix casing to floor via 50x50x5 thick galvanised steel folded channel which is bolted to floor at 300mm centres with expanding masonry type anchors. Fix panels to channels at 150mm centres with bolts and nuts.
 - 5 Alternatively construct casings from Tri-Lock not less than 1.15mm thick.
-

10.13.3 SANDWICH PANEL CONSTRUCTION

- 1 Construct casings with prefabricated cool room panels with metal skin both sides comprising polystyrene sheet to AS 1366.3 Class M of suitable thickness to suit range of operating pressures, minimum thickness 50mm with metal skin 0.55mm thick zinc coated steel sheet, colour bonded.
 - 2 Joints - aluminium extrusions inside and out and silicone bead seal.
 - 3 Penetrations - seal with galvanised aluminium sleeve and polyurethane sealant.
-

10.13.4 ACCESS DOORS

- 1 To allow full and easy access to all internal areas.
 - 2 Fit hinged doors with heavy duty chrome-plated die-cast alloy hinges and lever-type door catches.
 - 3 Use hinged door sealing gaskets of the replaceable closed cell foamed neoprene balloon type and fix them to the doors by riveted aluminium strips or approved adhesive.
 - 4 Construct and install all doors and door hardware so that a person from inside can readily open any door.
-

10.13.5 CONDITIONER LIGHTING

- 1 Weatherproof 18W fluorescent type such as Pierlite - Vandalite or Thorn Lighting - Casalux in each compartment.
-

10.13.6 ANCILLARY ITEMS

- 1 Supply and install access ladders, platforms, handrails, gratings and similar items necessary for safe, easy access to items such as valves, modulating motors, expansion tanks and the like.
- 2 Comply with AS 1657 and Local Authority (including Workplace Health and Safety) requirements.
- 3 Hot dip galvanise all steelwork subject to exposure or moisture.

10.14 AIR OUTLETS AND GRILLES

10.14.1 GENERAL REQUIREMENTS

- 1 Proprietary fittings of steel or aluminium fabrication. All cool air supply grilles, and others where condensation or water contact could occur, shall be of aluminium construction.
- 2 Free of distortion, bends, dents, blemishes rattling and irregular or open joints.
- 3 Powder coat finish to Architect's colour choice.
- 4 Mount with secure, concealed fixings.
- 5 Where possible, control air flows using a butterfly damper for each grille/diffuser/register in the flexible duct spigot on the branch duct, complete with a lockable adjustment arm which also indicates the blade position. If branch duct spigot is not accessible, provide an opposed blade damper behind the grille.
- 6 For each duct, mounted supply grille/register, provide a ganged multi-blade stream splitter damper.
- 7 For each duct, mounted return and exhaust grille, provide a ganged multi-blade opposed blade damper.
- 8 All dampers behind grilles/diffusers/registers to be lockable and adjustable through the face of the grille/diffuser/register.
- 9 Select for duty and specified noise levels.
- 10 Tested by NATA approved laboratory.
- 11 Suitable for VAV operation as applicable.
- 12 Slot diffusers, linear outlets and light air fittings to incorporate continuous adjustment for air pattern from horizontal to vertical.
- 13 Paint matt black all internal surfaces visible through outlets.
- 14 Install outlets with trim gaskets to accommodate movement.
- 15 Diffusers may also be used as return and exhaust air grilles when indicated on the drawings.

10.14.2 CUSHION HEAD BOXES AND PLENUMS

- 1 Where a grille/diffuser/register is connected to a flexible duct, provide a matching side entry cushion head or plenum box. Supply air boxes and plenums shall incorporate perforated baffles when the grille manufacturer requires them to ensure that the required air distribution pattern is achieved.
- 2 Boxes and plenums may be manufactured in accordance with the requirements for metal ductwork, or from pre-faced rigid phenolic insulation sheet. Metal boxes/plenums shall be internally insulated on supply and return air systems in accordance with the requirements for Internal Duct Insulation. Thermal insulation or phenolic board thickness shall be as required to achieve the R-Value of the connecting ductwork.
- 3 Ensure an air-tight seal is achieved between the box/plenum and the grille/diffuser/register.

10.14.3 LOUVRE FACE DIFFUSERS

- 1 Lay in type for exposed grid ceilings; flanged type for surface mounting in ceilings without grids.

- 2 Square or rectangular multi louvre blade type. Unless specifically noted on drawings, diffusers have 4-way blow faces.
 - 3 Provide blanking plates in the neck to achieve 1, 2 or 3-way blow.
 - 4 Provide a reducer neck if the outlet neck is smaller than the required diffuser face neck.
-

10.14.4 SWIRL DIFFUSERS

- 1 Lay in type for exposed grid ceilings; flanged type for surface mounting in ceilings without grids.
 - 2 Provide a reducer neck if the outlet neck is smaller than the required diffuser face neck.
-

10.14.5 SIDE WALL REGISTER

- 1 Double deflection type with front blades horizontal, rear blades vertical.
 - 2 Blades set at approximately 20mm centres and field adjustable in the range $\pm 45^\circ$.
 - 3 For blades over 600mm long provide notched mid-point support bar.
-

10.14.6 LINEAR SLOT DIFFUSERS

- 1 Extruded aluminium section construction comprising the number of slots shown on the drawings.
 - 2 Slots shall be continuous except where long lengths require jointing. Provide all required end caps, bends, etc. to provide complete architecturally acceptable diffusers.
 - 3 Provide support and alignment devices as recommended by manufacturer.
 - 4 All joints shall be flush and smooth.
 - 5 Volume controllable from the face or from damper at branch duct connection to main duct.
 - 6 Air deflection pattern adjustable from the face (up to 90° each way from vertical for each slot).
-

10.14.7 CIRCULAR DIFFUSERS

- 1 Multi core type allowing variation of discharge pattern from horizontal to vertical.
-

10.14.8 LINEAR BAR GRILLES

- 1 May be used for supply, return and exhaust as required.
- 2 Extruded aluminium section construction to sizes shown on the drawings.
- 3 Grilles shall be continuous except where long lengths require jointing. Provide all required end caps, bends, etc. to provide complete architecturally acceptable grilles.
- 4 Provide support and alignment devices as recommended by manufacturer.
- 5 All joints shall be flush and smooth.
- 6 Except where otherwise detailed, bars shall be approximately 3mm thick on 12mm centres, set at 0° deflection.
- 7 Where detailed, provide rear individually adjustable blades behind the front bars to allow supply air direction control.

10.14.9 RETURN/EXHAUST - HALF CHEVRON BLADE TYPE

- 1 Ceiling or wall mounted, lay in or flange type.
 - 2 Extruded aluminium blades set at approximately 25mm centres at an angle of 30° to 45°.
-

10.14.10 RETURN/EXHAUST/SUPPLY - EGG CRATE TYPE

- 1 Extruded aluminium frame, removable core.
 - 2 Aluminium egg crate 15mm or 25mm as noted on the drawings.
-

10.14.11 DOOR GRILLES

- 1 Anodised aluminium extrusion construction with full chevron blade inverted, sight proof, 50% free area.
- 2 Flanged surrounds with no fixings evident either side of the door.
- 3 Adjustable frame for mounting into doors of varying thickness.

11 THERMAL INSULATION

11.1 GENERAL

11.1.1 SCOPE

- 1 This section sets out the engineering and quality assurance requirements for the completion of the installation design, materials, components, general installation and testing of the Mechanical Services thermal insulation.
-

11.2 DESIGN

11.2.1 GENERAL

- 1 Complete the detail design and engineering of the thermal insulation installation to the specified requirements and in accordance with the NCC Section J requirements applicable to the project.
-

11.3 SUBMISSIONS

- 1 Product Fire rating test sheets.
-

11.4 GENERAL REQUIREMENTS

- 1 Installation by skilled tradesmen experienced and competent in this type of work.
 - 2 Use only insulation materials clearly marked or identified as to grade, materials that are dry and free from objectionable smells and materials which are suitable for the full range of operating conditions.
 - 3 Clean all surfaces thoroughly of rust, grease, oil and dirt prior to application of insulation.
 - 4 Complete all pressure and leak testing prior to application of insulation.
 - 5 Make insulation continuous with joints firmly butted together, cold tracking eliminated and vapour barrier for cold pipes sealed.
 - 6 Allow for thermal movement.
 - 7 Insulate equipment connections, flexible connections, valves and similar to the same level as the connecting piping.
-

11.5 EARLY FIRE HAZARD PROPERTIES

- 1 Use only insulation materials and systems tested in accordance with AS/NZS 1530.3 and complying with the NCC and relevant Statutory Authorities.
- 2 Thermal insulation systems including adhesives, vapour barriers, facings and coatings early fire hazard properties: Ignitability 0; Spread of Flame, 0; Heat Evolved 0 and Smoke Developed ≤ 3 .

11.6 THERMAL STORAGE TANK INSULATION

- 1 Refer to Mechanical Plant and Equipment Section.
-

11.7 REFRIGERANT PIPEWORK INSULATION

- 1 Flexible, closed cell, elastomeric, nitrile rubber of Armacell FR/Armaflex or flexible, closed cell, polyethylene foam Thermotec 4-Zero, or equal accepted 4-zero type.
 - 2 Thermal conductivity not greater than 0.042 W/mK at mean temperature of 23°C.
 - 3 Cover entire surface of pipework with insulation, do not slit.
 - 4 Fix with contact adhesive. Open joints will be rejected.
 - 5 Butt joint tightly together and glue all joints.
 - 6 Paint exposed insulation with 2 coats of water based paint supplied by the insulation manufacturer and suitable for the purpose.
 - 7 Install and tape joints to manufacturers recommendations.
 - 8 Material R-Values not less than Section J of the NCC>
-

11.8 CONDENSATE PIPEWORK INSULATION

- 1 Minimum 25mm thick flexible, closed cell, elastomeric, nitrile rubber of Armacell FR/Armaflex or flexible, closed cell, polyethylene foam Thermotec 4-Zero, or equal accepted 4-zero type.
 - 2 Thermal conductivity not greater than 0.042 W/mK at mean temperature of 23°C.
 - 3 Cover entire surface of pipework with insulation, do not slit.
 - 4 Fix with contact adhesive. Open joints will be rejected.
 - 5 Butt joint tightly together and glue all joints.
 - 6 Paint exposed insulation with 2 coats of water based paint supplied by the insulation manufacturer and suitable for the purpose.
 - 7 Install and tape joints to manufacturers recommendations.
-

11.9 MEDIUM TEMPERATURE PIPING INSULATION

11.9.1 GENERAL REQUIREMENTS

- 1 Operating conditions above ambient and not exceeding 300°C.
- 2 Sectional moulded resin bonded mineral wool or glass wool.
- 3 Thermal conductivity not greater than 0.043 W/mK at a mean temperature of 100°C.
- 4 Reinforced aluminium foil facing factory applied such as Sisalation 450 or equal.
- 5 Steam Pipework and Steam Condensate Pipework:

- 6 Material R-Values not less than Section J of NCC.

11.9.2 INSTALLATION

- 1 Fix insulation to piping with aluminium fixing bands at each butt joint and in mid position on each section (approx. 450 centres).
- 2 Overlap all joints of aluminium foil facing by 25mm and seal with non-flammable adhesive.

11.10 METAL CLADDING

- 1 Sheath piping with metal cladding when exposed to view (including exposed ceiling locations), weather, liable to damage by oil or water, where noted on drawings and in such areas as plant rooms, service tunnels, service shafts, store rooms and areas susceptible to physical damage.

11.10.1 REQUIREMENTS

- 1 Powder coated/colour bond zincanneal or galvanised steel sheet or bright aluminium.
- 2 Minimum thickness of metal cladding shall meet the following:

TYPE OF AREA	ZINCANNEAL OR GALVANISED STEEL (mm)	ALUMINIUM (mm)
Pipework of less than 150mm outside diameter over insulation	0.5	0.5
Pipework 150mm to 450mm outside diameter over insulation	0.6	0.7
Pipework / Vessels / Evaporators over 450mm outside diameter over insulation	0.9	1.0

- 3 Cut and roll sheeting to the required sizes with beaded transfer joints and 40mm overlapping circumferential joints.
- 4 Longitudinal joints faced away from view.
- 5 Fixed with galvanised steel or aluminium straps for chilled water pipe work or refrigerant pipework and either straps or self-tapping screws for medium temperature piping. Do not violate vapour barrier. Protect the vapour barrier with reinforced cloth tape to prevent screws and revits penetrating it.
- 6 Cut sheet to form lobster back segments for curved surfaces. Seal all holes.
- 7 Seal joints with sealing compound for piping exposed to weather or moisture.
- 8 Seal up all penetrations for gauges, instruments drain and vents.
- 9 Readily removable at evaporator heads, strainers, and similar areas where removal for maintenance is anticipated.

11.11 EXTERNAL DUCTWORK INSULATION

11.11.1 MINERAL WOOL OR FIBREGLASS

- 1 Resin bonded batt, board or blanket to AS/NZS 4859.1.
- 2 Thermal conductivity 0.036 W/mK at 23°C maximum.

- 3 Factory faced with reinforced aluminium foil of 0.007mm thickness (Sisalation 450 or equal.)
 - 4 Cover entire surface of ductwork with insulation including all flanges, stiffeners and support angles.
 - 5 Butt joints tightly together and overlap foil facing by at least 50mm and firmly adhere with fire resistant non-flammable adhesive.
 - 6 Tape all joints with 75mm aluminium foil tape.
 - 7 Fix bottom and sides of insulation with pin fixings at 450mm centres.
 - 8 Fix aluminium or polypropylene fixing bands at each joint in the insulation and between each joint at approximately 600mm centres when ductwork dimensions exceed maximum. Do not damage aluminium foil facing when placing fixing bands.
 - 9 Provide an overlap of at least 300 mm where insulation changes from the inside of the duct to the outside.
-

11.11.2 POLYETHYLENE DUCTWORK INSULATION

- 1 Flexible, laminated closed cell polyethylene foam of Thermobreak or equal.
- 2 Thermal conductivity not greater than 0.032 W/mK at mean temperature of 23°C.
- 3 Factory faced reinforced aluminium foil such as Sisalation 450 or equal.
- 4 Cover entire surface of ductwork with insulation including all flanges, stiffeners and support angles.
- 5 Fix with contact adhesive.
- 6 Butt joint tightly together and overlap foil facing by at least 50mm and firmly adhere with fire resistant non-flammable adhesive.
- 7 Tape all joints with 75mm wide aluminium foil tape.
- 8 Fix aluminium or polypropylene bands at each joint and between each joint at approximately 600mm centres when ductwork dimensions exceed 600mm.
- 9 Provide an overlap of at least 300 mm where insulation changes from the inside of the duct to the outside.

12 ELECTRICAL SERVICES FOR MECHANICAL PLANT

12.1 GENERAL

12.1.1 SCOPE

- 1 This section sets out the engineering and quality assurance requirements for the completion of the installation design, supply of materials, and components, general installation and testing of the electrical services for mechanical plant.
-

12.2 SUBMISSIONS

- 1 Provisional loads.
- 2 Variable speed drive technical data sheets.
- 3 Type test certificates for components, functional units and assemblies.
- 4 Shop drawings of switchboards and control panels showing as a minimum:
 - a Detailed dimensions.
 - b General arrangement, plan view, front elevations and cross-section of each compartment.
 - c Fault level and rated short circuit capacity characteristics.
 - d IP rating.
 - e Fixing details for floor or wall mounting.
 - f Front and back equipment connections and top and bottom cable entries.
 - g External and internal paint colours and paint systems.
 - h Quantity, brand name, type and rating of control and protection equipment.
 - i Construction, ventilation openings, internal arcing-fault venting and gland plate details.
 - j Single line power and circuit diagrams.
 - k Details of cable routes within assemblies.
 - l Internal separation and form of separation and details of shrouding of terminals.
 - m Labels and engraving schedules.
- 5 Details of:
 - a Cable tray routes co-ordinated with other services.
 - b Underground reticulation routes co-ordinated with other services.

12.3 GENERAL REQUIREMENTS

- 1 Carry out the Works Package, incorporating detailed design and construction, by a specialist mechanical electrical company using only experienced electrical mechanical trades personnel.
- 2 Use all new electrical equipment, wiring and fittings of best quality and of the same manufacture throughout the installation.
- 3 Confirm provisional loads prior to purchase of submains by Electrical Works Package.
- 4 Seal cable penetrations through non-fire rated building elements; maintain acoustic and pressure differential rating.
- 5 Provide uPVC sleeves formed from pipe sections, for circular penetrations through slabs and beams and external walls by cables not enclosed on conduit.

12.4 EXTENT OF WORKS

- 1 The electrical services works for the mechanical plant comprise the detailed design, supply, installation, testing, commissioning, handover and maintenance of the complete electrical installation as required for satisfactory operation, control, maintenance and safety of the mechanical services. This includes:
 - a Mechanical switch boards and control panels as specified in the equipment schedules.
 - b Motor starters, variable speed drives, switchgear and controls, complete with all necessary accessories for all electrically operated equipment.
 - c All final power circuits between the switchboards and the various plant components, including connections to boards and equipment.
 - d All power wiring to controllers including motorised valves, dampers and the like.
 - e As installed documentation.
 - f Testing and commissioning of the entire installation in conjunction with other Specialist Works Packages.

12.5 FIELD CABLE SYSTEMS

12.5.1 CABLE SELECTION

- 1 Polymeric insulated and/or sheathed and flexible cables to AS/NZS 5000.1 and AS 1125, 0.6/1 kV with the following temperature ratings:
 - a PVC up to 75°C: V75
 - b PVC over 75°C: V105
 - c XLPE and EPR: 90°C.
- 2 Flexible cords to AS/NZS 3191.
- 3 Fire resistant cables to AS/NZS 3013 with classification of WS52W or higher.
- 4 Use all multi-stranded high conductivity annealed copper conductors.
- 5 Minimum size conductors:

- a Power – maximum 1.5% voltage drop or 2.5mm², whichever is the greater.
 - b Field Control – 1.5mm² subject to control voltage drops.
 - c Electronic equipment wiring – as recommended by the manufacturer.
- 6 Utilise red insulation for A phase, white for B phase and blue for C phase.
 - 7 Mark all terminals and each control cable end with a numbering system reflecting the schematic wiring diagrams, including any spare cores.
 - 8 Power cables from variable speed drives to motors to also strictly comply with the requirements of the drive manufacturer (typically using screened cables).
 - 9 Cable colours (and cable enclosures and support systems where required to be painted) shall be consistent throughout the project to uniquely identify each service and type. Cable colour and types shall be as follows:

SYSTEM	CABLE SHEATH	ENCLOSURE / SUPPORT
Mechanical Electrical – LV	Orange or Black	Light Sky Blue
Mechanical Electrical – ELV	Brown	Light Sky Blue
Mechanical Electrical – BMS/Communications	Grey	Light Sky Blue
The requirements for other services are listed below for reference		
Electrical – LV	Orange or Black	Electric Orange
Electrical – ELV	Grey	Electric Orange
Electrical – LV Fire Rated	Red	Electric Orange
Data Backbone	Grey	Harbour Blue
Data Horizontal	Harbour Blue	Harbour Blue
ACID Services	White	Red-Orange (not Electrical Orange)
MATV Services	Black	Grey
Audio Visual services	Green	Green
CCTV services	Red-Orange	Red-Orange (not Electrical Orange)
Medical Gas Systems	Yellow	Yellow

12.5.2 CABLE INSTALLATION

- 1 Install all cables in accordance with AS/NZS 3000, AS/NZS 3008.1.1 and specifically in accordance with manufacturer's recommendations.
- 2 Fix fire resistant cables with stainless steel straps.
- 3 Loop cables at all terminations subjected to equipment vibration.
- 4 Run cables without joints.
- 5 Cable routes to be level, straight and parallel with building lines.
- 6 Install DDC cabling in accordance with the manufacturer's recommendations.

- 7 Installation and classification (minimum WS52W) of a fire rated wiring system applies to the complete system including the cable fixings (i.e. ties and/or clamps), cable support system, mechanical damage rating and cable support system fixing points.
 - 8 Coordinate with all other Works Packages to ensure that the correct level of segregation is provided between LV and ELV cabling, medical gases pipes, etc.
 - 9 Use the following systems unless alternatives are accepted:
 - a Accessible concealed spaces: Fully supported thermoplastic insulated and sheathed cables.
 - b Inaccessible concealed spaces: Cables in conduit.
 - c Plant rooms: Cables in heavy duty conduit, or on tray, in duct, or in trough.
 - d Plastered or rendered surfaces: Cables in conduit.
 - e Stud walls without bulk insulation: Thermoplastic insulated and sheathed cables.
 - f Walls filled with bulk thermal insulation: Cables in conduit.
 - g Underground and in concrete slabs: Cables in heavy duty conduit.
 - h Exposed to weather: Cables in heavy duty UV resistant rigid conduit, with all fittings sealed.
 - 10 Enclose cabling in cold and cool rooms in halogen-free plastic alloy conduit, suitable for use at low temperature. Cabling as follows:
 - a EPR insulated and CSP sheathed.
 - b Flexible without brittleness down to -20°C.
 - c Use multi-core flexible cable for connection to items within the rooms requiring maintenance.
-

12.6 FIELD CABLE SUPPORT SYSTEMS

12.6.1 GENERAL

- 1 Design and provide a complete cable support system. Unless otherwise noted, a combination of the following support systems is acceptable.
 - 2 Co-ordinate cable support systems with other services complete with all necessary brackets, off-sets, fixings, penetrations and sealing.
 - 3 Size support system to be able to handle an additional 50% of cables above those initially installed.
 - 4 Design support system for a maximum 10mm deflection for conduits, trays and ladders, and a maximum of 100mm for catenaries.
 - 5 Provide brackets, rods and similar to provide a complete and rigid support system – adhesive cable supports will not be accepted.
 - 6 Comply with AS 1170.4 for the complete support system.
-

12.6.2 CONDUIT AND FITTINGS

- 1 Circular steel conduit, heavy gauge welded galvanised with screwed connections complying with AS/NZS 2053, minimum nominal diameter 20mm.

- 2 Circular non-metallic rigid and flexible conduit of the high impact, self-extinguishing type, complying with AS/NZS 2053, minimum nominal diameter 20mm.
 - 3 Provide future use conduits with 2.5mm² galvanised steel draw wire, insulated stranded 2.5mm² earth wire, or minimum 5mm² polypropylene cords.
 - 4 Use only approved bending machine.
 - 5 Install conduit 100mm from all other pipe systems.
 - 6 Space conduit saddles 1000mm apart or reduce to 500mm where subject to high temperatures or severe duty. Use double sided saddles for 25mm diameter conduit and above.
 - 7 Provide draw in boxes at intervals not exceeding 25m horizontally and 7.5m in the vertical.
 - 8 Provide flexible conduit connection to motors/appliances, minimum length 150mm, maximum length 500mm.
 - 9 Provide flexible couplings where structural expansion joints occur.
 - 10 Fix conduits between top and bottom reinforcing steel where run in concrete slabs, space conduits 50mm apart, avoid crossovers and co-ordinate with structural requirements.
 - 11 Firmly fix conduits laid in plaster or wall chases to prevent movement and provide a minimum of 20mm final cover.
 - 12 Where flexible conduit is subject to mechanical damage, use jacketed steel wound 'Anaconda' type complete with all proprietary fittings installed in accordance with the manufacturer's instruction.
 - 13 Where conduits pass through cold chambers (e.g. low temperature side of air conditioner casings, cold and cool rooms) most conduiting should be run external to chamber and have cables silicone sealed to inside of conduit where passing through wall or ceiling. Condensation from inside the conduit must not be able to enter switches or fittings.
-

12.6.3 CABLE TROUGHING

- 1 Troughing constructed of folded 1.15mm zinc coated mild steel, 1.55mm half hard-aluminium sheet, 1.55mm thick extruded aluminium section or 2mm thick extruded rigid PVC section, complete with detachable lid.
 - 2 Use proprietary covers, cable retainers, bends, tees, joiners, blanking ends and junctions.
 - 3 Where troughing passes through walls or floors, provide a pop riveted section of lid extending 40mm each side of penetration.
 - 4 Support cabling within vertical troughing at a maximum of 4 metre intervals or at every floor level with an approved method of clamping to the trough.
-

12.6.4 CABLE TRAYS

- 1 Galvanised.
- 2 Minimum steel thickness:
 - a Trays < 150mm wide: 1.0mm.
 - b Trays ≥ 150mm, < 300mm wide: 1.15mm.
 - c Trays ≥ 300mm wide: 1.55mm.
- 3 Provide proprietary bends and tees.

12.6.5 CABLE LADDERS

- 1 Use two folded steel or extruded structural grade aluminium side rails with cable support rungs between the rails.
 - 2 Steel ladders to be galvanised.
 - 3 Rung spacing to be 300mm maximum.
-

12.6.6 CATENARIES

- 1 Utilise catenaries for internal final distribution only.
 - 2 No more than 6 individual cables shall be supported by each catenary
 - 3 Utilise separate catenaries for separate cable media.
 - 4 Provide catenary wire comprising of galvanised, multi-stranded wire. Earth the catenaries.
 - 5 Fix catenaries with galvanised eyebolts or approved proprietary fixings. Fix only to permanent structure elements. Use galvanised turnbuckles to tension catenary wire.
 - 6 Utilise intermediate supports at minimum spacing of 2.0m centres.
-

12.6.7 INSTALLATION

- 1 Provide rounded support surfaces under cables where they leave trays, troughs or ladders.
 - 2 Hot water pipes: 200mm maximum clearance.
 - 3 Boilers or furnaces: 500mm minimum clearance.
-

12.7 FIELD EQUIPMENT

12.7.1 MOTOR ISOLATING SWITCHES

- 1 Locate adjacent to and identify with the name of the drive. External labels to be of metal and mechanically fixed.
 - 2 Rated to interrupt 800% full load motor current and padlockable. Provide 003 keyed padlocks on fire smoke control equipment.
 - 3 Use emergency palm operated keyed release control isolators for motor 11kW and above.
 - 4 Provide metal clad isolators for fire equipment with an additional label 'DO NOT SWITCH OFF EXCEPT IN EMERGENCY'.
-

12.7.2 ELECTRIC RESISTANCE HEATERS

- 1 Arrange all electric resistance heaters to be balanced across phases under all normal operating conditions.
- 2 Provide each electric resistance heaters with isolation switch mounted 600 minimum distance away. Use heat resistant cable to electric resistance heaters.

12.7.3 LIFT MACHINE ROOM VENTILATION PANEL

- 1 Comply with SAA Lift Code AS 1735.1, AS 1735.2 and the requirements of the Local Authority.
- 2 Provide a wall mounted control panel in the LMR with isolating switch, motor starter, Auto-Off-Test switch, red high temperature alarm light and external alarm cancel button.
- 3 A high temperature condition shall be alarmed either in the main floor landing or in a permanently attended location (refer to AS 1735.2). In addition, a voltage-free signal shall be provided at the control panel (for use by the lift supplier if required to shut down the lift machinery).

12.8 SWITCHBOARDS AND CONTROL PANELS (BOARDS)

12.8.1 GENERAL

- 1 Supply and install all mechanical services switchboards and control panels (boards) in compliance with the following:
 - a Incorporate all necessary starting arrangements, associated controls and accessories/ switchgear as required to form a complete and functioning system.
 - b Designed to AS/NZS 3439.1 and built by a recognised specialist board manufacturer.
 - c Ascertain from drawings or site measurement the exact space available for the board.
 - d Provide a minimum of 25% spare capacity and space for future requirements to all elements of the board.
 - e Provide DIN rail mounting for BAS, kWh metering system and other interface terminal strips.
- 2 Withstand the short-time fault level of the incoming supply and not less than that in Schedules. Maximum current temperature rise limit 160°C by calculation to AS 3865.
- 3 Provide equipment which incorporates protection of semi-conductor components against potential damage caused by switching and other external transients.

12.8.2 INTERPRETATIONS

- 1 Proprietary boards: Switchboards and control panels available as a catalogue item comprising manufacturer's standard layouts and equipment.
- 2 Custom-built boards: Switchboards and control panels custom manufactured to order utilising proprietary components.
- 3 Rated currents: Continuous uninterrupted ratings within the internal board environment under in-service operating conditions.

12.8.3 DESIGN

12.8.3.1 SEPARATION

- 1 Internal separation shall be provided by standard construction (metal barriers or metal partitions).
- 2 Alternative segregation means described in AS3439.1 section 7.7.2 is unacceptable – insulation (i), housing (h) or a combination (ih).

- 3 Control gear associated with emergency / life safety equipment to be totally separated from other equipment by means of sheet steel barriers.
- 4 Emergency / life safety equipment including control and switchgear to be served by separate dedicated power supplies.

Emergency / Life Safety Equipment (air handling systems designed to exhaust and control the spread of fire and smoke, e.g. smoke spill fans, stairwell pressurisation fans, etc.)

Form 3b

Rated over and including 800 amps

Form 3b with incoming circuit segregated from outgoing zones (Form 2a for control section)

Rated over 250 amps and up to 800 amps

Form 2b

Rated up to and including 250 amps

Form 1

12.8.3.2 DEGREE OF PROTECTION

- 1 General: Minimum IP43.
- 2 Assemblies for outdoor use: Minimum IP55.

12.8.3.3 MOUNTING

- 1 Floor mounted: Boards generally.
- 2 Wall mounted: Front access boards with frontal areas <2m².

12.8.3.4 CONNECTION

- 1 Indoor board cable entries: Top and bottom.
- 2 Outdoor board cable entries: Bottom.

12.8.4 PROTECTION

- 1 Provide a fully discriminating/cascading protection system applicable to the supply. Liaise with Electrical Works Package to ensure discrimination with upstream protective devices
- 2 Discrimination shall occur for all fault conditions up to and including the maximum prospective 3 phase fault current at the circuit breaker line side terminals
- 3 Provide isolators, contactors and switches with upstream protection to prevent damage from downstream fault currents up to the maximum three phase bolted fault current at the load side of the device.

12.8.5 ARCING-FAULT CONTAINMENT

- 1 Switchboards and control panels in the following conditions shall have arcing-fault containment in accordance with AS 3439.1 – Standard Tests:
 - a Rated 1600A and above.
 - b Supplying hospitals, emergency facilities, telecommunications and similar critical applications.

12.8.6 TYPE TESTS

- 1 Unless otherwise accepted, all enclosures shall be provided as partially type-tested assemblies and strictly in accordance with the manufacturer's type test certificates including:

- a Verification of temperature-rise limits.
 - b Verification of the short-circuit withstand strength;
 - c Verification of the degree of protection and internal separation;
 - d Verification of the dielectric properties;
 - e Verification of the effectiveness of the protective circuit;
 - f Verification of clearances and creepage distances;
 - g Verification of mechanical operations.
-

12.8.7 QUALITY

- 1 Give notice so that inspection may be made at the following stages:
 - a Fabrication and painting completed.
 - b Board ready for routine testing and dispatch.
 - c Board installed and connected.
 - d Acceptance.
-

12.8.8 PROPRIETARY SWITCHBOARDS AND CONTROL PANELS

- 1 Construction strictly in accordance with the manufacturer's type test certificates.
 - 2 Provide lockable doors.
-

12.8.9 CUSTOM BUILT SWITCHBOARDS AND CONTROL PANELS

- 1 Construction strictly in accordance with the manufacturer's type test certificates.
- 2 Fabricate from sheet metal of rigid folded and welded construction. Obtain approval for non-welded forms of construction.
- 3 General: Minimum 1.6mm thick zinc-coated sheet steel, coating class Z200.
- 4 Outdoor assemblies: 2mm stainless steel.
- 5 Insect proof ventilation openings using non-combustible and non-corroding 1mm mesh.
- 6 Floor mounted assemblies to have a minimum 75mm high galvanised (class Z600) steel channel base frame.
- 7 Do not mount active equipment on the doors.

12.8.9.1 CABLE ENTRIES

- 1 Provide one or more removable gland plates to neatly accept incoming and outgoing cables, fitted with gaskets to maintain the required degree of protection. Use a maximum of 50% of the usable plate area to allow for future cable capability.
- 2 Gland plates to be metallic and non-magnetic. Minimum 3mm thick for multicore cables, and minimum 5mm thick for single core cables.

12.8.9.2 DOORS AND COVERS

- 1 Maximum width: 900mm.

- 2 At least 135° door swing.
- 3 Provide stays to outdoor board doors.
- 4 Space adjacent doors to allow both to open to 90° at the same time.
- 5 Doors exceeding 1000mm tall to have stiffening.
- 6 Provide sheet metal return from all casing sides, and fit suitable resilient sealing rubber doors to provide the degree of protection and prevent damage to paintwork. Seals to be housed in a suitable channel or housing and fixed with an approved industrial grade adhesive.
- 7 Hang doors on chromed brass lift-off hinges with stainless steel pins. Provide staggered pin lengths to achieve progressive engagement as doors are fitted. Provide 3 hinges for doors higher than 1m.
- 8 Doors to have chromed lever-type 'T' handles with key locking cylinders, operating a latching system with latching bar and guides strong enough to withstand explosive force resulting from fault conditions within the board (minimum three points of latching for doors taller than 1000mm).
- 9 Key all assemblies alike throughout project, 2 keys per board.
- 10 Protect or shroud door mounted equipment and terminals to prevent inadvertent contact with live terminals and wiring.
- 11 Maintain earth continuity to door mounted indicating or control equipment using multi-stranded, flexible earth wire, or braid of equal cross-sectional area, bonded to the door.
- 12 Maximum cover dimensions: 900mm wide and 1.2m² surface area. Fix covers to frames using at least 4 fixings fitted with chromed acorn nuts or captive knurled thumb screws. Do not use interlocked covers. Fit chromed 'D' type handles.
- 13 Provide hinged escutcheon plates with neat cut-outs for circuit breaker handles and the like. Plate cut-outs are to allow inter-changeability of varying pole circuit breakers, and the unused circuit breaker toggle cut-outs are to be fitted with blanking in-fill pole covers. Provide plates with chromed handles or knobs, and fix with chromed acorn nuts or captive knurled thumb screws. Hinges are to allow opening through a minimum of 90° and then permit the removal of the escutcheon plate.

12.8.9.3 FACTORY FINISHES

- 1 Apply protective coatings to all internal and external metal surfaces of boards including covers, except to stainless steel, galvanised, electroplated, or anodised surfaces.
- 2 Finish coat full gloss thermoset powder coating, or two-pack liquid coating. Casing colour to be X15 electrical orange to AS 2700 unless otherwise nominated in this specification. Internal covers and escutcheons are to be white.

12.8.10 INTERNAL WIRING

- 1 Provide 0.6/1kV stranded copper cables, 2.5mm² (minimum) for power and 1.5mm² (minimum) for control.
- 2 Use V90HT insulation where directly connected to active and neutral busbars, and minimum V75 insulation elsewhere (but selected to suit the actual operating temperatures of equipment). Utilise red insulation for A phase, white for B phase and blue for C phase.
- 3 Size cables for the greater of the maximum continuous rating of the equipment mounted in the switchboard or to withstand the 'let-through' energy of the circuit protective device.
- 4 Run cables neatly. Provide slotted PVC wiring ducting sized for future cables, or tie at 150mm maximum intervals using ties strong enough to withstand magnetic stresses created at the specified fault current. Do not use adhesive supports.

- 5 Terminate control cables and motor control circuits in tunnel terminals or, if necessary, use suitable palm type lugs and correct crimp tool.
 - 6 For equipment mounted on hinged doors run cables on the hinge side to avoid restricting the door opening. Bundle cables using spiral wrap PVC.
 - 7 If available, use proprietary multi-pole busbar assemblies to link adjacent circuit breakers instead of cable interconnections.
 - 8 Identify power and control cables at both ends using neat fitting ring type ferrules agreeing with work-as-executed circuit diagrams.
-

12.8.11 CONTROL SYSTEM INTERFACING

- 1 Provide separate blue colour terminal strips segregated in each switchboard for connection of Control System interface cabling.
 - 2 Provide potential-free low contact resistance compatible for use with extra low voltage Control System monitoring for status and alarm conditions.
 - 3 Do not mix Control System status information contacts and 240V circuit switching contacts on the same relay; provide additional slave relays as required for separation.
 - 4 Provide the required number of looped terminals for common connections to ensure every field interface cable core receives individual terminals.
-

12.8.12 BUSBARS

- 1 Unless otherwise accepted, boards exceeding 250A shall be provided with proprietary copper bus bar systems in compliance with AS/NZS 3439, AS 3768, AS 3865 and AS 60890.
- 2 Busbar assemblies to be verified for short circuit capacity and temperature-rise limits by type tests.
- 3 Fully insulate the busbar system using heat shrinkable polyolefin or double dipped polyethylene. Joints and terminations to be insulated by tape of plastic coating (thickness equal to the busbar insulation). Utilise red insulation for A phase, white for B phase and blue for C phase.
- 4 Neutral busbars to be of an equivalent size to the phase busbars. Extend into each switchboard compartment containing outgoing connections with neutral connections.
- 5 Current carrying capacity: De-rate busbars in accordance with AS/NZS 3429.1 Appendix C.
- 6 For current transformers, provide removable busbar links < 450mm long.
- 7 Pre-drill the main circuit supply busbar for future extensions and extend busbar droppers into future functional unit locations. Pre-drill each dropper to suit connection of future equipment of the same type as initially installed.
- 8 Use high tensile steel bolts, washers and nuts, with lock nuts or locking tabs for jointing. Do not use tapped holes, star washers, studs or the like for jointing current carrying sections.
- 9 Support busbar assemblies sufficient to withstand without damage the maximum prospective fault currents. Use non-hydroscopic insulation capable of withstanding 105°C.
- 10 In order to minimise eddy currents in the board metalwork run phase and neutral bars in the same busbar chamber, penetrating metal barriers in the same hole.

12.8.13 NEUTRAL AND EARTH LINKS

- 1 Also, provide terminals for future circuits.
- 2 Mount neutral links on an insulated base.
- 3 Provide separate neutral and earth links for control circuits.
- 4 Provide labels for neutral and earth terminals.
- 5 Provide bolts or studs for cables > 10mm².

12.8.14 SWITCH-ISOLATOR AND COMBINATION FUSE-SWITCH UNITS

- 1 Totally enclosed construction to AS/NZS 3947.3.
- 2 Independent manual operation including positive 'ON/OFF' indicator.
- 3 Provide for padlocking in the 'OFF' position.

12.8.15 MOULDED CASE AND MINIATURE CIRCUIT BREAKERS

- 1 Unless otherwise accepted, use:

a 0A	< load ≤	100A	–	MCB (Miniature Circuit Breaker)
b 100A	< load ≤	1200A	–	MCCB (Moulded Case Circuit Breaker)
- 2 To AS 60947.2, AS 2184 for moulded case circuit breakers. To AS 60898.1, AS 3111 for miniature circuit breakers. Circuit breaker trip curves shall be selected to ensure disconnection times shall not exceed 0.4 seconds. Circuit breakers shall utilise type “C” trip curves where they achieve a disconnection time for 0.4 seconds or less.
- 3 Maintain sufficient clearance around to allow installation and termination of all incoming and outgoing connections, including to spare poles, without overcrowding.

12.8.16 AIR CIRCUIT BREAKERS

- 1 Unless otherwise accepted or specified, use for loads above 1200A.
- 2 To AS 60947.2, AS 1930.
- 3 Open construction type, withdrawable 3 pole, back connected, trip free. Mutually interchangeable. Fitted with operation counters.
- 4 Full discrimination utilisation category.
- 5 Provide trip free closing mechanisms for operational current of 6A at 240V, 50Hz. Provide at least one spare normally-open and one spare normally-closed contact. Provide shunt trip release coil circuits with an early-make/late-break series connected auxiliary contact.
- 6 Provide space for up to nine sets of auxiliary contacts of normally open or normally closed type.
- 7 Protection system integral to the circuit breaker, incorporating a solid-state protection relay.
- 8 Provide for circuit breakers to be padlocked in the open position.
- 9 Provide breakers which cannot be used in the following operations:
 - a Slow closing or opening of contacts.

- b** Manual independent hand closure, if springs fail.
 - c** Release of charged springs while contacts are closed.
- 10** Mount circuit breaker on a withdrawable carriage with racking gear for racking in or withdrawing, and for positively fixing the unit into any of the 3 following positions:
 - a** Connected.
 - b** Test/isolated.
 - c** Disconnected.
 - 11** Alternately provide a portable trolley and lowering device to withdraw and move the circuit breaker.
 - 12** Auxiliary contacts: Use contacts that remain connected in the test/isolated position.
 - 13** Provide interlocking which prevents circuit breaker being racked in or withdrawn unless it is in a tripped condition and prevents the circuit breaker being closed unless located in either the connected or test/isolated position. Provide stored energy devices that are automatically discharged by any racking operation.
 - 14** Provide automatic shutters, which can be padlocked, covering busbar and incoming/outgoing circuit connections and labelled 'BUSBARS' and 'CIRCUIT' respectively.
 - 15** Provide earthing connection between withdrawable carriage and board earth busbar that makes before, and breaks after, other contacts on the circuit breaker carriage.
 - 16** Submit type test certificates verifying type tests in accordance with AS 1930.
 - 17** Provide for slow closing of the circuit breaker and for adjustment when disconnected.

12.8.17 INSTRUMENTS AND METERS

- 1** Hours run meters: Minimum 6 figure linear read out down to 0.1 hour increments.
- 2** Watthour Meters: Electronic type. If metering is connected across 3 phases, use polyphase meters suitable for balanced 3 phase, 4 wire loads. Use single phase meters for 2 or 1 phase metering only.

12.8.18 INDICATOR LIGHTS

- 1** To AS 60947.5.1.
- 2** Lights to be coloured as follows:
 - a** Green – Safe, may mean 'run' in certain conditions.
 - b** Red – Fault, Dangerous.
 - c** Amber – Change in condition, e.g. Fire Alarm.
 - d** Blue – Designated function, e.g. Economy Cycle Operating.
 - e** White – Special Designation if required.
- 3** Degree of protection at least that of the board.
- 4** Incandescent indicators will not be accepted.
- 5** Neon indicators 240V, minimum 12mm diameter with in-built resistor.
- 6** Multiple LED cluster type with corrosion-resistant bezel minimum 16mm diameter.

- 7 Provide a common press-to-test lamp push-button per compartment/ subsection.
-

12.8.19 FUSES

- 1 To AS/NZS 60269.2.1 and AS/NZS 60269.4.0.
 - 2 Fuses to be used for extra low voltage power supply protection only. Circuit breakers to be used for all other protection applications.
 - 3 Mount fuse-holders so that fuse carriers may be withdrawn directly out of the assembly and away from all live parts. Fuse holders to include insulation which shrouds live metal when the fuse carrier is withdrawn.
-

12.8.20 CONTACTORS

- 1 To AS 60947.4.1, Type 2 coordination.
 - 2 Block type, air break, electro-magnetic, 3 pole, rated to full load current of the controlled load + 25%, but not less than 16A.
 - 3 Rated duty:
 - a Motors: Intermittent class 0.1.
 - b Heater banks: Intermittent class 1.
 - 4 Utilisation category:
 - a Motors: AC-3 or DC-3.
 - b Heater banks: AC-1 or DC-1.
 - 5 Contacts life: 1 million operations at AC-3 or DC-3.
 - 6 Provide auxiliary contacts, utilisation category AC-1, with at least one normally-open and one normally-closed separate contacts with minimum rating of 6A at 240 V AC.
 - 7 Mount with sufficient clearance to allow full access for maintenance, removal and replacement of coils and contacts, without the need to disconnect wiring or to remove other equipment.
-

12.8.21 CONTROL AND TEST SWITCHES

- 1 To AS 60947.1, and AS 60947.5.1, utilisation category AC-22.
- 2 At least equal the degree of protection for the board.
- 3 Push-buttons:
 - a Type: Oil-tight, minimum 22mm diameter, or 22 x 22mm.
 - b Rated operational current: At least 4A at 240V AC.
 - c Marking: identify functions of each push-button. For latched push-buttons, label with instructions for releasing latches.
- 4 Rotary Switches:
 - a General: Cam operated type with switch positions arranged with displacement of about 60°.
 - b Off position: Locate at the 12 o'clock position.
 - c Rated operational current: Minimum 6A 240V AC.

- 5 Time Switches:
- a Operation: 7 day fully programmable including day omit, daylight saving and manual override facilities.
 - b Mains failure operation: By battery with 100-hour minimum operating capacity and guaranteed 10-year minimum life.
 - c Construction: Provide readily accessible means of adjustment. Provide operational settings that are clearly visible when switch cover is fitted.
 - d Digital type with hour and minute display visible with time switch cover closed.
-

12.8.22 CONTROL RELAYS

- 1 To AS 60947.5.1.
 - 2 Suitable for continuous operation with minimum mechanical life of 10 million operations.
 - 3 Latch plug-in types to DIN rail mounted bases using captive clips that can be applied and released without using tools.
 - 4 Pneumatic relays will not be accepted.
-

12.8.23 SURGE PROTECTION

- 1 Supply and install a surge diverter on the incoming supply of each mechanical services switchboard with a mains isolator rated at 100 amps and greater.
- 2 The maximum continuous operating voltage, U_c , shall be at least 275V between phase and neutral.
- 3 The maximum surge current, I_{max} , shall be at least 50kA for an 8/20 μ s waveform current impulse.
- 4 The nominal surge current, I_n , shall be at least 20kA for an 8/20 μ s waveform current impulse.
- 5 The voltage protection level, U_p , shall be less than 850V at 3kA 8/20 μ s waveform current impulse
- 6 It shall be provided with visual indication and voltage free contacts to indicate alarms. The voltage free-changeover contacts shall have no less than 3kV isolation from all other circuitry.
- 7 The surge diverter shall provide protection for all modes (L-N, L-E and N-E). A single metal oxide varistor (MOV) shall be connected between each phase and neutral, and a gas discharge tube (GDT) shall be connected between neutral and earth. A fuse shall be connected in series with each MOV.
- 8 The surge diverter shall comprise a thermal sensor for each phase that detects if the MOV overheats, but does not disconnect the MOV from circuit.
- 9 The surge diverter shall be housed in a metal enclosure.
- 10 Connect the surge diverter to busbars immediately downstream of the incoming isolator.
- 11 Use multistrand copper conductor of 10mm² minimum cross-sectional area.
- 12 Protect the surge diverter with a 32 amp 3 pole circuit breakers.
- 13 Provide a monitoring relay and a red panel lamp with integral lamp test facility to illuminate when the alarm contact in the surge diverter has operated.
- 14 Arrange mounting and cabling to minimise conductor lengths between surge diverters and busbars.
- 15 Locate in a readily accessible position for replacement purposes.

12.8.24 ANTI-CONDENSATION HEATERS

- 1 For outdoor switchboards, provide heaters rated at not less than 20W/m² of total external area.
 - 2 Black heat type, mechanically protected and thermostatically controlled.
-

12.8.25 GENERAL PURPOSE SOCKET OUTLETS

- 1 Provide all socket outlets mounted on switchboards with RCD.
 - 2 All GPOs to be minimum IP54.
-

12.9 MOTOR STARTERS

12.9.1 SELECTION

- 1 Motor starters to be:
 - a Direct on Line (DOL).
 - b Multi-speed.
 - c Star-Delta closed transition.
-

12.9.2 MINIMUM RATED VALUES

- 1 Rated operational current: The full load current of the load controlled.
 - 2 Rated duty: Intermittent class 12.
 - 3 Utilisation category: AC-3.
-

12.9.3 DIRECT-ON-LINE STARTERS

- 1 To AS 60947.4.1.
 - 2 Type: Direct-switching electromagnetic contactor.
 - 3 Overload protection: Thermal overload unit giving protection in each phase of supply.
-

12.9.4 MULTI-SPEED STARTERS

- 1 Comply with **Direct-on-line starters** and the following:
 - a Interlocked so that only a single speed can be selected.
 - b Time delay relay with nominal 0-30s adjustable time delay.
 - c Separate thermal overload protection for each speed configuration.
-

12.9.5 STAR-DELTA STARTERS

- 1 To AS 60947.4.1.

- 2 Provide electromagnetically operated starter assembly incorporating the following:
 - a Closed transition type.
 - b Adjustable time delay relay (nominal 0-30sec) for the star to delta switching contactors.

12.10 VARIABLE SPEED DRIVES

12.10.1 GENERAL

- 1 Microprocessor controlled solid state continuously rated electronic drives to control standard 3 phase fan and pump motors by stepless variation of voltage and frequency output without any motor derating or motor temperature rise above Class B.
- 2 Drives to be specifically engineered for mechanical services operation with built-in subroutines for at least fans and pumps, such as Vacon 100 HVAC, ABB ACH550 and Danfoss VLT HVAC FC101. Alternatives may be offered for consideration but will not necessarily be accepted.

ITEM	BASIC VSD	AVAILABLE WITH VACON 100 HVAC	AVAILABLE WITH ABB ACH550	AVAILABLE WITH DANFOSS VLT FC 101	AVAILABLE WITH DANFOSS VLT FC102
Digital inputs	4	6	6	4	6
Outputs	1 analog 2 relay	1 analog 3 relay Also many additional option boards	2 (programmable as analogue or digital) 3 relay (option board can expand to 6)	2 (programmable as analogue or digital) 2 relay	1 analogue and 2 digital 2 relay Also many additional option boards
Casing, protection	Mostly plastic, IP 54	Mostly plastic, IP 21, IP 54, IP 66	Mostly plastic, IP 54	Mostly plastic, IP 54	Mostly metal, IP 21, IP 55, IP 66
LED display	2 lines/ variables	Multi lines, up to 9 variables on display	4 lines	2 lines/ variables	4 lines/ 5 variables
Additional communication protocols available	N/A	LON Works Ethernet	Siemens FLN Option boards for LON Works, Profibus, Device Net, Ethernet	Siemens FLN	LON Works, Ethernet, Profibus, Device Net Siemens FLN
EMC RFI filters [Class B/Category C1 may possibly be needed for IT centres, a few hospitals, etc.]	Class A1 (Category C2) minimum 50-metres	Class A1 (Category C2) minimum 100-metres	Class A1 (Category C2) minimum 75-metres	Class A1 (Category C2) up to 50-metres Class B (Category C1) up to 10-metres	Class A1 (Category C2) up to 150-metres Class B (Category C1) up to 50-metres

- 3 Complete technical engineering service and spare parts facility available locally, with service and reinstatement of the drive to full working conditions within 24 hours following a failure.

Drives suitable for continuous operation at full load in an ambient temperature of not less than 47°C, and at reduced load in temperatures not less than 55°C.

- 1 Provide self-contained fully integrated minimum IP54 rated enclosures with forced draft ventilation (no ambient airflow across the electronics).
- 2 Drives installed outdoors are to be protected from direct sunlight, direct rain and over temperatures with ancillary ventilated enclosures.
- 3 In-built filters are to ensure the individual VSD harmonic emissions comply with AS 61000.1.1, AS 61000-3-12 and AS 61800.3.
- 4 In addition, the total mains borne harmonic distortion generated by all drives is to be less than the value prescribed by the electricity supply distributor (8%). The VSD supplier shall be responsible for this overall analysis, and provide additional filtering if needed to comply.
- 5 Drives to be C-Tick certified in accordance with the Australian Communications Authority regulations, and CE certified in accordance with the European Union EMC Directive legislation.
- 6 In-built Electromagnetic Compatibility (EMC) Radio Frequency Interference (RFI) filters are to limit the interferences generated by drives to not exceed that prescribed by AS 61800.3 Category C2 (equivalent to EN 55011 Class A1) with at least 50 metres of motor cable.
- 7 The drives must include at least the following built-in features:
 - a Serial communications link for RS-485.
 - b BACnet, Modbus and Metasys N2 high level communication protocols.
 - c Capability for operation with a remote-control panel (allowing relocation of 3 metres).
- 8 The drives shall have the following minimum specifications for the output:
 - a Frequency: 0 to 320Hz minimum.
 - b Switching Frequency: up to minimum 10kHz.
 - c Efficiency: Minimum 97.5% (full load, 50Hz).
- 9 All drives are to be located as close as possible to the motors being driven.
- 10 The drive supplier or a trained representative to attend site to properly set up and adjust the drives at time of commissioning to ensure optimum performance and ongoing trouble free operation, and to clearly document all internal set points for speed, ramp times, etc. following final adjustment.
- 11 Installation of the drives and cabling to motors from them to be strictly in accordance with the manufacturer's recommendations as a minimum. Provide a manufacturer's installation acceptance certification for all variable speed drives, including the complete VSD and motor power and control cabling systems.

12.10.2 RATING AND STABILITY

- 1 Select each drive on maximum motor full load 'nameplate' amps and not on motor kW rating.
- 2 Output voltage and frequency levels to remain constant at any given speed setting when supply voltage varies by not more than +/- 15%.
- 3 The output frequency to remain constant regardless of load variations or supply frequency variation of - 5%, + 15%. Output frequency to remain stable throughout the ambient temperature range of 0°C to 50°C.

12.10.3 COMPONENTS AND FUNCTIONS

- 1 Protect each drive with suitably rated high speed fuses or circuit breaker on the input side.
- 2 Speed control to be stepless varying both voltage and frequency. Frequency control via pulse width modulation generating a clean sine wave with an operating power factor of 0.96 or better throughout the entire speed range.
- 3 Motor audible noise shall be no greater than that of an equivalent DOL starter.
- 4 Drive to include at least:
 - a Two programmable analogue inputs.
 - b Four programmable digital inputs.
 - c One programmable analogue outputs.
 - d Two relay outputs.
- 5 The drive to accept at least one selectable switched input to override the speed control signal and run at fixed manually set speeds.
- 6 At least one input programmable for fire mode operation when in-built safety systems are bypassed as per AS 1668.1, and the drive either runs at a set speed or at varying speed.
- 7 Include at least two on-board independent PI/PID control loops.

12.10.4 SAFETY PROTECTION DEVICES

- 1 Provide the following safety protection features as a minimum requirement, allowing the drive to shut down without component damage.
 - a Adjustable torque limit.
 - b Adjustable overcurrent limit.
 - c Shut down drive on sustained power loss, and upon return of power automatically return the system to normal operation within a short period of time. The number of automatic fault resets and restart attempts and the time inferred between these restart attempts is to be agreed prior to commissioning.
 - d Shut down the drive on momentary power loss, and upon return of power automatically return the system to normal operation i.e. being capable of restarting a rotating motor immediately and regain positive speed control).
- 2 The following safety devices are also required, but may be bypassed in Fire Mode.
 - a On short circuit or instantaneous overcurrent shut down the drive.
 - b Shut down the drive on phase to earth short circuit protection fault.
 - c Under and over voltage trip.
 - d Shut down the drive when the operating temperature exceeds safe operating limits.
 - e Motor overloads (and thermistor protection where applicable) to be provided within the drive to protect the motor and drive at all operating speeds. The drive shall accept a PTC thermistor input directly (i.e. without any additional 'thermistor relay' or such).

12.10.5 SPEED CONTROL SIGNALS AND STATUS INDICATIONS

- 1 Control the output from an input signal derived from DDC or an electronic controller.

- 2 Provide internal manual adjustment allowing presetting of maximum and minimum speeds with the limits maintained regardless of the input signal.
- 3 Include an 'auto-off-manual' function and manual speed adjustment shall be possible via the keyboard integral with the drive to allow testing and commissioning of the unit. Provide indication on the BMS for local auto/off/manual status. Lock out the automatic speed control signal in the manual mode.
- 4 Provide status indication light emitting diodes and an LCD display on the control panel with plain English display for the safety, protection and operating controls specified. In addition, indication for power on, speed and drive enabled shall be provided. Display to be programmable for at least two simultaneous variables including current, power, speed, power consumption and output frequency. Coded messages are not acceptable.

12.11 MOTOR PROTECTION

12.11.1 GENERAL

- 1 Provide over-current protection as part of the equipment assembly for each motor starter and variable speed drive.
- 2 Overload and thermistor protection is not required for dedicated fire or smoke control equipment, or is to be overridden in the case of dual function drives when operating under fire condition.

12.11.2 THERMAL OVERLOAD PROTECTION RELAYS

- 1 To be provided for all motors except for dedicated fire or smoke control equipment.
- 2 Standard: To AS 60947.4.1, utilisation category AC-11.
- 3 For 3 phase operation provide triple pole relays with differential trip bar operation for single phase protection, and ambient temperature compensation. Provide the following:
 - a One normally-open and one normally-closed set of auxiliary contacts with minimum operational current of 4A at 240 V AC.
 - b Thermal overloads connected directly to contactor using proprietary links, except where operated separately by current transformers.
- 4 Reset: Manual.

12.11.3 THERMISTOR PROTECTION RELAYS

- 1 To be provided for all motors equal to or greater than 11kW.
- 2 To AS 60947.8.
- 3 Provide at least one normally-open and one normally-closed set of contacts rated at the starter control circuit voltage and minimum 4A. Connect contacts to open the starter at the setting temperature.
- 4 Utilisation category: AC-11.
- 5 Automatic reset following power failure.
- 6 Manual reset to restore the motor circuit when tripped due to excessive winding temperature, thermistor failure, or failure of other controls system components.

- 7 Light emitting diode indication required on the thermistor control unit to indicate that the circuit is in normal operating mode.
-

12.11.4 ELECTRONIC MOTOR PROTECTION RELAYS

- 1 To be provided for all motors serving as chiller drives:
 - a Standard: AS 60947.4.1.
 - b Single phasing and phase sequence protection.
 - c Thermal overload protection.
 - d Loss of load protection.
 - e Excessive motor run-up and stall protection.
 - f Earth fault protection.
 - g Adjustable settings of protection parameters.
 - h LED indication of fault conditions.
 - i Manual reset.
 - j Minimum one normally-open and one normally-closed set of auxiliary contacts with minimum current rating of 4A at 240V AC.
 - k Facilities for relay testing.
-

12.12 LABELLING

- 1 Provide labels including control and circuit equipment ratings, functional units, notices for operational and maintenance personnel, incoming and outgoing circuit rating, sizes and origin of supply and kW ratings of motor starters.
- 2 Provide labels fixed to access panels, doors, covers and escutcheon panels and internal equipment, indicating the relevant section and component.
- 3 Minimum Lettering Heights:
 - a Custom board designation: 25mm.
 - b Small proprietary boards: 10mm.
 - c Main switches: 10mm.
 - d Outgoing functional units: 8mm.
 - e Identifying labels (on outside of cabinet rear covers): 4mm.
 - f Danger, warning and caution notices: 10mm for main heading, 5mm for remainder.
 - g Other labels including equipment labels within cabinets: 6mm.
- 4 Label Colours:
 - a Generally: Black lettering on white background.
 - b Main switch and caution labels: Red lettering on white background.
 - c Danger, warning labels: White lettering on red background.

- 5 Fix labels securely using one of the following:
 - a Screws and double-sided adhesive.
 - b Fixed in extruded aluminium sections fixed to panels using rivets or countersunk screws.
 - 6 Provide warning notices stating if boards may be energised from the stand-by supply at any time.
 - 7 To prevent accidental switching off, provide caution notices for anti-condensation heaters.
 - 8 Identify wiring with numbered ferrules at both ends.
 - 9 Number each terminal of terminal strips – numbering system to match electrical and control shop drawings.
-

12.13 AS BUILT DIAGRAMS

- 1 Single line diagrams non-fading print, at least A3 size, showing the as-installed situation.
 - 2 Enclose in a non-reflective glazed metal frame and wall mount close to board.
-

12.14 COMPLETION

12.14.1 SPARES

- 1 Provide one set of racking tools for circuit breakers, and special installation, operation and servicing tools.
 - 2 For each 10 indicating lights, provide 2 spare lamps (at least one of each colour) and one lamp extractor. Locate in switchboard.
 - 3 Provide 2 spare fuse links for each rating of fuse link on each board, mounted on clips within the board.
-

12.14.2 COMPLETION TESTS

- 1 AS 3439 routine tests, both at factory and prior to practical completion.
- 2 Physical inspection of finish, materials, layout and clearances of board and equipment, both at factory and prior to practical completion.
- 3 Physical inspection of supports and structure to ensure consistency with type-test reports, both at factory and prior to practical completion.
- 4 Operational test of doors, covers and escutcheons, both at factory and prior to practical completion.
- 5 High impedance testing, both at factory and prior to practical completion.
- 6 Earth system continuity, both at factory and prior to practical completion.
- 7 High-potential test, both at factory and prior to practical completion.
- 8 Functional tests of all switchgear, both at factory and prior to practical completion. Provide simulated loads and inputs as necessary. Test circuit breakers for long time, short time, instantaneous and earth fault operation.
- 9 Functional tests, both at factory and prior to practical completion, of all control equipment and protection devices by means of simulated inputs, secondary current injection testing or manufacturers calibrated test kits. Protection devices include, but are not limited to, protection relays, motor overloads, etc.

- 10 Check, both at factory and prior to practical completion, of all power and control termination for suitability and effectiveness.
- 11 In addition, prior to practical completion:
- 12 Meter and transducer accuracy test.
- 13 Resistance test of busbar and cable terminations.
- 14 Adjustment of overcurrent and earth fault protection settings.
- 15 Balance the load over all phases when the building is occupied at Practical Completion. Rebalance again at the end of the Defects Liability Period.
- 16 Provide documented evidence of tests including test reports and test instrument printouts. Locate one copy within the maintenance manuals.
- 17 Colour thermographic tests during the warranty period on mechanical switchboards during normal operating loads, and add copies of the report to the maintenance manuals.

13 CONTROL SYSTEMS

13.1 GENERAL

13.1.1 SCOPE

- 1 This section sets out the engineering and quality assurance requirements for the completion of the installation design, materials, components, general installation and testing of the Mechanical Services control systems.
 - 2 Control systems shall be complete with all items necessary for their safe, reliable and efficient testing, commissioning, operation and maintenance.
-

13.2 DESIGN

13.2.1 GENERAL

Complete the detail design and engineering of the control systems to the specified requirements.

13.2.2 AUTHORITY STANDARDS AND CODES

Comply with applicable authority design guidelines and codes of practice and requirements:

13.3 SUBMISSIONS

- 1 Functional Descriptions
 - 2 Hardware data sheets
 - 3 Configuration schematics
 - 4 Long term maintenance proposal
 - 5 Owner/user/operator Training schedule
-

13.4 GENERAL REQUIREMENTS

- 1 Supply, design, installation and commissioning by specialist trades competent in this type of work with local support for ongoing maintenance and back-up for components offered.
- 2 This specification has been prepared to indicate 'intent' of systems operation and peripheral equipment deemed to be required. It is not intended to unduly restrict suppliers from offering their components.
- 3 Use Direct Digital Control systems.
- 4 Electronic controls throughout.
- 5 Use supplementary electric and electronic systems to fulfil operational requirements.
- 6 Use common brand and supplier throughout.

- 7 Offer deviations from specified intent only as an option.
 - 8 System level availability shall exceed 99.8% per annum.
 - 9 System shall facilitate periodic testing, monitoring and maintenance.
 - 10 System shall be capable of continuous operation and self-initiation after shutdown.
-

13.4.1 DEFINITIONS

- 1 Building Automation System (BAS). The complete facility control system comprised of mechanical system automation, security control, lighting control, automatic temperature control, etc., as defined in the contract documents. The BAS is comprised of a two-tier network structure. The first tier uses Ethernet, TCP/IP protocol in a 10 Base T wiring configuration. The second tier uses proprietary protocol for distributed control processing. The BAS also includes routers, gateways, bridges, the Central Control Unit, LAN wiring, raceways, etc.
 - 2 Control Unit (CU): Control product that incorporates solid state components to perform multiple control loops or functions.
 - 3 Control Wiring: Includes conduit, wire and wiring devices to install complete control systems including motor control circuits, interlocks, thermostats, EP and IP switches and like devices. Includes all wiring from Intelligent Devices and Controllers to all sensors and points required to execute the sequence of operation.
 - 4 Distributed Control: A system whereby control processing is decentralised and independent of a central computer.
 - 5 Intelligent Devices (IDs): Control products that incorporate solid state components to perform a single dedicated control loop or function (ex: actuators, sensors, switches).
 - 6 Graphic User Interface (GUI): A graphical, object oriented method by which an operator is capable of communicating with the control system. Graphic User interfacing allows the operator to manage, command, monitor, and program the system.
 - 7 Network: A system of distributed control units that are linked together on a communication bus. A network allows sharing of point information between all control units. Additionally, a network provides central monitoring and control of the entire system from any distributed control unit location.
 - 8 Operator Interface Terminal: A GUI device (PC, laptop or dumb display terminal) which incorporates the Network Services Interface (NSI), Application Program Interface (API) for remote network client services. The operator interface terminal plugs into any Intelligent device or controller via RJ-11 or RJ-45 connectors.
 - 9 Supervisory Control Unit (SCU): A controller that incorporates network services host API to perform localised network management and network access services over a group of channel(s). Supervises groups of intelligent devices and Control Units to perform a global sequence of operation.
-

13.4.2 EXTENT OF WORK

- 1 The digital control and monitoring system is to include but not limited by the following extent of work:
 - a Control Equipment.
 - b Graphic User Interfaces.
 - c Control System Equipment.
 - d Installation.
 - e Operation.

- f** Testing.
- g** Maintenance.
- h** Training.
- i** Documentation.
- j** BAS Functions.
- k** Mechanical Services:
 - i** Fire Mode Control System (FMC).
- l** Electrical Services:
- m** Fire Protection Services.
- n** Vertical Transportation Services.
- o** Hydraulic Services.
- p** Miscellaneous equipment and Independent Systems.

13.4.3 WORKS COVERED BY OTHER SECTIONS OF THIS SPECIFICATION

- 1** Mechanical Services electrical switchboards including items on each switchboard for each item of plant equipment:
 - a** Auto/Off/Test switch.
 - b** Green and red indication lights – as per AS 60947.5.1 and Section 9 of this specification.
 - c** Lead/Lag/Remote Control switch for standby/duty equipment.
 - d** Hours run meters.
 - e** Green (open) and amber (close) for each smoke zone control motorised damper.
- 2** Other Switchboard items include:
 - a** Amber fire alarm indication lights.
 - b** Blue economy cycle lights.
 - c** Ammeter.
- 3** kWh meters' installation for energy recording and trading.
- 4** Integral controls for equipment excluding thermostats and interface to the control system where applicable.
- 5** Local indicating devices including annubars, pressure gauge, temperature gauge etc.
- 6** All 240 Volt power cabling from mechanical electrical switchboards to motors, actuators, heaters etc.
- 7** Motor speed drives and controllers.

13.5 MECHANICAL SERVICES

13.5.1 SYSTEMS

CS1 Apartment Bathroom/Laundry Exhaust Fans

CS2 Apartment Air Conditioning System
CS3 Ground Level Toilet/Cleaners Room Exhaust Fans
CS4 Ground Level Fire Pump Room Ventilation System
CS5 Ground Level Bin Rooms
CS6 Ground Tenancy Kitchen Exhaust Fan
CS7 Car Park Ventilation System
~~CS8 Communal Areas Air Conditioning System~~
CS9 Ground Level Substation Ventilation System
CS10 Ground Level Switch Room Ventilation System
CS11 Ground Level Comms Room Air Conditioning System
CS12 Ground Level Fire Control Room Ventilation System
CS13 Corridor Ventilation System
CS14 Stair pressurisation Systems
CS15 Pool PAC
CS16 Pool Plant Ventilation
CS17 Condenser Water System
CS18 Fire Mode Operation

13.5.2 CONTROL FUNCTIONS

For tender pricing purposes, the contractor shall allow for detailed control sequences based on the requirements of this specification, including referenced specifications and documents, including operation in the event equipment failure, loss of communications, power failure, temperature/pressure out of limits, fire alarms, etc., duty cycling, flushing/chemical dispersion cycle and registering alarms, out of limits alarms, excessive operation alarms, load shedding, optimum start/stop, etc.

CS1 Apartment Bathroom/Laundry Exhaust Fans

The Bathroom/Laundry exhaust fan in each apartment shall be fitted with two or three inputs to a relay. One input shall be from a load sensor on the laundry dryer power circuit (supplied and installed by the main Electrical services contractor). The second input shall be from the bathroom lighting circuit. The third signal shall be from a second bathroom lighting circuit (if applicable). Following the termination of the input signal, the exhaust fan shall switch off

CS2 Apartment Air Conditioning System

The air cooled reverse cycle fan coil & water cooled PAC units shall be supplied and installed with proprietary hard-wired controls for each apartment.

The controller shall have as a minimum the following functions:

- a) Programmable 24 Hr. / 7 Day timer
- b) Manual On/Off, Automatic function
- c) Heat, Cool
- d) Manual and Automatic Fan speed control (Low, Med & High)

- e) Temperature setpoint adjust
- f) LED output display, showing functions, setpoint and room temperature.

CS3 Ground Level Toilet/Cleaners Room Exhaust Fans

The exhaust fans serving the toilets and cleaners room shall be started and stopped via a 7 day / 24 hour fully adjustable timer, incorporating the following default time schedule as follows:

- a) Monday – Sunday: 7:00am to 10:00pm (to be confirmed by client)

Provide an after hours run-on timer (fully adjustable) incorporating illuminated push “ON” button to initiate after hours operation via DDC. Provide engraved label above control button indicating area served by push button.

Provide fan run/fault lights and auto/off/manual switches at the Ground Level mechanical switchboard.

CS4 Ground Level Fire Pump Room

The Fire pump room ventilation system shall be temperature controlled when the electric pump is running and shall be overridden to full capacity when the diesel fire pump is operated & shall be interlocked to a signal from the pump(s) control switchboard. Provide fan run/fault lights and auto/off/manual switches at the respective switchboard. System to be monitored on the base building DDC front end.

Monitoring of status, faults and alarms shall be provided via BMS.

CS5 Ground Level Bin Rooms

Exhaust systems shall be operated 24/7 and shall be monitored on the DDC.

Provide fan run/fault lights and auto/off/manual switches at the respective mechanical switchboard.

CS6 Tenancy Kitchen Exhaust Fan

CS7 Car Park Ventilation System

The car park exhaust & outside air make-up ventilation systems shall be automatically controlled by signals from Carbon Monoxide (CO) sensors located throughout the car park.

The exhaust air fans shall be connected to variable speed drives to enable the fans to ramp-up or down in response to the levels of CO in the carpark. The flow rates are based on performance based solution therefore the control strategy shall be as per the CFD report.

Provide fan run/fault lights, and auto/off/manual switches at a local mechanical switchboard.

System to be monitored on the base building DDC front end.

~~CS8 Common Area Air Conditioning System~~

~~The water cooled reverse cycle ceiling mounted PAC units shall be supplied and installed with proprietary hard wired controls.~~

~~The units shall be supplied with a local temperature sensor / controller. The controller shall include a LCD display, temperature set point, low/med/high fan speed and thermostat.~~

~~The units shall be connected to a central proprietary master controller located in the Building Manager's Office, with unified monitoring and control for the AC split systems.~~

~~Where individual wall mounted controllers are located within areas accessible by the general public, lock-out or limiting use codes shall be applied to the controllers to prevent tampering & incorrect adjustment.~~

~~The Controller shall have the following functions, as a minimum:~~

- ~~a) Monitoring and operation of individual indoor units~~

- e) Indication of units in a graphical display
- d) Measurement of room temperatures, outdoor air temperatures.
- f) System settings
- g) Automatic controls — Scheduling (daily, weekly, monthly, annual)
- h) Remote access via web-based system
- i) Storage of historical errors
- j) Generation of Alarms & remote communication to Maintenance/Service technicians.

CS9 Ground Level Substation Ventilation System

The substation mechanical ventilation system shall operate according to a 2-stage/step thermostat located in the substation, which shall provide 3 outputs (Off/low/high) to control the 2-speed fans, based on the room temperature.

Provide fan run/fault lights, low/high speed and auto/off/manual switches at Substation DB.

This strategy shall be confirmed with Citipower prior to installation.

CS10 Ground Level Switch Room Ventilation System

The Switch Room ventilation fans shall operate according to a 2-stage/step thermostat located in the room, which shall provide 3 outputs (Off/low/high) to control the 2-speed fan, based on the room temperature 27 °C (adjustable).

Provide fan run/fault lights, low/high speed and auto/off/manual switches at the respective mechanical switchboard.

System to be monitored on the base building DDC front end.

CS11 Ground Level Comms Room Air Conditioning System

The air cooled, cooling only, wall mounted split system shall be supplied and installed with proprietary hard-wired controls for the Comms Room.

The system shall operate 7 days / 24 hours. The unit shall be supplied with a BACnet interface card for monitoring and control via the base building DDC front end.

An additional output shall be provided to indicate failure at the respective mechanical switchboard.

Unit temperature set point shall be 27 °C (adjustable).

CS12 Fire Control Room

The Fire Control Room mechanical ventilation system shall operate in accordance with the requirements of the National Construction Code.

The system shall provide 30 air changes per hour to the room, when the door to the Fire Pump Room is open. When the door is closed, the fan shall ramp down via VSD based on a differential pressure of 20 Pa between the room and the adjacent corridor / foyer.

CS13 Corridor Ventilation System

The ventilation fans the serving corridor ventilation system shall be supplied and installed with proprietary hard-wired controls.

The east tower fan shall operate 24/7 (adjustable) complete with supply air temperature sensor. Fan control logic to be adjustable to temperature with manual override

The west tower fan shall operate 24/7 (adjustable) complete with supply air temperature sensor. Fan control logic to be adjustable to temperature with manual override. HHW coil shall operate to achieve 18-26 °C (adjustable).

Provide fan run/fault lights, and auto/manual switches at a local mechanical switchboard.

System to be monitored on the base building DDC front end

CS14 Stair pressurisation Systems

The Staircase Pressurisation System shall be activated by a General Fire Alarm & shall be controlled by a pressure sensors located within the relevant staircase to control the fan speed by means of a variable speed drive. Control shall be according to guidelines in AS1668 Part1 & Part 2. (Including connection to FIP).

Provide fan run/fault lights, and auto/manual switches at a local mechanical switchboard.

System to be monitored on the base building DDC front end

CS15 Pool PAC

The Pool PAC shall operate during the pool opening hours. Flow rates shall achieve 10ACH. Temperature set point to be 29 °C (adjustable).

The Controller shall have the following functions, as a minimum:

- a) Monitoring and operation of the unit
- b) Measurement of room temperatures, outdoor air temperatures.
- c) System settings
- d) Automatic controls – Scheduling (daily, weekly, monthly, annual)
- e) Remote access via web based system
- f) Storage of historical errors
- g) Generation of Alarms & remote communication to Maintenance/Service technicians.

System to be monitored on the base building DDC front end.

CS16 Pool Plant Ventilation

Exhaust systems shall be operate when the pool plant is operating and shall be monitored on the DDC.

Provide fan run/fault lights and auto/off/manual switches at the respective mechanical switchboard

CS17 Condenser Water System

The condenser water system consists of a force draft cooling towers and primary/secondary pumping system hydraulically isolated via heat exchangers. Forced draft boiler and pumps provide heat injection to the condenser water system. Each cooling tower, boiler, pump and heat exchanger is sized for 60% of the total capacity for the area that it serves.

The condenser water system is designed to provide a constant condenser water flow/return temperature. The condenser water system is to operate 24 hours. Provide flow/return temperature sensors at plant level.

Cooling Towers

The cooling tower system consists of induced draft cooling towers, side stream filtration units, and automatic chemical dosing units.

The cooling towers shall be controlled under the Building Management System to maintain the required leaving water temperature at setpoint.

The cooling tower fan shall be monitored via HLI from the fan VSD to the BMS. The following control points shall be “connected” to each fan variable frequency drive unit and shall be displayed on the relevant cooling tower system graphic on the operator terminal of the Building Management System.

- Fan speed control.
- Fan operating status.
- Fan fault status.

The cooling tower motorised isolation valves shall be monitored by the BMS and displayed on the relevant cooling tower system graphic on the operator terminal of the Building Management System

The cooling towers are designed to provide a variable condenser entering/leaving water temperature with a peak entering/leaving water temperature 33°/27.5C.

Each cooling tower back wash filtering system operates on time schedule to maintain the desired water conductivity levels required within the cooling tower basin.

The automatic dosing system chemically treats basin water to reduce the risk of biological fouling of the water. The dosing system, which generally operates on a weekly cycle, must also operate during periods when cooling towers have not been operable for long periods.

Primary Pumps

The primary pumps serving the condenser water circuit shall operate in a lead / lag configuration; one pump runs as a lead and the second pump as lag. In the event that the lead pump fails, the lag pump is enabled and shall become the lead pump until the fault is cleared in the failed pump. Primary pump speed is controlled through the associated VSD to maintain a condenser water flow temperature of maximum 29.5°C (high select, temperature adjustable) in summer, and 22.0°C (low select, temperature adjustable) in winter. The lag pump shall stage on as required to achieve the target condenser water temperature setpoints, and shall be controlled through the associated VSD to maintain the temperature setpoints.

The following control points shall be provided for each pump and shall be displayed on the relevant condenser water system graphic on the operator terminal of the Building Management System.

- Pump speed control.
- Pump operating status.
- Pump fault status.

Secondary Pumps

The secondary pumps serving the condenser water circuit shall operate in a lead / lag configuration; one pump runs as a lead and the second pump as lag. In the event that the lead pump fails, the lag pump is enabled and shall become the lead pump until the fault is cleared in the failed pump. Secondary pump speed is controlled through the associated VSD to maintain a condenser water flow temperature in the high, mid & low rise secondary condenser water circuits of 29.5°C (high select, temperature adjustable) in summer, and 22.0°C (low select, temperature adjustable) in winter. The lag pump shall stage on as required to achieve the target condenser water temperature setpoints, and shall be controlled through the associated VSD to maintain the temperature setpoints.

The following control points shall be provided for each pump and shall be displayed on the relevant secondary condenser water system graphic on the operator terminal of the Building Management System.

- Pump speed control.
- Pump operating status.
- Pump fault status.

Raise an alarm if condenser water flow temperature exceeds 33.0°C in Summer (adjustable), or drops below 18.0°C in Winter (adjustable)

CCW By-Pass Control Valves

The condenser water bypass valves shall be modulated to maintain the system differential pressure at its set-point of 260 kPa (adjustable) (pumps set-point plus 10 kPa (adjustable)) whenever any of the respective condenser water pumps are running.

Boilers

The condenser water heating system consists of forced draft condensing boilers and pumps.

The boilers and pumps shall operate in a lead / lag configuration; one boiler / pump runs as a lead and the second boiler / pump as lag. In the event that the lead system fails, the lag boiler / pump is enabled and shall become the lead system until the fault is cleared. The boiler pumps shall operate at constant speed, set via VSD in commissioning.

When a heating call is made, the boilers shall modulate under their own internal control to maintain a condenser water flow temperature of 22.0°C (low select, temperature adjustable) in winter. The lag boiler / pump shall stage on as required to achieve the target condenser water temperature setpoints.

The following control points shall be provided for each boiler / pump and shall be displayed on the relevant condenser water system graphic on the operator terminal of the Residential Building Management System.

- Boiler operating status.
- Boiler fault status.
- Pump speed control.
- Pump operating status.
- Pump fault status.

Lead / Lag Pump Selection

An automatic weekly change over program exists for lead / lag pump selection. Pump VSD's shall be connected to the BMS via a high level interface (HLI) for monitoring.

CS18 Fire Mode Operation

All fire mode operation shall be in line with the requirements of AS1668 and as per the Fire Authority, Fire Engineer and Building Surveyor's requirements.

13.5.3 TEMPERATURE SENSORS

- 1 Provide temperature sensors of the bulb or thermistor type with ranges selected to suit the particular application.
- 2 House sensors so that access to terminal strips and cabling can only be achieved by removal of a cover.
- 3 Supply duct sensors of the averaging type with capillary adequately supported to prevent sagging.
- 4 Mount sensors such that effects of radiation from heating elements are minimised.
- 5 Provide insertion sensors complete with stainless steel wells.
- 6 Supply wells to the Pipework Works Package for fitting into pipes.
- 7 Mount sensors to ensure a rapid response to changing temperature (of the sensed medium) is achieved.
- 8 Nominate the location of all sensors to the Pipework Works Package.
- 9 Achieve calibration of sensors (to compensate for non-linear characteristics, line resistance and similar items) in the control unit programme.
- 10 When used in conjunction with the control system or a separate control unit, the accuracy of the temperature sensors displayed value is $\pm 0.1K$.

13.5.4 STATIC AND DIFFERENTIAL PRESSURE SENSORS (AIR)

- 1 Provide static pressure sensors of the differential pressure type.
- 2 Sensor range (span) to be adjustable.
- 3 Accuracy of sensor including controller to be $\pm 2\%$ of span.
- 4 Sensors to be capable of withstanding a total pressure differential of 1000 Pa.

13.5.5 STATIC AND DIFFERENTIAL PRESSURE SENSORS (WATER)

- 1 Provide static and differential pressure sensors of industrial quality complete with span and zero-point adjustment from either software or hardware techniques.
- 2 Accuracy of sensors to be $+1\%$ of span.

- 3 Sensors to be capable of withstanding pressure ranges of vacuum to 2000 kPa without permanent effect on the operation of the device.
-

13.5.6 ELECTRONIC CONTROLLER MODULES

- 1 Accept a signal from the associated electronic sensor and provide an analogue output to controlled items.
 - 2 Incorporate an adjustable authority setting in dual input controllers.
 - 3 Use proportional plus integral (P & I) controllers for static pressure control, chilled and heating water flow control and supply air temperature control.
 - 4 P & I controller to incorporate an adjustable reset time.
 - 5 Outputs to be compatible with the controlled item.
 - 6 Control output accuracy $\pm 1\%$ of output span.
-

13.5.7 ROOM THERMOSTATS (MECHANICAL)

- 1 Combine a temperature sensing element with a temperature controller.
 - 2 Complete with concealed adjustable set point and throttling range.
 - 3 Selectable control action (i.e. direct or reverse acting) on the thermostat.
 - 4 Incorporate remote summer/winter set point adjustment and direct reverse action changeover where specified.
 - 5 Complete with neat, corrosion protected casings.
 - 6 Suitable for exposed surface mounting.
 - 7 Install in positions shown on the drawings 1500mm above floor level unless otherwise stated.
-

13.5.8 MOTORISED CONTROL VALVES

- 1 Generally, as detailed in the 'Pipework, Valves and Fittings' section of this specification.
- 2 Suitable for all working pressures and pressure differentials experienced under normal operating conditions.
- 3 Design and materials of valves and motors to be such that leakage of water from the stem packing does not cause corrosion of any working part.
- 4 Select modulating control valves to demand authority of the items served.
- 5 Minimum fully open resistance to the flow of one and one half times that of the combined pressure drop of the branch pipe and the item served.
- 6 Do not use butterfly or ball valves for control through coils.
- 7 To verify the selections made, prior to installation of valves, submit a valve schedule detailing valve make and model, valve pressure drop at design flow, valve flow coefficient (KV), pressure drop of item served at design flow and valve actuator.
- 8 Prior to installation of the valves verify selections made.

13.5.9 VALVE AND DAMPER MOTORS

13.5.9.1 GENERAL

- 1 Conservatively select all motors for the duty required.
- 2 Select or adjust operating speeds so that the motor will remain in step with controllers without hunting, regardless of motor variations.
- 3 Motors operating in sequence with other motors to have adjustable operating ranges and starting points to permit adjustment of the control sequence as required by the operating characteristics of the system.
- 4 Life span in excess of 50,000 open-close operations.
- 5 Accept an analogue or pulsed digital signal directly from the BAS control unit.
- 6 Time proportional feedback into the BAS is acceptable.

13.5.9.2 DAMPER MOTORS

- 1 Spring return type (excluding VAV motors), such that, in the event of power failure, they will 'fail safe' in either the normally open or normally closed position to suit the job condition.
- 2 A maximum of 40 seconds' spring return time.
- 3 A maximum spring tension time of 200 seconds.
- 4 Once tensioned the spring shall not engage the actuator mechanism unless power supply is lost.
- 5 Provide sufficient motors to ensure correct operation of dampers under all operating conditions.
- 6 1.2m² maximum size damper (CRVD) driven by a single motor.

13.5.9.3 VALVE MOTORS

- 1 Motors to be linear in operation fitted with a manual operator such that, in the event of a power or other failure, manual operation can be achieved.
- 2 Select motors for all valves to ensure correct operation and close-off, of the valves controlled, under all operating conditions.

13.5.10 FAN STATUS INDICATION

- 1 Air flow switches to indicate the status of selected fans.
- 2 Air flow switches of the differential pressure type with adjustable set point incorporating a single pole double throw switch mechanism arranged to changeover on a pressure rise and vice versa.
- 3 Switches complete with pitot tubes to sense the differential pressure between the suction and discharge sides of the fan.
- 4 Position tubes to eliminate blockage of tube openings.

13.5.11 TRANSDUCERS

- 1 Generally active type with an accuracy of +1% of span.
- 2 Accept a signal from the necessary transformers (current and/or voltage) and convert the signal(s) to a signal compatible with the BAS control unit.

- 3 Supply transducers to the relevant switchboard supplier for installation.
 - 4 Use Electronic to pneumatic transducers of industrial quality.
 - 5 Accurate to 3% of span and repeatable to 3% of span.
 - 6 Supply and install above items as part of the control system.
 - 7 Temperature compensated over the full span of the device.
-

13.5.12 ELECTRONIC CONTROLLERS

- 1 Controllers shall accept a signal from the associated electronic sensor and provide an analogue output to controlled items.
 - 2 Where dual input controllers are required these shall incorporate and adjustable authority setting.
 - 3 Proportional plus integral (P & I) controllers shall be used where specified for static pressure control, chilled and heating water flow control and supply air temperature control P & I controller shall incorporate an adjustable reset time.
 - 4 Outputs from all controllers shall be compatible with the controlled item.
 - 5 Where required, controllers shall incorporate provision for remote set point adjustment. Controllers shall be of the plug-in module type such that controllers can be replaced without necessitating removal and replacing or wiring.
 - 6 Control output accuracy shall be $\pm 2\%$ of output span.
-

13.6 FLOW / ENERGY MEASURING DEVICES

13.6.1 GENERAL

- 1 Common manufacture and type throughout project.
 - 2 Low pressure loss type.
 - 3 Microprocessor based signal converter/transmitter to communicate with BMS. Transmitters shall be available for pulse output, mod-bus and 4-20mA and be of low voltage type.
 - 4 Install in accordance with manufacturers' recommendations and with adequate lengths of straight pipe on either side of the device.
 - 5 Label with brass plate stamped to indicate all relevant piping data, gauge ranges, flow and temperature coefficient.
-

13.6.2 MAGNETIC FLOW METER

- 1 Accuracy of 0.2 % ± 1 mm/s. (of measured value)
- 2 Operation within ambient temperature of -40 to +70
- 3 Temperature range of -10 to +70 for Chilled Water or Condenser Water
- 4 Temperature range of -20 to +130 for Heating Hot Water or Hot Water
- 5 Teflon (PTFE), EPDM, Neoprene or NBR hard rubber to suit water quality and chemical treatment additives and fluid temperature.

- 6 Hastelloy C-276 / AISI 316 Ti electrodes.
 - 7 Maximum operating pressure PN 16.
 - 8 Suitable for sensing flow in either direction
 - 9 Meter shall be Siemens F M Mag 5100 W (or 3100W for Heating Hot Water / Hot Water applications), Endress + Hauser Promag 50P Series, or approved equal.
-

13.6.3 ULTRASONIC FLOW METER

- 1 Clamp on ultrasonic flow meters shall only be used for existing systems / pipework unless noted otherwise.
 - 2 Meter accuracy shall be within the requirements of EN1434 Class 2
 - 3 Accuracy of 0.5 % \pm 1 mm/s. (of measured value)
 - 4 Maximum operating pressure 100 bar.
 - 5 Suitable for sensing flow in either direction
 - 6 Meter shall be Siemens UH50 Series for line sizes 25mm NB and above and Siemens 2WR6 Series for line sizes 20mm NB., or approved equal
-

13.6.4 GAS DETECTORS

- 1 General
 - a Provide NATA test certificates at time of commissioning.
- 2 Combustible Gas Sensors
 - a Suitable for detecting natural gas levels of contamination to sub lower explosive limits.
 - b The detector element shall be of the plug-in type.
 - c Either a 24V, 4-20mA output signal.
 - d Gas detectors are to be located in all Gas meter rooms and gas pipe risers.
- 3 Atmospheric Gas Sensors (Fixed)
 - a Atmospheric gas sensors shall be carbon dioxide (CO₂ sensors).
 - b Sensors shall be complete with sensing elements and electronics mounted in an aesthetic single piece casing.
 - c Provide analogue measurement to the control system.
 - d Sensors range, 0-2,000ppm with less than \pm 5% Accuracy of full scale.
- 4 Atmospheric Gas Sensor (Portable)
 - a Provide a portable 'Nata' certified carbon dioxide meter similar to VAISALA GM IIA.
 - b Based on NDIR gas sensing.
 - i Four-digit LCD display.
 - ii Alarm level set point adjustment.
 - iii Audible and visible alarm with Audible suppression.
 - iv Flow fail alarm.

- v 12-hour battery life (rechargeable) unit complete with recharger.
- vi IP65 casing.
- vii 0 to 3000ppm $\pm 3\%$ full scale accuracy.

13.7 MISCELLANEOUS EQUIPMENT AND INDEPENDENT SYSTEMS

13.7.1 CENTRAL EQUIPMENT

13.7.1.1 GENERAL

- 1 Locate the central equipment in the 'control room' connect, configure and verify operation.
- 2 Provide central equipment suitable for operation in a standard, air conditioned, office environment.
- 3 Provide central equipment suitable for operation in ambient conditions normally encountered in non-air conditioned plantrooms (up to 50°C). (Inclusive of all power supplies and input/output devices).
- 4 Humidity control and special Anti-Static measures not provided.
- 5 Clauses regarding electromagnetic and radio interference requirements of equipment (in other sections of this specification) are applicable to the control system.

13.7.1.2 EXTENT OF CENTRAL EQUIPMENT

- 1 Central Equipment Comprising:
 - a File Server Operators Interface Terminal.
 - b Operators Interface Terminal.
 - c Notebook computer.
 - d Printer
 - e Ethernet hub.
 - f Network ancillaries.
 - g Network cabling and system.
 - h Furniture.

13.7.1.3 FILE SERVER OPERATORS INTERFACE TERMINAL

- 1 Package all components in a single enclosure with modular construction designed to permit easy access for maintenance.
- 2 Provide all leads, cables and connections.
- 3 System Specifications:
 - a Computer – Industry Standard Personal Computer
 - b Operating System – Current Windows
 - c Microprocessor – Highest commercial available clock speed/MIPS

- d** Memory Cache – Highest commercial available Kbytes, Level 2
- e** Bus Architecture – 64 bit
- f** Memory – 4GB RAM
- g** Fixed Hard Drive – 1TB
- h** Graphics Card – Highest commercial available, 32mb min., high resolution
- i** Drive Controller Memory Cache – Highest commercial available, 8mb min.
- j** DVD Drive – Highest commercial available read/write
- k** Parallel port – (1) capable of supporting printers and network connection
- l** Serial port – (1) RS-485 and (1) RS-232
- m** USB port – (4) USB – 2
- n** Network port – (1) Internal 100Mb/s
- o** Monitor – 17” SGVA Colour LCD with 16mb VRAM
- p** Keyboard – Enlarged, 101 keys
- q** Mouse – 3 button
- r** Modem – Highest commercial available
- s** Interface Boards – Network Interface board driver

13.7.1.4 OPERATORS WORKSTATION

- 1** Package all components in a single enclosure with modular construction designed to permit easy access for maintenance.
- 2** Provide all leads, cables and connections.
- 3** System Specifications:
 - a** Computer – Industry standard personal computer
 - b** Operating System – Current Windows
 - c** Microprocessor – Highest commercial available clock speed/MIPS
 - d** Bus Architecture – 64 bit
 - e** Memory – 4GB RAM
 - f** Fixed Hard Drive – Size based on all installed software plus 75% free space, min. 80 Gb
 - g** Graphics Card – Highest commercial available, 32mb min., high resolution
 - h** CD/DVD Drive – Highest commercial available read/write
 - i** Parallel port – (1) capable of supporting printers
 - j** Serial port – (1) RS-232 and (1) RS-485.
 - k** USB port – (4) USB - 2
 - l** Network port – (1) Internal 100Mb/s
 - m** Memory – Highest commercial available, KB Level 2

- n** Monitor – 17” SGVA Colour LCD with 16mb VRAM
- o** Keyboard – Enhanced 101 keys
- p** Mouse – 3 button
- q** Interface boards – Network Interface board/driver

13.7.1.5 NOTEBOOK COMPUTER

- 1** Provide a fully configured colour screen notebook computer for the facility of network, field and remote interrogation.
- 2** Provide field connections, fly leads and any peripheral hardware required for connection to the control system.
- 3** System Specifications:
 - a** Computer – Industry Standard Personal Computer
 - b** Operating System – Current Windows
 - c** Microprocessor – Highest commercial available clock speed/MIPS
 - d** Memory Code – Highest commercial available Level 2
 - e** Bus Architecture – 32 bit
 - f** Memory – 4GB RAM (Expandable to 8GB)
 - g** Fixed Hard Drive – Size based on all installed software plus 75% free space, min. 500 Gb
 - h** Graphics Card – Highest commercial available, high resolution
 - i** CD/DVD Drive – Highest commercial available read/write
 - j** Parallel port – (1) Installed
 - k** Serial port – (1) RS-232 and (1) RS-485.
 - l** USB port – (2) USB – 2
 - m** Network port – (1) Internal 100Mb/s
 - n** Monitor – Min. 12.1” TFT XGA Resolution highest commercial available
 - o** Keyboard – Integral (with external connecting)
 - p** Mouse – Keyboard mounted touchpad (external capable)
 - q** Interface ports – 2-PCMCIA
 - r** Modem – (1) -internal 56K Industry Standard
 - s** AC adaptor – Integrated
 - t** Battery – Li-Ion

13.7.1.6 PRINTER

- 1** Provide a fully configured LaserJet printer configured to act as a network printer server.
- 2** Provide field connection, fly leads and any peripheral Hardware required for connection to the control system.
- 3** System Configuration:
 - a** Resolution – 600 dpi and > 120 levels of grey
 - b** Throughput – 24 ppm

- c Memory – 16mb
- d Media capacity
 - i (1) 500 sheet A4 Automatic feed
 - ii (1) 500 sheet A3 Automatic feed
 - iii (1) 100 sheet multipurpose Automatic and Manual feed
- e Interface – Network card
- f Operating System Support – Current Windows

13.7.1.7 ETHERNET HUB AND PATCH PANEL

- 1 Provide a 10 Base-T Ethernet Hub with adequate RJ45 connections to accommodate the number of network clients.
- 2 Provide for 5 spare RJ45 connections on the Hub.
- 3 Provide (1) BNC hub connection for server.
- 4 The hub shall be scaleable by stacking add on or accessory modules.
- 5 The hub shall be designed to have bridges, routers and switches added and managed as one system.
- 6 Hub to be capable of operation with Windows NT based SNMP management software which supports TCP/IP protocol and permits the development of user defined applications for seamless desktop Integration.
- 7 Provide a RJ-45 patch panel integrated into a 19" rack assembly.
- 8 Provide adequate patch panel leads to accommodate the number of network connections plus 5 spare.

13.7.1.8 NETWORK ANCILLARIES

- 1 Modem Gateways:
 - a Provide (1) Modem Gateway.
 - b Austel approved.
 - c Industry Standard.
 - d Capable of transmission rates auto adjustable at between 2400 and 56000 baud rate.
 - e Network connected and configured to act as a Network modem server.
 - f Network, OS and control system compatible.
 - g Supply all software.
- h Paging Gateway:
 - i Provide (1) Paging Gateway.
 - ii Austel approved.
 - iii Utilise for alarm notification.
 - iv Provide 2 pagers compatible to the system.
 - v Provide connection to a paging network (alpha numeric) system.
- i Interfaces:

- i Provide for system interconnection High Level Interfaces (HLI) by MODBUS plus 1 Mbit band real time link to allow the control system to be transparent and allow to control all output, monitor all inputs and trend all log points. Interface shall be capable of transmitting full alpha numeric descriptors.
- 2 Lontalk to Ethernet Gateway.
- 3 Other options may include PLCs, BACnet.
- 4 Email bridge.

13.7.1.9 NETWORK CABLING AND SYSTEM

- 1 Provide a local area network (LAN) with the following minimum physical and media access requirements.
 - a Ethernet; IEEE standard 802.3.
 - b Cable; 10 base-T, UTP-8 wire, category 5.
 - c Minimum throughput; 100 mb/s.
- 2 Supply and install all cable and equipment necessary to provide a complete system.
- 3 Conceal conduit in walls, ceiling, skirting and cable ducts. Provide receptacles, junction boxes repeaters, subnet hubs and other accessories as required.
- 4 Supply, test and commission LAN software.
- 5 Set-up and configure the BAS local area network hardware to permit the functional requirements of the BAS to be obtained. In addition, document and provide as a minimum the following network management procedures:
 - a Define all user password and log on names and security access privileges in all modes of communication from each network node.
 - b Automatic tape back-up of the file servers.
 - c Load and debug all software installations.
 - d Configure and set-up all node peripherals (printers, mouse, monitors, etc.).
 - e Power conservation mode.
 - f File server(s) disk transaction log set-up and automatic operation. Logs shall be generated in SQL format and imported to a graphical user spreadsheet application.
 - g Automatic disk mirroring to maintain consistency between the back-up file server(s).
 - h Set-up of group E-mail and scheduling utilities.
 - i Software and hardware inventory.
 - j Network Operating Software:
 - k General: Provide a 32 bit, disk-based multi-tasking, multi-user operating system to support the network functions and application routines. Provide the most current version of Windows NT advanced server for application and file servers and NT Workstation for the Operator Interface terminals, remote personal computers, and notebooks.
 - l The Multi-Tasking requirement means the concurrent processing of more than one application residing in memory:
 - m Virtual Memory Protection: Provide automatic memory protection to protect the memory area assigned to a particular task from other tasks executing in the system.

- n Priority Scheduling: Tasks shall receive access to processor time on a priority basis. Each task shall be assigned to a priority level. A minimum of 250 priority levels shall be provided. Provide a means to assure that tasks with the same priority can be interrupted at the occurrence of an alarm, pace designated event and on a time-basis. Memory allocation shall be accomplished dynamically. Tasks waiting to run shall be queued and brought in from the disk by priority.
 - o Task Swapping: Provide a means of interrupting an active task and swapping that task with a higher priority task on the disk. Tasks shall be declared swappable or not swappable at task creation. The interrupted task shall be swapped back into memory and continue at the point where it was interrupted.
- 6 Multi-User Structure: Multi-User means that multiple operators from multiple network nodes (for example, PCs, workstations, printers, and so forth) shall be able to concurrently issue commands to the system. The Network Operating System (NOS) shall also accept simultaneous operator commands, and program development.
 - 7 The NOS shall be based on the TCP/IP transport and network layer protocols. The network operating system shall permit different hardware manufacturers that support TCP/IP protocol to be used and interoperate with the hardware provided.
 - 8 The NOS shall permit MS-DOS, Macintosh, OS/2, POSIX Complaint and Windows based applications to run concurrently as protected application subsystems.
 - 9 The NOS shall offer a file management system that offers the following features:
 - a Hot fix and full raceway system to restore file integrity.
 - b Transaction log for disk structural integrity.
 - c Disk Mirroring.
 - d Drive Duplexing.
 - e Stripping.
 - f Support for uninterruptible power supplies.
 - 10 The NOS shall provide secure transfer of data, such as:
 - a Individual authentication.
 - b Discretionary access control.
 - c Auditing.
 - d Security assurance controls, including zeroing memory and configurable rights.
 - 11 The NOS shall have built-in workgroup features such as:
 - a Integrated voice and e-mail system.
 - b Group scheduling.
 - 12 Provide graphic network administration tools to permit any station (node) on the network to be used to perform network management functions. The tools shall permit the network manager to view network performance and current event or activities. In addition, provide management tools which permit the following functions:
 - a Distribute data files.
 - b Inventory of installed hardware and software.
 - c Distribute and installed software to clients (stations and servers.)
 - d Manage network applications.

- e Monitor network software installations and configurations to determine inconsistencies or improper set-up.
- 13** Provide Uninterruptible Power Supply (UPS) utilities to automatically execute an orderly shut-down of all network clients and servers, as well as backup. The UPS utility shall be initiated upon loss of main power and complete shut-down procedures within the UPS backup power time limit.
- 14** Software shall include as a minimum:
- a Network operating software.
 - b User interface software.
 - c Microsoft office.
 - d HVAC application software (BAS GUI).
 - e Telephoning software.
 - f Lighting control application software (may be included in BAS GUI).
 - g Electrical demand limiting (may be included in BAS GUI).
 - h Security System (may be included in BAS GUI).
 - i Energy management (may be included in BAS GUI)
 - j Fire and smoke control (may be included in BAS GUI)
 - k Power management (may be included in BAS GUI).

13.7.1.10 FURNITURE

- 1 Provide furniture for the User Interface Terminal equipment, printers and network management station (adjacent to database servers).
- 2 User Interface Workstations shall be arranged in a semicircle configuration around the operator. Work spaces shall be provided for A4 and A3 printed materials to be used without interference to provided controls, keyboards, etc.
- 3 User Interface workstation lighting shall be provided to supplement normal office lighting overhead. Such lighting shall be compatible with the type and colour spectrum of lighting overhead to prevent eye strain. All surfaces shall be washable.
- 4 Antistatic discharge pads or other methods shall be furnished to prevent any disruption of services at the consoles by electrostatic discharges.
- 5 A console chair with armrests and seat height adjustment shall be included for each workstation.
- 6 Network management station shall be in a 'L' shaped workstation. A minimum of 2500mm of table top space shall be provided. Table tops shall be of a standard Formica finish with plastic edging. Provide each station with two sets of two drawers, and locking lateral files.

13.8 GRAPHIC USER INTERFACE

13.8.1 OPERATING SYSTEM

- 1 Schedule all programmes for execution and support a multi-tasking programme environment which provides for the concurrent execution of multiple real time programmes and programme development.

- 2 Incorporate a multi-user capability such that multiple operation for multiple input/output devices shall be able to concurrently issue commands to the running system programme.
 - 3 Provide a foreground/background structure to allow the real-time control and operator interface programmes to run in the foreground while programme assembly, compiling, de-bugging and loading executes in the background.
 - 4 Manage a scheme of storage protection that will enable background activities to proceed without affecting the operating system or real time programmes. Such protection to prevent accidental modification of the Operating System or real time programmes resulting from execution of any background activities.
 - 5 Shutdown in an orderly manner when a power failure occurs.
 - 6 Automatically execute a 'bootstrap' routine to restart the system when power is restored.
 - 7 Return the system to full operation by automatic restart.
 - 8 Audibly annunciate a failure of any transmission data path on the system operator's terminals.
-

13.8.2 SYSTEM ACCESS

- 1 Operators to gain access to the system by 'signing on' to a operator's terminal.
 - 2 Achieve sign on by entry of a unique (to each operator) password and/or identification code.
 - 3 Assign each operator a system access level to enable that operator, once signed on, to access only those command and programme functions that have an equal or lower access level.
 - 4 Provide a minimum of 3 access levels.
 - 5 Provide point lockout capability.
 - 6 Assignment or reading of operator passwords (and/or identification codes) to be available only at the highest access level.
 - 7 Support a minimum of 20 separate operators.
 - 8 Record (in mass memory and optionally on a selected printer) each sign-on activity.
 - 9 Terminals to automatically sign-off after a pre-set time (adjustable 1 min. to 24 hours) if no keyboard activity has occurred.
 - 10 Manual 'sign off' by operators.
-

13.8.3 OPERATORS' TERMINAL DISPLAYS

- 1 Colour graphic Visual Display as specified herein.
 - a Dedicated change of state area at the top of the screen (for display of change of state information and alarm action messages).
 - b Display Header with the current date, time and operator (if the terminal is 'signed on')
 - c The operator shall be able to access displays via a pointing device and/or soft key menus with a choice of function keys, curser control keys or any key on the keyboard.
 - d Supported pointing devices shall include mouse, touch screen, light pen or track ball.
-

13.8.4 ALARM MONITORING

- 1 Provide monitored input alarms to the control system from any of the functional zones or remote site.

- 2 Assign as required or inhibit until required for each point of strategy.
- 3 Use time delays or filters to ensure an establishment time has elapsed prior to alarming or sequence changing.
- 4 Provide digital signals for monitoring high limit or high/low level fault conditions.
- 5 Provide time delays or filters to prevent spurious or spontaneous high or low limit faults for only short duration (i.e. non-critical).
- 6 Use analogue inputs for monitoring the condition of certain variables which incorporate high and low level inputs considered to be detrimental to operation comfort conditions.
- 7 Values of these high and low limits to be as directed during the commissioning process and automatic changes to set points in either occupied/unoccupied conditions.
- 8 Only use alarms of this type if the monitored equipment is scheduled to operate.
- 9 Apply different variable time delays once stabilisation has occurred following start up.

13.8.4.1 ALARM PRIORITIES

- 1 Prioritise each alarm:
 - a Level 1 – Critical – Urgent
 - b Level 2 – Important – Not Critical
 - c Level 3 – Maintenance
- 2 In each case log the alarm to a file and maintain an alarm history.
- 3 In each case print the alarm.
- 4 Include the date, type of alarm, time, current value, alarm priority, alarm limit, operator name, alarm group name and any comment.
- 5 User selectable for displays.

13.8.4.2 LEVEL 1 – CRITICAL – URGENT

- 1 Assign Level 1 alarms to critical operational aspects requiring immediate attention and rectification.
- 2 Sequence as follows:

13.8.4.3 DURING OCCUPIED TIMES

- 1 Local alarm at the control system front end computer using third party icon or multi-tasking prompt.
- 2 Local alarm at all personal computers connected to the control system or multi-tasking prompt.
- 3 Activate the pager link if not acknowledge within 5 minutes. Message - Level 1 alarm.

13.8.4.4 DURING UNOCCUPIED TIMES

- 1 Dial pager link. Message - Level 1 Alarm.
- 2 Further disseminate alarms and page to the relevant services personnel, e.g. fire, security, mechanical, electrical.

13.8.4.5 LEVEL 2 – IMPORTANT – NOT CRITICAL

- 1 Assign Level 2 alarms to either non-critical failure, or where failed plant has auxiliary back-up and will continue to operate satisfactorily without immediate action.
- 2 Sequence as follows:

- a During Occupied Times
 - i Local alarm at the BAS front end computer using third party icon or multi-tasking prompt.
 - ii Activate the pager link if not acknowledge within 60 minutes to a specially assigned pager. Message - Level 2 alarm.
- b During Unoccupied Times - Weekdays and Weekends
 - i Local alarm at the control system front end computer using third party icon or multi-tasking prompt.
- c During Unoccupied Times - Weekends - Daytime 8.00 am to 9.00 pm
 - i Dial pager link and page to a specially assigned pager. Message - Level 2 Alarm.
 - ii Further disseminate alarms and page to the relevant services personnel, e.g. fire, security, mechanical, electrical.

13.8.4.6 LEVEL 3 – MAINTENANCE

- 1 Assign Level 3 alarms to non-critical processes and use to flag matters overdue for maintenance attention. These may relate to filter life exceeded where failure is not likely, but if left unchecked could fail.
- 2 Sequence as follows:
 - a At All Times
 - i Local alarm at the control system front end computer using third party icon.

13.8.5 COLOURGRAPHIC VISUAL DISPLAY UNIT OPERATION

- 1 Provide 32 colour graphic capability in the graphics mode.
- 2 Incorporate instantaneous updating of dispersed real time data
- 3 Provide effective means for the operator to relate to the field.
- 4 Utilise full alphanumerics which spell out in plain English any condition, value, or action to be taken.
- 5 Incorporate in each graphic adequate freely assigned connected or calculated points (min 40).
- 6 Construct and store graphics in the CPU mass storage units ready to be displayed.
- 7 Position all dynamic data points to their respective location on the static portion of the graphic.
- 8 Provide keyboard programmable graphics and all related dynamic data display points without interfering with the on-line operation of the system.
- 9 Use an interactive, conversational mode to construct graphics data files and display them.
- 10 Use programmable colour graphics with dispersed dynamic data providing real time system information.
- 11 Provide a system diagram associated with a point in alarm indexed from the dedicated alarm section of the screen, displayed by activating a Command Function via the keyboard or (as a programmable option) automatically on receipt of an alarm.
- 12 Flashing symbols and point identifiers on the diagram in a pre-programmed alarm colour will enunciate until acknowledged.
- 13 An acknowledged alarm will stop flashing.
- 14 The point in alarm will return to normal when the alarm is corrected in the field, only after acknowledgement.

- 15 Periodically update graphics (<30 seconds) to keep displayed data current with actual field conditions.
- 16 Use a number of interactive construction programmes and a library of standard symbols representing devices such as coils, smoke detectors, temperature sensors, thermals, contacts, speakers, pumps, fans, dampers, motors and relays to enable easy development of system colour graphics via the keyboard and mouse controller.
- 17 Use graphic construct programmes to place the desired line drawings or symbols in the appropriate place on the screen, assign point type, colours and text.
- 18 Test completed diagrams for accuracy and validity.
- 19 Standard symbols library shall be augmented by user defined symbols at any time.
- 20 Provide editing features for adding, deleting and modifying data, as well as format controls.
- 21 Provide software controlled access to colour graphics so that only designated operators can display or modify files.
- 22 Identify each manually forced point (i.e., not in automatic control) on the graphic via inverse video with a different background colour to that associated with alarm.
- 23 Identify each point associated with a failed communications line and/or controller on the graphic via inverse video with a different background colour to either alarms or manual forcing function.
- 24 Provide control loops capable of being investigated by graphic penetration, i.e. construct all graphics in levels as follows.
 - a Level 1 – Graphics detailing building overview.
 - b Level 2 – Graphics detailing floor plans.
 - c Level 3 – Graphics detailing control loops on each floor/system.
- 25 System software to accept adequate penetration levels of graphics (min 6)
- 26 System software to raise and lower the level of the graphic by moving the cursor, via the mouse, to a selected window or entering a single character command via the keyboard.
- 27 Supply separate graphics for each sub-system and control loop within a sub-system.
- 28 Do not provide separate graphics for multiple identical equipment (ex. VAV boxes), re-use the graphic with specific tabular information inserted.
- 29 Provide facility for storage and retrieval of information pertaining to each group of equipment (ex VAV box) via a common logical group.
- 30 Allow for the construction of graphics for all control loops and sub systems or 60 off, whichever is greater.

13.8.5.1 LOGICAL GROUPS

- 1 Provide facility to assign system points into logical groups comprising related points.
- 2 Grouping to be independent of hardware configuration.

13.8.5.2 SYSTEM LOGS AND DISPLAYS

- 1 Provide facility for operator to display system logs (on either the visual display terminal or the printer) on request.
- 2 Logs to include:
 - a Alarm Summary logs: Summary of all current alarms.
 - b Status Logs: Review of the status of all system points.
 - c Time Schedule logs: Review of all, or selected, time schedules.

- d** Logical Group Logs: Review of all points in a particular group.
- e** Event Programme Logs: Review of all event programmes.
- f** Trend logs: Log of the value of selected points as recorded at predetermined intervals.
 - i** Provide for a minimum of 10 logs each trending 10 points.
 - ii** Provide for adjustment of sample times in one minute increments from 1 min. to 24 hrs.

Note: Destination of the log report (e.g. printer, file and/or operator's terminal) to be operator selectable.

13.8.5.3 TIME AND EVENT INITIATED PROGRAMMES

- 1** Provide a facility to issue commands to various points in the system from the control system central equipment.
 - a** Initiate commands as follows:
 - i** Manually, via operation of an operator's terminal keyboard.
 - ii** On a time, schedule basis (including holiday override).
 - iii** On an event basis. Events to consist of changes of state (e.g. controller system alarms including analogue alarms), fire alarms, power failures, changing of a point value (e.g. a calculation result) and similar items).
 - b** Include typical commands as follows:
 - i** Sequential starting or stopping of selected equipment (with time delays between starts)
 - ii** Changing the value of a controller system parameter (e.g. set point).
 - iii** Initiation of power fail modes.
 - iv** Initiation of a system report.

13.8.5.4 HISTORICAL LOGGING

- 1** Store selected information on the control system mass storage unit.
- 2** Contain historical data in a file in two ways - as a 'wrap around' file and as a 'one shot' file.
- 3** Overwrite the oldest information with new incoming data when a wraparound file is full.
- 4** Store information in a one shot fill to the limits of the defined capacity.
- 5** Audibly annunciate the fact that a one-shot file is almost full and initiate a COS message.
- 6** Select system activity to be stored in the historical files. Include the following options:
 - a** Selected (or all) change of state information (Off/On as well as Alarm/Normal)
 - b** Selected (or all) hours run information.
 - c** Selected (or all) analogue information (trend logs).
 - d** Any combination of the above.
- 7** Historically record all alarms and data for subsequent retrieval.
- 8** Record and automatically print hours run information from each plant (in a 'plant run' report) at the end of each week.

13.8.5.5 CONTROL UNIT PROGRAMMES

- 1** Retain a copy of all connected control unit programmes on the Central Equipment.
- 2** Downline load these programmes to the control units.

- 3 Upline load control unit programmes to update the Central Equipment.

13.8.5.6 CLOCK SYNCHRONISATION

- 1 Regularly synchronise the real-time clocks in each controller to ensure that each control unit operates in synchronisation with all other controllers.

13.8.5.7 HELP FUNCTION

- 1 Windows type help feature to guide system operators in the selection or operation of system functions.
- 2 Facility to enable operator to display help pages via operation of a single help key.

13.8.5.8 DOCUMENTATION

- 1 Software which enables display, print out and alteration of system configuration documentation, as detailed elsewhere in this section of the specification.

13.8.5.9 OPERATOR FUNCTIONS

- 1 Alter existing or enter new programmes.
- 2 Display reports (on visual display terminals or printers).
- 3 Display point information.
- 4 Command system points (including controller parameters).
- 5 Perform similar functions on-line from the 'signed-on' visual display terminal.
- 6 Examples of functions to be performed by authorised operators include:
 - a Display point status information.
 - b Alter system control parameters.
 - c Manually initiate time and event programmes.
 - d Display system logs and reports.
 - e Alter time schedules and creating new time schedules.
 - f Alter event programmes and create new event programmes by simple mouse driven graphics.
 - g Assign operator access levels and sign-on codes.
 - h Downline and up line loading programmes to controllers.
 - i Review historical data.
 - j Create or modify historical logging files.
 - k Alter controller control strategies and create new control strategies.
 - l Assign new input/output points.
 - m Alter existing, or assign new descriptors or action messages.
 - n Other similar functions.

13.8.6 RESPONSE TIMES

13.8.6.1 GENERAL

- 1 The response times detailed below are the maximum acceptable response times for various sequences/processes in the control system. (Note operator's interface terminal shall mean VDU and/or printer as appropriate).
- 2 Achieve times with a fully configured and operational system (as defined herein) not affected by addition of spare hardware or software as specified.

13.8.6.2 ALARM DISPLAYS

- 1 Time not to exceed 1 second for activation of an alarm (at the source) to registration on the operator's interface terminal.

13.8.6.3 CHANGE OF STATE REGISTRATION ON OPERATOR'S INTERFACE TERMINAL

- 1 Time not to exceed 2 seconds from activation of a change of status or value of a control unit input, to the update of the input in the data base and registration on the system operator's interface terminal.

13.8.6.4 GRAPHIC DISPLAYS

- 1 Time not to exceed 2 seconds from activation of an alarm, or change of status or value of an input, to the registration of this new information on a displayed graphic.
- 2 Time not to exceed 2 seconds for entry of a request for a graphic display until complete output of such display.

13.8.6.5 SYSTEM LOGS AND REPORTS

- 1 Time not to exceed 20 seconds from execution of a request for a system log or report to commencement of the printout or display of that report.

13.8.6.6 HISTORICAL DATA RETRIEVAL

- 1 Time not to exceed 30 seconds from execution of a request for display of historical data to commencement of the display.

13.8.6.7 EVENT INITIATED PROGRAMMES

- 1 Not to exceed 2 seconds from occurrence of an event (at the source) to the activation of an associated event programme.

13.8.6.8 MANUALLY INITIATED COMMANDS

- 1 Time not to exceed 1 second from execution of a manual command (via the system operator's interface terminals) to response of the commanded item.

13.8.7 CONTROL PRIORITIES

- 1 Control units to respond to programme control in the following priority (highest priority is listed

SOURCE	ACTION
Control Unit	Fire Mode Control
Control Unit	Power Fail Restart
Portable Operator's Interface Terminal/Central Equipment	Power Fail Restart
Portable Operator's Interface Terminal/Central Equipment	Manual override from operator's terminal

Portable Operator's Interface Terminal/Central Equipment	Time Schedule override
Control Unit	Local control programme

- 2 Arrange the control system programme such that manual override of equipment (dampers, etc.) will not prevent correct operation of plant during power fail and fire modes.
- 3 To ensure this priority it may be necessary to effect override control of equipment via a parameter change in the BAS programme, rather than 'forcing' control unit outputs/inputs.

13.8.8 SOFT STARTING

- 1 Monitor the Power Authority's incoming supply by a 3 phase, phase failure sensor.
- 2 Upon loss of Power Authority's supply allow all plant to shut down and auxiliary alternator to start.
- 3 Activate only essential equipment in a soft starting or delays schedule activation to ensure the essential supply circuit breaker does not trip.
- 4 Use the load information from this breaker to load shed if the current approaches a critical level.
- 5 Install current transformers for this purpose.
- 6 Before power restoration sequentially re-start all plant operating prior to Power Authority's supply failure.

13.8.9 POINT MONITORING

- 1 Carry out point monitoring for nominated control interactions.
- 2 Utilise point monitoring for maximum run times.
- 3 Allow to totalise run times for all equipment.
- 4 Utilise totalised run times for maintenance management of components to manufacturers' requirements through maintenance management software.
- 5 All the facility to monitor all connected equipment for both pressure failure and operation.

13.9 CONTROL SYSTEM EQUIPMENT

13.9.1 GENERAL

- 1 Locate control system equipment in accessible locations in plantrooms and mounted on associated equipment.
- 2 Equipment located in public accessible areas to be provided with lockable enclosures.
- 3 Provide equipment suitable for operation in ambient conditions normally encountered in non-air-conditioned plantrooms (up to 50°C) of input/output devices).
- 4 Provide central equipment suitable for operation in a standard, air conditioned, office environment.
- 5 Do not provide humidity control and special Anti-Static measures.

13.9.2 EXTENT OF CONTROL SYSTEM EQUIPMENT

- 1 Controllers.

- 2 Routers, Bridges, Repeaters and transceivers.
 - 3 Gateways.
 - 4 Control Panels.
 - 5 Hand held operator's terminal (portable).
 - 6 Power supply.
 - 7 Notebook computer.
-

13.9.3 CONTROL UNITS

13.9.3.1 GENERAL

- 1 Provide control units complete with power supplies, real time clock, input and output modules, memory and all other items necessary for proper and correct operation of the control system.
- 2 Control units shall be capable of standalone operation.
- 3 Each control unit shall support a fully operable connection by the control system LAN, laptop/notebook computer or hand held operator's terminal via a RJ-45, RJ-11 or DB9 connection.
- 4 Calibrate each analogue input to compensate for non-linear characteristics of input devices, line resistance and similar items.
- 5 Retain calibration data in controller memory.
- 6 Once programmed, calibration equipment must not require adjustment.
- 7 Allow for high and low alarm facility to be assigned to each analogue input.
- 8 Allow for 'Lock out' of alarms when associated equipment is not operating.
- 9 Use digital inputs in the form of voltage free contacts (with 'wetting' voltage supplied by the controller) which open for the ON, or alarm condition.
- 10 Use digital outputs in the form of voltage free contacts (relay outputs) which close for the ON position.
- 11 Include relays to achieve contact outputs where control units utilise switched voltage outputs.
- 12 Minimum rating of contacts, 80 VA at 24 V, 50 Hz.
- 13 Supply each output with an AUTO-ON-OFF switch which overrides the control unit output in the ON and OFF positions.
- 14 Isolate control unit inputs and outputs including transmission trunk, via optical couplers or other approved means, to provide protection against voltage surges, incorrect voltages and other such disturbances.
- 15 Input/output hardware used (provide as spares per control unit a minimum of 10% of each input and output type. These are not detailed on any point schedules).
- 16 In the event of a power failure, control units to perform the following functions:
 - a All operating programmes, data files and control algorithms to be contained in each control unit.
 - b Retain in memory for a minimum of 24 hours all programmes, data files, control algorithms and time schedules.
 - c Maintain current time by the real-time clock.
 - d De-energise all outputs when not scheduled to function.

- 17 Upon restoration of power, controllers to perform the following functions:
 - a Check all inputs (including the real-time clock).
 - b Perform necessary control actions to bring all outputs to the required state at the time of power restoration.
- 18 The control unit to recognise open or closed circuits on sensor inputs and annunciate as alarms.

13.9.3.2 SMALL POINT CONTROL UNITS

- 1 Monitor and control VAV terminals or any item of plant that requires only a small input/output capacity.
- 2 Include all hardware and programmes required for communications with control unit or other communications device.
- 3 Control programmes to reside in the control unit.
- 4 Application programmes to be maintained in ROM.
- 5 Set points and configuration data to be maintained in EE PROM (or similar).
- 6 Communications speed and protocol to be capable of ensuring that with the maximum number of control units on a channel, response times are such that safe, correct and timely operation of all controlled items is ensured.
- 7 Control units shall be complete with all inputs and outputs as required to monitor and control the connected equipment (e.g. VAV box) together with an additional 2 digital inputs and 2 digital outputs.

13.9.3.3 SOFTWARE

- 1 Utilise standard, proven software specifically designed for HVAC control functions for the control system.
- 2 Include diagnostic routines that check hardware for correct operation.
- 3 Annunciate all hardware faults on the operator's terminal.
- 4 Ensure systems are capable of forcing input and output values in the software to enable programme verification and diagnostics (e.g. capable of forcing an analogue input to set value). Highlight points 'in test' so forced when displayed on any display terminal (portable or central).
- 5 Scan times of programmes configured so as to ensure safe and correct operation of all controlled items.
- 6 Ensure the rate at which data is exchanged between different controllers is sufficient to enable correct and timely operation of equipment.
- 7 Maximum transfer time between controllers not to exceed 1 second.
- 8 Maximum scan and programme execution time to be 1 second (i.e. all inputs scanned and outputs altered in accordance with control strategies within this time).
- 9 Total response times of equipment in alarm and fire modes (e.g. from receipt of input to final positioning of output device) to be less than 30 seconds at all times.
- 10 Include the following software regardless of whether specifically required to perform functions described in this Specification.
 - a Communications software to enable monitoring, control and programming from the central equipment.
 - b Communications software to enable transfer of data between controllers (including small point controllers) without the requirement for any other communications device.
 - c Standard Energy Management software including Optimum start and stop, Enthalpy control (economy cycle), night purge, power peak demand forecasting and load shedding, duty cycling, night setback and load reset.
 - d Proportional, proportional plus integral and proportional plus integral plus derivative control.

- e On/off control and floating control.
- f Pulse width modulating control.
- g Time proportional control.
- h Time schedule (time switch) control based on time of day and calendar date (including holiday override)
- i 10 minutes' maximum increment for time control.
- j An independently adjustable start and stop time for each time controlled item.
- k Derived alarms (alarms resulting from a series of logic comparisons).
- l Sequential control.
- m Ability to develop control strategies using standard operations which include arithmetic operators (add, divide, multiply, subtract, square root etc.), timers, logic comparisons (less than, greater than, high select, low select etc.), logic sequences (if...then...) (or, and, nor) and other similar functions.

13.9.4 PROGRAMMING

- 1 Include for complete programming of the control system to achieve all functions described in this Specification (including configuration and provision of spare points as nominated earlier in this section).
- 2 Operating parameters and programming instructions capable of being loaded into the control units prior to the units being installed on site, such that the units are installed within the time limit capacity of the memory battery back-up system.
- 3 Provide facilities to print out the control programme of each control unit. This may be achieved locally (at the control unit) or via the central equipment.
- 4 Demonstrate satisfactory operation of control system hardware and all software programmes intended for the project, in his premises, before permission is given for loading software on site.
- 5 Programming to be loaded via the man-machine interface using basic English language instructions.
- 6 Control system programming is not to require a computer programmer.
- 7 Copy onto a floppy disk unit or similar approved device the entire programme and load back into the system via the unit in the event of memory loss.
- 8 Supply storage/recording device.
- 9 Include updating of programme parameters, as required during commissioning.
- 10 During the defects liability period carry out correction of any defective software as required.
- 11 Provide hard copies (printouts or other written records) of configuration data.
- 12 Provide the following in respect of ownership, support and general use of application software (including Central Equipment Software as described in this specification).
 - a Proprietor to retain ownership of application software.
 - b Allow unrestricted access to the Proprietor, both on and off site, to carry out modifications and adjustment to programmes as necessary.
 - c Tender price is deemed to include all royalties and other ownership fees payable for software.
 - d No agreements of any kind preventing the Proprietor's staff from modifying programmes themselves, after final completion.

13.9.5 ROUTERS, BRIDGES, REPEATERS AND TRANSCEIVERS

13.9.5.1 ROUTERS, BRIDGES AND REPEATERS

- 1 Equip each router and bridge with a network transceiver on each network port (inbound and outbound) as dictated by the network type.
- 2 The network router shall be designed to route messages from a segment, sub-net, or domain in full duplex communication mode.
- 3 Routers and bridges shall transparently route messages bound for a node address in another sub-net or domain.
- 4 Routers, bridges and repeaters shall be fully programmable and permit definition of message traffic, destination, and other network management functions.
- 5 The routers, bridges, and repeaters shall be capable of DIN rail or panel mounting and be equipped with status LED lights for Network traffic and power.

13.9.5.2 TRANSCEIVERS

- 1 Network Transceiver, Free Topology, Twisted Pair: Provide a transformer isolated, twisted pair transceiver capable of mounting directly on a printed circuit board. The Transceiver shall meet the following specifications:
 - a Differential Manchester encoded signalling for polarity insensitive network wiring.
 - b Transformer isolated for common mode rejection.
 - c 78kbs network bit rate up to distances of 2000m.
 - d Free topology supports star, home run, multidrop and loop wiring topologies.
- 2 Network Transceiver, Twisted Pair: Provide a transformer isolated twisted pair transceiver capable of mounting directly on a printed circuit board. The transceiver shall meet the following specifications:
 - a Differential Manchester encoded signalling for polarity insensitive network wiring.
 - b Transformer isolation for common mode rejection.
 - c 1.25mbps network bit rate up to distances of 1000 meters.
 - d Unpotted construction.
 - e Less than 1 mA power consumption with +5VDC input voltage.
- 3 Network Transceiver, Power Line:
 - a Provide a direct sequence, spread spectrum power line transceiver which is equipped with the following signal processing and error correction capabilities to provide robust and error free communications.
 - b Forward Error Correction (FEC) to enable the system to read and reconstruct corrupted packets without sacrificing throughput. The FEC shall required only six percent overhead for error correction.
 - c Automatic sensitivity adjustment algorithm that dynamically changes the receiver sensitivity based on noise characteristics.
 - d Oversampling correlation filter and adaptive data recovery algorithm to synchronise instantaneously to incoming packets.
 - e Tristate power amplifier/filter combination to provide a powerful output signal with a minimum number of components.

- f The transceiver shall be able to operate using the controller power supply and coupling circuit. Provide the following general features as a minimum:
 - g Packaged in a rugged, potted module.
 - h Programmable clock output (1.25, 2.5, 5 or 10 MHz).
 - i 10kps network transmission rate.
 - j Packet detect output to drive a status indicator led.
 - k -20 to +85°C operating temperature range.
- 4 Network Transceiver, Link Power: Provide a twisted pair transceiver that utilises the twisted pair communication media to provide power for Controller(s). The transceiver shall meet the following specifications.
- a Free single-in-line package (SIP) construction.
 - b Send both network data and power on a twisted wire pair.
 - c Differential Manchester encoded signalling for polarity insensitive network wiring.
 - d 78kps network bit rate up to distances of 320 meters.
 - e Supports star, home run, multidrop, and loop wiring.
 - f Supplies +5VDC @ 100 mA maximum for node power.
- 5 Network Transceiver, Radio Frequency: Provide a direct sequence, spread spectrum RF transceiver that meets the following specifications:
- a 100-meter open field range.
 - b Wireless communications extends network between buildings and to vehicles and portable devices.
 - c Low-cost miniature circuit board, SMT components.
 - d Carrier detect output to drive a status indicator LED.
 - e +7 to +15VDC input voltage.
 - f -20 to +60°C operating temperature range.

13.9.6 CONTROL PANELS

- 1 Install Control System equipment, together with associated relays, power supplies and ancillary devices in control panels located in the Mechanical Services plantrooms and electrical risers as required.
- 2 Panels shall be equivalent in construction standard to those panels specified in the Electrical Section of this Specification.
- 3 Provide labels in accordance with the Electrical Section.
- 4 Mount all control items on a removable panel within the control panel.

13.9.7 HAND HELD OPERATORS TERMINAL (PORTABLE)

- 1 Include as a minimum a keypad and 48 character LED single line display for the control system portable operator's interface terminal.
- 2 From the key pad allow to:

- a Read/reset device address.
 - b Install the device.
 - c Read/reset all set points and operating parameters.
 - d Read/reset all time of day schedules.
 - e Read/reset terminal unit controller time clock.
 - f Read all input values.
 - g Read all output states.
 - h Read all calculated values.
 - i Read alarm states.
 - j Override all inputs.
 - k Override all outputs.
 - l Bind network variables.
 - m Change configuration parameters.
- 3 Keyboard to include dedicated keys for commonly used functions (e.g., acknowledge, read input data, override output values and change parameter).
 - 4 'Plug in' operator's terminal at any control unit (including small point control unit), router, gateway, control unit, intelligent device or repeater, to allow local control and diagnostics using modular phone type plugs.
 - 5 Support simultaneous connection of the portable terminal and the central equipment.
 - 6 Provide battery charger, interface cord, carry case and operator's manual.

13.9.8 POWER SUPPLY

13.9.8.1 GENERAL

- 1 Power the control units from the Building Essential Power supply.
- 2 Include all transformers, voltage regulators, power conditioning, surge suppressors and similar items required to ensure safe and correct operation of the system.
- 3 Power the central equipment, excluding printers, from the Essential Power Supply and a local UPS.
- 4 Contractor is responsible for power supplies to each controller/data gathering panel. Each data gathering panel to be provided with internal battery backup where not connected to a UPS backed power supply.
- 5 Fire rate power supplies.
- 6 Supply surge and over voltage protection to ensure correct operation of control systems to account for any power supply disturbances throughout the maintenance and warranty period.
- 7 Supply each control unit with isolating transformers, filters and voltage regulators as a minimum.
- 8 Provide equipment compatible with the site power.

13.9.8.2 UNINTERRUPTIBLE POWER SUPPLY

- 1 Solid state, ac power supply equipped with battery back-up for continuous uninterrupted operation during a mains power failure.

- 2 The UPS shall have a sufficient reserve capacity to increase the connected load by 30%.
 - 3 Batteries shall be sealed lead-acid. An automatic current limiting circuit shall permit maximum controlled charging and protect the output of the charger. Sufficient recharge capacity to replenish depleted batteries within sixteen (16 hours). A disconnect circuit to protect batteries from damage during extended mains power failures.
 - 4 Sufficiency battery capacity for sixty (60 min) minutes operation, inclusive of the 30% reserve capacity.
 - 5 The UPS shall be capable of being mechanically or electrically interlocked with the Controls UPS distribution board to allow for the system to be put into maintenance by-pass with no break power supply operation.
-

13.10 INSTALLATION

13.10.1 GENERAL

- 1 In accordance with relevant clauses of the 'Electrical' Section of this specification and as further detailed below.
 - 2 The controls supplier to supply, install and connect all field mounted devices and pressure sensors and after hours' key switches.
-

13.10.2 WIRING

- 1 Install all wiring in plantrooms in heavy duty, rigid PVC conduit.
 - 2 Make terminations for field devices (e.g. temperature sensors) in plantrooms from flexible conduit.
 - 3 Alternatively, use metal cable duct for cabling installation (refer Electrical section).
 - 4 Select all wiring to suit control system.
 - 5 Use shielded cable where required to provide protection against induced noise.
 - 6 Use stranded cable with a minimum cross section of .8mm².
 - 7 Cables installed in concealed ceiling spaces may be installed neatly clipped to the underside of the floor in accordance with AS/NZS 3000 'Cables Likely to be Disturbed'. Cables to be PVC/PVC.
-

13.10.3 INTERFACE TO MECHANICAL SERVICES SWITCHBOARD/SWITCHPANEL

- 1 Controls supplier to wire control cabling to mechanical switchboards and terminate cables in terminal strips provided in each board.
- 2 Digital inputs to be voltage free contacts, opening for the on or alarm condition.
- 3 Digital outputs to be voltage free, closing for the on condition and suitable for switching of 24V 50Hz supplied from the mechanical services switchboard.
- 4 Incorporate all works not specifically mentioned in the Associated Works Section of this Specification under the BAS Scope of Works to achieve the intent of the BAS Contract Works.

13.11 OPERATION OF SYSTEMS

13.11.1 GENERAL

- 1 Monitor analogue and digital inputs and control analogue and digital outputs in accordance with the control system and programme.
- 2 All input sensors and devices and all output devices to be directly compatible with control system.
- 3 Control strategies: provide functional description of the manner in which the control system is programmed to control various items and systems. (Strategies are typical for typical units).
- 4 Nominated set points, time delays, deadbands, high and low limit values, proportional bands and similar items are indicative only. Adjustable parameters in the control system programme are required for these items. Provide facility for on line alteration of parameters.
- 5 Set adjustable parameters during commissioning.
- 6 Provide manual keyboard override facility for all control strategies.
- 7 Assign separate, independently adjustable parameters to each controlled item's (e.g., fan speed control, cooling valve) associated control strategy.

13.12 TESTING

13.12.1 GENERAL

- 1 Test and verify all equipment and strategies.
- 2 Supply all test equipment and communication devices (e.g., 2-way radio, mobile telephone).
- 3 Maintain a log book of all tests showing dates, time, personnel, observers initials, etc.
- 4 Provide valid calibration certificates for all test equipment.

13.13 MAINTENANCE

13.13.1 WARRANTY AND MAINTENANCE

- 1 Warrant and maintain the entire installation (including valves and other control components) throughout the defects liability period.
- 2 Warranty to include correction of all faults and defects (hardware and software) which occur during the above period.
- 3 Maintenance to include regular visits to site during the warranty period. As a minimum requirement visit the site for 1 full day (8 hours) per month.
- 4 Check operation of system and perform any maintenance required during these visits.
- 5 Allow in tender for more frequent visits to maintain particular items, if required.

- 6 Following each site visit submit a report detailing maintenance carried out and problems encountered to the Consultant Engineer.
-

13.13.2 LONG TERM MAINTENANCE

- 1 The successful Controls system supplier may be required to enter into a long-term maintenance agreement with the Proprietor.
 - 2 Submit a quotation for long term maintenance with tender as follows:
 - a Comprehensive maintenance on a five-year term.
 - b Comprehensive maintenance on an annual basis (price per year for three years).
-

13.14 TRAINING

- 1 Provide personnel skilled in all aspects of the operation of the control system for 3 weeks from date of practical completion to competently and thoroughly instruct the facility's personnel in all aspects of operation, maintenance and troubleshooting techniques associated with the installation.
 - 2 Training personnel will be required to work a total of 40 hours per week or alternatively, meet the proprietor's requirements.
-

13.15 DOCUMENTATION

- 1 Supply the following documentation as a minimum:
 - a Operator's Manual.
 - b Programmer's Manual.
 - c Functional description of the System Application programme, in English (submitted for approval prior to commencement of programming).
 - d Full programme listings and flow charts (as installed) including a printout of each supplier's programme.
 - e List of all inputs and outputs in the system including device type, location, point number, controller connected to, function and details of programmes using or controlling the point.
 - f Block diagram of system layout.
 - g Schematic diagram of each system and air conditioning unit.
 - h Panel layouts.
 - i Maintenance instructions for all system components submitted.
 - j Specifications, drawings and descriptions of operation of all system components.
- 2 Submit all system information for approval prior to commencement of work.
- 3 At completion provide all information listed above on CD, suitable for loading onto and modification via the Central Processing Unit.
- 4 Include all items listed above in the system operation and maintenance manual and submit as part of the overall maintenance manuals. (Refer to 'Testing and Commissioning Section').

14 NOISE & VIBRATION

14.1 GENERAL

14.1.1 SCOPE

- 1 This section sets out the engineering and quality assurance requirements for the completion of the installation design, materials, components, general installation and testing of the Mechanical Services noise and vibration.
 - 2 Refer to Schedule of Vibration Isolation and Schedule of Sound Levels for design criteria.
-

14.2 DESIGN

14.2.1 GENERAL

Complete the detail design and engineering of the noise and vibration to the specified requirements.

14.3 SUBMISSIONS

- 1 Details of each type of vibration isolation.
-

14.4 GENERAL REQUIREMENTS

- 1 Acoustically seal pipe, duct and cable penetrations through plantrooms and noise rated walls and acoustic enclosures. Ensure, where applicable, that service penetration details comply with those detailed in Acoustic Engineers / Architects issued details
 - 2 Statically and dynamically balance rotating machinery.
 - 3 Support rotating and reciprocating equipment on anti-vibration/vibration absorbing mounts or hangers as specified in schedules and shown on drawings.
 - 4 Inertia bases/floating slabs as specified herein and shown on the drawings.
 - 5 All static equipment in plantrooms with suspended floors to be separated from the structure with double thickness neoprene pads or equal.
 - 6 All connections to rotating equipment or assemblies containing rotating equipment shall be rendered flexible by anti-vibration hangers supporting ductwork and pipework and/or by flexible connections as specified.
 - 7 Plinths for all floor mounted equipment.
-

14.5 INFORMATION REQUIRED

- 1 Provide the following to demonstrate compliance with established criteria:

- a Noise measurements (room side and atmospheric as specified). Results to be expressed as per established criteria (dBA, NR, etc.)
- b Vibration measurements.
- c Vibration signatures.
- d Evidence of calibration of testing equipment.
- e Qualifications of person/organisation conducting testing/measurements.

14.6 NOISE CONTROL

14.6.1 ABSORPTIVE SILENCERS

1 Aerodynamic and Acoustic Performance Verification

- a Silencers shall maintain octave band centre frequency insertion losses under design operating conditions of not less than those specified on the applicable acoustic hardware schedules or specifications. Product manufacturers shall specify insertion losses from their selected silencers under the operational design conditions. This information shall be derived from measurements undertaken in accordance with International Standard ISO 7235:2003 *“Acoustics - Laboratory measurement procedures for ducted silencers and air terminal units - Insertion loss, flow noise and total pressure loss.”*
- b Silencers shall exhibit pressure losses at design flows and temperatures no greater than those specified on the applicable acoustic hardware schedules or specifications. Product manufacturer’s published pressure losses shall be derived from measurements undertaken in accordance with ISO 7235. Where the intended position of a silencer is known, suppliers shall confirm the likely pressure losses due to turbulence effects from adjoining duct elements.
- c In addition to certified insertion loss data, silencer suppliers shall confirm the 125 Hz to 8 kHz octave band sound power levels generated by their proposed silencers at the quoted operating conditions.

2 Silencer Constructional Requirements

- a The outer casing of all duct or duct mounted silencers shall be constructed in accordance with the current relevant ductwork specifications in terms of material thicknesses and seam constructions.
- b Silencer connections shall be drilled angle flanges, unless alternative connections are specified in the schedule. Flanges shall also conform to the relevant construction code or its equivalent.
- c Acoustic (splitter) elements in rectangular silencers 900 mm or more in length shall include faired leading and trailing edges (square ends will not be acceptable). Silencers less than 900mm in length shall have a faired leading edge only, unless specified otherwise.
- d The acoustic medium within the splitters shall comprise inert, non-hygroscopic, rot and vermin proof and non-combustible mineral wool or glass fibre. The medium shall be packed to a minimum density 48kg/m³. Splitters shall incorporate a glass fibre tissue facing, which will be retained by a perforated galvanised sheet steel facing or other approved protection membrane. Splitters shall be constructed so that no egress of acoustic medium will occur into the gas stream under operational design conditions.
- e The silencer construction shall include, as a minimum, a half-width splitter fixed to each side wall of the silencer casing. Splitters shall preferably be in a vertical orientation and the configuration shall have a regular splitter/airway dimension across the full width of the unit. It is, however, the responsibility of the supplier to ensure that the parallel splitter elements in the silencer are correctly oriented for the adjoining duct geometry, particularly where silencers are located close to bends, bifurcations, etc. Horizontal splitters will normally be

limited to silencers having a module width less than or equal to 900mm and should be stiffened to prevent flexing or airway restriction.

- f** For circular silencers, internal acoustic elements shall comprise an acoustic medium of mineral wool or glass fibre, as specified above for rectangular silencers. The medium will be retained by perforated galvanised metal facing, or other approved infill protection membrane. Splitters shall be constructed so that no egress of acoustic medium will occur into the gas stream under operational design conditions.
- g** For silencers manufactured in modules, the complete unit shall be shop assembled. This specification, together with the manufacturer's confirmed guarantee and acoustic and aerodynamic performance ratings, shall apply to the unit as a fully assembled product.
- h** Silencers shall be delivered to site with ends sealed to prevent contamination or damage by dust, rubble, etc. whilst on site. The direction of airflow through the silencer shall be clearly marked on the external duct casing (unless otherwise specified).
- i** High temperature silencers (e.g. for diesel exhausts, boiler flues, etc.) shall have casings manufactured from suitable gauge steel. Precautions shall be taken to cater for expansion and thermal shock. The internal elements shall be packed with an inert, non-hygroscopic, rot and vermin proof non-combustible mineral or glass fibre acoustic medium of at least 96kg/m³ density, and faced with a layer of glass fibre cloth behind a perforated metal facing. For very high temperatures, steel wool or equivalent materials may be used for the acoustic medium. Such requirements will be noted on the relevant acoustic hardware schedules as necessary.
- j** The cross-sectional dimensions detailed in the schedules are to be followed exactly. However, the supplier may propose alternative dimensions in line with his own standard sizes, provided the minimum acoustic and aerodynamic performance requirements are achieved.
- k** Melinex or other thin films between the perforated facing and the infill medium may be required for some applications. Such materials may reduce the acoustic performance of the silencer significantly, and this must be taken into account when interpreting the relevant acoustic hardware schedules. Film thicknesses of greater than 0.05mm will not be permitted, and the use of very thin films (0.008-0.010mm) is preferred.
- l** Special constructions and materials may be specified where corrosive, toxic gases or similar substances are present. Such constructions will be detailed as an addendum to this specification.
- m** Silencers shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

14.6.2 ACOUSTIC WEATHER LOUVRES

1 Performance Requirements

- a** Acoustic weather louvres shall provide insertion losses under operating conditions of not less than those indicated in the relevant acoustic hardware schedules. In addition, static pressure losses, under maximum operating duties, shall not exceed those shown in the schedules.
- b** The louvre shall be designed to prevent the penetration of rain, snow, hail etc. under normally encountered meteorological conditions.

2 Constructional Requirements

- a** Louvre framework shall be formed from suitable gauge galvanised mild steel or aluminium, supporting louvre blades of like material. The acoustic medium within each blade shall have a density of 60 - 100kg/m³ and comprise inert, rot and vermin proof, non-hygroscopic and incombustible mineral fibre, faced with glass fibre tissue and retained on the lower blade face by perforated, galvanised mild steel or aluminium.

- b** Louvres manufactured in sections shall be shop assembled and this specification, together with the manufacturer's own guarantee and performance ratings, shall apply to the unit as a fully assembled product.
- c** Acoustic louvres shall be supplied with integral bird screens of galvanised mild steel or aluminium mesh, fixed to the internal face. The mesh pitch shall be a maximum of 25mm.
- d** The louvres shall be supplied complete with all necessary flanges and fixings, etc., for fitting into the opening
- e** All gaps between the outside of the louvre frame and the opening or duct shall be made good and sealed to full depth with dense grout and/or non-hardening mastic sealant.
- f** The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

14.7 VIBRATION CONTROL

14.7.1 ACCEPTANCE CRITERIA

- 1** Complete systems including individual components not to exceed satisfactory levels as set out in AS 1359.114, AS 2625.1 and project specific Acoustic Engineer's requirements where established
- 2** Select anti-vibration mounts/hangers for life cycle of building and install in accordance relevant Earthquake criteria / standards.
- 3** Select and install anti-vibration mounts and hangers in locations to prevent transmission of vibration to adjoining areas and to prevent undue vibration, distortion or fatigue of equipment and connecting piping and cabling.
- 4** Select vibration isolation mounts/hangers to allow for deflections of building structures and finishes and for minimum static deflection as specified.

14.7.2 GENERAL

- 1** Where indicated on the relevant schedules by the code /R, the vibration isolation mountings or hangers shall be provided with a restraining or positioning device. These shall be designed to prevent the equipment position changing if its load alters; for example, during system draining or other maintenance.
- 2** Restraining devices shall comprise of a stud passing through an oversized hole with a nut/locknut combination providing restraint. A neoprene or fibre washer should be fitted between the nut and the restraining member, leaving an overall minimum clearance of 1mm.
- 3** Anti-vibration mountings/hangers shall provide static deflections as specified in the relevant vibration isolator schedules, under the design loaded equipment weight. Mounting selection shall allow for uneven load distribution or torque reaction, such that the required design static deflection is achieved on all equipment mountings under operational conditions.
- 4** The supplier shall take responsibility to ensure that all mountings are appropriate for the design loads, operating and environmental conditions that will prevail. Particular attention should be paid to mountings exposed to atmospheric conditions, to prevent corrosion.
- 5** Mountings shall be clearly marked and preferably colour coded, to indicate their load capacity to enable easy identification during installation.

- 6 Where the use of resilient supports allows omission of pipe flexible connections for vibration/noise isolation, it shall be the Contractor's responsibility to decide whether such devices are required to compensate for misalignment or thermal strain.
-

14.7.3 TYPE A MOUNTINGS (CAGED SPRING TYPE)

- 1 Each mounting shall comprise cast or fabricated telescopic top and bottom housings enclosing one or more helical springs as the principle isolation elements, and shall incorporate a built-in levelling device. The housing should be designed to permit clear visual inspection of the springs after installation, i.e. the springs must not be totally enclosed.
 - 2 The springs shall have an outside diameter of not less than 75% of the operating height, and be selected to have at least 50% overload capacity before becoming coil bound.
 - 3 The bottom plate of each mounting shall have a rubber/neoprene pad bonded to it, designed to attenuate any high frequency energy transmitted to the springs.
 - 4 Mountings incorporating snubbers or restraining devices shall be designed so that the snubbing, dampening or restraining mechanism is capable of being adjusted to have no significant effect during the normal operation of the isolated machine.
 - 5 All nuts, bolts or other elements used for adjustment of a mounting shall incorporate locking mechanisms to prevent the isolator going out of adjustment as a result of vibration or accidental or unauthorised tampering.
-

14.7.4 TYPE B MOUNTINGS (OPEN SPRING TYPE)

- 1 Each mounting shall consist of one or more helical steel springs as the principal isolation elements, and shall incorporate a built-in levelling device.
 - 2 The springs shall be fixed or otherwise securely located to cast or fabricated top and bottom plates, shall have an outside diameter of not less than 75% of the operating height, and shall be selected to have at least 50% overload capacity before becoming coil bound.
 - 3 The bottom plate shall have bonded to it a rubber/neoprene pad designed to attenuate any high frequency energy transmitted by the springs.
-

14.7.5 TYPE C MOUNTINGS (RUBBER/NEOPRENE TYPE)

- 1 Each mounting shall consist of a steel top plate and base plate completely embedded in oil resistant neoprene/rubber. Each mounting shall be capable of being fitted with a levelling device, and should have bolt holes in the base plate and a threaded metal insert in the top plate so that they can be bolted to the floor and equipment when required.
-

14.7.6 TYPE D MOUNTINGS (STEEL SPRING HANGERS)

- 1 The hanger shall incorporate a helical steel spring securely located in a steel cage.
- 2 The clearance hole in the bottom of the cage should allow a lateral movement of the lower hanger rod of at least 15° included angle.
- 3 Where hangers incorporate a positioning device, the adjustment system should incorporate a locking mechanism to prevent the hanger going out of adjustment as a result of vibration, or accidental or unauthorised tampering.

14.7.7 TYPE E MOUNTINGS (NEOPRENE ELEMENT HANGERS)

- 1 The hanger shall be essentially as described in 11.7.6 above except it shall incorporate a neoprene in shear element as described in section 11.7.5

14.7.8 TYPE F MOUNTINGS (COMBINED STEEL AND NEOPRENE ELEMENT HANGERS)

- 1 The clearance hole in the bottom of the cage should allow a lateral movement of the lower hanger rod of at least 15° included angle.
- 2 Where hangers incorporate a positioning device, the adjustment system should incorporate a locking mechanism to prevent the hanger going out of adjustment as a result of vibration, or accidental or unauthorised tampering.

14.7.9 TYPE A PLANT BASES (A.V. RAILS)

- 1 An A.V. Rail shall comprise a steel beam with two or more height saving brackets. The steel sections must be sufficiently rigid to prevent undue strain on the equipment and if necessary should be checked by the Structural Engineer.

14.7.10 TYPE B PLANT BASES (STEEL PLANT BASES)

- 1 Steel plant bases shall comprise an all-welded steel framework of sufficient rigidity to provide adequate support for the equipment, and fitted with isolator height saving brackets. The frame depth shall be approximately 1/10 of the longest dimension of the supported equipment, with a minimum of 150mm. This form of base may be used as a composite A.V. Rail system.

14.7.11 TYPE C PLANT BASES (CONCRETE INERTIA BASE, WITH STEEL SPRINGS)

- 1 These shall consist of an all-welded steel pouring framework with height saving brackets, and a frame depth of approximately 1/12 of the longest dimension of the supported equipment, with a minimum of 100mm. The bottom of the pouring frame should be blanked off, and concrete (2300kg/m³) poured in over steel reinforcing rods positioned 35mm above the bottom. The inertia base should be sufficiently large to provide support for all parts of the equipment, including any components which overhang the equipment base, such as suction and discharge elbows on centrifugal pumps.

14.7.12 TYPE D PLANT BASES (CONCRETE INERTIA BASE, WITH NEOPRENE PADS/MOUNTS)

- 1 These should comprise a concrete inertia base of sufficient size to permit support for all parts of the equipment, including any components which overhang the equipment base, such as suction and discharge elbows on centrifugal pumps. The inertia base should be cast onto a permanent bottom shuttering, and supported on the specified neoprene mounts or pads, the whole resting on a plinth as required. It should be noted that the construction of concrete bases on cork, expanded polystyrene or mineral wool slabs is not normally permitted. Where neoprene pads are used, small areas of pad must be equally spaced to provide the required static deflection. The number, dimensions and locations of such pads should be advised by the supplier

14.8 ACOUSTIC DOORS

14.8.1 PERFORMANCE

- 1 All acoustic doors shall provide a sound reduction index (SRI) (as tested in accordance with ISO 140-3: 1995 "Laboratory measurement of airborne sound insulation of building elements") of not less than that shown in the relevant schedule. Where the schedule refers to a mean SRI, the equivalent SRI spectrum should not be less than that indicated below:

MEAN SRI (100-3150Hz)	SRI (dB) AT OCTAVE BAND CENTRE FREQUENCIES (Hz)					
	125	250	500	1k	2k	4k
30	21	26	30	33	35	36
35	24	30	35	38	39	40
40	27	35	40	42	46	47
45	33	36	44	48	52	54
50	35	40	50	54	60	60

- 2 The manufacturer or supplier of acoustic doors shall guarantee the specified SRI, and ensure that the method of installation does not detract from the guaranteed performance. Any failure to meet the specification because of faulty design, manufacture or installation, will result in the manufacturer or supplier being held liable for remedial or replacement costs including consequential liability.

14.8.2 CONSTRUCTION

- 1 The acoustic doors shall be of hardwood or steel, and be complete with all seals and frames, and with furniture as specified by the Architect.
- 2 It is recommended that where a mean SRI equal to or greater than 35dB is required, the door should be of steel construction with double neoprene/rubber compression, or knife-edge, seals to head, jambs and threshold. Double doors should incorporate a central jamb or overlapping leaves to ensure an acceptable seal at the middle joint. Lower performance doors (35dB or less) may be fitted with magnetic seals.
- 3 The door fastener or lock should be designed to ensure the seal operates evenly over the whole periphery of the door.
- 4 Wiper seals will not be permitted at thresholds; doors must be fitted with a raised threshold and a compression seal, or with a mechanical drop-down seal for doors with ratings up to 35dB

14.9 ACOUSTIC ENCLOSURES

14.9.1 PERFORMANCE

- 1 The acoustic enclosure shall provide in its as-installed condition an overall sound reduction index (SRI) of not less than that shown in the relevant schedule. Full allowance shall be taken of any loss of insulation due to doors, windows, ventilation openings and panel joints. The manufacturer or supplier shall guarantee the specified SRI, and ensure that the method of installation does not detract from the guaranteed performance.

- 2 The internal surfaces of the enclosure panels shall be designed to give the following minimum average sound absorption coefficients when tested in accordance with AS ISO 354:2006 "Acoustics: Measurements of sound absorption in a reverberation room": -

FREQUENCY (Hz)	125	250	500	1K	2K	4K
Minimum average absorption coefficient (α)	0.2	0.5	0.7	0.8	0.8	0.7

14.9.2 CONSTRUCTION

- 1 The enclosure panels shall be constructed from galvanised mild steel sheet at least 1.6mm thick (16swg) or as otherwise specified. The absorbent internal lining shall be faced with glass fibre cloth or other infill protection membrane and be retained by perforated galvanised mild steel sheet having an open area preferably not less than 23%, and the whole panel should not be less than 50mm thick. Provision shall be made inside the panel to prevent settling of the acoustic medium.
- 2 Doors, access panels, windows and ventilation ducts or electrical cable penetrations shall be treated so as to maintain the specified acoustic insulation of the assembled enclosure.
- 3 Demountable sections shall be designed to allow easy disassembly and re-assembly by unskilled personnel without affecting the acoustic performance.
- 4 The supplier shall ensure that the assembled enclosure is designed and constructed to withstand site operating conditions such as wind and snow loads, roof mounted plant, etc., as appropriate, and if outside, to be suitably weatherproofed.
- 5 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

14.10 ACOUSTIC LINING PANELS

14.10.1 CONSTRUCTION AND PERFORMANCE

- 1 The acoustic lining panels shall comprise acoustically absorptive material (such as Class '0' fire rated open cell foam, mineral fibre or glass fibre) fixed in place with a non-obstructing fixing system. The total surface area of the acoustic lining panels shall be not less than the minimum specified area of treatment. As a minimum the panels should be 50mm thick (except where otherwise specified) and be faced with an abrasion and fibre erosion protection layer such as glass fibre scrim or glass fibre cloth and, where specified, be retained by galvanised mild steel sheet with a hexagonal perforation pattern giving an open area of not less than 23%. Where mineral fibre or glass fibre acoustic media are used, these should have a surface density of not less than 50kg/m².
- 2 The acoustic lining panels should provide not less than the following sound absorption coefficients:

ACOUSTIC ABSORPTIVE SECTIONS:	OCTAVE BAND CENTRE FREQUENCY (Hz)					
	125	250	500	1000	2000	4000
Min Absorption Coefficient	0.30	0.60	0.70	0.70	0.70	0.70

14.11 NOISE MEASUREMENTS

- 1 Measure and submit noise measurements in areas nominated above using sound level meter complying with AS IEC 61672.1 and .2 during the noisiest operating condition.
- 2 Where noise measurements exceed specified criteria, take additional noise readings in each octave band (125Hz to 4000Hz inclusive) in selected locations with reference to ISO 1996 (all relevant parts).

14.12 VIBRATION MEASUREMENTS

- 1 Take vibration levels at positions to be agreed in the event that vibration levels exceed acceptance criteria and are clearly perceptible.
- 2 Take and record vibration signatures in both radial and axial directions for major equipment as scheduled hereunder.
- 3 Vibration signatures to be measured with equipment/system completely assembled and in full working order.
- 4 Scheduled equipment to be equipped with permanent mounting points for accelerometers and all measurements for such machines to be taken for octave bands 10Hz to 10,000Hz.

14.13 NOISE SURVEYS

- 1 Noise surveys as required by the Health and Safety Regulations shall be provided for each plant enclosure and at each isolated plant item.
- 2 A registered 'Noise Officer' shall carry out surveys and the results of such shall be submitted to the Contractor.
- 3 Where a noise hazard exists and all practicable noise attenuation has been carried out, hazardous areas shall be defined by the erection of signs reading:

NOTICE

HEARING PROTECTION MUST BE WORN

IN THIS AREA

or

NOTICE

HEARING PROTECTION MUST BE WORN

WHEN THIS MACHINE IS RUNNING

- 4 Signs shall be 'Brady' Indoor/Outdoor, Personal Hazard Warnings or approved equivalent.

15 SCHEDULES

15.1 GENERAL

The following schedules have been prepared for tendering purposes and to convey design intent. They form a summary of the preceding Clauses in the Specification and must be read in conjunction with these Clauses and the Project Drawings.

Where reference Clauses are referred to, they shall be taken as the major Clause, but equipment shall also comply with all other relevant Clauses in the Specification.

Air and water quantities and temperatures may be changed slightly to suit the particular manufacturer's equipment, however full details shall be submitted for review. Changes shall not be in conflict with any By-Laws, Statutory Requirements (including NCC Section J where applicable), Public Health Requirements or the overall design in general including achievement of any energy compliance and Green Star criteria.

Pump and fan duties have been calculated from typical equipment and have been given as a guide only. Air system external system pressure drops include an allowance for filters. The Mechanical Works Package must carry out pump and fan duty calculations using pressure drops through the equipment offered, and through the ductwork and pipework layouts prepared as part of the construction and workshop drawings – Mechanical Works Package to allow for half loaded filters.

The schedules shall not be used directly for ordering of equipment.

The following schedules show details of mechanical equipment only.

THE EQUIPMENT PAGES OF THIS SCHEDULE MUST BE SUBMITTED WITH THE TENDER OFFER IN THE CURRENT TABULISED FORM WITH 'TENDER' COLUMNS AND ROWS COMPLETED. ANY DEVIATIONS ARE TO BE CLEARLY HIGHLIGHTED.

Schedule of equipment submitted on alternate forms, manufacturers' data sheets, Contractor work sheets, etc. will not be accepted.

Completion of the technical schedule for tender review does not constitute approval of proposed equipment nor does it absolve the requirement to satisfy the requirements of the specification.

15.2 COOLING TOWER

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Unit No.		CT-R-1		CT-R-2					
No. off		1		1					
Type		Crossflow		Crossflow					
Construction		Stainless Steel		Stainless Steel					
Capacity Each		650.0		650.0					
Max. Dimensions	mm	3700x1250x3000		3700x1250x3000					
Max. Weight	kg	2200		2200					
Ambient Temp.	°C WB	22.0		22.0					
External Static Pressure	Pa	50		50					
Water Quantity Each	L/s	28.3		28.3					
Water Entering Temp.	°C	35.0		35.0					
Water Leaving Temp.	°C	29.5		29.5					
Fan/Motor									
Type		Axial		Axial					
No. off		2		2					
Estimated Size	kW	2.2		2.2					
Voltage	V	415		415					
Maximum Speed	r/s								
Capacity Control		VSD		VSD					
Starting Arrangement		VSD		VSD					
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63									
125									
250									
500									
1000									
2000									
4000									

15.3 HOT WATER HEATER – ATMOSPHERIC TYPE

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Unit No.		HHWB-R-01,02,03,04		HHWB-R-05,06,07,08					
Type		Condensing		Condensing					
No. off		4		4					
Capacity Each	kW	157.0		157.0					
Capacity Steps									
Water Quantity	L/s	5.55		5.55					
Water Entering Temp.	°C	45		45					
Water Leaving Temp.	°C	60		60					
Max. Pressure Drop	kPa	15		15					
Working Pressure	kPa	600		600					
Flue Material		Stainless Steel		Stainless Steel					
Fuel		Natural gas		Natural gas					
Gas Mains Supply Pressure	kPa	1.1		1.1					
Accessories									
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63									
125									
250									
500									
1000									
2000									
4000									

15.4 WATER HEAT EXCHANGERS – PLATE

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Unit No.		HEX-R-01		HEX-R-02					
Service		Cooling Towers		Cooling Towers					
No. off		1		1					
Material		Stainless 316		Stainless 316					
Heat Exchange Capacity Each	kW	650		650					
Working Pressure	kPa	1000		1000					
Test Pressure	kPa	1300		1300					
Max. Pressure Loss	kPa	100		100					
Primary Flow	L/s	28.3		28.3					
Primary Water Entering Temp.	°C	29.5		29.5					
Primary Water Leaving Temp.	°C	35.0		35.0					
Secondary Flow	L/s	28.3		28.3					
Secondary Water Entering Temp.	°C	36.0		36.0					
Secondary Water Leaving Temp.	°C	30.5		30.5					

15.5 WATER PUMP

PUMP TYPES

HSC	-	Horizontally split casing pump
VSC	-	Vertically split casing, back pull out pump
HMP	-	Horizontal motor pump
VMP	-	Vertical motor pump
MSP	-	Multi- stage pumps
ICP	-	In- Line circulating pump

MECHANICAL SEAL TYPES

UMS	-	Unbalanced mechanical seal
BMS	-	Balanced mechanical seal
PGS	-	Packed gland seal

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Pump No.		PCCWP-R-01		PCCWP-R-02		SCCWP-R-01		SCCWP-R-02	
Service		Primary Condenser Water		Primary Condenser Water		Secondary Condenser Water		Secondary Condenser Water	
No. off		1		1		1		1	
Pump Type		End Suction (VSC)		End Suction (VSC)		End Suction (VSC)		End Suction (VSC)	
Capacity	L/s	28.3		28.3		28.3		28.3	
Estimated Head	kPa	180		180		300		300	
Design Pressure	kPa	600		600		600		600	
Minimum Efficiency	%	75		75		75		75	
Seal Type									
Motor									
Estimated Size Each	kW	15		15		25		25	
Voltage	V	415		415		415		415	
Starting Arrangement		VSD		VSD		VSD		VSD	
Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Pump No.		HHWP-R-01		HHWP-R-02		HHWP-R-03			
Service		HHW		HHW		Pool Plant HHW			
No. off		1		1		1			
Pump Type		End Suction (VSC)		End Suction (VSC)		End Suction (VSC)			
Capacity	L/s	30.0		30.0		5			
Estimated Head	kPa	100		100		300			
Design Pressure	kPa	600		600		600			
Minimum Efficiency	%	75		75		75			
Seal Type									
Motor									
Estimated Size Each	kW	10		10		5			
Voltage	V	415		415		415			
Starting Arrangement		VSD		VSD		VSD			

15.6 COIL – HEATING WATER

Specified / Tender		Specified	Tender
Entering/Leaving	°C	60/45	
General			
Coil Bank No.		HC-R-01	
No. Of Coils/Bank		1	
Nom. Coil Dimensions	mm	1300x700	
Air Quantity/Bank	L/s	1410	
Sensible Capacity/Bank	kWr	27.92	
Air Temp. On Coil	°C DB/°C WB	3.5	
Air Temp. Off Coil	°C DB/°C WB	20	
Maximum Air Pressure Drop	Pa	50	
Maximum Water Pressure Drop	kPa	20	

15.7 AIR FILTERS

Service/ Unit No.	No. of Cells	Total L/s	Type	Filter Gauge
LABEL	LOCATION	TOTAL L/S	TYPE	FILTER GAUGE
Communal WCU's	Filter Plenums	To Suit WCU Duty	Panel	F5
Apartment FCU's	Air Intake	To Suit FCU Duty	Panel	Proprietary Manufacturer
Switch Room	Air Intake	To Suit GEF-G-02	Lint Screen	-

Note. Quantity of filter cells to fit in location at 2.0 m/s maximum face velocity, and to fully cover the available area.

15.8 FAN TYPE ACCESSORIES

FAN TYPES

AA	-	Axial Aerofoil	SS	-	Smoke Spill
P	-	Propeller	RA	-	Roof mounted fan, axial
CB	-	Centrifugal backward curved blades	RC	-	Roof mounted fan, centrifugal
CF	-	Centrifugal forward curved blades	RM	-	Roof mounted fan, mixed flow
CI	-	Centrifugal In-line	DM	-	Dual motor drive
DW	-	Double inlet, double width	DF	-	Dual fan
SW	-	Single inlet, single width	DS	-	Two speed motor
VSD	-	Variable speed drive	EC	-	EC motor

COWL TYPE

DD	-	Downward discharge
VD	-	Vertical discharge

ACCESSORIES

DV	-	Downstream guide vane
IV	-	Inlet guide vane
DC	-	Discharge cone
IC	-	Inlet cone
ND	-	Non return damper
WI	-	Wire guard inlet
MB	-	Metal Blades
WO	-	Wire guard outlet

15.9 FAN

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Fan No.		CSF-G-01		OAF-G-01		OAF-G-02		GEF-12-02	
No. off		1		1		1		1	
Fan Type		AA		AA		AA		AA	
Cowl Type				-					
Fan Accessories				-					
Air Quantity	L/s	3150		320		450		300	
Estimated Duty	Pa	300		200		80		200	
Max. Speed	rpm	1440		2286		880		1440	
Motor									
Estimated Size	kW	1.65 kW		0.255 kW		0.37 kW		0.75 Kw	
Voltage	V	415V 3ph 50Hz		240V 1ph 50Hz		415V 3ph 50Hz		415V 3ph 50Hz	
Starting Arrangement		VSD		VSD		VSD		VSD	
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63		87		61		54		70	
125		86		75		57		76	
250		93		76		50		75	
500		85		71		47		75	
1000		85		75		43		73	
2000		83		70		45		70	
4000		79		65		44		66	
	60								

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Fan No.		GEF-G-01		GEF-G-02		GEF-G-03		GEF-G-04	
No. off		1		1		1		1	
Fan Type		AA		AA		AA		AA	
Cowl Type									
Fan Accessories									
Air Quantity	L/s	1500		300		50		500	
Estimated Duty	Pa	110		110		135		120	
Max. Speed	rpm	960		880		1950		880	
Motor									
Estimated Size	kW	0.825 kW		0.37 kW		0.04 kW		0.37 kW	
Voltage	V	415V 3ph 50Hz		415V 3ph 50Hz		240V 1ph 50Hz		415V 3ph 50Hz	
Starting Arrangement		VSD		VSD		VSD		VSD	
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63		73		54		39		60	
125		72		57		39		64	
250		68		50		45		57	
500		66		47		36		57	
1000		64		43		31		51	
2000		64		45		15		54	
4000		59		44		24		53	

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Fan No.		TEF-G-01		TEF-TypApt		OAF-03-01		GEF-03-01	
No. off		1		Per Apt		1		1	
Fan Type		AA		AA		AA		AA	
Cowl Type									
Fan Accessories									
Air Quantity	L/s	50		120		1550		1550	
Estimated Duty	Pa	145		120		250		200	
Max. Speed	rpm	1950		2500		1440		1440	
Motor									
Estimated Size	kW	0.044 kW		0.05 kW		1.21 kW		1.21 kW	
Voltage	V	240V 1ph 50Hz		240V 1ph 50Hz		415V 3ph 50Hz		415V 3ph 50Hz	
Starting Arrangement		VSD		EC		VSD		VSD	
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63		52		51		77		73	
125		45		52		77		77	
250		58		59		80		74	
500		54		58		79		72	
1000		53		59		73		73	
2000		57		57		70		70	
4000		51		50		63		65	

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Fan No.		CSF-03-01		CEF-03-01		OAF-04-01		OAF-04-02	
No. off		1		1		1		1	
Fan Type		AA		AA		AA		AA	
Cowl Type						-			
Fan Accessories						-			
Air Quantity	L/s	2610		11400		175		40	
Estimated Duty	Pa	300		350		200		200	
Max. Speed	rpm	1440		1440		2315		2526	
Motor		-							
Estimated Size	kW	1.65 kW		8.25 kW		0.1 kW		0.048 kW	
Voltage	V	415V 3ph 50Hz		415V 3ph 50Hz		240V 1ph 50Hz		240V 1ph 50Hz	
Starting Arrangement		VSD		VSD		VSD		DOL	
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63		88		96		52		58	
125		85		92		52		49	
250		82		94		61		58	
500		82		92		63		64	
1000		81		90		65		62	
2000		81		88		63		61	
4000		77		85		58		54	
	51								

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Fan No.		TEF-04-01		OAF-05-01		OAF-05-02		GEF-05-01	
No. off		+		+		+		+	
Fan Type		AA		AA		AA		AA	
Cowl Type		-		-		-		-	
Fan Accessories		-		-		-		-	
Air Quantity	L/s	400		300		75		120	
Estimated Duty	Pa	160		130		150		150	
Max. Speed	rpm	940		1380		2308		2605	
Motor		-		-		-		-	
Estimated Size	kW	0.28 kW		0.37 kW		0.048 kW		0.048 kW	
Voltage	V	240V 1ph 50Hz		415V 3ph 50Hz		240V 1ph 50Hz		240V 1ph 50Hz	
Starting Arrangement		VSD		VSD		VSD		VSD	
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63		64		63		56		58	
125		65		58		47		49	
250		60		59		56		58	
500		58		57		62		64	
1000		53		55		60		62	
2000		55		54		59		61	
4000		55		51		52		54	

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Fan No.		TEF-05-01		SAF-12-01		GEF-12-01		SPF-12-01 & 02	
No. off		4		1		1		2	
Fan Type		AA		AA		AA		AA	
Cowl Type		-							
Fan Accessories		-							
Air Quantity	L/s	135		665		515		8000	
Estimated Duty	Pa	100		200		200		200	
Max. Speed	rpm	2000		2880		2880		576	
Motor		-							
Estimated Size	kW	0.1 kW		0.407 kW		0.407 kW		3.3 kW	
Voltage	V	240V 1ph 50Hz		415V 3ph 50Hz		415V 3ph 50Hz		415V 3ph 50Hz	
Starting Arrangement		VSD		VSD		VSD		VSD	
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63		47		76		72		82	
125		52		83		84		83	
250		56		77		75		83	
500		57		74		73		84	
1000		58		72		71		78	
2000		60		69		68		77	
4000		55		65		66		72	

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Fan No.		SPRF-12-01		SAF-R-01		KEF-R-01		GEF-R-01	
No. off		1		1		1		1	
Fan Type		AA		AA		AA		AA	
Cowl Type									
Fan Accessories									
Air Quantity	L/s	6000		1410		3500		580	
Estimated Duty	Pa	200		250		350		250	
Max. Speed	rpm	1440		2880		1440		2880	
Motor									
Estimated Size	kW	3.3 kW (AOM)		0.85 kW (AOM)		3.00 kW		0.407 kW (AOM)	
Voltage	V	415V 3ph 50Hz		415V 3ph 50Hz		415V 3ph 50Hz		415V 3ph 50Hz	
Starting Arrangement		VSD		VSD		VSD		VSD	
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63		81		90		81		75	
125		81		86		75		75	
250		77		91		83		82	
500		76		89		88		75	
1000		75		91		89		73	
2000		76		86		86		70	
4000		71		82		82		68	

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Fan No.		SPF-R-01 & 02		SPRF-R-01					
No. off		2		1					
Fan Type		AA		AA					
Cowl Type									
Fan Accessories									
Air Quantity	L/s	10000		4000					
Estimated Duty	Pa	250		250					
Max. Speed	rpm	1400		2880					
Motor									
Estimated Size	kW	6.05 kW (AOM)		3.3 kW (AOM)					
Voltage	V	415V 3ph 50Hz		415V 3ph 50Hz					
Starting Arrangement		VSD		VSD					
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63		95		91					
125		91		97					
250		92		91					
500		91		89					
1000		89		86					
2000		86		85					
4000		83		82					

15.10 ATTENUATORS

No. & Service	Maximum Pressure Drop PA	Minimum Insertion Loss Db Octave Band Frequencies HZ						
		63	125	250	500	1k	2k	4k
Fans (General) Larger than 1,000 l/s.	20	4	9	17	28	35	31	22
Fans (General) Larger than 5,000 l/s.	20	8	16	30	47	50	50	47
Fans (Fire Isolated Exit Pressurisation) Larger than 5,000 l/s.	40	5	7	12	19	18	14	12
Fans (General) Larger than 10,000 l/s.	20	12	25	45	45	50	50	50
Fans (Fire Isolated Exit Pressurisation) Larger than 10,000 l/s.	40	5	7	12	19	18	14	12
Relief Air Fans	20	8	16	30	47	50	50	47

1. Attenuation to be provided upstream and downstream of fan equipment with exception of fire isolated exit pressurisation fan.
2. Attenuator Air Quantity shall be to suit Fan Schedule UNO.
3. Attenuator size shall be as required to suit the minimum insertion loss UNO.
4. Allow for all necessary intake and discharge transitions to suit adjoining ductwork.

15.11 AIR CONDITIONING UNIT – WATER COOLED

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Unit No.		WCU-G-01		WCU-G-02		WCU-G-03		WCU-G-04	
No. off		1		1		1		1	
Supply Air Quantity	L/s	190		500		500		500	
Outside Air Quantity	L/s	20		80		80		80	
Sensible Cooling Capacity Each	kWr	2.8		6.6		6.6		6.6	
Total Cooling Capacity Each	kWr	3.5		8.1		8.1		8.1	
Air Temp. on Cooling Coil	°C DB/°C WB	27 / 19		27 / 19		27 / 19		27 / 19	
External System Air Pressure Drop	Pa	150		150		150		150	
Total Heating Capacity Each	kW								
Air Temp. on Heating Coil	°C DB								
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W – Octave Band Centre Hz									
Frequencies	dB								
Hz									
125		62		66		66		66	
250		58		61		61		61	
500		54		59		59		59	
1000		53		59		59		59	
2000		49		56		56		56	
4000		46		50		50		50	

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Unit No.		WCU-G-05		WCU-04-01		WCU-04-02		WCU-05-01	
No. off		1		1		1		1	
Supply Air Quantity	L/s	320		560		320		500	
Outside Air Quantity	L/s	60		120		55		150	
Sensible Cooling Capacity Each	kWr	5.0		8.1		5.0		6.6	
Total Cooling Capacity Each	kWr	5.0		9.9		5.0		8.1	
Air Temp. on Cooling Coil	°C DB/°C WB	27 / 19		27 / 19		27 / 19		27 / 19	
External System Air Pressure Drop	Pa	150		150		150		150	
Total Heating Capacity Each	kW								
Air Temp. on Heating Coil	°C DB								
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W — Octave Band Centre Hz									
Frequencies	dB								
Hz									
125		64		66		64		66	
250		58		61		58		61	
500		57		59		57		59	
1000		57		59		57		59	
2000		54		56		54		56	
4000		48		50		48		50	

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Unit No.		WCU-05-02		WCU-05-03 (Floor-standing)					
No. off		4		4					
Supply Air Quantity	L/s	620		2100					
Outside Air Quantity	L/s	150		75					
Sensible Cooling Capacity Each	kWr	9.5		25.4					
Total Cooling Capacity Each	kWr	12.2		27.2					
Air Temp. on Cooling Coil	°C DB/°C WB	27 / 19		27 / 19					
External System Air Pressure Drop	Pa	150		150					
Total Heating Capacity Each	kW								
Air Temp. on Heating Coil	°C DB								
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W — Octave Band Centre Hz									
Frequencies		dB							
Hz									
125		62							
250		59							
500		59							
1000		59							
2000		55							
4000		53							

15.12 AIR CONDITIONED UNIT – SPLIT AND PACKAGE

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Unit No.		AC-G-01							
No. off		1							
Type		Wall Mounted							
Supply Air Quantity	L/s	200							
Outside Air Quantity	L/s	-							
Sensible Cooling Capacity Each	kWr	3.0							
Total Cooling Capacity Each	kWr								
Air Temp. on Cooling Coil (max)	°C DB/°C WB	27/19							
External System Air Pressure Drop	Pa	N/A							
Total Heating Capacity Each	kW	N/A							
Air Temp. on Heating Coil	°C DB	N/A							
Condenser									
Max Ambient Temps (for full cooling)	°C	45							
Min Ambient Temp (for full heating)	°C	-5							
Min Ambient Temp for cooling	°C	3.5							
Accessories									
Electrical Requirements									
Amps	A								
Volts	V	240							
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W – Octave Band Centre Hz									
Frequencies	dB								
Hz									
63									
125									
250									
500									
1000									
2000									
4000									

15.13 AIR CONDITIONING UNIT – WATER COOLED POOL PAC

Specified / Tender		Specified	Tender	Specified	Tender	Specified	Tender	Specified	Tender
General									
Unit No.		PAC-03-01							
Supply Air Quantity	L/s	2600							
Exhaust Air Quantity	L/s	2600							
Outside Air Quantity	L/s	2600							
Sensible Cooling Capacity Each	kW _r	15.0							
External System Air Pressure Drop	Pa	250							
Total Heating Capacity Each	kW	45.0							
Air Temp. on Heating Coil	°C DB	23.9							
Supply Air Temp.	°C DB	38							
Return Air Temp.	°C DB	29							
Evaporator Motor									
Estimated Size Each	kW								
Compressor									
Type		Scroll							
No. off		2							
Unloader Type									
Capacity Steps Each									
Motor Size Each	kW								
Starting Arrangement		VSD							
Condenser									
Water Quantity (Ceating)	L/s	0.85							
Water Quantity (Heating)	L/s	2.3							
Water Entering/Leaving Temp.	°C	30.5/36							
Max. Pressure Drop	kPa	50							
Working Pressure	kPa	2000							
Acoustic Performance									
Sound Power Levels, dB re 10 ⁻¹² W - Octave Band Centre Hz									
Frequencies	dB								
Hz									
63									
125									
250									
500									
1000									
2000									
4000									

The ambient space temperature is assumed to be 29 °C

The Pool PAC is to include the following features:

- 80% Efficient Sensible only Counterflow non-Metallic plate Heat Exchanger
- DX Heating and Cooling
- EC Plug fans and CPG constant volume fan speed controllers
- 50mm PIR coolroom panel construction (R=2.63)

15.14 APARTMENT AIR CONDITIONED UNITS

- 1 Unit selection shall consider the de-rated capacities based on refrigerant pipe layout as shown on reviewed workshop drawings.
- 2 Refer to section 3.4 for WCU & VRV distribution.
- 3 LR = Living Room
B1 = Bedroom 1
B2 = Bedroom 2
B3 = Bedroom 3
ST = Study

All units shall meet the requirements of the Acoustic Consultant's report.

General requirements are as follows:

VRV units:

Specified / Tender		Specified	Tender
General			
Unit No.		Refer Table Below	
No. off		Refer Table Below	
Type		Refer Table Below	
Heat Pump type		Air	
Air Temp. on Cooling Coil (max)		°C DB/°C WB	24/17
External System Air Pressure Drop		Pa	150
Connection Ratio		100%	
Air Temp. on Heating Coil		°C DB	20
Heater Type		Reverse Cycle	
Compressor			
Type		Scroll	
No. off		1	
Capacity Steps Each		Inverter	
No. Refrigerant Circuits		1	
Condenser			

Max Ambient Temps (for full cooling)	°C	35	
Min Ambient Temp (for full heating)	°C	3.5	
Min Ambient Temp for cooling	°C	10	

Unit No.	No. off	Unit Type	Sensible Cooling (kW)	Heating (kW)
AC-101-102-L/D	2	Bulkhead	2.1	1.9
AC-101-102-B1	2	Bulkhead	1.1	0.8
AC-103-203-L/D	2	Bulkhead	2.2	1.7
AC-103-203-B1	2	Bulkhead	0.7	0.4
AC-103-203-B2	2	Bulkhead	0.9	0.3
AC-104-204-L/D	4	Bulkhead	2.7	1.8
AC-104-204-B1	4	Bulkhead	1.1	0.8
AC-106-206-L/D	2	Bulkhead	2.3	1.8
AC-106-206-B1	2	Bulkhead	1.1	0.6
AC-106-206-B2	2	Bulkhead	1.0	0.5
AC-107-406-L/D	4	Bulkhead	2.4	1.9
AC-107-406-B1	4	Bulkhead	1.1	0.6
AC-108-407-L/D	4	Bulkhead	3.8	1.9
AC-108-407-B1	4	Bulkhead	1.0	0.7
AC-109-408-L/D	4	Bulkhead	2.1	1.4
AC-109-408-B1	4	Bulkhead	1.2	0.7
AC-109-408-B2	4	Bulkhead	1.3	0.8
AC-110-410-L/D	8	Bulkhead	1.7	1.3
AC-110-410-B1	8	Bulkhead	1.1	0.8
AC-112-L/D	1	Bulkhead	2.1	1.2
AC-112-B1	1	Bulkhead	1.1	0.8
AC-112-B2	1	Bulkhead	0.9	0.6
AC-113-L/D	1	Bulkhead	2.2	1.4
AC-212-L/D	1	Bulkhead	2.1	1.2
AC-212-B1	1	Bulkhead	1.1	0.8
AC-212-B2	1	Bulkhead	0.9	0.6
AC-305-405-L/D	2	Bulkhead	2.3	1.8
AC-305-405-B1	2	Bulkhead	1.3	1.0
AC-305-405-B2	2	Bulkhead	1.2	0.6
AC-311-411-L/D	2	Bulkhead	3.1	1.8
AC-311-411-B1	2	Bulkhead	1.1	0.8
AC-312-412-L/D	2	Bulkhead	5.2	2.3
AC-312-412-B1	2	Bulkhead	1.9	1.1
AC-312-412-B2	2	Bulkhead	1.1	0.7
AC-505-L/D	1	Bulkhead	2.3	1.8
AC-505-B1	1	Bulkhead	1.3	1.0
AC-505-B2	1	Bulkhead	1.2	0.6
AC-506-L/D	1	Bulkhead	2.4	1.9
AC-506-B1	1	Bulkhead	1.1	0.6
AC-507-L/D	1	Bulkhead	3.8	1.9
AC-507-B1	1	Bulkhead	1.0	0.7
AC-508-L/D	1	Bulkhead	2.1	1.4
AC-508-B1	1	Bulkhead	1.2	0.7
AC-508-B2	1	Bulkhead	1.3	0.8
AC-509-L/D	1	Bulkhead	1.8	1.3
AC-509-B1	1	Bulkhead	1.2	0.8
AC-510-L/D	1	Bulkhead	1.8	1.3
AC-510-B1	1	Bulkhead	1.2	0.8

AC-511-L/D	1	Bulkhead	3.3	1.8
AC-511-B1	1	Bulkhead	1.1	0.8
AC-512-L/D	1	Bulkhead	5.2	2.3
AC-512-B1	1	Bulkhead	1.9	1.1
AC-512-B2	1	Bulkhead	1.1	0.7
AC-E-608-908-L/D	4	Bulkhead	3.9	1.6
AC-E-608-908-B1	4	Bulkhead	3.0	1.1
AC-E-609-809-L/D	3	Bulkhead	4.9	2.0
AC-E-609-809-B1	3	Bulkhead	2.2	0.9
AC-E-609-809-B2	3	Bulkhead	3.0	1.1
AC-E-610-910-L/D	4	Bulkhead	1.7	1.2
AC-E-610-910-B1	4	Bulkhead	0.9	0.6
AC-E-611-911-L/D	4	Bulkhead	3.9	1.8
AC-E-611-911-B1	4	Bulkhead	2.2	0.7
AC-E-611-911-B2	4	Bulkhead	2.2	0.8
AC-E-612-812-L/D	3	Bulkhead	3.1	1.6
AC-E-612-812-B1	3	Bulkhead	2.6	1.1
AC-E-613-813-L/D	3	Bulkhead	3.9	2.0
AC-E-613-813-B1	3	Bulkhead	3.3	1.6
AC-E-613-813-B2	3	Bulkhead	2.2	0.8
AC-E-614-814-L/D	3	Bulkhead	2.9	1.3
AC-E-614-814-B1	3	Bulkhead	3.3	1.0
AC-E-614-814-B2	3	Bulkhead	3.6	1.2
AC-E-909-L/D	1	Bulkhead	5.0	2.0
AC-E-909-B1	1	Bulkhead	2.2	0.9
AC-E-909-B2	1	Bulkhead	3.0	1.1
AC-E-912-L/D	1	Bulkhead	3.1	1.6
AC-E-912-B1	1	Bulkhead	2.6	1.1
AC-E-913-L/D	1	Bulkhead	3.9	2.0
AC-E-913-B1	1	Bulkhead	3.3	1.6
AC-E-913-B2	1	Bulkhead	2.2	0.8
AC-E-914-L/D	1	Bulkhead	2.9	1.3
AC-E-914-B1	1	Bulkhead	3.3	1.0
AC-E-914-B2	1	Bulkhead	3.6	1.2
AC-E-1008-L/D	1	Bulkhead	4.0	1.6
AC-E-1008-B1	1	Bulkhead	3.1	1.2
AC-E-1009-L/D	1	Bulkhead	4.0	1.2
AC-E-1009-B1	1	Bulkhead	3.8	1.2
AC-E-1010-L/D	1	Bulkhead	4.4	1.4
AC-E-1010-B1	1	Bulkhead	2.2	0.8
AC-E-1010-B2	1	Bulkhead	3.2	0.8
AC-E-1011-L/D	1	Bulkhead	4.4	2.1
AC-E-1011-B1	1	Bulkhead	2.9	0.9
AC-E-1011-B2	1	Bulkhead	2.2	0.6
AC-E-1012-L/D	1	Bulkhead	3.3	1.9
AC-E-1012-B1	1	Bulkhead	2.4	1.2
AC-E-1013-L/D	1	Bulkhead	4.4	2.1
AC-E-1013-B1	1	Bulkhead	2.0	0.7
AC-E-1013-B2	1	Bulkhead	1.8	1.3

AC-E-1014-L/D	1	Bulkhead	4.5	1.8
AC-E-1014-B1	1	Bulkhead	2.0	0.9
AC-E-1108-L/D	1	Bulkhead	9.6	7.4
AC-E-1108-B1	1	Bulkhead	2.5	1.1
AC-E-1108-B2	1	Bulkhead	3.0	0.9
AC-E-1109-L/D	1	Bulkhead	7.9	2.6
AC-E-1109-B1	1	Bulkhead	2.2	0.9
AC-E-1109-B2	1	Bulkhead	2.1	0.7
AC-E-1110-L/D	1	Bulkhead	4.0	2.2
AC-E-1110-B1	1	Bulkhead	2.2	0.8
AC-E-1110-B2	1	Bulkhead	2.1	0.6
AC-W-1401-2301-L/D	10	Bulkhead	2.1	1.3
AC-W-1401-2301-B1	10	Bulkhead	2.8	1.0
AC-W-1401-2301-B2	10	Bulkhead	3.6	1.1
AC-W-1402-2302-L/D	10	Bulkhead	4.1	1.9
AC-W-1402-2302-B1	10	Bulkhead	2.7	0.9
AC-W-1402-2302-B2	10	Bulkhead	1.2	0.8
AC-W-1403-2403-L/D	11	Bulkhead	2.0	1.7
AC-W-1403-2403-B1	11	Bulkhead	1.0	0.8
AC-W-1404-2404-L/D	11	Bulkhead	2.1	1.4
AC-W-1404-2404-B1	11	Bulkhead	1.7	1.3
AC-W-1404-2404-B2	11	Bulkhead	1.7	1.1
AC-W-1405-2405-L/D	11	Bulkhead	3.6	1.7
AC-W-1405-2405-B1	11	Bulkhead	1.2	0.9
AC-W-1405-2405-B2	11	Bulkhead	3.0	0.9
AC-W-1406-2406-L/D	11	Bulkhead	5.2	2.4
AC-W-1406-2406-B1	11	Bulkhead	2.5	0.8
AC-W-1406-2406-B2	11	Bulkhead	2.4	0.6
AC-W-1406-2406-B3	11	Bulkhead	2.4	0.6
AC-W-1407-L/D	1	Bulkhead	2.0	1.3
AC-W-1407-B1	1	Bulkhead	2.3	1.0
AC-W-1407-B2	1	Bulkhead	1.0	0.5
AC-W-2401-L/D	1	Bulkhead	2.1	1.3
AC-W-2401-B1	1	Bulkhead	2.8	1.0
AC-W-2402-L/D	1	Bulkhead	4.1	1.9
AC-W-2402-B1	1	Bulkhead	2.7	0.9
AC-W-2402-B2	1	Bulkhead	1.2	0.8
AC-W-2407-L/D	1	Bulkhead	2.0	1.3
AC-W-2407-B1	1	Bulkhead	2.3	1.0
AC-W-2407-B2	1	Bulkhead	1.0	0.5
AC-W-2501-L/D	1	Bulkhead	7.6	2.4
AC-W-2501-B1	1	Bulkhead	3.9	1.3
AC-W-2501-B2	1	Bulkhead	2.8	1.3
AC-W-2501-B3	1	Bulkhead	1.2	0.8
AC-W-2501-ST	1	Bulkhead	1.4	0.4
AC-W-2502-L/D	1	Bulkhead	2.7	1.7
AC-W-2502-B1	1	Bulkhead	1.3	0.9
AC-W-2502-B2	1	Bulkhead	1.9	1.0
AC-W-2502-B3	1	Bulkhead	1.5	1.0

AC-W-2503-L/D	1	Bulkhead	3.4	1.9
AC-W-2503-B1	1	Bulkhead	2.6	0.9
AC-W-2503-B2	1	Bulkhead	2.2	0.7
AC-W-2504-L/D	1	Bulkhead	9.1	3.7
AC-W-2504-B1	1	Bulkhead	5.5	2.1
AC-W-2504-B2	1	Bulkhead	2.7	0.8
AC-W-2504-B3	1	Bulkhead	2.8	0.8
AC-W-2601-L/D	1	Bulkhead	6.9	3.5
AC-W-2601-B1	1	Bulkhead	1.1	0.7
AC-W-2601-B2	1	Bulkhead	1.1	0.7
AC-W-2601-B3	1	Bulkhead	1.3	0.9
AC-W-2602-L/D	1	Bulkhead	4.5	1.1
AC-W-2602-B1	1	Bulkhead	1.4	1.0
AC-W-2602-B2	1	Bulkhead	2.6	1.5
AC-W-2602-B3	1	Bulkhead	1.9	0.6
AC-W-2603-L/D	1	Bulkhead	9.5	3.4
AC-W-2603-B1	1	Bulkhead	2.5	0.8
AC-W-2603-B2	1	Bulkhead	2.6	0.8
AC-W-2603-B3	1	Bulkhead	4.4	1.3

WCU's:

Specified / Tender		Specified	Tender
General			
Unit No.		Refer Table Below	
No. off		Refer Table Below	
Type		Refer Table Below	
Heat Pump type		Water Source	
Air Temp. on Cooling Coil (max)	°C DB/°C WB	24/17	
External System Air Pressure Drop	Pa	150	
Air Temp. on Heating Coil	°C DB	20	
Heater Type		Reverse Cycle	

1 All WCU's serving apartments are day/night cycle as per section 3.4 and therefore have been sized according

Unit No.	No. off	Unit Type	Sensible Cooling (kW)	Heating (kW)
AC-113-B1	1	Bulkhead	1.2	0.6
AC-113-B2	1	Bulkhead	0.7	0.4
AC-114-1303-L/D	13	Bulkhead	2.0	1.7
AC-114-1303-B1	13	Bulkhead	1.0	0.8
AC-115-504-L/D	5	Bulkhead	1.7	1.2
AC-115-504-B1	5	Bulkhead	1.5	0.8
AC-116-216-L/D	2	Bulkhead	2.9	1.4
AC-116-216-B1	2	Bulkhead	0.8	0.5
AC-117-218-L/D	4	Bulkhead	2.3	1.4
AC-117-218-B1	4	Bulkhead	1.7	0.8
AC-119-219-L/D	2	Bulkhead	2.1	1.4
AC-119-219-B1	2	Bulkhead	1.8	1.1
AC-201-L/D	1	Bulkhead	2.1	1.9
AC-201-B1	1	Bulkhead	1.1	0.8
AC-202-L/D	1	Bulkhead	2.1	1.9
AC-202-B1	1	Bulkhead	1.2	0.8
AC-213-L/D	1	Bulkhead	2.2	1.4
AC-213-B1	1	Bulkhead	1.2	0.6
AC-213-B2	1	Bulkhead	0.7	0.4
AC-301-501-L/D	3	Bulkhead	3.7	2.1
AC-301-501-B1	3	Bulkhead	1.6	0.8
AC-302-502L/D	3	Bulkhead	2.3	1.6
AC-302-502-B1	3	Bulkhead	1.7	0.8
AC-302-502-B2	3	Bulkhead	1.1	0.8
AC-W-601-1301-L/D	8	Bulkhead	4.0	1.3
AC-W-601-1301-B1	8	Bulkhead	2.8	1.0
AC-W-601-1301-B2	8	Bulkhead	3.6	1.1
AC-W-602-1302-L/D	8	Bulkhead	4.1	1.9
AC-W-602-1302-B1	8	Bulkhead	2.7	0.9
AC-W-602-1302-B2	8	Bulkhead	1.2	0.8
AC-W-604-1304-L/D	8	Bulkhead	2.1	1.4
AC-W-604-1304-B1	8	Bulkhead	1.7	1.3
AC-W-604-1304-B2	8	Bulkhead	1.7	1.1
AC-W-605-1305-L/D	8	Bulkhead	3.6	1.7
AC-W-605-1305-B1	8	Bulkhead	1.2	0.9
AC-W-605-1305-B2	8	Bulkhead	3.0	0.9
AC-W-606-1306-L/D	8	Bulkhead	5.2	2.4
AC-W-606-1306-B1	8	Bulkhead	2.5	0.8
AC-W-606-1306-B2	8	Bulkhead	2.4	0.6
AC-W-606-1306-B3	8	Bulkhead	2.4	0.6

AC-W-607-1307-L/D	8	Bulkhead	2.0	1.3
AC-W-607-1307-B1	8	Bulkhead	2.3	1.0
AC-W-607-1307-B2	8	Bulkhead	1.0	0.5

15.15 WATER TREATMENT

The water treatment systems to be provided under this Specification shall be for the following piped services.

Condenser Water – Side-stream filtration and chemical dosing

15.16 SCHEDULE OF PIPING MATERIALS

SYSTEM	MATERIAL	PIPE SIZE RANGE mm dia	DESIGN PRESSURE kPa	DESIGN TEMP RANGE °C	PIPING STANDARD
Chilled Water Heating Water	Steel Steel	All All	1050 1050	6-40 6-100	AS4041, API Spec 5L Grade B Less than 150mm: 4.8mmWT 150mm to 250mm 6.4WT >250mm: Standard Weight
Chilled Water Heating Water	Copper	Up to 100	950	6-40 6-100	AS 1432 Type B Hard Drawn
Chilled Water Heating Water	Copper	Above 100 and up to 150	950	6-40 6-100	AS 1432 Type B Hard Drawn (Type A if >950kPa)
Condenser Water- open loop	ABS–Class 9 PN-UPVC 9	All	700	6-40	AS3518.1 and 2 AS/NZS 1477
Condenser Water – closed loop	As for Chilled water	All	1050	6-40	As for chilled water
Cold Water	Random Polythene	All	350	0-40	AS 3500
Vent and Drains	Copper	All	500	6-100	AS 1432 Type B Hard Drawn
Vent and Drains	UPVC	All	500	6-40	AS/NZS 1477
Natural Gas Above Ground	Copper	Up to 200	200	5-40	AS5601-2002 (AS 5601- 2002 (AGI 601 – 2002)) AS 1432 Type B Hard Drawn
Natural Gas Below Ground	Medium Density Polyethylene	All	200	6-40	AS5601 – 2002 (AG601), AS/NZS4130
LP Gas above Ground	Copper	Up to 200	140	5-40	AS5601-2002 (AG601) AS 1432 Type B Hard drawn
LP Gas below Ground	Medium Density Polyethylene	All	140	6-40	AS5601 – 2002 (AG601), AS/NZS4130

15.17 SCHEDULE OF PIPING SYSTEMS TEST CRITERIA AND PROCEDURES

SERVICE	TEST FLUID	PROCEDURE	TEST PRESSURE	TEST PERIOD
Water	Treated Water	Fill with pre-treated water and monitor pressure loss corrected for ambient temperature change No untreated water is to enter or remain in any piping system	1400 kPa or 1.5 design Pressure	24 Hours
Refrigeration	Dry Nitrogen	Initial test with rubber mallet, soap, glycerine and water		
		After rectification of any obvious leaks pressure test	Not less than sat vapour pressure at 660C high side, 450C low side	24 Hours
		When no loss in pressure achieved, undertake dehydration and evacuation	Less than 0.22mm Hg with pump in operation	6 Hours
		Stop Vacuum pump when pressure remains constant, isolate system and allow to stand		6 hours
		Break Vacuum install dryer cartridges and re-evacuate as above		
		Break vacuum with correct quantity of refrigerant and oil		
Natural Gas / LP Gas		In accordance with AGA and ALPGA requirements		24 hours
Open Vents and drains	Fluid being drained	Fill and visually check for leaks		

15.18 SCHEDULE OF DUCTWORK CLASSIFICATION

DUCTWORK	PRESSURE CLASSIFICATION	DESCRIPTION SEAL CLASS
Ventilation and Exhaust	As per AS4254 Section 1.7	As per AS4254 Section 1.7
Supply and Return	As per AS4254 Section 1.7	As per AS4254 Section 1.7
Kitchen Exhaust	As per AS4254 Section 1.7	As per AS4254 Section 1.7

Pressure classifications have been calculated from typical equipment and have been given as a guide only. The Contractor must carry out system static pressure calculations using pressure drops through the equipment offered and through the ductwork prepared as part of the construction and workshop drawings. Contractor shall submit for Consultant Engineers review any proposed reduction from the pressure classification listed above.

15.19 SCHEDULE OF THERMAL INSULATION – DUCTWORK

NOTES:

- Alternative insulations must satisfy the stricter of the NCC Section J requirements applicable to the project and the below Consultant Engineer requirements. Any alternative offer subject to review by Consultant Engineer.
- The Climate Zone appropriate to this Project is Climate Zone 6

DUCTWORK SYSTEM	DESCRIPTION
Rigid Supply and Return Air Ductwork (including pre-conditioned outside air and ductwork to / from heat exchangers/heat recovery wheels)	<p>Internal ductwork insulation where shown on Drawings. External ductwork insulation otherwise.</p> <p>Internal ductwork insulation material shall be mineral wool or fibreglass insulation in accordance with Section 7.</p> <p>External ductwork insulation material shall be mineral wool or fibreglass insulation in accordance with Section 8.</p> <p>Internal and external ductwork insulation material R-Values shall not be less than Section J of NCC.</p>
Flexible Circular Supply Air , Return Air and Evaporative Cooling Ductwork (including pre-conditioned outside air and ductwork to / from heat exchangers/heat recovery wheels)	<p>Flexible circular ductwork of no more than 3m in length.</p> <p>— Achieve a minimum material R-Value of 1.0.</p> <p>Flexible circular ductwork of more than 3m in length:</p> <p>— Comply with minimum material R-Values in the ductwork insulation table above.</p>
Flexible Circular Ductwork not forming part of a supply or return air system or an evaporative cooling system (i.e. ductwork drawing/transferring conditioned air / tempered air through an unconditioned / untempered space OR drawing / transferring un-conditioned / un-tempered air through a conditioned / tempered space)	Achieve a minimum Total R-Value as per NCC Section J
Rigid Ventilation / Exhaust Ductwork not forming part of a supply or return air system or an evaporative cooling systems (i.e. ductwork drawing / transferring conditioned air/ tempered air through an unconditioned / untempered space OR drawing/transferring un-conditioned /	<p>Internal ductwork insulation where shown on Drawings. External ductwork insulation otherwise.</p> <p>Internal ductwork insulation material shall be mineral wool or fibreglass insulation in accordance with Section 7 with thickness as noted on Drawings.</p>

DUCTWORK SYSTEM	DESCRIPTION
un-tempered air through a conditioned/tempered space)	External ductwork insulation material shall be mineral wool or fibreglass insulation in accordance with Section 8 and shall have minimum insulation thickness of 25mm.
Rigid Ventilation / Exhaust Ductwork (unless noted above)	Internal ductwork insulation where shown on Drawings. Un-insulated otherwise. Internal ductwork insulation material shall be mineral wool or fibreglass insulation in accordance with Section 7 with thickness as noted on Drawings.

15.20 SCHEDULE OF THERMAL INSULATION – HEATING HOT WATER PIPEWORK

NOTES:

- 1 Alternative insulations must satisfy the stricter of the NCC Section J requirements as applicable to the project and the below Consultant Engineer requirements. Any alternative offer subject to review by Consultant Engineer.
- 2 The Climate Zone appropriate to this Project is **6**
- 3 ENGINEER TO COMPLETE or DELETE REDUNDANT CLIMATE COLUMN BELOW

MATERIAL TYPE

Sectional moulded resin bonded mineral wool or glass wool in accordance with Section 8.

MATERIAL R-VALUES

Material R-Values shall not be less than:

SYSTEM SIZE AND LOCATION	MINIMUM R-VALUE		
	CLIMATE ZONE		
	1, 2, 3 & 5	4, 6 & 7	8
Heating hot water piping for systems of not more than 65kWh capacity			
located internally / underground	1.0	1.0	1.3
located within a wall space, an enclosed sub-floor or an enclosed roof space	1.1	1.1	1.4
located outside the building, within an unenclosed sub-floor or an unenclosed roof space	1.2	1.2	1.5
Heating hot water piping for systems of more than 65kWh capacity			
located internally / underground	1.0	1.0	1.7
located within a wall space, an enclosed sub-floor or an enclosed roof space	1.1	1.1	1.8
located outside the building, within an unenclosed sub-floor or an unenclosed roof space	1.2	1.5	1.9

15.21 SCHEDULE OF SWITCHBOARDS

GENERAL NOTES

- 1 Provision of maximum demand calculation in tabular format for each mechanical switchboard after finalisation of equipment selection. The table shall incorporate three columns representing the following calculation methodologies; AS3000 max demand calculations in kW, kVA, Amps per phase; equipment rating kW and Amps per phase; and equipment calculated running amps/kW (not FLA and not rated kW) based on the equipment selected capacity. The table shall include total demand for all connected equipment and there also should be Switchboard maximum demand taking into account the standby equipment and life safety equipment usually not operating during normal mode of operation. Consultant Engineer will then determine which demand figure is to be used (the default is the total designed loads times a diversity factor) for cable selection. Any submission not completed based on the above requirements will be rejected.
- 2 Provide fire alarm light to indicate fire signal to switchboard (one light for each fire zone signal)
- 3 Provide GPO and lights to be located inside each switchboard.
- 4 Provide Lamp Test to each switchboard
- 5 Run, fault lights are to indicate switchboard power available or fault and unit operation or fault.
- 6 Provide Economy Light for all AHU's with Economy Mode.
- 7 Switchboard schedule abbreviations.
 - a P = Provision for future installation. Provide tagged local isolator / coiled tails adjacent, future equipment location.
 - b X = Provide
 - c E = Essential Power Supply
 - d L = Load Shed
 - e N = Non-essential Power Supply
 - f F = Fire Essential Power Supply (Fire Rated Supply)

Switchboard : MSSB-G-01

Location : Ground Floor

Type : Life Safety

Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
OAF-G-02	3 / 0.37	VSD	F	X	X	X
GEF-G-04	3 / 0.37	VSD	F	X	X	X

Switchboard : MSSB-G-02
Location : Ground Floor
Type : Non-Essential
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
WCU-G-01	1 / 2.5	DOL	N	X	X	X
WCU-G-02	1 / 2.5	DOL	N	X	X	X
WCU-G-03	1 / 2.5	DOL	N	X	X	X
WCU-G-04	1 / 2.5	DOL	N	X	X	X
WCU-G-05	1 / 2.5	DOL	N	X	X	X
ØAF-G-01	1 / 0.255	VSD	N	X	X	X
GEF-G-01	3 / 0.825	VSD	N	X	X	X
GEF-G-02	3 / 0.37	VSD	N	X	X	X
GEF-G-03	1 / 0.04	VSD	N	X	X	X
GEF-G-04	3 / 0.37	VSD	N	X	X	X
TEF-G-01	1 / 0.044	VSD	N	X	X	X

Switchboard : MSSB-G-03
Location : Ground Floor
Type : Non-Essential
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
CSF-G-01	3 / 1.65	VSD	N	X	X	X

Switchboard : MSSB-3-01
Location : Ground Floor
Type : Non-Essential
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
CEF-3-01	3 / 8.25	VSD	N	X	X	X

Switchboard : MSSB-3-02
Location : Ground Floor
Type : Non-Essential
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
CSF-G-01	3 / 1.65	VSD	N	X	X	X

Switchboard : MSSB-05-01
Location : Ground Floor
Type : Non-Essential
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
PAC-03-01	3 / 27.2	DOL	N	X	X	X
WCU-04-01	1 / 2.5	DOL	N	X	X	X
WCU-04-02	1 / 2.5	DOL	N	X	X	X
WCU-05-01	1 / 2.5	DOL	N	X	X	X
WCU-05-02	1 / 2.5	DOL	N	X	X	X
WCU-05-03	1 / 2.5	DOL	N	X	X	X
OAF-03-01	3 / 1.21	VSD	N	X	X	X
GEF-03-01	3 / 1.21	VSD	N	X	X	X
OAF-04-01	1 / 0.105	VSD	N	X	X	X
OAF-04-02	1 / 0.048	DOL	N	X	X	X
TEF-04-01	1 / 0.28	VSD	N	X	X	X
OAF-05-01	3 / 0.37	VSD	N	X	X	X
OAF-05-02	1 / 0.048	VSD	N	X	X	X
GEF-05-01	1 / 0.048	VSD	N	X	X	X
TEF-05-01	1 / 0.1	VSD	N	X	X	X

Switchboard : MSSB-11-01
Location : Ground Floor
Type : Life Safety
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
SPF-12-1	3 / 12.1	VSD	F	X	X	X
SPF-12-2	3 / 12.1	VSD	F	X	X	X
SPRF-12-1	3 / 3.3	VSD	F	X	X	X

Switchboard : MSSB-11-02
Location : Ground Floor
Type : Non-Essential
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
SAF-12-01	3 / 0.407	VSD	N	X	X	X
GEF-12-01	3 / 0.75	VSD	N	X	X	X
GEF-12-02	3 / 0.75	VSD	N	X	X	X

Switchboard : MSSB-26-01
Location : Ground Floor
Type : Life Safety
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
SPF-R-1	3 / 12.1	VSD	F	X	X	X
SPF-R-2	3 / 12.1	VSD	F	X	X	X
SPRF-R-1	3 / 4.4	VSD	F	X	X	X

Switchboard : MSSB-26-02
Location : Ground Floor
Type : Non-Essential
Fault Level : 15kA

PLANT	MINIMUM ESTIMATED LOAD Ø/(kW)	STARTING ARRANGEMENT	POWER SUPPLY	AUTO / TEST	AUTO / OFF / TEST	RUN/FAULT, OPEN/CLOSED LIGHTS
SAF-R-01	3 / 1.65	VSD	N	X	X	X
KEF-R-01	3 / 2.42	VSD	N	X	X	X
GEF-R-01	3 / 0.407	VSD	N	X	X	X
PCCWP-R-01	3 / 15	VSD	N	X	X	X
PCCWP-R-02	3 / 15	VSD	N	X	X	X
SCCWP-R-01	3 / 18.5	VSD	N	X	X	X
SCCWP-R-02	3 / 18.5	VSD	N	X	X	X
HHWP-R-01	3 / 7.5	DOL	N	X	X	X
HHWP-R-02	3 / 7.5	DOL	N	X	X	X
HHWP-R-03	3 / 4.0	DOL	N	X	X	X
HHWB-R-01	1 / 0.6	DOL	N	X	X	X
HHWB-R-02	1 / 0.6	DOL	N	X	X	X
HHWB-R-03	1 / 0.6	DOL	N	X	X	X
HHWB-R-04	1 / 0.6	DOL	N	X	X	X
HHWB-R-05	1 / 0.6	DOL	N	X	X	X
HHWB-R-06	1 / 0.6	DOL	N	X	X	X
HHWB-R-07	1 / 0.6	DOL	N	X	X	X
HHWB-R-08	1 / 0.6	DOL	N	X	X	X
CT-R-01	3 / 2.2	VSD	N	X	X	X
CT-R-02	3 / 2.2	VSD	N	X	X	X

15.22 SCHEDULE OF SOUND LEVELS

Sound levels scheduled hereunder form the basis of design and are required to be maintained for all conditions of operation of plant, air distribution, flow rates and temperature fluctuations. Any spaces not listed should comply with the criteria shown in AS/NZS 2107 “Acoustics—Recommended design sound levels and reverberation times for building interiors”

Rectify any plant or systems which do not perform to specified levels or which contribute to noise levels which exceed the specified requirements.

Note that these are intended as criteria for all spaces which do not have project specific criteria specified which would supersede the targets shown below. The Contractor is to confirm with the Project Manager as to any Acoustic Engineer / Green Star criteria which would take precedence over the target shown below.

BUILDING AREA	MAXIMUM PERMISSIBLE SOUND LEVEL L_{AEQ} , DB(A)
Private Offices	35
General Offices	40
Board Rooms	35
Foyer	45
Lobby/Reception	40
Toilets	50
Computer Rooms	45
Loading Docks	65
Fire Control Rooms	65
Car Park	55
Stairwells	45
Plant Rooms	75
Property boundaries	Not to exceed the requirements of the Local Authority
Outdoor public and private areas	Not to exceed the L_{90} background noise level, as per AS 1055.2 for R4 noise area category, by more than 5dB(A) – or to Local Authority guidance

15.23 SCHEDULE OF VIBRATION ISOLATION

EQUIPMENT	TYPE OF MOUNTING OR HANGER	MINIMUM REQUIRED ANTI VIBRATION STATIC DEFLECTION	MINIMUM TOTAL ISOLATING EFFICIENCY
Pumps	Type A Plant Base Concrete Inertia base and spring mountings with neoprene pads	25mm	95
Axial Flow Fans	Spring hangers with neoprene inserts	25mm	98
Centrifugal Fans	Free standing spring mountings and neoprene pads	40mm	98
Axial Flow Fans (500-1000 L/s)	Spring hangers with neoprene inserts	4mm	80
Axial Flow Fans (1000-4000 L/s)	Spring hangers with neoprene inserts	15mm	95
Axial Flow Fans (>4000 /s)	Spring hangers with neoprene inserts	30mm	97
Centrifugal Fans (500-1000 L/s)	Free standing spring mountings and neoprene pads	15mm	90
Centrifugal Fans (1000-4000 L/s)	Free standing spring mountings and neoprene pads	30mm	97
Centrifugal Fans (>4000 L/s)	Free standing spring mountings and neoprene pads	40mm	98
Air Handling Unit Fans (500-1000 L/s)	Spring hangers with neoprene inserts	5mm	80
Air Handling Unit Fans (1000-4000 L/s)	Spring hangers with neoprene inserts	25mm	95
Air Handling Units (>4000 L/s)	Spring hangers with neoprene inserts	35mm	97
AHU's and FCU's	Type B Plant Base (Concrete Inertia base and neoprene pads)		

15.24 SCHEDULE OF SAMPLES

ITEM OF EQUIPMENT
Each supply, return and exhaust diffuser and grille
Flexible duct
Duct Joining method
Pipe insulation (each type)
Duct insulation (each type)
Temperature Sensor

15.25 SCHEDULE OF PAINTING

Paint the complete systems listed below, except normally bright and polished metal components, bearing surfaces, adjusting screws, foil faced insulation and similar items.

ITEM OF EQUIPMENT	NOTES
Switchboards and control panels	Red
Equipment such as chillers, boilers, pumps, heat exchangers	Manufacturers' Standard
Internal surfaces of air outlets and openings exposed to view	Matt Black
Ductwork, piping and related fittings and supports exposed to public view	To Architect's requirements
Ductwork, piping and related fittings and supports within plant rooms	
Air handling units	Manufacturers' Standard
Bases and plinths	Grey
Conduits exposed to view	To Architect's requirements
Cable-trays and electrical ducts exposed to view	To Architect's requirements

16 TENDER FORM

FOR

MECHANICAL SERVICES

AT

ONE WELLINGTON
8-12 PUNT RD & 3-7 WELLINGTON ST
ST KILDA VIC 3182

I/We, the undersigned, hereby tender to carry out the complete works in accordance with the Specification, Drawings, General Conditions of the proposed contract and addenda, for the sum set out hereunder:

Fixed Lump Sum Tender excluding Goods and Services Tax (GST) for the complete Mechanical Service Works Package as specified:		\$
Provisional Sums:		\$
GST:		\$
TOTAL INCLUDING GST:		\$

ADDENDUM

We, the undersigned, acknowledge having received the following addenda and have incorporated them in our tender proposal:

NUMBER	DESCRIPTION	DATE RECEIVED

DATED THIS DAY OF 2020

SIGNATURE OF TENDERER

COMPANY

ADDRESS

.....

Cost Option 1: Gas Boosters

Section Costs		ITEM COST
1	Cost associated with providing gas boosters as described in section 3.4.1.3	\$
2	Credit for reduced size of natural gas pipework as described in section 3.4.1.3	\$
3	Sub-Total (excluding GST)	\$
4	GST	\$
5	Total INCLUDING GST	\$

T.1 Sections of Tender Price

The amounts indicated in the total tender sum for the supply, installation and connection of all items including administration costs and profit for sections of the work are as follows:

SECTION COSTS	ITEM COST
1 General Requirements	\$
2 Cooling Tower Plant	\$
3 Heating Plant	\$
4 Pumps	\$
5 Apartment Air Conditioning	\$
6 Common Area Air Conditioning	\$
7 Ventilation/Exhaust Plant	\$
8 Miscellaneous Plant and Equipment	\$
9 Pipework, Valves and Fittings	\$
10 Ductwork, Sheet Metal items, Air Outlets	\$
11 Thermal Insulation	\$
12 Water Treatment	\$
13 Electrical Services for Mechanical Plant	\$
14 Control Systems	\$
15 Testing and Commissioning	\$
16 Maintenance and Servicing	\$
17 As Built Documentation	\$
Sub-Total (excluding GST)	\$
GST	\$
Total INCLUDING GST	\$

T.2 Schedule of Alternative Offers

We herein advise the following individual adjustments to the Base Tender Sum for each alternative listed below. Provide complete details, technical data and Tender sum cost impact for all alternatives to the compliant offer to enable full evaluation and individual selection.

ALTERNATIVES OFFERED	COST ADJUSTMENT

T.3 Schedule of Personnel

The following persons will be assigned to the contract. Persons nominated shall be employed by or be responsible to the Mechanical Services Works Package.

IN OVERALL CHARGE FOR THE CONTRACTOR

NAME		YEARS WITH COMPANY	
EXPERIENCE			

CHIEF SUPERVISOR

NAME		YEARS WITH COMPANY	
EXPERIENCE			

FOREMAN IN CONTINUOUS ATTENDANCE – ON SITE

NAME		YEARS WITH COMPANY	
EXPERIENCE			

DRAFTING PERSONNEL FOR THE PRODUCTION OF CONSTRUCTION AND AS INSTALLED DRAWINGS

NAME		YEARS WITH COMPANY	
EXPERIENCE			

T.4 Schedule of specialist installers

We advise that our Tender includes work as described below to be carried out in each case by the specialist installer stated.

ITEM	COMPANY
1 Pipework	
2 Ductwork	
3 Insulation	
4 Electrical	
5 Automatic Controls	
6 Water Treatment	
7 Painting	
8 Commissioning	
9 Service and Maintenance	

T.5 Schedule of major equipment manufacturers

We advise that our Tender includes equipment of manufacturers listed below. Any modifications to equipment shall fully meet the requirements of the Specification.

ITEM	MANUFACTURER AND TYPE
Condensers	
Cooling Towers	
Hot Water Heaters	
Water Heat Exchangers	
Water Pumps	
Expansion Tanks	
Coils	
Air Filters	
Fan Coil Units	
Fans	
Attenuators	
Acoustic Louvres	
Air conditioning Units	
Boiler	

T.6 Schedule of unit rates

The unit rates may be used as a guide for assessment of variation additions to the contract works.

All unit rates shall include all costs including but not limited to costs for supervision, administration, mark-up, travel and profit. Exclude GST.

Labour rates and profit margins are used for works not covered by the unit schedule rates.

1 Ductwork

For supply and installation of ductwork in false ceiling spaces, before ceiling is erected.

SHEET METAL DUCT SIZE MM	RATE PER METRE RUN - STRAIGHT LENGTHS 250 PA AS4254 PRESSURE CLASS – INTERNALLY INSULATED				
	R1.2	R1.6	R2.0	R2.4	R3.0
150 x 350	\$	\$	\$	\$	\$
200 x 350	\$	\$	\$	\$	\$
500 x 350	\$	\$	\$	\$	\$
600 x 350	\$	\$	\$	\$	\$
700 x 400	\$	\$	\$	\$	\$
800 x 800	\$	\$	\$	\$	\$
1000 x 1000	\$	\$	\$	\$	\$
2000 x 2000	\$	\$	\$	\$	\$

SHEET METAL DUCT SIZE MM	RATE PER METRE RUN - STRAIGHT LENGTHS 250 PA AS4254 PRESSURE CLASS – EXTERNALLY INSULATED				
	R1.2	R1.6	R2.0	R2.4	R3.0
150 x 350	\$	\$	\$	\$	\$
200 x 350	\$	\$	\$	\$	\$
500 x 350	\$	\$	\$	\$	\$
600 x 350	\$	\$	\$	\$	\$
700 x 400	\$	\$	\$	\$	\$
800 x 800	\$	\$	\$	\$	\$
1000 x 1000	\$	\$	\$	\$	\$
2000 x 2000	\$	\$	\$	\$	\$

SHEET METAL DUCT SIZE MM	RATE PER METRE RUN - STRAIGHT LENGTHS KITCHEN EXHAUST DUCTWORK
200 x 400	\$
300 x 400	\$
400 x 700	\$
500 x 800	\$
600 x 900	\$

SHEET METAL DUCT SIZE MM	RATE PER RADIUS BEND 250 PA AS4254 PRESSURE CLASS - INTERNALLY INSULATED				
	R1.2	R1.6	R2.0	R2.4	R3.0
150 x 350	\$	\$	\$	\$	\$
200 x 350	\$	\$	\$	\$	\$
500 x 350	\$	\$	\$	\$	\$
600 x 350	\$	\$	\$	\$	\$
700 x 400	\$	\$	\$	\$	\$
800 x 800	\$	\$	\$	\$	\$
1000 x 1000	\$	\$	\$	\$	\$
2000 x 2000	\$	\$	\$	\$	\$

SHEET METAL DUCT SIZE MM	RATE PER RADIUS BEND 250 PA AS4254 PRESSURE CLASS - EXTERNALLY INSULATED				
	R1.2	R1.6	R2.0	R2.4	R3.0
150 x 350	\$	\$	\$	\$	\$
200 x 350	\$	\$	\$	\$	\$
500 x 350	\$	\$	\$	\$	\$
600 x 350	\$	\$	\$	\$	\$
700 x 400	\$	\$	\$	\$	\$
800 x 800	\$	\$	\$	\$	\$
1000 x 1000	\$	\$	\$	\$	\$
2000 x 2000	\$	\$	\$	\$	\$

SHEET METAL DUCT SIZE MM	RATE PER TRANSITION 250 PA AS4254 PRESSURE CLASS - INTERNALLY INSULATED				
	R1.2	R1.6	R2.0	R2.4	R3.0
2000 x 2000 to 1500 x 1500	\$	\$	\$	\$	\$
1500 x 1500 to 1000 x 1000	\$	\$	\$	\$	\$
1000 x 1000 to 1000 x 400	\$	\$	\$	\$	\$
800 x 400 to 600 x 300	\$	\$	\$	\$	\$
600 x 300 to 400 x 200	\$	\$	\$	\$	\$

SHEET METAL DUCT SIZE MM	RATE PER TRANSITION 250 PA AS4254 PRESSURE CLASS - EXTERNALLY INSULATED				
	R1.2	R1.6	R2.0	R2.4	R3.0
2000 x 2000 to 1500 x 1500	\$	\$	\$	\$	\$
1500 x 1500 to 1000 x 1000	\$	\$	\$	\$	\$
1000 x 1000 to 1000 x 400	\$	\$	\$	\$	\$
800 x 400 to 600 x 300	\$	\$	\$	\$	\$
600 x 300 to 400 x 200	\$	\$	\$	\$	\$

FLEXIBLE DUCT SIZE MM	LOW PRESSURE INSULATED
150 dia.	\$
200 dia.	\$
250 dia.	\$
300 dia.	\$
350 dia.	\$

1 Supply Air Outlets

Unit rates for the following shall allow for work to be carried out after erection of the ceiling, but shall exclude costs for removal and replacement of ceiling tiles.

a	Installation of an additional perimeter zone supply air outlet including connection of 3m of flexible duct and spigot with butterfly damper fitted to main duct.	\$
b	Installation of an additional centre zone supply air outlet including connection of 3m of flexible duct and spigot with butterfly damper fitted to main duct.	\$
c	Relocation of a supply air outlet including reconnection of flexible duct but excluding costs of flexible duct.	\$

2 Pipework

For the supply and installation of pipe work in ceiling/floor spaces, before the erection of false ceiling or floor.

PIPE DIAMETER MM	RATE PER METRE RUN - STRAIGHT LENGTHS INSULATED (HHWF/R) MINERAL WOOL
15	\$
20	\$
25	\$
32	\$
40	\$
50	\$
65	\$
80	\$
100	\$

PIPE DIAMETER MM	RATE PER METRE RUN - STRAIGHT LENGTHS UNINSULATED (CCWF/R)
80	\$
100	\$
125	\$
150	\$
200	\$
250	\$

PIPE DIAMETER MM	RATE PER METRE RUN - STRAIGHT LENGTHS INSULATED (REFRIGERANT)
15	\$
20	\$
25	\$
32	\$
40	\$
50	\$
65	\$
80	\$
100	\$

PIPE DIAMETER MM	RATE PER METRE RUN - STRAIGHT LENGTHS INSULATED (REFRIGERANT)
150	\$
200	\$

1 Labour Rates

Labour rate applicable for work time on site and in factory and shall include all loadings and allowances apart from overhead and profit covered by Item 7 below.

	RATE PER HOUR		
	Normal Time	Time x 1½	Time x 2
Ductwork - Factory Manufacture	\$	\$	\$
Ductwork - Site Installation	\$	\$	\$
Pipework - Factory Manufacture	\$	\$	\$
Pipework - Site Installation	\$	\$	\$
Supervision - Site Installation	\$	\$	\$
Commissioning	\$	\$	\$
Drawing Office	\$	\$	\$
Maintenance	\$	\$	\$
	\$	\$	\$

1 Equipment and Materials

Mark up to be applied on cost to purchase materials and equipment	\$
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2 Specialist Installers

Mark up to be applied on specialist installer works (e.g. Thermal Insulation, Controls, Painting)	\$
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3 Overheads and Profit

Overheads and profit on total Contract value.	\$
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4 Variation Deductions

Percentage of addition rates to be applied for deductions.%
Add notes as applicable to describe how variation deductions will be costed.%

Provide complete details of those instances where the tender submission does not fully comply with the specified requirements.

[illegible]