# TUMUT MULTIFUNCTION FACILITY

# SPECIFICATION FOR MECHANICAL DESIGN SERVICES

# DOCUMENT NUMBER S494ASPE001 [B]

PREPARED BY:

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**CONSULTING ENGINEERS** ELECTRICAL LIGHTING MECHANICAL SECURITY COMMUNICATIONS AUDIO VISUAL
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## Document Details

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# 1. MECHANICAL SERVICES REQUIREMENTS

## 1.1 PRELIMINARIES

### 1.1.1 Introduction

The specification contains the requirements for the mechanical services installation for the proposed new multifunction facility and associated works at Tumut

The specification does not itemise all elements required to complete the installation of the Mechanical Services,but provide sufficient information that an experienced and competent Mechanical Contractor shall be able to price and complete the works. It is expected that all necessary ancillaries and fittings shall be supplied to complete the installation of a fully operational mechanical services system that is fit for purpose.

The specification is intended to be read in conjunction with the mechanical design drawings and relevant codes and standards.

The specification is also intended to be read in conjunction with the architectural and structural drawings as well as the specifications and drawings of other building services.

### 1.1.2 Definitions

The following definitions are applied throughout this specification:

| Term | Definition |
|---|---|
| Shall | An instruction that is to be carried out to the Works as specified in this specification. |
| Approved/Approval | Acceptable for the works in the option of the Superintendent, following review by the Architect, Engineer and/or by regulation of the Local Authority. |
| Suitable | Suitable in the opinion of the Site Manager. |
| Equal | Equivalent in performance, quality and material and approved by the superintendent. |
| Install | Set out, erect, mount, align, fix, connect, adjust, test and commission and hand over in proper working order and shall ALSO mean, unless stated clearly to the contrary, supply of the item(s). |
| Supply | Purchase, obtain, store off site as necessary, deliver to site, and off load, position, store and protect on site. |
| Provide | Supply and install. |
| Submit/Review | Supply information to the Superintendent for review. |
| The Work | The Whole of the Work to be carried out by the Mechanical Contractor. |
| The Contract | The Agreement between the Mechanical Contractor and the Proprietor. |
| Superintendent | The person nominated by the owner or principal to represent them on this project |

| Term | Definition |
|---|---|
| The Tenderer | The Tenderer is the Individual, Firm or Company offering a price to execute the Mechanical Contract Works work defined herein, who may be subsequently defined as the Mechanical Contractor. |
| The Mechanical Contractor | The Mechanical Contractor is the Individual, Firm or Company appointed to execute the Mechanical Contract Works, (as a Sub-Contractor or otherwise to the Main Contractor or Builder) either as a whole or in such parts as may be defined in the Contract Documents. The Mechanical Contractor shall hold current licences to perform the Works as described herein. |
| The Builder/Main Contractor | The building construction company or firm appointed to execute the complete building contract works (of which the Mechanical contract works are a part) and the main controlling/co-ordinating contractor for the project. |

## 1.2 RESPONSIBILITIES

### 1.2.1 Tenderer

The Tenderer is to fully inform themselves of all aspects of the project.

The Tender shall advise any discrepancies or omissions within the tender package during the tender period, otherwise, the Tenderer accepts responsibility for the documents and drawings (i.e. The Tenderer accepts and owns any liability for the documentation and drawings).

During the tender period the Tenderer shall attend site and inspect, as a minimum the following:

(a) Site conditions, restrictions and access;
(b) Location and status of existing services;
(c) Power Supply: If insufficient power supplies/MCB's available. Allow for new or additional;
(d) Condensate tundish: If not provided or in wrong position, allow for new or additional.

The tender is to submit a conforming tender.

### 1.2.2 Mechanical Contractor

The successful Mechanical Contractor shall be responsible for:

(a) Design development of the Mechanical Services, including but not limited to:

- Final duct sizing based on actual duct layout;
- Pipe sizing based on actual piping layout;
- Final selection of plant and equipment based on actual operating conditions, i.e. pressure drops, etc.;
- Handing of all equipment;
- Coordination of plant and equipment within the available ceiling space.

(b) Design of the mechanical electrical system including cable sizing, fuse/MCCB selection to be undertaken by a qualified electrician;

(c) Compliance with acoustic requirements of local council and with the project acoustic report, including any additional acoustic treatment not specifically nominated within the specification or on the design drawings;

(d) Full on-site coordination with all other trades;

(e) Setting out of work, final locations of plant and equipment including required service access etc.;

(f) All works noted in the section of this specification titled 'Extent and Scope of Work Under this Contract' and elsewhere in the specification and as shown on all associated design drawings.

### 1.2.3 Builder/Main Contractor

The Builder/Main Contractor shall be responsible for:

(a) The supply of all works and services noted in the section of this specification titled "Associated Work" at no charge to the Mechanical Contractor;

(b) The facilitation of site coordination of the Mechanical Contractor with other trades on site;

(c) Free access to the work site.

## 1.3 GENERAL DESCRIPTION OF WORK

The works covered by this specification include supply, delivery and installation on site, of air conditioning and mechanical services plant and equipment, and includes testing, commissioning, defects liability and maintenance of all equipment as specified, together with preparation of the Operating and Maintenance Manuals including 'As Installed' drawings (in DWG and PDF formats).

The works include all ancillary work required to complete the work, including but not limited to building works, penetrations, any required fees or submissions.

The Tenderer must allow for coordination of the works with all other trades, this is to be done in conjunction with all relevant parties without affecting the operation of the operating spaces.

## 1.4 EXTENT AND SCOPE OF WORK UNDER THIS CONTRACT

The following is a list of work items associated with the Mechanical Services installation for this project. The list is not meant to be exhaustive and final but rather to give an overview of the major components making up the Mechanical Services portion of the total contract. Items of work associated with the Mechanical Services installation but not normally undertaken as part of the Mechanical Services subcontract are listed in the following clause, Associated Works.

(a) Supply and Installation of a VRF air conditioning system/s to service front of house areas of the facticity as per schedules and design drawings;

(b) Supply and Installation of a dedicated air conditioning system to service comms room as per schedules and design drawings;

(c) Supply and installation of indirect evaporative coolers to service the sports hall as per schedules and design drawings;

(d) Supply and installation of circulation fans to service the sports hall as per schedules and design drawings;

(e) Supply and installation of electric radiant heaters to service the sports hall as per schedules and design drawings:

(f) Supply and installation of exhaust systems to services the amenities as per schedules and design drawings:

(g) Supply and installation of kitchen ventilation system to service the commercial kitchen as per schedules and design drawings

(h) Supply and installation of motorised relieve air dampers to each external low level louver on the sports hall east wall, refer to architectural drawings for sizing.

(i) Supply and installation of grilles as per design drawings and schedules;

(j) Supply and installation of air filters to Australian standards as per design drawings and schedules;

(k) Supply and installation of a complete system of metal and flexible ductwork with all required supply, return, exhaust and outside grilles and louvers, air control dampers, fire dampers, duct hanging systems and all other items required to complete the system;

(l) Supply and installation of a complete system of refrigeration and drainage pipework for each air conditioning system in compliance with manufactures requirement and relevant standards and codes;

(m) Supply and installation of a complete electrical wiring system for the mechanical services equipment including all required mechanical services switchboard;

(n) Commissioning of all installed equipment and systems, including balancing of air and electrical systems and any other work required to deliver a fully functional mechanical services system;

(o) End user training;

(p) Maintenance during the 12 month warranty period;

(q) Cranage and hoisting into position of the mechanical services equipment;

(r) Painting and labelling;

(s) Working drawings (Workshop Drawings);

(t) Operation and maintenance instructions and 'As Installed' drawings;

(u) Installation certification for the project, stating compliance with design and all relevant codes and standards;

(v) Manufactures certification for all equipment;

(w) Witness testing as required to comply with the specification and contract requirements;

(x) Minimum three (3) months system monitoring and fine tuning period, following completion and during facility operational periods.

## 1.5 NOMINATED PLANT AND EQUIPMENT

Where plant and equipment is nominated in this specification or on the tender drawings, unless otherwise noted, it is to assist in the tender process only and does not infer that this plant or equipment must be used in this project.

The successful tender is to select all plant and equipment to suit the design requirements and will take full responsibility for it suitability for the project.

Webb Group Australia accepts no responsibility for the suitability of the nominated plant or equipment for this project.

## 1.6 TENDER DRAWINGS

The drawings supplied with the specification at the time of tendering are diagrammatic and approximate only. These drawings, however, together with the specification, are intended to be mutually explanatory and to show the complete scope of the work required. All work set forth by one, if not by the other, shall be fully executed.

## 1.7 SETTING OUT OF WORKS

The Mechanical Contractor shall accurately set out the Works and keep them correct in accordance with the Architect's drawings and/or to the approval of the Site Manager.

Where services to be installed under this Contract are to be run adjacent to or near to other services, the setting out of the services are to be approved by the Main Contractor before installation proceeds. All outlets indicated on the tender drawings are indicative, and any outlet within a room, corridor, or workstation etc., may be relocated at no additional cost to the contract.

The Mechanical Contractor shall be responsible for and shall at his own cost, amend any errors arising from his inaccurate setting out, unless directed in writing by the Main Contractor.

The Mechanical Contractor shall be responsible for the full co-ordination of his work with that of other Contractors.

## 1.8 ASSOCIATED WORK

### 1.8.1 Scope

The following work items associated with the Mechanical Services installation shall be undertaken by other trades. However, the Mechanical Contractor must provide to the Main Contractor fully dimensioned and details drawings setting out requirements, such as penetrations through building elements, size of equipment platforms and loading points, tundish locations etc., in sufficient time to enable these provisions to be incorporated into the works in line with the construction programme.

Should penetrations through structural elements be missed as a result of the Mechanical Contractor not providing the necessary information in time to the Main Contractor then the cost of forming such openings at a later stage in the construction programme shall be borne by the Mechanical Contractor.

(a) Forming of openings through walls, floors, ceilings and roofs for the passage and installation of ductwork, pipework, etc. Sealing of all penetrations through internal elements following the installation of ductwork and pipework shall be the responsibility of the Mechanical Contractor;

(b) Under-flashing of roof penetrations. The Mechanical Contractor shall be responsible for ductwork over-flashing. All roof pipework penetrations are to incorporate 'Dektite' flashing systems, or approved equal, supplied and installed by the Mechanical Contractor;

(c) Removal and reinstallation of building elements required for the installation of the mechanical services plant and equipment, this may include ceilings, roofs, wall, floors etc.;

(d) Structural steel roof platform and decking on which to locate the roof mounted air conditioning units;

(e) Permanent roof access ladder and roof walkway system serving the above roof platform;

(f) Provision of 'half' ceiling tiles and intermediate tee-bars to support ceiling diffusers;

(g) Provision and installation of access panels and hatches required for the commissioning and ongoing maintenance of the mechanical services system. Access panels and hatches are to be of a suitable size to allow for safe and easy access to all equipment and plant;

(h) Installation only of door relief air grilles in those doors nominated on the Mechanical Services drawings;

(i) Provision of tundishes and waste points for the discharge of condensate from the air conditioning units;

(j) Provision of a cold water supply point at the roof platform;

(k) Provision of a three phase, 4 wire + E electrical sub-mains terminating in 3 metre tails adjacent to the Mechanical Services switchboard for final termination by the Mechanical Services subcontractor. Size of the required electrical sub-main is to be advised to the Main Contractor by the Mechanical Services subcontractor. The sub-main size nominated in this specification is for tendering purposes only;

(l) Decorative painting of the ductwork and air conditioning units exposed to view on the roof;

(m) Provision of a "Fire Trip" signal wiring from the F.I.P. or Security system.

## 1.9 PERFORMANCE REQUIREMENTS

### 1.9.1 Scope

The following section defines the performance requirements upon which this design is based. Any modification to the performance requirements shall require the design to be reviewed.

### 1.9.2 Design Conditions

Air conditioning systems are to satisfy the following criteria under the most adverse combination of external solar loading and the following conditions:

**Outside Design Conditions**

Summer: 38.3°C DB, 25.3°C WB

Winter: -1.6°C DB

*Note:* Outside design conditions are in accordance with AIRAH Design Manual DA9 and CAMEL Heat Load Calculation program.

**Internal Design Conditions**

| Area Served | Internal Design Conditions | | Normal Operating Hours | Maximum Noise Level (NR) |
|---|---|---|---|---|
| | °C DB | % RH | | |
| Front of House | 23±1.5 | 50 (1) | TBA | 40 |
| Meeting | 23±1.5 | 50 (1) | TBA | 40 |
| Office | 23±1.5 | 50 (1) | TBA | 40 |
| Sports Hall | 25 - 18 | 50 (1) | TBA | 45 |

*(1) Denotes no direct humidity control shall be provided however inherent psychrometric characteristics shall generally limit relative humidity to below 65% under most operating conditions.*

### 1.9.3 Load Allowances

**Air Conditioning Loads**

Air conditioning system capacities have been selected to satisfy the following equipment, light, people and outdoor air loads.

| Area Served | Equipment Load W/m2 | Lighting Load W/m2 | Occupancy M2/person | Outdoor Air l/s/person | Additional Outside Air l/s |
|---|---|---|---|---|---|
| Front of House | 10 | 10 | As-Indicated | 10 | - |
| Meeting | 25 | 10 | As-Indicated | 10 | - |
| Office | 25 | 10 | As-Indicated | 10 | - |
| Sports Hall | 5 | 10 | As-Indicated | 10 | - |

*Note: The specified filter efficiencies, supply air quantities and occupancies have been used to determine fresh air quantities as permitted by AS1668.2. Any modifications to these parameters shall require a re-assessment of fresh air rates.*

**Building Fabric**

Air conditioning load calculations have been determined from the building fabric at the minimum NCC and Basix requirements or as supplied by the client.

### 1.9.4 Design Parameters

**Duct Design Criteria**

| Duty | Velocity m/s | Pressure Drop Pa/m | Noise Rating NR |
|---|---|---|---|
| Supply Air – Main Duct | ≤9 | ≤1.0 | ≤NR45 |
| Supply Air – Branch Duct | ≤6 | ≤1.0 | ≤NR40 |
| Supply Air – Riser Duct | ≤12 | ≤1.2 | ≤NR50 |
| Return Air Duct | ≤6 | ≤0.8 | ≤NR40 |
| Exhaust Air Duct | ≤6 | ≤0.8 | ≤NR50 |
| Kitchen Exhaust Duct | ≥10 | - | ≤NR50 |
| Flexible Duct | ≤4 | | ≤NR25 |

Duct work is to be design to meet the most stringent requirement above.

**Copper Water Piping Design Criteria**

| Duty | Velocity m/s | Pressure Drop Pa/m | Noise Rating NR |
|---|---|---|---|
| Drain Piping | 1.2≤2.1 | ≤1000 | ≤NR |
| Flexible Connections | 1.8≤2.4 | ≤1000 | ≤NR |

Copper water piping is to be design to meet the most stringent requirement above.

## 1.10 NCC/BCA SECTION J REQUIREMENTS

### 1.10.1 Overview

The project has been designed to meet the requirements of the Building Code of Australia (NCC/BCA) Section J – current edition. This has been achieved by the Deemed to Satisfy provisions. All plant capacities and efficiencies included in the project schedules have been selected to achieve this requirement.

### 1.10.2 Requirement

All final plant selections shall achieve the minimum efficiency requirements as outlined in the schedules. Where the scheduled efficiency figures exceed the NCC/BCA DTS requirements, the more efficient criteria shall apply. Where a plant selection cannot be made which meets the efficiency requirements of the schedules or the NCC/BCA Deemed to Satisfy requirements, submit the most efficient plant selection available for review.

For the purposes of NCC/BCA assessment, the project is located in climate zone: 7

All final plant selections shall achieve the minimum efficiency requirements as scheduled.

Plant selections which do not meet the scheduled efficiency requirements may require the building energy model to be updated. Additionally any significant changes to the type of system or operating conditions may require the building energy model to be updated. The cost of this re-modelling shall be the responsibility of the mechanical contractor unless there is no selection possible which meets the scheduled requirements.

## 1.11 STANDARDS AND REGULATIONS

### 1.11.1 Requirement

Comply with the relevant rules and requirements of the following:

(a) Building Code of Australia with New South Wales amendments;

(b) AS 1170.4:2007 Earthquake actions in Australia Clause 8.1.4 (b);

(c) AS/NZS 1668.1 (2015), AS 1668.2 (2012) and AS 1668.4 (2012);

(d) AS/NZS 5149.1:2016;

(e) AS 1530.4:2014 Fire-Resistance Tests for Construction

(f) AS 3000 Wiring Rules;

(g) AS 3666;

(h) AS3500;

(i) The Electrical Supply and Distribution Authority;

(j) Communications provider;

(k) Local Council;

(l) Water Authority;

(m) Work Cover Australia (Workplace Health and Safety);

(n) Environment Protection Act and Authority;

(o) Noise abatement Authority;

(p) Any other Authority having jurisdiction over this installation;

(q) Relevant Australian standard specifications or codes, except where such specifications or codes shall be varied by any governing authority. Such compliance shall in all cases be with the current edition or issue of the specification or code concerned;

Where requirements of any governing authority or any applicable Australian or British standard specification or code differ from the requirements specified herein, the more stringent requirements shall prevail unless expressly stated otherwise or agreed with the Superintendent.

## 1.12 SUBMISSIONS

### 1.12.1 General

The Mechanical Contractor shall submit the following, least 2 weeks prior to commencing work on site:

(a) Full technical submissions on all plant and equipment being used on the project including but not limited to:

- Manufactures names and details;
- Plant and equipment capacities;
- Warranty details;
- Plant and equipment physical details.

(b) Design calculation for ducting system;

(c) Design details for control system;

(d) Working Drawings, as per section of this specification titled 'Working Details';

(e) Any assumptions on which the calculations are based;

(f) Details of any departures from this specification;

(g) Details of fire provisions;

(h) Mechanical contractor provision for attendance to breakdowns;

(i) Availability of service network of plant manufacturer;

(j) AREMA certification of equipment;

(k) Licence numbers and type of licences held by persons responsible for the installation.

## 1.13 SYSTEM GUARANTEES

### 1.13.1 Scope

Guarantee that the plant, when installed and operated in accordance with the Operating and Maintenance Manual, shall satisfy the following:

### 1.13.2 Capacities

The capacity performance of all equipment used in the installation are to be not less than the figures stated within the body of this Specification and/or Schedules, when operating under the specified conditions.

Obtain the air and/or water quantities and temperatures at all points as required by the drawings and specifications as necessary for the satisfactory operation of the system as a whole.

Make good any equipment requiring extra capacity or performance at no additional cost.

### 1.13.3 Operating Conditions

Provide control instruments and equipment capable of maintaining conditions within the limits detailed in this specification and set so that they achieve these conditions.

### 1.13.4 Equipment Duties

Select fan pressures, driving motor powers or any other such design requirement which is based finalised brand/ type selection or arrangement of ductwork, pipework or equipment.

Any such figures given in this Specification are estimates only for guidance.

Equipment selection is subject to the review of the Superintendent however notwithstanding this determine motor sizes, pressures and the like suitable for the installed systems.

### 1.13.5 Noise and Vibration

Comply with the requirements of the Noise and Vibration Control section of the specification to ensure that the noise level due to mechanical equipment (including ducts, dampers, registers, pipes and valves) does not exceed the specified levels. Select acoustic devices to suit the equipment and layout installed.

### 1.13.6 Manufacturers Requirements

Install and commission all equipment in accordance with the recommendations of the respective manufacturers.

### 1.13.7 Equipment Warranty

Warrant all work and equipment against defective workmanship and materials from the date of Practical Completion including the extension of any warranty provided by a manufacturer should it be for a lesser period.

## 1.14 WORKING DETAILS

### 1.14.1 Scope

Prepare details of the work to be carried out including Working Drawings and Functional Control Descriptions.

Submit working details together with additional manufacturers information describing application, selection, performance, installation, maintenance and where applicable, troubleshooting to fully describe and detail the work to be done.

Submit details in time to allow a minimum period of two (2) weeks for examination and return of each submission. Submit one A1/B1 print and PDF copy of each working drawing for each review submission.

Bear all cost associated with abortive and corrective work which result from work proceeding without stamped working details. Such abortive corrective work shall not be cause for extension of time.

Co-ordinate all working details with the structure and all other services prior to their submission. Ensure that all information from all sub-contractors, are fully and clearly cross-referenced.

### 1.14.2 Working Drawings (Workshop Drawings)

Prepare all drawings on Auto CAD, to Australian Standard AS 1100 using competent and experienced drafters. Working drawings, suitably modified to show the actual work installed and complying with the requirements of Section "AS INSTALLED DRAWING", may be suitable for submission as drawings of work as installed.

Include at least the following on the working drawings:

(a) Ductwork layouts at scale not less than 1:50 showing air quantities, positions and sizes of all ducts, dampers, registers, fans, etc. together with construction details and materials. Indicate also the extent, type and

thickness of insulating materials. Provide details of penetrations showing exact locations of the openings to be provided by the Main Contractor. Provide 1:20 and 1:50 details of all ductwork requiring co-ordination with other trades and the building. Show on drawings all duct heights above finished floor levels and show distances from grid lines to accurately position all ducts and to accurately co-ordinate the ducts with other trades. Show on drawings construction method of duct transverse seams and cross-joints as well as insulation installation methods and duct support methods;

(b) Layout drawings of all plant at scale not less than 1:50 showing relationship and clearances to plant room and other equipment and including details of mounting, plinths, pads, etc.;

(c) Schematic diagrams showing interconnection of all plant via ductwork and pipework including details of isolation and control valves, strainers, automatically controlled air dampers, etc. These drawings should also indicate equipment make, model number and performance data together with zone airflows and water quantities. Submit selection curves of fans, pumps, etc., for approval with the drawings;

(d) Wiring diagrams for all mechanical equipment and control circuits including switchboard layouts, switchboard construction details, and electrical components lists. (Also show location of cable trays, conduits and equipment isolators accurately dimensioned in position to co-ordinate with other trades);

(e) Panel layouts for all local control and switch panels including proposed terminologies for labelling/engraving;

(f) Schematic diagrams of all automatic controls clearly indicating control logic and system arrangement. Identify all items of control equipment and showing all connections;

(g) Carry out preparation and submission of working drawings in accordance with the construction program.

### 1.14.3 Functional Control Description

Prepare descriptions of the control functionality for all equipment and systems fully describing system operation and detailing all set points with ranges and differentials and as further detailed in section "Automatic Controls". Include details of control hardware selections and configuration.

## 1.15 SAMPLES

### 1.15.1 Requirement

Submit for approval prior to commencing installation samples of the following items which are proposed to be used in the works and install only such items as have been approved. Failure to comply with this may result in the rejection of such items.

In particular provide samples of:

(a) Room sensors and wall mounted switches;
(b) Diffusers, registers and grilles;
(c) Ductwork including joints and supports and insulation;
(d) Pipe services supports and insulation;
(e) Ducting for Refrigerant pipes'
(f) Colours and labelling;
(g) Any component exposed to general view.

In addition, provide samples as requested.

Samples may be retained until the completion of the work, and used as a standard for acceptance or rejection of the items provided.

## 1.16 AS-INSTALLED DRAWINGS

### 1.16.1 Requirement

"As-Installed" drawings are required to be submitted with the Operating and Maintenance Manuals prior to the date of practical completion. The drawings shall comprise those required as Working Drawings and brought up to date. Format: "As installed" drawings shall be prepared on (or copied to) a CAD System AutoCAD Version 2014, or later.

Provide two copies of final and approved Operating and Maintenance Manuals containing as a minimum:

(a) One (1) set of A1 or B1 prints;

(b) One (1) set of A3 reduced prints bound separately with the Operating and Maintenance Manuals;

(c) Two (2) soft copy sets in DWG and PDF format provided on USB or CD.

Preliminary Drawings: Submit preliminary drawings for examination prior to preparation of final drawings. Label all drawings "as-installed" and incorporate all amendments with the amendment block blanked. Revert issue number to A or 1.

## 1.17 DAMAGE TO SERVICES

The Contractor shall contact the Project Manager before commencing work on the site and shall inspect the location of all services in the presence of the Project Manager. The Contractor shall immediately notify the Project Manager in the event of damage to any water, gas, steam, compressed air, electric, drainage, sewerage, telephone, fire alarm, security system, control cable or other services in the area.

Where a service is identified to the Contract or is evident on the site or has been pointed out by the Project Manager, the Contractor shall be responsible for the cost of any necessary repairs to that service.

## 1.18 HOISTING AND LIFTING

Provide all cranes, hoists, loading platforms, temporary lifts and all other machinery necessary for the proper and efficient movement and lifting of personnel, plant, equipment and materials for the execution of the works.

All plant, equipment, goods and materials of whatever description requiring to be lifted shall be loaded and unloaded onto and from the lifting device, shall be delivered to the location as nominated by the Project Manager. The equipment shall be transported from the delivery point to on site locations by others. All lifting and unloading procedures and equipment operators shall be to Work Cover Authority requirements.

Arrange for, and pay any costs incurred, for Local Council/RMS/Police/WorkCover approval/involvement.

# 2. GENERAL EQUIPMENT STANDARDS

## 2.1 GENERAL

### 2.1.1 Scope

This section of the specification sets out the general requirements for all equipment as well as specific requirements for some sundry minor equipment.

### 2.1.2 Standards

Referenced Documents

The following standards are applicable to this Section:

| | |
|---|---|
| AS 1023 | Low Voltage Switchgear and Control Gear - Protection of Electric Motors; |
| AS 1210 | Unfired Pressure Vessels; |
| AS 1359 | Rotating Electrical Machines - General Requirements; |
| AS 1360 | Rotating Electrical Machines of Particular Types or for Particular Applications; |
| AS 1668 | The use of Mechanical Ventilation and Air-Conditioning in Buildings; |
| AS 2380.2 | Electrical Equipment for Explosive Atmospheres - Explosion- Protection Techniques – Flameproof Enclosure; |
| AS 2768 | Electrical Insulating Materials - Evaluation and Classification based on Thermal Endurance. |

### 2.1.3 Standard of Equipment

Provide only plant and equipment, which is the product of manufacturers who are normally engaged in the production of such equipment and who issue complete certified rating data for their products.

Supply all equipment with the manufacturers identification plates which contain details of capacity, type and model number, serial number and where applicable operating electrical characteristics. Provide identification plates, which are clearly visible after equipment is installed and operating.

Select all equipment to have the specified performance within the conditions of service and which is guaranteed by the manufacturers.

Furnish all equipment with reliable safety devices to protect people against accidents and the plant against damage. Provide safety devices in the form of guards on exposed moving parts, electrical interlocking of motor control circuits, machine overload protection, warning lights, alarms and other approved devices.

## 2.2 FIRE STOPPING

### 2.2.1 Scope

Supply and install Fire Stopping and fire proofing of penetrations through fire rated building elements for the passage of cables, conduits, pipes and ducts in accordance with the NCC and associated reference documents, comprising the following elements:

(a) Fire Resistant Pillow Systems;
(b) Fire Resisting Gap Filler;
(c) Foaming Sealants;
(d) Flexible Fire Barrier Materials;
(e) Fire Stop Collars.

### 2.2.2 Requirement

Install fire stopping to penetrations through fire rated elements of construction in accordance with the NCC, such that the fire resistance rating of the element is not reduced.

Seal holes through fire rated elements of construction in floors, ceiling and walls for cables, conduits, cable trays, busways, pipes, ducts, etc. with products and systems that have attained the required fire resistant performance when fire tested to the Standard Fire Test conditions as nominated in AS 1530.4 : Fire Resistance Test of Elements of Building Construction, or AS 4072.1 providing a minimum fire rating to match that of the fire rated element through which the cables, conduits etc., are installed.

Include within the Operation and Maintenance manuals a schedule of the fire stopping method and materials proposed for each type of penetration likely to be encountered in the project.

### 2.2.3 Sealing Materials

Provide sealing materials suitable for use as a fire barrier generally classified as follows:

(a) Fire Resistant Pillow Systems - suitable for openings up to approximately 200mm wide and consisting of pillows of fire-retardant fabric filled with expanding type fire resisting material;

(b) Fire Resisting Gap Filler - suitable for gaps greater than approximately 10mm and consisting of fire resisting gap filler of suitable consistency;

(c) Foaming Sealants - suitable for gaps less than approximately 10mm wide and consisting of a fire resisting compound which includes intumescent agents;

(d) Flexible Fire Barrier Materials - suitable for a wide variety of applications and consisting of fire retarding fibrous materials in the form of blanket, rope, or strip;

(e) Fire Stop Collars - suitable for providing a fire rated seal where PVC pipes penetrate a fire rated wall/floor and consisting of a suitably sized canister of intumescent material.

### 2.2.4 Labelling

Where penetrations are sealed, label these penetrations as follows:

**'CAUTION, FIRE BARRIER, MUST REMAIN SEALED'**

### 2.2.5 Approved Products

Use only the following products:

(a) Products approved under the CSIRO "Fire-sure" program;
(b) Products tested and certified by an independent authority as complying with AS 1530.4 or AS 4072.1.

### 2.2.6 Standards

Referenced Documents

The following standards are applicable to this Section:

| | |
|---|---|
| AS 1530.4 | Fire Resistance Test of Elements of Building Construction; |
| AS 4072.1 | Components for the protection of openings in fire-resistant separating elements - Service penetrations and control joints. |

### 2.2.7 Product Tests

For each type of fire stopping installation, provide a test certificate, within the operation and maintenance manuals, from an independent testing authority showing that a representative specimen of the element of construction, incorporating the proposed fire stopping, has attained the required fire resistance rating when tested to AS 1530 Part 4 or AS 4072.1.
Type Tests: Recent tests obtained by the manufacturer are acceptable provided the test specimens are truly representative of the project installations.

Projects Test: If an acceptable type test is not available, prepare and test a representative specimen at no cost to the project.

### 2.2.8 Maintenance Period

Co-extensive with the Defects Liability Period.

Maintenance Activities

During the maintenance period:

(a) Carry out six monthly inspections of all penetrations;

(b) Promptly rectify faults. Replace faulty materials and equipment without charge;

(c) Complete log book entries recording these procedures.

At the end of the maintenance period:

(a) Certify in writing that the installation complies with the reference documents.

## 2.3 ELECTRIC MOTORS

### 2.3.1 Requirement

Manufacture all motors in accordance with AS 1359 and with metric dimensions to AS 1360 Part 11 and as follows:

(a) Power Supply: Suitable for operation on the nominal voltage provided +6% or -10%. Provide three phase motors unless otherwise scheduled;

(b) Ratings: On fan and pump drives, since it may be necessary to increase equipment capacity either during or after commissioning, provide motors with a continuous maximum rating (CMR) at least equal to 130% of the power input requirement at the specified operating conditions;

(c) Insulation: Comply with AS 2768. TEFC motors to have minimum Class 130 insulation. Open type motors to have minimum Class 120 insulation;

(d) Starting: Rate motors to start as frequently as required by the drive under normal operating conditions, but in any case the motor, with load, will be capable of two starts in succession with the motor initially at normal running temperature. After a cooling period of 30 minutes with motor de-energised, it will then be capable of a third start, all in accordance with Clause 41.3 of AS 1359. Achieve full speed on all drives (except where fluid couplings or similar approved devices are fitted) in less than 8 seconds on starting. Make special provisions (e.g. installation of double cage high torque motors) for all high inertia loads such as low speed centrifugal fan drives to eliminate starting problems;

(e) Thermistor: Protect motors exceeding 11kW output by positive temperature co-efficient thermistors. For ratings exceeding 37kW embed the thermistors in the hot spot of each phase winding. Match thermistors to permissible winding temperature and wire to control units to provide tripping function Type TP2.

Thermistors will comply with AS 1023 Part 1. Indelibly mark motor nameplates in accordance with AS 1023 Part 1.

This requirement does not apply to high temperature motors.

### 2.3.2 Motor Selection

Select motor design, frame types and enclosures according to duty and location in accordance with the following principles:

| | | |
|---|---|---|
| Conditioner or plantrooms | - | Totally enclosed, weatherproofed and tropic proofed. |
| Exposed or damp conditions | - | Totally enclosed, weatherproofed and tropic proofed |
| In air stream of exhaust systems from fume cupboards other hazardous locations. | - | Motors selected for the specific hazard. (see below) |
| Areas where motor noise could affect sound level in occupied areas and where nominated on drawings or in other relevant section of specification. | - | Reduce noise level. (see below) |
| High temperature applications (i.e. in excess of 40°C) | - | Totally enclosed with suitable class lubricant. Weatherproofed and tropic proofed as required above. |
| In return or exhaust air system where ventilation system is required for smoke exhaust in accordance with AS 1668. | - | High ambient temperature in accordance with AS 1668.1 (see below) |

### 2.3.3 Miscellaneous Requirements

Note the following requirements:

(a) Rotors: Squirrel cage induction motors will generally be acceptable except where nature of load or starting conditions necessitate double cage rotors or wound rotor motors in which case provide such motors;

(b) Flameproof Motors: Comply with AS 2380.2. Supply a copy of SAA Certificate of Compliance for each flameproof motor;

(c) Sound Tested Motors: Specifically design and select sound tested motors for reduced mechanical and electrical noise. Provide certified sound power level data at the time of tender;

(d) High Ambient Temperature Motors: Manufacture motors for smoke spill fans to comply with the requirements of AS 1668.1. Mark the motor nameplate `Smoke Control'. The motors will be Class H insulation as a minimum;

(e) Multi-Speed Motors: Provide multi-speed motors where specified or required to obtain specified operation performance. Take care to ensure that power and starting torque characteristics are adequate at all speeds and operating conditions;

(f) Environment: Provide special treatments for motors, including damp, tropic, acid and vermin proofing where required by environment;

(g) Manufacture: Provide wherever possible, all electric motors for each contract of one manufacturer. Preference will be given to motors selected on the basis of low sound power levels and high efficiencies.

## 2.4 MACHINERY GUARDS

### 2.4.1 Requirement

Provide protective guards designed to prevent accidents to persons and damage to plant on all exposed rotating, reciprocating or dangerous machinery or equipment and as necessary to meet the requirements of the statutory authorities.

Fabricate guards with a heavy steel frame with either heavy galvanised expanded steel mesh or brass wire mesh infill panels.

Incorporate on guards on Vee-belt drives, shaft access slots to enable tachometer readings to be taken or driven pulley speeds unless the other end of the shaft is accessible.

All guards must be removable for maintenance service.

# 3. CORROSION PROTECTION, PAINTING AND LABELLING

## 3.1 GENERAL

### 3.1.1 Scope

This section sets out the treatments for equipment and plant as well as application requirements and labelling.

### 3.1.2 Samples

Submit for approval, samples of all labelling for all plant and equipment.

### 3.1.3 Schedules

Submit schedules for approval of all painting materials proposed to be used including associated data sheets. Ensure that all data proves adequately that the proposed materials are totally suited to the application.

## 3.2 CORROSION PROTECTION AND PAINTING TREATMENTS

### 3.2.1 General

Protect all surfaces against corrosion immediately after fabrication and/or erection using the methods specified in this section.

Do not paint baked enamel finishes, rubber hoses, flexible mountings, lubricated surfaces or name plates.

### 3.2.2 Treatments

Where painting is specified or scheduled, provide the following treatments:

(a) Treatment - 1
- Finish: Decorative - non-ferrous surfaces (mild conditions);
- Treatment: One coat of wash primer or wash down with etching solution followed by wash down with clean water and dry off. One coat of red oxide zinc chromate primer, one undercoat, two coats of enamel finishing paint.

(b) Treatment - 2
- Finish: Timber (mild conditions, not exposed to weather or moisture);
- Treatment: One undercoat followed by two coats of enamel finishing paint.

(c) Treatment - 3
- Finish: Timber (exposed to weather or moisture);
- Treatment: Prepare surfaces in accordance with "Surface Preparation" followed by one coat of priming paint, one undercoat and two coats of enamel finishing paint.

(d) Treatment - 4
- Finish: Decorative - Ferrous surfaces (mild conditions);
- Treatment: Hand clean all ferrous surfaces in accordance with "Surface Preparation" followed by one coat of red oxide zinc chromate primer, one undercoat, and two coats of enamel finishing paint.

(e) Treatment - 5
- Finish: Non Decorative - Ferrous surfaces (mild conditions, requiring priming only);
- Treatment: Ferrous surfaces such as steel fabricated brackets, fire dampers, flanges etc., must be hand cleaned in accordance with "Surface Preparation" and then immediately given one coat of red oxide zinc chromate or equal approved primer after any welding has been completed.

(f) Treatment - 6
- Finish: Oil/petrol resistance - Ferrous surfaces;
- Treatment: Degrease in accordance with "Surface Preparation" followed by one coat of red oxide zinc chromate primer, one undercoat and two coats of oil and petrol resistant paint;
- Colour: To the Superintendent's approval and in accordance with "SCHEDULES";
- Where hot dip galvanising is specified or scheduled, provide the following Treatment - 7:

(g) Treatment - 7
- Treatment: Ferrous surfaces must be hot dip galvanised in accordance with AS 1650, hot-dipped galvanised coatings on ferrous articles.

#### 3.2.2.1 Schedules of Treatments

| Surface | Treatment Description | Treatment Type |
|---|---|---|
| Steelwork exposed to weather or moisture | Hot dip galvanised after fabrication. | 7 |
| Steelwork not exposed to weather or moisture | Painted except where hot dip galvanised or alternate coating is specified. | 5 |
| Timber | Painted. | 2 or 3 |
| Ductwork and sheet metal work exposed to weather | Corrosion protected as specified in this section (e.g., brackets and steel work galvanised) and decorative painted by the Builder. | 7 |

### 3.2.3 Paint and Painting Practices

#### 3.2.3.1 Materials

Mix all paints and apply in strict conformity with the printed instructions of the manufacturer.

Supply all paints used for one painting system from one manufacturer.

Formulate wash primers and etching solutions to be compatible with subsequent primer, undercoats and finishing coats and procure them from the same manufacturer as the subsequent coatings.

#### 3.2.3.2 Workmanship

Perform all painting in a neat, thorough and workmanlike manner and only by experienced tradesmen.

Carry out all smoothing processes in accordance with the paint manufacturer's instructions to achieve a smooth finish. Remove all dirt and dust from surfaces with a soft brush prior to painting.

Each coat of paint must be uniform and free from runs, overspray, sags, dust and other imperfections. All edges and changes of colour must be true.

Adequately protect surfaces not required to be painted but adjacent to metal work that is to be cleaned and painted during cleaning and painting.

Cleaning Up: Upon completion of painting work remove any paint spots, oil or stains from floors, walls, steelwork, concrete, machinery, glass, hardware and surfaces that are not to be painted, leaving assemblies and their finish in a

clean and acceptable condition.

## 3.3 SURFACE PREPARATION

### 3.3.1 General

Carefully remove or repair weld splatter, slag, burrs or any other objectionable surface irregularities. Give sharp edges a radius.

Prepare porous surfaces with one coat of sealer.

Prepare steel surfaces and pre-treat in accordance with AS 1627.

### 3.3.2 Degreasing

Remove all oil, grease, wax, dirt, perspiration and other soluble and loosely adherent matter from the surfaces by use of one of the methods described in AS 1627.1 - "Cleaning Using Liquid Solvents and Alkaline Solutions".

### 3.3.3 Hand Cleaning and Power Tool Cleaning

Following degreasing as described above, remove all mill scale and other foreign substances likely to affect the adherence and uniformity of the finished coating by cleaning in accordance with AS 1627.2 - "Power Tool Cleaning".

Thoroughly clean cast iron surfaces of all moulding sand prior to cleaning by the methods described above.

### 3.3.4 Blast Cleaning

Following degreasing as described above, clean the surface to be treated to a "Class 3" standard of surface preparation by grit or sand blast cleaning, in accordance with AS 1627.4 - "Abrasive Blast Cleaning".

The surface roughness must be appropriate for the specified treatment (i.e., whether it is to be painted or metal sprayed).

### 3.3.5 Preparation of Timber Surfaces

Cut out large resinous knots and pitch pockets and replace by sound wood. Give smaller knots and pitch streaks two coats of either shellac knotting or aluminium paint applied carefully and sparingly. Make the knotting from genuine orange shellac dissolved in industrial methylated spirits.

Punch and putty protruding or exposed nails.

Cut out any defective putty or other filler and re-apply prior to painting.

Stop and fill the surface as required by the finish specified and thoroughly sand the surface.

## 3.4 GENERAL PROTECTIVE MEASURES

### 3.4.1 Contact between Dissimilar Metals

Where dissimilar metals are likely to result in cathodic corrosion, separate them by an air gap of 3mm or join them using either rubber, PVC, polythene or other appropriate insertion packing not less than 1.5mm thick. Fit bolts or fasteners with isolation ferrules and washer having an electrical resistance not less than the joining material used.

### 3.4.2 Welding and Machining of Corrosion Protected Surfaces

Where the specification specifies surfaces to be corrosion protected by hot dip galvanising or metal flame spraying, all welding and machining must be carried out prior to the application of the protective coating. Welding or machining will not be permitted after the coating has been applied.

Where other types of protective coatings are specified, welding or machining will not be permitted after the corrosion protection coating has been applied, unless the coating is restored to its original condition after welding or machining. Undertake coating restoration in accordance with the specified requirements for the original coating.

Where high quality field welding is required by the specification, omit shop-applied priming coats for a distance of 75mm either side of field welded edges. Carry out completion of the protective coating in accordance with the specified requirements for the original coating.

### 3.4.3 Metal Surfaces in Contact

Clean and prime before assembly, surfaces of metal work that will be in contact with other metal work or concrete after assembly, except as otherwise specified. The preparation and priming treatment must be the same as specified for other surfaces of the same metal work.

### 3.4.4 Surfaces Inaccessible After Installation

Surfaces to be painted that will be inaccessible after installation must be completely painted prior to installation.

### 3.4.5 No Particular Treatment Specified

Treat surfaces for which no particular treatment is specified in the specification with the manufacturer's standard finish providing that this conforms to good trade practice.

### 3.4.6 Painting Before Despatch to Site

Paint all equipment, pre-fabricated pipework and ferrous metal work (excluding galvanised iron and zincanneal) in the shop before despatch to the site of the works. Fully prime metal work that requires blast cleaning before leaving the shop, using a primer, which is known to be compatible with the intended top-coats.

### 3.4.7 Handling Treated Surfaces

Handle treated surfaces carefully to prevent damage to the coating.

### 3.4.8 Repairs to Defective or Damaged Surface Treatments

Restore at the end of the Defects Liability Period all painted finishes that have been damaged during maintenance or while carrying out repairs. Carry out the repair of defective or damaged surface coatings prior to the expiry of the Defects Liability Period as follows at the Subcontractor's expense:

Painted Surfaces: Remove paint that is loose, weakly bonded, blistered, abraded or otherwise defective and re-clean and paint the surface in accordance with the treatment originally specified. Before applying subsequent coats of paint, clean and repair all areas of previous coats, which are defective or damaged. Cleaning and repair must be in accordance with the treatment originally specified.

After installation of equipment, make good any damage to finished painted surfaces. Repairs must be in accordance with the treatment originally specified. Before applying the specified treatment roughen the damaged coating to provide a key. For epoxies or coal tar epoxies, soften or wire brush existing edges after cleaning underlying exposed surfaces, then apply specified treatment.

Galvanised or Metal Flame Sprayed Surfaces: Surfaces damaged will not be accepted unless authority is given for the surface to be repaired on site.

## 3.5 LABELLING AND IDENTIFICATION

### 3.5.1 General

Label all equipment including gauges, meters, sensors, controls, switchboards, plant casings and the like, to facilitate operation and maintenance. Labels shall be direct engraved on switches and similar items; otherwise engraved labels must be fixed as required.

Labels must:

(a) Be 3 layer laminated plastic generally, White/Black/White, with special or emergency equipment labelled in other colours e.g., Red/White/Red;

(b) Be fixed firmly in position with pins, screws or in slide holders which allow for replacement. Approved adhesive fixings may be used on plastic accessories;

(c) Sized to suit importance and application and must be uniform for similar items. Minimum letter size will be 3 mm and 0.3 mm line thickness.

### 3.5.2 Equipment

Suitably sign-write all items of equipment with letters 50 mm high, 8 mm thick for major items of plant and 20 mm high for other items of plant. Label thermometer bulbs and remote sensing points to indicate their function.

### 3.5.3 Control Wiring

Identify at terminations with engraved, interlocking ferrule type labels. Identification shall correspond with associated wiring diagrams. Use an approved numbering system.

### 3.5.4 Electrical

Refer to "Electrical" Section.

# 4. NOISE AND VIBRATION CONTROL

## 4.1 GENERAL

### 4.1.1 Scope

This section applies to noise and vibration associated with the operation of the air conditioning and mechanical services as shown on the drawing(s) and included in this contract.

### 4.1.2 Criteria

To ensure that the transmission of noise and vibration from air conditioning and mechanical services is minimised and complies with the criteria levels set by this specification, the following sections include criteria for:

(a) Noise and vibration;
(b) Equipment selection;
(c) Equipment balancing;
(d) Equipment isolation;
(e) Sound absorption;
(f) Sound attenuation.

### 4.1.3 Equipment

Supply and install equipment and components which are not mechanically faulty, over-stressed or over-loaded and which do not have distinct noise or vibration effects inconsistent with the type or class of equipment.

## 4.2 NOISE AND VIBRATION CRITERIA

### 4.2.1 Standards: Noise - Building and Occupied Spaces

Acceptable levels of noise and the instruments and methods to assess these are defined in

Australian Standard (AS) 2107 - Acoustics - Recommended Design Sound Levels and Reverberation Times for Building interiors, and to acoustic engineer's details.

### 4.2.2 Standards: Noise – Environmental

Acceptable levels of noise at neighbouring boundaries and the instruments and methods to assess these are defined by the Environmental Protection Authority (EPA) and/or Noise Control Legislation relevant to the particular locality.

### 4.2.3 Standards: Vibration

Keep vibration from all air conditioning and mechanical services plant to a minimum and isolate vibration to achieve criteria defined in Australian Standard AS 2670. Evaluation of human exposure to whole body vibration:

AS 2670.1 General requirements;
AS 2670.2 Continuous and shock-induced vibration in buildings (1 to 80 Hz);
AS 2670.3 Evaluation of exposure to whole-body Z-axis vertical vibration in the frequency range 0.1to0.63Hz.

Use the 'ASHRAE' 2003 Application Handbook as a guide.

The above documents apply to acceptable vibration levels except where amended or required by the Schedules - Maximum Vibration Levels.

### 4.2.4 Standards: Balancing

For the static and dynamic balancing of all rotary machinery, comply with the requirements of:

| | |
|---|---|
| AS 1359 Parts 50 and 51 | General Requirements for Rotating Electrical Machines; |
| AS 2625 | Rotating and Reciprocating Machinery - Mechanical Vibration. |

## 4.3 TESTING ON COMPLETION

### 4.3.1 Standards

Criteria detailing the testing of noise and vibration are provided in section "TESTING". Levels of noise and/or vibration that impair the efficiency of working or standard of comfort or do not comply with the specified maximum levels in any environment will not be accepted.

### 4.3.2 Unacceptable Results

In the event of unacceptable noise or vibration levels resulting from faulty plant or negligence during the installation, carry out all alterations and additions to the installed plant as directed by the Superintendent, in order to reduce levels to acceptable values. Carry out this work without variation to the contract price. In the event of unacceptable noise or vibration being a result of the location, construction or selection of plant particularly stated and contained in this specification, then the cost of the work necessary to reach acceptable levels will be a variation order.

### 4.3.3 Test Results

Provide a certificate of conformance and certified copies of results.

## 4.4 AIR BORNE NOISE

### 4.4.1 General

Execute the installation, balancing and adjustment of all air handling systems and mechanical services fluid systems to minimise noise generation and result in levels which do not exceed the criteria specified. Select air diffusion equipment for efficient air distribution and low noise levels at all operating conditions. Remove from all duct interiors, air outlets, dampers and similar air distribution equipment, raw edges of metal, sharp screw ends or pop rivets projecting into the air streams.

### 4.4.2 Ductwork

Provide the attenuation of fan and air handling equipment noise by acoustic lining of ductwork and/or packaged attenuators as shown on the drawing(s) and as specified.

### 4.4.3 Clearance Holes

Seal the clearance hole where pipes, ducts, cables and any other services provided in this contract pass through walls, roofs and floors.

### 4.4.4 Extent

There is no responsibility of the Subcontractor for the attenuation of all air borne noise passing through the building fabric. A suspended ceiling will not be required to act as a noise attenuator.

## 4.5 STRUCTURE BORNE NOISE AND VIBRATION

### 4.5.1 General

Isolate all mechanical equipment from the building structure such that the transmission of energy into the structure

results in minimum noise and vibration levels not in excess of the criteria specified. Incorporate the following method(s) below to minimise the transmission of energy to building structure.

### 4.5.2 Balancing

Statically and dynamically balance all equipment containing rotating components to manufacturer's instructions, and within limits necessary to ensure satisfactory operation without undue vibration when installed and connected up for normal operation.

### 4.5.3 Fans and Air Handling Units

Isolate all fans from ductwork with flexible connections.

### 4.5.4 Flanking Transmission Paths

Support ducting from the building fabric using vibration isolation mounts and hangers where shown on the drawing(s) and listed in the schedule. Additionally where shown on the drawing(s) or scheduled, connect rotating and reciprocating equipment to ductwork, piping etc., with flexible connections. For all service connections such as electrical, drainage, flues etc., to resiliently mounted equipment, provide a flexible section of approved type installed between the equipment and nearest support.

### 4.5.5 Mounts

Mount equipment on support channels, frames or rigid bases supported by vibration isolators.

## 4.6 SYSTEM GENERATED NOISE

### 4.6.1 General

Ensure that generated noise within the air distribution system due to installation, layout and equipment are kept to a minimum and comply with the specified criteria.

### 4.6.2 Ductwork

Install ductwork as shown on the drawing(s) with the minimum number of bends and offsets and shall be free from internal noise generating features.

### 4.6.3 Diffusers and Grilles

Select air diffusers, grilles and accessories to ensure that their self-generated noise does not cause the required space noise level to be exceeded. Fit cushion heads to outlets as standard detail.

### 4.6.4 Dampers

Use branch dampers for balancing with only minor adjustment made at the diffuser face. Where dampening of diffusers indicates an oversupply of air, reduce the fan speed. Re-balance air distribution systems, which are noisy due to excessive dampening.

### 4.6.5 Terminal Units

Select constant volume and variable volume terminal boxes, induction units etc., to ensure that their self-generated duct and radiated noise, together with the noise from the main system which is transmitted through the ductwork, does not cause the required space noise levels to be exceeded under any condition of operation.

## 4.7 CLEARANCE HOLES

### 4.7.1 General

Minimise the noise transmission across penetrations, and vibration energy transmission at penetrations, of a building structure or element where services pass from one area to another.

### 4.7.2 Sleeves

Provide sleeves for pipes and cables penetrating the building slabs or walls, firmly grouted in place by the Builder. Size the sleeves to allow a uniform clearance around the item and pack this space through its depth with an approved resilient material, fire rated where necessary. Seal the packing on both sides using a non-hardening resilient compound.

### 4.7.3 Acoustic Seals

Provide flexible acoustical seals where all pipes, ducts and conduits penetrate plant rooms, critical floor and ceiling slabs or acoustic walls.

### 4.7.4 Clearance

At penetrations where mechanical fixing of the pipe or duct to the building structure is not required, allow clearance between the pipe (or duct wall) and the structure penetration of approximately 12mm. Insert into this cavity one of the following materials where appropriate and subject to fire rating requirements etc.:

(a) Bradflex Generation II pipe insulation - minimum wall thickness 13 mm;

(b) Dimet Compriband or Pabco Presstite bitumen impregnated polyurethane foam sealant compressed at least 50%;

(c) Sponge rubber;

(d) Rockwool;

And finish off with an approved non-setting mastic or synthetic rubber sealant.

Fire Rated Elements: Seal any gaps with fire rated wall, ceiling or floor penetrations in accordance with section "Fire Stopping".

## 4.8 VIBRATION ISOLATION MOUNTS

### 4.8.1 General

Isolate all equipment incorporating rotating or reciprocating machinery on anti-vibration mounts. Provide these mounts with transmissibility low enough so as not to cause excessive vibration of the building structure.

### 4.8.2 Materials

Provide isolation mounts and connections for reciprocating and rotating equipment manufactured by approved manufacturers and of approved materials.

### 4.8.3 Selection

Make selections of vibration isolating mounts based on the design minimum isolation efficiency, floor static deflection, and plant/equipment mass, rotational/reciprocating speeds and power requirements. Select the method of vibration isolation carefully for each particular application.

### 4.8.4 Installation

Strictly observe, unless otherwise specified, the manufacturer's recommendation for installation of vibration isolation

mounts.

### 4.8.5 Locations

Locate mounts high enough or spaced far enough apart to prevent the machine rocking excessively. Provide mountings that are easily visible and accessible for inspection and maintenance.

### 4.8.6 Bridging

When mounts are bolted down, the bolts shall not bridge out any acoustic pad on the underside of the mounting.

### 4.8.7 Care During and After Construction

During the construction period, ensure that mountings are not subject to prolonged excessive deflection due to piping and ducting being supported from equipment. Use load spreaders or pads under mountings to ensure that allowable structural point loadings are not exceeded. Ensure that any debris between items of plant and the building structure is removed.

### 4.8.8 Exposed Locations

Provide mountings for use in exposed or moist locations with galvanised steel housings and epoxy coated springs set in self-draining locating cups.

### 4.8.9 Mounting Schedule

Determine the static deflection and type of mountings required under each item of equipment from the schedule.

### 4.8.10 Pad-Isolation

Vibration isolation for deflections up to 10 mm may be provided by either double deflection neoprene mounts or multiple layers of ribbed neoprene pad with a thin steel sheet between layers. For optimum performance the neoprene pads should be of approximately 40 durometer hardness and loaded to not in excess of 350 kPa.

## 4.9 ANTI-VIBRATION MOUNTS SPECIFICATIONS

### 4.9.1 General

Provide all vibration isolating mountings and hangers of the one approved commercial manufacture and with proven ratings.

### 4.9.2 Specification (A) - Waffle Pad Mount

Provide mounts consisting of a double pad of neoprene moulded into a waffle configuration with a 10.5 mm nominal thickness. The pad shall be sized so that the load on the ribbed element does not exceed the manufacturer's recommendations or 350 kPa whichever is the lesser. If necessary a steel plate (1.6mm) will be used to spread the load over the pad.

### 4.9.3 Specification (B) - Neoprene Mount

Provide mounts consisting of "double deflection" type in which the neoprene or rubber is loaded in a combination of shear and compression and have a minimum static deflection of 9 mm. All metal surfaces to be moulded within the mountings, with friction pads top and bottom. Mount shall be provided with metal pads or inserts allowing secure and separate attachment to machine and base or floor. Bolt holes will be provided in the base and top and a tapped hole for fixing to equipment. Where necessary the neoprene or rubber-like materials will be of special grades or types to withstand oils, greases, solvents etc.

### 4.9.4 Specification (C) - Spring Hanger

Provide hangers containing a steel spring and a single deflection neoprene element in series, all contained within a steel box. The neoprene element is to have a minimum static deflection of 5 mm. The spring will have a minimum static deflection of 25 mm. Spring diameter and the lower hole size of the hanger box will be large enough to permit the hanger rod to swing through a 15° arc.

## 4.10 FLEXIBLE CONNECTIONS

### 4.10.1 General

Unless otherwise indicated, provide flexible connections to prevent vibration from rotating equipment, through piping and ductwork to the building structure.

### 4.10.2 Installation and Alignment

Arrange and install flexible connections where used, so that they do not unduly restrain the vibrating machine to which they are attached. Maintain piping and duct alignment at the connection.

### 4.10.3 Selection – Deflections

Select flexible connections to accommodate the maximum axial, lateral, and torsional dynamic deflections of the equipment to be isolated.

### 4.10.4 Location

Locate the flexible connections as close to the rotating/reciprocating machinery as is practical and anchor the connection on the pipe or ductwork side of the flexible connection and as close to the flexible connections as is possible.

### 4.10.5 Piping Connections

Install flexible connections with their axes perpendicular to the direction of movement. Do not exceed the manufacturer's recommendation on permissible vibration amplitudes and take care not to introduce twisting. Flexible connections are to be suitable for the working pressures, temperatures and fluids.

Vibration direction: Where vibration is not limited to one plane or direction, install two flexible connections at right angles to each other.

Spherical pipe connections: Flexible pipe connections of the spherical type shall have their flanges drilled and tapped to avoid the use of nuts on flange bolts. Flange bolts shall not project more than one thread through the flexible connection flange.

## 4.11 SCHEDULES

### 4.11.1 Maximum Noise Levels

| Location | Noise Level |
|---|---|
| Occupied Areas | NR 35 |
| Plant Areas | NR 85 |

### 4.11.2 Isolation Mountings

| Plant | Isolation Mounting |
|---|---|

| | |
|---|---|
| Plant Room / Roof Mounted Equipment | Waffle Pad Mounts to Specification A |
| Indoor Air-Conditioning Units | Spring Hanger Specification C |

# 5. VARIABLE REFRIGERANT VOLUME UNITS

## 5.1 AIR COOLED VRF INVERTER HEAT PUMP/HEAT RECOVERY SPLIT TYPE

### 5.1.1 General Description

An air cooled, split type multi-unit reverse cycle air conditioner system of the variable refrigerant flow type consisting of outdoor condensing units connected to multiple fan coil units, each having the capability of individual set point control, with the ability to connect each condensing unit up to 16 indoor units of different types and capacities on one refrigerant circuit.

### 5.1.2 Ambient Conditions

To be capable of operating within a wide range of ambient temperatures. Select condensing units to provide cooling within an ambient range of -5˚Cdb to 43 ˚Cdb, and heating in the range -20 ˚Cdb to 15 ˚Cdb. Achieve this by automatic control of compressor motor frequency, head pressure control (by varying fan speeds) and hot gas bypass.

### 5.1.3 Two Pipe System

Utilise the two pipe system such that the indoor units will either all cool or all heat as determined by the 'master' unit (refer controls section).

### 5.1.4 Indoor Units

Provide indoor units as specified in the equipment schedule.

Electronic Expansion Valve: Fit each indoor unit with an electronic proportional expansion valve which controls the refrigerant flow in response to the load variations in the room. The electronic proportional expansion valve is to be controlled via a computerised PID control sensing the return air temperature, refrigerant inlet and outlet temperatures. During the cooling operation the electronic expansion valve linearly controls the refrigerant superheat degree at the evaporator.

Indoor Unit Fans: Direct driven of the DWDI multi-blade type, statically and dynamically balanced to ensure low noise and vibration free operation.

Coils: To be direct expansion, constructed from copper tubes expanded into aluminium fins to form a mechanical bond.

Unit Control Board: Include in the indoor unit a printed circuit board complete with power input fusing, address switches for a variety of operation controls, emergency operation switch and fault/operation indication LED's. Thermally protect fan motors.

Unit Casing: The indoor unit casing to be fully insulated and sealed to prevent condensation.

Condensate Drain: Install a 25mm condensate drain pipe from each indoor unit to the nearest waste. Insulate these condensate pipes.

Unit Control: In case of individual and group control, set the addresses of each fan coil unit automatically by the system to minimise commissioning time. In case of centralised control, set the addresses by the liquid crystal remote controller. Dip and rotary switches are not acceptable.

### 5.1.5 Condensing Units

To be fully weatherproofed, factory assembled and pre-wired with all necessary electronic and refrigerant controls. Construct the casing from mild steel panels coated with a baked enamel finish. Provide the condenser coil with a corrosion resistant finish.

Condensing Units: Incorporate two compressors in condensing units 23.0kWr and larger, one of which is inverter driven. To allow for a compressor breakdown, provide for the system to be able to operate in an emergency mode and run with only one compressor.

Sound Pressure Level: Not to exceed 60 dBA measured horizontally one metre away from the unit and 1.5m above ground level.

Modular Design: Allow for side by side installation, by the modular design of the condensing units.

Fan Motor Speed Control: The condensing unit fan motors to have variable speed operation to maintain constant head pressure control in all ambient temperatures and modes of operation. Use fan motors of high static resistance type of 59Pa as standard.

Drain Tray (Field Installed): Provide each outdoor unit with a field supplied condensate tray of galvanised sheet steel construction. Connect the condensate tray with the nearest floor waste with a 25mm (min.) drain.

Compressors: Provide highly efficient hermetic scroll type compressors. Provide the inverter compressor with electronic controls, capable of changing speed to follow the variations in cooling and/or heating loads, using a HIDECS/R circuit (Hi Inverter Drive and Electronic Control System Recovery). Provide inverter control together with independent multi variable PID (Proportional Integrated Derivative) control for precise monitoring of status of the system. The inverter to be of the IGBT (Insulated Gate Bipolar Transistor) type for efficiency and quietness.

Condensing Unit Compressors: The 22.4kW and higher units to have variable capacity control ranging upwards from 14% to meet load fluctuations and indoor unit capacity control to be determined electronically by sensing ambient temperatures and operational pressures.

Heat Exchanger: Construct the heat exchanger from HI-X (rifle bore), seamless copper tubes mechanically bonded to aluminium fins to form a cross fin coil. Treat the aluminium fins with an anti-corrosion resin film.

Refrigerant Circuit: Complete the refrigeration circuit of the condensing unit with refrigeration compressors, motors, fans, condenser coils, electronic expansions valve, solenoid valves, 4 way valve, distribution headers, capillaries, filters, shut off valves, service ports, receivers and accumulators and all other components which are essential for safe and satisfactory operation.

Safety Devices: Provide the following safety devices as a part of the outdoor unit: High pressure switch, fuses, crankcase heater, fusible plug, over current protector for inverter and short re-cycling guard timer.

Oil Recovery: Equip the units with an oil recovery system to ensure stable operation for systems with long refrigerant piping. Operate the oil recovery system after the first hour of operation and then every consecutive eight hours of operation. Also fit high efficiency oil separators to the discharge side of the compressor together with an oil equalisation system.

Selection Switches: Fit the condensing unit printed circuit board (PCB) with selection switches for the length of pipework, ambient range selection, emergency operation switches and service mode switches, together with LED indications for the number of fan coil units connected, frequency status and operation/fault indication.

### 5.1.6 Control

Unless otherwise described under the automatic control section the following shall apply.

Use computerised PID control to maintain a correct room temperature. For the fan coil units incorporate an on/off switch, fan speed selector, thermostat setting and liquid crystal display which indicates temperature setting, operational mode, malfunction codes and filter clean reminder.

Fan-Coil Control: Accomplish by the use of individual controllers for each fan coil unit. The individual controllers to be capable of controlling a maximum of 16 fan coil units as a group.

Fault Diagnosis: Equip the system with a self-diagnostic function for quick and easy maintenance and service. Retain the most recent malfunction code for easy maintenance.

Automatic Changeover Cool/Heat: Changeover from heating to cooling (and vice versa) of the VRV Invertor system to be automatic as a result of demand from the fan coil units. Provide as part of the systems control logic.

Master Unit Control Cool/Heat: Accomplish changeover of the VRV Inverter system by the appointment of master fan coil units in each system for calling up of cooling and/or heating. The master fan coil unit/s shall determine the operating mode/s of the system.

### 5.1.7 Multi-Function System Controllers

Supply and install a Multi-Function system controller for each indoor unit and located where indicated on the drawings. Functions available from the centralised controllers:

(a) Temperature setting for each indoor unit;
(b) Temperature set point adjustment;
(c) Group on/off control;
(d) Indication of operating condition;
(e) Fan Speed adjustment.

### 5.1.8 Refrigerant

Factories assemble and test both the fan coil unit and condensing unit. Charge with refrigerant R410a at the factory. Any additional refrigerant is to be weighed in on site. Clearly label each condenser and fan coil unit with appropriate labels and numbering system.

### 5.1.9 Refrigeration Piping Distance Limits

To be capable of refrigerant piping runs up to 150m between the condensing unit and fan coil units with 50m level difference without any oil traps or double risers. The level difference between fan coil units connected to the same refrigerant circuit can be extended to 15m.

### 5.1.10 Refrigerant Pipework - VRV

Supply, install, test and commission all interconnecting pipework between the condensing unit and the fan coil units. Use refrigerant quality seamless copper tube with brazed connections and the appropriate (REFNET) headers and joints. Utilise longest possible lengths of copper pipe to minimise joints on site and appropriate refrigeration tools must be used to avoid the use of elbows. During brazing, pass dry nitrogen through the pipework. The gas used for the brazing process must be dry nitrogen (oxygen, carbon dioxide and flon gases are not acceptable).

Joint Orientation: Install the proprietary REFNET refrigeration pipe joints and headers in an appropriate orientation to enable correct distribution of refrigerant.

Cleanliness of Piping: All pipework must be kept clean and free from contamination to prevent breakdown of the system. Seal all pipe ends and keep sealed until immediately prior to making a joint.

Pressure Testing: Immediately after installation of pipework and prior to sealing of insulation joints and start-up of equipment, vacuum dehydrate the pipework; pressure test to 2,800kPa; hold for a minimum of 24 hours, check for leaks and repair if necessary. Following this, vacuum dehydrate the pipework to (-755mmHg) and hold for one to four hours depending on the pipe length.

Additional Charge: Additional refrigerant charge weight must be calculated to the actual length of the refrigerant pipework. The refrigerant charging process must be carried out with an appropriate charging station and under supervision.

Piping Insulation: Insulate all pipework with slip on closed cell elastomeric pipe insulation having a wall thickness of not less than 10mm. All proprietary REFNET joints to be insulated with the REFNET split case preformed insulation section. Insulation must be protected when exposed to the atmosphere by special paint or covered by an enclosure. Glue all insulation (after pressure and leak testing) to provide a complete seal to prevent any condensation.

Fixing Pipework: Fix and support pipework at a minimum of 2 metre centres by galvanised mild steel brackets. Where required, run on galvanised trays.

Labelling: Tag all pipework with the condensing unit identification numbers at 3 metre intervals.

Buried Pipework: Pipework buried underground to be insulated to the above requirements, wrapped in tape of a woven synthetic fabric impregnated with a neutral petroleum based compound and an over wrap of high impact polyethylene film to provide mechanical protection.

### 5.1.11 Branch Selector Unit (for Heat Recovery Systems)

Supply and install branch selector unit boxes where indicated on the drawings and to the manufacturers specifications. Utilise the Branch Selector (BS) units in conjunction with the three pipe system whenever individual simultaneous heating and cooling is required.

Solenoid Valve Control: Provide each with two solenoid valves which are opened by a signal to cool or heat from the remote controller. Provide a temperature differential switch to set the heating/cooling set point band between 0-7K, on the branch selector PCB.

Factory Assembly: The branch selector unit to be completely pre-wired and pre-piped and internally insulated.

# 6. EVAPORATIVE AIR COOLERS

## 6.1 GENERAL

### 6.1.1 RESPONSIBILITIES

**General**

Requirement: Provide type-tested, proprietary evaporative air coolers, as documented.

### 6.1.2 STANDARDS

**General**

Evaporative air coolers: To AS 2913 (2000).

Microbial control: To AS/NZS 3666.1 (2011) and the recommendations of SA/SNZ HB 32 (1995).

### 6.1.3 INTERPRETATION

**Definitions**

General: For the purposes of this work section, the following definitions apply:

- Evaporative air cooler: A device that cools air by the evaporation of water. It has the same meaning as evaporative air conditioner.
- Evaporative efficiency: When tested to AS 2913 (2000), the cooling performance of the equipment, representing the extent to which the available wet bulb depression will be achieved as the dry bulb temperature drops.

### 6.1.4 SUBMISSIONS

**Tests**

Type tests: Submit results, as follows:

- Evaporative air coolers: Submit evidence of type test to AS 2913 (2000).

## 6.2 PRODUCTS

### 6.2.1 INDIRECT EVAPORATIVE AIR COOLERS

**General**

Requirement: Provide factory fabricated and assembled Indirect Direct Evaporative Cooler (IDEC) unit, included components will consist of cabinet, intake air filter, internally isolated fan, motor and inverter drive assembly, indirect evaporative heat exchanger, electronic control and automatic water management system, complete with components necessary for operation.

Minimum evaporation efficiency when new: 80%.

Pad face velocity: ≤ 2.9 m/s.

**Standards**

Safety: Conform to AS/NZS 60335.2.98 (2005).

**Materials**

Requirement: Manufacture from corrosion-resistant, UV stabilised materials suitable for outdoor operation. Select from the following:

- Stainless steel: Type 304.
- Aluminium: Alloy 5251 to AS/NZS 1734 (1997).
- Glass reinforced plastic.
- Structural polymer.

Fasteners: Stainless steel, plastic or corrosion-resistant non-ferrous material compatible with the materials in contact with them.

Sumps: Provide sumps with radiused corners free from gussets and stiffeners, and arranged to facilitate cleaning.

Alternatives to documented materials: Provide materials with equivalent or higher corrosion resistance and durability and compatible with the materials in contact with them.

**Cabinet Construction**

The chassis shall be made of acrylic coated marine grade aluminium of 1.2mm thickness, with a rolled section galvanised steel forklift lifting slots and mechanical fasteners in stainless steel or aluminium.

Within the unit there shall be a drain pan constructed from pressure formed ABS that catches all the surplus water from the heat exchangers and channels it back to the water reservoir.

The water reservoir shall be constructed from pressure formed ABS and will be designed such that the drain pans discharge the surplus water into the water reservoir without spillage or leakage.

The water reservoir shall contain provision for the mounting of an electrically operated drain valve and an overflow of sufficient size to carry the full water supply volume in a fault condition.

**Indirect stage - Heat Exchanger Core**

The Heat Exchanger shall be a single stage counter-flow heat exchanger which uses indirect evaporative cooling to ensure that moisture is not added directly to the supply air stream.

The heat exchanger shall be constructed so to direct all the intake air through the dry side air passages. The 30% of the intake air shall be directed in a counter-flow direction through the wet side air passages and then to the exhaust.

This allows the unit to use only one fan for primary and secondary air stream.

The media shall utilize a self-cleaning design that allows it to retain its efficiency over long periods of constant use.

**Direct stage - Direct Evaporative Pad**

Direct Cooling pad shall be a paper-based cooling pad covered by thermoset resin to suit the harshest climates with 4mm flute and a minimum saturation efficiency of 91%.

**Air Filters**

Air filters shall be washable and replaceable, constructed from a pleated material that has a G4 (MERV 8) rating enclosed in a metal frame.

Sand trap louvers shall be easily applied into the air inlet filter cowling in case of installation in areas where sandstorms can occur.

**Water Management System**

The unit shall have an electronic water management system which maintains the water level, controls the TDS of the water in the reservoir, and provides an automatic water treatment to maintain water freshness.

The unit shall incorporate an auto drain function to empty the water tank/reservoir after 72 hours of non-use of the cooler.

The water management system shall have an automatic chlorinator electronically controlled to generate chlorine at low rate and mitigate against the low risk of harmful bacteria growing in the tank and the heat exchange cores.

**Fan and Motor**

The fan shall be a backward curved centrifugal type fitted with a direct coupled EC motor. Motor shall have degree of protection IP55, insulation class "F" and 60°C of max duty point operating temperature.

**Bleeds, drains and overflows**
Requirement: Provide bleed valve, drain valve and overflow for each cooler.

Automatic bleed: Provide an automatic bleed solenoid valve, controlled by a water conductivity sensor sensing total dissolved solids (TDS), to bleed water to waste.

Automatic dump: Provide automatic drain for sump to empty the sump contents and prevent re-filling when out of use. Provide timed automatic control as follows:

- Continuous running coolers: Dump the whole sump contents at 24 to 72 hour intervals to suit water conditions.
- Intermittently running coolers: Dump the whole sump contents and prevent refilling 4 hours after the fan stops.

Bleed controls: Adjustable from inside the unit and secured so that settings cannot change without intentional intervention during servicing.

**Dampers**

General: Provide either a motorised damper interlocked to the fan or a self-closing damper.

**Controls**

The unit shall be supplied with a complete electronic control system, housed in an external weatherproof cabinet (IP66), which monitors the status of unit's operation key aspects for commissioning trials and diagnostics, displaying and recording a "fault occurrence".

The cooler shall be supplied with a wall mountable control module with built in temperature and humidity sensor that can be used to control the three below operating modes:

- COOL Mode with automatic speed control to maintain space temperature and relative humidity by automatically varying the connected cooler(s) fan speed.
- VENT Mode, with manual speed control to keep connected cooler(s) running at a constant speed with no cooling stage enabled
- PROGRAM mode to maintain space temperature and relative humidity on a "set and forget" seven-day program.

An additional remote indoor sensor shall be supplied for a better temperature and humidity control inside the building

Remote control shall be available from an external BMS, via either digital and analogue voltage signals or direct Modbus / BACnet connection, to switch ON/OFF the unit, change the fan speed, switch the operating mode, switch ON/OFF the direct stage, check the status of all the components inside the unit, and show any “fault occurrence”.

## 6.3 EXECUTION

### 6.3.1 INSTALLATION

#### Mounting

Frames: Mount the cooler on a rigid frame fabricated from either stainless steel or steel hot-dip galvanized after fabrication. Arrange the frame to take the mass of the cooler evenly on all sides. Provide neoprene waffle pad mounts under the unit and bolt the cooler to the frame and the frame to the slab or building structure.

Clearance: ≥ 400 mm under the cooler.
Ground mounted coolers: Provide a concrete plinth under the cooler.

Lifting eyes: Provide lifting eyes on each corner.
Wind and rain: Conform to AS/NZS 1170.2 (2021) for wind action. Design to prevent entry of rain to the supply air duct under all likely conditions.

Seismic restraint: Conform to **SEISMIC RESTRAINT OF NON-STRUCTURAL COMPONENTS**.

#### Connections

Ground mounted coolers: Run water, drain and electrical under the plinth.

Roof mounted coolers: Run water, drain and electrical under the roof.

Location: Rise adjacent to the cooler support frame leg.
Isolation: Provide electrical and water isolation adjacent to each unit.

#### Water supply

Backflow prevention: To PCA (2022) B5. Provide one of the following:

- A separate backflow prevention device to each cooler and to each associated hose cock.
- A common backflow prevention device to protect a group of coolers and associated hose cocks.

Hose cock: Provide a hose cock for cleaning purposes adjacent to each cooler or group of coolers.

Water treatment: In hard water areas, provide a water softener to evaporative the cooler manufacturer's recommendations.

#### Drains

General: Drain to waste. Provide a visible air gap arranged so that the bleed rate can be measured.

Overflow: Run the overflow to drain. Arrange so any overflow is visible.

#### Duct connections

Requirement: Provide flexible duct connections at the unit to FLEXIBLE CONNECTIONS in Ductwork.

### Bushfire-prone areas

Site with Bushfire Attack Level (BAL) 12.5, 19 or 29 to AS 3959 (2018): Protect evaporative coolers to AS 3959 (2018) including sealing of all penetrations and provision of either non-combustible butterfly dampers to AS 3959 (2018) or non-combustible mesh covers to AS 3959 (2018).

Water piping: If external and above ground, provide metal pipes and fittings to AS 3959 (2018).

## 6.4 COMMISSIONING

### General

Requirement: Conform to commissioning. Commission to the manufacturer's recommendations.

Cleaning: Before setting into operation, clean the air handling system and remove foreign matter.

Air balancing: Achieve the design airflow with all relief paths open in the spaces served.

Water: Adjust bleed controls, automatic dump and sump water level to the manufacturer's recommendations and to minimise water consumption having regard to the operating conditions, available water quality and site. Adjust water flow over pads to achieve even wetting.

Controls: Calibrate and adjust all controls and test safety devices. Adjust automatic dump to suit site conditions and the manufacturer's recommendations.

## 6.5 MAINTENANCE

### General

Requirement: Provide maintenance as documented. Conform to maintenance section.

# 7. FANS

## 7.1 GENERAL

### 7.1.1 Section Introduction

Specified in this section are the minimum requirements for the construction, testing and installation of fans for heating, ventilating and air conditioning.

### 7.1.2 Requirements

Provide all fans of the same manufacturer. Only fans for which spare parts are readily available are to be provided.

Fans are to be of Fantech or Fans Direct or approved equal.

Check the scheduled estimated system resistances in the light of equipment offered. Make any necessary adjustments and submit curves with the workshop drawings showing the operating points for approval before placing orders. Calculations for the final fan pressure capacities are the responsibility of the Mechanical Services subcontractor. Fan static pressures and motor kilowatt ratings are given for guidance purposes only.

Fan motors must have rated power output of not less than 130% of the fan power required at initial operating conditions.

Fans are to be provided with motors and drives selected to allow the fan to run up to full speed in less than 8 seconds on starting. Motors are to be rated to start as frequently as required under normal operating conditions, but in any case, it must be possible to immediately restart a motor after prolonged operation at full load and at maximum ambient temperature without overheating or operation of protection devices.

Fans, which are arranged to operate in parallel discharging into, or drawing from a common duct or chamber, must have pressure operated non-return dampers fitted to the fan discharge.

Fan intakes and discharges are to be connected to ductwork and plenums by flexible connections.

Fans are to be manufactured to a fully developed design currently in production and readily available and supported by test data sheets and complete service facilities and spare parts. Statically and dynamically balance rotating parts on assembly.

The fan noise level must not exceed the scheduled values.

### 7.1.3 NCC Section J Compliance

NCC Requirement, Section J: For a Deemed to Satisfy Section J solution, where a fan serves as an exhaust to a conditioned space, or a habitable room in climate zones 4, 5, 6, 7 & 8 (as defined by the NCC), provide the fan fitted with a sealing device such as a self-closing damper or the like.

NCC Requirement, Section J: For fans with an air flow rate greater than 1000 L/s, provide fans that have motor shaft power to air flow rate ratio or motor input power to air flow rate ratio in accordance with the more stringent of either the mechanical schedules, or Section J of the NCC for requirements for power in the case of with / without filters).

### 7.1.4 Standards

The following standards apply to this section:

| | |
|---|---|
| AS 1044 | Limits of Electromagnetic Interference for Electrical Appliances and Equipment; |
| AS 1650 | Galvanised Coatings; |
| AS 1668.1 | The use of Mechanical Ventilation and Air Conditioning in Buildings: Part 1 Fire and Smoke Control |
| AS 2784 | Endless Wedge Belt and V-Belt Drives; |
| AS 4680 | Hot-dip galvanized (zinc) coatings on fabricated ferrous articles; |
| BS 848 | Fans for General Purposes: Part 1 - Methods of Testing Performance Part 2 - Fan Noise Testing |
| AG 601 | Gas Installation Code. |

## 7.2 CENTRIFUGAL FANS – SHEET METAL

### 7.2.1 Description

Fans are to Centrifugal fans – general purpose except as varied below.

Performance: The fan curves and performance tables and noise data must comply with British Standard BS 848 parts 1 and 2.

### 7.2.2 Construction

Casting: Metallic-coated steel sheet, riveted or spot welded with joints sealed.

- Scroll: 1.2 mm minimum thickness;
- Side plates: 2 mm minimum thickness.

Impeller:

- Type: Backward or forward curved section, laminar or aerofoil as scheduled;
- Construction: Extruded aluminium or metallic-coated steel blades secured between reinforced galvanized steel plates.

Bearings: Self-aligning sealed for life ball or roller type.

Drive: Integral motor/fan impeller assembly incorporating external rotor motor and integral thermal protection.

Motor: Suitable for speed control, minimum degree of protection: IP51.

Bases: Formed from pressed metallic-coated steel sheets, bolted to casings. Provide at least 4 brackets for mounting.

Finish: Brush and prime spot welds with zinc-rich organic primer to AS/NZS 3750.9.

## 7.3 CENTRIFUGAL FANS – INLINE

### 7.3.1 Description

Provide fans with non-overloading power characteristics and suitable for inserting into ductwork.

Performance: The fan curves and performance tables and noise data must comply with British Standard BS 848 parts 1 and 2.

### 7.3.2 Construction

Casing: Rectangular or circular with spigot or flanges for duct mounting, with construction as follows:

- Steel: Metallic-coated steel sheet, spot welded. Brush and prime spot welds with zinc-rich organic primer to AS/NZS 3750.9;
- Glass reinforced plastic (GRP) or plastic: Moulded GRP or impact resistant plastic with integral support foot.

Impeller: Backward inclined or forward curved style as scheduled, constructed from metallic-coated steel, extruded aluminium or polypropylene. Balance impellers statically and dynamically.

Drive: Integral motor/fan impeller assembly incorporating external rotor motor and integral thermal protection.

Motor: Suitable for speed control.

Electrical Connection: Provide terminal box external to fan casing and wired to fan motor.

Access to Impellers: < 350 mm diameter: Provide fan manufacturer's standard fast clamps both sides of the fan to permit removal of the impeller-motor assembly or fan as a whole.

## 7.4 AXIAL FLOW FANS

### 7.4.1 Description

The fans must possess non-overloading characteristics with an electrical terminal box mounted external to the fan casing and wired to the fan motor.

Performance: The fan curves and performance tables and noise data must comply with British Standard BS 848 parts 1 and 2.

Airflow Direction: Is to be suitable for operation with axis horizontal or vertical with air flow directions to produce maximum motor cooling and quietest operation.

### 7.4.2 Construction

Casing: Are to be tubular, with pre-drilled flanges at each end for connection to ductwork. Materials are to be mild steel, hot dip galvanised, after manufacture.

Impellers: Shall be:

- Aerofoil section;
- Injection moulded glass reinforced plastic or cast aluminium alloy;
- Fixed or adjustable pitched, refer to Fan schedule;
- Statically and/or dynamically balanced.

Drive: Direct mount motor to impeller.

Motors: In accordance with Section 'General Equipment Standards'.

Mounting Feet: Provide mounting feet as either:

- Bolt on type;
- Welded to fan housing.

Coned Inlets: Inlet cones or bell mouths nominally 0.2 x diameter long and reducing from 1.2 x diameter are to be provided where fans do not have a ducted inlet. Acoustic attenuator fitted to fan inlet is to have cone located upstream from the attenuator.

Discharge Cones**:** Discharge cones nominally 1.0 x dia. long expanding to 1.25 x dia. are to be provided where fans do not have a ducted outlet. Where an acoustic attenuator is fitted to the discharge, the cone is to be located downstream from the attenuator.

Guards: Provide heavy galvanised steel or bronze wire mesh guards to discharge and intake of fans where these are not connected to system ductwork and where shown on the drawings.

Access to Impellers:

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

Electrical Connection: Provide terminal box external to fan casings and wire to fan motors.

Kitchen Exhaust Fans:

- Type: Axial flow with non-combustible casing and cowl (if fitted);
- Access for cleaning: Large gasketed access panels;
- Finish: Hot-dip galvanized then epoxy painted;
- 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 the duct. Make sure that fire rating provisions permit easy access for inspection, cleaning and maintenance;
- Materials generally: Except for minor items such as grommets, junction boxes, etc., construct from materials with a temperature of fusion > 1000°C.

Swing Out Casing**:** Is to be long, fully enclosing tubular type with pre-drilled flanges at each end for connection to ductwork. Hinged section carrying motor and impeller is to have quick release fasteners.

## 7.5 ROOF MOUNTED

### 7.5.1 Description

Exhaust fan with weatherproof housing suitable for roof mounting and capable of either free air flow or connection to inlet ductwork.
Performance: The fan curves and performance tables and noise data must comply with British Standard BS 848 parts 1 and 2.

### 7.5.2 Construction

Housing: Shall be suitable for flashing over a roof upstand with weatherproof cowl over fan discharge.

Housing shall be manufactured from either:

- Pre-coloured UV- stabilised plastic;
- Fibreglass;
- Galvanised sheet steel;
- Hot dipped galvanised steel.

Fit bird mesh guards between the housing and the cowl.

Cowl: To be removable for access to the fan motor and drive. Cowls shall be downward discharge or vertical discharge as scheduled.

Impeller: Shall be either:

- Axial flow;
- Mixed flow;
- Backward inclined centrifugal, non-overloading.

The Impeller shall be dynamically balanced.

Drive: Belt or direct as appropriate:

- Belt Drive: Comply with Centrifugal fans – general purpose.

Motor: Shall be in accordance with Section 'General Equipment Standards' and multispeed or single as scheduled.

Shutters: Fit lightweight backdraft shutters.

Electrical Connection: Provide terminal boxes external to fan casings and wired to fan motors.

Kitchen Exhaust Fans:

- Housing, base and casing: Hot-dip galvanized steel or stainless steel only;
- Materials generally: Except for minor items such as grommets, junction boxes, etc., construct from materials with a temperature of fusion > 1000°C.

Finish: Fan assemblies are to be finished in a factory applied coating in accordance with section "Corrosion Protection, Painting and Labelling". Colour shall match the roof colour, refer to architectural specification.

## 7.6 IN LINE MIXED FLOW

### 7.6.1 Description

The fans must possess non-overloading characteristics with an electrical terminal box mounted external to the fan casing and wired to the fan motor.

Performance: The fan curves and performance tables and noise data must comply with British Standard BS 848 Parts 1 and 2.

Airflow Direction**:** Is to be suitable for operation with axis horizontal or vertical with air flow directions to produce maximum motor cooling and quietest operation.

### 7.6.2 Construction

Housing: Shall be reinforced injection moulded plastic with integral mounting foot.

Impellers: Shall be:

- Mixed flow design;
- Injection moulded plastic;
- Direct drive.

Motors**:** In accordance with Section “General Equipment Standards”.

## 7.7 RING PLATE AXIAL

### 7.7.1 Description

The fans are to possess non-overloading characteristics with an electrical terminal box mounted on the fan motor, or a flying lead suitable for site connection.

### 7.7.2 Construction

Housing: Ring plate fans are to be spun or pressed aluminium or spun or pressed steel powder coated. Provide corrosion protected wire wound or mesh guards.

Impellers: Galvanised steel with paint finish.

Motors: In accordance with Section 'General Equipment Standards'.

## 7.8 MULTIVANE CENTRIFUGAL

### 7.8.1 Description

Fans are to be of single or double inlet of a classification suitable for the performance scheduled. Fans are to be direct driven (arrangement 4).

### 7.8.2 Construction

Housing: Pressed steel complete with:

- Curved aerodynamic inlet;
- Inlet and outlet connection spigots where ducted.

Impeller: Forward curve laminar blade, multivane, constructed of mild steel, polypropylene or FRP.

Shaft: Mild steel unless otherwise scheduled.

Motor: In accordance with section "General Equipment Standards".
Bearings: Self aligning ball or roller factory lubricated for life.

Base: Pressed steel housing bolted to a steel support bracket to which is attached the bearing or motor pedestal.

Finish: Fan assemblies are to be finished in a factory applied coating in accordance with section "Corrosion Protection, Painting and Labelling".

## 7.9 BIFURCATED AXIAL FANS

### 7.9.1 Description

Direct driven fixed casing type with fan motor in duct but protected from duct stream and independently ventilated.

Airflow Direction: Is to be suitable for operation with axis horizontal or vertical with air flow directions to produce maximum motor cooling and quietest operation.

### 7.9.2 Construction

Housing: Is to be long, fully enclosing cylindrical type with flanges at either end for connection to ductwork. Motor is to be mounted centrally and encased such that the fluid handled passes around the motor encasement in an annulus. Provide aerofoil ducts between motor casing and external casing for motor ventilation. The casing is to be mild steel, hot dip galvanised, after manufacture.

Impellers: Shall be either:

- Aerofoil section;
- Cast aluminium;
- Adjustable pitch to suit system resistance.

Motors: In accordance with the section “General Equipment Standards”.

## 7.10 ROOF MOUNTED COWL

### 7.10.1 Description

Curb mounted downward or vertical intake/discharge roof cowl.

### 7.10.2 Construction

Roof mounted cowls shall be constructed from either:

- UV-stabilised plastic;
- Fibreglass;
- Galvanised sheet steel;
- Aluminium.

Steel components to have a corrosion-resistant finish, either galvanised sheet steel, hot dipped galvanised steel, stainless steel or a powder-coated finish.

Bird mesh guards are to be fitted.

Shall be suitable for flashing over a roof upstand.

Vertical discharge cowls shall be fitted with lightweight, butterfly type, gravity air-operated backdraft dampers.

## 7.11 INSTALLATION

### 7.11.1 Access

General: Arrange fans and accessories to allow service access for maintenance, removal or replacement of assemblies and component parts, without disturbance of other items of plant, fire rating material and/or the building structure.

### 7.11.2 Duct Connections

Flexible Connections: Provide flexible connections to prevent transmission of vibration to ductwork. If under negative pressure, make sure that flexible connection does not reduce fan inlet area. If necessary, provide spacer pieces between fans and flexible connections.

### 7.11.3 Drains

General: Where moisture is likely to enter or condense inside a fan provide a trapped drain in conformance with AS/NZS 3666.1.

### 7.11.4 Vibration isolation

General: Provide each assembly with at least four anti-vibration mountings, selected to give an isolation efficiency not less than 95%.

Type: As recommended by the fan manufacturer to achieve the required isolation efficiency for the specific fan under the documented operating conditions. Provide levelling screws and locknuts on metal spring mounts.

Location: Locate the mountings so that the mounts deflect uniformly when the fan is operating and subject to all loads, including those imposed by the duct.

Duct Connections: Arrange flexible duct connections so that the fan vibration isolation efficiency is not adversely affected.

### 7.11.5 Marking

Labels:

Show the following:

- Manufacturer's name;
- Model;
- Serial number;
- Size;

Direction of rotation, marked on casing.

# 8. SPACE HEATING

## 8.1 GENERAL

### 8.1.1 RESPONSIBILITIES

**General**
Requirement: Provide space heating equipment, as documented.

### 8.1.2 STANDARDS

**General**
Gas installations: To AS/NZS 5601.1 (2022).
Gas-fired appliances: To AS 3814 (2018), AS/NZS 5263.0 (2017) and AS/NZS 5263.1.3 (2021).
Gas radiant heaters: To AS/NZS 5263.1.4 (2017).
Gas direct fired air heaters: To AS/NZS 5263.1.10 (2019).

### 8.1.3 SUBMISSIONS

**Certification**
Space heating equipment performance: Submit certified reports, type test results, calculations and other details to demonstrate that the documented performance will be achieved with the equipment offered.

Gas appliances with gas inputs under 500 MJ/hour: For each appliance where an approval code exists, submit a certificate from the manufacturer stating that the appliance has AGA approval for operation with the designated gas type.

**Shop drawings**
In-floor heating systems: Submit shop drawings showing the layout and details of heating systems embedded in floors.

**Subcontractors**
In-floor heating systems: Submit names and details of the experience of proposed installers, of heating systems embedded in floors.

## 8.2 PRODUCTS

### 8.2.1 GENERAL

**Marking**
Identification: Marked to the requirements of general requirements and to show the following:
- Nominal capacity and corresponding conditions.

**Availability of spare parts**
Requirement: Provide equipment for which spare parts are readily available in Australia.

**Gas appliances**
Requirement: Provide gas-fired appliances with the following:
- Electronic ignition.
- Non-sealed combustion units.
- Oxides of nitrogen (NOx) emissions: ≤ 200 mg/kWh of delivered energy.
- Flame safeguard system.
- AGA approval label.

### 8.2.2 RADIANT HEATERS - ELECTRIC

**General**

Type: Thin film flat panel heaters or oil filled tube.
Exterior surface temperature: ≤ 50°C.
Mounting: Floor mounted.
Heater controls/thermostats: Tamperproof and accessible only by a key.
Control systems: Provide simple resetting procedures in event of power failure.
Spot radiant heaters: If required for localised heating, control with local time switches.
- Maximum operating time: 45 to 60 minutes before restarting.

## 8.3 EXECUTION

### 8.3.1 INSTALLATION

**General**
Access for maintenance: To 0171 General requirements.
Duct connections: To 0741 Ductwork.
Gas-fired equipment venting: To AS/NZS 5601.1 (2022). Install so there is no leakage of combustion products into the building. Provide stainless steel flues and weatherproof cowls.
Installation and clearances: Install to manufacturer's recommendations.
Piping: To 0751 Mechanical piping.

### 8.3.2 COMMISSIONING

**General**
Requirement: Conform to commissioning section of this specification. Commission to the manufacturer's recommendations.

### 8.3.3 3.3 MAINTENANCE

**General**
Requirement: Provide maintenance as documented. Conform to maintenance section of this specification.

# 9. REFRIGERATION PIPEWORK

## 9.1 GENERAL

### 9.1.1 Scope

This section of the specification sets out the requirements for the supply and installation of the refrigeration and condensation drainage piping systems including insulation.

### 9.1.2 Requirement

All refrigeration and drainage piping is to be installed in accordance with the relevant codes and standards and in accordance with the air conditioning system manufactures requirements.

### 9.1.3 NCC Section J Compliance

All refrigeration and condensate drainage piping will be insulated in accordance with section J of the NCC BCA Volume 1.

The NCC BCA is available free of charge from The Australian Building Codes Board at http://www.abcb.gov.au/.

### 9.1.4 Standards

Referenced Documents: The following standards are applicable to this Section:

AS 1366.3 Rigid Cellular Plastics Sheets for Thermal Insulation - Rigid Cellular Polystyrene - Moulded (RC/PS - M);
AS 1397 Steel Sheet and Strip - Hot-Dipped Zinc-Coated or Aluminium/Zinc Coated;
AS 1566 Copper and Copper Alloys - Rolled Flat Products;
AS 1571 Copper - Seamless Tubes for Air Conditioning and Refrigeration;
AS 1572 Copper and Copper Alloys – Seamless Tubes for Engineering Purposes;
AS 1734 Aluminium and Aluminium Alloys-Flat Sheet, Coiled Sheet and Plate;
AS 4041 Pressure Piping.

## 9.2 PIPING SPECIFICATIONS

### 9.2.1 Copper - Refrigerant

Piping: Seamless tubes to AS 1571 suitable for high pressure series R400 refrigerants.

### 9.2.2 Joints

(a) Silver soldered capillary type;
(b) In small, soft copper tubes, joints may be made with approved flare compression fittings;
(c) Keep the interior of the pipework clean of all dirt, flux, swarf or turnings;
(d) Blow through each section with dry nitrogen once erected and seal the ends until the next section is erected.

### 9.2.3 Unplasticised PVC (UPVC) For Waste and Vent Applications

Piping and Installation: To AS 1415.

Joints: Solvent cement jointing and rubber ring expansion type jointing.

Fittings: Moulded type or fabricated type.

Do not use UPVC piping inside ducts or conditioner housings. Do not install UPVC piping adjacent to boilers, hot water lines, steam lines, etc., or in direct sunlight without protection.

### 9.2.4 Pipework Schedules

| System | Pipe Materials | Standard | Insulation | Sheathing or Finishing | Vapour Barrier |
|---|---|---|---|---|---|
| Refrigerant | Copper | Series R400 refrigerants | Expanded Rubber To BCA Specification J5.2c | Colorbond Weather Protection | Inherent in closed cell insulation |
| Condensate | UPVC or Copper | AS 1415 or AS 1477 Type C or D to AS 1432 | Expanded Rubber To BCA Specification J5.2c | Colorbond Weather Protection | Inherent in closed cell insulation |

## 9.3 INSULATION

### 9.3.1 Insulation Materials

Expanded Rubber: Flexible, closed cell, chemically blown PVC nitrile rubber sponge type of material equivalent to "ARMAFLEX/FR" or equal approved.

Provide with thermal conductivity to comply with specification J5.2c of the BCA.

Provide the insulation in tubular form, without a longitudinal joint. Do not split the tubular insulation longitudinally to install on pipework except where approved. Join the insulation as necessary using an appropriate contact adhesive as recommended by the insulation manufacturer to maintain vapour barrier integrity.

## 9.4 GENERAL INSTALLATION REQUIREMENTS

### 9.4.1 Generally

Install pipework in straight lines and uniform grades without sags. Provide bends and sets as required. Remove burrs and obstructions. Arrange pipes to give neat, workmanlike appearance and true alignment without obvious damage to any component.

### 9.4.2 Cleaning

Pre-cleaning: Before installation, clean pipes and fittings by a suitable method such as blowing through with compressed air or pulling a brush through. Remove loose scale, burrs, fins and obstructions.

Capping Off: During construction, temporarily seal open ends of pipes and valves to prevent the entry of foreign matter into the pipework system. Provide purpose-made covers of pressed steel or rigid plastic. Do not use wood plugs, rags, paper or the like.

Cleaning Out: Remove loose scale, dirt, and the like from the pipework and leave the system free from foreign matter on completion.

### 9.4.3 Building Penetrations

Provide full co-ordination to ensure accurate interface and penetration sizing.

Set-out: Obtain approval of the set-out of core holes and sleeves by way of working drawings before proceeding. Pass all pipes through walls and floors at right angles.

Sleeves: Where pipes pass through concrete slabs, provide copper tube sleeves. Refer drawings.

External Penetrations: Penetrations through the roof of the building, use “Dektite” proprietary roof flashing system to water proof all external penetrations.

### 9.4.4 Supports

Generally: Provide supports including hangers, saddles, bolted clips and the like, to support it at joints, at changes of direction, and at intervals suitable to the size and type of pipe, and as necessary to prevent sagging of pipework. Make provision for adjustment of height.

Proprietary Supports: Use approved proprietary support systems. In general, support horizontal pipe runs by two piece split ring clamps hung from steel rods or, when approved, clamped to bearers or brackets. Clamp vertical pipe runs to horizontal brackets using bolted metal saddle clamps.

Support Material: Galvanised steel or non-ferrous metals, with inert material sleeves to separate dissimilar metals. Provide fixings of suitable compatible material.

Support Spacing: (Maximum distance between pipe supports):

| Pipe Material | Horizontal | Vertical |
|---|---|---|
| For UPVC and polyethylene pipes: | 1000mm | 1000mm |
| For copper pipes: - 25mm and below:<br>- 32mm to 40mm:<br>- 50mm and above: | 2000mm<br>2500mm<br>3000mm | 3000mm<br>4000mm<br>4000mm |

Fixing to Masonry: Galvanised steel or non-ferrous metal bolts or screws into expanding metal masonry anchors. Do not use explosive powered fixings.

### 9.4.5 Flexibility

Expansion and Contraction: Install the pipework with sufficient bends, expansion loops or expansion devices along with pipe anchors and pipe guides so that it can absorb its own expansion and contraction without developing excessive stresses in the pipework, in connected equipment, or in the supporting structure.

Expansion Bends:

(a) Construct expansion bends from the pipe and fittings material specified for the service;
(b) Bends with distortions or ridges resulting from bending will be rejected;
(c) Provide properly selected pipe guides at not less than two support locations on both sides of the expansion bend.

Condensate:

Provide a drain pipe from each air conditioning unit to the nearest appropriate waste connection or as shown on the drawings. Provide drain pipes which are not less than 20mm diameter. Note that drains are required to be insulated where they run internal within the building.

## 9.5 TESTING AND EVACUATION OF REFRIGERANT SYSTEMS

### 9.5.1 Pressure Tests

To AS/NZS 5149.2:2016

### 9.5.2 Requirement

Dehydrate the refrigerant gas system by an approved evacuation process not inferior to the triple evacuation method before charging with the refrigerant gas.

Triple Evacuation: Carry out the process only when room ambient temperature is above 16°C (to prevent ice forming in the system). Use a high-vacuum pump, capable of reducing the pressure in the system to less than 25Pa (188 micrometres Hg) absolute, connected to both high and low pressure sides of the system with valves open and controls connected. Measure the pressure with approved calibrated electronic vacuum gauges, not by wet-bulb determination.

(a) First evacuation: Establish stable vacuum conditions in the system by running the pump at capacity until the pressure is less than 25Pa absolute, then closing off the system and letting it stand for as long as is necessary to verify that the pressure is stable, taking into account ambient temperature conditions. If stability is not achieved, repeat the evacuation. When stability is achieved, break the vacuum with clean dry nitrogen;

(b) Second evacuation: Establish stable vacuum conditions as specified for the first evacuation. When stability is achieved, break the vacuum with clean dry refrigerant, and raise the pressure to above zero. Install drier cartridges and moisture indicators in the system;

(c) Third evacuation: Run the pump at capacity, and then charge the system with the correct quantity of refrigerant and oil.

### 9.5.3 Testing

Test for leaks with a halide torch or an electronic detector.

### 9.5.4 Retesting

If at any time within the Defects Liability Period, after the system has been charged, any joints have to be broken or remade, the whole system must be pumped down; pressure tested an evacuated again as detailed above.

Dissimilar Metals: Do not install copper in contact with steel, zinc, or other materials likely to generate electrolytic, galvanic or corrosive action. Make isolation junctions between dissimilar metals with fittings manufactured in suitable compatible material.

Changes of Direction: Use long radius bends or elbows in preference to short radius elbows.
Use elbows where pipes are led up or along walls and through to fixtures.

Arrangement: Arrange pipework runs adjacent to, and horizontally parallel with each other and with walls, beams, and the like. Keep at least 150mm above ground surface if under suspended ground floors. Provide adequate spacing, measured clear of pipe insulation, of at least 25mm between pipes, 50mm between pipes and electrical cables. Take off branches at right angles unless otherwise shown on the Drawings or specified.

### 9.5.5 Inspection

Give sufficient notice so that inspection may be made at the following stages:

(a) Final Evacuation testing of all refrigeration circuits.

Required Notice: Unless otherwise specified, not less than: 48hrs

# 10. DUCTWORK

## 10.1 GENERAL

### 10.1.1 Scope

This section sets out the construction and installation requirements for air conditioning and ventilation systems ductwork, including insulation.

### 10.1.2 Standards

Referenced Documents: The following standards are applicable to this Section:

| | |
|---|---|
| AS 1192 | Electroplated Coatings - Nickel and Chromium; |
| AS 1366.2 | Rigid cellular plastics sheets for thermal insulation - Rigid cellular polyisocyanurate (RC/PIR); |
| AS 1397 | Steel sheet and strip - Hot-dipped zinc-coated or aluminium/zinc-coated; |
| AS1530 | Methods for fire tests on building materials, components and structures; |
| AS 1682.2 | Fire dampers – Installation; |
| AS/NZS 1668 | The use of mechanical ventilation and air-conditioning in buildings:<br>Part 1: Fire and Smoke Control in Multi Compartment Buildings;<br>Part 2: Ventilation Design for Indoor Air Containment Centre 1;<br>Part 3: Smoke Control Systems for Large Single Compartment or Smoke Reservoirs. |
| AS 1734 | Aluminium and aluminium alloys-Flat sheet, coiled sheet and plate; |
| AS 2338 | Preferred dimensions of wrought metal products; |
| AS 1874 | Aluminium and aluminium alloys ingots and castings; |
| AS 4254.1 | Ductwork for air-handling systems in buildings Part 1: Flexible duct; |
| AS 4254.2 | Ductwork for air-handling systems in buildings Part 2: Rigid duct. |
| SMACNA | Sheet metal and air conditioning contractors' association. |

### 10.1.3 NCC Section J Compliance

Supply and return air ductwork is to be sealed and insulated in accordance with relevant section J of the NCC Volume 1.

## 10.2 RIGID DUCT

### 10.2.1 Requirement

All rigid ductwork is to be constructed in accordance with AS 4254.2:2012, AS1668.1 and supplemented where appropriate with SMACNA.

Dented or patched or damaged ducts will be rejected and replaced.

Ducts are to be constructed with neat and accurate fabrication independent of whether they are concealed or exposed to view.

### 10.2.2 Classification

The ductwork is to be constructed to the following classes as per AS4254.2:2012:

| Ducts | Pressure Class | Seal Class |
|---|---|---|
| Air Conditioning Ducts | 500Pa | B |
| Toilet Exhaust Ducts | 250Pa | B |

### 10.2.3 Construction

Fabricate ductwork and fittings from sheet metal, as scheduled, machine bent and free from waves and buckles. Remove burrs and sharp edges and ensure that there are no protrusions into the airways.

Materials: All metal ducts shall be constructed using lock-forming grades of sheet metal in accordance with AS 4254.2:2012 Section 2 as follows:

| Material | Standard | Notes |
|---|---|---|
| Galvanised Steel | Base grade: G2 to AS 1397.<br>Thickness tolerance: Class A2 AS 2338.<br>Coating mass: Class Z275.<br>Surface finish: N.<br>Zinc coated: To AS 1397 | |
| Stainless Steel | To AS 1449 alloy 304L sheet | Provide reinforcement and fasteners of stainless steel. |
| Aluminium | To AS 1734 Grade A, 3003-H14 sheet | Reinforcement and other extrusions to be to AS 1866 alloy 6063 |

Duct Sealing: All duct sealing will be in accordance with AS 4254.2:2012 Section 2.2.

Rectangular Duct Reinforcement: All rectangular duct reinforcement shall be in accordance with AS 4254 Section 2.3.

Longitudinal Seams: Longitudinal seams on straight duct and fittings are to be constructed in accordance with AS 4254.2:2012 Section 2.3.2, using Pittsburgh Lock Seams. Snaplock button punched joints may be used on straight ducts up to 1000mm wide but not on:

(a) Ducts 750Pa static pressure or more;
(b) Ducts in riser shafts;
(c) Ducts in excess of 1.0mm material thickness or;
(d) Aluminium ducts.

Transverse Joints: Transvers joints shall be to AS 4254.2:2012 Table 2.3 (H) “Rectangular Duct Transverse Joint Types and Ratings (J)”.

Rectangular Ductwork Fittings: Provide rectangular ductwork fittings, including tapers and offsets, bends, tees, branch take offs and connection and end closures where required and as specified in accordance with AS 4254.2:2012 Section 2.3.

Bends: Radius bend elbows are to be installed where ever possible. Fit internal vanes where the throat radius is less than 50% of the duct width. Square throat elbows shall only be used where shown on the specification drawing and shall be installed with aerofoil turning vanes.

Obstructions: If it is impossible to offset a duct around an obstruction such as a pipe or small beam, or around a small building column, the obstruction may be encompassed with a two piece streamliner. The area of the duct at the obstruction must not be less than 100% of the area of the duct before the obstruction. Refer to AS 4254.2:2012 Figure 2.3(0).

Round Duct Construction: All round ducts shall be constructed in accordance with AS 4254.2:2012 Section 2.4.

Oval Duct Construction: All oval ducts shall be constructed in accordance with AS 4254.2:2012 Section 2.5.

### 10.2.4 Installation

All rigid ductwork shall be installed in a neat and professional manner and in accordance with NCC Section J, AS 4254.2:2012 and AS1668.
Arrange the ductwork to present a neat appearance. Provide adequate access to ductwork components requiring inspection, entry, maintenance and repairs and to other ductwork or associated plant and equipment for the installation of the specified thermal insulation system and air outlets.

Hangers and Support Systems: All hangers and support systems shall be accordance with AS 4254.2:2012 Section 2.6. Do not use duct supports to support piping, cabling, ceilings and other loads additional to the ductwork.

Building Penetrations: Seal penetrations with materials as specified in Section "Noise and Vibration Control". The penetration shall be sealed through its depth. Attach the material to the structure to form an acoustic barrier completely covering the opening between the duct and the building. Trim the opening with a galvanised steel sheet angle of 50 x 50 x 2mm on both sides of the opening. The angle is to be sealed to the duct and building with a bead of sealant.

Penetrations through fire rated building elements are to be treated in accordance with Section "Fire Stopping".

## 10.3 FLEXIBLE DUCTWORK

### 10.3.1 Requirement

All flexible ductwork is to be constructed and tested in accordance with NCC Volume 1 Section J and relevant Specification, AS 4254.1:2012 and AS1668.1:2015 Clause 2.3.

All flexible ductwork must be supplied from an approved manufacture and all flexible ductwork must be supplied from the same manufacture.

Damaged or patched flexible ducts and flexible ducts over 6m will be rejected and replaced.

### 10.3.2 Construction

Materials: All flexible ducts shall be constructed in accordance with AS 4254.1:2012 Section 2.8 as follows:

| Material | Standard | Notes |
|---|---|---|
| *Reinforced Fabric* | AS 4254 Part 1 Section 2.3 | |
| *Metal* | AS 4254 Part 1 Section 2.3 | |

### 10.3.3 Installation

All flexible ductwork shall be installed in a neat and professional manner and in accordance with NCC Volume 1 Section J, AS 4254.1:2012 Section 2.5 and AS1668.1:2015.

The maximum length of any one flexible duct run shall be 6m.

Flexible ducts shall be installed in whole lengths; no flexible ducts are to be joined.

Flexible ducts are to be supported in accordance AS 4254.1:2012 Section 2.5.3 and shall not be supported by the ceiling or the ceiling support system.

Do not make test holes in flexible ducts.

Provide dampers at flexible duct take-offs. Dampers to be quadrant type with locknut system indicating damper position.

Do not penetrate any building structure with flexible duct.

### 10.3.4 Insulation of Flexible Ductwork

The insulation of flexible ductwork is to comply with the NCC Section J Specification and AS4254.1:2015 Section 2.7.

## 10.4 WEATHER PROTECTION

Ductwork exposed to weather external of the building enclosure is to be constructed and installed in accordance with AS 4254.2:2012 Section 3 and as follows:

Wind loading - Any external duct, cowl and the like must be designed for the wind loading. Submit certification that the external component is suitable for the wind loading.

Sealing - Seal all exposed ductwork joints, duct supports where they attach to the duct and all reinforcement attachments so that moisture cannot be retained in any gap or crevice. Exterior duct sealing shall comply with AS 4254.2:2012 Section 3.4.

All exposed supports, hangers and frames shall be galvanised after fabrication.

All ductwork and any sheet metal work exposed to weather shall be cross broken on top to prevent water ponding and corrosion protected by painting in accordance with section "Corrosion Protection, Painting and Labelling".

## 10.5 HARDWARE MATERIALS

Quality: The quality of the handles, latches, hinges and the like is to be not less than the following:

Mild steel: Galvanised or electro zinc plated;
Aluminium alloy castings: To AS 1874. Alloy AS303;

Access Panels
Provide access panels where shown on the drawings and where specified by Code requirements and where required for maintenance access or operation.

Construction: The access panels shall be equal to Bullock Industries AP series.

Sizes: The largest size panel that the local duct dimensions will allow:

Type: Galvanised steel construction, internally insulated with 25mm thick fibreglass. Panels are to be stiffened as necessary to prevent distortion.

Cold Bridging: Construction is to be such as to prevent cold bridging.

Frames: Provide panels with rigid matching galvanised steel frames securely attached to the duct. Ensure that no part of the panel or frame protrudes into the airstream where such protrusion would be detrimental to the airflow.

Seals: Rubber or soft neoprene gaskets mechanically fixed to either the panel or the frame. The panel is to be airtight when latched in the closed position. Where fire rating is required, use woven ceramic fibre material.

Latches: Wedge type sash latches. A minimum number of 4 latches required.

Details: Prior to commencement of work, submit details of the proposed installation.

Access Doors
Provide hinged access doors where shown on the drawings or where required for maintenance or operation adequately reinforced to prevent distortion.
Construction: The access doors shall be Bullock Industries AD series or approved equal.

Door Size: 1350mm high x 650mm wide or as shown on the drawings.

Type: Galvanised steel construction, insulated with 25mm thick fibreglass.

Cold Bridging: Construction is to be such as to prevent cold bridging.

Frames: Provide doors with rigid matching galvanised steel frames securely attached to the duct. Ensure that no part of the door frame protrudes into the airstream where such protrusion would be detrimental to the airflow.

Latching: Provide sufficient chrome-plated adjustable wedge-lock type latches and handles, which can be operated from both the inside and the outside of the door.

Seals: Mechanically fix rubber or soft neoprene gaskets to either the door or the frame. The door is to be airtight when latched in the closed position. Where fire rating is required, use woven ceramic fibre material.

Details: Prior to commencement of work, submit details of the proposed installation.

Probe Holes
Probe holes for testing air flow and temperature are to be provided in the main duct runs. Probe holes are to consist of plugged 10mm diameter sockets.

Rodent and Bird Screens
Screens must be provided behind all outside air inlets, exhaust system discharges and vents to provide an effective barrier for rodents and birds.

Screens are to be manufactured from 12mm (maximum) mesh. 0.5mm galvanised wire netting. Screens shall be fitted with folded 0.6mm galvanised sheet steel frames and be attached with cadmium plated bolts and nuts to allow simple removal.

## 10.6 DAMPERS

### 10.6.1 General

Dampers are to be free of rattles, fluttering or slack movement, and be capable of adjustment over the desired range without excessive self-generated noise or the need for special tools. Blades are not to have sharp edges and must be sufficiently rigid to eliminate movement when locked. After balancing the system, lock the balancing device and permanently mark the position.

External dampers should be fitted with bird mesh.

Face Dimensions: Duct size unless otherwise shown on the Drawings.

### 10.6.2 Volume Control Dampers

#### 10.6.2.1 Non-Motorised Control Dampers – Blade Type

Provide butterfly rotating blade type dampers on all duct spigots to flexible ducts unless otherwise noted on the drawings or agreed. Balancing at the air outlet at the end of a flexible duct will only be done if access cannot be achieved to the flexible duct spigot on the branch duct or where shown on the drawings or where agreed prior to construction.

Provide multi-blade balancing dampers on all branch ducts serving two or more diffusers or grilles and where otherwise required to properly balance the systems.

Construction: Construct volume dampers in accordance with AS 4254.2:2012 Figure 2.3H and SMACNA Figures 2-14 and 2-15 and as detailed below:

(a) Frames: Extruded aluminium with mitred corners, mechanically locked with heavy aluminium gussets or welding;

(b) Blades: Extruded aluminium aerofoil blades;

(c) Shafts: Zinc plated steel rod pinned through the blade and shaft;

(d) Linkage: Zinc plated steel interconnecting hardware driven by blade shafts not by blades;

(e) Bearings: Self-oiling sintered bronze or nylon bearings.

**10.6.2.2 Motorised Control Dampers – Blade Type**

Construction: Comply with Clause "Volume Control Dampers – Blade Type".

Bearings: Self-oiling sintered bronze. Nylon bearings are not acceptable.

Seals: Self-inflating blade and end seals constructed to allow ease of replacement.

Side Seal: Flexible aluminium or stainless steel.

Leakage: Not greater than 25 litres per second per square metre at 1500 Pa pressure differential.

Installation: Locate dampers and motors to permit access for maintenance.

Maximum motorised damper size per actuator is to be 1m2

**10.6.2.3 Splitter Dampers**

Splitter dampers are to be adjusted by push-pull rod, fixed to leading edge of damper blade by yoke and clevis pin and terminating outside the duct wall with butterfly and locking nuts. Splitter dampers shall be fabricated from 1.2mm galvanised steel.

Frames: Extruded aluminium with mitred corners, mechanically locked with aluminium gussets or welding. Refer to damper schedule on drawings for damper sizes.

Blades: Extruded aluminium airfoil blades.

Shafts: Zinc plated steel rod pinned through the blade and shaft.

Linkage: Zinc plated steel or aluminium interconnecting hardware driven by blade shafts, not by the blades.

Bearings: Bearings of self-oiling sintered bronze or ball bearings in press fit rack (nylon bearings are not acceptable).

Seals: Self-inflating blade and end seals constructed to allow ease of replacement.

Side Seal: Flexible aluminium or stainless steel.

Leakage: Not greater than 25 l/s per m² at 1500 Pa pressure differential.

Banking of dampers will be rejected unless approved by the Superintendent prior to construction.

**10.6.2.4 Damper Operation**

Operating Mechanism:

Manual operation - Fit, in a position accessible for visual inspection, maintenance and adjustment, a means of providing damper adjustment and locking in any desired position, such as lever and quadrant. Label the OPEN and CLOSED positions clearly and permanently.

Motor operation - Mount motors in an accessible position. The mounting must be rigid enough to prevent flexing or distortion of the ductwork during operation. Provide modulating test switches on each modulating damper motor.

**10.6.2.5 Damper Spindles**

Damper spindles are to be of cadmium plated steel, square or round section and are to pivot in sintered bronze or oilite bearings mounted on the outside of the damper frame. One spindle end is to be squared to accommodate a quadrant lever. The spindles are to be of adequate size to ensure rigidity and must not be less than the following table:

| Damper Length | Spindle Size |
|---|---|
| Up to 600mm | 10mm |
| 610mm to 900mm | 12mm |
| 910mm and over | 12mm with intermediate bearings at not more than 900mm centres |

**10.6.2.6 Non-Return Dampers**

Construction: Comply with Clause “Volume Control Dampers - Blade Type”.

Operation: Dampers must close against any reverse flow, offer minimum resistance to air flow and close by gravity.

Blades: Provide damper blades, which are silent in operation, free from flutter and be capable of withstanding frequent cycling.

Testing: Prototype tested all non-return dampers. Only non-return dampers with test results will be accepted.

**10.6.2.7 Fire and Smoke Dampers**

Construction: To AS 1682, having a free cross section area not less than 85% of the face area. The dampers must be rated for a 4 hour fire rating unless otherwise approved and as an effective barrier to smoke.

Marking: To AS 1682 Section 5.

Certification: Prior to commencement of work submit test certificates from an independent testing authority registered for the appropriate tests, evidencing compliance with AS 1682 Section 4 for air leakage and fire resistance.
Installation: To AS 1668 Section 3 and AS 1682 Part 2 and as shown on the Drawings. Provide for easy access for maintenance. Provide duct access panels to access all fire dampers.

Fire dampers must be installed within the thickness of the wall or floor slab to the approval of statutory authorities. Where necessary local thickening of the wall or slab or extension of the damper frame to achieve this shall be carried out.

Closure: In positions where dampers cannot be installed to close in the direction of the air flow, submit details of the proposed installation prior to commencement of work. The dampers must be capable of closure against air flows 50% higher than maximum duct air flows.

Thermally Released Links:

Type: Frangible bulb or fusible links to AS 1890.

Maintenance: Mount links so that they can be replaced with one hand without the use of bolts or the like.

Maintenance testing: Dampers must be capable of being tested for closure without the actuation of the thermally released links.
Motorised Smoke Dampers: Under control of spring control motors controlled from the fire or smoke alarm system.

Motorised dampers must be arranged for positive operation when a fire or smoke signal occurs.

Linkages: Provide rigid mechanical type linkages between motor and damper, positive in action in the operation of the damper and counter-weighted as necessary. Wire pulleys are not acceptable.

Operation: On operation of the alarm release mechanism, the spring return action of the motor will shut the damper air-tight. On cancelling the alarm, the motor will operate and return the damper to the normal position.

## 10.7 INSULATION

### 10.7.1 General

Materials and installation: Comply with AS 4254.2:2012 Section 2.7 and SMACNA Insulation Standards.

### 10.7.2 NCC Section J Compliance

All supply and return air ductwork and fittings for heating or cooling must be thermally insulated with insulation complying with AS/NZS 4859.1, to achieve Total R-Value complying with section J Specification for the climate zone of the installation.

The above Section J requirements do not apply to air registers, diffusers, outlets, grilles and flexible fan connections. These components should be lined with 25mm minimum thickness insulation for conditioned space and 50mm insulation for unconditioned spaces.

### 10.7.3 External insulation

Material: Non-hygroscopic resin bonded fibreglass of not less than 28kg/m3 density specifically designated by the manufacturer as duct insulation.

Form: Flexible type.

External Facing: Factory bonded reflective foil.

Thermal Conductivity: Not greater than 0.036W/mK at a mean temperature of 20°C.

Application: Wrap the insulation around the outside of the duct. Completely cover the portions of the duct designated to be insulated. Keep the number of joints to a minimum.

### 10.7.4 Internal Insulation

Material: Non-hygroscopic resin bonded fibreglass of not less than 32kg/m3 density specifically designated by the manufacturer as duct insulation.

Form: Semi-rigid batt or board.

Thermal Conductivity: Not greater than 0.036W/mK at a mean temperature of 20°C.

Facing: Factory faced on the side exposed to the air stream with perforated reflective foil.

Application: Place the insulation so that the surface designed to be exposed faces the air stream. Completely cover the portion of the duct designated to be lined, using an individual piece of insulation for each side of the duct. Support the insulation against the duct surface by means of fixing pins and sheet metal angles at the corners. Do not butt join insulation or laminate unless unavoidable due to the size of the duct. Allow insulation to extend proud of ductwork cross points to allow cushion points to fully seal during assembly.

Sheeting: Within 100 mm of where dampers operate and where elsewhere specified, sheet over the insulation with 0.5 mm perforated zinc-coated steel sheet.

Do not cross break internally insulated ducts. For ducts used for smoke spill, comply with AS 1668.

### 10.7.5 Electric Air Duct Heater Insulation

Comply with clause “Electric Air Duct Heaters” and AS 1668, Part 1.

### 10.7.6 Internal Acoustic Insulation to Plant Casings including Return air plenums

Material: Non-hygroscopic resin bonded fibreglass or mineral wool of not less than 28kg/m3 density specifically designated by the manufacturer as duct insulation.

Form: Semi-rigid batt or board.

Thermal Conductivity: Maximum thermal conductivity 0.048 W/mK at 20ºC.

Facing: Factory faced on the side exposed to the air stream with perforated reflective foil.

Application: Place the insulation on the inside of the plant casing and return air plenums.

Fixing: Use 50 x 50 x 50 mm Z sections manufactured from 0.6 mm galvanised steel fixed to walls or ceilings with expandable anchors or equal, at 600 mm centres. Leave the Z sections 150 mm clearance above all floors and be finished at this point with ‘U’ channels manufactured from 0.6 mm galvanised steel.

Sheathing: Apply 0.6 mm acoustic grade perforated zinc coated sheeting to the Z sections with a minimum overlap of 20 mm at all joints. At exposed edges of sheets and at all flashings around ducts, doors and openings the edge of the sheeting to have a 10 mm feather to give a neat finish. Fix the perforated metal with pop rivets at 150 mm centres.

### 10.7.7 Insulation Surface Facings

Aluminium Foil: Reflective foil laminate to AS/NZS 4200.1 with a heavy duty classification, bonded to the base insulation material as part of the manufacturing process.

Internal facing: Use perforated reflective foil and perforated metal sheet where specified.
External facing as vapour barrier: Use reflective aluminium foil laminate.

### 10.7.8 Vapour Barrier

Duct conveying cold air must be protected by vapour barrier on the outside of the insulation.

A Vapour barrier should be provided on the warm side of the insulation on ductwork, sheet metal and duct mounted equipment carrying refrigerated cooled air, to prevent condensation, sweating and water logging of the insulation. Provide a vapour barrier, which forms a complete seal, completely free of perforations or leaks and adequately isolated throughout from the cold side.

Fix the vapour barrier and insulation over all joints and standing seams, make it continuous around access panels and doors using gaskets. Where pipes and fittings pass through the vapour barrier make the seal continuous using gaskets or other approved methods.

Where cold bridges are unavoidable, provide a drained copper drip tray under the duct to collect condensate.
Use the following methods of providing a vapour barrier for ductwork and casings:

Internally insulated ductwork: Place the insulation inside the duct so that the duct or casing forms the vapour barrier.

Externally insulated ductwork: Place the insulation on the outside of the duct or casing with the vapour barrier on the outside of the insulation. Lap the vapour barrier at least 75 mm at the joints and bond with an approved adhesive. Seal with reinforced laminated aluminium foil pressure sensitive tape. Where the blanket is impaled over pins, apply a 100 mm square piece of pressure sensitive tape over the pins or cover the pins with a water-based mastic vapour barrier.

# 11. FILTERS

## 11.1 GENERAL

### 11.1.1 Section Introduction

Specified in this section are the minimum requirements for the construction, testing and installation of filters to be used in air handling units, fan coil units, packaged air conditioners, ventilation systems and the like.

### 11.1.2 Requirements

Filter Performance: Minimum performance to AS1668.2.

Component Size:

- To commercials availed standard sizing as far as practicable;
- Standardised throughout the installation as far as practicable.

Installation: Filters of the type specified are to be installed in accordance with the relevant sections of this specification and the manufacturer's recommendations and to prevent air bypassing the filter media.

Fire Resistance: Early fire hazard indices of clean filter media to AS 1530:

- Spread of flame 0 (zero);
- Smoke developed 3 (three) maximum.

Rigidity: Provide filter framework, including where applicable, media support frames, media frames and holding frames, which are true and square and sufficiently rigid to resist distortion during handling and operation.

Finish: Protect surfaces from atmospheric corrosion.

Air Sealing: Each filter cell is to be designed to positively prevent air bypassing the filter media. All joints in each filter frame and between filter frames and/or air handling plant casing is to be sealed to positively prevent air bypassing the filter bank. Use flexible gaskets to achieve the air seal.

Sealants must be resistant to air, entraining water and oil, and microbial growth.

Attachment: Rigidly attach the filter unit to the air handling plant casing (wall, ceiling, floor, plenum or the like) by a system of bolting and sealing which will allow individual filter maintenance to be readily carried out without disturbing the filter bank.

Blanking Plates: Fit blanking plates and seal if necessary to close gaps where dimensions of the filter do not match those of the air handling plant casing.

Adhesive Performance**:**

- Characteristics under environmental conditions: Odourless, non-toxic, non-migrating, non-evaporating and non-hardening, and resistant to microbial growth;
- Environmental conditions: Normal temperature, sustained temperatures up to 60°C, and operating air velocities.

### 11.1.3 Standards

Australian Standards:

| | |
|---|---|
| AS 1342.2 | Methods of test for air filters for use in air conditioning and general ventilation; |
| AS 1324.1 | Air filters for use in air conditioning and general ventilation - application, performance and construction; |
| AS 1530 | Methods for fire tests on building materials, components and structures; |
| AS 1668.2 | Mechanical ventilation for acceptable indoor-air quality; |
| AS 1807.1 | Determination of air velocity and uniformity of air velocity in clean workstations and laminar flow safety cabinets; |
| AS 4260.1 | (INTERIM) High efficiency particulate air (HEPA) filter. |

## 11.2 HEPA / ABSOLUTE FILTERS

Filters: Type 1, Class A.

Selection: Email Airpure or approved equal.

Efficiency: 99.99% to HOT DOP test, described in AS 4260.1 (INTERIM).

Leak Test: Free of pinhole leaks when tested by COLD DOP test.

Resistance: Maximum when clean 250 Pa.

Face Velocity: For applicable velocities refer to AS 1386.2 and AS 1386.3.

Mounting: Clamped into gasketted frames.

Size: As scheduled.

Testing/Marking: Every filter to be individually NATA Authority tested and certified for HOT DOP efficiency. Certificates to be supplied with the filter. Filters to carry the Australian Standards mark in a readily visible location.

Installation Test: Prior to Practical Completion, provide NATA approved Authority test certificate proving the installation has no less efficiency than individual filter cells. Penetration of cold DOP shall be less than 0.01%.

## 11.3 HIGH EFFICIENCY

Filters: Type 1, Class A.

Selection: Email Econocell or approved equal.

Efficiency:

| | Standard | Hospital |
|---|---|---|
| To HOT DOP test, described in AS 4260.1(INTERIM) | 60% | 95% |

Resistance

| | Standard | Hospital |
|---|---|---|
| Maximum when clean | 200Pa | 280Pa |

Face Velocity: For applicable velocities refer to AS 1386.2 and AS 1386.3.

Mounting: Clamped into gasketted frames.

Size: As scheduled.

Testing/Marking: Every filter to be individually NATA Authority tested and certified for HOT DOP efficiency. Certificates are to be supplied with the filters.

### 11.4 DEEP BED FILTERS

Filter: Type 1, Class B.

Selection: Email Multipeak or approved equal.

Size: Generally 610 x 610 x 570 or as otherwise required or scheduled.

Media Type: Throw away.

Efficiency/Arrestance: Guaranteed minimum No 1 test dust efficiency of 23% and average arrestance of 96%, 90%, 90% for Nos 2, 3 and 4 test dusts respectively to AS 1324.2.

Dust Holding: No 4 dust 1200g per filter cell at 125 Pa final resistance.

Resistance: Maximum 42 Pa when clean.

Face Velocity: 2.54 m/s maximum.

Mounting: Gasketted epoxy coated mild steel frames and wire baskets to be substantial enough to build up in banks to a height of 2000mm without additional support. Frames to incorporate basket retaining clips.

### 11.5 PANEL FILTERS (DISPOSABLE)

Filter: Type 1, Class A.

Selection: Email Envopleat or equal approved.

Size: Generally 600 x 600, or as otherwise required or scheduled.

Thickness: As scheduled 95mm.

Efficiency/Arrestance: No 1 test dust minimum efficiency to be 20% and No 2 and No 4 test dust average arrestance to be 89% and 90% respectively.

Initial Resistance: 35Pa

Dust Holding: No 4 dust 245g at 160 Pa.

Face Velocity: 1.75 m/s.

Enclosing Frame: Cardboard derivative.

Mounting: Gasketted galvanised steel frames substantial enough to build up into banks to a height of 2 metres without additional support. Frames to incorporate panel retaining clips.

### 11.6 FILTERS IN SERIES (MULTISTAGE)

Frame: Where filters are installed in series, it is preferred that they are installed together in a proprietary frame allowing access to each stage of filtration without disturbing other stages or the requirement to use tools.

## 11.7 INSTALLATION GENERALLY

### 11.7.1 Attachment

General: Rigidly attach filter frames to the air handling plant casing (such as duct, or return air plenum) with a system of bolting or blind pop riveting. Locate bolts or rivets clear of the filter element. Do not fix to the casing insulation. Make sure that the installation of the filter does not reduce its rated performance.

Access: Make sure that individual filter inspection and maintenance can be readily carried out without disturbing the filter bank.

Sealing: Make sure that there are no leaks between the filter holding frame and the casing. Seal individual filter units to each other. Seal filter connections to adjoining equipment, panelling or supporting framing. Do not use adhesive tapes for sealing.

Slide-in filter units: Do not use.

Plinth: Where possible, provide a 50 mm high plinth below the filter bank.

### 11.7.2 Cell frames

Access: Install filters so that they are accessible for maintenance and do not accumulate moisture.

Sealing: Seal filter frames to the plenum or duct in which they are installed.

### 11.7.3 Blanking plates

General: Close gaps where the dimensions of the filter plenum do not match those of the framing. Seal air tight to make sure no air bypasses the filters.

Material: ≥ 0.8 mm metallic-coated steel or grade 304 stainless steel sheet.

### 11.7.4 Additional bracing

General: Provide stiffeners between or behind the joint of every second column along the narrowest dimension of the plenum.

Stiffeners: Fabricate from ≥1.6 mm metallic-coated steel or grade 304 stainless steel.

Maximum deflection of filter bank under operating conditions (ratio of deflection: height or width): 1:500 under maximum system final resistance.

### 11.7.5 Manometers

General: Provide a manometer on each filter bank with more than one cell or handling more than 600 L/s.

Type: Minimum 75 mm diameter non-liquid, diaphragm type marked to show differential pressure across each filter bank.

Differential Pressure Gauge Unit: Include pipework, termination and fittings necessary for correct operation and maintenance.

Indicator Scale: Mark in 10 Pa divisions with full scale deflection no more than twice the maximum dirty filter condition.

Location: Outside unit casing in a readily readable location.

Marking: Mark clean and maximum dirty pressure drops on manometer scale.

### 11.7.6 Filter banks

General: Provide holding frames.

Filter Access Platforms: Make sure that platforms and ladders do not obstruct filter access.
Standard: To AS 1657.

## 11.8 CLEANING

General: Before start-up, make sure that the installation is free from debris and dirt, and check the integrity of the filter bank and plenum installation.

Temporary Pre-Filters: If provided, remove at completion of commissioning.

# 12. AIR GRILLES, DIFFUSERS AND LOUVRES

## 12.1 GENERAL

### 12.1.1 Section Introduction

This section of the speciation details the materials, components, methods of construction, installation, and performance requirements for air grilles, registers, diffusers, louvres, and their ancillary equipment, supplied and/or installed as part of the works.

### 12.1.2 Performance Data

Certified performance data and published selection tables, stating guaranteed air flows, throws, velocities, pressure drops and noise levels shall be available.

### 12.1.3 Sizes

Provide the sizes of equipment as shown on the drawings and as scheduled.

### 12.1.4 Support

Support grilles, registers, diffusers and louvres from ductwork, plenums or cushion head boxes. Support plenums and cushion head boxes from the structure or substantial ceiling system components. Supports must not unduly stress or distort adjacent surfaces.

### 12.1.5 Positions

Locate and position as shown on the drawings. Co-ordinate final positions with other services, or building elements, to the approval of the Architect.

### 12.1.6 Installation

Grilles, registers, diffusers and louvres must be close fitting to walls and ceilings. Securely fix all items by means of concealed fastenings.

### 12.1.7 Gaskets

Use gaskets between flanges and walls or ceiling faces to prevent leakage and marking of adjacent surfaces.

### 12.1.8 Volume Control

Provide air volume control, and for supply air diffusers, air pattern adjustment devices for all individual items except where otherwise specified.

Adjustment: Such devices are to be in an accessible position for adjustment, and must not require tools not commonly used or readily available.

Visible items: Volume control or pattern adjustment devices which are visible through an air diffuser, register, grille or louvre are to be painted black.

### 12.1.9 Finish

The finish of air grilles, registers, diffusers, louvres, and their ancillary equipment will be standard commercial or special surface treatments as specified for individual items. The finish of all items will be of a high standard free of imperfections and blemishes. Mitred joints must be neat and even, without gaps, and with matching surfaces correctly aligned. Internal surfaces to be matt black if visible from outside.

### 12.1.10 Samples

Submit for approval representative samples of all air grilles, registers, diffusers, louvres, and their ancillary equipment to be supplied as part of the works. Any sample which fails to comply with specified requirements will be rejected, and a new sample must be submitted for approval. Manufacture of any item must not commence until the representative sample has been approved. Samples will be retained for comparison with items subsequently supplied for incorporation in the works. The colour is to be selected by the Superintendent.

### 12.1.11 Air Balancing and Commissioning

Balance air flows at all air grilles, registers, diffusers and louvres to the quantities indicated on the drawings. Adjust all directional or pattern control elements, to achieve correct, even and draught-free air distribution, or to satisfy particular specified requirements. Fine tuning where agreed or shown on the drawings may occur at the outlets, however major system balancing must occur at the ductwork dampers and flexible duct spigot dampers.

## 12.2 RADIAL OUTLET

### 12.2.1 Description

Each radial outlet face is to have twenty four radial blades that provide a highly inductive radial discharge pattern that spreads horizontally above the occupancy zone. Outlet frames are to facilitate installation in the ceiling or to the ducts, as applicable. Submit a sample of the outlet for approval.

### 12.2.2 Construction

Ceiling swirl diffusers shall be made entirely of powder coated zinc plated steel.

Pattern: For uniformity of appearance, the blow pattern is to be achieved by specialised ½ and ¼ collars disks (blanking plates) shall alter the discharge pattern to two or three-way blow, if required.

### 12.2.3 Operation

The diffuser shall be suitable for a maximum temperature difference between supply air and room air of -15K when cooling and +10K when heating (for ceiling heights up to 3m).

A selection of interchangeable collars (neck reducers) shall provide a variety of operational airflow rate ranges. For each operational airflow rate range the diffuser shall be suitable for a turndown ratio to approximately 30% (eg. for VAV applications) in maximum cooling mode whilst maintaining an air diffusion performance index (ADPI) in excess of 90%, and shall not exceed a sound power level of 40 dB(A) at 100% airflow.

### 12.2.4 Volume Control

Volume control must not be provided at the diffuser, but at the branch take-off supplying the diffuser.

### 12.2.5 Connection

Provide cushion head boxes fitted to the necks of the diffusers, for connection of flexible ducts.

### 12.2.6 Finish

The finish of each diffuser is to be powder-coat in colour to be advised. Submit a sample of the diffuser for approval.

## 12.3 CEILING DIFFUSERS, LOUVRE FACE

### 12.3.1 Description

Each diffuser face is to be the multi-louvred type of 1, 2, 3 or 4 way blow pattern as shown on the drawings and appropriate for proper distribution of the air. Diffuser frames are to facilitate installation in the ceiling or to the ducts, as applicable. Submit a sample of the diffuser for approval.

### 12.3.2 Construction

The ceiling diffusers are to be fabricated from extruded or die-cast aluminium.

Pattern: For uniformity of appearance, the blow pattern is to be achieved by blanking behind redundant faces of 4 way diffusers.

Core: The louvred core is to be easily removable, but the fixing arrangement is to be concealed.

Safety chain: On any diffuser mounted more than 3m above floor level. A safety chain is to connect the core to the outer frame, with the chain sheathed in soft PVC tubing.

### 12.3.3 Volume Control

Volume control must not be provided at the diffuser, but at the branch take-off supplying the diffuser.

### 12.3.4 Connection

Provide cushion head boxes fitted to the necks of the diffusers, for connection of flexible ducts.

### 12.3.5 Finish

The finish of each diffuser is to be powder-coat in colour to be advised. Submit a sample of the diffuser for approval.

## 12.4 CEILING DIFFUSERS, VARIABLE AIR VOLUME

The thermally powered VAV diffusers shall be a proprietary manufactured item comprising of an appearance panel mounted within a diffuser frame with an inbuilt hinged damper assembly to adjust the supply air volume from the outlet, under the control of two inbuilt room temperature sensing thermal elements. An additional thermal element shall be installed within the outlet to change over from cooling to heating control.

The cooling and heating temperature sensing thermal elements shall be separately adjustable on site for differing room heating/cooling settings. The changeover thermal elements shall be factory preset to engage the heating mode at 27°C and the cooling mode at 21°C. Use fully concealed fixings.

## 12.5 LINEAR DIFFUSERS, SLOT TYPE

### 12.5.1 Description

Each diffuser face is to incorporate single or multiple slots providing 1 or 2 way blow pattern as shown on the drawings and appropriate for proper distribution of the air. Diffuser frames are to facilitate installation in the ceiling or to the ducts, as applicable.

### 12.5.2 Construction

The linear diffusers are to be fabricated from extruded aluminium.

Core: Each slot is to incorporate pairs of adjustable blades for pattern and volume adjustment.
Blades are to be modular, maximum length 500 mm, to facilitate pattern variation.

Frame: The frame is to be of the 'multiple tee' type, with concealed internal spacing frames and alignment keyways for true and accurate alignment in continuous applications. Provide neatly mitred corner fittings for changes in direction, and framed end fittings to terminate non-continuous diffusers.

### 12.5.3 Variable Pattern

The core blades are to be capable of adjustment to enable controlled variation of air discharge pattern from individual slots, between vertical and horizontal in either direction (180° adjustment).

### 12.5.4 Volume Control

Opposed blade dampers are to be incorporated at the inlet to the diffuser plenum.

### 12.5.5 Connection

Provide internally insulated plenum boxes fitted to the necks of the diffusers, with centre or end inlets, sized and arranged as shown on the drawings. Insulation is to be as specified for ductwork connecting the plenums, unless otherwise indicated.

## 12.6 EXHAUST/RETURN AIR GRILLES AND REGISTERS CEILING

### 12.6.1 Description

The grilles or registers are to incorporate fixed lattice "egg-crate" cores with 35° sloping cores. Frames are to facilitate installation in the ceiling or to the duct, as applicable. Submit a sample of the diffuser for approval.

### 12.6.2 Construction

The grilles and registers are to be fabricated from extruded aluminium.

Core: The core is to comprise a lattice formed from 13 mm deep aluminium sections inter-connected on a nominal 13 mm x 13 mm grid, but with one grid sloping at 35° to the vertical.

### 12.6.3 Volume Control

Opposed blade dampers are to be incorporated in the neck of the register.

Volume control must not be provided at the register, but at the branch take-off connecting the register to the duct.

### 12.6.4 Connection

Connect the grilles or registers directly into the ductwork as shown on the drawings.

Provide plenum boxes fitted to the necks of the grilles or registers, for connection of flexible ducts.

### 12.6.5 Finish

The finish of each grille or register is to be powder-coat in colour to be advised.

## 12.7 RELIEF GRILLES, CEILING

### 12.7.1 Description

The grilles shall incorporate fixed lattice "egg-crate" cores with 35° sloping cores. Frames are to facilitate installation in the ceiling or to the duct, as applicable. Submit a sample of the diffuser for approval.

Construction: The grilles and registers are to be fabricated from extruded aluminium.

Core: The core is to comprise a lattice formed from 13 mm deep aluminium sections inter-connected on a nominal 13 mm x 13 mm grid but with one grid sloping @ 35° to the vertical.

### 12.7.2 Connection

Provide plenum boxes fitted to the necks of the grilles or registers, for connection of flexible ducts.

### 12.7.3 Finish

The finish of each grille or register is to be powder-coat in colour to be advised.

## 12.8 RELIEF GRILLES, DOORS AND WALLS

### 12.8.1 Description

The grilles are to incorporate fixed horizontal full-chevron blades forming a sight-proof barrier. Frames are to facilitate installation in the door, partition or wall, as applicable. Submit a sample of the diffuser for approval.

### 12.8.2 Construction

The grilles and registers are to be fabricated from extruded aluminium.

Core: The core is to incorporate a bank of multiple full-chevron blades mounted in parallel, firmly and durably retained in the frame. Blades are to be nominally of 20 mm depth at 20 mm centres.

Frame: The frame is to be in 2 pieces, the main frame housing the core, and the back-frame serving to firmly and positively interlock with the main frame to sandwich the door, partition or wall, providing concealed fixing.

### 12.8.3 Connection

Connect the grilles directly into the doors, partitions or walls as shown on the drawings.

### 12.8.4 Finish

The finish of each grille is to be powder-coat in colour to be advised.

## 12.9 EXTERNAL LOUVRES, WEATHERPROOF

### 12.9.1 Description

The louvres are to incorporate fixed horizontal or vertical blades designed to prevent the ingress of rain under varying wind conditions. Frames are to facilitate installation in the wall, structure, duct or plenum as shown on the drawings.

### 12.9.2 Construction

The louvres are to be fabricated from extruded aluminium. Unsupported blade lengths must not exceed 1200 mm. Provide concealed reinforcing mullions on louvres where blade length exceeds 1200 mm.

Louvres must incorporate internal vermin-proof galvanised wire mesh screens, minimum 1.6 mm thickness and nominal 13 mm x 13 mm mesh. Rainwater collected by the louvres is to be completely discharged to the weather side.

Core: The core is to be of single stage construction and consist of a series of horizontal blades mounted in parallel, firmly and durably retained in the frame. Each set of blades is to be nominally of 100 mm depth and must incorporate a minimum of 2 rain traps in the blade extrusion. Minimum free area must be 55%.

### 12.9.3 Connection

Connect the louvres directly into the walls or structure as shown on the drawings.

### 12.9.4 Finish

The finish of each louvre is to be powder-coat in colour to be advised.

## 12.10 VOLUME CONTROL DEVICES

### 12.10.1 General

Volume control devices are to be provided for diffusers and registers where shown on the drawings or specified elsewhere in this sub-section.

### 12.10.2 Opposed Blade Dampers

Description: Adjustable counter-rotating multiple blades mounted in a rectangular frame for attachment to the neck of a register or diffuser. Blades fully closed at 45o angle to air flow direction, adjustment screw accessible through face of register or diffuser.

Construction: Fabricated from aluminium extrusions, with blades firmly and durably supported in the frame.

Finish: Matt or low gloss black powder-coat or paint finish.

### 12.10.3 Stream Splitter Dampers

Description: Adjustable curved multiple blades pivoted on their trailing edges and securely linked on their leading edges, mounted in an angled rectangular frame for attachment to the neck of a register or diffuser. Adjustment screw accessible through face of register or diffuser.

Construction: Fabricated from zinc coated steel, with blades firmly and durably supported in the frame.

Finish: Matt or low gloss black powder-coat or paint finish.

### 12.10.4 Blade (Butterfly) Dampers

Description: Adjustable circular blades pivoted, mounted in a cylindrical frame for attachment to main branch ductwork.

Construction: Fabricated from zinc coated steel, with blades firmly and durably supported in the frame, adjustable manually.

## 12.11 CUSHION HEAD/PLENUM BOXES

### 12.11.1 General

Cushion head and/or plenum boxes are to be provided for air grilles, registers and diffusers where shown on the drawings or specified elsewhere in this sub-section.

### 12.11.2 Cushion Head Boxes

Description: Internally insulated plenum fitted to the neck of a supply air diffuser, sized to suit the neck of the diffuser, and incorporating a circular or (where space is limited) oval spigot for connection of a flexible supply duct.

Construction: Galvanised steel plenum constructed as for low pressure steel ductwork, insulated internally with minimum 25 mm thick (50mm under roofs) internal duct insulation faced with matt-black perforated foil laminate. All joints must be sealed air tight.

As an alternative to galvanised steel construction, plus insulation, cushion head boxes may be fabricated from 20 mm thick rigid urethane sandwich panel bonded on both surfaces to 80 micron thick aluminium laminate as per P3 ductal panel distributed by Innovative Air Systems (Telephone: 07 3277 9165).

# 13. ELECTRICAL

## 13.1 SCOPE

### 13.1.1.1 Outline Description

The work includes but is not restricted to the detailed design, manufacture, supply, installation, testing and maintenance of electrical works associated with the mechanical services installation.

## 13.2 SUPPLY MAINS POWER

415/240 Volts, 3 phase, 4 wire, MEN system.

### 13.2.1.1 Source of Power

Main Building Switchboard and individual distribution boards.

## 13.3 TESTING AND ACCEPTANCE

### 13.3.1.1 Site Tests

Tests must include but not be limited to the following:

(a) insulation resistance using 1,000 volt Megger between each conductor and all others in cable, conduit or switchgear and between conductors and earth;

(b) earth resistance tests in accordance with AS 3000;

(c) verification of polarity and phase rotation;

(d) functional tests of all switchgear, controls and systems including safety devices;

(e) harmonic tests for variable speed drives.

## 13.4 CABLES GENERALLY

### 13.4.1.1 Cable Manufacture

To applicable Australian Standards.

### 13.4.1.2 Cable Selection

Cable Design and selection shall be in accordance with the following standards:

- AS 3008.1: Electrical installations—Selection of cables
- AS 3013: Electrical installations - Classification of the fire and mechanical performance of wiring system elements

### 13.4.1.3 Minimum Size

2.5 mm² for circuits rated at 20 amps.
1.5 mm² for control circuits.

#### 13.4.1.4 Colour Code

To AS 3000.

#### 13.4.1.5 Motor Sub-Circuits

Minimum cable sizes will be determined in accordance with the following principles:

(a) PVC and XLPE insulated cables shall carry no more than 70% of current rating determined in accordance with AS 3008.1 when motor is fully loaded.

## 13.5 CABLE INSTALLATION

#### 13.5.1.1 Handling Cables

Handle cables so as to avoid damage to insulation and serving or sheathing. Report all damage and replace or repair damaged cable as directed.

#### 13.5.1.2 Straight-through Joints

Unless unavoidable due to length or difficult installation conditions, run cables for their entire route length without intermediate straight-through joints. Locate approved joints as directed.

#### 13.5.1.3 Installation

Cables including enclosures and supports are to be concealed wherever possible, in normally occupied and public areas unless specified otherwise. Install and adequately support fixed wiring throughout the installation and generally run parallel with building lines.

Support all power and control cables to equipment such as chillers, pumps, fans, hot water generators, air handling units, cooling towers and the like on cable tray or cable ladder or in conduit. All minor control and power cabling within ceiling void space shall be supported clear of the ceiling by either using cable tray or conduit or catenary wire or secured directly to the structure using appropriate fixings.

#### 13.5.1.4 Tagging

Identify multi-core cables and trefoil groups at each end and at crowded intermediate points by means of stamped, non-ferrous tags, clipped around each cable, or trefoil group.

#### 13.5.1.5 Multiphase Circuits

Single core cables of 3 phase circuits must be installed in trefoil (RWB) or quadrefoil (RWBN) groups.

#### 13.5.1.6 Terminations

Unless otherwise approved, terminate copper conductors to equipment, other than small accessory and control equipment terminals, by means of compression-type lugs of the correct size for the conductor, compressed only by the correct tool. Terminals shall incorporate locknuts, spring washers, etc., to prevent loosening in service.

## 13.6 CABLE LADDERS AND TRAYS

#### 13.6.1.1 Requirement

Provide cable ladders and trays generally to support multiple cable runs. Ladders and trays are to be sized with at least 30% spare capacity for future additions.

#### 13.6.1.2 Type

Ladders and trays are to be corrosion resistant, pressed and folded zincalume finish or galvanised steel. The design is to comprise a ventilated rib with side rail and folded edges.

#### 13.6.1.3 Installation

Install in accordance with manufacturer's instructions with a maximum deflection/span ratio of 1:200. Install complete with all necessary splice plates, bends, etc.

#### 13.6.1.4 Support

Provide substantial supports comprising plain or angle brackets of galvanised steel angle, Unistrut or similar, fixed to walls or floors or suspended from structure where applicable.

#### 13.6.1.5 Access

Position the support system to give adequate access for inspecting, replacing, or adding cable.

#### 13.6.1.6 Cable Installation

Install cables neatly, generally to one side leaving as much free space on other side as possible for future additions.

#### 13.6.1.7 Cable Fixing

Fix cable generally to the support system by proprietary nylon ties or stainless steel straps or saddles, at maximum 1000 mm centres for vertical runs and 2000 mm centres for horizontal runs. Single conductors of multi-phase circuits shall be adequately secured to prevent separation under short circuit conditions.

Large Conductors: Large conductors shall be fixed by Proprietary cable cleats of appropriate size. For long straight runs the cleats shall be arranged to fasten cables firmly at 5000 mm to 7000 mm intervals. Intermediate fixings shall provide clearance to allow cable movement for thermal expansion and contraction.

### 13.7 CONDUITS

#### 13.7.1.1 Minimum Sizes

20mm, with minimum size of 25mm when embedded in concrete slabs and columns.

#### 13.7.1.2 Standards

Metallic conduit and fittings: To AS 2052
Non-metallic conduit and fittings: To AS 2053

#### 13.7.1.3 Type

(a) Galvanised steel where required to meet AS 3013 classification, where subject to high temperatures and where exposed to sunlight. Paint to approval;

(b) Rigid PVC generally otherwise;

(c) Rigid HD, PVC orange where installed underground.

#### 13.7.1.4 Corrugated Plastic Conduit

May be used where embedded in concrete and to effect changes in direction of surface runs of rigid PVC conduit and for final connections to equipment. Use with manufacturer's approved accessories.

#### 13.7.1.5 Draw Cords

Polypropylene draw cords are to be installed in all spare conduits and in all conduits including submains conduits which have spare capacity which may be used in future.

#### 13.7.1.6 Conduits Embedded in Concrete

Location: Locate conduit run in concrete slabs entirely within the structural slab. Do not run conduits in concrete topping unless approved.

Steel Conduit: Steel conduit are to be galvanised if run in concrete slabs.

Corrugated Conduit: Where embedded in concrete, corrugated conduit is to be high crush resistant type Aussieduct Koncrete Konduit.

## 13.8 CABLE DUCTS

#### 13.8.1.1 General

Fabrication: Cable ducts must be fabricated of sheet steel except where rigid PVC ducts are specified.

Size: Care is to be taken to ensure that the size of the ducts complies with S.A.A. Wiring Rules requirements, and ducts shall be adequately sized for the installation of 30% additional cables. Installation: Ducts are to be installed neat and square with building lines.

#### 13.8.1.2 Support

Provide substantial supports comprising plain or angle brackets of galvanised steel angle, Unistrut or similar, fixed to walls or floors or suspended from structure where applicable. Provide corrosion resistant spacers between duct and surface where fixed direct to a wall.

#### 13.8.1.3 Steel Ducts

Construction: Ducts and lids are to hall be galvabond or zincanneal (where painted) sheet steel of thickness to prevent deformation.

Lids: Lids are to be provided unless specified otherwise and all ducts with lids must be electrically continuous and lids and top edges of ducts are to have a 10 mm to 15 mm return edge for fastening and stiffening purposes.

Fixings: Lids are to be fastened at ends and at maximum 1500 mm intervals between with galvanised steel gutter bolts and captive nuts.

Retaining: Lids are to be held by retaining chains or nylon cords properly anchored and approx.
300 long.

Cable Installation: Vertical runs of duct are to be provided with an approved means of supporting the vertical runs of cable at intervals of 5000 mm maximum. This may be accomplished by provision of support bars with cleats or saddles within the duct or for smaller cables by an arrangement of steel pegs sleeved with PVC which form a matrix through which the cables weave and are supported by friction.

Painting: Where exposed to view in public areas and where shown or specified, paint with undercoats and finish coat of durable semi-gloss enamel, colour to approval.

## 13.9 SWITCHGEAR ASSEMBLIES GENERALLY

#### 13.9.1.1 Requirements

Equipment must provide protection and control of all apparatus, motors, etc., to satisfy the operational requirements of the system and in accordance with the relevant standards and requirements of the Authorities.

#### 13.9.1.2 Control Wiring Diagrams

The control wiring diagrams shown on the drawings are indicative only and are intended to show the required control system features and logic. They are not intended to be detailed wiring diagrams.

#### 13.9.1.3 Drawings

Submit copies of shop drawings and wiring diagrams for inspection prior to manufacture.

#### 13.9.1.4 Standards

To AS/NZS 61439.1 Low Voltage Switchgear and Control-gear Assemblies.

#### 13.9.1.5 Design and Manufacture

Equipment must be designed and manufactured by a manufacturer experienced in mechanical services switchgear and control-gear.

#### 13.9.1.6 Standard Equipment

Assemblies must be of an established and proven design where possible.

#### 13.9.1.7 Fault Withstand Capacity

The entire assembly and switchgear must be capable of withstanding the potential short circuit fault level at the incoming terminals.

Fault Level: Refer to electrical services documentation for fault level rating.

## 13.10 LABELLING

#### 13.10.1.1 Requirement

Label and identify cubicles and equipment to approval with appropriate engraved labels to indicate function and/or designation.

#### 13.10.1.2 Label

Label separately each:

- Cabinet;
- Isolator or main switch;
- Compartment or zone;
- Switch-fuse unit with rating of fuse cartridges;
- Circuit breaker and set of fuses except where typed schedules are provided;
- Relay, motor starter or other control device;

- Meter, switch and pilot lights;
- Outgoing circuit load stalks in cable compartment;
- Set of fault current limiting fuses;
- Terminal strip to indicate function.

#### 13.10.1.3 Supply

Under assembly name label, or adjacent to main isolator, provide a label stating origin of circuit supplying switchboard including location and name of board of origin and size and type of cables.

#### 13.10.1.4 Controls

Label function of device and control positions.

#### 13.10.1.5 Size

Letter size is to vary from 3 mm to 10 mm depending on importance.

#### 13.10.1.6 Colour

Labels are to generally be white with black letters and red with white letters for essential equipment or warning notices or otherwise as required by Supply Authority.

# 14. TESTING AND COMMISSIONING

## 14.1 GENERAL

### 14.1.1 Scope

This section sets out the requirements for testing and evaluation and commissioning of all systems.

### 14.1.2 Inspections

Notice: Give reasonable written notice so that the Superintendent and, where applicable, the authorised representative of the relevant regulatory authority, may attend and inspect testing required by the Contract. State the date, time and place of the test.

Insufficient notice: If the Superintendent is unable to attend a test because of insufficient notice, he may order the test to be repeated at the Subcontractor's cost.

Requirement: Commission and test the entire mechanical services systems to prove the systems comply with every requirement of this specification and the design intent of the system.

Equipment: Provide everything necessary for the carrying out of the required tests, including labour, materials, instruments and apparatus.

Program: Submit a proposed testing and commissioning program consistent with and part of the construction program. Include particulars of test stages and procedures.

Certification: All testing must be provided by NEBB registered Subcontractors.

Seasonal Tests: On air conditioning systems, during the maintenance period carry out two performance tests (summer and winter) generally as specified for acceptance testing.

Testing Conditions: If the ambient and other conditions specified for a test are not obtainable at the programmed test time, the test may, if so approved, be either:

(a) Deferred until suitable conditions occur, or
(b) Modified to suit the actual conditions.

### 14.1.3 Testing Stages

Definitions: The following definitions will apply:

Site Tests: Tests carried out on the site installation to demonstrate the satisfactory operation and performance of the system and its components. Includes acceptance tests and may include preliminary tests.

Preliminary Tests: Tests (usually site tests) required to be carried out by the Subcontractor to demonstrate that the system appears to meet the performance and operating requirements prior to acceptance testing. (Also called performance tests, operating tests, preliminary acceptance tests).

Acceptance Tests: Tests carried out on the completed installation to demonstrate that the system, including all components and equipment, operates correctly, safety and efficiently, meets the performance requirements, and is acceptable for handover. Hold points are noted through the specification against acceptance tests.

Final Tests: Acceptance tests carried out before expiry of the Defects Liability Period to demonstrate that the system has been properly maintained during the Defects Liability Period and complies with the Specification.

### 14.1.4 Test Records

For each required test, provide a report or certificate in a form suitable for inclusion in an operation and maintenance manual, signed and dated, legibly typed recording:

(a) The type of test;
(b) The test procedures;
(c) The apparatus and instruments used;
(d) The date, time and place of the test;
(e) The ambient and other relevant conditions;
(f) The name, status, function and signature of each person present;
(g) The test results;
(h) Where applicable, calculations, instrument readings, control settings, name plate ratings, and the like;
(i) Variations to the specification, if any.

Samples: Before starting to test, submit samples of the form of report or certificate for approval.

### 14.1.5 Manufacturers' Certificates

For each factory or type test provide a certificate from the manufacturer stating that the relevant item has been tested and meets the specified requirements. Certify that each type tested item is identical with the specified production item.

Imported Items: Manufacturers' certificates of tests performed in the country of origin may be accepted for imported items at the Superintendent's discretion.

Pressure Vessels: Provide the manufacturer's certificate required by AS 1210 clause 7.7 and statutory requirements. Mount the certificate in a glazed frame on a wall adjacent to the vessel.

### 14.1.6 Instrument Calibration

Certification: For each measuring instrument included in the site test apparatus, provide a current calibration certificate from an approved authority, showing the information listed in AS 2415 Clause 4.9.

Recalibration: Recalibrate each instrument on or before the certified date for recalibration. Recalibrate or replace faulty instruments or instruments rejected by the Superintendent.

Scales: Electrical instrument scales will be such that readings will be at least one half of the full scale deflection. Scales for other instruments such as gauges, thermometers and the like are to be calibrated over the range of test readings.

Order of Accuracy: +/- 1% of full scale deflection.

### 14.1.7 Remedial Work

If a tested item fails to meet the performance requirements, then the item must be rectified before Practical Completion and retested.

### 14.1.8 Testing Controls

During the testing of a service system, test the associated control system. Record control settings and tolerances on work-as-executed drawings. Prove by test that the requirements of section "Automatic Controls" is achieved in all aspects.

### 14.1.9 System Acceptance Tests

Preliminary Test: When the installation is complete, commission the plant by putting it into working order and operating it for not less than the specified minimum running period. Make the adjustments necessary to achieve the required performance under continuous operating service conditions, including balancing, setting the controls, checking the operation of overload and safety devices, and correcting malfunctions. Then carry out preliminary tests of the acceptance test requirements. Record and submit the results.

Acceptance Tests: Acceptance tests will commence only when the Subcontractor's preliminary test results demonstrate to the Superintendent's satisfaction that the plant is ready for acceptance test.

Test Loads: Where necessary to test the performance of equipment such as chiller sets, provide artificial loads by approved means.

Adjustments: Carry out necessary adjustments by methods designed to promote optimum equipment life and operating economy consistent with the required performance.

Final Tests: Carry out final acceptance tests immediately prior to the expiry of the Defects Liability Period.

### 14.1.10 Handover

The Principal is to accept handover of the plant when the system acceptance tests demonstrate that the required performance has been achieved.

Progressive Handover: If so required and approved, bring designated sections of the plant progressively up to the handover stage.

Handover Period: A handover period of 2 days may run from the acceptance of handover by the Principal.

Plant Operation: During the handover period arrange for one experienced operators to be in constant attendance during working hours, and on call at other times, to monitor the plant operation, and make adjustments as necessary to keep it operating properly.

Operational Instruction: The maintenance operators must be available during working hours in the handover period, and thereafter at times, to be agreed with the Superintendent, coinciding with the maintenance service visits, to instruct the Principal's operational and maintenance staff in the recommended methods of maintenance and control of the systems.

## 14.2 NOISE AND VIBRATION TESTING

### 14.2.1 Type Tests

Where noise levels are specified for individual items of equipment, submit type test data stating the sound level of the equipment offered, and the method of determination used to prove that the plant complies with the specified performance.

### 14.2.2 Acceptance Tests

Carry out noise level acceptance tests in conjunction with the acceptance tests of the completed installation. Demonstrate that individual items of equipment and the complete service system do not exceed the required noise level limits under operating conditions. Refer to NOISE AND VIBRATION CONTROL for maximum noise levels.

### 14.2.3 Measuring Instruments

Sound level: Sound level meters to AS 1259 Types 1 and 2, as appropriate, calibrated to the dB(A) scale.

Frequency: An approved bandpass filter.

### 14.2.4 Measurements

Take readings (with the plant operating normally) over the full spectrum of octave band centre frequencies from 31.5Hz to 8kHz and associated dB(A) readings.

Measurement position: Not less than 1m above the floor, not closer than 1 m from walls or equipment. Take readings at points 2m and 16m distant from large items of equipment such as the plant area.

### 14.2.5 Background Noise

During testing, background noise is to be relatively steady and continuous at the usual level. Measure background sound spectrum and dB(A) levels with the plant stopped.

### 14.2.6 Test Report

The test report is to schedule the noise spectra and dB(A) readings with the plant on and off. The schedule will also note the specified required noise level in dB(A). Preliminary test reports are to detail the reasons for any non-conformance with the specified required noise levels, and the proposed method of resolution.

## 14.3 AIR CONDITIONING PERFORMANCE TESTS

### 14.3.1 Requirement

Test the capacities and performance of air conditioning systems under both summer and winter conditions where the system includes both heating and cooling. Test the performance of economy cycle, morning warm-up operation and night purge operation.

### 14.3.2 Temperature and Humidity Measurement

Record humidity and temperatures as follows:

(a) In all conditioned rooms and areas: at 9 am and 3 pm on two consecutive half-hour intervals, measure dry-bulb and wet-bulb temperatures. Separate measurements are to be taken for each 100m²;

(b) Adjust and refine air volumes and controls as necessary to rectify the areas which fall outside of the specified temperature and humidity control tolerance ranges. Retest until all areas fall into the specified control tolerance ranges;

(c) During the Defects Liability Period, the air quantities and controls shall be adjusted as necessary to achieve an even temperature balance and stable control;

(d) Where a humidity or temperature gradient or differential is specified in DESIGN CONDITIONS, then these are to be tested and adjustment made to the controls to achieve the specified requirements.

### 14.3.3 Coils

Test the capacity performance of cooling coils under summer conditions.

General:

(a) Ambient temperatures: Dry-bulb and wet-bulb;
(b) Air temperatures: Air dry-bulb and wet-bulb temperatures on and off the coil (wet-bulb for cooling coils only);
(c) Air flow: Across the coil;
(d) Calculate capacity using the above data.

### 14.3.4 Volume Control

Test the response of the air conditioning system to changes in the required total supply air at the VAV terminals. Prove the variable speed control. The test is to be carried out at 5 points between minimum and maximum fan volume to prove that the system is properly responding to changes in air supply. Prove stable control.

### 14.3.5 Temperature Control

The VAV controls and temperature control is to be tested to prove compliance. Schedule the calibration tests. The tests are to include minimum and maximum VAV terminal volumes, temperature sensor calibration, and response of the air conditioning units to VAV terminal cooling and heating demand and the like.

### 14.3.6 Motor-Driven Appliances

Test each appliance for operation to name-plate rating. Adjust thermal overloads for actual starting and running load during maximum ambient conditions.

## 14.4 AIR BALANCING

### 14.4.1 Requirement

Balance the air distribution system to give flow rates within + 10% /- 0% of the specified air quantities, subject to the following conditions:

Distribution: The air is evenly distributed over the face of the outlets.

Fan: There is the minimum practicable air resistance at the fan, and the fan is set to run at the lowest practicable fan speed and power consumption.

### 14.4.2 Method

Balancing is to be carried out by use of duct dampers mounted in the main and branch duct runs. Register dampers are only to be used for minor throttling and only where agreed prior to construction or shown on the drawings. Balancing devices are to be locked after balancing. Submit the proposed balancing method for acceptance before commencing to balance.

### 14.4.3 Procedure

Commence balancing only when the air handling installation is complete and the building is clean and sealed. Before energising the fans for balancing, clean the air handling system and remove dust, foreign matter, and the like.

Multiple systems: If there is more than one air handling system, operate all the systems concurrently, but without simultaneous starting.

Filter resistance: Air quantities are to be measured under `simulated dirty filters' condition, simulate a resistance across filter banks equal to the mean of the initial and final resistance of the filter bank.

Where the total air quantity of a system is more than 10% above or more than 0% below the specified quantity, adjust the fan speed, blade pitch, pulley size and motor, as appropriate.

### 14.4.4 Records

Include the following:

(a) Static pressure differentials across systems;
(b) Air quantities at air outlets after balancing;

(c) Fan capacity, blade pitch, and fan speed. Show the final operating point on the fan characteristic curve;
(d) VAV terminal maximum and minimum air volumes.

### 14.4.5 Outlets

Air flow patterns are to be adjusted for air distribution that eliminates down draft. Adjustments to air quantities causing noise levels in excess of those specified will be carried out.

### 14.4.6 Final Air Quantities

Some trimming may be required to achieve the specified temperature balance.

## 14.5 TESTING AND EVACUATION OF REFRIGERANT SYSTEMS

### 14.5.1 Definition

Refrigerant systems comprise the refrigerant pipework, pressure vessels, compressors, and accessories including valves, gauges, instruments and the like.

### 14.5.2 Pressure Tests

To AS/NZS 5149.4:2016.

### 14.5.3 Requirement

Dehydrate the refrigerant gas system by an approved evacuation process not inferior to the triple evacuation method before charging with the refrigerant gas.

Triple Evacuation: Carry out the process only when room ambient temperature is above 16°C (to prevent ice forming in the system). Use a high-vacuum pump, capable of reducing the pressure in the system to less than 25Pa (188 micrometres Hg) absolute, connected to both high and low pressure sides of the system with valves open and controls connected. Measure the pressure with approved calibrated electronic vacuum gauges, not by wet-bulb determination.

(a) First evacuation: Establish stable vacuum conditions in the system by running the pump at capacity until the pressure is less than 25Pa absolute, then closing off the system and letting it stand for as long as is necessary to verify that the pressure is stable, taking into account ambient temperature conditions. If stability is not achieved, repeat the evacuation. When stability is achieved, break the vacuum with clean dry nitrogen;

(b) Second evacuation: Establish stable vacuum conditions as specified for the first evacuation. When stability is achieved, break the vacuum with clean dry refrigerant, and raise the pressure to above zero. Install drier cartridges and moisture indicators in the system;

(c) Third evacuation: Run the pump at capacity, then charge the system with the correct quantity of refrigerant and oil.

### 14.5.4 Testing

Test for leaks with a halide torch or an electronic detector.

### 14.5.5 Retesting

If at any time within the Defects Liability Period, after the system has been charged, any joints have to be broken or remade, the whole system must be pumped down, pressure tested and evacuated again as detailed above.

## 14.6 ELECTRICAL WORKS TESTING

### 14.6.1 Tests

Wiring and Switchboards must be tested in accordance with Section Electrical.

# 15. OPERATION AND MAINTENANCE

## 15.1 GENERAL

### 15.1.1 Scope

This section of the specification sets out the maintenance requirements for all systems and details the Operating and Maintenance Manuals.

### 15.1.2 Operational Maintenance

During the maintenance period provide experienced operators to perform the comprehensive maintenance required for safe, efficient and reliable operation, including the following:

(a) Regular maintenance: Make service visits at least monthly in order to carry out the regular maintenance procedures;

(b) Defects: Make good faults or damage caused by defects in the installation, and replace defective parts;

(c) Materials: Supply the necessary maintenance materials including lubricants, cleaning materials, refrigerant, replacement parts, filters and the like.

### 15.1.3 Service Callout

The Subcontractor is to provide to the Principal telephone numbers at which his maintenance staff can be contacted in the event of a breakdown. These numbers will enable the Proprietor to obtain the services of maintenance staff on site within 24 hours for a service call out that is not an emergency.

### 15.1.4 Manufacturer's Requirements

The servicing and maintenance work is to incorporate all of the requirements of the manufacturer of any item of plant (or systems) to ensure that the warranty provided is not prejudiced by incorrect or inadequate procedures.

### 15.1.5 Tools

If non-standard tools are required for the regular maintenance procedures, provide them, and leave them on the site at the end of the maintenance period, with written instructions for their use. Install a shadow board for storage of special tools.

### 15.1.6 Program

Before the start of the maintenance period, submit a maintenance program showing the proposed dates of required service visits. State the contact telephone numbers of the service operators to be provided, and describe the arrangements for prompt attention to emergency calls.

### 15.1.7 Records

Record the result of each service visit in the log book, including comments on the functioning of the system, work carried out, items requiring corrective action, testing results, any necessary remedial action, adjustments made, name of service operator, and the like, and obtain the signature of the Principal's designated representative.

### 15.1.8 Site Control

Report to the Principal's designated representative on arriving and before leaving the site.

### 15.1.9 Certification

At the end of the maintenance period, make a final service visit and, upon satisfactory completion of the above procedures, certify in writing that the system is operating in as-installed condition. The Subcontractor remains liable until the system is returned where necessary to the as-installed condition.

## 15.2 MAINTENANCE ACTIVITIES

### 15.2.1 Requirement

The minimum servicing requirements of the system are set out below:

(a) Replace all faulty and damaged parts of the installation. Replace all expendable components such as filter media, etc., as necessary. Make all necessary adjustments;

(b) Service all equipment in accordance with the recommendations of all equipment and component manufacturers;

(c) Check all bearings for correct operation and lubrication;

(d) Lubricate all equipment as necessary;

(e) Check and adjust as necessary belt tensions and alignment of all belt drives and couplings. Check couplings and pulleys for wear and tightness. Replace worn belts;

(f) Check all motors for excessive operating temperatures and record current draw;

(g) Check all anti-vibration supports for deterioration of rubber or springs, and for freedom of movement of assembly;

(h) Examine all flexible pipe and duct connections for any damage and for correct adjustment and tightness;

(i) Check operation of all air filters. Measure and record pressure drop across media. Check condition of media and estimate remaining life. Clean all cleanable filters. Replace filter material if likely to run out before next visit. Remove old filter material from site;

(j) Check all cooling and heating coils for cleanliness and clean as necessary. Ensure condensate trays and drains are clean, and clean eliminator plates (where fitted);

(k) Drain down, clean and flush all water piping systems, together with water passages of heat exchangers and strainers immediately after commencement of plant operation. Also allow for draining down, cleaning and flushing water piping system, on a further occasion at the end of the Defects Liability Period. For all except initial cleaning and flushing, allow for the work to be carried out at the Principal's convenience. Ensure all work is carried out in accordance with AS 3666;

(l) Check operation of all automatic controls and rectify all faults completely. Respond to all occupant complaints and remedy. Adjust to correct set points as necessary. Carry out a full calibration of all controls such as thermostats, VAV terminals and motorised dampers and return to setpoint at 6 month intervals (minimum) in the maintenance period or as deemed to be necessary. Record all control settings;

(m) If any on-going complaint is received from the occupants, install a continuous temperature plotter for a period of 48 hours in the area of complaint, and determine the solution to the problem. Retain the plots in the log book. Carry out all adjustment of air balance where this is necessary to remedy solutions;

(n) Check space conditions in air conditioned areas by measurement each month. The areas served by process cooling units are to be continuously measured over 24 hours at each visit. Other air conditioned areas shall be measured over a half hour interval. Make all necessary adjustments to air balance and controls to achieve required conditions;

(o) Check and adjust all safety controls at least every six (6) months. Record all cut out settings;

(p) Read and record all meter readings at each visit. Check operation of all test and control switches and relays, and prove correct operation of all control sequences in rotation. Replace burnt-out pilot lights, coils and contacts, and all faulty illumination lights within equipment housings;

(q) At intervals of not greater than three (3) months, clean and adjust all switchgear, contactors, starters, etc. and all other electrical contacts. Also prove operation of, and record settings of thermal overload and other protection devices by means of stall tests etc. At the same time, check and ensure tightness of all equipment fastenings within switchboard and clean whole of cubicle;

(r) Reset diffuser air pattern controls as necessary. Correct any problems of draft;

(s) Check operation of all modulating and fixed dampers controlling air flow. Lubricate all damper bearings and linkages as necessary;

(t) Record readings of all gauges;

(u) Check all refrigerant systems for leaks and repair such leaks. Maintain the correct refrigerant and oil charge;

(v) Check that all air handling systems operate in accordance with AS/NZS 1668 .1 and AS/NZS1668.2;

(w) Check that all systems comply with AS/NZS 3666 including cleaning and elimination of ponding water;

(x) Paintwork damaged through the actions of maintenance staff shall be repaired at the Subcontractors cost to provide a surface finish in keeping with undamaged section on the component concerned;

(y) Conduct a full controls and monitoring system audit at the end of the defects liability period to prove operation of all controls and monitoring components. Provide a written report. Rectify all defects;

(z) Check and confirm operation of fire alarm relays.

### 15.2.2 Service Contract

Submit during the Defects Liability Period, in draft form, a proposal for a service agreement covering regular inspections and servicing of the installation, to take effect on the expiration of the Defects Liability Period.

Consult with the Superintendent and the Principal prior to submitting the draft service agreement. Submit alternate proposals together with relevant prices if required.

Clearly set out the current hourly rates for service, both for work done during normal hours and for work done on an overtime basis. These rates should apply without change for the period of the service contract, but where this is not possible, full details of costs adjustment formulae shall be submitted.

## 15.3 MANUALS

### 15.3.1 Requirement

A draft copy of the proposed Operating and Maintenance Manual shall be submitted in sufficient time for approval and completion at least two (2) weeks before Practical Completion. Practical Completion Certificates will not be issued until the manuals are provided and completed. Provide 3 sets of manuals.

### 15.3.2 Form

A4 size, typed on durable printing paper, each page consecutively numbered, neatly bound in durable hard-backed vinyl covers permanently labelled. Place diagrams on the same page as the relevant text, or on the facing page, or on gatefold pages at the end of the volume. The type, style and manual form is to be continuous through the manual. In consultation with the Main Contractor, determine a common presentation and format methodology to ensure that all manuals required from the different subcontractors are identical in presentation for all services.

### 15.3.3 Manual

Provide the information necessary for the satisfactory long-term operation and regular maintenance of the installation, including:

Binder Information: Provide the following information:

(a) Project name and service on the spine;
(b) Project name and service on the front cover along with the Principal's name, Contractor's name, Subcontractor's name and the Superintendent's Representative's name.

Title Page: Provide the name of the Subcontractor and his address and contact numbers and the expiry date of the Defects Liability Period.

Index: Provide a comprehensive Table of Contents.

General Description: Providing an easy to read description of the installation covering all systems and their functions. Reference is to be made to later and more detailed descriptions of plant or systems.

List of Plant: Containing each item of plant installed with maker's name and address, equipment model, serial number and name plate data. The list must identify the functional purpose of the plant and its operational capabilities. The lists are to be tabulated in titled tables.

Show also, data necessary in identifying replacement components.
When an item of plant includes ancillary equipment, similar information will be provided for such equipment.

Operating Instructions: For the correct starting, operating, shut down, fault finding, etc. for each system and item of plant, and instructions for adjusting all controls and cut out settings. These will include instructions for actions to be taken in the event of abnormal or emergency conditions. A complete schedule of the normal operating conditions of all items of plant including motor currents, temperatures, pressures, etc. and the settings of all safety and other controls. The instructions are to be put together in such a way as will allow pages to be removed should it be necessary to correct or expand any procedure. Where operation, test or maintenance involves a hazard to personnel or equipment, the description of that action is to be immediately preceded by a warning, caution or note.

Maintenance Instructions: Setting out in detail all requirements for preventative and corrective maintenance of the complete plant. This is to be arranged in tabulated sections of recommended daily, weekly, monthly and annual maintenance in the form of a log book as described further below.

The instructions are to note periodicity, performance standards to be maintained, physical inspections to be performed, cleaning, lubrication, adjustments, special tools required, special materials required, testing procedures, trouble shooting and fault diagnosis procedures, dismantling and assembly procedures.

Manufacturer's Instructions: For maintenance, repair or overhaul for each item of equipment, including calibration of all controls and instruments. These instructions are to be included in the maintenance instructions.

Manufacturer's Literature: Copies of manufacturer's manuals and equipment specific brochures. Originals of the manuals and brochures are to be installed and photocopies will be rejected. The literature is to provide physical details such as size, shape, weight, mounting and securing, interconnection, etc.

Test Records and Commissioning Data: The data is to be typed with the same text format as all other text and is to be contained in ruled, titled tables with an index. Hand written tables will be rejected. The records will at least contain the results of all performed tests. Sufficient space must be left for Final Tests and other required Tests.

Drawings: "As-Installed", complete with index. All drawings for inclusion in the manuals are to be reduced-scale, preferably 1:200 scale, on A3 sheets. Care must be taken in the drafting of the drawings to ensure that the reproductions are legible. All drawings are to have a graphic scale as well as a designated scale.

Log Book: Include in the manual, log book pages set up for recording the maintenance items listed above (operational and maintenance actions and procedures, periodicity, performance standards, adjustments made, materials used, test results, comments for future maintenance actions, notes covering the condition of the installation, etc.), sufficient in number to receive the entries for the maintenance period and for a further period of 12 months. Make entries recording the operational and maintenance activities performed up to the time of Practical Completion of the Contract.

### 15.3.4 Certificates

Include in the log book the test and approval certificates.

### 15.3.5 Amendments

The manuals are to be amended and upgraded as modifications occur during the Defects Liability and Warranty period.

### 15.3.6 Photographs

Photographs of concealed works, which may require maintenance, are to be provided.

### 15.3.7 Operating and Maintenance Instructions

Will be in SI Units and must be in clear concise English language.

### 15.3.8 Disk Copies

Provide separate and duplicate diskette copies of the following:

(a) All text within the Operating and Maintenance Manuals;
(b) As-installed drawing CAD files.

The disk copies are to be presented in a labelled proprietary diskette storage container. Each diskette is to contain one file and be clearly labelled with a typewritten label.

Provide within the manuals, all information and instructions necessary for retrieval of information from the disks including instructions for transferring and decompression of files.

### 15.3.9 Work As-installed Drawings

Before the date of Practical Completion, provide the Superintendent's Representative with one sepia transparency of "As-installed" drawings for approval. These drawings are to be the Construction Drawings and include all changes and variations made during the execution of the Subcontract. Sets of approved as-installed drawings must be included in the Operating and Maintenance Manuals. The drawings must include the following information:

(a) Layout drawings showing actual duct positions, plant position, sizes and location of dampers and measured air quantities at all fan discharges, air outlets, fresh air inlet, return air inlets and all other items and quantities relevant to the system;

(b) Schedules showing the following data:

- All air conditioning system final setpoints and pipe system final setpoints;
- Fan size, type, speed, static pressure, air quantity;
- Motor size, type, speed;
- Similar complete as-installed capacity and performance details for all other items of equipment.

(c) Remove all details and notes specific to construction only and not specifically required to show work as-installed.

(d) Submit the following with the Operating and Maintenance Manuals:

- One (1) set of A1 or B1 prints;
- Three (3) sets of A3 reduced prints bound separately as part of the Operating and Maintenance Manuals;
- Two (2) sets of CAD files on compact disks.

# 16. AUTOMATIC CONTROL

## 16.1 GENERAL

The intent of the system shall be a complete operating controls system generally as specified within the specification and drawings. All items to provide a complete and operating system shall be included. The base building / house Mechanical Switchboard shall incorporate AUTO/ON/OFF switch for all equipment.

## 16.2 VRV CENTRAL CONTROLLER

Provide a multi-functional centralised controller installed at reception or to clients details, as supplied by Daikin there ***Intelligent Touch Manager*** model complete with offsite access and individual power consumption reporting for individual indoor units (PPD), options. and all required hardware to allow for the control of installed ventilation fans and other specified HVAC equipment The System shall be capable of performing the following functions:

(a) Monitor all zones within the building;
(b) Individual power consumption reporting for individual indoor units (PPD Option);
(c) Provide interface to miscellaneous fans for adjustable time schedule and on off operation;
(d) Provided with Web access capabilities for offsite control and monitoring:
- Temperature setting for each zone, or group, or indoor unit.
- On/Off as a zone or individual unit.
- Indication of operating condition.
- Select one of 10 operation modes for each zone.

(e) Has a wide screen liquid crystal display and can be wired by a non-polar 2-wire transmission cable to a distance of 1 km away from the indoor unit;
(f) Set an operation schedule for indoor units (including twice on/off a day and holiday).

## 16.3 INDIVIDUAL OFFICES AIR CONDITIONING CONTROLL

Wall mounted wired controller located in an agreed location. The controller shall provide the following functions:

(a) ON/Off;
(b) Fan speed HIGH/MEDIUM/LOW;
(c) Temperature indication and control;
(d) Heating and Cooling mode switching.

Temperature control shall be via wall sensor. All time clock functions shall be performed at the local controller.

## 16.4 COMMON AREAS AIR CONDITIONING CONTROLL

Common areas shall be provided with a local wired controller limited to the following functions:

(a) ON/Off control;
(b) Temperature indication.

Remaining common areas controls shall be via the central Controller. Final local controller locations to be agreed at construction stage.

## 16.5 COMMS ROOM AIR CONDITIONING

This unit shall operate continuously as required by the room. Temperature within the room shall be via the unit's self-contained controller and wall switch. Monitoring only shall be provide by the central controller

## 16.6 GENERAL AIR CONDITIONING CONTROL

The local wired controller shall provide the following functions:

(a) Temperature setting / Indication;
(b) Status Indication;
(c) Manual On/Off;
(d) Operation to a pre-set adjustable time schedule;
(e) Manual On/Off override for individual unit;
(f) Indication of operating condition;
(g) Change Heating / Cooling operation.

Final local controller locations to be agreed at construction stage

### 16.7 TOILETS EXHAUST SYSTEM

The system shall be interlocked to the central controller and shall be controlled via an adjustable time clock schedule.

### 16.8 MISCELLANEOUS EXHAUST AND SUPPLY SYSTEMS

Unless otherwise stated all other ventilation systems shall be operate to an adjustable time switch to be co-ordinated with the client to their requirements.

### 16.9 COMMERCIAL KITCHEN EXHAUST AND SUPPLY SYSTEMS

Provide a wall mounted kitchen exhaust on off switch, speed controller complete with light indicator, final location to client's detail.
Interlock the kitchen exhaust fan with the makeup air fan so as to ramp up and down in unison utilising their associated VSD.

### 16.10 FIRE MODE

When the building is in fire mode the following actions shall take place:

| | | |
|---|---|---|
| (a) | General exhaust fans | STOP |
| (b) | General Supply air Fans | STOP |
| (c) | Ducted Air conditioning systems | STOP |
| (d) | Commercial Kitchen Ventilation | Maintain Operational Status (Can operate in Fire Mode) |

Unless otherwise stated by fire services engineer.

An AUTO/OFF/MANUAL switch shall be provided on the essential switchboard to allow testing of the systems.

Override facilities shall be provided at the fire indicator panel FIP, for the car park exhaust and supply in accordance with AS1668 Part1.

When the duct mounted smoke detector is activated, the associated shutdown system can re-start once smoke is cleared and no smoke has been detected for a period of 60-90 seconds continuous.

# 17. EQUIPMENT SCHEDULE

## 17.1 AIR CONDITIONING UNIT SCHEDULE

All Outdoor systems shall be suitable for operation over ambient dry bulb temperature range -5 – 45°C.

### 17.1.1 AIR COOLED VRV SYSTEM

| **Condenser Unit Reference** | | **CU-01** | | | | |
|---|---|---|---|---|---|---|
| Location | | Plant Room Outdoor | | | | |
| Nominal Capacity | kW | 48.9 | | | | |
| Make | | Daikin VRV 6R(BYM9) AUS NZ | | | | |
| Type | | Inverter Heat Recovery | | | | |
| Model No | | REYQ20BYM9 | | | | |
| Total Weight | KG | 357 | | | | |
| **Unit Reference** | **Area Served** | **Model Number** | **Nominal Cooling kW** | **Outside Air (L/S)** | **Static (Pa)** | **Type** |
| FCU-01 | Office | FXFQ25AVM | 2.3 | 30 | - | Ceiling Cassette |
| FCU-02A | Entry | FXMQ140PAVE | 15.1 | 130 | 200 | Ducted |
| FCU-02B | Entry | FXMQ160PV1A | 15.9 | 150 | 200 | Ducted |
| FCU-03 | Meeting | FXFQ50AVM | 5.0 | 60 | - | Ceiling Cassette |
| FCU-04 | First Aid | FXAQ20BVM | 1.7 | 30 | - | Wall Hung |
| FCU-05A | Referee 1 | FXAQ20BVM | 1.0 | 20 | - | Wall Hung |
| FCU-05B | Referee 2 | FXAQ20BVM | 1.0 | 20 | - | Wall hung |
| FCU-06 | Kitchen | FXFQ40AVM | 4.1 | 40 | - | Ceiling cassette |

**Notes:** Contractor to use above selection or approved equal.

### 17.1.2 SPLIT AIR CONDITIONING SYSTEMS

All Outdoor systems shall be suitable for operation over ambient dry bulb temperature range -5 – 45°C.

| **Reference** | # | **FCU-07 / CU-07** |
|---|---|---|
| **Area Served** | | Comms Room |
| **AC Unit Type** | | Inverter Split – Wall Hung |
| **Model (Indoor Unit)** | | FTXV50WVMA |
| **Model (Outdoor Unit)** | | RXV50WVMA |
| **Outdoor Unit Weight** | Kg | xx |
| **Air Flow** | L/S | 267 |
| **Total Cooling Capacity** | KW | 4.36 |
| **Starter Type** | | DOL |
| **Type of Electrical Service** | | 1/50/240 |
| **Refrigerant** | | R32 |
| **Compressor** | | Inverter Controlled |

**Notes:** Contractor to use above selection or approved equal.

### 17.2 EVAPORATIVE COOLER

| | **EC-01 to 06** | | |
|---|---|---|---|
| Area served | Sports Hall | | |
| Type | Indirect | | |
| Make | Seeley | | |
| Model | Climate Wizard CW-H15S Plus | | |
| Discharge type | Horizonal | | |
| Cooling Capacity (kW) | 26.0 | | |
| Supply Air Temp. Min. (°C) | 15.1 | | |
| Air On DB/WB (°C) | 37.9/18.5 | | |
| Air flow at maximum speed (L/s) | 1600 | | |
| External resistance to the above air flow (Pa) | 80 | | |
| Fan speed control type | Y | | |
| Input Power (Ph/Volts/Amp per Ph) | 3/415/4.9 | | |
| Water Consumption (L/hr) | 56 | | |
| Heat Exchangers - | | | |
| Indirect Evaporative | 3 Cores | | |
| Direct Evaporative | 3 Chillcel Pads | | |
| Radiated sound power (dB) re $10^{-12}$ watts at: | 75 | | |
| 125 Hz | 71 | | |
| 250 Hz | 70 | | |
| 500 Hz | 66 | | |
| 1000 Hz | 64 | | |
| 2000 Hz | 61 | | |
| 4000 Hz | 55 | | |
| 8000 Hz | 48 | | |
| Weight – Operating (kg) | 345 | | |

## 17.3 EXHAUST AIR FANS

| Fan No. | Type | Air Vol. | Resist | Input Power | VSD | Serving | Base Selection |
|---|---|---|---|---|---|---|---|
| # | | l/s | Pa | kW | | | |
| TEF-01 | Roof Mounted | 1550 | 150 | 1.10 | Y | Amenities | Fantech – GUE454V |
| TEF-02 | In Line | 60 | 80 | 0.04 | N | Acc WC | Fantech – RIL-150SW (Lo Speed) |
| TEF-03 | In Line | 90 | 80 | 0.04 | N | Referee | Fantech – RIL-150SW (Lo Speed) |
| KEF-01 | Roof Mounted | 1600 | 200 | 1.02 | Y | Kitchen Hood | Fantech – CHDEC50DD |
| | | | | | | | |

**Notes:** Contractor to use above selection or approved equal.

## 17.4 SUPPLY AIR FANS

| Fan No. | Type | Air Vol. | Resist | Input Power | VSD | Serving | Base Selection |
|---|---|---|---|---|---|---|---|
| # | | l/s | Pa | kW | | | |
| SAF-01 | In Line | 150 | 80 | 0.03 | Y | A/C units | Fantech – JETLINE-200ECO |
| KEF-01 | Roof Mounted | 1280 | 150 | 0.55 | Y | Kitchen Hood | Fantech – Powerline Ultra CE Series |
| | | | | | | | |

**Notes:** Contractor to use above selection or approved equal.

## 17.5 CIRCULATION AIR FANS

| Fan No. | Type | Air Vol. | Resist | Input Power | VSD | Serving | Base Selection |
|---|---|---|---|---|---|---|---|
| # | | l/s | Pa | kW | | | |
| CF-01 to 08 | Suspended Ceiling | 2882 | - | .39 | Y | Sports Hall | Airius – 630 Elmerald EC |
| | | | | | | | |

**Notes:** Contractor to use above selection or approved equal.

## 17.6 ROOF COWELS

| Item No. | Type | Air Vol. | Resist | Serving | Base Selection |
|---|---|---|---|---|---|
| # | | l/s | Pa | | |
| RC-01 | Alpha Relief Series | 60 | 0 | Toilets | Fantech – MRV2 |
| RC-01 | Alpha Relief Series | 90 | 0 | Toilets | Fantech – MRV2 |
| | | | | | |
| | | | | | |

**Notes:** Contractor to use above selection or approved equal.

## 17.7 RADIENT HEATERS – ELECTRIC

| | RAD-1 to 20 | | |
|---|---|---|---|
| Location | Sports Hall | | |
| Type | Short Wave Infrared | | |
| Make | Tansun | | |
| Model | Apollo Range A3K2 60IP | | |
| Nominal width (mm) | 1282 | | |
| Nominal height (mm) | 255 | | |
| Nominal depth (mm) | 110 | | |
| Input Power (Ph/Volts/Amp per Ph) | 3/415/8.7 | | |
| Output (kW) | 6.0 | | |
| Weight (kg) | 8.0 | | |

**Notes:** Contractor to use above selection or approved equal

# 18. TENDER FORMS

**PROJECT:** **TUMUT MULTIFUNCTION FACILITY**
**ADDRESS:**
**SPECIFICATION NO:** **S494ASPE001_mECH**

## 18.1 SCHEDULE OF PRICES

Prices for all items listed are to be inserted by the Tenderer. The Prices shall include all Contractor's costs, including overheads and profit, but exclude the cost of any material or service to be provided free of charge to the Sub-contractor by the Principal.

The Principal reserves the right to reject any tender if the prices submitted are considered unreasonable.

| Item | Description | Pricing |
|---|---|---|
| 1. | Airconditioning Units | |
| 2. | Refrigeration Piping | |
| 3. | Evaporative Coolers | |
| 4. | Radiant Heaters | |
| 5. | Circulation fans | |
| 6. | Fans & Roof Cowls | |
| 7. | Duct including grilles fixing etc. | |
| 8. | Controls | |
| 9. | Electrical | |
| 10. | Switchboards | |
| 11. | Cranage | |
| 12. | Commissioning | |
| 13. | Work shop and as build drawings | |
| 14. | Site Set up and Management Costs | |
| 15. | End user training | |
| 16. | 12 Months warranty service | |
| 17. | Other – Provide details and attached to tender return | |
| | | |
| | **Subtotal** | |
| | **GST** | |
| | **TOTAL (including GST)** | |

Name of Tender: ……

Address: ……

Tenders Signature: …….. Date: …….

Name: …….. Position: …….