Project Title:

Mechanical Services

for

Redevelopment of Council Workshop Office

at

Council Workshops, 25-31 Dunn Street, Biloela

Client: **Banana Shire Council**

Architect: **AMF Building Design**

DOCUMENT PREPARED BY:

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Specification Identification	22214-1
Issue	A
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ATTACHMENTS AND INCLUSIONS:

Drawings No 22214-M001
Tender Forms (1 off)

Date	Revision	Details	Approved
14/12/2022	P1	22214-1	DW
18/01/2023	A	22214-1	DW

0700 MECHANICAL SERVICES - SCHEDULE TO ACESPEC REFERENCE SPECIFICATION

STRUCTURE OF THE SPECIFICATION

Format

General: This Specification uses a reference (2 part) format, and comprises two parts as follows:

- This Project Schedule
- The ACESPEC Reference Specification Worksections (Acespec is based on Natspec with alteration as noted)

Application: The reference Specification Worksections form part of the Specification, subject to amendments made to the Reference Specification Sections by the Project Schedule and drawings. Requirements of this Project Schedule and drawings override conflicting requirements in the reference Specification Sections. Where conflicts in requirements occur within the specifications and drawings the most onerous requirement shall be applied

The reference Specification Sections are attached.

KEYWORDS

Clauses in the Reference Specification Worksections are called up by the keywords in the Project Schedule.

Clauses are deleted, modified or extended by noting against the keyword.

Types and Options are indicated in the Project Schedule as are any modifications to the standard worksection required for this project.

0701 MECHANICAL SYSTEMS

0701.1 GENERAL

This contract shall include for the design, supply, delivery, placing, installation, testing, proving, compliance certification, commissioning and twelve (12) months guarantee and maintenance of the services as specified and shown on the accompanying drawings, including the following.

- ***Air conditioning:*** Four (4) off DX split systems, including pipework, insulation, anti-vibration mounts, condensate drainage, switching, controls and connection to electrical power supplies.
- ***Ventilation:*** One (1) off, outdoor air systems including fans, interlocks, controls and connection to electrical power supplies.
- ***Ventilation:*** One (1) off exhaust systems, including fans, including ductwork, insulation, attenuators, switching and controls.
- ***Electrical:*** Electrical cabling to all new equipment.
- ***Testing and commissioning:*** Preliminary testing, commissioning, acceptance testing, final testing of all systems including detailed reports.
- ***Operating and maintenance manuals:*** Manuals including complete as-installed drawings.
- ***Comprehensive maintenance and warranty:*** To be provided for the 1 year defect period from the date of practical completion. Provide comprehensive maintenance systems including full warranty on all equipment and systems.

- ***Painting and labelling:*** Provide corrosion protection painting of all plant and equipment, pipework and ductwork.

0701.2 DRAWINGS

The following drawings form part of this document.

Drawing No.	
22214/M001	Air Conditioning & Ventilation Layout.

0701.3 ASSOCIATED WORKS BY OTHERS

The sub-contractor shall be responsible for the co-ordination with other trades that will carry out the following associated works:

By Principal:

- Nil

By Building Contractor and other Trades:

- Forming of all openings in walls, floors, ceilings and roofs for the passage of ducts, pipes, registers, conduits and the like and weather sealing where necessary and shall include acoustic packings, sleeves, fire rated packing, decorative escutcheons, special flanges or other fittings
- Under-flashing and over-flashing where ducts, pipes and conduit penetrate roofs and outer walls
- Patching and making good of building elements after the work for the mechanical services including building-in of electrical conduits, pipes and the like
- Boxing-in of ductwork and services where required
- Access panels and/or doors to ceiling mounted or boxed-in equipment
- Drainage points generally adjacent to necessary plant to accept waste from:
    - Air conditioning units and condensers

Electrical Work:

- Nil

0701.4 INTERRUPTIONS TO SUPPLY

NO UNSCHEDULED INTERRUPTIONS to any site services shall occur – including electricity, telephones, water, fire services, refrigeration – and the contractor shall ensure full care is taken to avoid such interruptions.

Any required interruptions shall be fully discussed between all parties and the interruptions shall be planned to be of minimum time period and of minimum number. Obtain written confirmation for the interruptions prior to the event.

This clause does not require live work or that Workplace Health and Safety requirements are not to be adhered to.

Provide temporary power supplies or other temporary services as nominated to maintain services to the site as required.

0701.5 SITE VISITS

Tenderers are requested to visit the site by prior appointment (minimum 24 hours notice), arranged with nominated person scheduled of tender details.

Where as installed and maintenance manuals' exist for the particular equipment, these may be viewed; arrangements to be made also with the above.

Detailed inspection of the site and plant is recommended to all tenderers so that the full scope of the required works, access and similar items may be assessed. No increase to the contract sum will be granted for required works ascertainable from careful inspection of the site, equipment and, where available, the `As installed and maintenance manuals.

0701.6 CROSS REFERENCES

General

Requirement: Conform to the following worksections included in this specification:

0701 Mechanical systems
0703 General requirements - Mechanical
0722 Room air conditioners
0731 Fans
0732 Air filters
0741 Ductwork
0744 Ductwork insulation
0746 Air grilles
0771 Automatic controls
0781 Mechanical electrical
0791 Mechanical commissioning
0792 Mechanical maintenance

0701.7 CERTIFICATION

Prior to Practical completion provide compliance certification and Form 12 for the specified work. The compliance certificate shall state as follows:

> “I certify that the electrical installation to the extent it is affected by the electrical work, has been tested to ensure that it is electrically safe in accordance with the requirements of The Wiring Rules and any other Standard applying under the Electricity Safety Regulation 2013 to the electrical installation”.
>
> The installation complies fully with all requirements of the contract documents as well as all relevant Standards, Acts and Regulations
>
> All systems installed as part of this sub-contract have been fully inspected, tested, commissioned and function to the specified requirements
>
> The installation is fully operational including all connections to other services (installed by other trades)
>
> Installation methods, safety and operating controls are in accordance with the manufacturer’s requirements and no warranties are voided

At the end of the defects liability period, provide a second compliance certificate stating that the installation has been maintained as specified and in accordance with relevant Australian Standards throughout the defects liability period.

Also provide a Form 12 in accordance with the requirements of the Department of Housing and Public Works for all services included in the contract.

Where sub-contractors are used to complete specialist services, provide a written certificate and Form 12 for each.

Provide compliance certification and registration for all RPZ valves.

All certificates shall be signed by the tradesperson responsible, with the contractor’s licence number stated.

Provide one copy of each compliance certificate and Form 12 in each of the maintenance manuals.

0701.8 DEMOLITION

Requirement: Disconnect and remove from site three (3) off existing split system air conditioning systems. The demolition shall include all associated items, which are made redundant with the demolition and removal of the air conditioning systems.

Associated items: These shall include, as applicable pumps, pipes, controls, electrical, plinths, supports and the like.

Environmental: Comply with statutory and best practice in relation to environmental issues, ensuring there is no environmental contamination due to the works.

Handover: Return the three (3) off split system air conditioning systems to the client after removal.

0701.9 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0701-Mechanical Systems attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Design	Yes
1.3	Precedence	Yes
1.4	Cross References	Yes
1.5	Referenced Documents	Yes
1.6	Standards	Yes
1.7	Interpretation	Yes
1.8	Contract Documents	Yes
1.9	Submissions	Yes
2	**Execution**	
2.1	Work on Existing Systems	Yes
2.2	Support of Plant and Equipment	Yes
2.3	Installation	Yes

0701.10 SCHEDULE OF MECHANICAL DESIGN CONDITIONS

Outdoor design conditions shall be as follows:

Property	Biloela
Cooling: Dry bulb (°C)	36.7
Cooling: Wet bulb (°C)	25.6
Heating: Dry bulb (°C)	5.3

0701.11 INDOOR DESIGN CONDITIONS SCHEDULE

Indoor design condition shall be as follows:

Property	All Areas
Dry bulb (°C)	24.0
Relative humidity	50%*

*non controlled

0701.12 SCHEDULE OF INSPECTIONS

Give notice so inspection may be made of the following:

Item	Notice
Practical completion	1 Week

0703 GENERAL REQUIREMENTS - MECHANICAL

0703.1 GENERAL

Conform to general requirements as shown on the drawings and specified herein.

0703.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0703 – General Requirements - Mechanical attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Design	Yes
1.3	Precedence	Yes
1.4	Cross References	Yes
1.5	Referenced Documents	Yes
1.6	Interpretation	Yes
1.7	Familiarisation with the site	Yes
1.8	Variation claims	Yes
1.9	Complementary documents	Yes
1.10	Contract Documents	Yes
1.11	Submissions	Yes
1.12	Inspection	Yes
2	**Products**	
2.1	General	Yes
2.2	Materials and Components	Yes
3	**Execution**	
3.1	Samples	No
3.2	Shop Drawings	Yes
3.3	Off-Site Disposal	Yes
3.4	Wall Casing	Yes
3.5	Fixing	Yes
3.6	Services Connections	Yes
3.7	Services installation	Yes
3.8	Building Penetrations	Yes
3.9	Concrete plinths	No
3.10	Support and Structure	Yes
3.11	Pipe Supports	Yes
3.12	Plant and Equipment	Yes
3.13	Access for Maintenance	Yes
3.14	Vibration Suppression	Yes
3.15	Seismic Restraint of Non-Structural Components	Yes
3.16	Finishes to building Services	Yes
3.17	Marking and Labelling	Yes
3.18	Software	No
3.19	Warranties	Yes
3.20	Record Drawings	Yes

3.21	Operation and Maintenance Manuals	Yes
3.22	Electronic Facility and Asset Management Information	No
3.23	Tools and Spare Parts	No
3.24	Testing	Yes
3.25	Training	No
3.26	Cleaning	Yes
3.27	Periodic maintenance of Services	Yes
3.28	Post Construction Mandatory Inspections and Maintenance	No
3.29	Interruptions to Supply	Yes
3.30	Associated Work Normally Sub-Contracted (AWNS)	No
3.31	Site Access	Yes
3.32	Asbestos	No
3.33	Fire Detectors	No

0703.3 SUBMISSIONS SCHEDULE

General	
Submit to	Superintendents representative
Submission response times	
Shop Drawings	5 working days
Samples and prototypes	5 working days
Manufacturers' or suppliers' recommendations	5 working days
Product data	5 working days
Product/design substitution or modifications	5 working days
Electronic submissions	
Electronic copies file format	PDF
Transmission medium	Email

0703.4 CORROSION RESISTANCE SCHEDULE

Corrosivity category shall be as follows:

Exterior atmospheric corrosively category	C3

0703.5 SHOP DRAWING SCHEDULE

Shop drawing submission requirements shall be as follows:

Submission medium	Electronic
Drawing size	A1
Standard	1:50
CAD base drawings	AutoCAD (minimum version 2011)

0703.6 NOISE LEVEL SCHEDULE

Maximum noise levels shall be as follows:

Property	A
Externally	To relevant statutory requirements
Internally	Not exceed maximum recommendations of AS 2107

0703.7 WARRANTY SCHEDULE

Minimum warranties shall be as follows:

Warranty	Period
All equipment	12 months

0703.8 MAINTENANCE REQUIREMENT SCHEDULE

Minimum maintenance period shall be as follows:

Provision	Maintenance period (months)
All new equipment	12 months

0703.9 SEISMIC RESTRAINT OF NON-STRUCTURAL COMPONENTS SCHEDULE

Seismic restraints to AS 1170.4 are required for this project.

The basis of the seismic restraints shall be as follows. Prior to final design compare with structural and architectural specified values.

Earthquake design category	ECD II
Importance level of structure	3
Probability factor (kp)	1.3
Hazard factor (Z)	0.09
Site Sub Soil Class	Ce

0722 ROOM AIR CONDITIONERS

0722.1 GENERAL

Provide new, small, split DX air conditioning systems as shown on the drawings and specified herein.

0722.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0722 –Room Air Conditioners attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Standards	Yes
1.4	Interpretation	Yes
1.5	Submissions	Yes
2	**Products**	
2.1	General	Yes
2.2	One-Piece Units	No
2.3	Split Systems	Yes
2.4	Controls	Yes
3	**Execution**	
3.1	Refrigeration Piping Installation	Yes
3.2	Condensate Drains	Yes
3.3	Unit Installation	Yes
3.4	Hat Sections	Yes
3.5	Condenser Slab Mounting	No
3.6	Condenser Wall Mounting	Yes

0722.3 ROOM AIR CONDITIONERS PERFORMANCE SCHEDULE

Minimum room, air conditioning unit performance shall be as follows:

Unit	AC-1	AC-2	AC-3	AC-4
Area served	Entry	Lunch	Office	Office
System Type	Split system	Split system	Split system	Split system
Indoor Unit Type	Wall Mounted	Ceiling Cassette	Ceiling Cassette	Compact Cassette
Cooling: Total Capacity (kW)	2.9	7.8	6.0	2.9
Cooling: Sensible Capacity (kW)	2.5	5.5	4.8	2.5
Cooling: Latent Capacity (kW)	0.3	2.3	1.2	0.4
Cooling: Indoor coil entering air dry bulb (°C)	24	24.0	24.0	24.0
Cooling: Indoor coil entering air wet bulb (°C)	17.0	17.0	17.0	17.0
Ambient Dry Bulb (°C)	39.0	39.0	39.0	39.0
Minimum EER	2.9	2.9	2.9	2.9
Condenser: Maximum Sound Level (dB(A)@1m)	48	48	48	48
Condensate pump	Yes	Yes	Yes	Yes

0722.4 PIPING SCHEDULE

Piping types shall be as follows:

Service	Material	Class
Refrigerant	Copper	AS 1432 Type B
Condensate	PVC	AS 1477

0722.5 PIPING INSULATION SCHEDULE

Piping insulation shall be as follows:

Property	IS1	IS2
Piping system	Refrigerant-general	Condensate
Location	All	All
Insulation material	Elastomeric foam	Elastomeric foam
Insulation finish	N/A	N/A
Vapour barrier	N/A	N/A
Sheathing	Hat Section	Hat section
Minimum R-Value	1.3	1.0

0731 FANS

0731.1 GENERAL

Provide fans as shown on the drawings and scheduled herein.

0731.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0731- Fans attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Design	Yes
1.3	Cross References	Yes
1.4	Interpretation	Yes
1.5	Submissions	No
2	**Products**	
2.1	General	Yes
2.2	Marking	Yes
2.3	Materials	Yes
2.4	Centrifugal Fans – General Purpose	No
2.5	Centrifugal Fans – Sheet Metal	No
2.6	Centrifugal Fans – In-Line	No
2.7	Centrifugal Fans – Plug	No
2.8	Axial Flow Fans	No
2.9	Bifurcated (Protected Motor) Axial Flow Fans	No
2.10	Roof Mounted Fans	Yes
2.11	Plate Mounted Fans	No
2.12	Window/Wall Fans	No
2.13	Fume Cupboard Fans	No
2.14	Impulse Car Park Ventilation Fans	No
2.15	Roof Cowls	No
2.16	Mixed Flow Fans	Yes
2.17	Outdoor Air Heat Exchangers	Yes
3	**Execution**	
3.1	Installation	Yes

0731.3 SCHEDULE OF FAN PERFORMANCE

Minimum fan performance shall be as follows:

Unit	DEF-1	OAF-1
Area served	Amenities	Office
Function	Exhaust	Supply
Preferred make and model	Fantech Mixvent or approved equal	Fantech Mixvent or approved equal
Fan type	Duct Mounted	Duct mounted
Maximum air quantity (L/s)	145	150
Static Pressure at maximum L/s (Pa)	100	150
Impeller Style	Mixed Flow	Mixed flow
Impeller Material	GRP	GRP
Casing Material	GRP	GRP
Maximum sound pressure level @3 induct dB (A)	48	48
Power Supply (V/phase)	240/1	240/1
Motor input power (kw)	0.10	0.10
Fan minimum total efficiency (%)	27	25.2
Fan minimum static efficiency (%)	-	-
Speed Controller	Yes	Yes
Additional requirements	N/A	N/A

0732 AIR FILTERS

0732.1 GENERAL

Provide new air filters to existing air conditioning unit AC-1 and outdoor air fan OAF-3, as shown on the drawings and specified herein.

0732.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0732 – Air Filters attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Standards	Yes
1.4	Interpretation	Yes
1.5	Submissions	Yes
1.6	Inspection	No
2	**Products**	
2.1	Materials	Yes
2.2	Components	Yes
2.3	Dry Media Filters (Type 1) and Viscous Impingement Filters (Type 2)	Yes
2.4	HEPA Filters	No
2.5	MEPA filters	No
2.6	Filter Terminals	No
2.7	Electrostatic Precipitation Filters (\type 3)	No
2.8	Gas Phase Absorber Cells	No
2.9	Grease Filters	No
3	**Execution**	
3.1	Installation Generally	Yes
3.2	Cleaning	Yes

0732.3 AIR FILTERS SCHEDULE

Air filter types shall be as follows:

Property	OAF-1
Filter type to AS 1324.1	1 (Panel)
Filter class to AS 1324.1	B
Filter performance rating to AS 1324.1 clause 2.1.1	G4
Cell dimensions (mm) W x H x D	300 x 300
Maximum face velocity (m/s)	2.5
Maximum clean filter resistance (Pa)	50
Manometer	No
Preferred make and model	AES Environmental DY or approved equal
Additional requirements	Side withdrawal

0741 DUCTWORK

0741.1 GENERAL

Provide new ductwork as shown on the drawings and specified herein.

0741.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0741 – Ductwork attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Standards	Yes
1.4	Interpretation	Yes
1.5	Submissions	No
1.6	Inspection	No
1.7	Design Criteria	No
2	**Products**	
2.1	Fire Performance	Yes
2.2	Materials and Components	Yes
2.3	Sheet Metal Ductwork	No
2.4	Pre-Insulated Rigid Rectangular Ductwork	No
2.5	Pre-Insulated Rigid Rectangular Ductwork Fabrication	No
2.6	Pre-Insulated Rigid Round Ductwork	No
2.7	Pre-Insulated Rigid Round Ductwork Fabrication	No
2.8	Pre-Insulated Rigid Ductwork Sealing	No
2.9	PVC-U Ductwork	No
2.10	Flexible Duct	Yes
2.11	Kitchen Exhaust Ductwork	No
2.12	Fire Protection of Ductwork	No
2.13	Flexible Connections	Yes
2.14	Dampers – General	Yes
2.15	Volume Control Dampers	Yes
2.16	Splitter Dampers	No
2.17	Motorized Dampers	No
2.18	Non-Return Dampers	No
2.19	Fire and Smoke Dampers	No
2.20	Subducts	No
2.21	Access openings – Location	Yes
2.22	Access Panels	Yes
2.23	Access Doors	Yes
2.24	Electric Duct Heaters	No
2.25	Kitchen Hoods	No
2.26	Fume Cupboards	No
3	**Execution**	

3.1	Ductwork Installation	Yes
3.2	Pre-Insulated Rigid Ductwork Installation	No
3.3	Leakage Testing	No

0741.3 DUCTWORK SCHEDULE

Ductwork shall be as follows:

Ductwork type	Material	Pressure class to AS 4254
Air conditioning general	Galvanised steel	500
Exhaust system general	Galvanised steel	500

0744 DUCTWORK INSULATION

0744.1 GENERAL

Provide ductwork insulation as specified herein and shown on the drawings.

0744.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0744 – Ductwork Insulation attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Standards	Yes
1.4	Interpretation	Yes
1.5	Submissions	Yes
2	**Products**	
2.1	General	Yes
2.2	Fire Performance	Yes
2.3	Insulation Materials	Yes
3	**Execution**	
3.1	General	Yes
3.2	Internal Insulation – Laminate Faced	Yes
3.3	Internal Insulation – Metal Faced	Yes
3.4	External Insulation – Laminate Faced	Yes
3.5	External Insulation – Laminate Faced and Metal Sheathed	No
3.6	Insulation of Ductwork Components and Fittings	Yes
3.7	Insulation of Duct Flexible Connections	Yes

0744.3 DUCTWORK INSULATION SCHEDULE

Ductwork insulation shall be as follows:

Situation	Insulation type	Insulation vapour barrier and facing
Air conditioning- Ductwork, external insulation	Glass wool - Blanket	Aluminium foil laminate faced
Air conditioning- Ductwork, internal insulation	Glass wool – Batt	Aluminium foil laminate faced
Ventilation ductwork, internal insulation	Glass wool – Batt	Aluminium foil laminate faced

0746 AIR GRILLES

0746.1 GENERAL

Provide air grilles as specified herein and shown on the drawings.

0746.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0746 – Air Grilles attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Standards	Yes
1.4	Interpretation	Yes
1.5	Submissions	Yes
14.6	Samples	No
2	**Products**	
2.1	Manufacture	Yes
2.2	Volume Control Dampers	Yes
2.3	Air Grille Types	Yes
3	**Execution**	
3.1	Installation of Air Grilles	Yes

0771 AUTOMATIC CONTROLS

0771.1 GENERAL

Provide replace existing controls, and provide new controls to achieve the requirements of the functional control description as specified herein and shown on the drawings.

0771.2 FUNCTIONAL CONTROL DESCRIPTION

771.2.1 SMAL SPLIT SYSTEM AIR CONDITIONING UNITS

Interlocks: Interlock air conditioning units to the security systems. Air conditioning units shall be only able to operate when the security system is de-activated. Air conditioning units are to shut down when the security system is activated.

On/off switching is to be otherwise from the standard wall mounted control panel.

Provide proprietary interface cards for the air conditioning units as necessary to allow the interface to the security system.

0771.3 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0771 – Automatic Controls attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Standards	Yes
1.4	Interpretation	Yes
1.5	BACnet Certification	No
1.6	Drawings	Yes
1.7	Execution Details	No
1.8	Products and Materials	No
1.9	Samples	No
1.10	Tests	No
2	**Products**	
2.1	Control Components	No
2.2	Software	No
2.3	Digital Systems Controller Interface	No
2.4	Operator Workstations	No
2.5	Controllers	Yes
2.6	Input Devices – General	Yes
2.7	Input Devices – Temperature	Yes
2.8	Input Devices – Humidity	No
2.9	Input Devices – Pressure	No
2.10	Input Devices – Flow and Velocity	No
2.11	Input Devices – Flow Meters	No
2.12	Gas Sensor	No
2.13	Input Devices – Others	No
2.14	Actuators	No
2.15	Automatic Control Valves	No
2.16	Chilled water Bypass Valve and Actuator	No

2.17	Solid State Heating Controllers	No
3	**Execution**	
3.1	General	Yes
3.2	Installation – Components	Yes
3.3	Interface to Fire Systems and Fire Mode Operation	No
3.4	Testing and Commissioning	Yes
3.5	Training	No
4	**Functional Descriptions**	
4.1	Chillers	No
4.2	Cooling Towers	No
4.3	Ducted Air Conditioning Systems	No
4.4	Small Split System Air Conditioning Systems	Yes
4.5	Outdoor Air Heat Exchangers	No
4.6	Ventilation Systems	No
4.7	Outdoor air preconditioners	Yes

0771.4 SCHEDULE OF CONTROL REQUIREMENTS

Control requirements shall be as follows:

Unit	Type of control	Settings and requirements
AC-1	Small split system air conditioning unit	Proprietary individual, hard wired, wall mounted control panel with time clock functionality. Interlock to security system.
AC-2	Small split system air conditioning system	Proprietary individual, hard wired, wall mounted control panel with time clock functionality. Interlock to security system.
AC-3	Small split system air conditioning system	Proprietary individual, hard wired, wall mounted control panel with time clock functionality. Interlock to security system.
AC-4	Small split system air conditioning system	Proprietary individual, hard wired, wall mounted control panel with time clock functionality. Interlock to security system.
OAF-1	Ventilation system	Interlock to AC-1, AC-2, AC-3 & AC-4, 10 minute delay at startup
TEF-1	Ventilation system	Interlock to Lights in area served, 15 minute run on timer.

0781 MECHANICAL ELECTRICAL

0781.1 GENERAL

Provide circuit breakers on existing switchboard SB-1/SB-2 and all electrical cabling and isolators to new mechanical services equipment as specified herein and shown on the drawings.

0781.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0781 – Mechanical Electrical attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Design Documentation	Yes
1.4	Products and Materials	No
1.5	Samples	No
1.6	Shop Drawings	Yes
1.7	Electrical Accessories	Yes
1.8	Coordination	Yes
2	Cable Support and Duct Systems	
2.1	Responsibilities	Yes
2.2	Metallic Conduits and Fittings	No
2.3	Non-Metallic Conduits and Fittings	Yes
2.4	Cable Duct/Trunking	No
2.5	Cable Tray/Ladder Support Systems	No
2.6	Unsheathed Cables - Installation	No
2.7	Conduit Systems – Installation	Yes
2.8	Cable support Systems – Installation	No
2.9	Cables in Trenches – Installation	No
3	**Low Voltage Power Systems**	
3.1	Responsibility	Yes
3.2	Standards	Yes
3.3	Interpretation	Yes
3.4	Power Cables	Yes
3.5	Electrical Accessories	Yes
3.6	Earthing	Yes
3.7	Fire-Resisting Cables	No
3.8	Copper Conductor Terminations	Yes
3.9	Testing	Yes
3.10	Spare Parts	No
3.11	Isolation Switches	Yes
4	**Switchboards**	
4.1	Responsibilities	No
4.2	Standards	No
4.3	Interpretation	No
4.4	Custom Built Switchboard Construction	No

4.5	Cable Entries	No
4.6	Doors and Covers	No
4.7	Factory Finishes	No
4.8	Busbars	No
4.9	Neutral Links and Earth Bars	No
4.10	Internal Wiring	No
4.11	Assembly Installation	No
4.12	Assembly Entries	No
5	**Switchboard Components**	
5.1	Responsibilities	No
5.2	Requirements	No
5.3	Switch-Isolator	No
5.4	Fuse-Switch units	No
5.5	Moulded Case and Miniature Circuit Breakers	No
5.6	Fuses with Enclosed Fuse Links	No
5.7	Current Transformer Interface	No
5.8	Instruments and Meters	No
5.9	Electrical Indicating Measuring Meters	No
5.10	Contractors	No
5.11	Control Devices and Switching Elements	No
5.12	Semiconductor Controllers and Contractors	No
5.13	Programmable Logic Controllers (PLC)	No
5.14	Indicator Lights	No
5.15	Indicating Counters	No
5.16	Audible Alarm Services	No
5.17	Extra-Low Voltage Transformers	No
5.18	Anti-Condensation Heaters	No
5.19	Spares Cabinet	No
5.20	Marking and Labelling	No

0781.3 SCHEDULE OF ELECTRICAL POWER SUPPLIES

Sources of electrical power supply shall be as follows:

Unit	Source of electrical supply
AC-1	Connect to switchboard SB-1/SB-2 and modify as required.
AC-2	Connect to switchboard SB-1/SB-2 and modify as required.
AC-3	Connect to switchboard SB-1/SB-2 and modify as required.
AC-4	Connect to switchboard SB-1/SB-2 and modify as required.
OAF-1	Connect to switchboard SB-1/SB-2 and modify as required.
TEF-1	Connect to switchboard SB-1/SB-2 and modify as required.

0791 MECHANICAL COMMISSIONING

0791.1 GENERAL

Fully commission new air conditioning systems as shown on the drawings and specified herein.

0791.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0791 – Mechanical Commissioning attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Standards	Yes
1.4	Interpretation	Yes
1.5	Independent Certification of Commissioning Agent	No
1.6	Submissions	Yes
1.7	Inspection	Yes
2	**Execution**	
2.1	Commissioning	Yes
2.2	Related Tests	Yes
2.3	Instrumentation	Yes
2.4	Sound Pressure Level Measurements	No
2.5	Air Balancing	Yes
2.6	Manufacturer's Recommended Commissioning Procedures	Yes
2.7	Fire Mode Operation	No
2.8	VAV System Operation	No
2.9	Motorized Damper Leakage	No
2.10	Air balance Reports	Yes
2.11	Room air Pressure Differentials	No
2.12	Water Balancing	No
2.13	Heating Valve leakage	No
2.14	Electric Duct Heaters	No
2.15	Water Balance Reports	No
2.16	Automatic Controls	No
2.17	Safety Controls	No
2.18	Plant Operation Period	No
2.19	Completion Tests	No

0792 MECHANICAL MAINTENANCE

0792.1 GENERAL

Provide maintenance to all new equipment for the duration of the defects liability period as shown on the drawings and specified herein.

0792.2 SPECIFICATION REFERENCES

Refer ACESPEC reference Worksection 0792 – Mechanical Maintenance attached herein, referenced subsections as follows:

Subsection	Name	Applicable
1	**General**	
1.1	Responsibilities	Yes
1.2	Cross References	Yes
1.3	Standards	Yes
1.4	Interpretation	Yes
1.5	Submissions	Yes
1.6	Inspection	No
2	**Products**	
2.1	General	Yes
3	**Execution**	
3.1	Maintenance Requirements	Yes
3.2	Emergency Repairs	Yes
3.3	Periodic Maintenance	Yes
3.4	End of Maintenance Period Service	Yes
3.5	Recommissioning	Yes
3.6	Completion	Yes
4	**Selections**	
4.1	Maintenance	Yes

0792.3 MAINTENANCE REQUIRED SCHEDULE

Maintenance requirements shall be as follows:

Provision	Requirement
Mechanical maintenance period	12 Months
Maximum call out response time	1 Day
Frequency of periodic maintenance and performance reports	Monthly
Recommissioning frequency	12 Months

0793 SAFE DESIGN RISK REGISTER

0793.1 GENERAL

A safe design risk register has been developed in line with Workplace Health and Safety Queensland's requirements, during the design phase of the project. The register includes identified hazards or environmental impacts and proposed control measures.

A copy of the risk register is included in Appendix A and is considered to be a living document that should be developed further by the contractor prior and during the project.

It mains the obligation of contractors and their workers to take reasonable precautions and exercise proper diligence to provide a safe workplace. If requested our office will assist where it can.

TENDER FORM 1 – SCHEDULE OF TECHNICAL DATA

Tenderers shall complete and submit concurrently with the tender the following schedule of technical data. This schedule is of a limited nature only and considered tenderers may be called upon to supply additional information. Upon entering into a contract the successful tenderer will be required to submit, for approval, full details of all equipment prior to placing orders for such equipment.

TENDERER:

Name of tenderer ……

Contact Name ……

Telephone No.: ……

Facsimile ……

Small Split System Air Conditioning Units

No.	Make	Model	Total capacity (kW)	Sensible capacity (kW)	Latent capacity (kW)	Supply air (L/s)	**Coil Air On**	
							°C DB	**°C WB**
AC-1								
AC-2								
AC-3								
AC-4								

Fans

Unit	**Make**	**Model**	**Capacity (L/s)**	**Static pressure (Pa)**	**Noise level (dbA @ 3m in duct)**	**Fan speed (rev/s)**
OAF-1						
TEF-1						

The above details and attachments accurately describe the equipment offered. It is understood that acceptance of this schedule of technical data in no way removes full liability of the contractor to complete the installation to the requirements of the specification and drawings and to provide the required performance.

APPENDIX A – SAFE DESIGN RISK REGISTER

Incorporating the Safety Report as per Ref 295 of the QLD Workplace Health & Safety Regulation 2011.

RISK ASSESSMENT													
Activity or Task	**Hazards or Environmental Impacts**	**Hazards or Environmental Impacts**	**Perceived Risk**			**Control Measures (Eliminate, Substitute, Isolate/Engineering Controls, Administrative Controls, PPE)**	**Residual Risk**			**Person responsible for Controls**	**Status**	
			Consequence	**Likelihood**	**Risk Rating**		**Consequence**	**Likelihood**	**Risk Rating**			
Construction	**Working at heights**	**Risk of fall**	**4**	**3**	**12**	**•Use lifting devices such as trolleys & lifting gantries •Work off scaffold •Use personal awareness, site walkover (assess site hazards) •Control access to site, Daily Pre-start tool box meetings**	**2**	**2**	**4**	**Builder**	**Identified**	
Construction	**Working at heights**	**Falling objects**	**4**	**3**	**12**	**•Control access to site, Daily Pre-start tool box meetings •The use of barricades, fences, locks & site supervision**	**2**	**2**	**4**	**Builder**	**Identified**	
Construction	**Pipe work and Ductwork install**	**Crush injuries**	**4**	**3**	**12**	**•Use lifting devices such as trolleys & lifting gantries •Support and secure pipework •Use personal awareness, site walkover (assess site hazards) •Control access to**	**4**	**2**	**8**	**Builder**	**Identified**	

						site, Daily Pre-start tool box meetings					
Construction	**Lifting and carrying equipment**	**Muscle strain / sprain due to lifting & carrying equipment**	**3**	**3**	**9**	**•Use lifting devices such as trolleys & lifting gantries •Never lift and twist in one motion •Keep back straight during lift •Use lifting handles where supplied •If required use 2 person lift**	**3**	**1**	**3**	**Builder**	**Identified**
Construction	**Unauthorised personnel entering work area**	**Unauthorised personnel entering work area**	**4**	**3**	**8**	**•Control access to site, Daily Pre-start tool box meetings •The use of barricades, fences, locks & site supervision**	**3**	**1**	**3**	**Builder**	**Identified**
Construction	**Construction hoses & cables**	**Trips, slips & falls**	**3**	**3**	**9**	**•Use personal awareness, site walkover/driver (assess site hazards) •Control access to site, Daily Pre-start**	**3**	**1**	**3**	**Builder**	**Identified**

						tool box meetings •Remove hazard by either the use of cable holder to raise hazard off the floor or cable covers					
Construction	**Use of hand tools**	**Crush injuries during the use of hand tools**	**2**	**2**	**4**	**•Keep hands and fingers clear where possible •Cut resistant gloves**	**2**	**1**	**2**	**Builder**	**Identified**
Construction	**Elevated noise.**	**Hearing loss from elevated noise.**	**3**	**3**	**9**	**•Wear hearing protection. •Use engineering controls to isolate noisy equipment where possible i.e. enclose equipment**	**3**	**1**	**3**	**Builder**	**Identified**
Construction	**Electrical equipment**	**Electrocution**	**5**	**2**	**10**	**•All electrical field equipment must be tagged & tested every 3 months•Residual Current Devices (RCD's) are to be used for all extension leads & devices at the front of the circuit •Lockout Tagout process to be performed when conducting maintenance or if electrical equipment is faulty**	**5**	**1**	**5**	**Builder**	**Identified**

Construction	**Fire**	**Fire**	**4**	**2**	**8**	**•If there are ignition sources follow Hot Work Permit Procedure • fire extinguisher kept on site (Staff trained in extinguisher use)**	**4**	**1**	**4**	**Builder**	**Identified**
Construction	**Confined spaces**	**Confined spaces**	**5**	**2**	**10**	**only trained staff in confined spaces and do not work alone**	**5**	**1**	**5**	**Builder**	**Identified**
Construction	**Work on switchboards and electrical circuits**	**Electrocution**	**5**	**3**	**15**	**prove each circuit is dead prior to working . Use tag out process where practical. No live work should be required for this project.**	**5**	**1**	**5**	**Builder**	**Identified**
Maintenance	**Working at heights**	**Risk of fall**	**4**	**3**	**12**	**•Locate major equipment at ground level**	**1**	**1**	**1**	**Designer**	**Identified**
Maintenance	**Working at heights**	**Risk of fall**	**4**	**3**	**12**	**•Use lifting devices such as trolleys & lifting gantries •Work off scaffold •Use personal awareness, site walkover (assess site hazards) •Control access to site, Daily Pre-start tool box meetings**	**2**	**2**	**4**	**Builder**	**Identified**

Maintenance	**Working at heights**	**Falling objects**	**4**	**3**	**12**	**•Control access to site •The use of barricades, fences, locks & site supervision**	**2**	**2**	**4**	**Builder**	**Identified**
NORMAL HAZARDS/RISKS DURING ALL PHASES ARE THE RESPONSIBILITY OF THE RELEVANT PARTY DURING THE PHASE CONCERNED (E.G. CONTRACTOR DURING CONSTRUCTION, OWNER/OPERATOR DURING OPERATIONS, MAINTENANCE CONTRACTOR(S) DURING MAINTENANCE ETC.)											

SAFETY AND ENVIRONMENTAL HAZARD IDENTIFICATION/RISK ASSESSMENT

LIKELIHOOD

5	**Event will occur**	The event is a common occurrence on all projects
4	**Event almost certain to occur**	The event will probably / is likely to occur at least once during most projects
3	**Event may occur**	The event is possible to / might occur during some projects
2	**Event not likely to occur**	The event is unlikely to occur (though it could occur during similar work activities)
1	**Event rarely occurs**	The event could occur, but it is rare / only in exceptional circumstances

PROJECT (Level 1) RISK RATINGS

1-4	**Low**	*Maintain effectivements of current Controls and mange by routine procedures* *Monitoring and review schedule should be considered based on potential rapid escalation/volatility of the risk* *As required, provide risk update as relevant to governing body or management team and risk stakeholders*
5-8	**Medium**	*Within 3 months - evaluate for treatment planning requirements based on cost/benefit and resource prioritisation* *Quarterly - Review by risk owner. This includes risk treatment update (if applicable).* *As required, provide risk update as relevant to governing body or management team and risk stakeholders*
9-15	**High**	*Within 1 month - commence treatment planning for moderation* *Monthly - review by risk owner until risk is effectively moderated. This includes risk treatment status updates.* *Monthly - provide risk update as relevant to governing body or management tram and risk stakeholders*
16-25	**Extreme**	*As soon as possible (and within 1 month) commence treatment planning for moderation* *Monthly - review by risk owner until effectively moderated. This includes risk treatment status updates* *Monthly - provide risk update as relevant to governing body or management team (e.g. Project Board, Divisional Leadership Team, Executive Committee or Executive Management Team) and risk stakeholders*

	DESCRIPTOR	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
5	Event will occur	5 MEDIUM	10 HIGH	15 HIGH	20 EXTREME	25 EXTREME
4	Event almost certain to occur	4 LOW	8 MEDIUM	12 HIGH	16 EXTREME	20 EXTREME
3	Event may occur	3 LOW	6 MEDIUM	9 HIGH	12 HIGH	15 HIGH
2	Event not likely to occur	2 LOW	4 LOW	6 MEDIUM	8 MEDIUM	10 HIGH
1	Event rarely occurs	1 LOW	2 LOW	3 LOW	4 LOW	5 MEDIUM

Highest Level of Control ← → **Lowest Level of Control**

Elimination | Substitution | Isolation/Engineering | Administration | PPE

Level	Descriptor	CONSEQUENCE / SEVERITY / IMPACT
5	**Catastrophic**	*Reportable fatality (as defined by S35 Work Health * Safety Act (QLD) 2011)*
4	**Major**	*Serious injury or illness with permanent impairment (as defined by S36 Work Health & Safety Act (QLD) 2011)*
3	**Moderate**	*Lost time injury or serious injury or illness without permanent impairment (as defined by S36 Work Health & Safety Act (QLD) 2011)*
2	**Minor**	*Medical treatment injury. A full shift/workday has not been lost.*
1	**Insignificant**	*No injury. First aid treatment only. No time lost.*

ACESPEC SPECIFICATION REFERENCE

0701 MECHANICAL SYSTEMS

1 GENERAL

1.1 RESPONSIBILITIES

General
Requirement: Provide the mechanical services, as documented.

1.2 DESIGN

Design for durability and maintainability
Design for durability: Develop the design so the systems achieve the documented performance, reliability, service life, energy efficiency and safety requirements, and are easily maintainable.

Access for maintenance: Develop the design so the systems conform to **ACCESS FOR MAINTENANCE** ***in the 0703 General requirements mechanical worksection.*** ***Rev 2017-01***

Outdoor design conditions
Requirement: As documented.

Indoor design conditions
Requirement: As documented.

Heat rejection equipment design conditions
Requirement: Select heat rejection equipment in conformance with the **Heat rejection equipment design conditions schedule**.

1.3 PRECEDENCE

General
Order of precedence:

- The requirements of other worksections of the specification override conflicting requirements of this worksection.
- The requirements of the worksections override conflicting requirements of their referenced documents. The requirements of the referenced documents are minimum requirements.

1.4 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

Rotating and reciprocating machinery noise and vibration: Vibration severity in Zone A to AS 2625.1 and AS 2625.4.

1.5 REFERENCED DOCUMENTS

General
Requirement: Conform to the 0703 General requirements mechanical worksection. ***Rev 2017-01***

1.6 STANDARDS

General
Mechanical ventilation and air conditioning: To AS/NZS 1668.1 and AS 1668.2.

Microbial control: To AS/NZS 3666.1, AS/NZS 3666.2 and the recommendations of SAA/SNZ HB 32.

Refrigeration systems: To AS/NZS 1677.2 and the recommendations of the Australia and New Zealand Refrigerant Handling Code of Practice Part 1 and the Australia and New Zealand Refrigerant Handling Code of Practice Part 2.

Flammable refrigerants: To the recommendations of *AIRAH Flammable Refrigerants - Safety Guide*.

Plumbing, drainage and water supply: To AS/NZS 3500.0, AS/NZS 3500.1, AS/NZS 3500.2, AS/NZS 3500.3 and AS/NZS 3500.4 and the PCA.

1.7 INTERPRETATION

Definitions
General: For the purposes of this worksection the definitions given in the *0703 General requirements* mechanical worksection apply.

1.8 CONTRACT DOCUMENTS

General
Requirement: Conform to the 0703 General requirements mechanical worksection. ***Rev 2017-01***

1.9 SUBMISSIONS

General
Requirement: Conform to the 0703 General requirements mechanical worksection. ***Rev 2017-01***

Calculations
Requirement: Submit calculations as documented.

Certification
Requirement: Submit certification that the plant and equipment submitted meets the requirements and capacities of the contract documents except for departures that are identified in the submission.

Electrical loading information for mechanical services
General: Submit electrical loading information for all equipment before completion of the main switchboard shop drawings.

Loading and connection: Submit the information for items not supplied from the services switchboards.

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

Switchboards: Submit the following information for each building services switchboard:

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

Mechanical services shop drawings
Requirement: Submit the following detail drawings at minimum 1:100 scale, showing:

- Fire and smoke dampers including dimensional tolerances.
- Floor wastes.
- Ductwork, plinths, pipework and equipment layouts and sections. Show the location of fire-resisting building elements.
- Diffuser, grille, terminal and chilled beam reference numbers corresponding to design values and commissioning test results.
- Each item of equipment with its identifying name or code and key performance data.
- Riser layouts and sections.
- Plant room layouts and sections.
- Locations of automatic control sensors, motors and valves.
- Acoustic details.
- Conditioner construction details.
- Seismic restraint details.
- Provisions for access for maintenance and removal of components to **ACCESS FOR MAINTENANCE** ***in the 0703 General requirements mechanical worksection.*** ***Rev 2017-01***
- Lifting provisions for heavy items.

- Piping and other schematic drawings including numbering of each valve to correspond to the valve tag notation. For refrigerant piping include slope of horizontal runs, oil traps, double risers and valving.
- Submission drawings required by authorities.
- Connections to other services.
- Switchboard details.
- Wiring diagrams.

Operations and maintenance manuals

Requirement: Conform to the 0703 General requirements mechanical worksection. ***Rev 2017-01***

Smoke control systems: Document commissioning procedures, operation and maintenance to AS/NZS 1668.1.

Technical data

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

Equipment: Before ordering equipment, calculate the respective system pressure losses based on the equipment offered and layouts shown on the shop drawings and submit the proposed selections.

Submissions: Submit technical data for all items of plant and equipment.

Data to be submitted: Include at least the following information in technical submissions:

- Assumptions.
- Calculations.
- Model name, designation and number.
- Capacity of all system elements.
- Country of origin and manufacture.
- Materials used in the construction.
- Size, including required clearances for installation.
- Certification of conformance to the applicable code or standard.
- Technical data schedules corresponding to the equipment schedules in the contract documents. If there is a discrepancy between the two, substantiate the change.
- Manufacturers' technical literature.
- Type-test reports.

1.10 INSPECTION

Notice

Inspection: Give notice so inspection may be made where scheduled. ***Rev 2017-01***

2 EXECUTION

2.1 WORK ON EXISTING SYSTEMS

Equipment removal

General: Decommission, isolate, demolish and remove from the site all existing redundant equipment including minor associated components that become redundant as a result of the demolition.

Breaking down: Disassemble or cut up equipment where necessary to allow removal.

Recovered materials: Recover all components associated with the listed items. Minimise damage during removal and deliver to the locations documented.

Existing air and water systems

General: Before starting work on equipment measure the following:

- Existing air and water quantities.
- Total flows and pressure drops.
- Total and static pressures at significant points in the system.

Condition of existing systems:

- If the existing condition does not conform to the documented requirements in the contract documents, submit proposals to rectify the deficiencies with related costing, time and other impacts.
- Subject to the rectification works on existing systems, achieve the performance in the contract documents.

2.2 SUPPORT OF PLANT AND EQUIPMENT

Support of roof mounted plant and equipment

Platforms: If a horizontal platform is required, or the area of the plant and equipment is extensive, obtain the advice of a professional engineer for the documentation of a suitable platform.

Balustrades: If balustrades or screening are required, obtain the advice of a registered architect.

- Roof level support: If any of the following apply to roof level support, obtain the advice of a professional engineer:
  - The total load from any unit of plant or equipment exceeds 500 kg.
  - The load from a unit of plant or equipment to any single support point exceeds 100 kg.
  - The average loading of plant and equipment over the area extending 1 m on all sides beyond the plant and equipment exceeds 25 kg/m².
- Sloping roofs:
  - Roof slope ≥ 10°: Adopt the roof material manufacturer’s documented installation procedures, or seek the advice of a professional engineer.
  - Roof slope < 10°: Provide appropriate continuous supporting members, compatible with the roof material, laid parallel to the span of the roof sheeting. Extend the continuous support members in both directions to the first purlin or joist that is more than 1 m from the face of the plant or equipment it supports.

Support of ground level plant and equipment

Ground level: Conform to the following:

- If the ground slope is 15° or more, or the area of the plant and equipment is extensive, obtain the advice of a professional engineer for the documentation of a suitable slab or platform.
- In all other cases, provide proprietary plastic or concrete supports installed with falls that achieve a raised, impervious and water shedding bearing surface.

Balustrades: If balustrades or screening are required, obtain the advice of a registered architect.

2.3 INSTALLATION

Manufacturer's recommendations

Requirement: Install all items to manufacturer's recommendations.

0703 GENERAL REQUIREMENTS - MECHANICAL

1 GENERAL

This section is based on Natspec section 0171 General Requirements.

1.1 RESPONSIBILITIES

General
Noise levels: Install systems within the limits of the contract design and documented equipment performance and as documented in the **Noise level schedule**.

Performance
Structural: If required, provide structures, installations and components as follows:

- Fixed accessways: To AS 1657.
- Structural design actions: To the AS 1170 series.

1.2 DESIGN

Design development
General: The works include development of the design beyond that documented, as required.

Design by contractor: ***Develop the design so the systems achieve the documented performance and coordination with other building elements. Minor modifications will not be considered to be a variation to the contract.*** ***Rev 2018-01.***

Conflict with the documents: If it is believed that a conflict exists between statutory requirements and the documents, notify the contract administrator immediately and provide a recommendation to resolve the conflict.

1.3 PRECEDENCE

General
Order of precedence:

- The requirements of other worksections of the specification override conflicting requirements of this worksection.
- The requirements of the worksections override conflicting requirements of their referenced documents. The requirements of the referenced documents are minimum requirements.
-

1.4 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

Cross referencing styles
General: Within the text, titles are cross referenced using the following styles:

- Worksection titles are indicated by *Italicised* text.
- Subsection titles are indicated by **BOLD** text.
- Clause titles are indicated by **BOLD** text.
- Subclause titles are indicated by **Bold** text.

1.5 REFERENCED DOCUMENTS

Contractual relationships
General: Responsibilities and duties of the principal, contractor and contract administrator are not altered by requirements in the documents referenced in this specification.

Current editions
General: Use referenced documents which are the editions, with amendments, current 3 months before the closing date for tenders, except where other editions or amendments are required by statutory authorities.

1.6 INTERPRETATION

Documentation conventions
Imperative mood and streamlined language: The words shall or shall be are implied where a colon is used following a keyword or within a sentence or sentence fragment.

Subject of sentences and phrases: Specification requirements are to be performed by the contractor, unless stated otherwise.

Abbreviations
General: For the purposes of this specification the following abbreviations apply:

- AS: Australian Standard.
- BCA: National Construction Code Series Volume One: Building Code of Australia Class 2 to 9 Buildings and Volume Two: Building Code of Australia Class 1 and Class 10 Buildings.
- GRP: Glass Reinforced Plastic.
- IP: Ingress protection.
- NATA: National Association of Testing Authorities.
- NCC: National Construction Code.
- NZS: New Zealand Standard.
- PCA: National Construction Code Series Volume 3: Plumbing Code of Australia.
- PVC: Polyvinyl Chloride.
- PVC-U: Unplasticised Polyvinyl Chloride. Also known as UPVC.
- SDS: Safety data sheets.
- VOC: Volatile Organic Compound.
- WHS: Work Health and Safety.

Definitions
General: For the purposes of this specification, the following definitions apply:

- Access for maintenance: Includes access for maintenance, inspection, measurement, operation, adjustment, repair, replacement and other maintenance related tasks.
- Accessible, readily: Readily accessible, easily accessible, easy access and similar terms mean capable of being reached quickly and without climbing over or removing obstructions, mounting upon a chair, or using a movable ladder, and in any case not more than 2.0 m above the ground, floor or platform.
- Attendance: Attendance, provide attendance and similar expressions mean give assistance for examination and testing.
- Contract administrator: Has the same meaning as architect or superintendent and is the person appointed by the owner or principal under the contract.
- Contractor: Has the same meaning as builder and is the person or organisation bound to carry out and complete the work under the contract.
- Default: Specified value, product or installation method which is to be provided unless otherwise documented.
- Design life: The period of time for which it is assumed, in the design, that an asset will be able to perform its intended purpose with only anticipated maintenance but no major repair or replacement being necessary.
- Documented: Documented, as documented and similar terms mean contained in the contract documents.
- Economic life: The period of time from the acquisition of an asset to the time when the asset, while still physically capable of fulfilling its function and with only anticipated maintenance, ceases to be the lowest cost alternative for satisfying that function.

- Electricity distributor: Any person or organisation that provides electricity from an electricity distribution system to one or more electrical installations. Includes distributor, supply authority, network operator, local network service provider, electricity retailer or electricity entity, as may be appropriate in the relevant jurisdiction.
- Fire hazard properties: To BCA A2.4.
- Geotechnical site investigation: The process of evaluating the geotechnical characteristics of the site in the context of existing or proposed construction.
- Give notice: Give notice, submit, advise, inform and similar expressions mean give notice (submit, advise, inform) in writing to the contract administrator.
- High level interface: Systems transfer information in a digital format using an open system interface.
- Hot-dip galvanized: Zinc coated to AS/NZS 4680 after fabrication with coating thickness and mass to AS/NZS 4680 Table 1.
- Ingress protection: IP, IP code, IP rating and similar expression have the same meaning as IP Code in AS 60529.
- Joints:
  . Construction joint: A joint with continuous reinforcement provided to suit construction sequence.
  . Contraction joint: An opening control joint with a bond breaking coating separating the joint surfaces to allow independent and controlled contraction of different parts or components, induced by shrinkage, temperature changes or other causes. It may include unbound dowels to assist vertical deflection control.
  . Control joint: An unreinforced joint between or within discrete elements of construction which allows for relative movement of the elements.
  . Expansion joint: A closing control joint with the joint surfaces separated by a compressible filler to allow axial movement due to thermal expansion or contraction with changes in temperature or creep. It may include unbound dowels to assist vertical deflection control.
  . Sealant joint: A joint filled with a flexible synthetic compound which adheres to surfaces within the joint to prevent the passage of dust, moisture and gases.
  . Structural control joint: A control joint (contraction, expansion and isolation) in structural elements when used with applied material and finishes.
  . Substrate joint: A joint in the substrate which includes construction joints and joints between different materials.
  . Weakened plane joint: A contraction joint created by forming a groove, extending at least one quarter the depth of the section, either by using a grooving tool, by sawing, or by inserting a premoulded strip.
- Local (government) authority: A body established for the purposes of local government by or under a law applying in a state or territory.
- Low level interface: Systems transfer information via terminals and voltage free contacts.
- Manufacturer’s recommendations: Recommendations, instructions, requirements, specifications (and similar expressions) provided in written or other form by the manufacturer and/or supplier relating to the suitability, use, installation, storage and/or handling of a product.
- Metallic-coated: Steel coated with zinc or aluminium-zinc alloy as follows:
  . Metallic-coated steel sheet: To AS 1397. Metal thicknesses specified are based metal thicknesses.
  . Ferrous open sections zinc coated an in-line process: To AS/NZS 4791.
  . Ferrous hollow sections zinc coated by a continuous or specialised process: To AS/NZS 4792.
- Network utility operator: The entity undertaking the piped distribution of drinking water or natural gas for supply or is the operator of a sewerage system or external stormwater drainage system.
- Obtain: Obtain, seek and similar expressions mean obtain (seek) in writing from the contract administrator.
- Pipe: Includes pipe and tube.
- Practical completion or defects free completion: The requirements for these stages of completion are defined in the relevant building contract for the project.

- Principal: Principal has the same meaning as owner, client and proprietor and is the party to whom the contractor is legally bound to construct the works.
- Professional engineer: As defined by the BCA.
- Proprietary: Identifiable by naming the manufacturer, supplier, installer, trade name, brand name, catalogue or reference number.
- Prototype: A full size mock-up of components, systems or elements to demonstrate or test construction methods, junctions and finishes, and to define the level of quality.
- Provide: Provide and similar expressions mean supply and install and include development of the design beyond that documented.
- Record drawings: Record drawings has the same meaning as as-installed drawings, as-built drawings and work-as-executed drawings.
- Referenced documents: Standards and other documents whose requirements are included in this specification by reference.
- Registered Testing Authority:
  . An organisation registered by the National Association of Testing Authorities (NATA) to test in the relevant field; or
  . An organisation outside of Australia registered by an authority recognised by NATA through a mutual recognition agreement; or
  . An organisation recognised as being a Registered Testing Authority under legislation at the time the test was undertaken.
- Required: Required by the contract documents, the local council or statutory authorities.
- If required: A conditional specification term for work which may be shown in the documents or is a legislative requirement.
- Sample: A physical example that illustrates workmanship, materials or equipment, and establishes standards by which the work will be judged. It includes samples, prototypes and sample panels.
- Statutory authority: A public sector entity created by legislation, that is, a specific law of the Commonwealth, State or Territory.
- Supply: Supply, furnish and similar expressions mean supply only.
- Tests – completion: Tests carried out on completed installations or systems and fully resolved before the date for practical completion, to demonstrate that the installation or system, including components, controls and equipment, operates correctly, safely and efficiently, and meets performance and other requirements. The superintendent may direct that completion tests be carried out after the date for practical completion.
- Tests – pre-completion: Tests carried out before completion tests, including:
  . Production: Tests carried out on a purchased item, before delivery to the site.
  . Progressive: Tests carried out during installation to demonstrate performance in conformance with this specification.
  . Site: Tests carried out on site.
  . Type: Tests carried out on an item identical with a production item, before delivery to the site.
- Tolerance: The permitted difference between the upper limit and the lower limit of dimension, value or quantity.
- Verification: Provision of evidence or proof that a performance requirement has been met or a default exists.
- ***Or equal: Where an item is specified by name 'or equal' it is anticipated that the named product will be used. The term 'or equal' only allows substitution where the Superintendent's Representative gives approval for the item. A request for use of an 'equal' item shall be accompanied by a comparison with the originally nominated product showing in what way the product is superior and/or the associated cost savings.*** ***Rev 2017-01***

1.7 FAMILIARISATION WITH THE SITE

Prior to submitting tenders, it is recommended that the tenderer complete the following:

- ***Detailed inspection of the site to determine the full extent of required work. It is noted that the tenderer shall make an appointment with the Principal prior to attending site.***
- ***Inspect full structural and architectural documentation of the proposed construction.***
- ***No increase in the sub-contract sum will be approved for works that could have been ascertained by the above inspections.***

Rev 2022-5.

1.8 VARIATION CLAIMS

Variation claims for delays and additional costs for alternative delivery methods or similar will not be granted unless the following proofs are provided by the sub-contractor.

- ***The request for pricing during the tender period indicated that the delivery times required were not reasonable.***
- ***The order for equipment was placed with the required delivery date as soon as practical after acceptance of the sub-contract***
- ***All due care was taken during the delivery period to ensure that the required delivery date was met including follow-ups***
- ***The reason for late delivery was beyond the control of the sub-contractor and the supplier***
- ***Approved alternatives are not available***
- ***Such delays affect the contract critical path***

Rev 2022-5.

1.9 COMPLEMENTARY DOCUMENTS

The specification and drawings are complementary documents. Requirements indicated in one but not in the other shall still form part of the sub-contract.

Any conflict between the specification and the drawings shall be brought to the attention of the Superintendent's Representative who shall decide on which will apply. No variation will be applied for the completion of the work decided as applicable. ***Rev 2022-5.***

1.10 CONTRACT DOCUMENTS

Services diagrammatic layouts

General: Layouts of service lines, plant and equipment shown on the drawings are diagrammatic only, except where figured dimensions are provided or calculable.

Before commencing work:

- Obtain measurements and other necessary information.
- Coordinate the design and installation in conjunction with all trades ***and architectural details.***

Accurate details and dimensions shall be taken from the architectural drawings and at the site.

Rev 2022-5.

Levels

General: Spot levels take precedence over contour lines and ground profile lines.

Drawings and manuals for existing services

Subsurface services: Information shown on the drawings relating to underground or submerged services is accurate to the following quality level:

- Quality level to AS 5488

Warranty: No warranty is given as to the completeness or accuracy of drawings and/or manuals of existing services.

1.11 SUBMISSIONS

Requirement

General: Submit the following, as documented:

- Authority approvals: Notes of meetings with authorities whose requirements apply to the work and evidence that notices, fees and permits have been sought and paid, that authority connections are complete and that statutory approvals by the authorities whose requirements apply to the work have been received.
- Building penetrations: Details of the methods to maintain the required structural, fire and other properties to **EXECUTION**, **BUILDING PENETRATIONS**.
- Certification: Certification of conformance to documented requirements, including certification that the plant and equipment submitted meets all requirements of the contract documents and that each installation is operating correctly.
- Design documentation: Design data and certification of proposed work, if required and as documented.
- Electronic facility and asset management information: For the whole of the work to **EXECUTION**, **ELECTRONIC FACILITY AND ASSET MANAGEMENT INFORMATION**.
- Execution details: Execution programs, schedules and details of proposed methods and equipment. For building services include the following:
  . Embedded services: Proposed method for embedding services in concrete walls or floors or chasing into concrete or masonry walls.
  . Fixing of services: Typical details of locations, types and methods of fixing services to the building structure.
  . Inaccessible services: If services will be enclosed and not accessible after completion, submit proposals for location of service runs and fittings.
- Marking and labelling: Samples and schedules of proposed marking and labels to **EXECUTION**, **MARKING AND LABELLING.**
- Operation and maintenance manuals: For the whole of the work to **EXECUTION**, **OPERATION AND MAINTENANCE MANUALS**.
- Products: Products and materials data, including manufacturer's technical specifications and drawing, evidence of conformance to product certification schemes, performance and rating tables and installation and maintenance recommendations.
- Records: As-built documents, photographs, system diagrams, schedules and logbooks to **EXECUTION**, **RECORD DRAWINGS**.
- Samples: Representative of proposed products and materials and including proposals to incorporate samples into the works, if any to **EXECUTION**, **SAMPLES**.
- Shop drawings: To **EXECUTION**, **SHOP DRAWINGS**.
- Substitutions: To PRODUCTS**, GENERAL, Substitutions**.
- Tests:
  . Inspection and testing plan consistent with the construction program including details of test stages and procedures.
  . Certificates for type tests.
  . Fire hazard properties: Evidence of conformance of proposed proprietary products to documented requirements for fire hazard properties.
  . Test reports for testing performed under the contract to **EXECUTION**, **TESTS**.
- Warranties: To **EXECUTION**, **WARRANTIES**.

Contractor review: Before submissions, review each submission item and check for coordination with other work of the contract and conformance to contract documents.

Submission times

Default timing: Make submissions at least 5 working days before ordering products or starting installation of the respective portion of the works.

Submission response times: Allow in the construction program for times as scheduled.

Rev 2017-01

Proposed products schedules: If major products are not specified as proprietary items, submit a schedule of those proposed for use within 3 weeks of site possession.

Identification
Requirement: Identify the project, contractor, subcontractor or supplier, manufacturer, applicable product, model number and options, as appropriate and include relevant contract document references. Include service connection requirements and product certification.

Non-conformance: Identify proposals that do not conform with project requirements, and characteristics which may be detrimental to successful performance of the completed work.

Errors
Requirement: If a submission contains errors, make a new or amended submission as appropriate, indicating changes made since the previous submission.

Electronic submissions
Format and transmission medium as scheduled. ***Rev 2017-01***

1.12 INSPECTION

Notice
Concealment: If notice of inspection is required for parts of the works that are to be concealed, advise when the inspection can be made before concealment.

Tests: Give notice of the time and place of documented tests.

Minimum notice: As documented in the **Notices schedule**.

Light levels
Requirements: To AS/NZS 1680.2.4.

Attendance
General: Provide attendance for documented inspections and tests.

2 PRODUCTS

2.1 GENERAL

Manufacturers' or suppliers' recommendations
General: Provide and select, if no selection is given, transport, deliver, store, handle, protect, finish, adjust and prepare for use the manufactured items in conformance with the recommendations of the manufacturer or supplier.

Proprietary items/systems/assemblies: Assemble, install or fix to substrate in conformance with the recommendations of the manufacturer or supplier.

Project modifications: Advise of activities that supplement, or are contrary to the recommendations of the manufacturers or supplier.

Sealed containers
General: If materials or products are supplied by the manufacturer in closed or sealed containers or packages, bring the materials or products to point of use in the original containers or packages.

Prohibited materials
General: Do not provide the following:

- Materials, exceeding the limits of those listed, in the Safe Work Australia Hazardous Substances Information System (HSIS).
- Materials that use chlorofluorocarbon (CFC) or hydro chlorofluorocarbon (HCFC) in the manufacturing process.

Substitutions
Identified proprietary items: Identification of a proprietary item does not necessarily imply exclusive preference for the identified item, but indicates the necessary properties of the item.

Alternatives: If alternatives to the documented products, methods or systems are proposed, submit sufficient information to permit evaluation of the proposed alternatives, including the following:

- Evidence that the performance is equal to or greater than that specified.
- Evidence of conformity to a cited standard.
- Samples.
- Essential technical information, in English.

- Reasons for the proposed substitutions.
- Statement of the extent of revisions to the contract documents.
- Statement of the extent of revisions to the construction program.
- Statement of cost implications including costs outside the contract.
- Statement of consequent alterations to other parts of the works.

Availability: If the documented products or systems are unavailable within the time constraints of the construction program, submit evidence.

Criteria: If the substitution is for any reason other than unavailability, submit evidence that the substitution:

- Is of net enhanced value to the principal.
- Is consistent with the contract documents and is as effective as the identified item, detail or method.

2.2 MATERIALS AND COMPONENTS

Consistency

General: For each material or product use the same manufacturer or source and provide consistent type, size, quality and appearance.

Corrosion resistance

General: Conform to the following atmospheric corrosivity category as defined in AS 4312 and the AS/NZS 2312 series.

Galvanizing

Severe conditions: Galvanize mild steel components (including fasteners) to AS/NZS 1214 or AS/NZS 4680 as appropriate, if:

- Exposed to weather.
- Embedded in masonry.
- Exposed to or in air spaces behind the external leaf of masonry walls.
- In contact with chemically treated timber, other than copper chrome arsenate (CCA).

2.3 ALTERNATIVE PRODUCTS

Where alternative products from that specified are provided the contractor shall prove them as equal by providing specified and offered alternative information for comparison. Also the contractor shall complete all design calculations to show that the alternative product will meet all requirements of the design criteria.

Obtain design criteria from the Superintendent's Representative and include calculations within the maintenance manuals. **Rev 2018-01**

3 EXECUTION

3.1 SAMPLES

General

Incorporation of samples: Only incorporate samples in the works which have been endorsed for inclusion. Do not incorporate other samples.

Retention of samples: Keep endorsed samples in good condition on site, until the date of practical completion.

Unincorporated samples: Remove on completion.

3.2 SHOP DRAWINGS

General

Documentation: Include dimensioned drawings showing details of the fabrication and installation of structural elements, services and equipment, including relationship to building structure and other services, cable type and size, and marking details.

Diagrammatic layouts: Coordinate work shown diagrammatically in the contract documents, and prepare dimensioned set-out drawings.

Record drawings: Amend all documented shop drawings to include changes made during the progress of the work and up to the end of the defects liability period.

Services coordination: Coordinate with other building and service elements. Show adjusted positions on the shop drawings.

Space requirements: Check space and access for maintenance requirements of equipment and services indicated diagrammatically in the contract documents.

Building work drawings for building services: On dimensioned drawings show all relevant:

- Access doors and panels.
- Conduits to be cast in slabs.
- Holding down bolts and other anchorage and/or fixings required complete with loads to be imposed on the structure during installation and operation.
- Openings, penetrations and block-outs.
- Sleeves.
- Plinths, kerbs and bases.
- Required external openings.

3.3 OFF-SITE DISPOSAL

Removal of material

General: Dispose of building waste material off site to the requirements of the relevant authorities.

3.4 WALL CHASING

Holes and chases

General: If holes and chases are required in masonry walls, make sure structural integrity of the wall is maintained. Do not chase walls nominated as fire-resistance or acoustic rated.

Parallel chases or recesses on opposite faces of a wall: Not closer than 600 mm to each other.

Chasing in blockwork: Only in core-filled hollow blocks or in solid blocks which are not designated as structural.

Concrete blockwork chasing table

Block thickness (mm)	Maximum depth of chase (mm)
190	35
140	25
90	20

3.5 FIXING

General

Suitability: If equipment is not suitable for fixing to non-structural building elements, fix directly to structure and trim around penetrations in non-structural elements.

Fasteners

General: Use proprietary fasteners capable of transmitting the loads imposed, and sufficient for the rigidity of the assembly.

3.6 SERVICES CONNECTIONS

Connections
General: Connect to network distributor services or service points. Excavate to locate and expose connection points. Reinstate the surfaces and facilities that have been disturbed.

Network distributors' requirements
General: If the network distributor elects to perform or supply part of the works, make the necessary arrangements. Install equipment supplied, but not installed, by the authorities.

3.7 SERVICES INSTALLATION

General
Fixing: If non-structural building elements are not suitable for fixing services to, fix directly to structure and trim around holes or penetrations in non-structural elements.

Installation: Install equipment and services plumb, fix securely and organise reticulated services neatly. Allow for movement in both structure and services.

Concealment: Unless otherwise documented, conceal all cables, ducts, trays and pipes except where installed in plant spaces, ceiling spaces and riser cupboards. If possible, do not locate on external walls.

Lifting: Provide heavy items of equipment with permanent fixtures for lifting as recommended by the manufacturer.

Suspended ground floors: Keep all parts of services under suspended ground floors at least 150 mm clear of the ground surface. Make sure services do not impede access.

Arrangement: Arrange services so that services running together are parallel with each other and with adjacent building elements.

Dissimilar metals
General: Join dissimilar metals with fittings of electrolytically compatible material.

Temporary capping
Pipe ends: During construction protect open ends of pipe with metal or plastic covers or caps.

Piping
General: Install piping in straight lines at uniform grades without sags. Arrange to prevent air locks. Provide sufficient unions, flanges and isolating valves to allow removal of piping and fittings for maintenance or replacement of plant.

Spacing: Provide at least 25 mm clear between pipes and between pipes and building elements, additional to insulation.

Changes of direction: Provide long radius elbows or bends and sets where practicable, and swept branch connections. Provide elbows or short radius bends where pipes are led up or along walls and then through to fixtures. Do not provide mitred fittings.

Vibration: Arrange and support piping so that it remains free from vibration whilst permitting necessary movements. Minimise the number of joints.

Embedded pipes: Do not embed pipes that operate under pressure in concrete or surfacing material.

Valve groupings: If possible, locate valves in groups.

Pressure testing precautions: Isolate items not rated for the test pressure. Restrain pipes and equipment to prevent movement during pressure testing.

Differential movement
General: If the geotechnical site investigation report predicts differential movements between buildings and the ground in which pipes or conduits are buried, provide control joints in the pipes or conduits, as follows:

- Arrangement: Arrange pipes and conduits to minimise the number of control joints.
- Magnitude: Accommodate the predicted movements.

3.8 BUILDING PENETRATIONS

General

Requirement: Unless specified to be completed by other trades, complete all penetrations and sealing to make good. **Rev 2018-01**

Penetrations

Requirement: Maintain the required structural, fire and other properties when penetrating or fixing to the following:

- Structural building elements including external walls, fire walls, fire doors and access panels, other tested and rated assemblies or elements, floor slabs and beams.
- Membrane elements including damp-proof courses, waterproofing membranes and roof coverings. If penetrating membranes, provide a waterproof seal between the membrane and the penetrating component.

Flashings

Requirement: Provide under and over-flashings to maintain the building as waterproof. **Rev 2018-01**

Sealing

Fire-resisting building elements: Seal penetrations with a system conforming to AS 4072.1.

Non fire-resisting building elements: Seal penetrations around conduits and sleeves. Seal around cables within sleeves. If the building element is acoustically rated, maintain the rating.

Sleeves

General: If piping or conduit penetrates building elements, provide metal or PVC-U sleeves formed from pipe sections as follows:

- Movement: Arrange to permit normal pipe or conduit movement.
- Diameter (for non fire-resisting building elements): Sufficient to provide an annular space around the pipe or pipe insulation of at least 12 mm.
- Prime paint ferrous surfaces.
- Terminations:
  - If cover plates are fitted: Flush with the finished building surface.
  - In fire-resisting and acoustic rated building elements: 50 mm beyond finished building surface.
  - In floors draining to floor wastes: 50 mm above finished floor.
  - Elsewhere: 5 mm beyond finished building surface.
  - Termite management: To AS 3660.1.
- Thickness:
  - Metal: 1 mm or greater.
  - PVC-U: 3 mm or greater.

Sleeves for cables: For penetrations of cables not enclosed in conduit through ground floor slabs, beams and external walls provide sleeves formed from PVC-U pipe sections.

3.9 CONCRETE PLINTHS

Construction

General: Provide concrete plinths as documented and under all equipment located on concrete floor slabs as follows:

- Height: 75 mm or greater, as documented.
- Concrete: Grade N20.
- Finish: Steel float flush with the surround.
- Reinforcement: Single layer of F62 fabric.
- Surround: Provide galvanized steel surround at least 75 mm high and 1.6 mm thick. Fix to the floor with masonry anchors. Fill with concrete.

3.10 SUPPORT AND STRUCTURE

General
Requirement: Provide incidental supports and structures to suit the services.

3.11 PIPE SUPPORTS

Support systems
General: Provide proprietary support systems of metallic-coated steel construction.

Vertical pipes: Provide anchors and guides to maintain long pipes in position, and supports to balance the mass of the pipe and its contents.

Saddles: Do not provide saddle type supports for pipes greater than DN 25.

Dissimilar metals: If pipe and support materials are dissimilar, provide industrial grade electrically non-conductive material securely bonded to the pipe to separate them. Provide fixings of electrolytically compatible material.

Uninsulated pipes: Clamp piping supports directly to pipes.

Insulated pipes:

- Spacers: Provide spacers at least as thick as the insulation between piping supports and pipes. Extend either side of the support by at least 20 mm.
- Spacer material: Rigid insulation material of sufficient strength to support the piping and suitable for the temperature application.

Support spacing
Cold and heated water pipes: To AS/NZS 3500.1 Table 5.6.4. Provide additional brackets, clips or hangers to prevent pipe movement caused by water pressure effects.

Sanitary plumbing: To AS/NZS 3500.2 Table 10.2.1.

Fuel gas: To AS/NZS 5601.1 Table 5.5.

Other pipes: To AS/NZS 3500.1 Table 5.6.4.

Hanger size table

Nominal pipe size (DN)	Minimum hanger diameter for single hangers (mm)
50 maximum	9.5
65 to 90	12.7
100 to 125	15.8
150 to 200	19.0

3.12 PLANT AND EQUIPMENT

General
Location: Locate so that failure of plant and equipment (including leaks) does not create a hazard for the building occupants and causes a minimum or no damage to the building, its finishes and contents including water sensitive equipment or finishes.

Safe tray and an overflow pipe: Provide to each tank, hot water heater and storage vessel.

3.13 ACCESS FOR MAINTENANCE

General
Requirement: Provide access for maintenance of plant and equipment.

Standards: Conform to the relevant requirements of AS 1470, AS 1657, AS/NZS 1892.1, AS 2865 and AS/NZS 3666.1.

Work Health and Safety: Conform to the requirements of the applicable Work Health and Safety regulations.

Protection from injury: Protect personnel from injury caused by contact with objects including those that are sharp, hot or protrude at low level.

Trip hazards: Do not run small services including drains and conduits across floors where they may be a trip hazard.

Manufacturer's standard equipment: Modify manufacturer's standard equipment when necessary to provide the plant access documented.

Clearances

Minimum clearances for access: Conform to the following:

- ≥ 2100 mm clear vertically above horizontal floors, ground and platforms.
- Preferably ≥ 750 m clear, but in no case less than 600 mm horizontally between equipment or between equipment and building features including walls.
- If tools are required to operate, adjust or remove equipment, provide sufficient space so that the tools can be used in their normal manner and without requiring the user to employ undue or awkward force.
- If equipment components are hinged or removable, allow the space recommended by the manufacturer.
- Within plant items: Conform to the preceding requirements, and in no case less than the clearances recommended in BS 8313.

Elevated services other than in occupied areas

Access classifications:

- Access class A: Readily accessible. Provide clear and immediate access to and around plant items. If plant or equipment is located more than 2.0 m above the ground, floor or platform, provide a platform with handrails accessible by a stair, all to AS 1657.
- Access class B: If the plant item requiring access is located more than 2.0 m above the ground, floor or platform, provide a platform with handrails accessible by a non-vertical ladder, all to AS 1657.
- Access class C: Locate plant so that temporary means of access conforming to Work health and Safety regulations can be provided.

Temporary means of access: Make sure there is adequate provision in place which is safe and effective.

Areas in which access is restricted to authorised maintenance personnel: Provide access as follows:

- Instruments, gauges and indicators (including warning and indicating lights) requiring inspection at any frequency: Readily accessible.
- Access required monthly or more frequently: Access class A.
- Access required between monthly and six monthly: Access class A or B.
- Access required less frequently than six monthly: Access class A, B or C.

Other areas: Provide access as follows:

- Locate to minimise inconvenience and disruption to building occupants or damage to the building structure or finishes.
- In suspended ceilings, locate items of equipment that require inspection and/or maintenance above tiled parts. If not possible, provide access panels where located above set plaster or other inaccessible ceilings. Arrange services and plant locations to reduce the number of access panels. Coordinate with other trades to use common access panels where feasible.
- Do not locate equipment requiring access above partitions.
- Instruments, gauges and other items requiring inspection at any frequency: Readily accessible.
- Labelling: If equipment is concealed in ceilings, provide marking to **MARKING AND LABELLING**, **Equipment concealed in ceilings**.

Facilities for equipment removal and replacement

Requirement: Provide facilities to permit removal from the building and replacement of plant and equipment, including space large enough to accommodate it and any required lifting and/or transportation equipment. Arrange plant so that large and/or heavy items can be moved with the minimum of changes of direction.

Removal of components: Allow sufficient space for removal and replacement of equipment components including air filters, tubes of shell and tube heat exchangers, removable heat exchanger bundles, coils and fan shafts. Provide access panels or doors large enough to permit the safe removal and replacement of components within air handling units.

Facilities for access

Equipment behind hinged doors: Provide doors opening at least 150°.

Equipment behind removable panels: Provide panels with quick release fasteners or captive metal thread screws.

Removable panels: Provide handles to permit easy and safe removal and replacement.

Insulated plant and services: If insulation must be removed to access plant and services provide access for maintenance, arranged so it can be repeatedly removed and replaced without damage.

Piping

Requirement: Conform to the following:

- Provide access and clearance at fittings which require maintenance, inspection or servicing, including control valves and joints intended to permit pipe removal.
- Arrange piping so that it does not interfere with the removal or servicing of associated equipment or valves or block access or ventilation openings.
- Preferably run piping, conduits, cable trays and ducts at high level and drop vertically to equipment.

Electrical and controls

Electrical equipment: Provide clearances and access space to AS/NZS 3000.

Switchboards and electrical control equipment: Locate near the main entrance to plant space. Arrange plant so that, to the greatest extent possible, switchboards are visible from the plant being operated.

Control panels: Locate near and visible from the plant controlled.

3.14 VIBRATION SUPPRESSION

General

Requirement: Minimise the transmission of vibration from rotating or reciprocating equipment to other building elements.

Standard

Rotating and reciprocating machinery noise and vibration: Vibration severity in Zone A to AS 2625.1 and AS 2625.4.

Speeds

General: If no maximum speed is prescribed do not exceed 1500 r/min for direct driven equipment.

Connections

General: Provide flexible connections to rotating machinery and assemblies containing rotating machinery. Isolate pipes by incorporating sufficient flexibility into the pipework or by use of proprietary flexible pipe connections installed so that no stress is placed on pipes due to end reaction.

Inertia bases

General: If necessary to achieve the required level of vibration isolation, provide inertia bases having appropriate mass and conforming as follows:

- Construction: Steel or steel-framed reinforced concrete. Position foundation bolts for equipment before pouring concrete.
- Supports: Support on vibration isolation mountings using height saving support brackets.

Vibration isolation mountings

General: Except for external equipment that is not connected to the structure of any building, support rotating or reciprocating equipment on mountings as follows:

- For static deflections < 15 mm: Single or double deflection neoprene in-shear mountings incorporating steel top and base plates and a tapped hole for bolting to equipment.
- For static deflections ≥ 15 mm: Spring mountings.

Selection: Provide mountings selected to achieve 95% isolation efficiency at the normal operating speeds of the equipment.

Installation: Set and adjust vibration isolation mounting supports to give clearance for free movement of the supports.

Spring mountings: Provide freestanding laterally stable springs as follows:

- Clearances: ≥ 12 mm between springs and other members such as bolts and housing.
- High frequency isolation: 5 mm neoprene acoustic isolation pads between baseplate and support.

- Levelling: Provide bolts and lock nuts.
- Minimum travel to solid: ≥ 150% of the designated minimum static deflection.
- Ratio of mean coil diameter to compressed length at the designated minimum static deflection: ≥ 0.8:1.
- Snubbing: Snub the springs to prevent bounce at start-up.
- Vertical resilient limit stops: To prevent spring extension when unloaded, to serve as blocking during erection and which remain out of contact during normal operation.
-

3.15 SEISMIC RESTRAINT OF NON-STRUCTURAL COMPONENTS

General

Buildings designated as either Earthquake Design Category II or III shall have mechanical components restrained against seismic forces as detailed in AS 1170.4. *Rev 2019-06*

Referenced documents. *Rev 2019-06*
AS 1170.4 – Minimum Design Loads on Structures – Part 4: Earthquake Loads. ***Rev 2017-01***

Components

The following mechanical components and their connections shall be designed for seismic restraints as detailed in AS 1170.4:

1. ***Smoke control systems.***
2. ***Life safety system components.***
3. ***Boilers, furnaces, incinerators, water heaters, and other equipment using combustible energy sources or high-temperature energy sources, chimneys. Flues, smokestacks, vents and pressure vessels.***
4. ***Reciprocating or rotating equipment.***
5. ***Utility and service interfaces.***
6. ***Anchorage of lift machinery and controllers.***
7. ***Machinery.***
8. ***Electrical panel boards.***
9. ***Ducts and piping distribution systems.***
10. ***Supports for ducts and piping distribution systems, except supports in the following situations:***

- ***For gas piping less than 25mm inside diameter.***
- ***For piping in boiler and mechanical rooms less than 32mm inside diameter***
- ***For all other piping less than 64mm inside diameter.***
- ***For all electrical conduit less than 64mm inside diameter.***
- ***For all rectangular air-handling ducts less than 0.4m² in cross-sectional area.***
- ***For all round air-handling ducts less than 700mm in diameter.***
- ***For all ducts and piping suspended by individual hangers 300mm or less in length from the top of the pipe to the bottom of the support for the hanger.*** *Rev 2019-06*

Coordination

All components that are connected to building structure shall be coordinated with the relevant trade. Connection details and the mass of components and allow for the seismic design of the structural elements. *Rev 2019-06*

Seismic Restraint Design

Design and install all systems, plant and equipment, fixings, supports, mountings, hangers and attachments in accordance with AS 1170.4

The Contractor shall design seismic restraints in accordance with AS 1170.4, based on equipment selected. Seismic restraints are to be designed by an RPEQ and the seismic restraint design and associated Form 15 are to be submitted for review as part of the mechanical services shop drawings. *Rev 2019-06*

Seismic Mounts

Vibration isolation mounts, including spring mounts and rubber mounts, shall be restrained against both horizontal and vertical motion. Mounts shall be capable of withstanding the earthquake forces in accordance with AS 1170.4. *Rev 2019-06*

Where seismic mounts are not practical, restrain equipment with all directional seismic snubbers, capable of withstanding the earthquake forces in accordance with AS 1170.4.

Rev 2019-06

3.16 FINISHES TO BUILDING SERVICES

General

Requirement: If exposed to view (including in plant rooms), paint building services and equipment.

Surfaces painted or finished off-site: Conform to the *0183 Metals and prefinishes* worksection.

Exceptions: Do not paint chromium or nickel plating, anodised aluminium, GRP, stainless steel, non-metallic flexible materials and normally lubricated machined surfaces. Surfaces with finishes applied off-site need not be re-painted on-site provided the corrosion resistance of the finish is not less than that of the respective finish documented.

Standard: Conform to the recommendations of AS/NZS 2311 Sections 3, 6 and 7 or AS/NZS 2312.1 Sections 6, 7 and 8, as applicable.

Powder coating

Standard: Conform to the following:

- Aluminium for architectural applications: To AS 3715.
- Other metals: To AS 4506.

Painting systems

New unpainted interior surfaces: To AS/NZS 2311 Table 5.1.

New unpainted exterior surfaces: To AS/NZS 2311 Table 5.2.

Paint application

Coats: Apply the first coat immediately after substrate preparation and before contamination of the substrate can occur. Make sure each coat of paint or clear finish is uniform in colour, gloss, thickness and texture and free of runs, sags, blisters or other discontinuities.

Combinations: Do not combine paints from different manufacturers in a paint system.

Protection: Remove fixtures before starting to paint and refix in position undamaged when painting is complete.

Underground metal piping

Corrosion protection: Provide corrosion protection for the following:

- Underground ferrous piping.
- Underground non-ferrous metal piping in corrosive environments.

Protection methods: Select from the following:

- Cathodic protection: Sacrificial anodes or impressed current. Incorporate a facility for periodic testing. Conform to the recommendations of AS 2832.1.
- Continuous wrapping using proprietary petroleum taping material.
- Impermeable flexible plastic coating.
- Sealed polyethylene sleeve.

Low VOC emitting paints

Paint types: To the recommendations of AS/NZS 2311 Table 4.2.

3.17 MARKING AND LABELLING

General

Requirement: Mark and label services and equipment for identification purposes as follows:

- Locations exposed to weather: Provide durable materials.

- Pipes, conduits and ducts: To AS 1345 throughout its length, including in concealed spaces.
- Cables: Label to indicate the origin and destination of the cable.

Consistency: Label and mark equipment using a consistent scheme across all services elements of the project.

Label samples and schedules

Submission timing: Before marking or labelling.

Schedule: For each item or type of item include the following:

- A description of the item or type of item for identification.
- The proposed text for marking or labelling.
- The proposed location of the marking and labelling.

Electrical accessories

Circuit identification: Label isolating switches and outlets to identify circuit origin.

Operable devices

Requirement: Mark to identify the following:

- Controls.
- Indicators, gauges, meters.
- Isolating switches.

Equipment concealed in ceilings

Location: Provide a label on the ceiling, indicating the location of each concealed item requiring access for routine inspection, maintenance and/or operation. In tiled ceilings, locate the label on the ceiling grid closest to the item access point. In flush ceilings, locate adjacent to closest access panel. Items to be labelled include but are not limited to:

- Fan coil units and terminal equipment (e.g. VAV terminals).
- Fire and smoke dampers.
- Isolating valves not directly connected to items otherwise labelled.
- Motorised dampers.
- Wall mounted equipment in occupied areas: Provide labels on wall mounted items in occupied areas including the following:
  - Services control switches.
  - Temperature and humidity sensors.
  - Filters.

Points lists

Automatic control points: Provide plasticised, fade-free points lists for each automatic control panel. Store in a pocket on the door of the panel. Lists to include terminal numbers, point addresses, short and long descriptors.

Pressure vessels

General: Mount manufacturer’s certificates in glazed frames on a wall next to the vessel.

Valves and pumps

General: Label to associate pumps with their starters and valves. Screw fix labels to body or attach label to valve handwheels with a key ring.

Underground services

Survey: Accurately record the routes of underground cables and pipes before backfilling. Include on the record drawings.

Records: Provide digital photographic records of underground cable and pipe routes before backfilling. Include in operation and maintenance manual.

Location marking: Accurately mark the location of underground cables and pipes with route markers consisting of a marker plate set flush in a concrete base, engraved to show the direction of the line and the name of the service.

Markers: Place markers at ground level at each joint, route junction, change of direction, termination and building entry point and in straight runs at intervals of not more than 100 m.

Marker bases: 200 mm diameter x 200 mm deep, minimum concrete.

Direction marking: Show the direction of the cable and pipe run by means of direction arrows on the marker plate. Indicate distance to the next marker.

Plates: Brass, aluminium or stainless steel with black filled engraved lettering, minimum size 75 x 75 x 1 mm thick.

Plate fixing: Waterproof adhesive and 4 brass or stainless steel countersunk screws.

Marker height: Set the marker plate flush with paved surfaces, and 25 mm above other surfaces.

Marker tape: Where electric bricks or covers are not provided over underground wiring, provide a 150 mm wide yellow or orange marker tape bearing the words WARNING – electric cable buried below, laid in the trench 150 mm below ground level.

Labels and notices

Materials: Select from the following:

– engraved two-colour laminated plastic. ***Rev 2019-07***

Emergency functions: To AS 1319.

Colours: Generally to AS 1345 as appropriate, otherwise black lettering on white background except as follows:

- Danger, warning labels: White lettering on red background.
- Main switch and caution labels: Red lettering on white background.

Edges: If labels exceed 1.5 mm thickness, radius or bevel the edges.

Labelling text and marking: To correspond to terminology and identifying number of the respective item as shown on the record drawings and documents and in operating and maintenance manuals.

Lettering heights:

- Danger, warning and caution notices: Minimum 10 mm for main heading, minimum 5 mm for remainder.
- Equipment labels within cabinets: Minimum 3.5 mm.
- Equipment nameplates: Minimum 40 mm.
- Identifying labels on outside of cabinets: Minimum 5 mm.
- Isolating switches: Minimum 5 mm.
- Switchboards, main assembly designation: Minimum 25 mm.
- Switchboards, outgoing functional units: Minimum 8 mm.
- Switchboards, sub assembly designations: Minimum 15 mm.
- Valves: Minimum 20 mm.
- Self-adhesive flexible plastic labels:
  . Labels less than 2000 mm above floor: 3 mm on 6 mm wide tape.
  . Labels minimum 2000 mm above floor: 8 mm on 12 mm wide tape.
  . Other locations: Minimum 3 mm.

Label locations: Locate labels so that they are easily seen and are either attached to, below or next to the item being marked.

Fixing: Fix labels securely using screws, rivets, proprietary self-adhesive labels or double-sided adhesive tape and as follows:

- If labels are mounted in extruded aluminium sections, use rivets or countersunk screws to fix the extrusions.
- Use aluminium or monel rivets for aluminium labels.

Vapour barriers: Do not penetrate vapour barriers.

3.18 SOFTWARE

General

Requirement: Provide the software required for the operation and management of building services systems and equipment.

3.19 WARRANTIES

General

Requirement: If a warranty is documented, name the principal as warrantee. Register with manufacturers as necessary. Retain copies delivered with components and equipment.

Warranty period: Start warranty periods at acceptance of installation.

Approval of installer: If installation is not by manufacturer, and product warranty is conditional on the manufacturer's approval of the installer, submit the manufacturer's written approval of the installing firm.

3.20 RECORD DRAWINGS

General

Requirement: Show the following:

- Installed locations of building elements, services, plant and equipment.
- Off-the-grid dimensions and depth if applicable.
- Any provisions for the future.

Recording, format and submission

Progress recording: Keep one set of drawings on site at all times, expressly for the purpose of marking changes made during the progress of the works.

Drawing layout: Use the same borders and title block as the contract drawings.

Quantity and format: Conform to format scheduled for shop drawings**.**

Endorsement: Sign and date all record drawings.

Accuracy: If errors in, or omissions from, the record drawings are found, amend the drawings and re-issue in the quantity and format documented for **SUBMISSIONS.**

Date for submission: Not later than 2 weeks after the date for practical completion.

Services record drawings

General: To **General** and **Recording, format and submission** and the following:

- Contents: As for the respective shop drawings.
- Extensions and/or changes to existing: If a drawing shows extensions and/or alterations to existing installations, include sufficient of the existing installation to make the drawing comprehensible without reference to drawings of the original installation.
- Detention: If on-site detention tanks or pondage are provided, include the volume required on the drawing and the permitted flow rate to the connected system.
- Domestic cold water or fire mains: Show the pressure available at the initial connection point and the pressure available at the most disadvantaged location on each major section of the works.
- Stormwater: If storm water pipes are shown, include the pipe size and pipe grade together with the maximum acceptable flow and the actual design flow.

Diagrams: Provide diagrammatic drawings of each system including the following:

- Controls.
- Piping including all valves and valve identification tags.
- Principal items of equipment.
- Single line wiring diagrams.
- Acoustic and thermal insulation.
- Access provisions and space allowances.
- Fixings.
- Fixtures.
- Switchgear and control gear assembly circuit schedules including electrical service characteristics, controls and communications.
- Charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.

Subsurface services: Record information on underground or submerged services to the documented quality level, conforming to AS 5488.

3.21 OPERATION AND MAINTENANCE MANUALS

General

Authors and compilers: Personnel experienced in the maintenance and operation of equipment and systems installed, and with editorial ability.

Referenced documents: If referenced documents or technical worksections require that manuals be submitted, include corresponding material in the operation and maintenance manuals.

Subdivision: By installation or system, depending on project size.

Contents

Requirement: Include the following:

- Table of contents: For each volume. Title to match cover.
- Directory: Names, addresses, email addresses and telephone and facsimile numbers of principal consultant, subconsultants, contractor, subcontractors and names of responsible parties.
- Record drawings: Complete set of record drawings, full size.
- Drawings and technical data: As necessary for the efficient operation and maintenance of the installation. Include:
  - . Switchgear and controlgear assembly circuit schedules including electrical service characteristics, controls and communications.
  - . Charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
- Installation description: General description of the installation.
- Systems descriptions and performance: Technical description of the systems installed and mode of operation, presented in a clear and concise format readily understandable by the principal's staff. Identify function, normal operating characteristics, and limiting conditions.
- Systems performance: Technical description of the mode of operation of the systems installed.
- Baseline data: To AS 1851 and AS/NZS 1668.1.
- Documentation to AS 1851 including the schedule of essential functionality and performance requirements.
- Digital photographic records to **Underground services**.
- Equipment descriptions:
  - . Name, address, email address and telephone and facsimile numbers of the manufacturer and supplier of items of equipment installed, together with catalogue list numbers.
  - . Schedules (system by system) of equipment, stating locations, duties, performance figures and dates of manufacture. Provide a unique code number cross-referenced to the record and diagrammatic drawings and schedules, including spare parts schedule, for each item of equipment installed. Equipment schedules in tabular form including the equipment designation used on the drawings, manufacturer's name and contact details, equipment name plate data, function of item, associated system and capacity data.
  - . Manufacturers' technical literature for equipment installed, assembled specifically for the project, excluding irrelevant matter. Mark each product data sheet to clearly identify specific products and component parts used in the installation, and data applicable to the installation.
  - . Supplements to product data to illustrate relations of component parts. Include typed text as necessary.
- Certificates:
  - . Certificates from authorities.
  - . Copies of manufacturers' warranties.
  - . Product certification.
  - . Test certificates for each service installation and all equipment.
  - . Test reports

  - Test, balancing and commissioning reports.
  - Control system testing and commissioning results.
- 7 day record of all trends at commissioning.
- Operation procedures:
  - Manufacturers' technical literature as appropriate.
  - Safe starting up, running-in, operating and shutting down procedures for systems installed. Include logical step-by-step sequence of instructions for each procedure.
  - Control sequences and flow diagrams for systems installed.
  - Legend for colour-codes services.
  - Schedules of fixed and variable equipment settings established during commissioning and maintenance.
  - Procedures for seasonal changeovers.
  - If the installation includes cooling towers, a water efficiency management plan.
- Maintenance procedures:
  - Detailed recommendations for periodic maintenance and procedures, including schedule of maintenance work including frequency and manufacturers' recommended tests.
  - Manufacturer's technical literature as appropriate. Register with manufacturer as necessary. Retain copies delivered with equipment.
  - Safe trouble-shooting, disassembly, repair and reassembly, cleaning, alignment and adjustment, balancing and checking procedures. Provide logical step-by-step sequence of instructions for each procedure.
  - Schedule of spares recommended to be held on site, being those items subject to wear or deterioration and which may involve the principal in extended deliveries when replacements are required. Include complete nomenclature and model numbers, and local sources of supply.
  - Schedule of normal consumable items, local sources of supply ,and expected replacement intervals up to a running time of 40 000 hours. Include lubrication schedules for equipment.
  - Schedules for recording recommissioning data so that changes in the system over time can be identified.
  - Instructions for use of tools and testing equipment.
  - Emergency procedures, including telephone numbers for emergency services, and procedures for fault finding.
  - Safety data sheets (SDS).
  - Instructions and schedules conforming to AS 1851, AS/NZS 3666.2, AS/NZS 3666.3 and AS/NZS 3666.4.
- Maintenance records:
  - Prototype service records conforming to AS 1851 prepared to include project specific details.
  - Prototype periodic maintenance records and report to AS/NZS 3666.2, AS/NZS 3666.3 and AS/NZS 3666.4 as appropriate, prepared to include project specific details.
  - For hard copies: In binders which match the manuals, loose leaf log book pages designed for recording completion activities including operational and maintenance procedures, materials used, test results, comments for future maintenance actions and notes covering the condition of the installation. Include completed log book pages recording the operational and maintenance activities performed up to the time of practical completion.
  - Number of pages: The greater of 100 pages or enough pages for the maintenance period and a further 12 months.
- Emergency information: For each type of emergency, including fire, flood, gas leak, water leak, power failure, water failure, system or sub system failure, chemical release or spill, include the following:
  - Emergency instructions.
  - Emergency procedures including:
    * Instructions for stopping or isolating.

* Shutdown procedures and sequences.
* Instructions for actions outside the property.
* Special operating instructions relevant to the emergency.
* Contact details relevant to the emergency.

Emergency information manual

Form of emergency information: Provide one of the following:

- An index and coloured tabs identifying emergency information for each type of emergency within the Operation and maintenance manual.
- A separate Emergency manual containing copies of emergency information from the main Operation and maintenance manual.

Format – electronic copies

Scope: Provide the same material as documented for hardcopy in electronic format.

Quantity and format: Conform to **SUBMISSIONS , Electronic submissions**.

Printing: Except for drawings required in the **RECORD DRAWINGS** clause provide material that can be legibly printed on A4 size paper.

Format – hard copy

General: A4 size loose leaf, in commercial quality, 4 ring binders with hard covers, each indexed, divided and titled. Include the following features:

- Cover: Identify each binder with typed or printed title *OPERATION AND MAINTENANCE MANUAL*, to spine. Identify title of project, volume number, volume subject matter, and date of issue.
- Dividers: Durable divider for each separate element, with typed description of system and major equipment components. Clearly print short titles under laminated plastic tabs.
- Drawings: Fold drawings to A4 size with title visible, insert in plastic sleeves (one per drawing) and accommodate them in the binders.
- Pagination: Number pages.
- Ring size: 50 mm maximum, with compressor bars.
- Text: Manufacturers' printed data, including associated diagrams, or typewritten, single-sided on bond paper, in clear concise English.

Number of copies: 3.

Date for submission

Draft submission: The earlier of the following:

- 4 weeks before the date for practical completion.
- Commencement of training on services equipment.

Final submission: Within 2 weeks after practical completion.

3.22 ELECTRONIC FACILITY AND ASSET MANAGEMENT INFORMATION

Provide electronic facility and asset management information as scheduled. ***Rev 2017-01***

3.23 TOOLS AND SPARE PARTS

Spare parts

General: Provide spare parts listed in the appropriate worksections.

Replacement: Replace spare parts used during the maintenance period.

Tools and spare parts schedule

Submission timing: At least 8 weeks before the date for practical completion.

Requirement: Prepare a schedule of tools, portable instruments and spare parts necessary for maintenance of the installation. For each item state the recommended quantity and the manufacturer's current price. Include the following in the prices:

- Checking receipt, marking and numbering in conformance with the spare parts schedule.
- Packaging and delivery to site.
- Painting, greasing and packing to prevent deterioration during storage.

- Referencing equipment schedules in the operation and maintenance manuals.
- Suitable means of identifying, storing and securing the tools and instruments. Include instructions for use.

Replacement: Replace spare parts used during the maintenance period.

3.24 TESTING

Attendance
General: Provide attendance on tests.

Testing authorities
General: Except for site tests, have tests carried out by a Registered testing authority.

Test instruments: Use instruments calibrated by a Registered testing authority.

Test reports
General: Indicate observations and results of tests and conformance or non-conformance with requirements.

Notice
Inspection: Give sufficient notice for inspection to be made of the commissioning and completion testing of the installation.

Controls
General: Calibrate, set and adjust control instruments, control systems and safety controls.

Circuit protection
General: Confirm that circuit protective devices are sized and adjusted to protect installed circuits.

Completion tests
General: Test the works under the contract to demonstrate conformance with the documented performance requirements of the installation.

Functional checks: Carry out functional and operational checks on energised equipment and circuits and make final adjustments for the correct operation of safety devices and control functions.

Type test reports: Required, as evidence of conformance of proprietary equipment.

Sound pressure level measurements: Conform to the following:

- Correction for background noise: To AS/NZS 2107 Table B1.
- External: To AS 1055.1.
- Internal: To AS/NZS 2107.
- Measurement positions: If a test position is designated only by reference to a room or space, do not take measurements less than 1 m from the floor, ground or walls.
- Sound pressure level analysis: Measure the sound pressure level and the background sound pressure level over the full range of octave band centre frequencies from 31.5 Hz to 8 kHz at the designated positions.
- Sound pressure levels: Measure the A-weighted sound pressure levels and the A-weighted background sound pressure levels at the designated positions.

Certification
General: On satisfactory completion of the installation and before the date of practical completion, certify that each installation is operating correctly.

3.25 TRAINING

General
Duration: Instruction to be available for the whole of the commissioning and running-in periods.

Format: Conduct training at agreed times, at system or equipment location. Also provide seminar instruction to cover all major components.

Operation and maintenance manuals: Use items and procedures listed in the final draft operation and maintenance manuals as the basis for instruction. Review contents in detail with the principal’s staff.

Certification: Provide written certification of attendance and participation in training for each attendee. Provide register of certificates issued.

Demonstrators
General: Use only qualified manufacturer's representatives who are knowledgeable about the installations.

Maintenance
General: Explain and demonstrate to the principal's staff the purpose, function and maintenance of the installations.

Operation
General: Explain and demonstrate to the principal's staff the purpose, function and operation of the installations.

Seasonal operation
General: For equipment requiring seasonal operation, demonstrate during the appropriate season and within 6 months.

3.26 CLEANING

Final cleaning
General: Before the date for practical completion, clean throughout, including all exterior and interior surfaces except those totally and permanently concealed from view.

Labels: Remove all labels not required for maintenance.

3.27 PERIODIC MAINTENANCE OF SERVICES

General
Requirement: During the maintenance period, carry out periodic inspections and maintenance work as recommended by manufacturers of supplied equipment, and promptly rectify faults.

Emergencies: Attend emergency calls promptly.

Annual maintenance: Carry out recommended annual maintenance procedures before the end of the maintenance period.

Maintenance period: The greater of the defects liability period and the period documented in the **Maintenance requirements schedule**.

Maintenance program
General: Submit details of maintenance procedures and program, relating to installed plant and equipment, 6 weeks before the date for practical completion. Indicate dates of service visits. State contact telephone numbers of service operators and describe arrangements for emergency calls.

Maintenance records
General: Record in binders provided with the Operation and maintenance manuals.

Referenced documents: If referenced documents or technical worksections require that log books or records be submitted, include this material in the maintenance records.

Certificates: Include test and approval certificates.

Service visits: Record comments on the functioning of the systems, work carried out, items requiring corrective action, adjustments made and name of service operator. On completion of the visit, obtain the signature of the principal's designated representative on the record of the work undertaken.

Site control
General: Report to the principal's designated representative on arriving at and before leaving the site.

3.28 POST-CONSTRUCTION MANDATORY INSPECTIONS AND MAINTENANCE

General
Requirement: For the duration of the defects liability period, provide inspections and maintenance of safety measures required by the following:

- AS 1851.
- Other statutory requirements applicable to the work.

Records: Provide mandatory records.

Certification: Certify that mandatory inspections and maintenance have been carried out and that the respective items conform to statutory requirements.

Annual inspection: Perform an annual inspection and maintenance immediately before the end of the defects liability period.

3.29 INTERRUPTIONS TO SUPPLY

General

NO UNSCHEDULED INTERRUPTIONS to any site services shall occur – including electricity, telephones, water, fire services, refrigeration – and the contractor shall ensure full care is taken to avoid such interruptions.

Any required interruptions shall be fully discussed between all parties and the interruptions shall be planned to be of minimum time period and of minimum number. Obtain written confirmation for the interruptions prior to the event.

This clause does not require live work or that Workplace Health and Safety requirements are not to be adhered to.

Provide temporary power supplies or other temporary services as nominated to maintain services to the site as required.

3.30 ASSOCIATED WORK NORMALLY SUB-CONTRACTED (AWNS)

General

It is our understanding that the BSA requirements for a mechanical services contractor does not allow an aggregate of more than $1100 worth of work to be sub-contracted (unless they have a builder's licence).

Accordingly, where structural and building work is required to be completed for access, construction, installation, operation and maintenance of items covered by this specification, obtain a separate tender form from a registered builder to complete these works. Such works will become part of a contract directly between the client and the builder; contract conditions for which shall be the Master Builders Standard Contract for Minor Works (MWC-2). The tender from the builder shall be submitted at the time of tender.

The mechanical contractor shall not be responsible for the builder but shall provide sufficient information in adequate time to the Client's Representative to enable the work to be carried out in a suitable and timely manner.

Where work is not nominated at tender time for completion by the builder but is later found to be necessary the work shall be carried out by the builder and the cost for the works will be deducted from the mechanical contract value.

Where associated works sub-contracted are less than $1100, submit the builder's tender form as NIL and complete all necessary works nominated above.

Submit the scope of building works as agreed between the Mechanical Contractor and the Builder, within 5 working days from the close of tenders.

3.31 SITE ACCESS

General

Follow all site requirements regarding contractor sign-in for access to the site and for obtaining of keys.

3.32 ASBESTOS

General

Prior to commencing on site, obtain and review the Asbestos Management Plan. Comply with requirements of this plan throughout the project.

Where penetrating or removing asbestos, employ a Class A asbestos remover.

Also employ an independent asbestos surveyor to certify work completed. Include all necessary air monitoring, etc. Provide certificates at completion.

3.33 FIRE DETECTORS

General

During periods where construction is being undertaken and smoke detectors are installed, provide covers over detectors to ensure dust does not enter the detector. Also isolate zones where work is being undertaken.

Alarms caused due to failure to carry this out will be charged to the contract/sub-contract.

Where detectors have not been suitably protected, clean and recalibrate units. ***Rev 2017-01***

0722 ROOM AIR CONDITIONERS

1 GENERAL

1.1 RESPONSIBILITIES

General

Requirement: Provide room air conditioners, as documented.

Split systems: Supply indoor and outdoor units of split systems designed and rated by the manufacturer to operate together.

Selection and performance

General: Provide air conditioning equipment to meet the documented configurations and functions.

Performance: Provide air conditioning equipment that meets the documented performance.

1.2 CROSS REFERENCES

General

Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

1.3 STANDARDS

General

Refrigeration systems: To AS/NZS 1677.2 and the recommendations of SAA HB 40.2.

Microbial control: To AS/NZS 3666.1and the recommendations of SAA/SNZ HB 32.

Ductwork and insulation: To AS 4254.2.

Air filter performance and construction: To AS 1324.1.

Flammable refrigerants: To the recommendations of *AIRAH Flammable Refrigerants - Safety Guide*.

1.4 INTERPRETATION

Abbreviations

General: For the purposes of this worksection the following abbreviations apply:

- DN: Nominal diameter.
- DX: Direct expansion.
- kW(r): Kilowatts refrigeration capacity.

Definitions

General: For the purposes of this worksection the following definitions apply:

- Packaged air conditioning: Room air conditioner: < 8 kW(r).
- Packaged air conditioner: ≥ 8 kW(r).

1.5 SUBMISSIONS

General: Submit warranties. Make sure the principal is named in any warranty that extends beyond the end of the defects liability period.

2 PRODUCTS

2.1 GENERAL

Standards

Safety: Conform to AS/NZS 3350.2.34 and AS/NZS 3350.2.40.

Construction

Insulation: Insulate and vapour seal to prevent external condensation under all operating conditions.

Supply fan: Centrifugal with multi-speed or variable speed motor.

Filter type: Type 1 (dry media), Class C (washable media in a re-usable frame) to AS 1324.1.

Filter performance tested to AS 1324.2:

- ≥ 20% efficiency to test dust No. 1.
- ≥ 85% arrestance to test dust No. 4.

Condenser fans: Low speed propeller or axial.

Coils: Copper tube, aluminium plate fin type with no moisture carry over.

Drains: Provide aluminium, stainless steel or plastic drain trays to collect all moisture generated inside unit. Provide trapped drain to waste.

Refrigeration system

Requirement: Provide the following:

- Copper pipe: to AS/NZS 1571
- Expansion device.
- High-pressure and low-pressure compressor cutouts.
- Suction pressure gauge connection points.
- Isolating valves between split units.
- Defrost timer/thermostat with sensing bulb (reverse cycle units only).
- Refrigerant reversing valve (reverse cycle units only).

Refrigeration pipe insulation

Material R-Value: To BCA Spec J5.2c.

Refrigeration pipework insulation to have a thickness appropriate to achieve thermal resistance as follows: ***Rev 2017-01***

Location of Ductwork	*Minimum Insulation R - Value*
Generally	***1.3***
Areas air conditioned 24 hours	***2.0***

Type: Chemically blown closed cell nitrile rubber or polyethylene in tubular form.

Physical properties:

- Maximum thermal conductivity: 0.04 /mK at 0°C.
- Moisture absorption: Non-hygroscopic.
- Water vapour permeability: ≤ 0.065 nh/Pa.m.s.

Tests

Production tests: Provide air conditioning equipment that has been subjected to physical test in conformance to the following:

- Non-ducted air conditioners: To AS/NZS 3823.1.1, standard test condition T1.
- Ducted air conditioners: To AS/NZS 3823.1.2, standard test condition T1.

Fire hazard properties

Insulation: Conform to the following for all materials tested to AS/NZS 1530.3:

- Spread-of-Flame Index: 0.
- Smoke-Developed Index: ≤ 3.

Labelling

Required: To AS/NZS 3823.2.

Refrigerant: Show the type of refrigerant at the charging point and on indicator panels.

Warranty

Warranty period: Minimum 5 years.

2.2 ONE-PIECE UNITS

General
Requirement: Provide room air conditioners housing the compressor, condenser and evaporator coils, associated fans and electrical controls in one unit.

Wall mounted types
Description: One-piece units housed in an externally mounted vertical cabinet, with supply and return connections through the wall.

Inside fascia: Provide user controls, switchable motorised sweep supply grille and return air grille with filter behind.

Window/wall types
Description: Single chassis units housed in a metal cabinet fixed in an opening in the window or wall. Chassis removable from room side leaving cabinet in place.

Inside fascia: Provide user controls, switchable motorised sweep supply grille, and return air grille with filter behind.

2.3 SPLIT SYSTEMS

General
Requirement: Provide split room air conditioning systems, including indoor supply air units, outdoor condensing sections, interconnecting refrigeration piping, insulation, and operating and safety controls.

Ceiling mounted recessed indoor units (Type I)
Type: Above ceiling (cassette) type with only the faceplate visible within the room. Provide return air grille and filter, internal access and perimeter air distribution system and condensate pump.

Ceiling suspended indoor units (Type II)
Type: Indoor unit surface mounted below ceiling. Provide return air grille and filter, internal access and one-way air distribution system. Slimline construction, with single louvre discharge.

Wall mounted indoor units (Type III)
Type: Slimline construction, with adjustable louvre blades to allow horizontal or 45° downward air discharge.

Mounting height: To manufacturer's recommendations.

Floor mounted indoor units (Type IV)
Type: Slimline console with air discharge vertical or angled upward.

Compact ceiling mounted recessed indoor units (Type V)
Type: Above ceiling (cassette) type with only the faceplate visible within the room 600 x 600 faceplate. Provide return air grille and filter, internal access and perimeter air distribution system and condensate pump.

Ceiling suspended cassette indoor units (Type VI)
Type: Indoor unit surface mounted into ceiling. Provide return air grille and filter, internal access and perimeter air distribution system below. Slimline construction, with 4-way discharge. ***Rev 2017-01***

Control panel location
Floor mounted units: Locate within indoor unit.

All other types: Mount on wall to sense representative room temperature and so that is not affected by direct sunlight or local heat sources.

Wireless control: If the control is a wireless type (e.g. infrared), provide a wall mounting bracket for the control.

Outdoor units
Type: Weatherproof units suitable for outdoor operation, housing, compressor, outdoor coil and main electric controls.

2.4 CONTROLS

Microprocessor control

General: Provide microprocessor controller with the following functions:

- ON/OFF switch.
- Evaporator fan speed selector switch.
- Timer selector switches: Provide (Time on, Time off, Sleep mode, no timer control). Time switch adjustable in hourly increments up to 12 hours.
- Mode selector switch: DEHUMIDIFY – COOL – HEAT – AUTO.
- Supply grille sweep ON-OFF.
- Indicating lamps, LEDs or LCD display for:
  - . Unit operating.
  - . Defrost cycle.
  - . Filter clean reminder.

Drive

Requirement: Provide inverter drive for the compressor and use it to control capacity.

2.5 REFRIGERATION PIPING

General

Requirement: Conform to equipment manufacturer's recommendations for the refrigerant used. Provide refrigeration piping designed and installed so that the complete system meets the documented performance under the documented operating conditions.

Design

Standards: Conform to the recommendations of one or more of the following:

- ***Equipment: To manufacturer's recommendation for the refrigerant used.***
- ***AIRAH Design Application Manuals.***
- ***ASHRAE Handbooks.***
- ***CIBSE Guides.***

Methods of calculation: Manual or software that employs the data and methods in the applicable standard.

Suction lines: Size for pressure drop less than 1.0 K saturated suction temperature at documented supply air flow, documented cooling coil entering conditions, documented condenser air entering condition and unit manufacturer's rated total capacity, saturated condensing temperature and saturated suction temperature under the above conditions.

Oil return: Size for oil return to compressor. If velocity for oil return would result in the suction line pressure drop exceeding pressure drop limit, provide double suction risers. Prevent oil draining back on the off cycle.

Liquid lines: Size for pressure drop less than 1.0 K saturated liquid temperature when handling the manufacturer's unit capacity under the documented operating temperatures.

Layout

General: Install pipework in straight lines and uniform grades without sags. Grade horizontal hot gas lines and suction lines at not less than 1 in 200 in the direction of gas flow.

Location: When possible, run suction and liquid lines inside common insulation.

Pipe support

General: Provide hangers, brackets, saddles, clips, and support system components, incorporating provisions for adjustment of spacing, alignment, grading and load distribution. Support pipework from associated equipment or building structure. Support valves, strainers and major line fittings so that no load is placed on adjacent tubes or transmitted to them during operation and maintenance.

Support type: Proprietary metallic-coated steel channel section with clamps and hangers sized to match external diameter of pipe being supported.

Vertical pipes: Provide anchors and guides to maintain long pipes in position, and supports to balance the mass of the pipe and its contents.

Saddles: Do not provide saddle type supports for pipes DN 25 or over.

Uninsulated pipes: Clamp piping supports directly to pipes.

Insulated pipe support:

- ***Spacers: Provide spacers at least as thick as the insulation between piping supports and pipes. Extend either side of the support by at least 20 mm.***
- ***Spacer material: Rigid insulation material of sufficient strength to support the piping and suitable for the temperature application.***
- ***Vapour barriers: For cold pipes apply aluminium foil tape over the circumference of the spacer to form a vapour barrier.***
- ***Metal sheathing: Provide a 0.55 mm thick metallic-coated steel band between the aluminium foil tape and the support, for the full width of the spacer.***

Pipe support spacing table

Nominal pipe size, DN	*Maximum spacing (m)*	
	Horizontal	*Vertical*
10	*1*	*2*
≥ 15, ≤ 20	*1.5*	*2.5*
25	*2*	*3*
32	*2.5*	*3*
40	*2.5*	*4*
50	*3*	*4*
65	*3*	*4*

Pipes

Piping: Provide copper tubes as follows:

- ***≤ DN 15: To AS/NZS 1571, 0 temper.***
- ***> DN 15: To AS/NZS 1571, 1/2H temper. Use annealed (0 temper) copper only for pulled bends.***

Pipe wall thickness:

- ***Pipes ≤ DN 50: To AS 1432 type B.***
- ***Pipes > DN 50: ≥ 1.6 mm.***

Bends

Pulled bends: Form bends without flattening or wrinkling with an inside radius minimum 3 pipe diameters using the correct tool size for the pipe diameter.

Pipe fittings

Copper alloy fittings: To AS 3688, dezincification resistant, welded, brazed or compression type only.

Pre-formed fittings: Pre-formed refrigerant capillary line tees, bushes, couplings and elbows. Wherever possible, make reductions at elbows, tees, line devices or equipment connections with reducing fittings, otherwise provide reducing bushes or reducing couplings.

Compression fittings: Flareless twin ferrule, torque free, mechanical grip fittings which can be gauged using a precision ground and hardened metal gap inspection gauge.

Screwed joints: Use only if equipment items are not available with flare, flanged or brazed capillary connections.

Brazed joints

General: Provide pre-formed capillary fittings or form capillary unions by expanding one pipe end. Prevent flux and brazing alloy from entering pipes. Use dry nitrogen to purge air from pipes before brazing. During brazing, maintain a flow of dry nitrogen through pipes to prevent oxidation.

Brazing alloy: To AS/NZS 1167.1 Table 2 alloy B4 ≥ 15% silver content.

Brazing alloy for jointing dissimilar metals: To AS/NZS 1167.1 Table 1 alloy A18 or an alloy with an equivalent silver content (≥ 34%) and impurity levels.

Sleeves

General: Provide pipe sleeves where pipes pass through building elements.

Valves

General: Provide valves of the type and in the location recommended by the recommendations of the Australia and New Zealand Refrigerant Handling Code of Practice Part 2. Make provision for charging and withdrawal of refrigerant. If a gauge is not permanently connected (for example commissioning connections), seal the outlet of the isolating valve with a flared seal cap nut.

Valve types

Service valves: Back-seating type with gasketed cap.

Solenoid line valves: Solenoid coil and valve parts replaceable without disturbing valve body or refrigerant piping.

Refrigeration pipe insulation

General: Insulate all refrigerant piping that may sweat. Apply insulation un-slit where possible. If slit, refix slit faces with adhesive applied to full area.

Joining: Use only an adhesive or jointing system recommended by the insulation manufacturer.

Timing: Leak test piping before insulating joints, fittings and valves.

VRF fittings: Insulate proprietary VRF fittings with the fitting manufacturer's split case preformed insulation. ***Rev 2017-01***

2.6 CONDENSATE DRAINS

General

Condensate drains: Provide trapped drain lines with uniform and continuous fall to connect condensate trays to the nearest building drain point. Provide drains from:

- Each indoor coil.
- Each outdoor coil, unless the casing freely drains to a roof or other location where condensate and/or rain water will not cause damage or ponding.
- Each safety tray.
- Other moisture or rainwater collecting areas.

Material: As documented.

- Copper: To AS 1432 Type B.
- PVC-U: To AS/NZS 1477, installed to AS/NZS 2032.

Size: Unit drain connection size or DN 20, whichever is the larger.

Pipe support spacing: To AS/NZS 3500.1 Table 5.6.4.

Sealing: Seal drain pipes where they penetrate casing.

Termination: Terminate drains to allow visual inspection of condensate flow.

Traps: To withstand more than 2 times fan static pressure and constructed from either:

- Transparent and kink resistant hose.
- PVC-U trap with removable caps and a visible air break.

Falls and drains: Check that the condensate tray falls conform to AS/NZS 3666.1 and in particular that trays and sumps are graded to the outlet to prevent moisture retention. Test drains by pouring a measured quantity of water into upstream end.

Safety tray: If leaks or condensation could cause damage to the building or its occupants, provide a safety tray under packaged units and under the indoor units of split systems.

2.7 UNIT INSTALLATION

General

Requirement: Supply all necessary components, including but not limited to:

- Means of attachment to the structure.
- Anti-vibration mounting.
- Appropriate flexible connections.
- Trim and sealing around openings.
- Electrical connections.
- Drainage connections.
- Field connection of refrigerant lines in split systems.

Alignment: Install units level, plumb and to manufacturer's recommendations.

Fixing: Bolt units in place with minimum 4 anchors or suspension rods.

Outdoor equipment

Arrangement: Provide clearance around units for condenser air flow and maintenance access. Make sure discharge air does not short-circuit to condenser intake.

Plinths: If located on grassed or similar permeable surfaces, provide concrete plinths under outdoor equipment.

Ducted units

Requirement: Conform to the *0741 Ductwork* worksection.

2.8 HAT SECTIONS

Requirement: All pipework exposed to view shall be covered with hat section unless otherwise specified.

Hat sections are to comprise a galvanised steel back tray fixed to the wall or slab and 'Colorbond' cover, pop riveted to backing tray.

All cut-outs to be minimal in size with edges protected to prevent damage to existing pipework or cabling.

Hat section to run to the associated condenser unit and to be attached at point of pipe entry to the unit

All ends and holes to be covered to prevent vermin entry.

Colour to best match wall colour.

2.9 CONDENSER SLAB MOUNTING

Condenser Mounts: Condensers located on concrete slabs to be mounted on double deflection rubber mounts. Mounts to be EMBELTON NRD or approved equal. Select mounts to suit weight and frequency of units. Bolt mounts to concrete slab.

2.10 CONDENSER WALL MOUNTING

Requirement: Where shown wall mount all condenser units. All wall mounted condensing units shall be supported with certified proprietary galvanised steel support systems.

If non-proprietary support systems are used, all such supports shall be designed and certified by a Registered Professional Structural Engineer Queensland (RPEQ). ***Rev 2017-01***

0731 FANS

1 GENERAL

1.1 RESPONSIBILITIES

General
Requirement: Provide fans, as documented.

1.2 DESIGN

Fan energy considerations
Absorbed power
Requirement: If the documented fan maximum air quantity is greater than 1000 L/s, provide fans with absorbed power conforming to BCA J5.

Centrifugal fans
Requirement: Select fans so the air flow can be increased ≥ 10% above the rate documented in **Fan schedules** as follows:

- Against the corresponding increased system resistance as installed.
- Without unstable operation.
- Without motor change.
- By speed change alone.

Axial flow fans
Requirement: Select fans so the air flow can be increased not less than 10% above the rate documented in **Fan schedules** as follows:

- Against the corresponding increased system resistance as installed.
- Without unstable operation.
- Without motor change.
- By pitch angle change alone.

Variable volume systems
Requirement: Provide fans for variable volume systems selected for:

- Maximum fan efficiency at 70% to 80% of design air flow rate.
- Operation from 30% to 110% of design air flow without going into a surge condition.

Fans with variable speed drives
Requirement: Conform to the following:

- All fans: Provide fans selected to operate at no more than 50 Hz under all conditions.
- Fans with belt drives: Adjust fan speed during commissioning for motor to operate at no more than 50 Hz under all conditions.

Fans with multi-speed motors
Requirement: Conform to the following:

- Two speed fans: Provide fans selected to perform duties documented in the **Fan schedules**.
- Fans with 3 or more speeds and single phase fans with adjustable speed control: Provide fans selected to achieve the duty documented at a speed not more than 80% of highest speed.

1.3 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for mechanical services. ***Rev 2017-01***

1.4 INTERPRETATION

Abbreviations
General: For the purposes of this worksection the following abbreviations apply:
- EC: Electronically commutated (motors).

1.5 SUBMISSIONS

Products and materials
Type tests: Provide only fans type-tested by a Registered testing authority. Submit evidence of type tests as follows:
- Fan performance: To AS ISO 5801.
- Fan sound power levels: To BS EN ISO 5136 or ISO 10302-1.
- Smoke spill fans: To AS 4429.

2 PRODUCTS

2.1 GENERAL

Exhaust fans
Self-closing damper: If required by BCA J3.5, provide exhaust fans with a sealing device such as a self-closing damper.

Parallel fans
Dampers: If fans operating in parallel discharge into, or draw from, a common duct or plenum, provide each with a motorised damper or pressure operated non-return damper to prevent air short circuiting through an idle fan.

2.2 MARKING

Labels
Identification: Show the following:
- Manufacturer’s name.
- Model.
- Serial number.
- Size.
- Direction of rotation, marked on casing.

2.3 MATERIALS

Galvanized steel components
Hot-dip galvanized components: Conform to AS/NZS 4680.
Coating thickness and mass: To AS/NZS 4680 Table 1.

2.4 CENTRIFUGAL FANS – GENERAL PURPOSE

Casings
Construction: Welded steel scroll and side plates, reinforced to prevent flexing and drumming.
Split casing: If the fan impeller is more than 1200 mm diameter, provide a horizontally split casing.
Inlet bells: Removable, shaped for aerodynamically efficient air entry and close approach to impeller.
Access panels: Provide inspection/access panels to casings of fans with impellers ≥ 650 mm diameter. Seal panels airtight with neoprene gaskets.
Outlets: Provide flanged or spigoted outlets to suit connected ductwork or equipment.
Guards: For fans not connected to ductwork provide removable inlet guards, discharge guards or both.

Drain point: Where moisture is likely to enter or condense inside a fan provide a 25 mm drain point welded into base of scroll and stopped with non-ferrous screwed plug.

Minimum casings thickness table

Impeller diameter (mm)	Side plates (mm)	Scroll (mm)
≤ 450	2	1.6
> 450, ≤ 800	2.5	2
> 800, ≤ 1000	3	2.5
> 1000, ≤ 1500	3	3
> 1500	5	3

Bases

General: Form from fully welded steel sections integral with or bolted to casings.

Mounting brackets: Provide at least 4 height saving mounting brackets.

Impellers

Blade type: Backward inclined aerofoil or laminar single thickness type, flat or curved section, with non-overloading power characteristics, as documented in **SELECTIONS,FANS**.

Characteristics: Provide the following:

- Statically and dynamically balanced.
- Keyed to drive shafts by means of taper-lock fixing devices or taper keys.
- For overhung driven fans more than 1000 mm diameter, retained onto drive shafts by positive devices such as washers and set screws into tapped holes in shaft ends.
- Countersink in shaft for tachometer.

Inlet guide vanes

Requirement: If documented, provide inlet guide vanes with rattle-free, radially mounted, interlocked blades pivoting on sintered bronze, nylon or sealed ball bearings.

Control: Provide automatic control to maintain air volumes to within ±5% of the air flow rate set point without surging.

Range: Control air flow from 25% to 110% of the documented system maximum air quantity.

Bearings

For single width fans with impellers less than 1250 mm diameter and double width fans with impellers less than 950 mm diameter: Provide pillow-block mounted, self aligning ball bearings, sealed for life, with a minimum rating fatigue life of 40 000 hours.

For single width fans with impellers at least 1250 mm diameter and double width fans with impellers at least 950 mm diameter: Provide plummer-block mounted roller bearings to AS 2729, with seals and grease relief, with a minimum rating fatigue life of 20 000 hours. Extend grease nipples for ready access.

Motors

General: Provide electric motors that are compatible with fan requirements, providing efficient non-overloading fan units.

Power rating: The greater of the following:

- The fan limit load power at speed required for the air flow and resistance required in **DESIGN**.
- The power required by the fan when the air flow is increased by 5% above the design air flow rate required in **DESIGN**, against the corresponding increased system resistance.

Motor protection: Minimum IP54.

Belt drives

Drive sizing: Size for at least 125% of motor power and capable of transmitting the full starting torque without slip.

Belts: Wedge belts to AS 2784, consisting of matched sets of at least 2 belts. Mark belt size in a prominent location on the fan casing.

Belt tensioning: Provide adjustment of belt drive tension by either movement of motor on slide rails or by pivoting support. Do not use the weight of motors to provide belt tension. Restrain motors with locknuts on bolts, clamping motors in place.

Drive shafts

Characteristics: Provide the following:

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

Drive guards

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

- Tachometer opening.
- Perforated sides on double width, double inlet fans.
- Weatherproof construction, ventilated and drained where exposed to weather.

Material: Open mesh or perforated metallic-coated sheet steel.

Finishes

Primer: Prime all surfaces with zinc phosphate primer to AS/NZS 3750.20 and apply manufacturer's standard paint system to external surfaces.

High temperature exhaust fans

Requirement: Provide heat slingers and guards on shafts between the in-board bearings and fan casings. Locate in-board bearings clear of fire-resisting insulation applied to fan casings.

Kitchen exhaust fans

Additional requirements: Provide the following:

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

2.5 CENTRIFUGAL FANS – SHEET METAL

Standard

General: To **CENTRIFUGAL FANS – GENERAL PURPOSE** except as follows:

- Casing construction: Metallic-coated steel sheet, riveted or spot welded with joints sealed.
  - . Scroll: 1.2 mm minimum thickness.
  - . Side plates: 2 mm minimum thickness.
- Bases:
  - . Formed from pressed metallic-coated steel sheets, bolted to casings.
  - . Provide at least 4 brackets for mounting.
- Impellers:
  - . Type: Backward or forward curved section, laminar or aerofoil, as documented.
  - . Construction: Extruded aluminium or metallic-coated steel blades secured between reinforced galvanized steel plates.

- Bearings:
  . Self-aligning sealed for life ball or roller type.
  . Finish: Brush and prime spot welds with zinc-rich organic primer to AS/NZS 3750.9.
- Motors:
  . Minimum degree of protection: IP51.

2.6 CENTRIFUGAL FANS – IN-LINE

General
Requirement: Provide fans with non-overloading power characteristics.

Casings
Casing types: 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.

Impellers
Requirement: Backward inclined or forward curved style, as documented.

Construction: Metallic-coated steel, extruded aluminium or polypropylene.

Balance: Balance impellers statically and dynamically.

Motors: Direct mounted to impellers with minimum thermal class 155 (F) insulation to IEC 60085.

Bearings: Sealed for life bearings with a minimum rating fatigue life of 40 000 hours at 40^{o}C ambient.

Electrical connection: Terminal box external to fan casing and wired to fan motor.

Access to impellers up to 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.

2.7 CENTRIFUGAL FANS - PLUG

General
Type: Centrifugal fans with a direct driven motor impeller assembly without an external fan scroll.

Requirement: Non-overloading power characteristics.

Impeller
Construction: Aluminium backward curved blades in a welded design.

Motor
Select from the following:

- Electronically commutated (EC) direct-drive motor.
- Standard 4, 6 or 8 pole induction motor.

Drive
Select form the following:

- Direct drive with impeller mounted on the motor shaft.
- Integral motor/fan impeller assembly incorporating an external rotor motor.

Base
Requirement: Mount the fan on a rolled steel fabricated frame to form a complete unit. Provide anti-vibration mounts.

2.8 AXIAL FLOW FANS

General
Requirement: Non-overloading power characteristics.

Casing
Type: Tubular, flanged at each end, constructed from mild steel, fully welded, hot-dip galvanized after fabrication.

Access:

- < 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.

Mounting feet: Provide mounting feet, either bolt to the flanges or welded to fan housing.

Impellers

Requirement: Aerofoil section blades constructed from cast aluminium alloy or glass reinforced plastic.

Material: As documented in the **Axial flow fan schedule**.

Pitch angle: Manually adjustable.

Balancing: Balance impellers, statically and/or dynamically.

Unducted inlets/outlets

Inlet cones: Provide aerodynamically shaped cones to inlets of fans.

Outlets: Provide manufacturer's standard 15º conical diffuser to convert velocity head to static pressure.

Guards: Provide galvanized steel or bronze mesh guards.

Motors

General: Direct mount to impellers with minimum thermal Class 155 (F) insulation to IEC 60085.

Bearings: Provide sealed for life bearings or grease packed bearings fitted with lubrication lines extending through the casing. Provide bearings with a minimum rating fatigue life of 17,500 hours, suitable for horizontal or vertical mounting as appropriate.

Motor protection: Minimum IP54.

Electrical connection

General: 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-resistance level (FRL): If fan is installed in a fire-resisting duct system and not installed in a separate fire-resisting room or enclosure, provide FRL to the same standard as the duct. Make sure the fire-resisting 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.

2.9 BIFURCATED (PROTECTED MOTOR) AXIAL FLOW FANS

General

Requirement: Conform to **AXIAL FLOW FANS** and the following:

- Type: Direct driven fixed casing axial flow fan.
- Motor location: Mount the fan motor inside the casing, separated from the fluid handled and independently ventilated.
- Airflow direction: Suitable for operation with the fan axis horizontal or vertical with air flow directions to produce maximum motor cooling and quietest operation.

Casing

Type: Long, fully enclosing cylindrical type with flanges at each end for connection to ductwork. Mount the motor 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.

2.10 ROOF MOUNTED FANS

Types

General: Centrifugal, mixed flow, aerofoil axial or propeller.

Axial flow and propeller: Conform to **AXIAL FLOW FANS**.

Centrifugal fans: To **CENTRIFUGAL FANS - GENERAL PURPOSE** except as varied in the following:

- Casing: Scroll at least 1.2 mm and side plates at least 2 mm thick zinc-coated steel, riveted or spot welded with joints sealed.
- Bases: Metallic-coated steel sheets bolted to casings with at least 4 mounting brackets.
- Impellers: Constructed with extruded aluminium or zinc-coated steel blades secured between reinforced galvanized steel plates.
- Bearings: Self-aligning sealed for life ball or roller type.
- Finish: Brush and prime spot welds with zinc-rich organic primer to AS/NZS 3750.9.
- Motor minimum degree of protection: IP44.

Mixed flow fans:

- Impeller: Mixed flow with rotating parts vibration isolated from the unit casings by suitable resilient mountings.
- Arrangement: Position the motor above the impeller to allow servicing from above the roof.

Housing

Requirement: House fans in compact bases fitted with weathering skirts and a hinged or removable weatherproof cowl with bird screen.

Material: UV stabilised ABS, polypropylene, polyethylene, glass-fibre reinforced polyester or steel, hot-dip galvanized (HDG) after manufacture, as documented.

Vertical discharge

Requirement: Weatherproof galvanized steel, plastic or aluminium backdraft dampers where the weather may enter when units are stopped.

Backdraft damper closure: Counterweighted or electrically driven.

Vermin mesh: Where backdraft dampers are not fitted, provide vermin mesh guards to AS/NZS 3666.1 clause 2.2.1.

Motors

Bearings: Sealed for life or grease-packed, fitted with lubrication lines extending through roof cowls. Provide bearings with a minimum rating fatigue life of 40 000 hours. Provide access to grease relief ports.

Minimum degree of protection: IP55.

Drive: Belt or direct as appropriate.

Belt drive: Conform to **CENTRIFUGAL FANS - GENERAL PURPOSE**.

Electrical connection

General: 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.

2.11 PLATE MOUNTED FANS

General

Type: Plate mounted fans designed for diaphragm, wall or cowl mounting, as documented.

Impeller: Direct driven with metallic-coated curved steel or glass reinforced plastic blades and balanced statically and/or dynamically.

Bearings: Sealed for life suitable for horizontal or vertical mounting.

Cowls: Glass fibre or fabricated metal.

Unducted inlets and outlets: Provide metallic-coated steel or bronze mesh guards.

Finish to metal parts: Air drying enamel or powder coat.

2.12 WINDOW/WALL FANS

General

Impeller: Plastic or metallic-coated steel propeller type, adjustable pitch axial or centrifugal.

Housing: Provide the following:

- Isolating mountings.
- Discharge cowls with birdmesh guards.
- Backdraft shutters constructed from lightweight nylon or aluminium blades, arranged to gravity close when fans are not operating.

Filtered supply units

Construction: Provide easily removable disposable filter.

Filter performance classification: G4 to AS 1324.1.

2.13 FUME CUPBOARD FANS

Standard

Requirement: To AS/NZS 2243.8.

Type

Requirement: Select from the following:

- SISW centrifugal fan to **CENTRIFUGAL FANS – GENERAL PURPOSE**.
- Axial flow fan to **AXIAL FLOW FANS** but with bifurcated casing.
- Centrifugal in-line fan to **CENTRIFUGAL FANS – IN-LINE** but with bifurcated casing.

Motor

Type: Variable speed.

Construction

Requirement: Designed and constructed to handle fume cupboard exhaust without deterioration caused by corrosion or solvent action.

Fan location: Locate outside the building. If at ground level, provide a lockable enclosure.

Materials: To the respective fan type clause except as follows:

- Casing: PVC-U.
- Impeller: PVC-U or polypropylene impeller.
- Other components in contact with exhaust air flow: No less resistance to corrosion and solvents than the fan casing.

2.14 IMPULSE CAR PARK VENTILATION FANS

Standards

Air flow: Tested to ISO 5801.

Noise: Tested to ISO 3745.

Thrust air performance: Tested to BS 848-10.

Construction

Impellers: Axial flow, mixed flow or centrifugal as documented.

Casing and internal sheet metal components: Metallic-coated steel with visible surfaces powder coated.

Motors: Induction or EC motors as documented with sealed for life ball bearings.

2.15 ROOF COWLS

General

Type: Proprietary fibreglass weatherproof roof cowl fitted with gravity type wind-resistant backdraft dampers.

Construction

Requirement: Compact bases fitted with weathering skirts and a hinged or removable weatherproof cowl with bird screen.

Material: UV stabilised ABS, polypropylene, polyethylene, glass-fibre reinforced polyester or steel, hot-dip galvanized after manufacture, as documented.

2.16 MIXED FLOW FANS

General requirement: Conform to CENTRIFUGAL FANS-IN LINE and the following:

- ***Casing:*** ***Galvanised steel impellor.***
- ***Impellor:*** ***Mixed flow GRP impellor.***
- ***Motor:*** ***Direct drive motor mounted inside casing.*** ***Rev 2017-01***

2.17 OUTDOOR AIR HEAT EXCHANGERS

Requirement: Provide and install new outdoor air heat exchangers.

Heat exchangers shall be proprietary packaged units suitable for wall mounting, or in-ceiling mounting as scheduled.

The heat exchanger package shall incorporate the heat exchanger media, speed controlled supply and exhaust fans and filters.

Heat exchangers shall be enthalphy type, capable of transferring both sensible and latent heat from the supply air to the exhaust air streams.

Heat exchangers shall be Air Change ERV-WM or ERV-IC type as scheduled.

Heat exchangers shall be wall mounted or in-ceiling type as scheduled.

Allow for decorative painting of the external portion of wall mounted outdoor air heat exchangers in colour to later advice. ***Rev 2017-01***

3 EXECUTION

3.1 INSTALLATION

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-resistance level of materials and/or the building structure.

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.

Drains

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

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.

0732 AIR FILTERS

1 GENERAL

1.1 RESPONSIBILITIES

General
Requirement: Provide air filters, as documented.

1.2 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

1.3 STANDARDS

Air filters
Performance and construction: To AS 1324.1.

Microbial control: To AS/NZS 3666.1 as required by the BCA and the recommendations of SAA/SNZ HB 32.

1.4 INTERPRETATION

Abbreviations
General: For the purposes of this worksection the following definitions apply:
- DOP: Dioctylpthalate.
- HEPA: High efficiency particulate arrestance.
- MEPA: Medium efficiency particulate arrestance.

Definitions
General: For the purposes of this worksection the following definitions apply:
- Filter class: To AS 1324.1.
- Filter type: To AS 1324.1.

1.5 SUBMISSIONS

Tests
Type tests: For each type of filter, submit evidence of filter type tests conducted by a Registered testing authority within the past 5 years.

Standards: Conform to the following:
- HEPA and MEPA filters: To AS 4260.
- Other particulate filters: To AS 1324.2.

Filter size for test: 610 x 610 mm face dimension.

1.6 INSPECTION

Notice
Inspection: Give notice so that inspection may be made of the following:
- HEPA filters: Site filter tests.

2 PRODUCTS

2.1 MATERIALS

General
Sealants performance: Resistant to air, entrained water and oil, and microbial growth.

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.

2.2 COMPONENTS

Component sizes
General: Standardised throughout the installation as far as practicable.

Filters
Consistency: For filters of the same type provide filters from only one manufacturer.

Filter performance
Minimum performance: To AS 1668.2.

Metal components
Material: Stainless steel or metallic-coated steel with powder coat finish.

Cell frames
Design: Capable of withstanding distortion arising from the final pressure drop across the filter.

Air by-pass: Frames must stop air by-passing the filter media.

Holding frames
General: True and square. Provide gaskets and clamping systems which maintain an airtight seal between the frame and the filter.

Filters and media
Requirement: Supply filters and media that are odourless, non-toxic, non-migrating, non-evaporating, non-hardening, resistant to microbial growth, and which do not shed fibres in service.

2.3 DRY MEDIA FILTERS (TYPE 1) AND VISCOUS IMPINGEMENT FILTERS (TYPE 2)

Filter performance rating
Performance: If filters are documented by performance rating to AS 1324.1 clause 2.1.1, conform to the following:

- ≥ 20% average efficiency when tested with AS 1324.2 Test Dust No. 1.
- ≥ 85% average arrestance when tested with AS 1324.2 Test Dust No. 4.

Filter media
General: Provide filter media:

- That does not support microbial growth and is resistant to fungal and vermin attack.
- That does not shed fibres in service.

Class A filters
Construction: Provide cells in which the medium is permanently enclosed in a disposable frame.

Mounting: Mount the disposable cell in a fixed metal holding frame to the manufacturer's recommendations. Hold each cell in place with spring-loaded clips or clamps. Seal between the cell and mounting frame so no air bypasses the cell.

Class B and C filters
Construction: Provide a rigid metal frame into which the medium is installed.

Mounting: Support the medium on the mounting frame to provide even air flow. Shape pre-formed media to fit the frame. Hold the medium in place with clips, tabs or similar devices so it does not move in service.

Class D filters

Media advance mechanism: Automatic.

Differential pressure setting for the system: Adjustable.

Override controls: Provide a means of stopping the media advance mechanism.

2.4 HEPA FILTERS

General

Standard: To AS 4260.

Type and grade: Type 1 (dry) and Class A (fully disposable) to AS 1324.1 arranged so the filter cell can be removed without disturbing the mounting frame.

Performance

Face size for performance below: 600 x 600 mm.

Filter performance: As documented.

Initial resistance: < 250 Pa at the rated air flow for the cell.

Air flow per cell: Not less than the capacity in AS 4260 Table 3.2.3 for an initial resistance of 250 Pa.

Media: Provide media to either of the following:

- MILSPEC to US Military Standard F-51079.
- Non-MILSPEC to AS 4260.

Operating environment: Provide filters suitable for continuous operation at 40°C and 100% relative humidity.

Seals

Seal type: Provide seals as follows:

- Horizontal cells, vertical air flow: Fluid type.
- Other situations: Closed cell neoprene gasket compressive type.

Frames generally: Support each cell in a mounting frame fitted with spring-loaded screw type clamps or equivalent fasteners. Adjust the clamps for even pressure to achieve an airtight seal under all conditions of service.

Fluid seal frames: Provide a formed channel to accommodate the edge skirts of the filter cell frames to form an airtight seal with the filter frame edge skirt when filled with a non-Newtonian fluid that does not support microbial growth.

Installation

General: Install filters to enable testing to AS 1807.6 to be performed including access to the air entering and leaving faces and provision for injection of the test medium.

Testing

Filters Grade 2, 3 or 4 to AS 4260:

- Production test: Test and mark each cell to AS 4260.
- Initial site testing: Test on site and certify to AS 1807.6 on installation.
- Repeat site testing: At not more than 12 month intervals until the end of the maintenance period.

2.5 MEPA FILTERS

General

Construction and performance: Conform to **HEPA FILTERS** except as follows:

- Filter performance: ≥ 95% filtration efficiency for nominal 0.3 µm diameter particles when passing the rated air flow.
- Initial resistance: < 100 Pa at the rated air flow for the cell.
- Testing: Not required.

2.6 FILTER TERMINALS

General

Type: Proprietary filter terminals intended for use with HEPA or MEPA filters and arranged so the casing remains in position when the filter cell is replaced.

Construction

Casing: 1.2 mm metallic-coated steel with a spigot duct connection. Conform to the *0741 Ductwork* worksection.

Insulation: To match the associated rigid supply duct.

Screen: Provide a removable perforated 0.6 mm stainless steel screen mounted below the filter face.

Access: Arrange the terminal so all access for inspection, testing, medium injection and filter removal is from the air leaving side.

Fans

General: If documented provide a resiliently mounted direct drive variable speed centrifugal fan mounted in the filter terminal.

Speed control: Provide a solid state electronic speed control device adjustable from the air leaving side.

2.7 ELECTROSTATIC PRECIPITATION FILTERS (TYPE 3)

Construction

Framework material: Aluminium or metallic-coated steel.

Collector cells

General: Easily removable for service.

Type: Select from the following:

- Aluminium collector plates: Equally spaced and supported on tie rods between end plates.
- Integral units: Consisting of ionisers, collector cells mounted director on the frame of the filter bank.

Power packs

Installation: Install equipment in a dustproof sheet metal cubicle, with a lockable access door.

Electrical safety equipment

Type: Provide isolating switches for each filter assembly, air handling unit door interlock switches, cutout switches on power pack access doors and high voltage warning signs on access doors.

2.8 GAS PHASE ABSORBER CELLS

Construction

Filter medium: Select from:

- Activated carbon with at least 60% retentivity to carbon tetrachloride.
- Activated alumina with at least 5% by weight potassium permanganate.

Cell units: Modular. Maximum capacity per cell, as scheduled.

Cell bypass: Prevent odour bypass due to granule packing through vibration.

Holding: Secure cell units in a corrosion resistant holding frame.

Packaging: Deliver absorbent elements in air tight packaging. Remove packaging only when system is ready for testing.

2.9 GREASE FILTERS

General

Construction: Crimped mesh filter media, in a holding frame with handles.

Material: Aluminium or stainless steel.

Installation: Hold in place with quick release catches. Mount within 30° of vertical.

Frames: Provide mounting frames and install to minimise air leakage around the filter.

Thickness: 50 mm nominal.

Installation: To AS 1668.2.

Clean pressure drop: < 30 Pa at 1.8 m/s face velocity.

Face velocity: ≤ 1.8 m/s.

2.10 MARKING

Standards

Marking: To AS 1324.1.

Filter

General: Permanently and legibly mark, on a suitable section of the filter, the following:

- Filter type and class.
- Direction of airflow.
- Proprietary type, model and serial number.
- Filter performance rating to AS 1324.1.

Replaceable element

General: On the clean air side, fix the name of the supplier, proprietary type, filter type to AS 1324.1 and filter performance rating to AS 1324.1.

3 EXECUTION

3.1 INSTALLATION GENERALLY

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.

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.

Blanking plates

General: Close gaps where the dimensions of the filter plenum do not match those of the framing. Seal airtight so that no air bypasses the filters.

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

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 type 304 stainless steel.

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

Manometers

General: Provide a manometer on each filter bank as scheduled. ***Rev 2017-01***

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.

Piping: Pipe manometers using aluminium tubing. ***Rev 2017-01***

Filter banks

General: Provide holding frames.

Filter access platforms

General: Make sure that platforms and ladders do not obstruct filter access.

Standard: To AS 1657.

Access doors: All access doors for filters, of all types to comply with Clause Access Doors in Specification Section 0741 Ductwork.

Label filter access doors to indicate filter model and rating. ***Rev 2017-01***

3.2 CLEANING

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

General: If provided, remove at completion of commissioning.

0741 DUCTWORK

1 GENERAL

1.1 RESPONSIBILITIES

General
Requirement: Provide ductwork, as documented.

1.2 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for Mechanical Services ***Rev 2017-01***

1.3 STANDARDS

General
Flexible ductwork: To AS 4254.1.

Rigid ductwork: To AS 4254.2.

Proprietary and non-standard systems
Standard: Conform to the test criteria in AS 4254.1 and the functional criteria in AS 4254.2.

Pre-insulated rigid duct systems
Standard: To ANSI/SMACNA 022. The requirements of this worksection take precedence over any conflicting requirements in ANSI/SMACNA 022.

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

1.4 INTERPRETATION

Abbreviations
General: For the purposes of this worksection the following abbreviations apply:

- FRL: Fire-resistance level.

Definitions
General: For the purposes of this worksection the following definitions apply:

- Pre-insulated rigid ductwork: (Also referred to as composite board ductwork.) Rigid ductwork fabricated from panels consisting of an insulating core faced on each side with metal.

1.5 SUBMISSIONS

Certification
Fire and smoke dampers: Submit test certificates showing conformance as follows:

- Fire and smoke dampers: To AS 1682.1 for air leakage.
- Fire dampers: To AS 1530.4 for FRL.

Flexible duct: Submit a flexible duct conformance report summary to AS 4254.1 Appendix A as certification of conformance with AS 4254.1.

Rigid ductwork: Submit test data verifying the assembled ductwork conforms to AS 4254.2 clause 2.1.2.

Execution details
Access panels: Submit proposed alternative sizes, if any.

Mechanical fire dampers: For positions where dampers cannot be installed to close in the direction of the air flow, submit proposed installation details.

Sealing: Submit details of proposed sealing methods and materials. Include the following:

- Proposals for conforming to the sealing requirements of AS 4254.2 and this specification.
- Proposed sealing materials including mastics and tapes.
- Proposed standard for leakage testing.

- Proposals for sealing builders' work components incorporated into the air path including, but not limited, to plenum ceilings, outside and return air plenums and risers.
- For each system to be leakage tested, a drawing showing the extent of the system to be tested including the total surface area of the system and the surface area of the portion to be tested.

Fire performance

Fire hazard properties: Submit evidence of conformity to PRODUCTS, **FIRE PERFORMANCE**, **Fire hazard properties**.

Fire-resistance level: Submit evidence of conformity to PRODUCTS, **FIRE PERFORMANCE**, **Fire-resistance of building elements**.

Products and materials

Type tests: Submit type test certificates showing conformance with the following standards:

- Sealants: To AS/NZS 1530.3.

Samples

Flexible duct: Submit a sample 2 m length of 300 mm diameter flexible duct with sheet metal spigot attached.

Pre-insulated rigid ductwork: Submit a sample 1.2 m length of 400 x 300 mm section pre-insulated rigid ductwork with joint flange in the middle, and a circular round sheet metal spigot and access panel installed.

Tests

Leakage testing reports: Submit a report on each system tested. Include in the report:

- Details of the system tested including a sketch of the portions of the system tested.
- Test pressure in Pa and as a percentage of the design operating pressure.
- The measured leakage rate in L/s and as a percentage of the design air quantity.
- If the section tested exceeded the maximum permissible leakage rate under test, provide details of the leakage sources identified and measures taken to rectify them.

Leakage retesting: If a system is retested, provide additional reports containing the information above.

Subcontractors

Training: Submit evidence that persons manufacturing and installing pre-insulated rigid ductwork have received training from the panel supplier.

Warranty

Pre-insulated rigid ductwork: Submit manufacturer's standard warranty.

1.6 INSPECTION

Notice

Inspection: Give notice so that inspection may be made of the following:

- Leakage testing of each duct system documented to be tested.

1.7 DESIGN CRITERIA

Maximum Duct velocities where size not shown or different air quantities are used, as follows:

Main Supply Ducts: 6 m/s
Main Return Ducts: 4.5 m/s
Branch Ducts: 4.5 m/s
Flexible Ducts: 2.5 m/s

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2 PRODUCTS

2.1 FIRE PERFORMANCE

Fire hazard properties

Ductwork materials: Tested to AS/NZS 1530.3. Fire hazard indices as follows:

- Spread-of-Flame Index: 0.
- Smoke-Developed Index: ≤ 3.

Facing materials: Tested to AS 1530.2: Flammability Index ≤ 5.

Assembled duct systems: Pass the UL 181 burning test.

Fire-resistance of building elements

Fire-resistance level of ductwork: Tested to AS 1530.4.

2.2 MATERIALS AND COMPONENTS

Corrosion resistance

General: Conform to the **Corrosion resistance table** for the external and internal atmospheric corrosivity categories documented in *0171 General requirements*. Alternatively, provide proprietary products with metallic and/or organic coatings of equivalent or higher corrosion resistance.

Requirement: In the **Corrosion resistance table** ductwork includes fittings and dampers other than fire, smoke and motorised dampers.

External category:

- Ductwork outside the building.
- Fire, smoke and motorised dampers in ductwork outside the building.
- Fire, smoke and motorised dampers located in the discharge air path within 3 m of the point of discharge from the building.
- Fire, smoke and motorised dampers located in the outside air or mixed air/recycle air path up to the filters.

Internal category:

- Ductwork inside the building not included in external situation.

Corrosion resistance table

Atmospheric corrosivity category to AS 4312	Fire, smoke and motorised dampers	Ductwork	Pre-insulated rigid ductwork
C1, C2 and C3	Metallic-coated sheet Z275/AZ150	Metallic-coated sheet Z275/AZ150	Aluminium foil facing ≥ 0.06 mm thick with UV resistant varnish applied at ≥ 3 g/m^2
C4	Stainless steel Type 316	Stainless steel Type 316	Stainless steel foil facing ≥ 0.1 mm thick

Duct tapes

Mechanical properties:

- Minimum tensile strength: 490 N/100 mm.
- Maximum tape thickness: 0.14 mm.

Adhesive: Non-toxic, high tack, synthetic pressure-sensitive type.

Liner: Easy release film.

Backing: Aluminium foil laminate or dead soft aluminium foil.

2.3 SHEET METAL DUCTWORK

Material

Galvanized steel duct and steel components less than 3 mm thick: Prime quality lockforming galvanized steel to AS 1397 Grade G2 or G3 to AS 2338 with Z275 coating to AS 1397.

Thickness: To AS 2338.

Components for stainless steel and aluminium ductwork: Use materials with corrosion resistance not less than that of the duct wall material.

Fasteners

Selection: Conform to **Fasteners material table**.

Rivets: Minimum size:

- For sheet metal to sheet metal: 3 mm.
- For sheet metal to supports, brackets and rolled steel angles: 4.8 mm.

Self-drilling and tapping screws: Provide only if base material into which they screw is thicker than 1.5 mm and they are unlikely to be removed or replaced.

Washers: Provide washers under nut and bolt heads.

Fasteners material table

Type	Galvanized steel duct	Aluminium duct	Stainless steel duct
Rivets	Expanding solid end type, aluminium base alloy	Expanding solid end type, aluminium base alloy	Stainless steel
Self-tapping screws	Zinc-plated steel	Stainless steel	Stainless steel
Self-drilling and tapping screws	Zinc-plated steel	Stainless steel	Stainless steel
Bolts, nuts washers and drop rods	Zinc-plated steel, service condition number 2	Stainless steel. Exception: Parts not in contact with air stream or corrosive conditions may be zinc-plated steel, service condition number 2	Stainless steel. Exception: Parts not in contact with air stream or corrosive conditions may be zinc-plated steel, service condition number 2

Drawbands

Material: Select from the following:

- Metallic-coated steel or stainless steel worm drive hose clamps.
- Metallic-coated steel or stainless steel packaging binders tensioned with a proprietary device designed for the material used.

Duct sealing

Duct seal class: Not lower than Class C to AS 4254.2 Table 2.2.1 regardless of air quantity, duct pressure or location.

Extent of sealing:

- Where the expression "Use duct sealant throughout" is used in AS 4254.2, apply sealant to the full length of all joints so no gaps or holes remain through which air might leak.
- Seal all holes, gaps and other openings in ductwork including, but not limited to branches, access doors, access panels, and connections to equipment.
- Seal as specified for ductwork all associated air handling equipment including but not limited to air handling units, fan coil units, diffusers and grilles, plenum and cushion head boxes, terminal equipment including VAV terminals and chilled beams.
- Seal holes for pipes, conduits, cables and rotating shafts including damper shafts.

Sealant materials: Use only sealants that:

- Do not foster microbial growth.
- Have a Smoke-Developed Index less than 3 and a Spread-of-Flame Index of 0 tested to AS/NZS 1530.3.
- Will maintain their sealing performance for the life of the duct system.
- Bond to the surface of application without primers.
- Are resistant to oils, refrigerants and water after curing.
- Are non-toxic.
- Have high elastomeric properties over the range of operating temperatures after curing.
- Are suitable for application by gun or hand tools.

Duct tapes: Do not use duct tape as the primary duct sealing agent. Use only as a secondary sealant on joints sealed by other means such as mastic, liquids or gaskets. Do not use duct tapes for non-sealant purposes.

Machine rolled flanges: Seal holes at corners.

2.4 PRE-INSULATED RIGID RECTANGULAR DUCTWORK

Panels

Construction:

- Core: Polyurethane or phenolic closed cell insulation in the R-Value documented.
- Facing: Provide facing materials as documented as follows:
  - . Aluminium: Aluminium foil with UV resistant varnish applied at ≥ 3 g/m².
  - . Anti-microbial coated aluminium: Aluminium foil with silver impregnated anti-microbial coating.
  - . Stainless steel.

Performance: Conform to the following:

- Operating temperature range: -35°C to +110°C.
- Operating pressure: ≤ 2000 Pa.
- Panel stiffness: Class R5 (> 358 kN/mm²).
- Corrosion resistance: Withstand saturated salt mist spray for 96 hours.
- Water vapour transmission: > 2000 m².hPa/mg.
- Insulation structure: 90% closed cell.

Storage and handling: Conform to panel manufacturer's recommendations.

Extrusions

Requirement: Provide extruded aluminium profiles supplied by the panel manufacturer to suit the panel thickness.

Insulation

Exemption: The insulation of pre-insulated rigid ductwork is not required to conform to *0744 Ductwork insulation* provided it conforms to this clause.

Insulation performance

Insulation R-Value (m^2.K/W): To BCA J5.5 and as documented.

Warranty

Requirement: Provide manufacturer's standard warranty on panels and associated products.

Warranty period: 15 years.

2.5 PRE-INSULATED RIGID RECTANGULAR DUCTWORK FABRICATION

Fabrication methods

Requirement: Conform to ANSI/SMACNA 022 and panel manufacturer's recommendations. The panel manufacturer's recommendations take precedence over ANSI/SMACNA 022.

Fabrication methods: Fabricate ducts using manual or automatic equipment to supplied by the panel manufacturer.

Stiffening

Requirement: Provide internal or external stiffening to meet the documented pressure class.

Bends and fittings incorporating bends

Select from:

- Long radius bend with dimensions to AS 4254.2 Figure 2.3(J) (a) formed from flat panels to the panel manufacturer's recommendations.
- Square back bend with turning vanes.

2.6 PRE-INSULATED RIGID ROUND DUCTWORK

Materials

Requirement: Provide materials as follows:

- Straight duct: Composite sections with polyurethane insulation.
- Fittings: Composite polyurethane insulated fittings supplied by the straight duct manufacturer.

Construction:

- Core: 25 mm thick polyurethane closed cell insulation.
- Internal and external facing: 120 micron aluminium foil with UV resistant varnish applied at ≥ 3 g/m².

Performance: Conform to the following:

- Operating temperature range: -35°C to +110°C.
- Operating pressure: ≤ 2000 Pa.
- Panel stiffness: Class R5 (> 358 kN/mm²).
- Corrosion resistance: Withstand saturated salt mist spray for 96 hours.
- Water vapour transmission: > 2000 m².hPa/mg.
- Insulation structure: 90% closed cell.

Extrusions
Requirement: Provide extruded aluminium profiles supplied by the panel manufacturer to suit the core thickness.

Insulation
Exemption: The insulation of pre-insulated rigid ductwork is not required to conform to *0744 Ductwork insulation* provided it conforms to this clause.

Insulation performance
Insulation R-Value (m^2.K/W): To BCA J5.5 and as documented.

Warranty
Requirement: Provide manufacturer's standard warranty on panels and associated products.

Warranty period: 15 years.

2.7 PRE-INSULATED RIGID ROUND DUCTWORK FABRICATION

Fabrication methods
Requirement: Conform to duct manufacturer's recommendations.

Joints in exposed round duct: Provide manufacturers invisible joints.

2.8 PRE-INSULATED RIGID DUCTWORK SEALING

Duct seal class
Standard: Notwithstanding AS 4254.2 conform to EUROVENT 2/2.

Requirement: Seal ducts to achieve the following performance:

Duct internal pressure	Duct seal Class to EUROVENT 2/2
-700 to 0 Pa	C
1 to 400 Pa	C
401 to 1000 Pa	B
1001 to 2000 Pa	B

Adhesive
Requirement: Provide 2 part water-based adhesive supplied by the duct material manufacturer.

Sealants
Requirement: Provide supplied sealants supplied by the duct material manufacturer.

2.9 PVC-U DUCTWORK

Material
Fire hazard properties: To AS 4254.2 clause 2.1.2.

Sheet:

- External applications: Pressed grey PVC-U sheet with UV inhibitors.
- Internal applications: Extruded grey PVC-U sheet with or without UV inhibitors.

Ducts: PVC-U pipe, with UV inhibitors.

Sheet stiffening
General: Attach stiffeners on edge, at 600 mm maximum centres. If necessary, provide additional stiffening to prevent flexing, drumming or sagging.

Material: Same as duct.

PVC-U ductwork thickness and stiffening table

Round duct diameter (mm)	Rectangular duct longest side (mm)	PVC-U sheet thickness (mm)	Rectangular duct stiffening (mm)	Flange width(mm)	Flange thickness (mm)
≤ 400	≤ 400	3	-	25	4
> 400, ≤ 600	> 400, ≤ 600	4	-	30	6
> 600, ≤ 750	> 600, ≤ 680	4.5	-	40	6
> 750, ≤ 900	> 680, ≤ 750	5	-	40	6
> 900, ≤ 1200	> 750, ≤ 1050	6	-	40	8
> 1200, ≤ 1500	> 1050, ≤ 1300	6	40 x 5	40	8
> 1500, ≤ 2100	> 1300, ≤ 1800	6	50 x 5	50	10

Welding

General: Continuously weld joints, including seams, stiffeners, flanges, and corners of fabricated bends, tees and fittings. Weld stiffeners on both sides. Back weld slip socket joints.

Butt welding: Vee type. Use hot air equipment.

- Thickness ≤ 4 mm: One run of 3 mm welding rod.
- Thickness > 4 mm: Triple welding rod or 3 runs of 3 mm welding rod.

Locations inaccessible for butt welding: Solvent weld, with continuous PVC-U H-section jointing sockets, heat formed for round duct cross joints.

Bending

Requirement: Immediately before bending sheet material, heat both sides to avoid thinning and high stress concentrations. Heat bend corners of rectangular ductwork to an inside radius equal to the material thickness, or 5 mm, whichever is the greater.

Seams

Requirement: Minimise longitudinal seams. Locate welded seams away from corners, preferably in the middle of a short side.

Cross joints

Flanged: Weld flanges to ductwork and connect using 6 mm diameter bolts at 25 mm maximum centres. Provide soft PVC gaskets or non-setting compound resistant to the duct's internal and external environmental conditions.

Slip sockets: Heat form sockets or form by welding PVC-U collars on to adjoining duct sections. Solvent weld overlapping duct sections before back welding.

Fittings

Material: The same material as the duct.

Joints: Welded.

Lobster-back bends: Fabricate bends for round ductwork from at least 5 segments, butt welded, with centreline radius at least 1.5 times the duct diameter.

Dampers

Requirement: Fabricate parts within ducts from PVC-U.

Supports for PVC-U ductwork

Requirement: Do not fix self-tapping screws into the duct.

2.10 FLEXIBLE DUCT

Requirement: All flexible ducts to be insulated. ***Rev 2017-01***

Materials

Uninsulated flexible duct: Select from the following:

- Aluminised fabric clamped on a formed metal helix. Do not use adhesives. Reinforce lap joints in the fabric.
- Coated steel wire laminated between two layers of aluminised polyester fabric using fire-resisting adhesive. Reinforce lap joints in the fabric.

Flexible ducts used for air containing free moisture: Locate supporting helix outside airstream.

Insulated flexible duct: As for uninsulated flexible duct with flexible blanket insulation wrapped around duct and covered with an outer vapour barrier and the following:

- Insulation joints: Lap insulation at least 50 mm at longitudinal and transverse joints.
- Minimum insulation R-Value (m^2.K/W): To BCA J5.5.

Minimum thermal resistance

Flexible Duct Application	*Minimum Insulation R-Value*
Air conditioning - Up to 3 m length	***1.0***
Air conditioning - Greater than 3m length	***2.0***
Ventilation	***1.0***

Rev 2017-01Insulation material: Conform to *0744 Ductwork insulation*.

2.11 KITCHEN EXHAUST DUCTWORK

Standard

Requirement: To AS 1668.1.

Construction

Ductwork: Do not crossbreak.

Grading: To AS 4254.2 and AS 1668.1.

Joints: Seal to AS 4254.2 clause 2.2.2.

Access panels: Provide access panels in the locations requiring liquid-tight cleanouts to AS 4254.2 and in addition at:

- The bottom of kitchen exhaust risers.
- Adjacent to sprinkler heads and duct sampling units inside the duct.

Drains: Provide a grease gutter and DN 25 drain socket and plug as follows:

- At the lowest point of each run of ducting.
- At the bottom of vertical risers.

Spark arrestance: To AS 1668.1 clause 6.2.9.

2.12 FIRE PROTECTION OF DUCTWORK

Sprayed coatings

Type: Fire resisting sprayed coating to achieve the required FRL. Provide additional cement hard set finishing coat in locations requiring protection against damage or water.

Composite systems

Type: Wraps or modular duct systems to achieve the required FRL.

Access

Fire damper access: Where access is required to the duct interior such as at fire damper access panels and damper quadrants, provide easily removable panels of FRL equivalent to the required FRL of the duct.

Exhaust fan access: For items such as smoke exhaust and kitchen exhaust fans that are too large or heavy to remove through access panels, provide a fire-resisting enclosure around the item with fire-resisting doors or removable fire-resisting panels large enough to permit removal of the item.

2.13 FLEXIBLE CONNECTIONS

General

Requirement: Isolate fans and air handling unit casings from ductwork, by means of airtight flexible connections.

Materials:

- Generally: Heavy duty, waterproof.
- In kitchen exhaust ductwork: To AS 4254.2 clause 2.1.3.

Length: Provide enough slack to allow free movement and vibration isolation under operating and static conditions.

Alignment: Align openings of connected equipment.

Fixing: Fix to attachments with metallic-coated steel strip. Seal joints. Do not paint flexible material.

Fire protection: To achieve the FRL of the attached duct.

Maintenance: Arrange to permit easy removal and replacement without disturbing ductwork or plant.

Restriction: Do not protrude connections or frames into the airstream if this would be detrimental to the air flow.

2.14 DAMPERS – GENERAL

Location

Balancing dampers: Provide at each branch duct or tee, as follows:

- Splitter type: Use only for supply branches up to 300 mm maximum dimension and with velocity in main duct less than 10 m/s. Do not use on return or exhaust ducts.
- Opposed blade dampers: Use for any size supply and for all return and exhaust ducts. Locate in each branch.

2.15 VOLUME CONTROL DAMPERS

General

Requirement: Provide dampers which are free of rattles, fluttering or slack movement and capable of adjustment over the necessary range without excessive self-generated noise or the need for special tools.

Material: To **Corrosion resistance** and the **Corrosion resistance table**.

Dampers required by AS 1668.1: To AS 1682.1.

Face dimensions: Duct size.

Connections: Mating angle flanged cross joints.

Frames: 1.6 mm minimum thickness metallic-coated steel or 2 mm minimum thickness aluminium folded to form channel sections at least 150 mm wide and welded at corners.

Dampers required to provide tight shut-off: Conform to the following:

- Side seals: Aluminium or stainless steel.
- Blade tip seals: Neoprene or silicone rubber.
- Leakage: ≤ 25 L/s.m^2 at 1.5 kPa pressure differential.
- Bearings: Sealed-for-life ball bearings only.
- Drive shafts: Keyed, square or hexagonal.

Dampers in smoke-spill systems: Metallic-coated steel or stainless steel blades and frames.

Blades

Material: Metallic-coated steel, aluminium or stainless steel.

Form: No sharp edges. Sufficiently rigid to eliminate movement when locked.

Minimum thickness:

- Metallic-coated sheet steel and stainless steel:
  - Single thickness blades: 1.6 mm.
  - Double thickness blades: 1.2 mm.
- Aluminium:
  - Single thickness blades: 2.4 mm.
  - Double thickness blades: 1.8 mm.

Maximum length: 1200 mm. If necessary provide intermediate mullions.

Single blade dampers:

- For single thickness blades: 600 mm maximum length, 600 mm maximum width or 600 mm maximum diameter.
- For single thickness blades with 6 mm minimum edge breaks: 1200 mm maximum length x 175 mm minimum width.
- For double thickness blades: 1200 mm maximum length x 300 mm minimum width.

Multi-blade dampers:

- For single thickness blades with 6 mm minimum edge breaks: 1200 mm maximum length 175 mm minimum width.

Bearings
Type: Oil impregnated sintered bronze bearings, sealed-for-life ball bearings or engineering plastic sleeve bearings that do not require lubrication for the life of the duct system. If the operating temperature is more than 50°C, provide sealed-for-life ball bearings only.

Housings: Rivet to damper frames.

Spindles
Material:

- Stainless steel dampers: Stainless steel.
- Other dampers: Zinc-plated steel or stainless steel.

Construction: Securely fix to damper blades.

Minimum diameter:

- Blade lengths ≤ 600 mm: 10 mm.
- Blade lengths > 600, ≤ 1200 mm: 12 mm.

Linkages
Fixing: Fix securely to blades so that the blades rotate equally and close tightly without slip.

Damper adjustment
Requirement: Provide a way to adjust the damper and lock it in position. Locate in an accessible position. Label the open and closed positions clearly and permanently.

2.16 SPLITTER DAMPERS

Construction
Standard: Fabricate to AS 4254.2 Figure 2.3 (H) with a minimum length 1.5 times the width of the larger branch.

Push rods: 5 mm diameter on 600 mm centres with screw locking bushes to fix position.

2.17 MOTORISED DAMPERS

Construction
Requirement: To **VOLUME CONTROL DAMPERS** and the following:

- Side seals: Aluminium or stainless steel.
- Blade tip seals: Neoprene or silicone rubber.
- Leakage: ≤ 25 L/s.m^2 at 1.5 kPa pressure differential.
- Bearings: Sealed-for-life ball bearings only.
- Drive shafts: Keyed, square or hexagonal.

Control characteristics
Flow characteristics: Linear flow relative to damper motor drive shaft rotation.

Type:

- Outdoor air/return air mixing dampers: Parallel blade type with air streams directed towards each other.
- Face and bypass dampers: Parallel blade type with air streams directed towards each other.
- Other modulating dampers: Opposed blade type.
- Two position shutoff dampers: Parallel or opposed blade type.

2.18 NON-RETURN DAMPERS

Construction
Requirement: Conform to **VOLUME CONTROL DAMPERS**. Counterweight the assembly so that it:

- Offers minimum resistance to air flow.
- Closes by gravity.

2.19 FIRE AND SMOKE DAMPERS

General

Specification: To AS 1682.1.

Fire damper type: Mechanical or intumescent, as documented.

Requirement: Provide free cross section area at least 85% of the face area. Provide oversize damper and enlarge duct both sides of damper if necessary to achieve this.

Material: As documented in the **Fire and smoke damper schedule**.

Links

Mechanical fire dampers: Provide frangible bulb or fusible links.

Smoke dampers: Provide fusible links activated by either local heat or a low power external electrical impulse.

Installation: Mount for easy replacement.

Access panels

General: Provide for maintenance of dampers and replacement of links.

2.20 SUBDUCTS

General

Standard: To AS 1668.1.

Material: Same as connecting ductwork or shaft.

2.21 ACCESS OPENINGS – LOCATION

Access doors

Location: Provide an access door in each section of air handling units where access is required for maintenance, inspection or removal of components. Removable panels may be used instead of doors where access is required only for removal of coils.

Access panels

Location: Conform to the following:

- Next to each component located inside the duct requiring regular inspection and maintenance including, but not limited to:
  - Fire and smoke dampers.
  - Smoke detectors.
  - Motorised dampers.
  - Filters.
  - On the air entering side of electric duct heaters.
  - On the air entering side of duct mounted heating coils.
- In air handling units where unit size is insufficient to fit an access door.
- As documented in **KITCHEN EXHAUST DUCTWORK**.
- In the vicinity of moisture producing equipment, to AS/NZS 3666.1 clause 2.11.3.
- In other documented locations.

2.22 ACCESS PANELS

Sizes

Access panels: Minimum clear opening:

- Personnel access: 450 x 600 mm.
- Hand access: 200 x 300 mm.

Construction

Type: Double panel, deep formed, zinc-coated steel construction, insulated to match the duct, or filled with at least 25 mm glass wool or rock wool insulation.

Cold bridging: Arrange to prevent condensation on cold surfaces.

Frames: Provide rigid matching galvanized steel frames securely attached to the duct. Do not protrude any part of the panel or frame into the airstream.

Seals: Mechanically fixed to either the panel or the frame for an airtight seal against the operating pressure when latched in the closed position. Use a fixing method that permits easy replacement. Conform to the following:

- Fire-resisting seals: Woven ceramic fibre material.
- Other seals, Silicone rubber or soft neoprene.

Latches: Wedge type sash latches.

Number of latches:

- For personnel access: 4.
- For hand access: 2.

Handles: Provide a D handle on access panels for personnel access.

2.23 ACCESS DOORS

Construction

General: Provide rigid, reinforced access doors.

Thickness: ≥ 50 mm.

Construction: Provide either:

- Sandwich panel: As documented for wall and ceiling panels. Form door edging with a heavy gauge aluminium extrusion with double web seal to both skins. Mitre corner and firmly secure to panel with countersunk head screws.
- Folded: Two-piece press formed or machine folded from zinc coated steel at least 1.6 mm thick.

Size: 1350 mm high x 600 mm wide clear opening or larger dimensions if:

- Necessary to permit safe removal of equipment inside the section, or
- Chamber: To BCA G1.2 in which case the minimum clear opening is 1500 mm high x 600 mm wide.

Door swing: Except where the pressure differential would require an excessive force to open the door, swing doors against air pressure as follows:

- Doors on the inlet side of the fan: To open outwards
- Doors on the discharge side of the fan: To open inwards.

Cold bridging: Arrange to prevent condensation on cold surfaces.

Jamb, stiles and head: Rigid matching ≥ 2.5 mm zinc-coated steel, or ≥ 3.0 mm PVC-U or fibreglass securely mounted.

Door hardware:

- Catches: Provide at least 2 heavy duty proprietary clamping-type latches with permanently attached handles that can be operated from both the inside and the outside of the door. Provide satin chrome plated finish to exterior components.
- Hinges: Hang doors on edge-mounted, rising butt type self-closing hinges capable of holding the door fully open. Construct from chrome plated brass or heavy duty aluminium alloy. Provide stainless steel hinge shaft and nylon bearing surfaces.
- Installation: Securely bolt hardware to the door and frame by a method which minimises cold bridging and prevents the forming of condensation on the outside of the air handling unit.

Seals: Mechanically fix to the door to create an airtight seal when the latched is closed. Use a fixing method that permits easy replacement.

- Fire-resisting seals: Woven ceramic fibre material.
- Other seals: Silicone rubber or soft neoprene.

Insulation: Construction and insulation properties including material R-Value to match the insulation of the duct, plenum or casing in which the door is located.

2.24 ELECTRIC DUCT HEATERS

General

Standards: To AS/NZS 3102 and AS 1668.1.

Elements: Sheathed in steel or nickel alloy. Provide brazed spiral steel fins.

Connections: Connect the elements in each heater bank so that the load is balanced over the three phases. Earth cover plate and frame.

Frames: Assemble elements in a metal frame with terminal connections in an enclosed terminal box.

Heating section: Install to allow access to the terminal box and removal of the assembly without disturbing other components.

Fin rating: < 20 W/m^2.

Heat distribution: Provide uniform heating across the duct cross section.

Maximum temperature air rise across the heater: 7.5 K at the maximum supply air flow rate.

Airflow: Maintain uniform air velocity across the duct cross section.

Velocity: Between 2 m/s and 5 m/s.

Electrical connection: Permanent electrical connection to the heater.

2.25 KITCHEN HOODS

Standards

Requirement: To AS 1668.1 and AS 1668.2.

Materials

Material: As documented, and as follows:

- Stainless steel: 1.2 mm thick, 2B finish. Continuously weld seams. Grind the weld smooth and polish affected areas.
- Metallic-coated steel: Metallic-coated sheet Z275/AZ150.

Volume dampers

General: If there is more than one duct take off, provide a volume damper at each duct take off. Adjust dampers for uniform air flow over the face of the hood.

Luminaires

General: Provide access doors for the installation of luminaires.

Glass panels: Heat resistant and sealed to the hood with gaskets, to prevent entry of grease and moisture but allowing thermal expansion.

2.26 FUME CUPBOARDS

Type

Requirement: Non-recirculating fume cupboards to AS/NZS 2243.8.

Arrangement: Single sided or double sided, as documented.

Standards

Safety in laboratories: To AS/NZS 2243.1.

Hazardous areas: To AS/NZS 60079.10.1.

Fume cupboards: To AS/NZS 2243.8.

Fans

Requirement: To **FUME CUPBOARD FANS** in *0731 Fans*.

Construction

Materials and fabrication: To **PVC-U DUCTWORK**.

Shell and interior generally: Welded PVC-U.

Work surface: One piece welded PVC-U.

Sash: Vertically sliding toughened glass or clear acrylic ≥ 6 mm thick with stainless steel sash cords and corrosion resistant counterweights. Arrange so sash stays in place at all stopped positions.

Double sided fume cupboards:

- Interlock sashes so both cannot be open at the same time.
- Provide control panel and service valves on both sides.

Fixed minimum opening: 50 mm.

Finish of internal fixtures and components: Of corrosion and solvent resistance not lower than the material of the shell and interior.

Ductwork

Material: PVC-U to **PVC-U DUCTWORK** or stainless steel type 316 to **SHEET METAL DUCTWORK**, as documented.

Installation: Minimise horizontal duct runs. If horizontal ducts are unavoidable, slope downwards in the direction of air flow to trapped drain points.

Damper: Provide a lockable damper in each system for air flow adjustment.

Discharge: To AS/NZS 2243.8 clause 3.2.7.

Drains

Location: Provide permanently connected drains ducts for condensate removal at the lowest point of the fan casing and low points in ducts.

Construction:

- Material DN 50 PVC-U.
- Trap: Provide a removable water seal P-trap of sufficient depth to suit the duct pressure.

Discharge: Run drains to waste.

Services

Requirement: Provide the following services integral to the fume cupboard and as documented:

- Lighting: One separately switched fluorescent luminaire (flame proof, vapour sealed and corrosion proof) to provide 400 lux at the work surface.
- Power: Locate socket outlets outside the chamber.
- Waste treatment: Provide an acid neutralising tank and pass waste through it.

Controls

Requirement: Provide the following outside the chamber:

- Separate fan and light controls.
- Controls for water and gas services.
- Automatic fan speed control to maintain constant face velocity at all sash opening heights.
- Labelled emergency isolation switches for electricity and gas.
- Automatic isolation of electricity and gas in the event of inadequate air flow.

3 EXECUTION

3.1 DUCTWORK INSTALLATION

Arrangement

Ductwork: Arrange ductwork neatly. Provide access to ductwork components which require inspection, entry, maintenance and repairs to *0171 General requirements*, **ACCESS FOR MAINTENANCE**. Where possible, arrange duct runs adjacent and parallel to each other and to building elements.

Spacing

Requirement: Provide minimum clear spacing, additional to duct insulation, as follows:

- 25 mm between adjacent ducts.
- 25 mm between duct flanges or upper surfaces of ducts and undersides of beams and slabs.
- 50 mm between ducts and electric cables.
- 150 mm between ducts and ground, below suspended floors.

Flexible duct

General: Install flexible duct as straight as possible with minimum number of bends. Maximise bend radius but not less than required by AS 4254.1 clause 2.5.3(i).

Cutting length: Make sure the inner core is fully extended before cutting. cut to this length. Do not leave excess lengths of flexible duct for possible future relocation of air terminal devices.

Joints: Securely fix flexible duct to rigid spigots and sleeves using sealant and draw band encased in tape as detailed in AS 4254.1. If used, place mastic between the flexible and rigid duct, not as a fillet.

Support: To AS 4254.1. Limit sag to less than 40 mm/m.

Flexible duct hanging supports shall be Kwik-Flex, or approved equal proprietary product.

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Maximum length of flexible duct sections: 6 m including the length of any rigid duct or sleeves used to join lengths of flexible duct.

Substitution: If rigid duct is shown on the drawings do not substitute flexible duct.

Fire and smoke dampers
Installation: To AS 1682.2.

Motorised dampers
Maintenance access: Locate dampers and damper motors in accessible positions, for blade and motor maintenance and blade seal replacement.

Mounting: Sufficiently rigid to prevent flexing or distortion of the frame or ductwork during operation.

Operation: If 2 sets of dampers are connected to a single motor, provide linkages which allow either damper to be adjusted without affecting the other.

Cleaning
Requirement: During installation progressively remove construction debris and foreign material from inside ducts.

Drainage
Requirement: Provide drainage to AS/NZS 3666.1 at locations in ductwork where moisture may accumulate including at outside air intakes.

Ductwork exposed to weather
Requirement: Conform to the following:

- Seal all parts of all ductwork joints.
- Provide watertight protective shields over joints.
- Seal all duct supports where they attach to the duct.
- Seal all reinforcement attachments so that moisture is not retained in any gap or crevice.
- Profile or cover the top side of ductwork to shed water.

3.2 PRE-INSULATED RIGID DUCTWORK INSTALLATION

General
Fire dampers in pre-insulated rigid ductwork
Requirement: Install to AS 1682.2 and the panel manufacturer's recommendations including the use of F profile extrusions.

Duct supports
Supports and spacing: Conform to ANSI/SMACNA 022 and panel manufacturer's recommendations. The panel manufacturer's recommendations take precedence over ANSI/SMACNA 022.

3.3 LEAKAGE TESTING

Standard
Leakage testing methods: Select from the following:

- ANSI/SMACNA 016.
- The Building and Engineering Services Association publication B&ES DW/143.

Test pressure: To AS 4254.2

Maximum leakage rate under test: Less than 5% of the total design air quality of the duct system, times the ratio of the duct surface area under test to the total duct surface area of the system.

Test method
Amount of system to be tested: At least 10% of the total surface area of the system including a pro-rata proportion of the following:

- Floor distribution, riser and plant room ducts.
- Each seam, joint and sealing construction type.
- Longitudinal seams.
- Circumferential joints.
- Rigid ductwork.
- Flexible ducts.
- Flexible connections.
- Diffusers grilles and other terminal devices.
- Air handling plant and plenums.
- VAV terminals and other duct mounted equipment.

- Supply, return, outside air and exhaust ducts.
- Builders' work risers used in lieu of ducts specified in this worksection.

Duration of the test: Maintain the test pressure within ± 5% for at least 5 minutes.

Instruments: Conform to *0791 Mechanical commissioning.*

Leakage flow rate measurement: Use instruments that have been certified by an Accredited Testing Laboratory in the past 12 months and have:

- Accuracy: Better than ± 5% of measured value.
- Resolution: Better than 1% of measured value.

Failure under test

Requirement: If the leakage in the duct system exceeds the documented maximum leakage rate under test:

- Locate leaks and mark their position on the outside of the duct.
- Rectify leaks.
- Record the generic location of leaks and corrective action.
- Retest the system as above but with at least 20% of the total surface area of the system.

Repeat test: If the leakage in the duct system under retest exceeds the documented maximum leakage rate under test, retest with 100% of the total surface area of the system.

Reports

Requirement: Conform to **SUBMISSIONS**.

0744 DUCTWORK INSULATION

1 GENERAL

1.1 RESPONSIBILITIES

General
Requirement: Provide insulation of ductwork and related items, as documented.

Alternative insulation methods and materials
General: Do not submit alternatives for materials or methods that have lesser quality or characteristics in terms of the following:

- Cold bridging.
- Corrosion resistance.
- Durability during and after installation.
- Performance.
- R-Value.

1.2 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

1.3 STANDARDS

General
Ductwork insulation: To AS 4254.1 and AS 4254.2.

Performance and technical provisions: To AS/NZS 4859.1.

Installation of glass wool and rock wool insulation
Glass Wool and Rock Wool insulation: Conform to the
ICANZ Industry code of practice for the safe use of glass wool and rock wool insulation.

1.4 INTERPRETATION

Definitions
General: For the purposes of this worksection the following definitions apply:

- FBS-1 (fibre-bio-soluble) mineral wool: Insulation composed of bio-soluble glass or rock fibres.
- Fire hazard properties: Terminology to BCA A5.5.

1.5 SUBMISSIONS

Fire performance
Fire hazard properties: Submit evidence of conformity to PRODUCTS, **FIRE PERFORMANCE**, **Fire hazard properties**.

Products and materials
Thermal insulation performance: Submit evidence of conformance to AS/NZS 4859.1.

Alternative insulation methods and materials: If offering alternatives, submit evidence that they are equal or superior quality and characteristics than that documented. Include comparison of the following:

- Cold bridging.
- Corrosion resistance.
- Durability during and after installation.
- Suitability for the operating temperature range.
- Thermal and other performance.

Samples
Requirement: Submit samples of the following:

- Each type of insulation, applied to a sample 1.5 m long section of ductwork, including a site applied insulated transverse joint.

Cutaway sections: For each sample, provide cutaway sections to permit inspection of application details including insulation materials, adhesives, mastics, fixings and sheathing.

2 PRODUCTS

2.1 GENERAL

Storage and handling

Labelling: Deliver mineral wool products to site in packaging with third party mark of conformity indicating product is bio-soluble and not listed as a hazardous material in the Safe Work Australia Hazardous Chemical Information System (HCIS).

Insulation performance

Insulation R-Value: To NCC J5.5 and as documented.

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Location of Ductwork	*Minimum Insulation R - Value*
Ductwork exposed to direct sunlight	***3.0***
All other locations	***2.0***
Within air conditioned space	***1.2***

2.2 FIRE PERFORMANCE

Fire hazard properties

Insulation materials: Tested to AS/NZS 1530.3. Fire hazards indices as follows:

- Spread-of-Flame Index: 0.
- Smoke-Developed Index: ≤ 3.

Facing materials: Tested to AS 1530.2: Flammability index ≤ 5.

Materials with reflective facing: Tested to AS/NZS 1530.3 and the recommendations of Appendix A6.

Assembled duct systems: Pass the UL 181 burning test.

2.3 INSULATION MATERIALS

Type

Form: Batt, board or blanket, and the following materials, as scheduled: ***Rev 2017-01***

- Glass wool.
- Rock wool.
- Polyester: Thermally bonded polyester fibres.
- Polyolefin: Closed cell cross-linked polyolefin foam.

Insulation materials

Standard: To AS/NZS 4859.1.

Insulation blowing agents

Restricted agents: Conform to **MATERIALS AND COMPONENTS**, **Prohibited materials** in *0171 General requirements*.

Vapour barrier

Standard: If vapour barrier performance is documented, provide a system with a vapour membrane classification of Class 1 to AS/NZS 4200.1.

Semi-rigid insulation

General: Physical properties:

- Alkalinity: pH 7 to 9.
- Moisture absorption: Non-hygroscopic.

Type: Batt or board form with a maximum mean deflection of 6 mm for 50 mm thick material and 20 mm for 25 mm thick material, tested as follows:

- Freely support a 900 x 1500 mm test piece on its longer sides.
- Allow the test piece to stand for 10 minutes and measure the vertical deflection.
- Turn the test piece over and repeat the test.
- Average the results.

Minimum absorption coefficients table

Insulation R-Value (m^2.K/W)	Absorption coefficients (nominal) to AS ISO 354 at					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1.2	0.13	0.43	0.89	1.02	0.89	0.82
2.0	0.33	1.05	1.25	1.06	0.98	0.91
3.0	0.60	1.21	1.21	1.13	1.09	0.99

Adhesives

Type: Suitable for bonding facing to the insulation. Apply in an even coat.

Smoke-Developed-Index: 0.

Aluminium foil laminate sheet

Standard: To AS/NZS 4200.1 as follows:

- Internal insulation: Heavy duty before perforation.
- External insulation: Heavy duty unperforated.

Test criteria: To UL 181 with performance to AS 4254.1.

Duct tapes

Mechanical properties:

- Minimum tensile strength: 490 N / 100 mm.
- Maximum tape thickness: 0.14 mm.
- ***Minimum tape width: 100mm*** ***Rev 2017-01***

Adhesive: Non-toxic, high tack, synthetic pressure-sensitive type.

Liner: Easy release film.

Backing: Aluminium foil laminate or dead soft aluminium foil.

Elastomeric foam insulation

Material: Chemically blown closed cell nitrile rubber in sheets or rolls. Provide with a smooth natural finish and vapour barrier properties.

Standard: To ASTM C534/C534M.

Physical properties:

- Thermal performance: As for the attached duct.
- Moisture absorption: Non-hygroscopic.
- Water vapour diffusion resistance μ: ≥ 5000 to EN 13469.

Adhesives: Adhesive fix and seal exterior joints. Provide only solvent-based adhesive supplied by insulation manufacturer and designed specifically for the material being used.

Protection: Metal sheath insulation where:

- Exposed to sunlight.
- Subject to mechanical damage.

Alternative protection: Where exposed to sunlight but not exposed to mechanical damage, provide 2 coats of tintable, water-based, rubberised, UV resistant, flexible paint finish to outdoor installations.

3 EXECUTION

3.1 GENERAL

Fixing devices

Standard: To AS 4254.2 clause 2.7.

Pins: Stud welded fully annealed metallic-coated steel.

Speed clips: Bevel edged metallic-coated steel with an area not less than that of a 25 mm circle. Secure speed clips flush to the face of the insulation.

Protection: Cut off excess length of pins after insulation and speed clips have been applied or bend parallel with the insulation surface. Cover fixing pins and speed nuts on external insulation with aluminium foil laminate tape.

Insulation overlap

General: Provide an overlap of at least 300 mm where insulation changes from the inside of the duct to the outside.

Joints

Requirement: Install insulation with the least number of joints practicable.

Use of multiple layers: If insulation is applied in more than one layer, stagger longitudinal and end joints.

Insulation near moisture producing equipment

General: If the likelihood exists of moisture accumulation inside ducts, in the vicinity of moisture producing equipment use only external insulation.

Metal sheath external insulation: In plant rooms and as documented in the **Ductwork insulation schedule**.

Vapour barriers

Type: Free from perforations and leaks, continuous, and sealed continuously at penetrations.

Location: Place vapour barriers on the side of the insulation that will be warm during cooling mode operation.

Cold bridging

Requirement: If cold bridging cannot be prevented by any of the methods documented, provide a drained copper, stainless steel or PVC-U drip tray under the duct to collect condensation and run to waste.

Application of tapes

Tape width: ≥ 72 mm.

Adhering surface: Make sure surfaces are dry and free of dust and grease before applying tapes.

Completion of fabrication

General: After each length of duct or each fitting has been insulated inspect and remove any off cuts, drill swarf or other loose material.

Storage: Store under cover and protected from weather and the entry of foreign matter.

Internal insulation of ductwork connected to evaporative coolers

Protection: Moisture resistant or protected with a moisture resistant membrane.

3.2 INTERNAL INSULATION – LAMINATE FACED

System description

Insulation type: Semi-rigid board or batt.

Surface facing: Factory applied perforated aluminium foil laminate.

Application

General: Cover parts of ducts designated to be insulated, with individual pieces of insulation for each side of the duct. Where this is not possible, butt join edges of adjacent pieces. Where multi-layers are used (round or oval ducts) stagger all joints.

Joins in insulation

General: Cover joins with 100 mm wide strip of facing material or tape located centrally over the join.

Longitudinal joins: Locate behind corner angles or cover strips.

Fixing method

Method: Select from the following:

- Corner angle and end nosing method.
- Free edge method.

Fixing pins: Provide to AS 4254.2 clause 2.7.1.

Corner angle and end nosing method

Installation: Conform to the following:

- Overlap insulation on adjacent sides at corners.
- Hold insulation in position with metallic-coated steel corner angles.
- Fix corner angles under the turn back of the end nosing.
- For corner angles longer than 1600 mm, provide additional fixing at 1600 mm maximum centres.

Corner angles:

- Ducts with faces < 300 mm: 25 x 25 x 0.55 mm, minimum.
- Other ducts: 40 x 40 x 0.55 mm, minimum.

End nosings: At ends of ducts, hold insulation in position with U-shaped metallic-coated steel end nosings, with edges crimped towards the insulation surface. Rivet end nosings to ducts.

Size: 0.55 mm thick with a minimum 50 mm turn back over the insulation.

Butt joints: Square cut and butt tightly together edges of adjacent pieces of insulation. Cover with 50 x 0.55 mm metallic-coated steel strip. Rivet cover strips under corner angles or under turn-back of end nosings. For cover strips longer than 1600 mm, provide additional fixing at 1600 mm maximum centres.

Fixing pins: For ducts with faces ≥ 300 mm, fix the insulation at 300 mm maximum centres with at least one row per duct face.

Free edge method

General: Use only where larger duct side is no more than 300 mm.

Edges: Extend insulation proud of ductwork at each end, to provide cushion joints that fully seal during assembly.

3.3 INTERNAL INSULATION – METAL FACED

Location

General: Apply metal facing to internal insulation in the following locations:

- 300 mm each side of fire, smoke and volume control dampers.
- Air handling plant casings and plenums.
- All other locations where insulation may be subject to mechanical damage.
- Other locations as documented.

System description

Insulation type:

- Rectangular ductwork: Semi-rigid batts.
- Circular and oval ductwork: Flexible batts.

Surface facing: Perforated metal.

Application

General: Cover parts of ducts designated to be insulated with individual pieces of insulation for each side of the duct. Where this is not possible, butt join edges of adjacent pieces. Overlap adjacent sides at corners.

Rectangular ductwork

Metal facing: Support insulation against duct surfaces with metal facing, cut and folded to the inside dimension of the duct to form overlapping joints at corners. Rivet the overlap at 300 mm maximum centres.

Facing material: 0.55 mm metallic-coated steel uniformly perforated with 2.5 mm diameter holes providing 10% open area.

End nosings: At ends of ducts hold insulation and metal facing in position with U-shaped metallic-coated steel end nosings, with edges crimped towards the surface. Rivet end nosings to ducts and rivet the overlap with the metal facing at 300 mm maximum centres, with at least one rivet per duct face.

Nosing size: 0.55 mm thick with a minimum 25 mm turn-back over the metal facing.

Fixing: Z section 0.55 mm metallic-coated steel fastened to ductwork and to facing with blind rivets. Provide adhesive cloth tape between the Z section and the duct. For duct sides over 600 mm, hold in

position at 600 mm maximum centres with at least one row of rivets per duct face. Arrange to prevent condensation on cold surfaces.

Circular ductwork

Metal facing material: Metallic-coated steel uniformly perforated with 2.5 mm diameter holes providing 10% open area.

Method: Fabricate the facing in the same manner as the circular duct, with helical lock seams for longitudinal joints. Lap transverse joints in the facing in the direction of air flow with a minimum overlap of 75 mm. Wrap insulation around the facing so that the surface designed to be exposed faces the air stream, and fix with polypropylene straps. Slide the insulated cylinder into the circular ductwork sections. Where the insulation is terminated, and at joints, provide end caps or channels.

Metal facing table

External duct diameter (mm)	Metal facing thickness (mm)
≤ 650	0.6
> 650, ≤ 950	0.8
> 950, ≤ 1250	1.0

3.4 EXTERNAL INSULATION – LAMINATE FACED

System description

Insulation type: Flexible batts or blanket.

Surface facing: Factory applied aluminium foil laminate.

Application

General: Wrap insulation around the outside of ducts, covering the parts designated to be insulated. Minimise the number of joints.

Joints: Square cut and butt together the edges of adjacent pieces of insulation.

Insulation of bends: Apply a single piece of insulation to each face of a bend or transition. Insulate bends and transitions on round and flat oval ducts with individually mitred gores cut to fit the fitting.

Vapour sealing: Seal the vapour barrier at joints with 100 mm wide aluminium foil laminate tape, applied centrally over the joint. Where the insulation is impaled over pins, seal the vapour barrier by covering pins with water-based mastic vapour barrier or reinforced aluminium foil faced tape at least 100 x 100 mm.

Flanges, stiffeners and joints: Maintain insulation thickness over flanges, joints, stiffeners and other items that protrude from the face of the duct. Use one of the following methods:

- Carry the insulation material over the protruding item without cutting or joins.
- Insulate with 150 mm wide strip of the same material as used to insulate the duct. Fix with a row of pins and speed nuts on each side of the protruding item. Provide a continuous vapour barrier.

Polyolefin foam insulation: Apply proprietary 120 mm wide polyolefin foam flange strips over flanges, joints and stiffeners.

Fixing method

Materials other than polyolefin foam: Select from the following:

- Pin method: Provide pins to each face of the duct as follows:
  - . Horizontal ducts < 380 mm wide: Pins not required.
  - . Horizontal ducts > 380, < 760 mm wide: One row of pins along centreline to side and bottom duct faces at 380 mm maximum centres.
  - . Horizontal ducts ≥ 760 mm wide: Pins spaced at 380 mm maximum centres.
  - . Vertical ducts < 610 mm wide: Pins not required.
  - . Vertical ducts ≥ 610 mm wide: Pins spaced at 380 mm maximum centres.
- Strap and pin method: Provide 12 mm wide polypropylene strapping at maximum 600 mm intervals.
  - . Horizontal ducts ≥ 600 mm wide: Hold insulation in position on the underside with fixing pins spaced at 400 mm maximum centres with at least one row per duct face.
  - . Vertical ducts ≥ 600 mm wide: Provide pins to all faces at 400 mm maximum centres.

- Corner angle and strap method: Provide metallic-coated sheet steel corner angles on all four sides of the duct. Retain with 12 mm wide polypropylene strapping at maximum 750 mm intervals. Provide angles as follows:
  . 25 mm nominal thickness insulation: 38 x 38 mm.
  . 50 mm nominal thickness insulation: 63 x 63 mm.

Polyolefin foam: Provide pins spaced 50 mm from all edges and spaced 200 to 300 mm apart in all directions.

3.5 EXTERNAL INSULATION – LAMINATE FACED AND METAL SHEATHED

System description

Insulation type: Semi-rigid batts.

Surface facing: Factory applied aluminium foil laminate.

External protection: Metal sheathing.

Application

General: Conform to **EXTERNAL INSULATION – LAMINATE FACED**, **Application**.

Support: Support insulation against the duct surfaces with 0.55 mm metallic-coated steel cut and folded to the outside dimensions of the insulated duct.

Joints in sheathing: Lap joints in sheathing at least 30 mm and rivet at 100 mm centres. Factory made joints may be of the grooved seam or spot welded type. Where necessary, provide for sheathing removal for maintenance or access, by providing self tapping screws that do not penetrate the vapour barrier.

Sealing: If exposed to weather, seal joints with silicone mastic sealant.

3.6 INSULATION OF DUCTWORK COMPONENTS AND FITTINGS

Extent

Requirement: Except for packaged air conditioning plant required to conform to MEPS, insulate all components and fittings carrying cooled and/or heated air, including the following:

- Access doors and panels.
- Air handling units.
- Attenuators.
- Chilled beams.
- Dampers.
- Electric duct heaters.
- Fan coil units.
- Fans not inside insulated air handling units.
- Plenums and cushion head boxes on air grilles.
- Variable air volume terminals.
- Other fittings and duct-mounted components, and builder’s work items having the above functions.

Insulation R-Value

Minimum: To BCA J5.5 and as documented.

Installation

Access for maintenance: Arrange insulation to permit easy access to items within requiring routine inspection or maintenance.

Operation: Arrange insulation so that it does not impede the operation of dampers, fans and other components.

Plenum and cushion head boxes on air grilles

Insulation type: Internal insulation, with perforated aluminium foil laminate, black finish.

Insulation fixing: Turn facing back over raw edges of insulation for at least 75 mm and bond the turn back to the insulation before installation. Provide fixing pins at 250 mm maximum centres with at least one pin per face. Fully bond insulation around neck with adhesive.

Dampers
Internal: Leave clearance between insulation and edges of the splitter or manually operated damper blades.

External: For manual and motorised dampers, provide removable insulated sheet metal top hat sections to encase dampers.

Access doors and panels
General: Provide insulation to access doors and panels. Arrange to prevent condensation on cold surfaces.

Electric duct heaters
Requirement: Provide insulation to AS/NZS 3102.

3.7 INSULATION OF DUCT FLEXIBLE CONNECTIONS

General
Requirement: Insulate duct flexible connections if the temperature of the air inside the duct may cause condensation on the outside of the flexible connection.

Minimum insulation R-Value: Same as the connected duct.

Method
General: If the insulation of the connecting ductwork is:

- External laminate faced on one or both sides of the flexible connection: Insulate duct flexible connection as required in **EXTERNAL INSULATION – LAMINATE FACED**.
- Any other insulation system: Insulate duct flexible connection with elastomeric foam as required in **ELASTOMERIC FOAM INSULATION**.

0746 AIR GRILLES

1 GENERAL

1.1 RESPONSIBILITIES

General
Requirement: Provide air grilles, as documented.

1.2 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

1.3 STANDARDS

General
Requirement: To AS 4254.1 and AS 4254.2.

1.4 INTERPRETATION

Abbreviations
General: For the purposes of this worksection the following abbreviations apply:
- VAV: Variable air volume.

Definitions
General: For the purposes of this worksection the following definitions apply:
- ***Accessible ceiling: A ceiling in which the item requiring access can be reached by temporary or permanent means, conforming to WHS regulations.*** ***Rev 2019-03***
- Air grille: An air grille of metal or other material fitted to the inlet or outlet end of an air duct or within walls, floors, ceilings or doors. It includes all types of diffusers, registers and other grilles.
- Diffuser: A supply air grille mounted in a ceiling or on the underside of a duct through which air is supplied and distributed within a room or interior space of a building.
- Register: A supply air grille mounted in a wall or on the side of a duct.
- Cushion head box: A plenum box fitted above a diffuser.
- Louvres - continuous: Louvres that run continuously past, and are supported by, concealed framing or brackets.
- Louvres - horizontal: Louvres that span between frames stiles, mullions or vertical supports.
- Louvres - vertical: Louvres that span between frame heads and sills, or horizontal supports.
- Plenum box: A lower velocity (larger volume) duct element behind an air grille intended to allow equalisation of air flow over the air grille.

1.5 SUBMISSIONS

Products and materials
Type tests: Submit test results as follows:
- Acoustic performance: To ISO 5135 or ANSI/ASHRAE 70.

1.6 SAMPLES

General: Submit a sample of each type of air grille. Include plenum box or cushion head box and blanking plates, as documented.

2 PRODUCTS

2.1 MANUFACTURE

General

Proprietary air grilles: Conform to the following:

- Free from distortion, bends, surface defects, irregular joints, exposed fastenings and operation vibration.
- With flange corners neatly mitred, butted and buffed, with no joint gaps.

Material: Steel or aluminium.

Finish:

- Exposed surfaces: Powder coated to the nominated colour.
- Visible internal elements: Matt black enamel.

Fixings: Provide secure, concealed fixings that allow removal without damage to surrounds or air grilles.

Variable volume systems

General: Provide air grilles tested for variable volume applications.

2.2 VOLUME CONTROL DAMPERS

Dampers controlling a single air grille attached to flexible duct

General: Provide damper as follows:

- Duct spigot located above tiled or accessible ceiling: Provide a butterfly damper in the rigid duct spigot.
- Duct spigot not located above tiled or accessible ceiling: Provide an opposed blade damper behind the face of the air grille.

Butterfly dampers

Type: Single-blade round dampers with external locking quadrant indicating butterfly damper position.

Stream splitter dampers

Type: Duct mounted ganged, multi-blade, stream splitter type.

Location:

- At rigid duct take-offs to outlets.
- Location: Conform to **Dampers controlling a single air grille attached to flexible duct**.
- Behind duct mounted registers.

Opposed blade dampers

Type: Multi-blade type with blades linked for ganged operation. If located at the air grille, provide adjustment accessible through the grille face. If visible through the air grille, paint the damper matt black.

Location:

- At the at end of duct spigot take-offs.
- Behind supply air grilles attached to flexible duct if the spigot at the rigid duct is not accessible through the ceiling.
- Behind return and exhaust air grilles connected to ducts.

2.3 AIR GRILLE TYPES

Louvre ceiling diffusers

Type: Select from:

- Multi-bladed, removable core 4-way blow configuration, fitted with a blanking plate for 1-, 2-, or 3-way blow, as appropriate; or
- Multi-bladed, removable core 1-, 2-, 3- or 4-way blow configuration.

- ***Four-way multi-directional with 4 separate one-way cores, each independently rotatable to 4 positions.*** ***Rev 2019-03***

Reducer necks: If the outlet neck is smaller than the outlet necessary to suit the louvre face size, provide a reducer neck.

Frame: To suit the type of ceiling and ceiling grid mounting requirements.

Cushion head: If the diffuser is connected to a flexible duct, provide a cushion head box.

Air volume control: Conform to **VOLUME CONTROL DAMPERS**.

Circular diffusers

General: As for **Louvre ceiling diffusers** but with adjustable threaded multi-core allowing variation of discharge pattern from horizontal to vertical by rotation of the centre core.

Material: Spun circular aluminium.

Cushion head: If the diffuser is connected to a flexible duct, provide a cushion head box.

Air volume control: Conform to **VOLUME CONTROL DAMPERS**.

Curved blade diffusers

General: As for **Louvre ceiling diffusers** but with individually adjustable curved blades of extruded aluminium rotating in the support frame. Support blades firmly without rattle or flutter.

Cushion head: If the diffuser is connected to a flexible duct, provide a cushion head box.

Air volume control: Conform to **VOLUME CONTROL& DAMPERS**.

Perforated plate diffusers

General: Supply diffusers conforming to **Louvre ceiling diffusers** but with a hinged perforated face plate with minimum free area of 50%. Fold plate edges so that perimeter gaps do not exceed 0.5 mm.

Cushion head: If the diffuser is connected to a flexible duct, provide a cushion head box.

Air pattern control: Provide hidden air pattern control louvres adjustable to produce 1, 2, 3 or 4 way pattern.

Air volume control: Conform to **VOLUME CONTROL DAMPERS**.

Perforated face air grilles

General: Return or exhaust air grilles conforming to **Perforated plate diffusers** but omitting air pattern control.

Swirl diffusers

General: As for Louvre ceiling diffusers but with fixed radial blades arranged to produce radial, axial and tangential airflow.

Material: Powder coated metallic-coated steel sheet.

Cushion head: If the diffuser is connected to a flexible duct, provide a cushion head box.

Air volume control: Conform to VOLUME CONTROL DAMPERS. ***Rev 2019-03***

Luminaire air diffusers

Type: Single sided or double sided, to conform to design of light fitting.

Physical compatibility: To AS 2946.

Performance:

- Maximum flow per slot: 50 L/s.
- Maximum pressure drop at maximum flow: 30 Pa, including damper.
- Maximum throw when delivering the maximum air flow: 5 m at 0.1 m/s terminal velocity.

Construction: Metallic-coated steel sheet ≥ 0.55 mm thickness, folded and welded to produce an airtight assembly. Provide a circular or oval spigot for flexible duct connection.

Air flow deflection: Provide an adjusting device which can be operated through the slot in the luminaire to provide horizontal pattern designed to maximise Coanda effect.

Air volume control: Conform to **VOLUME CONTROL DAMPERS**.

Slot diffusers

Type: Linear slot type ceiling diffusers with one or multiple slots, nominally 20 mm wide and integral air pattern control.

Construction: Extruded aluminium with parallel, inverted Tee members supported and spaced to form continuous discharge slots.

Plenum: Supply air to the active lengths of each diffuser via plenum ducts on the back of the diffuser with circular or oval spigots for flexible duct connections. Design the plenum ducts for even distribution of air flow along the active length of the diffuser.

Frame: Flanged with outside edge returned and coordinated with the ceiling system.

Finished appearance: Continuous and unbroken irrespective of the purpose of the slot. Blank off all slots not used for supply or return air. For long lengths, provide mechanical aligning devices to produce a rigid assembly that minimises the visibility of joints.

Air pattern control: Provide an adjusting device which can be operated from the face of the diffuser through the slot to allow 180° deflection of air pattern from vertical to horizontal in either direction.

Air volume control: Conform to **VOLUME CONTROL DAMPERS**.

Side wall registers

Type: Double deflection type with horizontal front louvre blades and vertical rear blades at 19 mm nominal centres, capable of field adjustment of air throw over the range ± 45°.

Construction: Extruded aluminium with mitred corners and aerofoil section blades which rotate in non-metallic bearings in the support frame. Hold blades firmly so they do not rattle or flutter.

Core: Removable core (support frame and blades).

Blades > 600 mm long: Support at mid-point on a notched support bar.

Dampers: Stream splitter or opposed blade type damper behind each register, to provide even air flow across the register face.

Jet diffusers

General: Provide 3 concentric sections made of spun aluminium, bolted together.

Air pattern control: Adjustable in two planes for direction and to give either jet or diffuser pattern.

Cushion head: If the diffuser is connected to a flexible duct, provide a cushion head box.

Air volume control: Conform to **VOLUME CONTROL DAMPERS**.

Mounting: Suitable for either ceiling, wall or direct duct mounted application.

Thermally powered VAV diffusers

Type: Proprietary VAV diffuser with integral actuator and dampers to adjust air volume in response to temperature sensed at the diffuser. Provide uniform air distribution pattern to maximise Coanda effect over the operating range from full open to the minimum air flow.

Construction: Appearance panel mounted within a pressed diffuser frame.

Material: Powder coated metallic-coated steel sheet.

Frame style: To suit the type of ceiling, and ceiling grid mounting requirements.

Operation: Integral hinged dampers to vary the outlet supply air volume under the control of an inbuilt room temperature sensing element.

Control: Provide one of the following:

- Self-powered type with expanding wax or similar temperature sensitive elements.
- Line powered with integral 24 volt transformer.

Heating operation: If the system operates in both heating and cooling modes, provide a factory preset supply duct temperature sensor that reverses the control action between heating and cooling. Operate in cooling mode when the air supply is below 20°C and in heating mode when supply air is above 27°C.

Room temperature set point: Adjustable from below the face of the diffuser over the range 21°C to 26°C.

Cushion head: If the diffuser is connected to a flexible duct, provide a cushion head box.

Air volume control: To **VOLUME CONTROL DAMPERS**.

Weatherproof louvre grilles

Type: Extruded aluminium with fixed horizontal blades set into a fixed frame.

Louvre blades: Set at nominal 45° angle and incorporating at least one hooked edge to prevent ingress of water under all operating conditions. Brace and stiffen to prevent rattling or movement.

Frame: Flanged or channel to suit the installation profile.

Pressure drop: ≤ 15 Pa at the documented air flow.

Screens: Provide metallic-coated steel wire or PVC mesh screens behind louvres to prevent the entry of vermin, birds, rodents and wind-blown extraneous material such as leaves and papers.

Return or exhaust air grilles – indoor

Type: Extruded aluminium with fixed horizontal blades set into a fixed support frame with mitred corners. Fit blades tightly into the frame to prevent rattling or movement. Brace and stiffen to produce a rigid assembly.

Pressure drop: ≤ 10 Pa at the documented air flow.

Blades:

- Half chevron type: Blades at nominal 45° angle on a nominal 25 mm pitch.
- Chevron type: Blades at nominal 25 mm pitch. Provide a telescopic frame with clip-on pattern surround frames on both sides.
- Light proof grilles: Chevron type but with double chevron blades, blade pitch and edge detail designed to stop light penetration.

Air volume control: If the air grille is connected to a duct, provide an opposed blade damper behind the grille core, key operated without removing the core.

Mesh air grilles

Light duty type: Fabricate from 1.5 mm thick galvanized steel or bronze wire at 12 mm centres fixed into a folded metallic-coated steel or aluminium frame.

Heavy duty type: Fabricate from 3 mm thick galvanized steel or bronze wire at 20 mm centres, welded into a 3 mm thick galvanized steel frame.

Bronze mesh: If bronze mesh is provided on external grilles, provide a bronze frame.

Egg crate return or exhaust air grilles

Type: Nominal 12 x 12 mm square, 12 mm deep egg crate type aluminium core fixed in an extruded aluminium frame with mitred corners. Fit core tightly into the frame to prevent rattling or movement.

Free area: ≥ 90% of nominal face area.

Air volume control: If the air grille is connected to a duct, provide an opposed blade damper behind the grille core, key operated without removing the core.

Swirl diffusers

General: As for Louvre ceiling diffusers but with fixed radial blades arranged to produce radial, axial and tangential airflow.

Material: Powder coated metallic-coated steel sheet.

Cushion head: If the diffuser is connected to a flexible duct, provide a cushion head box.

Air volume control: Conform to VOLUME CONTROL DAMPERS. ***Rev 2019-03***

Outdoor air grilles

Type: Egg crate grilles to the requirements of 'Egg Crate Return or Exhaust Air Grilles'.

Fit with pad filter behind core. Retain filter with clips attached to core.

Door grilles

Type: Horizontal blade grille to the requirements of 'Return or Exhaust Air Grilles- Indoor', light proof grille type. ***Rev 2017-01***

3 EXECUTION

3.1 INSTALLATION OF AIR GRILLES

Protection

Wrapping: Leave protective wrappings in place until final mounting.

Mounting

General: Provide a matching escutcheon to close gaps between the air grille and its surrounds. Provide air grilles with flanges to cover penetrations and irregularities in surrounds.

Tiled ceilings: Locate air grilles to minimise cut tiles. Otherwise, locate the air grille symmetrically in the tile.

Appearance: Install square.

Fixing

Accessibility: Provide fasteners which allow removal of the air grille without damage to surrounds or air grille.

Gaskets: Provide foam type gaskets under air grille flanges or flanged supports.

Plenum and cushion head boxes

General: Provide side entry plenum or cushion head boxes to air grilles connected to flexible ductwork.

Design: To achieve even air flow across the face of the air grille.

Construction: Cushion head boxes to be constructed from thermic-insulating, rigid urethane sandwich panel, clad with 80 micro aluminium sheet. The minimum thickness of the insulation shall be 20mm and increased as required for air conditioning supply and return air applications to achieve R2.0. Construct to detail shown on drawings. ***Rev 2017-01***

Painting: Paint the interior of plenum box matt black, if visible through the air grille.

Flexible duct connections: To AS 4254.1. Provide round or oval spigots on plenum boxes.

Support of plenum boxes: For louvre ceiling and slot diffusers, support the plenum from either of the following:

- From above and independently of the ceiling.
- From the ceiling main Tees, provided the load is less than the ceiling system manufacturer's recommended maximum.

0771 AUTOMATIC CONTROLS

1 GENERAL

1.1 RESPONSIBILITIES

General

Requirement: Provide automatic control systems to provide the documented control functions and system performance.

Performance

Control performance: Within the documented plant capacities, maintain the documented conditions. Supply and commission control systems that are safe and stable in operation under all anticipated operating conditions including start up, shut down and fault condition.

Service interruption: Except for documented manual restoration of operation, provide fully automatic restoration of control system operation after any service interruption of any duration.

Safety: Provide control devices and software to protect personnel from injury and equipment from damage by either normal or abnormal operation of the control system, including the removal and reapplication of power whether expected or unexpected.

Security: Provide security measures to prevent unauthorised persons from accessing, modifying or controlling the systems.

Operating environment: Provide components that function correctly in their local environment.

Existing controls

Compatibility with existing controls: If the documented control systems interface or connect to existing control systems, provide new control components and software that are either identical to the existing or, if not identical, compatible. If not identical, provide evidence that the proposed components are compatible.

System response times

General: Provide a control system to achieve the following response times (in conjunction with the building management system where appropriate):

- Change of state: ≤ 5 seconds for change of state or value of a field point to register an alarm or update at the workstation.
- Global data transfer: ≤ 3 seconds for data to travel between controllers.
- Graphics display: ≤ 8 seconds to display a full graphic with current parameter values.
- Local control event: ≤ 2 seconds for a controller to initiate an output action after change of input.
- Manual command: ≤ 3 seconds for a manual command from the workstation to override field device.
- System logs: ≤ 8 seconds to display a system log or report.

1.2 CROSS REFERENCES

General

Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

1.3 STANDARDS

General

Building automation system protocol: To ANSI/ASHRAE 135 including Annex J (referred to in this worksection as BACnet).

1.4 INTERPRETATION

Abbreviations

General: For the purposes of this worksection the following abbreviations apply:

- AAC: Advanced application controller.
- ASC: Application specific controller.
- BACnet: (Building automation control network) Data communication services and protocols conforming to ANSI/ASHRAE 135.
- BC: Building controller.
- BMS: Building management system.
- FFCP: Fire fan control panel.
- FIP: Fire indicator panel.
- LAN: Local area network.
- LED: Light emitting diode.
- OWS: Operator workstation.
- PID: Proportional plus integral plus derivative.
- RTD: Resistance temperature device.
- SA: Smart actuator.
- UPS: Uninterruptible power supply.

Definitions

General: For the purposes of this worksection the following definitions apply:

- Accuracy: The closeness of the agreement between the result of a measurement and the true value of the particular quantity being measured.
- K: The flow rate of water in m^3/h through a fully open control valve that creates a pressure drop of 1 bar across the valve.
- $_v$Portable operator's terminal: A device that is portable, not permanently connected and used for human communication with the system.

1.5 BACNET CERTIFICATION

BACnet conformance: Submit evidence of conformance to the following BACnet device profiles to ANSI/ASHRAE 135 and that the devices are certified to the respective profile by being listed in the BACnet Testing Laboratories Product Listing:

- Building controllers conform to BACnet Building Controller (B-BC) device profile and, in addition, have demonstrated interoperability during at least one BMA Interoperability Workshop.
- Advanced application controllers conform to BACnet Advanced Application Controller (B-AAC) device profile
- Application specific controllers conform to BACnet Application Specific Controller (B-ASC) device profile.
- Smart actuators that conform to BACnet Smart Actuator (B-SA) device profile.

1.6 DRAWINGS

Requirement: Submit the following:

- Detailed drawings, at 1:50 scale or larger, showing floor plans with the locations of all controllers and sensors. These may be incorporated into ductwork layouts.
- Coordination drawings showing interface terminal numbers and cross referenced wire numbers for all connections between the control system and other equipment.
- Full details of each control station including equipment, wiring diagrams and terminal layouts.
- Fully detailed wiring diagrams for the entire control, monitoring and electrical cabling installation.

Execution details

Functional descriptions and schematics: Submit proposed project specific software and documentation in hard copy form including the following:

- Fully developed functional descriptions, written in simple sentences, of each system including but not limited to start up, normal running, shut down, fire mode operation, operation in fault conditions, alarms, safety controls and manual over-ride provisions.

- Control schematics or diagrams illustrating control logic, valve and damper sequences, external interlocks, and interfaces.

Operation and maintenance manuals

Additional requirements: Provide the following information in addition to the requirements of **OPERATION AND MAINTENANCE MANUALS** in the *0171 General requirements* worksection:

- Software: Details listed in **SUBMISSIONS, Execution details,** amended to reflect the as-installed installation.
- Technical data: Details listed in *0701 Mechanical systems*, **SUBMISSIONS, Technical data** amended to reflect the installation as installed.
- Remote communications system: Details of provisions for remote access and/or monitoring.
- Graphics: A screen dump of each graphic supplied, annotated as necessary to explain its significance and function.
- Logs and trend logs: Include standard items provided and instructions for programming new items.
- Operational procedures: Plant start, stop and after hours operational procedures.
- Safety controls: Plant fault protection, re-start procedures, and alarm arrangements.
- Self documentation: Automatically generate reports using self-documentation software on controllers.

1.7 PRODUCTS AND MATERIALS

Requirement: Submit additional information on the proposed project specific software and documentation in hard copy form including the following:

- Logic flow charts.
- Provisional values and nomographs for set points and other control parameters.
- Input, output and software points schedules including corresponding point addresses, short form and full text labels.
- Details of communication standards and protocols.
- Details of connections to external interfaces and components outside the automatic control system.
- Format of proposed graphics.
- When requested, provide manuals, data sheets and other explanatory information needed to interpret the material submitted.
- Test reports: Submit a report showing the test results. Carry out necessary modifications and re-test.
- Data sheets for each type of controller, actuator, sensor and other hardware component.
- Control valve schedules showing size, valve coefficient, design flow rate, coil and valve pressure drop, static pressure at location, valve body working pressure and shut-off head.

1.8 SAMPLES

Requirement: Submit samples of the following:

- Each control component to be mounted within occupied areas.

1.9 TESTS

Off-site test procedure proposals: Submit the proposed procedure for off-site tests at least two weeks before commencing testing.

After off-site testing: Submit a report showing the test results. Carry out necessary modifications and re-test.

2 PRODUCTS

2.1 CONTROL COMPONENTS

Performance
Sensors and control components: Conform to the following:

- Of corrosion resistant construction.
- Suitable for the respective operating environment.
- Not affected by the accumulation of dust or moisture, extraneous influences or variation of ± 30% in supply voltage.
- Protected against the entry of vermin.
- Selected for a response time appropriate to the application.
- Provided with proprietary connections suitable for the size and type of cable used.

Reporting accuracy
Performance: Provide a system that reports values with minimum end-to-end accuracy that is in conformance with the following:

- For sensors: Within the documented accuracy of the respective sensor.
- For calculated values: Within the accuracy calculated from statistical combination of the sensor accuracies.

[220.5]Control stability and accuracy
Performance: Provide control loops that maintain the measured variable at set point within documented tolerances.

2.2 SOFTWARE

General
Inclusions: As part of the automatic control installation provide:

- Software to perform the required project specific functions.
- Facilities to alter time schedules, set points and manually override control functions.
- Diagnostic routines within the controller to continuously monitor for faults and to raise alarms.
- Time scheduling including provision for weekends, holidays and automatic adjustment to daylight saving times.
- Control algorithms for standard control functions to meet the functional specification including PID loops and calculate psychrometric properties.
- All calculations and data in SI metric units.
- Multi-level passwords to limit access to controller and variable speed drive functions.

Test mode
General: Provide each software module or logical set of modules with a test mode, software test module or equivalent means that enables simulation of all inputs. Provide visual representation of module outputs.

2.3 DIGITAL SYSTEM CONTROLLER INTERFACE

Standard
Building automation system protocol: To ANSI/ASHRAE 135.

Interface
General: Provide interface to Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), and Smart Actuators (SA) to achieve the documented performance and functionality.

Stand-Alone Operation: Provide controllers that perform their control and their energy management functions as stand-alone units including trends, schedules and alarm functions. Include the following:

- Required communication hardware in each panel.
- Control for each piece of equipment from only one controller.

- All input and output points documented for the piece of equipment integral to its associated controller.

Backup

General: Provide automatic backup to the BMS of all data held locally on the controller. Automatically download backed up data after restoration of power after power failure.

BACnet

General: Provide the following BACnet interface functionality on the controllers:

- Building Controllers (BCs): Provide BCs that have demonstrated interoperability during at least one BMA Interoperability Workshop and that conform to BACnet Building Controller (B-BC) device profile to ANSI/ASHRAE 135.
- Advanced Application Controllers (AAC): Provide AACs that conform to BACnet Advanced Application Controller. (B-AAC): device profile as specified in ANSI/ASHRAE 135, BACnet and that are listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
- Application Specific Controllers (ASCs): Provide ASC that conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135 and that are listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
- Smart Actuators (SAs): Provide SAs that conform to BACnet Smart Actuator (B-SA) device profile to ANSI/ASHRAE 135 and that are listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.

Connections between BACnet networks and IP internetwork: Via BACnet/IP Broadcast Management Device (BBMD) capability.

Objects: Each object must be BACnet object if the BACnet specification provides for the object.

Communication

General: Provide controllers with the following communications functionality:

- Each BC to reside on or be connected to a BACnet network using ISO/IEC 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
- BACnet routing to be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
- Service Port: Provide each controller with a service communication port for connection to a Portable Operator's Terminal.
- Signal Management: Use BC and ASC operating systems to manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
- Data Sharing: Arrange each BC and AAC to share data as required with each networked BC and AAC.

2.4 OPERATOR WORKSTATIONS

General

Requirement: Conform to the *0186 Building IT components* worksection.

2.5 CONTROLLERS

General

Type: Modular and expandable electronic controllers, either application-specific or universal type, programmed for the required functions.

One-to-one connection: Connect each piece of equipment to only one controller and include on that controller all input output points related to the piece of equipment.

Stand-alone operation: In the event of communication failure control connected equipment in standalone mode in as near as possible to normal mode including trends, schedules and alarm functions. Use either default values or equivalent logic to substitute for values normally read over the network.

Hardware and facilities

Memory: Provide memory to hold operating system, software, database, programming and set points. Hold BIOS and application programming in non-volatile memory or battery backed up for ≥ 72 hours in the event of power loss.

Connections: Provide connections and software for:

- Each external input or output point via terminal strip or termination card.
- Connection of a Microsoft Windows based laptop computer to the controller for use as a portable operator's terminal for programming, setting up and troubleshooting. Provide for upload and download of programs and logged data.
- Connection of a portable operator's terminal to nominated space temperature sensor ports.

Power supply and backup: Provide:

- Control power source switch (on-off) for each controller.
- Power supply or supplies rated for 125% of the total load of the controller with all input and output modules energized and without diversity.
- Separate transformers for controllers and field devices.
- Protection against power surges and over voltage.
- Overcurrent protection. If fused, provide spare fuses adjacent.
- Control circuits operating at a standard extra-low voltage (ELV).

Enclosure: If the controller is located outdoors or in a wet environment provide an IPX6 enclosure to AS 60529.

Operator interface

Display: Provide backlit alphanumeric liquid crystal display (LCD) for sensed values and faults.

Operator interface: In addition to the portable operator's terminal interface, provide the controller with keyboard or push buttons operating through a menu system to permit access limited by password to change set points, time schedules and manually override control functions. Provide diagnostic LEDs for power, communication and processor.

Controller software

General: Locate all application software in system controllers. Provide each controller with the following:

- Alarms: Provide for alarm processing and reporting including the ability to redirect alarms according to alarm priority and time schedules. Provide software that prevents consequential alarms caused by power failure.
- Clock: Provide each controller with a real-time clock and daylight saving adjustment. Automatically synchronise time with the other parts of the system at least weekly.
- Data processing: Provide analog totalisation and pulse accumulation totalisation and rate calculation.
- Diagnostics: Provide software in the controller to continually check its processor and memory circuit status and to generate an alarm on abnormal operation. In the event of abnormal operation provide continuous operation using the last reliable data.
- Energy algorithms: Provide algorithms for energy management, demand limiting and staggered start. Include algorithms to:
  . Accumulation and conversion of instantaneous power or flow rates to energy usage data.
  . Calculate sliding-window average (moving average) with operator adjustable window interval.
  . Calculate a fixed-window average with software initiated start and window interval.
- Logging: Provide trend logging, event logging and hours run of selected points. Provide selectable logging time intervals.
- Maintenance management: Provide an algorithm to totalise runtime for each digital input and output. Generate maintenance alarms when equipment exceeds nominated runtime, equipment starts, or performance limits.
- On-off control with differential: Provide direct-acting and reverse-acting on-off algorithms with adjustable differential to cycle a digital output based on a controlled variable and set point.

- PID control: Provide direct-acting and reverse-acting PID algorithms including anti-windup and selectable controlled variable, set point and PID gains. Calculate in each algorithm a time-varying analog value that can be used to position an output or to stage a series of outputs.
- Remote communication: Provide automatic communication with the operator workstation or server on receipt of critical alarms.
- Scheduling: Provide calendar function and facilities for daily, weekly and day-omit (holiday) scheduling.
- Security: Provide multi-level password controlled access.
- Self documentation: Provide self documentation software generate descriptive information regarding program and network variables.
- Sequencing: Provide for sequencing and rotating start order of related items of equipment on normal start up and on power restoration after failure.
- Short cycling: Protect digital output objects from short cycling by means of adjustable minimum on-time and off-time settings.
- Spare points: Provide software necessary to handle nominated spare points.
- System coordination: Provide means for grouping related equipment based on function and location and to use these groups for scheduling and other applications.

Input-output facilities

General. Hard wire input and output points to controllers.

Number: Provide sufficient input-output modules to perform the required functions. Provide spare space for future expansion.

Protection: Protect against damage caused by shorting an input or output point to itself, to another point or to earth. Protect from input or output point contact with ≤ 24 V for any duration.

Input-output types: Provide the following to suit the connected equipment:

- Analog inputs: Provide analog inputs to monitor low voltage (0 to 10 V d.c.), current (4 to 20 mA), or resistance (thermistor or RTD) signals and compatible with, and field configurable to, commonly available sensing devices.
- Digital inputs: Provide digital inputs to monitor the on-off signal from voltage free contacts on the remote device. Provide a wetting current of at least 12 mA and protect against contact bounce and noise. For push button inputs provide means for holding the signal to suit the scan time. Sense digital input dry contact closure without application of power external to the controller.
- Pulse accumulation inputs: Conform to the requirements for digital inputs plus accumulate pulses at up to 10 per second.
- Analog outputs. Provide analog outputs modulating either a 0 to 10 V d.c. or 4 to 20 mA signal to suit the connected output device. Provide each analog output with a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Limit drift of analog outputs to < 0.4% of range per annum.
- Digital outputs: Provide digital outputs selectable for normally open or normally closed operation to send an on or off signal to connected devices. Provide voltage free contacts. Provide digital outputs with three-position (on-off-auto) override switches and status lights.
- Pulsed digital outputs: Provide adjustable pulse length for pulsed outputs.
- Digital/analog and analog/digital conversion: ≥ 14 bit.
- Tri-state outputs: Control three-point floating electronic actuators without feedback using tri-state outputs (two coordinated digital outputs).
- Universal inputs and outputs: Inputs and outputs that can be designated as either digital or analog in software may be provided for inputs or outputs provided they conform to the requirements for the respective type above and are suitable for their proposed use.
- Protection: Protect against damage caused by shorting an input or output to itself, to another point or to earth and reverse polarity. Protect from input or output point contact with ≤ 24 V for any duration.

2.6 INPUT DEVICES – GENERAL

General

Requirement: Provide input devices with the following characteristics:

- With range, accuracy and response time appropriate to the required control function including the effects of transducer accuracy and signal transmission errors.
- Maintain documented performance over time.
- Protected by location or otherwise from extraneous influences including sunlight, heat sources and non-representative locations.
- Requiring maintenance or re-calibration to maintain performance at not more often than 12 month intervals.
- Designed for the type of location and application in which they are installed.
- Readily accessible location for inspection, calibration, cleaning and maintenance.
- Tamperproof if located in occupied areas.
- Not affected by induced voltages or EMI.

Transducers

General: If required for signal conversion, provide signal transducers to convert sensed signal to the required system signal standard. Provide transducers with integral, accessible zero and span adjustments, open and short circuit protection and reverse polarity protection.

2.7 INPUT DEVICES – TEMPERATURE

Temperature sensors – room

General: Provide tamperproof sensors in an ABS or polycarbonate case ventilated to the room air and thermally insulated from the wall.

Sensing element: Resistance temperature device (RTD) or thermistor.

Accuracy: ± 0.3°C over the temperature range required for the project application.

Repeatability: ± 0.1°C.

Temperature sensors – duct

General: Provide sensors not affected by dirt accumulation or internal condensation. Mount the sensing element in a stainless steel or brass tube with a metal, ABS or polycarbonate case designed specifically for duct mounting.

Location: Locate so that representative temperatures are sensed.

Sensing element: Resistance temperature device (RTD) or thermistor.

Accuracy: ± 0.3°C over the temperature range required for the project application.

Repeatability: ± 0.1°C.

Temperature sensors, averaging – duct and air handling unit

Type: Designed for mounting in ducts or air handling units to sense average air temperature and not affected by dirt accumulation or internal condensation. Provide a metal, ABS, polycarbonate or glass filled polyester case attached to the duct or air handling unit wall.

Location: Locate so that representative temperatures are sensed.

Sensing element: Provide a series of thermistors or platinum resistors equally spaced along an insulated cable. Provide ≥ 3 m of cable per 1 m² of duct or air handling unit cross section.

Accuracy: ± 0.3°C over the temperature range required for the project application.

Repeatability: ± 0.1°C.

Temperature sensors – immersion

Type: Suitable for immersion mounting either in piping or a through tank or heat exchanger wall.

Requirement: Provide sensing element mounted in a stainless steel tube of sufficient length to for accurate measurement. Provide a metal, ABS, polycarbonate or glass filled polyester case. Protect against internal condensation.

Sensing element: Resistance temperature device (RTD) or thermistor.

Degree of protection: IP65. Protect against internal condensation.

Accuracy: Over the temperature range required for the project application:
- Chilled water and condenser water: ± 0.1°C.
- Heating water: ± 0.3°C.

Repeatability: ± 0.1°C.

2.8 INPUT DEVICES – HUMIDITY

Humidity sensors – room

General: Provide tamperproof sensors in an ABS or polycarbonate case ventilated to the room air and thermally insulated from the wall.

Sensing element: Provide separate humidity and temperature sensing elements as follows:
- Humidity: Thin film polymer capacitive sensing element.
- Temperature: Type and performance conforming to **Temperature sensors – room**.

Construction: Seal the humidity sensing element so it is unaffected by moisture condensation.

Accuracy:
- Humidity: ± 5% over the range 10 to 90% relative humidity.
- Temperature: Conform to **Temperature sensors – room**.
- Stability: 1% relative humidity per annum.

Humidity sensors – duct

General: Provide sensors not affected by dirt accumulation or internal condensation. Mount the sensing element in a stainless steel or brass tube with metal, ABS, polycarbonate or glass filled polyester case designed specifically for duct mounting.

Sensing element: Provide separate humidity and temperature sensing elements as follows:
- Humidity: Thin film polymer capacitive sensing element.
- Temperature: Type and performance conforming to **Temperature sensors – duct**.

Construction: Seal the humidity sensing element so it is unaffected by moisture condensation.

Accuracy:
- Humidity: ± 5% over the range 10 to 90% relative humidity.
- Temperature: Conform to **Temperature sensors – duct**.
- Stability: 1% relative humidity per annum.

2.9 INPUT DEVICES – PRESSURE

Differential pressure sensor – duct

General: Provide differential sensors in a metal, ABS, polycarbonate or glass filled polyester case.

Sensing element: Temperature compensated electronic type with amplifier.

Pressure connections: Provide barbed fittings for connection of polyethylene tube.

Range: Provide sensors selected so the normal operating point is ≥ 50% of the manufacturer's sensor range.

Accuracy: ± 1% full scale.

Operating pressure: Able to withstand continuous operation at positive or negative pressures 50% greater than the calibrated span without damage or loss of accuracy.

Building static pressure differential: Pipe pressure sensor's low-pressure port through a high-volume accumulator to a static pressure probe located on the outside of the building. Pipe the high pressure port to behind a thermostat cover in a representative location within the building.

Differential pressure switch – duct

General: Provide differential switches not affected by dirt accumulation, shock or vibration. House in a corrosion resistant case. Provide screw set point adjustment.

Pressure connections: Barbed fittings for connection of polyethylene tube.

Repeatability: ± 1%.

Operating pressure: Able to withstand continuous operation at positive or negative pressures 50% greater than the calibrated span without damage or loss of accuracy.

Differential pressure sensor – piping

General: Provide differential with gold plated contacts mounted in a metal, ABS, polycarbonate or glass filled polyester case.

Sensing element: Temperature compensated electronic type with amplifier.

Construction:

- Wetted parts: Stainless steel.
- Degree of protection: IP65.
- Pressure connections: Screwed.

Pressure rating: Diaphragm proof pressure ≥ 1 MPa. Over-range limit (differential) ≥ 2 MPa.

Accuracy: ± 0.15 % of span.

Stability: ± 0.2% over ten years.

Differential pressure switch – piping

General: Provide differential pressure switch with gold plated contacts mounted in a metal, ABS, polycarbonate or glass filled polyester case.

Construction:

- Wetted parts: Stainless steel.
- Degree of protection: IP65.
- Pressure connections: Screwed.

Pressure rating: Diaphragm proof pressure ≥ 1 MPa. Over-range limit (differential) ≥ 2 MPa.

Switching differential: Screw adjustable.

Repeatability: ± 2% of range.

2.10 INPUT DEVICES – FLOW AND VELOCITY

Velocity sensor – air

Type: Multi-point pitot type on a metallic grid, sized to suit the duct dimensions.

Installation: Locate to sense representative duct velocity. Provide support within the duct.

Accuracy: ± 3% of span.

Velocity sensor – piping

Sensing device: Select from the following:

- Pitot type: Provide a low loss pitot type device conforming to **Pitot type sensors** in the *0751 Mechanical piping* worksection. Provide a transducer conforming to **Differential pressure sensor – piping** with at range matched to the differential pressures of the sensing element. Provide cascading transmitters if necessary to achieve the documented accuracy over the anticipated measuring flow range.
- Magnetic type: Provide magnetic sensor selected for flow requirements, not line size and suitable for sensing flow in either direction. Provide a turndown of ≥ 100:1 and a calibration accuracy of ≤ 2% between 20 to 100% of maximum design flow. Provide PTFE lined tube type with stainless steel electrodes.

Flow switch – air

General: Conform to **Differential pressure switch – duct**.

Flow switch – piping

Standard: To AS/NZS IEC 60947.5.9.

Type: Paddle type. Adjust paddle length to suit the pipe.

Construction:

- Wetted parts: Stainless steel or copper alloy.
- Degree of protection: IP65.
- Pressure connections: Screwed.

Pressure rating: Able to withstand the system test pressure.

Switch point:

- Up to 1.5 m/s in DN 50 pipe.
- Up to 4.0 m/s in DN 150 pipe.

2.11 INPUT DEVICES – FLOW METERS

Requirement: Provide a magnetic flow meter of Siemens or Honeywell manufacture. The flow meter shall be fully adjustable for zero damping, set points, span and range and shall provide an amplified signal converted to output current and suitable for integration with the BMS system.

Wall mount the digital display component in locations to be agreed on site. Provide cover for protection from weather when installed externally. Install a label on the display, engraved with the flow set point. Rev 2017-01

2.12 GAS SENSORS

Refrigerant sensor

Type: Refrigerant specific with low cross sensitivity to other refrigerants and gases. Provide display of refrigerant concentration in parts per million and means to automatically re-zero. Provide 3 alarm levels, each with a front panel light and a latching binary contact closure for the control of remote devices.

Flammable refrigerants: To the recommendations of *AIRAH Flammable Refrigerants - Safety Guide.*

Range: Measure and display at least 0 to 999 parts per million with resolution of 1 part per million.

Ambient temperature operating range: At least 10°C to 50°C.

Activation alarm: At less than the practical limit for the respective refrigerant in AS/NZS 1677.1 Table 3.1.

Sensitivity: Better than ± 10% of the practical limit for the respective refrigerant in AS/NZS 1677.1 Table 3.1.

Regular maintenance requirements: Limited to recalibration once per year and monthly confirmation of clean air source for recalibration.

Output:

- Continuous: Analog corresponding to local display value.
- Alarm: Latching binary contact closed if level exceeds set point.

Sensors for carbon dioxide or carbon monoxide – duct

General: Provide sensors not affected by dirt accumulation.

Case: Provide a metal, ABS or polycarbonate case designed specifically for duct mounting.

Type: Gas specific with low cross sensitivity to other gases.

Display: LCD display of concentration in parts per million, setup and calibration menus.

Range:

- Carbon dioxide: 0 to 2000 parts per million.
- Carbon monoxide: 0 to 500 parts per million.

Ambient operating range: At least 0°C to 50°C, 15% to 95% relative humidity, non-condensing.

Accuracy: ± 5% of reading.

Time between calibration: > 12 months.

Location: Locate so that representative gas concentrations are sensed.

2.13 INPUT DEVICES – OTHER

Float switches

Type: Micro switch. Provide one level switch for each liquid level to be detected.

Construction: Double encapsulated hermetic construction designed for long life submerged. Provide a clamp to permit accurate adjustment of levels.

Cable: Low moisture absorption type.

Electrical

Current transformers, wattmeters and watt-hour meters: Conform to the *0943 Switchboard components* worksection.

Other input

Digital input: Connect to nominated digital input devices through voltage free contacts.

2.14 ACTUATORS

General

Requirement: Provide actuators designed for the type of location and application in which they are installed and the required control function.

Type: Electronic, incorporating a disengagement mechanism that permits manual operation in the event of power failure without disconnecting the actuator. Provide a position indicator on the actuator.

Position feedback: If a position signal is required, provide a potentiometer on the actuator.

Mounting: Provide actuators and mounting selected to provide sufficient torque to allow changes of position with the fans or pumps operating.

Protection: Minimum IP54 enclosure. If the actuator is located outdoors provide additional weather protection.

Overload and stall: Protect actuators against overload. Provide electronic or magnetic clutch type stall protection effective throughout the entire actuator stroke. Do not rely on end switches that require field adjustment.

Fail safe operation: If fail-safe operation is required, provide integral spring return via clutch only.

Noise: Provide actuators that are inaudible in occupied areas.

Override provision

General: Provide a manual positioner adjacent to the respective controller for each of the following:

- Each modulating valve.
- Each motorised damper except those in VAV terminals or required to operate in fire mode.

Facilities: Provide the following:

- An AUTO-OFF-MANUAL override switch to enable the position to be manually set.
- Position adjustment potentiometer to drive the controlled device to any position in manual mode. Mark the potentiometer to indicate the position of the controlled device.
- A reversing switch.

Non-powered operation: To permit the actuator to be manually positioned when not powered:

- Provide non-spring return actuators with an external manual gear release.
- Provide spring return actuators having > 7 N.m torque capacity with a manual crank.

Damper actuators

Connection to damper: Provide slip-resistant connection to the damper shaft by means of toothed clamp or square or hexagonal holed link.

Motion: Power driven in both directions except where spring return is required by AS/NZS 1668.1. Permanently mark normal operating position.

Spring return: If spring return is required provide a clutch.

Torque: The greater of the following:

- 5 Nm/m^2 of damper area.
- Sufficient to operate the damper smoothly and without overload through its entire travel, including tight shut-off.

Large dampers: Divide dampers into sections to limit the operating torque to ≤ 15 Nm per section. Provide an independent drive shaft for each section sized to withstand the operating torque.

[22]Valve actuators

Type: Removable from the valve without removing the valve from the piping.

Closing force: Provide valve actuators that achieve leak-tight valve shut-off under all operating conditions and valve differential pressures.

Closing time: Sufficiently long to prevent water hammer.

Actuators for steam valves: Spring return type.

VAV controllers

General: Provide VAV terminal control actuators as follows:

- Pressure independent type.
- Dedicated integrated actuator-controller assembly with built-in pitot-type velocity sensor.
- Motor-actuator with:
  . Fast response: < 30 s full travel.
  . Low radiated noise: < 35 db(A) at 1 m.

Connection: Provide a service port on the associated VAV temperature sensor for connection of a portable operator's terminal to enable VAV values to be displayed and for VAV unit calibration and commissioning.

2.15 AUTOMATIC CONTROL VALVES

General

Type: Provide valves with characteristic and porting to suit the application (i.e. mixing or diverting). Do not use 3-way valves for 2-way control.

Valve characteristics: Use:

- Equal percentage characteristic for heating and cooling coils. Do not use butterfly or ball valves.
- Linear or equal percentage characteristics for bypass control.
- Quick acting characteristics for isolation or shut-off control without causing water hammer.

Construction:

- Plug type with screwed connections: Brass or bronze valve body with brass or stainless steel plug and stainless steel spindle.
- Plug type with flanged connections: Cast iron valve body with brass or stainless steel plug and stainless steel spindle.
- Ball type with screwed or flanged connections: Stainless steel or nickel or chrome plated brass valve body with stainless steel equal percentage ball and spindle.

Seals: Provide double ethylene-propylene-diene-monomer (EPDM) O rings with dirt seals on the spindle.

Connections:

- ≤ DN 50: Screwed to AS ISO 7.1.
- > DN 50: Flanged to AS 2129.

Valve pressure drop at design flow rate: Provide valves selected as follows:

- Modulating control of heat exchange devices: Sufficient to achieve accurate control under all operating conditions. Select coil control valves for 100% to 150% of coil pressure drop at maximum flow.
- Open cooling tower bypass: ≤ 10 kPa but not more than the static head between the tower spray nozzle or distribution tray and the sump.
- Isolation and shut-valves: Full line size and selected for ≤ 5 kPa at maximum flow.

Rangeability: ≥ 40.

Working pressure rating: The greater of 1.4 MPa and the system working pressure at the location.

Working temperature rating: To suit the system requirements.

Maximum leakage rate when closed:

- 2 port throttling valves: < 0.05% of K_{vs}.
- 2 port shut-off valves: Zero.
- 3 port valves:

. Control path: < 0.05% of K_{vs}.
. Bypass path: < 1% of K_{vs}.

Indication: All control valves must be provided with a clearly visible position indicator. A flow direction arrow must be cast in raised metal on the body of each control valve.

Pressure drop: Control valves pressure drops must not exceed 150kPa but in no case is the pressure drop to be greater than that recommended for good control by the control manufacturer and shall be approximately equal to twice the coil pressure drop at maximum flow. ***Rev 2017-01***

2.16 CHILLED WATER BYPASS VALVE AND ACTUATOR

Requirement: Provide a bypass valve to serve the chilled water system. The valve shall be a fast positioning, magnetic modulation valve – Siemens MXG Series or approved equal.

Additional requirements:

- ***Full stroke positioning time of 1 second (maximum)***
- ***Able to operate against and close control valve against the chilled water systems***
- ***Direct acting on valve steam without other linkages and levers***
- ***Manual adjustment***
- ***Mechanical position indicator***
- ***In-built position feed back for BMS***
- ***Extra low voltage power supply***
- ***IP55 or better***
- ***Mounted so no condensate from valves or other components will fall on or enter the actuator.*** ***Rev 2017-01***

2.17 SOLID STATE HEATING CONTROLLERS

Controllers
General: If required, provide solid state heating controllers.

Type: Solid state, low heat dissipation type, zero switching with built-in input power surge protection.

Mounting: Mount on heat sinks and locate so that heat will not affect other electronic components.

Heating circuit: Provide separate contactor connected to heater protection circuit in accordance with AS/NZS 1668.1.

3 EXECUTION

3.1 GENERAL

Marking
Requirement: Mark each control component.

3.2 INSTALLATION – COMPONENTS

Sensors in occupied areas
Installation: Conform to the following:

- Securely attach to walls, ceilings or columns.
- Mount on concealed junction boxes and seal cable entries to prevent air from the cavity entering the junction box.
- Conceal all wiring from view inside wall, column or ceiling space.

Wall or column mounted sensors: Locate 1500 mm above floor level.

Sensors in unoccupied areas
Installation: Conform to **Sensors in occupied areas** except that sensors may be mounted on surface mounted junction boxes with wiring in exposed conduit.

Sensors – outdoor air

Installation: Either locate in the outdoor air stream of an air handling unit that operates at all times outside air temperature is required or locate in an accessible external location on a south facing wall and protected from rain and sun.

Temperature and/or humidity sensors – duct mounted

Installation: Position sensor at least 100 mm into air stream in the centre of air flow. Screw the sensor to the duct wall. Provide manufacturer's spacer, if necessary, on insulated ducts.

Temperature sensors, averaging – duct and air handling unit

Installation: Install averaging sensors in a serpentine manner across duct or air handling unit spaced evenly to accurately sense the average temperature. Support the sensors and cable. Support each bend with a capillary clip.

Temperature sensors – immersion

Installation: Install as follows:

- Conform to the *0751 Mechanical piping* worksection.
- Insert into a thermometer well or test plug fitting so that the response time is suitable for the application.
- Locate the well or test plug so the sensor can be easily removed.
- Provide a separate thermometer pocket or test plug fitting adjacent to each sensor for calibration.
- If wells are installed in insulated pipe, extend the well clear of the insulation.

Differential pressure switch – duct

Mounting: Attach to the duct or air handling unit wall.

Pressure probes: Provide proprietary brass or stainless steel static pressure probes each with a right angle tip projecting not less than 100 mm into the air stream and located to accurately sense static pressure. Connect to the pressure switch with polyethylene tube.

Differential pressure sensor – duct

Mounting: Attached to the duct or air handling unit wall and connect to the pressure probes with polyethylene tube. Mount transducers in a vibration-free location readily accessible for service.

Pressure probes: Provide proprietary brass or stainless steel static pressure probes each with a right angle tip projecting not less than 100 mm into the air stream and located to accurately sense static pressure.

Differential pressure sensor – piping

Mounting: Install to one of the following:

- Fix to a wall or other permanent rigid surface. Pipe to pressure tappings and provide a gauge valve and capped test port for each pressure tapping.
- Direct mount on the flow rate sensor using the manufacturer's standard manifold.

Differential pressure switch – piping

Mounting: Fix to a wall or other permanent rigid surface. Pipe to pressure tappings and provide a gauge valve and capped test port for each pressure tapping.

Velocity sensor – piping

Piping: Conform to the *0751 Mechanical piping* worksection.

Pitot type: Pipe between the connections on the sensing device and the transducer. Provide isolating valves at the sensor and capped tee-off valves for calibration.

Refrigerant sensor

General: Conform to AS/NZS 1677.2 clause 8.8.

Location: Locate sensors to accurately sense concentrations. Conform to the manufacturer's recommendations.

Venting: Provide a 50 mm copper vent line from the safety valve assembly to atmosphere. Install a T-piece at the safety valve flange to provide a dirt leg and sampling valve. Provide a flexible piping connection at the safety valve and support pipework so no load is exerted on the valve assembly. Provide a stainless steel mesh screen to prevent foreign matter entering the vent.

Installation - controllers

Location: Install controllers within dedicated switchboard enclosures.

Points lists: Provide plasticised fade-free points lists in enclosure door pocket. Include in the list terminal numbers, point addresses and short and long descriptions.

Installation – automatic control valves

General: Conform to the *0751 Mechanical piping* worksection.

Installation: Install valves with stems vertical.

Mounting: Mount the valves with the actuator above the valve and thermally isolated from the valve body.

3.3 INTERFACE TO FIRE SYSTEMS AND FIRE MODE OPERATION

General

Standards: Conform to the following:

- BCA.
- AS/NZS 1668.1.

Connections: Provide numbered terminals for connection to the FIP and FFCP.

Relays: Provide all necessary relays, of compatible voltage, to enable override of normal mode operation in case of fire signal and to transfer control to Fire Indicator Panel and Fire Fan Control Panel.

Reset: Provide a manual reset button and status lamps on each motor control centre for fan run and stop.

Cabling: Provide fire-resistance rated cable and associated components to dampers that operate in fire mode.

Dampers: Where separate minimum and maximum outside air dampers are provided for air handling system function, provide separate damper actuators to each section to meet the requirements of AS/NZS 1668.1 for fire mode operation.

3.4 TESTING AND COMMISSIONING

Off-site tests

General: Before delivery to site, test controllers and software under all possible operating and fault sequences.

Demonstration

General: Demonstrate by software simulation using simulated inputs and outputs that the project specific software achieves the required functions, operation and safety sequences and accurately computes the related values. Demonstrate each control loop including all calculations and global functions.

Commissioning

General: Conform to the *0791 Mechanical commissioning* worksection. Commission all parts of the system in detail to verify that the equipment and systems operate correctly and achieve the required control functions.

Program: Before commissioning starts submit a program description of the proposed work to commission and test the systems including a time schedule.

Supplier's representative: Use a representative of the controls supplier to coordinate testing, to be present during all tests and training, and to attend site until the control systems are fully commissioned and operational.

Minimum requirement: Carry out the following:

- Point tests and wiring verification: Test all field wiring from terminals to field interface terminal strips and attend the testing of all equipment that interfaces to the controllers to confirm the operation of such equipment from the controller interface terminals.
- Component function: Test each component for correct function and operation. Check the operation of controlled devices to make sure that they operate in the required direction and through the correct range of physical movement relative to the applied control signal.
- Local control loop tests: Test and verify calibration of all controller inputs and outputs, actuators and sensors for proper response by actual operation of the devices.

- Panels: Test and commission all control panels separately before connecting to the network.
- Supervisory function tests: Test the host computer installation, including power supplies and batteries. Verify local area network communications to remote systems and controlled devices. Test the required operation of each control point from the operator's workstation and verify the status of all points and alarm functions on the computer database and graphic displays.
- Host software: Verify and demonstrate dynamic point information, alarm detection and action, time functions, control strategies including, but not limited to, energy management and fire mode, database functions and trending functions.
- Plant operation: Test the operation of the plant and control systems in the documented modes to make sure that the documented plant operation and controlled variable conditions are consistently achieved and in a stable manner.

Records: Record all commissioning tasks and results on either neatly hand written or typed standard test forms. Include the records in the Operation and Maintenance Manual.

3.5 TRAINING

General

Operator training: In addition to training documented elsewhere, provide on-site operator training during the defects liability period.

Number and duration of training sessions: Provide training sessions of at least 4 hours at 3 month intervals (a total of 4 sessions).

4 FUNCTIONAL DESCRIPTIONS

4.1 CHILLERS

General: The chillers shall operate to maintain the specified leaving water temperature. The standard capacity control offered by the chiller supplier may be used, modified where required to suit the overall system control requirements.

All water temperature probes shall be of platinum resistor type mounted in the underside of piping to prevent collection of condensate on the sensor housings.

Chiller operating sequence: Whenever any air handling unit is switched ON and the combined opening of the control valves (other than the bypass) is greater than or equal to one step of chiller capacity the chilled water pump shall start. After a minimum time delay of 2 minutes and once chilled water and condenser water flows are proved the low load chiller will start and load up under its micro-processer controls to maintain the leaving chilled water set point.

The controls system is to measure the fully mixed return chilled water temperature and must start the lag chiller when the mixed return water temperature is 1°C (adjustable) or greater above the return water set point (approximately 13°C) for an adjustable period of 0-20 minutes initially set at 10 minutes. Confirm that the lead chiller is at full load by measuring current. Raise an alarm if it was not at full current when the lag chiller was commanded on. Raise an alarm if the bypass valves were not closed when the lag chiller was commanded on. The two chillers must share the load equally.

Monitor the current drawn by each chiller. If the previous chiller sequence can handle the load, then after a delay of 0 to 20 minutes, initially set to 10 minutes, unload the last chiller on line and return to the previous chiller sequence. The unloading sequence is to be the reverse of the loading sequence. The pumps must run on for an adjustable period of 0-20 minutes, initially set to 5 minutes when any chiller is shut down. Monitor the bypass valves and confirm they are open when unloading the lag centrifugal chiller and raise an alarm if the bypass valves were not open.

Monitor the chillers for failure and the manual/off/auto switches for each chiller. If a chiller fails or is switched off line, reconfigure the loading and unloading sequence to delete the unavailable chiller and to continue full operation.

A loss of a cooling call will shut down the chiller plant after a delay of 0-20 minutes initially set to 10 minutes. The pumps running at the time must run on for an adjustable period of 0-20 minutes

initially set to 5 minutes. When a chiller is switched to manual, recognise this and work the loading sequence accordingly.

A paddle type flow switch shall be wired direct into the chiller controls as a safety interlock.

Hours run: Arrange each centrifugal chiller for lead/lag configuration. Accumulate hours run for each chiller. Use this difference in hours run to automatically change the lead/lag configuration when the difference is in the order of 250 hours. Prevent this change from shutting down the plant when it is running

Chilled water bypass control: Accurate bypass water control is required to maintain the flow through the chillers to ± 5% of design through all variations in chiller/pump duty and cooling coil valve operation.

Control chilled water bypass valve based on flow meter/s or differential at chiller/s.

Chilled water pump: The chilled water pump shall be started and stopped based on a signal from the chiller.

Condenser Water Pump: The Condenser water pump shall be started and stopped based on a signal from the chiller. Where fitted with a VSD the pump speed shall be controlled from the chiller.

Condenser Water Bypass Valve: Where installed, the condenser water bypass valve shall be controlled from the chiller.

4.2 COOLING TOWERS

Cooling Tower Fan Control: Vary the speed of the cooling tower fan to maintain the lowest chiller condenser water entering temperature at set point. Confirm temperature limits with chiller supplier.

4.3 DUCTED AIR CONDITIONING SYSTEMS

Switching: Units shall run on time schedule control and where scheduled, push button and run timer for after hours control. Provide the following for each air conditioning system.

- ***For non-DDC control equipment, a time switch of electronic programmable type with 7 day calendar and battery maintained memory.***

- ***Where after hours push button is scheduled, provide a control panel comprising engraved stainless steel face plate engraved to read 'Air conditioning unit' and the unit identifier, push button engraved 'Press for after hours operation' and green 'run' light. An 'after hours run' relay initially set to two hours, but adjustable***

When the time switch is not calling for the unit to be on, the push button shall activate a timed over-ride. It shall then require the push button to be operated a second time for another timed period.

Time schedules: Each air handling unit must be assigned separate time schedules in the BMS.

Status control: Auto/OFF/ON switches located, for each air conditioning unit, at the switchboard shall start/stop the air conditioning unit. In 'auto' position the start signal shall be derived from the control panel. In the 'on' position the air conditioning units shall start.

Temperature control: Provide thermostats in the locations shown, initially set to 23°C with a control range of ± 1°C. The thermostat shall have a plain front cover with neither adjustment nor indication.

Monitor the space temperatures and when a space is outside a range of 21°C to 24°, for an adjustable period of 0-60 minutes, initially set to 30 minutes, raise an alarm. Modulate the chiller water valve to satisfy the cooling demands.

Chilled water valve control: Where fitted, derive a cooling call when any cooling water valve is open to an adjustable 10% to 50% initially set to 30% for an adjustable period of 0-20 minutes

initially set to 10 minutes. Relay the cooling calls to the central plant. Shut the chilled water valves when the unit is switched off or when it is commanded off by the BMS.

Humidity control: Where scheduled, supply and install a humidity sensor located adjacent to the temperature sensor. Configure the controls to engage reheat via the electric duct heater when the room relative humidity exceeds 65%

When the air conditioning units are operating at maximum capacity, temperature control shall take precedence over humidity control i.e. engage reheat but do not exceed room temperature set point, although the temperature set point can rise to 25℃ in this instance.

Heating control: The unit shall operate in reverse cycle where available, otherwise by electric duct heaters if available.

Control and safeties: Internal controls and safeties shall be standard as supplied by the manufacturer.

4.4 SMALL SPLIT SYSTEM AIR CONDITIONING UNITS

Controls and thermostats: Controls and thermostats for split systems shall be proprietary items as supplied standard with the units. Each unit shall have an individual thermostat installed behind its return air grille.

Control panel: Where multiple small split system air conditioning units are installed in a room all the units shall be switched from a single control panel, unless otherwise scheduled.

The control panel shall be a proprietary item supplied by the manufacturer of the air conditioning units. The control panel shall be of a type suitable for permanent wall mounting and hard wired to the air conditioning units.

The control panel shall have the facility for ON/OFF switching of the units, adjustment of temperature set point and time clock settings. The control panel shall also incorporate an LCD display that indicates as a minimum, the current temperature, air conditioning unit status and mode and time clock settings.

Switching: ON/OFF switching of the air conditioning units shall be by way of the control panel ON/OFF push button and time clock.

Interlocks: Provide the required interface cards to permit the air conditioning to provide and receive interlock signals, to permit interlocking operation with security systems, ventilation fans and the like.

4.5 OUTDOOR AIR HEAT EXCHANGERS

The outdoor air heat exchanger associated with each air conditioning unit shall be linked to start when the air conditioning unit supply air fan starts.

Provide an adjustable time delay relay, initially set to 10 minutes, to delay the start of the outdoor air heat exchanger fans for a set period after the air conditioning unit is started.

Provide an isolating switch to each outdoor air fan. Label switch: 'OUTDOOR AIR FAN ? MAINTENANCE ISOLATION SWITCH'. Locate switch adjacent.

4.6 VENTILATION SYSTEMS

The fans are to be switched by interlocks to the light switch in the area served or interlocked to air conditionings or are to run continuously, or to have local ON/OFF switch as scheduled.

Supply and install a proprietary speed controller to each fan. The speed controller shall be capable of controlling the fan speed in the range 20% to 100%. Locate the speed controller adjacent to fan. Attach to the face plate of the speed controller an identification label engraved with 'Speed Controller – Fan No. ?'.

Where scheduled, provide an adjustable time delay relay, initially set to 10 minutes, to delay the start of the outdoor air heat exchanger fans for a set period after the air conditioning unit is started.

Provide an isolating switch to each outdoor air fan. Label switch: 'OUTDOOR AIR FAN ? MAINTENANCE ISOLATION SWITCH'. Locate switch adjacent.

4.7 OUTDOOR AIR PRE-CONDITIONERS

Switching/interlocks: The outdoor air pre-conditioner is to be switched by interlocks to the associated air conditioning unit.

Temperature and humidity control: Provide temperature and humidity sensors in the supply duct from the outdoor air pre-conditioner and in area served. Provide an electronic controller to interface between pre-conditioner standard controls and temperature and humidity sensors.

The outdoor air pre-conditioner shall normally operate in humidity control mode to maintain humidity If humidity is satisfied the unit shall operate in temperature mode to maintain a constant supply.

Controls and safeties: Internal controls and safeties shall be standard as supplied with the unit. ***Rev 2017-01***

0781 MECHANICAL ELECTRICAL

1 GENERAL

1.1 RESPONSIBILITIES

General
Requirement: Provide mechanical electrical installations, as documented.

Surge protection devices (SPD)
General: Provide surge protection as documented.

1.2 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

1.3 DESIGN DOCUMENTATION

Low voltage power systems: Submit the following information for each main, submain and final subcircuit for which calculation is the responsibility of the contractor:

- Single line diagram.
- Fault levels at switchboards.
- Maximum demand calculations.
- Cable and conductor cross sectional area and insulation type.
- Cable operating temperature at design load conditions.
- Voltage drop calculations at design load conditions.
- Protective device characteristics.
- Discrimination and grading of protective devices.
- Prospective short circuit current automatic disconnection times.
- Earth fault loop impedance calculations for testing and verification.
- Certification of conformance to AS/NZS 3000, for electrical services.
- Stringing calculations for aerial cables.

Final subcircuits: May be treated as typical for common route lengths, loads and cable sizes.

1.4 PROUCTS AND MATERIALS

Cable support and duct systems: Submit technical data for the following:

- Ducted wiring enclosure systems.
- Cable support systems.
- Proprietary pits.
- Proprietary columns.
- Load calculations for aerial cable supports.

Type tests: Submit certificates for components, functional units and assemblies. Verify that type tests and internal arcing-fault tests, if any, were carried out at not less than the designated fault currents at rated operational voltage.

Alterations to TTAs: Submit records of alterations made to assemblies since the tests.

Switchboard product data: Submit the following:

- Makes, types and model numbers of items of equipment.
- Type test certificates for components, functional units and assemblies including internal arcing-fault tests and factory test data.

- Default IP rating.

1.5 SAMPLES

Low voltage power systems: Submit samples of all visible accessories and equipment.

Cabling accessories: Submit switched socket outlets, light switch plates and other accessories.

1.6 SHOP DRAWINGS

Submit shop drawings of the following:

General:

- Cable routes.
- Busduct systems including routes, dimensions and connection details.

Cable support and duct systems:

- Cable tray and trunking routes.
- Layout of cable supports and enclosures on the current architectural background coordinated with the structure and other services.
- Layout of underground conduits, pits and drainage trenches.
- Invert levels for underground conduits.
- Depth of burial for cables and conduits.
- In situ pits.
- Provision for expansion and ground movement.
- Fabricated columns.
- Footing for columns.

Switchboards:

- ***Switchboard layout***
- ***Single line diagrams***

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1.7 ELECTRICAL ACCESSORIES

General

Responsibilities: Provide accessories as documented and to the requirements of **LOW VOLTAGE POWER SYSTEMS**.

Proprietary equipment: If proprietary equipment is selected by the contractor, the requirements of this specification over-ride the specifications inherent in the selection of a particular make and model of accessory.

Uniformity: Provide all accessories and outlets located in close proximity of the same manufacture, size, finish and material.

Default finish: Select from the manufacturers' standard range.

1.8 CO-ORDINATION

Requirement

After final selection of equipment but before ordering of plant, provide a maximum demand calculation for each MSSB, MCC and other separate items. Provide to the electrical sub-contractor to ensure electrical supplies are fully co-ordinated. Complete rectification works without additional cost where co-ordination is not carried out.

2 CABLE SUPPORT AND DUCT SYSTEMS

2.1 RESPONSIBILITIES

General
Requirement: Provide cable support, trunking and duct systems, as documented.

Sizes
Requirement: Conform to the following:

- Underground: ≥ 25 mm.
- Telecommunications: ≥ 25 mm.
- Other locations: ≥ 20 mm.

Fasteners
Surface mounted: Double sided fixed.

Galvanized water pipe
Medium or heavy: To AS 1074.

2.2 METALLIC CONDUITS AND FITTINGS

General
Standards: To AS/NZS 61386.21 and AS/NZS 61386.23.

Fasteners
Saddles: Conform to the following:

- Internal: Zinc plated.
- External: Hot-dipped galvanized.

Corrosion protection
Steel conduits: Paint ends and joint threads with zinc rich organic primer to AS/NZS 3750.9.

2.3 NON-METALLIC CONDUITS AND FITTINGS

General
Standards: To AS/NZS 2053.3, AS/NZS 61386.21, AS/NZS 61386.22 or AS/NZS 61386.23.

Number of joints: Use minimum number of joints, subject to commercially available lengths.

Bends: Where practical, conduit changes of direction shall be by solid formed large radii bends. ***Rev 2017-01***

Flexible conduit
Requirement: Provide flexible conduit to connect with equipment and plant subjected to vibration. If required, provide for adjustment or ease of maintenance. Use the minimum possible length ***and not more than 500mm.*** ***Rev 2017-01***

Associated fittings
Type and material: Same as the conduit.

Wall boxes on PVC-U conduits: For special size wall boxes not available in PVC-U, provide prefabricated earthed metal boxes.

Fixings: Fixings shall be installed along the length of the conduit at the minimum of 1000m for horizontal runs and 2000mm for vertical runs using two fixings per saddle. Select suitable fixings for each type of surface the saddles arte to be fixed to. ***Rev 2017-01***

Inspection-type fittings
Requirement: Use only in accessible locations and where exposed to view.

Joints
Locations: Install flexible couplings at structural expansion joints with saddles close to the coupling.

At all times where possible install conduit out of direct sunlight. Where conduits are exposed to sunlight they shall be stabilized and be guaranteed for this type of installation for a minimum of 15 years. ***Rev 2017-01***

Type: Cemented or snap-on joints.

2.4 CABLE DUCT/TRUNKING

General

Standards: To AS/NZS 4296.

Communications cabling: To AS/NZS ISO/IEC 14763.2.

Cable duct

Material: Metal.

Material finish: Metallic-coated to AS 1397 Grade G2, Coating Class Z275.

Construction: Solid.

Covers for accessible locations: Screw-fixed or clip-on type removable only with the use of tools.

Accessories: Purpose-made to match the duct system.

Cable support: Except for horizontal runs where the covers are on top, support wiring with retaining clips at intervals of not more than 1000 mm.

2.5 CABLE TRAY/LADDER SUPPORT SYSTEMS

General

Standard: To NEMA VE-1.

Type tests: To NEMA VE-1.

Manufacture: Provide proprietary cable support, fittings and accessories from a single manufacturer for the same support system.

Selection: Select cable supports in conjunction with support system installation to achieve the loading and deflection requirements.

Material finish: Metallic-coated to AS 1397, Grade G2, Coating Class Z275.

Spare capacity: Minimum 50%.

2.6 UNSHEATHED CABLES – INSTALLATION

General

Requirement: Provide permanently fixed enclosure systems, assembled before installing wiring.

Draw wires: Provide draw wires to pull in conductor groups from outlet to outlet, or provide ducts with removable covers.

2.7 CONDUIT SYSTEMS – INSTALLATION

Conduits in roof spaces

Location: Locate below roof insulation and sarking. In accessible roof spaces, provide mechanical protection for light-duty conduits.

Draw cords

General: Provide 5 mm^2 polypropylene draw cords in conduits not in use.

Draw-in boxes

General: For conduits in accessible locations provide draw-in boxes as follows:

- In straight runs at > 30 m: Spacing ≤ 30 m.
- At changes of level or direction.

Underground draw-in boxes: Provide gasketed covers and seal against moisture. Install in accessible pits.

Expansion

General: Allow for thermal expansion/contraction of conduits and fittings due to changes in ambient temperature conditions. Provide expansion couplings as required.

Rigid conduits

General: Install in straight long runs, smooth and free from rags, burrs and sharp edges. Set conduits to minimise the number of fittings.

Routes

Set-out: If exposed to view, install conduits in parallel runs with right angle changes of direction.

Bends: Install conduits with no more than 2 right angled bends per cable draw-in run.

Concealed conduits: Run conduits concealed in wall chases, embedded in floor slabs or installed in inaccessible locations directly between points of termination, minimising the number of sets. Do not provide inspection fittings. Use large radius bends or elbows.

Overhead conduits in mechanical plant rooms: If overhead conduits service mechanical equipment installed on plinths in plant rooms, provide support and protection. Alternatively, use cable support system.

Conduits in concrete slabs

Route: Do not run in concrete toppings. Do not run within pretensioning cable zones. Cross pretensioning cable zones at right angles. Route to avoid crossovers and minimise the number of conduits in any location.

Parallel conduit spacing: ≥ 50 mm apart.

Conduits in mechanical plant room slabs: Avoid installation of conduits in plant room slabs (boiler rooms, mechanical plant rooms and tank rooms) if conduits and cables are likely to experience high temperatures, be subject to core hole drilling, drilling of large anchor bolt points or where exact plant locations are unknown at time slab is poured.

Minimum cover: The greater of the conduit diameter and 20 mm.

Construction joints: Provide sleeving over conduit to allow movement of the conduit across the joint due to any slab movement.

Fixing: Fix directly to the top of the bottom layer of reinforcing.

Conduits in hollow-block floors

Location: Locate conduits in the core-filled sections of precast hollow-block type floors.

Conduits in columns

Number and size of conduits in columns: As determined by the structural engineer.

Bends: Enter columns with radius sweep bends greater than or equal to 150 mm. Do not use elbows.

Chasing: Do not chase columns.

2.8 CABLE SUPPORT SYSTEMS – INSTALLATION

General

Standard: To NEMA VE-2.

Design: Support cable support systems as follows:

- Horizontal runs:
  - Concealed cable support system: At spacing which is less than length of cable support section.
  - Visible cable support: Loaded deflection ≤ span/200.
- Vertical runs: To manufacturer’s recommendation, taking into account the weight of cables installed.

Fixing to building structure

General: Fix supports to the building structure or fabric with threaded rod hangers greater than or equal to 8 mm attached to hot-dip galvanized U-brackets, or by means of proprietary brackets.

Cable fixing

General: Provide strapping or saddles suitable for fixing cable ties.

Inside bend radius

Requirement: At least 12 times the outside diameter of the largest diameter cable carried.

Cable protection

General: Provide rounded support surfaces under cables where they leave trays or ladders.

Clearances

Access requirement: At least 150 mm free space above and at least 600 mm free space on at least one side of cable tray and ladders.

From hot water pipes: > 200 mm.

From boilers or furnaces: > 500 mm.

Electromagnetic interference (EMI): Locate support systems for electrical power cabling and communication cabling to minimise electromagnetic interference.

2.9 CABLES IN TRENCHES – INSTALLATION

Sand bed and surround

General: Conform to the *0223 Service trenching* worksection.

Sand bed and surrounds: Provide at least 150 mm clean sharp sand around cables and conduits installed underground.

Sealing ducts and conduits

General: Seal buried entries to ducts and conduits with waterproof seals as follows:

- Spare ducts and conduits: Immediately after installation.
- Other ducts and conduits: After cable installation.

3 LOW VOLTAGE POWER SYSTEMS

3.1 RESPONSIBILITIES

General

Requirement: Provide low voltage power systems, as documented.

System description

Supply: Conform to the following:

- Nominal supply voltage: 230/400 V.
- Number of phases: 3.
- Frequency: 50 Hz.
- Number of wires – system: 4.
- Neutral connection: MEN.

Selection: Provide wiring systems appropriate to the installation conditions and the function of the load.

3.2 STANDARDS

General

Requirement: To AS/NZS 3000 Part 2, unless documented otherwise.

Electrical design: To AS/NZS 3000 and SAA HB 301.

Electrical equipment: To AS/NZS 3100.

Fire and mechanical performance classification: To AS/NZS 3013.

Selection of cables: To AS/NZS 3008.1.1.

Distribution cables: To AS/NZS 4961.

Degrees of protection (IP code): To AS 60529.

Electromagnetic compatibility (EMC): To AS/NZS 61000.

Communications systems: To AS/CA S008, AS/CA S009, AS/NZS 3080 and AS/NZS ISO/IEC 14763.2.

Testing

Standard: To AS/NZS 3017.

3.3 INTERPRETATION

Definitions

General: For the purposes of this worksection the following definitions apply:

- Embedded generator: Electricity generator connected to the local electrical distribution network.
- Extra-low voltage: Not exceeding 50 V a.c. or 120 V ripple-free d.c.

- High voltage: Exceeding low-voltage.
- Extra-low voltage: Not exceeding 50 V a.c. or 120 V ripple-free d.c.

3.4 POWER CABLES

Standards

Polymeric insulated cables: To AS/NZS 5000.1.

Aerial cables:

- Copper conductors: To AS 1746.
- Aluminium conductors: To AS 3607 or AS 1531.

Cable

Requirement: Select multi-stranded copper cables.

Default insulation: V-75.

Default sheathing: 4V-75.

Minimum size: Conform to the following:

- Lighting subcircuits: 1.5 mm^2.
- Power subcircuits: 2.5 mm^2.
- Submains: 6 mm^2.

Voltage drop: Select final subcircuit cables within the voltage drop parameters dictated by the route length and load.

Fault loop impedance: Provide final subcircuit cables to satisfy the requirements for automatic disconnection under short circuit and earth fault/touch voltage conditions.

Underground residential distribution (URD) systems: Cables to AS/NZS 4026.

Distribution cables: To AS/NZS 4961.

Colours

Conductor colours: For fixed wiring cables, provide coloured conductor insulation or at least 150 mm of close fitting coloured sleeving at the termination points of each conductor.

Active conductors in single phase circuits: Red.

Active conductors in polyphase circuits:

- A phase: Red.
- B phase: White.
- C phase: Blue.

Sheath: White.

Cable installation

Classifications: To AS/NZS 3013.

Handling cables: Report damage to cable insulation, serving or sheathing.

Stress: Do not use installation methods that exceed the cable's pulling tension. Use cable rollers for cable installed on tray/ladders or in underground enclosures.

Straight-through joints: Unless unavoidable due to length or difficult installation conditions, run cables without intermediate straight-through joints.

Cable joints: Locate in accessible positions in junction boxes and/or in pits.

Individual wiring of extra-low voltage circuits: Tie together at regular intervals.

Tagging

General: Identify multicore cables and trefoil groups at each end with stamped non-ferrous tags clipped around each cable or trefoil group.

Marking

General: Identify the origin of all wiring by legible indelible marking.

Submains and final sub-circuits

Installation: Provide the following:

- Cables with diameter less than 13 mm: Run in conduit, cable ducts or support on cable trays or ladders.
- Single core cables of 3 phase circuits : Install unenclosed single core cables of diameter greater than 13 mm laid on cable tray in trefoil (RWB) or quadrofoil (RWBN) groups.
- Cables for lighting systems: Run in conduit, cable ducts, suspend on catenary systems or support on cable trays or ladders.
- Accessible concealed spaces: Install thermoplastic insulated and sheathed cables.
- Inaccessible concealed spaces: Install cable in PVC-U conduit.
- Roof spaces: Install cable below heat insulation and sarking. If not protected from high ambient roof space temperatures by thermal insulation, derate the cables, to AS/NZS 3008.1.1 Table 27, for an assumed ambient temperature of 55^{o} C.
- Accessible ceiling voids: Support and enclose cables on ceiling surfaces or ceiling suspension systems.
- Plastered or rendered masonry: Install cable in PVC-U conduit.
- Double sided face brick partition: Install cable in PVC-U conduit installed within the brick wall by slotting bricks or using any pathways provided in the brick.
- Stud framed walls with bulk insulation: Install cables in PVC-U conduit.
- Stud framed walls without bulk insulation: Thermoplastic insulated and sheathed cables allowing rewirability.
- Horizontal cable trays or ladders: Fix cables using proprietary nylon cable ties or straps, cable saddles or clips at 2000 mm intervals.
- Vertical cable risers: Fix cables using proprietary nylon cable ties or straps, cable saddles or clips at 1000 mm intervals.
- Plant rooms: Install cable in heavy duty PVC-U conduit or on tray or in duct.

3.5 ELECTRICAL ACCESSORIES

General
Style: Provide accessories of the same style and from the same manufacturer, as documented.

Emergency stop switches
Standard: To AS/NZS IEC 60947.5.5.

Type: Mushroom head with latch and twist releaser.

3.6 EARTHING

Earthing systems
Protective earthing system with a multiple earth neutral (MEN) connection: To AS/NZS 3000 Section 5 and as documented.

3.7 FIRE-RESISTING CABLES

Protection
General: If exposed to mechanical damage, provide protection to AS/NZS 3013.

3.8 COPPER CONDUCTOR TERMINATIONS

General
Requirement: Other than for small accessory and luminaire terminals, terminate copper conductors to equipment, with compression-type lugs of the correct size for the conductor. Compress using the correct tool or solder.

Within assemblies and equipment
General: Loom and tie together conductors from within the same cable or conduit from the terminal block to the point of cable sheath or conduit termination. Neatly bend each conductor to enter directly

into the terminal tunnel or terminal stud section, allowing sufficient slack for easy disconnection and reconnection.

Alternative: Run cables in PVC-U cable duct with fitted cover.

Identification: Provide durable numbered ferrules fitted to each core, and permanently marked with numbers, letters or both to suit the connection diagrams.

Spare cores: Identify spare cores and terminate into spare terminals, if available. Otherwise, neatly insulate and neatly bind the spare cores to the terminated cores.

3.9 TESTING

Site tests

Inspection: Visually inspect the installation to AS/NZS 3000 before testing. Record on a checklist.

Ventilation: Test and verify the installation to AS/NZS 3000 Section 8 using the methods outlined in AS/NZS 3017. Record the results of all tests.

Electricity networks: Test and verify the connections to electricity networks to AS 4741. Record the results of all tests.

3.10 SPARE PARTS

General

Spare parts: As documented.

3.11 ISOLATION SWTICHES

Requirement: All motors and field equipment shall have isolation switches mounted on wall or ceiling directly adjacent the item serve. Isolation switches are not to be mounted directly to the equipment served. Isolation switches shall comply with the following:

- ***Rated at not less than locked rotor current of motor***
- ***Fault making and load breaking***
- ***Spring assist manual closing***
- ***Suitable for prospective fault current***
- ***Include arc chutes on each pole***
- ***Include mechanical "ON" and "OFF" indicators***
- ***Lockable in the "OFF" position***
- ***IP55 degree of protection of better*** ***Rev 2019-04***

4 SWITCHBOARDS

4.1 REPONSIBILITIES

General

Requirement: Provide custom-built switchboards and distribution pillars, as documented.

4.2 STANDARDS

General

Standards: To AS/NZS 3000, and AS/NZS 3439.1 or AS/NZS 61439.1.

4.3 INTERPRETATION

Definitions

General: For the purposes of this worksection the following definitions apply:

- Custom-built assemblies: Low voltage switchgear and controlgear assemblies manufactured to order and incorporating either purpose built or proprietary components or either purpose built or proprietary bus-bar assemblies.

- Fault current limiters: Circuit opening devices designed or selected to limit the instantaneous fault current.
- Incoming busbars: Busbars connecting incoming terminals to line side terminals of main switches.
- Main circuit supply busbars: Busbars connecting incoming functional unit terminals, or incoming busbars where no main switches are included, to outgoing functional unit terminals or outgoing functional unit tee-offs.
- Proprietary assemblies: Low voltage switchgear and controlgear assemblies available as a catalogue item, consisting of the manufacturer's standard layout and equipment. Minor modifications are permissible to accommodate equipment and accessories, whilst retaining standard format.
- Rated currents: Continuous uninterrupted current ratings within the assembly environment under in-service operating conditions.
- Rated short-circuit currents: Maximum prospective symmetrical root mean square (r.m.s.) current values at rated operational voltage, at each assembly incoming supply terminal.
- Tee-off busbars: Busbars connecting main busbars to incoming terminals of outgoing functional units.

4.4 CUSTOM-BUILT SWITCHBOARD CONSTRUCTION

Separation
Default: Form 1.

Spare capacity
Default spare poles: Minimum 20%.

IP rating
Default rating: IP42 minimum.

Weatherproof: IP56 minimum.

Supporting structure
Assemblies:

- Wall mounted: Maximum 2 m^2.
- Floor mounted: Greater than 2 m^2.

Ventilation
General: Required to maintain design operating temperatures at full load.

Equipment layout
General: Position equipment to provide safe and easy access for operation and maintenance. Group devices by function.

Connection: Front connected.

Compartments: Separate shipping sections, subsections, cable and busbar zones, functional unit modules and low voltage equipment compartments using vertical and horizontal steel partitions which suit the layout and form of separation.

Form 1 enclosures: Separate into compartments with partitions at 1.8 m maximum centres.

Equipment on doors: Set out in functional unit groups and to allow access without the use of tools or keys.

Segregation
General: Segregate BCA emergency equipment from non-emergency equipment with metal partitions designed to prevent the spread of a fault from non-emergency equipment to emergency equipment.

BMS equipment: Accommodate extra low voltage BMS equipment in a separate compartment.

Enclosure materials
General: Fabricate from sheet metal of rigid folded and welded construction. Obtain approval for non-welded forms of construction.

Material: Metallic-coated sheet steel to AS 1397.

Material thickness:

- Diagonal dimension:

. < 900 mm: Minimum 1.6 mm.
. ≥ 900 mm: Minimum 2.0 mm.

Coating class:

- Indoor assemblies: Z200.
- Outdoor assemblies: Z450.

Insect proofing

General: Cover ventilation openings with non-combustible and corrosion resistant 1 mm mesh.

Equipment mounting panels

General: To support the weight of mounted equipment.

Metallic panels: Construct from metal greater than or equal to 3 mm thick with heavy metal angle supports or plates bolted or welded to enclosure sides.

Non-metallic panels: Provide non-metallic to support the weight of the mounted equipment and design the mounting structure for stability and stiffness.

Non-metallic boards: To IEC 60893-1.

Equipment fixing

Spacing: Provide 50 mm minimum clearance between busbars for the following:

- Lifts, fire services and building emergency services.
- General installation services busbars.
- Equipment.

Mounting: Bolts, set screws fitted into tapped holes in metal mounting panels, studs or proprietary attachment clips. Provide accessible equipment fixings which allow equipment changes after assembly commissioning.

Installation: For lightweight equipment, provide combination rails and proprietary clips.

Construction

Lifting provisions: For assemblies with shipping dimensions exceeding 1800 mm high x 600 mm wide, provide fixings in the supporting structure and removable attachments for lifting.

Supporting structure: Provide concealed fixings or brackets to allow mounting and fixing of assemblies in position without removing equipment.

Floor-mounting: Provide mild steel channel plinth, galvanized to class Z600, with toe-out profile, nominal 75 mm high x 40 mm wide x 6 mm thick, for mounting complete assemblies on site. Drill M12 clearance holes in assembly and channel and bolt assemblies to channel. Prime drilled holes with zinc rich organic primer to AS/NZS 3750.9.

4.5 CABLE ENTRIES

General

Requirement: Provide cable entry facilities within assembly cable zones for incoming and outgoing power and control cabling. Provide sufficient clear space within each enclosure next to cable entries to allow incoming and outgoing cables and wiring to be neatly run and terminated, without unnecessary bunching or sharp bends.

Cover and gland plates

Cover plates: Provide 150 mm maximum width cover plates butted together and covering the continuous cable entry slot.

Gland plates: Provide removable gland plates fitted with gaskets to maintain the degree of protection.

Materials: Conform to the following:

- Generally: 1.5 mm thick steel, 5 mm thick composite material or laminated phenolic.
- For MIMS cables and cable glands: 6 mm thick brass.

4.6 DOORS AND COVERS

Door layout

Maximum width: 900 mm.

Minimum swing: At least 90°.

Door stays: Provide stays to outdoor assembly doors.

Adjacent doors: Space adjacent doors to allow both to open to 90° at the same time.

Door construction

Protection: Provide single right angle return on all sides and fit suitable resilient sealing rubber to provide the documented IP rating and prevent damage to paintwork.

Hinges: Provide the following:

- Generally: Corrosion-resistant pintle hinges or integrally constructed hinges to support doors.
- For removable doors: Staggered pin lengths to achieve progressive engagement as doors are fitted.
- For doors higher than 1000 mm: 3 hinges.
- For non lift-off doors: Restraining devices and opposed hinges.

Door hardware: Provide the following:

- Corrosion resistant lever-type handles, operating a latching system with latching bar and guides strong enough to withstand explosive force resulting from fault conditions within the assembly.
- Dual, edge mounted, corrosion resistant T handles with provision for key locking cylinder.
- Captive, corrosion resistant knurled thumb screws as an alternative to handles.

Locking: Incorporate cylinder locks in the latching system. Key alike, 2 keys per assembly.

Door mounted equipment: Protect or shroud door mounted equipment and terminals to prevent inadvertent contact with live terminals, wiring, or both.

Earthing: Maintain earth continuity to door mounted indicating or control equipment with multi-stranded, flexible earth wire, or braid of equal cross-sectional area, bonded to the door.

Covers

Maximum dimensions: 900 mm wide and 1.2 m^2 surface area.

Fixing: Fix to frames with at least 4 fixings, using corrosion-resistant acorn nuts with serrated washers.

Rest cover edges on the cubicle body or on mullions. Do not provide interlocked covers.

Handles: Provide corrosion-resistant D type handles.

Escutcheons

General: For doors enclosing circuit breakers, provide escutcheon plates as barriers between operating mechanisms and live parts.

Escutcheon plates

General: Provide plates or removable covers with neat circuit breaker toggle cut-outs allowing interchangeability of 1, 2 and 3 pole circuit breakers. Provide corrosion-resistant lifting handles or knobs. Provide unused circuit breaker toggle cut-outs with blanking infill pole covers.

Maximum dimensions: 900 mm wide and 1.2 m^2 surface area.

4.7 FACTORY FINISHES

General

Standard: To AS 2700.

Extent: Apply protective coatings to internal and external metal surfaces of assembly cabinets including covers, except to stainless steel, galvanized, electroplated, or anodised surfaces and to ventilation mesh covers.

Finish coats: Thermoset powder coating to AS 4506 or two-pack liquid coating of AS/NZS 3750.13 primer and proprietary or epoxy acrylic full gloss spray finish.

Factory finish colours

Mounting structure (brackets): To match enclosure.

Enclosure - indoor:

- Indoor assemblies: Orange X15.
- Assembly interior: Orange X15.

Enclosure - outdoor:

- Outdoor assemblies: Avocado green G34.

- Assembly interior: White.

Escutcheons - removable equipment panels:

- Internal assemblies: Orange X15.
- External assemblies: Off white Y35.

Doors: To match enclosure.

Plinths: Black.

4.8 BUSBARS

General

Requirement: Provide main circuit supply busbars within assemblies, extending from incoming supply terminals to the line side of protective equipment for outgoing functional units and for future functional units.

Standards: To AS 60890.

4.9 NEUTRAL LINKS AND EARTH BARS

Terminals

General: Provide terminals for future circuits.

Links

Assembly capacity > 36 poles: Provide neutral links and earth bars at the top and bottom of the circuit breaker section.

Assembly capacity ≤ 36 poles: Provide links and bars at the point of entry of incoming supply cables.

Mounting: Mount neutral links on an insulated base.

Control circuits: Provide separate neutral links and earth bars.

Labels: Provide labels for neutral and earth terminals.

Cables > 10 mm^2: Provide bolts or studs.

Communications earth: Make provision for connection of communications systems earth at switchboard earth bar to AS/CA S009.

4.10 INTERNAL WIRING

Wiring

Cable type: 0.6/1 kV copper cables. Provide V-90HT insulation where directly connected to active and neutral busbars.

Cable interconnections

General: For the main circuit supply, provide cable interconnections as follows:

- ≥ 1.5 mm^2 internal cables, with minimum V75 insulation rating with stranded copper conductors rated to AS/NZS 3008.1.1. Provide cables with current ratings suitable for the internal assembly ambient air temperature and for temperature rise limits of equipment within the assembly.
- Run cables clear of busbars and metal edges.
- Provide cables capable of withstanding maximum thermal and magnetic stresses associated with relevant fault level and duration.
- Run cables neatly. Provide slotted trunking sized for future cables or tie at 150 mm maximum intervals with ties strong enough to withstand magnetic stresses created at the specified fault current. Do not provide adhesive supports.
- Provide for installation of wiring for future equipment without removal of existing equipment.
- Identify power and control cables at both ends with neat fitting ring type ferrules agreeing with record circuit diagrams. Mark to AS/NZS 4383 series.
- Terminate control cables and motor control circuits in tunnel terminals or, if necessary, provide suitable palm type lugs and correct crimp tool.
- For equipment mounted on hinged doors run cables on the hinge side to avoid restricting the door opening. Bundle cables with spiral wrap PVC and secure to door.

- If recommended by device manufacturers, provide shielded wiring.

Adjacent circuit breakers: If suitable proprietary multi-pole busbar assemblies are available to link adjacent circuit breakers, do not provide cable interconnections.

Cables > 6 mm²

Terminations:

- Tunnel terminals: Single cables.
- Other connection points or terminals: ≤ 2 cables.

Doors: Do not run cables to hinged doors or removable panels.

Supports:

- Spacing at enclosure: ≤ 200 mm from a termination.
- Spacing generally: ≤ 400 mm.
- Strength: Capable of withstanding forces exerted during fault conditions.

Single core cables rated ≥ 300 A: Do not provide ferrous type metal cable saddles.

Terminals marked: Terminate marked cables for connection to external controls in correspondingly marked terminals within the assembly.

Control and indication circuits

General: Provide conductors sized to suit the current carrying capacity of the particular circuit.

Minimum size: 1 mm^2 with 32/0.2 stranding.

Cable colours

General: Colour code wiring as follows:

- A phase: Red.
- B phase: White.
- C phase: Blue.
- Neutral: Black.
- Earthing: Green-yellow.

4.11 ASSEMBLY INSTALLATION

Fixing

General: Before making inter-panel connections, fix assemblies and metering equipment enclosures into position, level and plumb.

4.12 ASSEMBLY ENTRIES

Cable entries

General: Neatly adapt one or more cable entry plates, if fitted, to accept incoming cable enclosure. Provide the minimum number of entry plates to leave spare capacity for future cable entries. Do not run cables into the top of weatherproof assemblies.

Single core cables rated > 300 A: Pass separately through non-ferrous gland plates. Do not use ferrous metal saddles.

Cable enclosures

General: Continue cable enclosures to or into assemblies and fit cable entry plates so that the IP rating of the assembly and the fire rating of the cable are maintained.

Cable supports

General: Support or tie mains and submains cables within 200 mm of terminations. Provide cable supports suitable for stresses resulting from short circuit conditions.

5 SWITCHBOARD COMPONENTS

5.1 RESPONSIBILITIES

General

Requirement: Provide switchboard components, as documented.

5.2 REQUIREMENTS

General

Selection: To AS/NZS 3000 clause 1.7 and Section 2.

Rated duty: Uninterrupted.

Rated making capacity (peak): ≥ 2.1 x fault level (r.m.s.) at assembly incoming terminals.

Utilization category: To AS/NZS IEC 60947.1 clause 4.4 and the recommendations of Annex A.

- Circuits consisting of motors or other highly inductive loads: At least AC-23.
- Other circuits: At least AC-22.

Coordination: Select and adjust protective devices to discriminate under overload, fault current, and earth fault conditions.

Enclosure: IP4X minimum.

5.3 SWITCH-ISOLATOR

General

Standard: To AS/NZS IEC 60947.1 and AS/NZS IEC 60947.3.

Poles: 3.

Operation: Independent manual operation including positive ON/OFF indicator.

Shrouding: Effective over range of switch positions.

Fault make/fault break switch-isolators

Rated breaking capacity: To AS/NZS IEC 60947.3 Table 3.

Rated short-time withstand current: As defined in AS/NZS IEC 60947.1 clause 4.3.6.1 and the manufacturer's recommendation for the prospective fault current conditions.

Rated short-circuit making capacity: As defined in AS/NZS IEC 60947.1 clause 4.3.6.2, to conform to the manufacturer’s recommendation for the prospective fault current conditions.

Rated short-circuit breaking capacity: To AS/NZS IEC 60947.1 clause 4.3.6.3 and the manufacturer’s recommendation for the prospective fault current conditions.

Load make/load break switch-isolators

Rated making and breaking capacity: As defined in AS/NZS IEC 60947.1 clause 4.3.5 to conform to AS/NZS IEC 60947.3 Table 3 and the manufacturer's recommendations for the prospective fault current conditions.

Rated short-time withstand current: As defined in AS/NZS IEC 60947.1 clause 4.3.5, to conform to the manufacturer’s recommendation for the current conditions.

5.4 FUSE-SWITCH UNITS

General

Standard: To AS/NZS IEC 60947.1 and AS/NZS IEC 60947.3.

Operation: Provide an extendable operating handle.

Fuse links

Requirement: Isolate when switch contacts are open. Provide 3 phase sets of high rupturing capacity (HRC) fuse links.

5.5 MOULDED CASE AND MINIATURE CIRCUIT BREAKERS

General

Moulded case breakers: To AS/NZS IEC 60947.1 and AS/NZS IEC 60947.2.

Miniature circuit breakers: Interrupting capacity classification to AS/NZS 60898.1 or AS/NZS 3111.

- For general building services: Type C.
- For motor protection: Type D.

Operation: Independent manual operation including positive ON/OFF indicator.

Trip type: Conform to the following:

- Moulded case breakers: Adjustable thermal, fixed magnetic.
- Miniature circuit breakers: Fixed thermal and fixed magnetic.

Isolation facility: Required.

Current limiting: Moulded case breakers required.

Mounting: Mount circuit breakers so that the ON/OFF and current rating indications are clearly visible with covers or escutcheons in position. Align operating toggles of each circuit breaker in the same plane.

Clip tray chassis: For miniature overcurrent circuit breakers, provide clip tray assemblies capable of accepting single, double or triple circuit breakers and related busbars. Provide moulded clip-on pole fillers for unused portions.

Utilisation category: Moulded case breakers:

- Final subcircuits category: Category A.
- Mains and submains: Category B.

Trip settings: Set as documented, seal, and label.

Interchangeable trip units: Connect trip units so that trip units are not live when circuit breaker contacts are open.

Fault current limiting circuit breakers: Select breaker frame sizes from one manufacturer's tested range of breakers to give cascade and discrimination protection within the switchboard and downstream switchboards as required.

5.6 FUSES WITH ENCLOSED FUSE LINKS

General

Standards: To IEC 60269-1 and IEC 60269-2.

Fuses with fuse links for the protection of semiconductor devices: To IEC 60269-4.

Fuses with fuse links used as fault current limiters: Coordinate fuse type and rating with the protection switchgear manufacturer's recommendation if used downstream of the fault current limiters. Provide labels adjacent to the fuse holder stating FAULT CURRENT LIMITER and fuse size.

Fuse links: Enclosed, high rupturing capacity type mounted in a fuse carrier.

Breaking range and utilisation category:

- Distribution/general purpose: gG.
- Motors: gM.

Fuse holders: Mount fuse holders so that fuse carriers may be withdrawn directly towards the operator and away from live parts. Provide fixed insulation which shrouds live metal when the fuse carrier is withdrawn.

Barriers: Provide barriers on both sides of each fuse link, preventing inadvertent electrical contact between phases by the insertion of screwdriver.

Spare fuse links: Provide 3 spare fuse links for each rating of fuse link on each assembly. Mount spares on clips within the spares cabinet.

Spare fuse holder carriers: Provide 3 spare fuse holder carriers for each size of fuse holder carrier on each assembly. Mount spares on clips within the spares cabinet.

Busbar mounted fuse holders: Provide fuse carriers with retaining clips, minimum fuse holder 32 A.

5.7 CURRENT TRANSFORMER INTERFACE

General

Standard: To AS 60044.1.

Type: Cast resin encapsulated window type with busbar clamping devices.

Rated short time current: At least the short time current equivalent to the assembly fault level.

Rated short time: At least the maximum time setting of the related protective relay. Minimum 1 s.

Rated primary current: Equal to assigned current rating of the associated functional unit.

Rated secondary current: 5 A. Connect star point to earth.

Interposing transformers: Provide to the protective relay manufacturer's recommendations.

Characteristics: Conform to the protective relay manufacturer's recommendations.

Test links: Provide test terminals and current transformer secondary shorting links in accessible positions within instrument panels. Provide a set of DIN rail mounted test links, consisting of screw clamped slide links and earth links, for each current transformer group.

Installation: Install transformers to permit easy removal.

Removable links: Provide removable links of minimum lengths for transformers fitted on busbar systems.

Markings: Mount transformers in the assembly enclosure, so that polarity markings and nameplate details are readily viewed right side up without removing the transformers.

5.8 INSTRUMENTS AND METERS

Electricity meters (watthour meters)

Standards:

- Socket mounting system: To AS 1284.4.
- Electronic: To AS 62053.21.

Electricity meters: Class 0.5.

3-phase metering: Polyphase meters suitable for balanced 3 phase, 4 wire loads.

1 or 2 phase metering: Single phase meters.

Current rating: To suit load and overload conditions. Provide direct connect meters suitable for current range of 15 to 100 A and meters with current transformers suitable to 5 A secondary.

Register: Provide a direct reading register of the large figure type. Mark on the scale the metering transformer ratios and the multiplying factor applied to the meter constant.

Covers: Seal main covers.

5.9 ELECTRICAL INDICATING MEASURING METERS

General

Standard: To the IEC 60051 series.

Accuracy: Conform to the following:

- Indicating Instruments and accessories: ≤ Class 1.5.
- Thermal maximum demand indicators: Class 3.
- Power factor meters, phase angle meters and synchroscopes: 2 electrical degrees maximum error.
- Transducers: Class 0.5.

Mounting: Flush mount.

Meter size:

- Minimum: 96 mm square bezel type.
- If located on Form 3 and Form 4 motor starter enclosures: 76 mm square bezel type.

Labels: If associated exclusively with one phase, label meters RED, WHITE, or BLUE as applicable.

Meter potential protection devices: Group together behind associated meter cover or hinged door, preferably next to current transformer test links.

Accessories: Mount next to associated instruments, inside cabinets.

Transducers: If necessary for transducer operation, provide auxiliary supply. Connect outputs to dedicated rail-mounted isolating type terminals.

Ammeters and voltmeters

Standard: To IEC 60051-2.

Ammeters: Conform to the following:

- Type: Moving iron type oil dampened for motor starter circuits, 90°.

- Overscale: For ammeters subject to motor starting currents, overscale to at least 5 x full load current.
- Selector switches: 4-position type with positions designated R/W/B/OFF. Mount under or beside relevant ammeters.

Voltmeters: Conform to the following:

- Type: Moving iron, 90°.
- Selector switches: 7-position voltage transfer type for measurement of phase-to-phase and phase-to-neutral voltages with off. Mount under or next to relevant voltmeters.

Maximum demand indicators

General: Provide a meter in each phase with 15 minute response time. Provide for sealing the reset mechanism. Provide a combination 3-point indicator consisting of an instantaneous red ammeter pointer, a red maximum demand slave pointer with external reset facility, and a white maximum demand pointer.

Instantaneous type: Combined type with bi-metal maximum demand ammeter element and moving iron instantaneous ammeter element.

Thermal type: Combined type with bi-metal maximum demand ammeter element.

Wattmeters and varmeters

Standard: To IEC 60051-3.

General: Suitable for balanced 3 phase, 4 wire loads. Connect to measurement transducers.

Frequency meters

Standard: To IEC 60051-4.

Type: Either an analog type, or vibrating reed type with 7 reeds.

Analog type: Graduated in 0.1 Hz increments.

Scales:

- Analog: Graduated 45/65 Hz.
- Vibrating reed: Horizontal reed bar graduated 47/53 Hz.

Synchroscopes

Standard: To IEC 60051-5.

General: Continuously rated, rotating vane type movement, with spring loaded bearings and silicone fluid dampening, positive and negative arrows, black pointer and 12 o'clock marking.

Scales: 360.

Phase angle meters

Standard: To IEC 60051-5.

General: Provide for 3 phase, 4 wire balanced loads.

Scales: 0.5 leading to 0.5 lagging.

Hours-run meters

General: 6 figure (minimum), horizontal linear digits dial with last digit read-out in 0.1 hour increments.

5.10 CONTACTORS

General

Standard: To AS/NZS IEC 60947.4.1.

Type: Enclosed, block type, air break, electromagnetic.

Poles: 3.

Rated operational current: The greater of:

- Full load current of the load controlled.
- ≥ 16 A.

Mechanical durability: 10 million cycles to AS/NZS IEC 60947.4.1.

Electric durability: ≥ 1 million operations at AC-22 to AS/NZS IEC 60947.4.1.

Mounting: Mount with sufficient clearance to allow full access for maintenance, removal and replacement of coils and contacts, without the need to disconnect wiring or remove other equipment.

Auxiliary contacts: Provide auxiliary contacts with at least one normally-open and one normally-closed separate contacts with rating of 6 A at 230 V a.c., utilisation category AC-1.

Slave relay: If the number of auxiliary contacts exceeds the number which can be accommodated, provide separate slave relays.

5.11 CONTROL DEVICES AND SWITCHING ELEMENTS

Standards

General: To AS/NZS IEC 60947.1 and AS/NZS IEC 60947.5.1.

Switching elements:

- Electrical emergency stop device with mechanical latching function: To AS/NZS IEC 60947.5.4.
- Electromechanical control circuit devices: To AS/NZS IEC 60947.5.1.
- Proximity switches: To AS/NZS IEC 60947.5.2.

Rotary switches

General: Cam operated type with switch positions arranged with displacement of 60°.

Off position: Locate at the 12 o'clock position. Test positions must spring return to off position.

Rated operational current: At least 6 A at 230 V a.c.

Escutcheon plates: Provide rectangular plates securely fixed to the assembly panel. Identify switch position and function.

Time switches

Type: 7 day fully programmable with holiday override function.

Daylight saving switch: Required.

Mains failure operation: 100 hour minimum operating capacity.

Contact rating: ≥ 16 A at 230 V a.c. resistive load.

Construction: Provide readily accessible means of adjustment. Provide operational settings which are clearly visible when switch cover is fitted.

Dial: Digital with hour and minute display.

Override switch (manual): Required.

Control relays

Standard: To AS/NZS IEC 60947.5.1.

Requirement: Provide heavy duty fixed mounted type 3 relays.

Operation: Suitable for continuous operation.

Construction: Plug-in types. Receptacle bases with captive clips which can be operated without using tools.

Type: Modular block.

Contact elements: Electrically separate, double break with silver alloy, non-welding contacts.

Configuration: For standard relays, provide assemblies with ≥ 2 sets of contacts and expandable to 8 sets of contacts in the same assembly. Provide at least one normally-open and one normally-closed contact.

Plug-in types: If required provide the following:

- Receptacle bases with captive clips which can be operated without using tools.
- Changeover type contacts to allow either normally-open or one normally-closed configuration.

Control relay selection table

Relay type	Minimum mechanical life (million operations)	Base	Minimum contact rating	Inter-changeable	Minimum number of contact elements
1	5	Plug-in	$1.25I_L$	Yes	2
2	10	Plug-in	5 A at 240 V	Yes	2
3	10	Fixed mounting	5 A at 240 V	Yes	4

Time delay relays
Adjustable range: Adjustable over the full timing range with timing repeatability within ± 12.5% of nominal setting.

Electronic relays: Incorporate light emitting diodes indicating energisation states of relays.

Pneumatic relays
General: Provide sealed chamber type with internal circulating air with linear calibrated time adjustment.

Synchronous relays
General: Provide synchronous motor drive type relay fitted with anti-stalling device which protects gearing during normal operation.

Phase failure relays
General: Provide separate solid-state phase failure relays conforming to the following:

- Detect less than 85% of normal voltage.
- Detect single phase failure.
- Detect reverse phase sequence after an appropriate time delay.
- Automatic reset on detection of normal power supply.

Sensing circuit: To reject induced voltage spikes and disturbances with frequencies other than 50 Hz.

Back-up protection: Provide high rupturing capacity fuses to each phase.

Push-buttons
Type: Oil-tight, minimum 22 mm diameter, or 22 x 22 mm.

Rated operational current: At least 4 A at 240 V a.c.

Emergency stop devices with mechanical latching: To AS/NZS IEC 60947.5.5.

Marking: Identify functions of each push-button. For latched STOP or EMERGENCY STOP push-buttons, provide label with instructions for releasing latches.

5.12 SEMICONDUCTOR CONTROLLERS AND CONTACTORS

General
Requirement: Provide semiconductor controllers and contactors rated for the characteristics of the controlled load.

Standard: To AS/NZS IEC 60947.4.3.

5.13 PROGRAMMABLE LOGIC CONTROLLERS (PLC)

General
Requirement: Provide complete programmable logic controllers including central processing unit, input/output modules and mounting hardware, as follows:

- Modular in construction and of the same manufacture, with interchangeable peripherals and software.
- Provided with an integral power supply of sufficient capacity to satisfy the requirements of the central processing unit and input/output module combinations which can be located within the mounting hardware.
- Designed and constructed to operate in electrically noisy environments.
- Located in the low voltage control section of the associated functional unit.

Central processing units
General: Provide the following:

- Separate run, monitor and program functions.
- Operating system: Stored in non-volatile memory.
- Programmed software: Stored so that loss of power to the unit for a period up to 1 year will not cause corruption of data and will allow automatic restarting and correct operation immediately on power restoration.

Inputs and outputs (minimum):

- External inputs: 24.
- External outputs: 16.
- Internal relays: 128.

Input/output modules
Status: Clearly identified and indicated by a light emitting diode.

Diodes: Not obscured by assembly wiring.

Analog input: 4 to 20 mA or 0 to 10 V d.c., opto-isolated.

Analog output: 4 to 20 mA or 0 to 10 V d.c., into a burden of ≥ 600 Ω.

Digital input: 24 V d.c., opto-isolated.

Digital output: Volt-free relay contacts or opto-isolated solid state switches for switching an output load of at least 2 A at 24 V a.c. or d.c.

Programmer
Operation: Using ladder logic, allowing for editing without the need to re-enter the whole program. Include test and monitoring functions which facilitate testing, running and debugging of software and provide for input/output number check.

Hand-held programmers: Provide moulded connectors and 2 m connection cable.

5.14 INDICATOR LIGHTS

Standard
General: To AS/NZS IEC 60947.5.1.

LED indicators
Voltage range: 12 or 24 V as necessary, in corrosion-resistant bezel, nominal 5 mm diameter.

Press-to-test:

- Compartments/subsections with < 5 indicating lights: Provide each indicating light with a fitted integral press-to-test lamp actuator.
- Compartments/subsections with ≥ 5 indicating lights: Provide a common press-to-test lamp push-button.
-

5.15 INDICATING COUNTERS

General
Requirement: Provide the following:

- At least 6 digits.
- Digits at least 3.5 mm high.
- Continuous duty rated.
- Non-reset type.
- 500 V surge diverters.

5.16 AUDIBLE ALARM DEVICES

Sound level
General: Not less than the greater of the following:

- 65 dB(A) at 1 m.
- 15 dB(A) above ambient sound levels at any location in designated areas.

5.17 EXTRA-LOW VOLTAGE TRANSFORMERS

General
Requirement: Provide the following:

- Centre tap on secondary winding.
- Primary and secondary windings wired out on opposite sides of transformer case.

- Primary and secondary windings separated by means of an earthed screen wired out to an insulated terminal.
- Transformer rating greater than or equal to 125% of maximum output load, taking account of degree of ventilation and ambient temperature within assembly, and supplied load.

5.18 ANTI-CONDENSATION HEATERS

General

Rating: Provide heaters rated at not less than 20 W/m^2 of total external area including top of weatherproof enclosure.

Type: Black heat type with surface temperature less than or equal to 50°C, mechanically protected and thermostatically controlled.

5.19 SPARES CABINET

General

Requirement: Provide a spares cabinet with main name plate, labelled shelves and non-lockable door. Size for storing racking handles, special tools, spare lamps, spare fuse links and other equipment necessary for satisfactory assembly operation.

Location: Either of the following:

- Incorporated into assembly enclosure.
- Wall mounted in main switchroom.

Finish: To match switchboard assembly.

5.20 MARKING AND LABELLING

General

General: Provide labels including control and circuit equipment ratings, functional units, notices for operational and maintenance personnel, incoming and outgoing circuit rating, sizes and origin of supply and kW ratings of motor starters.

Labels and assembly exteriors

Manufacturer’s name: Required.

Assemblies: Label with essential markings.

Designation labels: For other than main assemblies, provide designation label stating source of electrical supply. Identify separate sections of enclosures.

Assembly controls: Label controls and fault current limiters, including the following:

- Circuit designation for main switches, main controls and submains controls.
- Details of consumers mains and submains.
- Use different colours on labels to distinguish operational requirements such as normal operation, operation under fire or emergency conditions.
- Incoming busbar or cable rating to first tee-off.
- Fuse link size.

Labels and assembly interiors

General: Provide labels for equipment within assemblies. Locate so that it is clear which equipment is referred to, and so that lettering is not obscured by equipment or wiring.

Moulded case circuit breakers: If circuit breaker manufacturer’s markings are obscured by operating handle mechanisms or motor operators, provide additional markings open to view on, or next to, the circuit breaker.

Arrestors: Label each group of primary arrestors, stating their purpose and the necessary characteristics.

Danger, warning and caution notices

Busbars: If polymer membrane coating is used without further insulation, provide warning notices on the front cover near the main switch or local main switch and on rear covers, indicating that busbars are not insulated.

Fault current limiters: In assembly sections containing fault current limiter fuses provide caution notices fixed next to the fault current limiters, stating that replacement fuse links are to match the installed fuse link ratings, make and characteristics. Provide separate label stating make and fault current limiting fuse ratings.

Externally controlled equipment: To prevent accidental contact with live parts, provide warning notices for equipment on assemblies not isolated by main switch or local main switch.

Stand-by power: Provide warning notices stating that assemblies may be energised from the stand-by supply at any time.

Anti-condensation heaters: To prevent accidental switching off, provide caution notices for anti-condensation heaters.

Insulation and shrouding: For insulation or shrouding requiring removal during normal assembly maintenance, provide danger notices with appropriate wording for replacement of insulation shrouding before re-energising assemblies.

Positioning: Locate notices so that they can be readily seen, next to or, if impracticable, on busbar chamber covers of functional units and behind the front cover of functional units. Provide circuit identification labels in the cabling chamber of each functional unit, located next to external terminations.

Marking cables

General: Identify the origin and cable size of wiring with legible indelible marking.

Identification labels: Provide durable labels fitted to each core and sheath, permanently marked with numbers, letters or both to suit the connection diagrams.

Multicore cables and trefoil groups: Identify multicore cables and trefoil groups at each end with durable non-ferrous tags clipped around each cable or trefoil group.

0791 MECHANICAL COMMISSIONING

1 GENERAL

1.1 RESPONSIBILITIES

General
Requirement: Provide commissioning of all mechanical systems, as documented.

1.2 CROSS REFERENCES

General
Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

1.3 STANDARDS

General
Measurement of fan and duct air quantities > 1000 L/s: To ISO 5802.

Testing, balancing and commissioning except fan and duct air quantity measurement: Select from the following:

- ASHRAE STD 111.
- CIBSE CCA,CIBSE CCB, CIBSE CCC,CIBSE CCR and CIBSE CCW.
- National Environmental Balancing Bureau (NEBB) Procedural Standards.
- AIRAH DA24.
- AIRAH DA27.
- AIRAH DA28.

Statistical analysis: To ASHRAE Guideline 2.

Fire operation of air handling systems: To AS/NZS 1668.1.

Orifice plates and venturi meters: To BS 1042.

Microbial control: To AS/NZS 3666.1 as required by BCA and the recommendations of SAA/SNZ HB 32.

Pressure equipment: To AS/NZS 3788.

Fume cupboards: To AS/NZS 2243.8.

1.4 INTERPRETATION

Abbreviations
General: For the purposes of this worksection the following abbreviations apply:

- VAV: Variable air volume.

Definitions
General: For the purposes of this worksection the following definitions apply:

- Accuracy: The closeness of the agreement between the result of a measurement and the true value of the particular quantity being measured.
- Branch: A duct with no terminals connected to it.
- Error: The measured value minus the true value of the particular quantity being measured.
- Resolution: The smallest difference between indications of a displaying device that can be meaningfully distinguished.
- Sub-branch: A duct connected to one or more terminals.
- Terminal (mechanical services): A supply, return or exhaust diffuser, grille or equivalent device discharging air into, or drawing air from, a space.

- Total air quantity: The sum of air flows to connected terminals, branches or sub-branches under the conditions of measurement.

1.5 INDEPENDENT CERTIFICATION OF COMMISSIONING AGENT

General
Requirement: Use only a Registered testing authority.

1.6 SUBMISSIONS

Certification
Instrumentation: On request, submit copies of current calibration certificates issued by a Registered testing authority.

Conformance to contract documents: Submit certification of conformance to the contract documents.

Statutory requirements: Submit certification of conformance to the relevant statutory requirements.

Completion program
Submissions: Submit a program consistent with, and forming part of, the construction program as follows:

- Set out the proposed program for completion, commissioning, testing and instruction.
- Identify related works and timing of the works prerequisite to successful and timely completion of the works.

Revisions: Submit revisions of the program as the project proceeds.

Plant operating period: Include time in the program for the documented plant operating period before the date for practical completion.

Records
Report: Submit a report demonstrating that equipment has been properly installed and is functioning correctly, including the following.

- Air balance: To **AIR BALANCE REPORTS**.
- Air flow rate: To **AIR BALANCE REPORTS**. Show on the reports where return and exhaust quantities have been varied from design values to achieve differential pressures.
- Room air pressure differential: Submit the measured or detected room pressure differentials to **ROOM AIR PRESSURE DIFFERENTIALS**.
- Sound pressure levels: To **SOUND PRESSURE LEVEL MEASUREMENTS**.
- Water balance: To **WATER BALANCE REPORTS**.

1.7 INSPECTION

Notice
Inspection: Give notice so that inspection may be made of the following:

- Starting up each item (5 working days).
- Commissioning of the installation.

2 EXECUTION

2.1 COMMISSIONING

General
Requirement: Commission mechanical services when:

- The respective systems or parts of systems are complete.
- The building work on which commissioning depends is complete.

Adjustments: Make the adjustments necessary to achieve the documented performance under continuous operating service conditions, including balancing, setting the controls, checking the operation of overload and safety devices, and correcting malfunctions.

Associated facilities
Requirement: Provide associated facilities for the documented testing and commissioning, including provision of test loads, fuel and energy.

Other trades: If testing and commissioning requires assistance of other trades arrange for this to be provided.

Fire safety
Requirement: Complete testing and certification of all fire safety measures before occupation of the building.

Reports
General: Submit reports indicating observations and results of tests and compliance or non-compliance with requirements.

Starting up
Requirement: If documented in the respective worksection, execute starting up under the supervision of manufacturers' representative and appropriate contractors' personnel, in conformance with manufacturers' recommendations.

Coordination: Coordinate schedules for starting up of various systems and equipment.

Checks: Before starting, verify that each piece of equipment has been checked for proper lubrication, drive rotation, belt tension, control sequence, circuit protection or for other conditions which may cause damage.

Tests: Verify that tests, meter readings, and documented electrical characteristics agree with those required by the manufacturer.

Wiring: Verify wiring and support components for equipment are complete and tested.

Manufacturers' representatives: If respective worksections require the attendance of a manufacturer’s representative, have the manufacturers' representatives present on site to inspect and/or check the system installation before starting up, and to supervise placing the equipment and operation.

2.2 RELATED TESTS

Retesting
Failure to meet documented performance: Identify and correct the cause of failure and repeat the test.

Statutory authorities
General: Provide demonstrations and tests for witnessing by the statutory authorities. Complete testing of systems before witness testing by the statutory authorities.

Other trades
General: Provide assistance to other trades for testing related non-mechanical systems.

2.3 INSTRUMENTATION

Calibration and certification
General: Use only instruments that have current calibration certificates issued by a Registered testing authority.

Maximum period since last calibration: As recommended by the manufacturer but not more than 12 months, except as documented.

Air quantity at diffusers, outlets and grilles
Hood adjustment factors: Determine adjustment factor for each hood and associated anemometer by one of the following methods:

- Certified by a Registered testing authority for the type, size and configuration of diffuser or grille and direction of air flow being measured.
- Determined by duct pitot traverse for the particular type, size and configuration of diffuser or grille and direction of air flow being used on the project.

Instruments:

- Accuracy: Better than ± 5% of measured value.
- Resolution: Better than 1% of measured value.

- Range: Measured velocity within 17% to 83% of the instrument calibrated range.

Air pressures and differential pressures

Instrument specifications:

- Pressures ≤ 50 Pa: Electronic meter or inclined manometer with 50 Pa full scale, accuracy better than 5% full scale.
- Pressures > 50 Pa: Electronic meter, mechanical meter or inclined manometer with full scale not more than 400% measured value, accuracy better than 2.5% full scale.

Water pressure and differential pressures

Instrument specifications:

- Accuracy: Better than ± 1% of full scale.
- Scale: Not more than 400% measured value.

Temperature

Air temperature instruments specifications:

- Accuracy: ± 0.2 K or better at measured value.

Chilled water and condenser water temperature instrument specification:

- Accuracy: ± 0.2 K or better at measured value.

Instrument specifications for other temperature applications:

- Accuracy: ± 0.5 K or better at measured value.
- Scale divisions (mercury-in-glass): 1.0 K or better.

Humidity

Instruments specifications: Sling psychrometer, aspirated psychrometer or electronic humidity meter.

- Accuracy:
  - ± 3% from 10 to 90% relative humidity where measured value tolerance is ≥ ± 5% relative humidity.
  - ± half measured value tolerance from 10 to 90% relative humidity where measured value tolerance is < ± 5% relative humidity.

Water flow

Instrument specifications:

- Accuracy: ± 5% including accuracy of differential pressure instrument (if used).
- Type: Pitot tube type flow sensors to the *0751 Mechanical piping* worksection.

Electrical

Instrument specifications:

- Voltage < 600 V a.c.: Accuracy ± 3% of full scale.
- Voltage < 30 V d.c.: Accuracy ± 3% of full scale.
- Currents < 100 A: Accuracy ± 3% of full scale.
- Maximum period between calibration: To the manufacturer’s recommendations but not more than 6 months.

Rotational speed

Instrument specifications:

- Accuracy: ± 5% of measured value.
- Maximum period between calibration: To the manufacturer’s recommendations but not more than 24 months.

Recording instruments

Specifications for instruments collecting measured values over time:

- Accuracy: At least equal to that specified for the corresponding physical parameter above.
- Type: Electronic data logger with appropriate sensors or thermohydrograph.

Thermohydrographs: Charge sensing element before use to the manufacturer’s recommendations.

2.4 SOUND PRESSURE LEVEL MEASUREMENTS

General

Sound pressure level measurements: Provide sound pressure measurements as documented.

Internal: To AS/NZS 2107.

External: To AS 1055.1.

Sound pressure levels: Measure the A-weighted sound pressure levels and the A-weighted background sound pressure levels at the documented positions.

Sound pressure level analysis: Measure the sound pressure level and the background sound pressure level over the full range of octave band centre frequencies from 31.5 Hz to 8 kHz at the documented positions.

Correction for background noise: To AS/NZS 2107 Table B1.

Measurement positions: If a test position is documented only by reference to a room or space, do not take measurements less than 1 m from the floor, ground or walls. For large equipment items including chillers, measure at 2 m and 7 m from the equipment item.

Report

Requirement: Submit a report giving sound pressure levels measured with the plant on and off. Include documented sound pressure levels, explanation of non-conformance, if any, and method of rectification.

2.5 AIR BALANCING

General

Requirement: Balance each air handling system.

Completion: Balancing is complete when all the following conditions are met:

- All air quantities are within the tolerances in the **Air quantity tolerance table**.
- For the same component, each measured air quantity deviates by less than the instrument accuracy from the previous measured air quantity.
- Resistance across the cooling coil bank (if present) is equal to the wetted coil resistance. If necessary to achieve this, simulate wet coil resistance by blanking or other means.
- Resistance of the filter bank (if present) is equal to the average of its clean resistance and resistance of the filter when fully loaded with dirt. If necessary to achieve this, simulate filter resistance by blanking.
- For fans with variable speed drives, the frequency to the motor is between 45 and 50 Hz.
- At least one outlet on each branch has its damper at the minimum pressure drop position.
- At least one sub-branch damper is at the minimum pressure drop position.
- At least one branch damper is at the minimum pressure drop position.
- The fan speed or pitch angle is at the lowest value consistent with the above.

Air quantity tolerance table

System type	Terminal air quantity tolerance	Branch air quantity tolerance	Total air quantity tolerance
Low velocity supply, return or exhaust system where all terminals on any one sub-branch serve the same space	+20% -0%	+10% -0%	+10% -0%
Low velocity supply, return or exhaust system where the terminals on any one sub-branch serve more than one space	+15% -0%	+10% -0%	+10% -0%

Diversity
General: For VAV and other systems where the sum of the design terminal air quantities is greater than the design fan air quantity, adjust the system as follows:

- The flow rate at the terminals is within tolerance for all possible load situations.
- The fan air flow is within the tolerance limits for total air quantity in the **Air quantity tolerance table**.

Measurement methods
Air quantities > 1000 L/s including system total and branch air quantities: Measure in situ to ISO 5802.

Other air quantities: Use balancing and measurement methods recommended by ASHRAE or CIBSE.

Prohibited: Do not use the following methods for air quantity measurement:

- Coil, damper or filter traverse using any kind of instrument.
- Measurement using an instrument operating with air flow in the reverse direction to that for which it has been calibrated.
- Air quantity measurement derived from fan curves or fan performance tables.

Preparation for air balancing
General: Before starting air balancing make sure that:

- All building work that may affect the air balance is complete, including:
  - All ceiling tiles are in place.
  - All doors are hung and door grilles (if applicable) are installed.
  - All doors and windows are open or shut consistent with their normal state.
  - The building is airtight.
  - The builder's work ducts, shafts and ceiling plenums are sealed airtight.
- All ductwork is complete and its interior clean.
- Systems for which leakage testing is documented: Leakage testing and leak rectification to the *0741 Ductwork* worksection is complete.
- Other systems: There are no air leaks that can be felt. Check for leaks through doors, access panels, penetrations and joints in air handling units.
- Flexible duct is installed as documented and has not been damaged.
- All fire and balancing dampers are open.
- All interrelated air handling systems are complete and operating concurrently.
- Fans, coils filters and other mechanical components are complete and operating correctly.
- All electrical components including overloads and safety devices are complete and operating correctly.
- All other related work is complete and operating correctly.

Additional adjustment of air quantities
General: Even if air quantities have been measured and are within tolerance, if directed, adjust space air quantities to:

- Minimise drafts.
- Achieve temperatures in individual rooms or parts of rooms that are within the documented design conditions.

Resubmit reports: If air quantities are altered after submission of air balance reports, resubmit reports showing new values.

On completion of air balancing
General: When air balancing is complete:

- Mark final position of dampers.
- Seal test holes in ductwork as follows:
  - Duct pressure class to AS 4254.2 ≤ 500: Provide rubber or plastic plugs.
  - Duct pressure class to AS 4254.2 > 500: Provide gasketted cover plates of the same material as the duct.
- Set system into normal operation.

2.6 MANUFACTURER'S RECOMMENDED COMMISSIONING PROCEDURES

General
Requirement: If manufacturers provide commissioning procedures, commission to those recommendations subject to the following:

- Instrumentation: Conform to the performance and calibration requirements in **INSTRUMENTATION** for the variable measured.
- Tolerances on measured values: Within the limits documented.

2.7 FIRE MODE OPERATION

General
Requirement: Test all systems required to operate in fire mode.

Standards: To AS/NZS 1668.1 and AS 1668.3.

Related systems: Test air handling systems for correct operation in conjunction with fire protection and other related systems.

Reset: Verify that all systems return to normal operating mode after fire mode operation.

Fire and smoke dampers: Commission to AS 1682.2. Test that fire and/or smoke dampers close fully with fans operating.

Fire isolated exit pressurisation: Test to AS/NZS 1668.1 including door velocity, door opening force and pressure differentials.

Timing: Complete testing before the date for practical completion.

2.8 VAV SYSTEM OPERATION

Air quantity control
Requirement: Test the response of the system to changes in the supply air quantity at the fan. Test at five points between fan maximum and minimum air quantity by altering the air quantity at the VAV boxes.

Pass criteria: At each test point and when moving between test points, system operation is stable and the air quantity at the VAV boxes matches the air quantity set point.

Static pressure tests: At each test condition, measure the duct static pressure in the duct between the air handling plant and first branch.

Temperature control
Chilled and heating water: To **WATER BALANCING**.

Air quantities: To **AIR BALANCING**. In addition, measure the maximum and minimum primary air quantity for each VAV box.

Controls: To **AUTOMATIC CONTROLS**.

2.9 MOTORISED DAMPER LEAKAGE

Testing
Dampers: Test all dampers required to close fully under any operating mode of the plant including motorised outside air dampers but excluding fire and/or smoke dampers.

Leakage criterion: Less than the documented maximum damper leakage rate.

Procedure:

- Drive damper fully open and closed. Check for uneven motion and correct.
- Drive damper fully closed and test for leakage.

Site leakage test methods: Select one of the following:

- Scan blade edges for leaks with a smoke pencil provided that gaining access to the damper will not affect the test results.
- Measure leakage air quantity by shutting the return air damper and measuring leakage air quantity by pitot traverse in a suitable straight section of duct. Do not use damper velocity traverse methods. Correlate to damper manufacturer's published pressure/leakage charts.

2.10 AIR BALANCE REPORTS

General

Requirement: Include the following on the air balance reports:

- Cover sheet for each system:
  - . Project and system identification.
  - . Date, time and place of test.
  - . Instrumentation used and its date of calibration.
  - . Name, position and signature of person responsible for test and certifying the correctness of the results.
  - . Ambient temperature and/or other relevant factors.
  - . Summary of design values and commissioned performance.
- For each terminal, grille, diffuser and chilled beam:
  - . The reference number of the item as shown on the shop drawings. List on a branch by branch basis.
  - . Design air quantity.
  - . Measured value (e.g. L/s, m/s).
  - . Hood or instrument factor.
  - . Manufacturer's area or similar factor for the item, if applicable.
  - . Site measured air quantity in L/s calculated from the above.
  - . Measured air quantity as a percentage of design air quantity.
  - . Sum of measured branch and system air quantities and percentage of design.
- For each fan:
  - . Fan designation and location.
  - . Measurement method used to determine total air quantity.
  - . Location of measurement point.
  - . Simulated wet cooling coil pressure drop and dirty filter pressure drop, if applicable.
  - . Design air quantity.
  - . Pitot readings (if used) or other measured values used to independently determine total fan air quantity.
  - . Site measured air quantity in L/s calculated from the above.
  - . Measured air quantity as a percentage of design air quantity.
  - . Measured air quantity as a percentage of the sum of the individual diffuser and grille air quantities.
  - . Blade pitch and/or fan speed as applicable.
  - . If a variable speed drive is provided, the variable speed drive output frequency.
  - . Measured motor current and nameplate full load current.
  - . Motor input power.
  - . A fan performance curve, marking the final operating point on the curve.
- Outside air quantity: Maximum and minimum values and quantities under varying system conditions.
- Static pressure differentials across:
  - . Each filter bank when clean, that is, after removal of simulated dirty pressure drop.
  - . Each cooling and heating coil except where access for test points is not possible or contrary to manufacturer's recommendations.
  - . Each fan.
- Duct static pressure at:
  - . Entry to filters.
  - . Entry to each fan.

. The duct discharge from air handling unit.
. Each riser connection for supply and return systems serving multiple floors.

2.11 ROOM AIR PRESSURE DIFFERENTIALS

General

Adjustment: Adjust air flows and controls (where available) to achieve documented differential pressures between spaces or required to meet applicable codes and standards. Adjust systems to achieve the required sequence of differential pressures between successive rooms.

Pressure differentials without numerical value: Adjust the systems so that the required air flow or pressure differential between the rooms is detectable.

Test conditions: Adjust systems with the rooms in normal operating condition and doors closed except where the normal operating condition requires that the doors be open.

Notification: Report locations of excessive building air leakage so they can be sealed.

Procedure

General: Adjust systems in the following sequence:

- Balance supply air to documented values and tolerances.
- Balance return and exhaust air to documented values and tolerances.
- Adjust controls (if applicable) to documented functions.
- Measure differential pressures.
- Re-adjust return and exhaust air quantities to achieve documented differential pressures if not achieved through the above. Do not alter supply air quantities from documented values.

2.12 WATER BALANCING

General

Requirement: Balance each water system.

Completion: Balancing is complete when all of the following conditions are met:

- All water quantities are within documented tolerances.
- For the same component, each measured water quantity deviates from of the previous measured water quantity by less than the instrument accuracy.
- At least one balancing valve on each branch is fully open.
- At least one branch balancing valve is fully open.
- For pumps with variable speed drives, the frequency to the motor between 45 and 50 H_z.
- The pump balancing valves (if fitted) are fully open.
- If the speed of the pump is fixed, the pump impeller diameter is not more than 5% greater than that required to achieve the above.
- Any other steps required to achieve lowest practicable pump power consumption have been taken.

Water quantity tolerances

General: Balance water systems to the documented water quantities within the following tolerances:

- Chillers, cooling towers, heat exchangers and boilers: ± 5% designated flow rate.
- Coils and terminals: ± 10% documented flow rate.
- Bypass on coils with three way valves: ± 10% documented flow rate.
- Total system flow: ± 5% documented flow rate.
- Water consumption: Adjust supply and bleed rates to give the lowest practicable water consumption.

Diversity

General: For systems where the sum of the design coil water quantities is greater than the design pump water quantity, adjust the system as follows:

- The flow rate at the coils is within tolerance for all possible load situations.
- The total flow is within ± 5% design pump flow rate.

Preparation for water balancing

Requirement: Before starting water balancing, make sure of the following:

- The system is complete including all piping insulation.
- Initial chemical cleaning, flushing and treatment for corrosion and microbial control is complete.
- Pressure testing is complete and no leaks exist.
- All system cleaning is complete and the system is filled with final treated water, if used.
- Air has been thoroughly vented from all parts of the system.
- All automatic control valves are fully open.
- All strainers and water filters are clean.
- The related heating and/or chilling plant is operating with water temperatures are close to documented operating temperatures.
- All inter-related systems are complete and operating concurrently.
- All electrical components including overloads and safety devices are complete and operating correctly.

Water flow measurement methods

General: Use balancing and measurement methods recommended by ASHRAE or CIBSE.

Multiple pump systems: If duty and standby pumps are documented, test the total flow of each pump individually.

Alternative methods: In addition to the recommendations of ASHRAE and CIBSE, the following measurement methods are acceptable:

- Calibrated balancing valves: Microprocessor based electronic meter supplied by the valve manufacturer, designed specifically for the purpose and displaying results in units of flow rate (not differential pressures).
- Any type of flow: Pitot type flow measuring device certified by the manufacturer to be accurate to within ± 5% over the range of water flow anticipated.
- Do not use the following methods for water flow rate measurement:
  . Water flow rate derived from uncertified manufacturer's data on flow rate equivalent to pressure drops.
  . Water flow rate derived from pump manufacturer's curves or tables for pump flow rate and pressure differential.

Completion

General: When water balancing is complete:

- Lock final balancing position of calibrated balancing valves.
- Mark balanced position of lever on lever operated valves.
- Record turns open for screw operated valves.
- Remove any temporary provisions.
- Set system into normal operation.

2.13 HEATING VALVE LEAKAGE

Testing

General: Test all heating valves for leakage.

Procedure: Conform to the following:

- Make sure that the heating water system is fully charged and all air has been purged.
- When this is complete, operate the system in automatic mode.
- Drive each heating control valve fully closed in turn. After residual heat has dissipated in the corresponding heating coil, measure and record water temperatures across the coils.
- Treat any drop in water temperature greater than the measurement tolerance as evidence of heating control valve leakage.
- Rectify any detected heating valve leakage and retest.

2.14 ELECTRIC DUCT HEATERS

Testing
Standard: To AS/NZS 3102.

2.15 WATER BALANCE REPORTS

General
Requirement: Include the following in water balance reports:
- Date time and place of test.
- Instrumentation used and its date of calibration.
- Name, position and signature of person responsible for test and certifying the correctness of the results.
- Ambient temperature and/or other relevant factors.
- For each coil, chilled beam or terminal:
  . Coil designation and location.
  . Measurement method.
  . Design water quantity.
  . Measured values used to determine water quantity.
  . Manufacturer's factor (if applicable).
  . Site measured water quantity calculated from the above measured values.
  . Measured water quantity as a percentage of design water quantity.
  . Measured water quantity as a percentage of sum of individual coil water quantities.
  . Handwheel setting of calibrated balancing valves (where applicable).
- For each pump:
  . Pump designation and location.
  . Impeller diameter.
  . Water quantity.
  . Head.
  . If variable speed drive (VSD) is provided, the variable speed drive output frequency.
  . Measured motor current and name plate full load current.
  . Motor input power.
  . The final operating point on the pump characteristic curve.
- For each heat exchanger including heat exchange components of chillers:
  . Heat exchanger designation and location.
  . Pressure drop in each circuit.
  . Design flow in each circuit.
  . Measured flow in each circuit.
  . Temperatures under maximum design conditions.
  . Measured water temperatures under maximum design conditions.
- Water temperatures appropriate to the system and plant installed.
- Setting of balancing valves (e.g. number of turns open).

2.16 AUTOMATIC CONTROLS

General
Requirement: Test controls hardware and software for correct operation.

Sensors
Calibration: Calibrate sensors to within the documented accuracy of the sensor.

Set points: Adjust sensors to documented values.

2.17 SAFETY CONTROLS

Testing

General: Test each safety control and facility by simulating the unsafe condition that the control is intended to protect against.

Monitoring: Make sure that monitoring and safety measures are in place for the test to protect personnel from injury and the building and equipment from damage.

2.18 PLANT OPERATION PERIOD

General

Requirement: Provide a plant operation period after the installation has passed completion tests and before the date for practical completion.

Plant operation period: ≥ 5 days.

Plant operation: Operate the mechanical systems continuously during the plant operation period. Provide one or more experienced operators in constant attendance in working hours and on call at other times to monitor the plant operation and make necessary adjustments to keep it operating properly.

2.19 COMPLETION TESTS

General

Requirement: Carry out completion tests.

Heating and air conditioning performance tests

General: In addition to balancing and commissioning, test performance of air conditioning systems during the maintenance period.

Instrumentation: Select from the following:

- Electronic data logger with temperature and humidity sensors or thermohydrograph. Conform to **INSTRUMENTATION**.
- If the automatic control system has been documented to have facilities for logging sensed values, provide trend logs of sensor values over the same periods.

Performance: Record dry-bulb and relative humidity at each location continuously for 2 separate periods of at least 48 hours. If necessary to test performance under both cooling and heating, carry out one of the test periods during the defects liability period.

Reports: Provide graphical printout of values recorded by instrument together with control system log graphs where this facility is provided.

Electric duct heaters

Performance tests: Test operation step-by-step, measuring operating current and checking operation of controls.

Motors

Motor-driven equipment performance tests: Test for performance. Adjust thermal overloads to suit the actual currents. Record the measured currents and overload settings.

0792 MECHANICAL MAINTENANCE

1 GENERAL

1.1 RESPONSIBILITIES

General

Requirement: Maintain the mechanical systems for the documented maintenance period so that the performance and service delivery including indoor conditions and indoor air quality, reliability, service life, compliance with statutory requirements, energy efficiency and safety of the system is equal to or better than that at the beginning of the maintenance period in parallel with and including:

- Periodic and statutory maintenance, cleaning and replacement of consumables.
- Emergency repairs.
- Condition reporting.

Maintenance period: As documented.

1.2 CROSS REFERENCES

General

Requirement: Conform to all worksections included herein for Mechanical Services. ***Rev 2017-01***

1.3 STANDARDS

General

Air handling system maintenance: To AS 1851.

Microbial control: To AS/NZS 3666.2.

Pressure equipment:

- Maintain to AS 3873.
- Inspect to AS/NZS 3788.

Refrigeration systems: To AS/NZS 5149.4.

1.4 INTERPRETATION

Definitions

General: For the purpose of this worksection the following definitions apply:

- Consumable: Materials or components intended to be replaced within the service life of the associated plant or equipment.
- Periodic maintenance: Planned routine maintenance of plant and equipment (proactive), including fire safety measures and statutory requirements.
- Repairs: Unplanned/corrective maintenance (reactive).
- Emergency repairs: Repairs to restore the normal operating state or safety of the plant or systems.
- Replace/replacement: Replacement of components on a regular cycle on a like for like basis, e.g. repainting, replacement of plant.
- HEPA: High efficiency particulate air, using or containing a filter designed to remove 99.97% of airborne particles, measuring 0.3 µm or greater in diameter passing through it.

1.5 SUBMISSIONS

Records

Maintenance records: Conform to the 0703 General requirements worksection. ***Rev 2017-01***

Maintenance records: Conform to *0171 General requirements*.

Periodic maintenance and performance report: At the frequency documented, submit reports summarising the maintenance performed and the performance of the mechanical plant in the preceding period. Set out the report in a form that permits comparison with previous reports. Include the following as minimum requirements:

- Dates and number of site labour hours for periodic maintenance. Exclude travelling time.

- Dates, number of site labour hours and nature of work for emergency repairs. Exclude travelling time.
- Dates and number of site labour hours for defects liability rectification if within the defects liability period. Exclude travelling time.
- Quantity and type of refrigerant used.
- Peak load and load profile for chillers.
- Peak load and load profile for electrical power consumed by mechanical plant.
- For each separately metered item, the water or energy use for each month of the reporting period.
- Flow rates and pressure drops across heat exchangers.
- Mechanical plant gas consumption and load profile.
- Mechanical plant electrical power consumption and load profile
- List of any motors for which the motor current varied by more than 10% from the current measured during commissioning.
- Results of recommissioning if scheduled for the period.
- Flow rates and pressure drops across heat exchangers.
- Details of energy efficiency maintenance undertaken including any corrective action.
- Recommended action by the principal.
- Recommendations for changes to maintenance frequency and actions in the light of maintenance experience.
- Recommendations for changes to access for maintenance.
- Result of testing of oil in each refrigeration circuit.
- Photographic records of scans of joints and cable terminations.

Statutory certification

Annual and other certification: Inspect and submit certification for all items required to be inspected annually or more frequently under statutory requirements including but not limited to air handling systems required for fire and smoke control, boilers, pressure vessels, cooling towers and warm water systems.

Statutory reporting

Requirement: Submit statutory reports to AS 1851, AS/NZS 3666.2, AS/NZS 3666.3 and AS/NZS 3666.4 including those required for pressure vessels.

Chilled beam condition report

Report: When the system has been operating for 12 months, provide a report on the condition and cleanliness of the chilled beam systems with recommendations for future cleaning and maintenance, including frequency, based on the observed condition.

1.6 INSPECTION

Notice

Inspection: Give notice so that an inspection may be held simultaneously with the final programmed maintenance visit.

2 PRODUCTS

2.1 GENERAL

Product selection

Proprietary items: Select products, as consumables or replacement items, of the same make, model and type as those being replaced.

Substitutions: Where the existing product is no longer available, provide products with at least the same performance, energy profile and construction characteristics.

3 EXECUTION

3.1 MAINTENANCE REQUIREMENTS

General

Requirement: Provide all labour and material necessary to maintain the mechanical installation including, but not limited, to filter media, belts, refrigerants, lubricants and all items commonly referred to as consumable.

Maintenance required

Minimum level: To the operation and maintenance manual and the manufacturer's recommendations.

Frequency: Carry out the actions, at no lower frequency than the intervals recommended in AIRAH DA19 for Maintenance Level A.

3.2 EMERGENCY REPAIRS

General

Requirement: Respond to call outs for breakdowns or other faults requiring emergency repairs . Rectify faults and replace faulty materials and equipment.

Remedial work: Carry out any remedial work, including temporary work, necessary to restore each system to safe and satisfactory operation. Verify each system is operating correctly before leaving the site. Do not leave the plant in an unsafe condition.

Temporary work: Promptly replace temporary work with permanent rectification.

Contact details

General: Provide contact details including mobile phone numbers for normal working hours and emergency call outs.

Response time

Emergency repair: Attend site for emergency service within the documented response time.

Response period: Starts at the time of notification to the contractor's nominated contact point.

3.3 PERIODIC MAINTENANCE

General

Routine visits: Make routine service visits at the frequency documented. Service items of equipment in conformance with the maintenance schedules in the operation and maintenance manuals and the manufacturer's recommendations.

Notification of defects: When defects in the mechanical services systems are identified, give notice.

Requirement: Conform to the recommendations for Maintenance level A to AIRAH DA19 including, but not limited, to the following:

- Check for and repair corrosion.
- Check for and rectify any unsafe conditions.
- Replace faulty or damaged parts and consumable components.
- Check anti-vibration supports, brackets and clamps, holding down bolts and flexible duct and tape connections, for deterioration and for freedom of movement of assembly.
- Rectify, including repainting, any damage that occurs as a result of maintenance work.
- At the conclusion of each maintenance visit, return plant to operating condition, replace items in their original position, clean plant rooms and remove waste.
- Maintain pipe, conduit and duct identification to AS 1345.
- Maintain safety signs to AS 1319.

System and component maintenance: In addition to the requirements documented below, conform to the recommendations for Maintenance level A to AIRAH DA19 for the following:

- Air handling and air distribution systems.
- Air filters.
- Air quality.
- Automatic and safety controls.
- Boilers and burners.

- Chilled beams.
- Chillers.
- Coils.
- Condensers.
- Cool rooms.
- Cooling towers and cooling water systems.
- Drives.
- Ductwork including kitchen exhaust ducts and hoods.
- Electrical systems.
- Electrical duct heaters.
- Electric motors.
- Electrical switchboards.
- Evaporative coolers.
- Fans.
- Filters.
- Fire and smoke dampers.
- Fume cupboards.
- Heating hot water systems.
- Heat exchangers.
- Humidifiers.
- Insulation of ductwork and piping.
- Liquid fuel systems and tanks.
- Kitchen exhaust systems.
- Motorised dampers.
- Packaged air conditioning plant and room air conditioners.
- Piped systems.
- Pumps.
- Refrigeration systems.
- Smoke and heat vents.
- Space heating equipment.
- Storage vessels.
- Tanks for feed expansion.
- Variable air volume systems.
- Vibration isolation and control.

Manufacturer’s recommendations: Conform to the manufacturer’s recommendations for maintenance and frequency of maintenance.

Replacement materials and consumables

Requirement: Provide replacement materials and consumables of the same brand, type and model as those in the existing systems.

Substitution: If proposing substitution of materials or consumables, submit the following:

- Evidence that replacement materials of the same brand, type and model as the original are no longer available.
- Evidence that the performance of the proposed substitution is equal to or greater than the original.
- Evidence of conformity of the proposed substitution to cited standards.
- Essential technical information relating to the proposed substitution, in English.
- Statement of cost implications including costs outside the contract.
- Statement of consequent alterations to other parts of the works.

Maintenance for energy efficiency

Requirement: Carry out tasks necessary to maintain the energy efficiency of the systems is equal to or better than that at the beginning of the maintenance period. Conform to the recommendations of AIRAH DA19 and
Guide to best practice maintenance & operation of HVAC systems for energy efficiency. Include the following:

- Verify sensor calibration is within tolerance.
- Verify correct operation of economy cycles.
- Adjust operation of terminal and zone devices including VAV boxes and chilled beams for energy efficient operation.

Cleaning

Requirement: At the end of the maintenance period:

- Remove waste, inspect and, if necessary, clean all parts of the installation.
- Inspect and clean interior of switchboards, switchgear, contactors and other electrical contacts.
- Inspect and clean interior or air handling plant.
- Inspect and clean strainer baskets.

Contamination: If a product or process is likely to be contaminated, provide adequate containment and protection.

Disposal of contaminated materials: In a manner appropriate to the contaminant.

Time tolerances for periodic maintenance table

Service intervals	**Maximum time before/ or after the required date**
Weekly	Omit for no more than 1 week
Fortnightly	Omit for no more than 2 weeks
Monthly or 4 weekly	1 week
Quarterly, 3 months or 12 weeks	2 weeks
Half yearly, 6 months or 24 weeks	3 weeks
Annually, 12 months or 50 weeks	1 month
Biennially, 24 months or 100 weeks	1 month
Triennially, 36 months or 150 weeks	2 months

Air handling systems

Requirement: For each air handling and ventilation system, conform to the following:

- Carry out maintenance routines to AS 1851.
- Carry out maintenance required by AS/NZS 3666.2 or AS/NZS 3666.4 as documented including inspecting and, if necessary, cleaning both sides of cooling coils and condensate trays and drains.
- If fitted, inspect and clean eliminator plates.
- Check coils for fin damage and repair.
- Check and clean fan impellers and blades.
- Check fan balance. Rebalance out of balance fans.
- Rectify air leaks including leaks in air handling units.
- Rectify reported drafts including, adjusting diffuser air flow patterns.
- Check motorised damper operation and lubricate linkages. Rectify defective operation.
- Check that motorised dampers seal tight when closed. Repair or replace defective seals.
- Check air handling and water systems for temperature, pressure, flow and leakage. Adjust if necessary. Repair all leaks.
- Check penetrations and outside air intakes and exhaust outlets for foreign matter water entry and leaks. Clean where necessary.
- Check condition of insulation and vapour barriers for damage and repair.
- Air filters: Carry out maintenance in conformance with **Air filters**.

- Check that electric duct heaters are not tripped.
- Inspect the interior of ductwork near moisture producing equipment to AS/NZS 3666.2 or AS/NZS 3666.4 as documented.
- Inspect and maintain kitchen exhaust systems to AS 1851 including checking interior of ducts for accumulated grease. Clean if found.

Air filters

Requirement: Conform to the following:

- Air filters: To AS 1324.1 Section 3.
- Grease filters: To AS 1851.

HEPA filters: Test integrity annually to AS 1807.6 or AS 1807.7, as appropriate to the method of mounting.

Air intake and discharge

Requirement: Inspect and maintain to AS/NZS 3666.2 or AS/NZS 3666.4, as documented.

Air pressure differentials

Requirement: If spaces are documented to have an air pressure differential between them, test as documented and rectify if necessary.

Air quality

Requirement: Check and report to the recommendations of AIRAH DA19.

Automatic controls

Requirement: Conform to the following:

- Check operation and safety controls for variable speed drives. Check and record output frequency. Adjust if incorrect. Rectify defects.
- Record readings of thermometers, gauges, meters, current draw of motors and heaters, sample readings, control set points and controlled space conditions.
- Check sensor calibration. Recalibrate if incorrect.
- Check and adjust all safety controls at intervals not exceeding 6 months.
- If space temperatures are repeatedly in error, provide an electronic data logger to **Heating and air conditioning performance tests** in *0791 Mechanical commissioning* to record space conditions for at least 48 hours. Determine the cause of the error, rectify it and submit a report on the error and rectification work.
- Check the operation of all control systems at intervals not exceeding 12 months, rectify defects and submit a report.
- Check electrical and control systems, including safety limits for temperature, pressure and humidity. Adjust if incorrect. Rectify defects.

Boilers and burners

Requirement: Conform to the following:

- Conform to statutory requirements for the respective boiler type.

Service: Conform to AS 3814, including the recommendations for maintenance and checks of safety devices of Appendix G. Inspect each appliance for correct operation including flame fail safe valve, thermocouple, thermostat and burners.

Chilled beams

Requirement: Perform the recommended actions at the intervals recommended in AIRAH DA19.

Chillers

Requirement: Conform to the following:

- Provide condenser water tube inspection and clean annually.
- At intervals not exceeding 6 months, sample oil in each refrigeration circuit and have it tested by an independent chemist for acidity and dissolved materials. Submit a report.
- Carry out maintenance in conformance with **Refrigeration systems.**

Cooling towers and cooling water systems

General: Conform to AS/NZS 3666.2 or AS/NZS 3666.3, as documented.

Drives

Requirement: Conform to the following:

- Check drives and couplings. Rectify faults.
- Check belt drives for belt wear and tension. Replace worn or broken belts.
- Check pulley alignment and re-align if out of alignment.
- Check motors and machinery for excessive operating temperature, bearing noise and excessive vibration. Rectify defects.
- Lubricate equipment.

Ductwork including electric duct heaters, kitchen exhaust ducts and hoods

Cleanliness: Inspect and maintain to AS 1851, AS/NZS 3666.2 or AS/NZS 3666.4, as documented.

Electric duct heaters: To AS 1851.

Electrical systems

General: Conform to the following:

- Check for hot joints, burnt insulation, burn contacts and repair.
- Check electrical connections for tightness. Tighten loose connections.
- Check operation of all electrical components. Rectify defects.
- Check indicating lights and replace defective lamps.
- Check and record motor currents.
- Check overload settings. Adjust if necessary.
- Check and report any changes to controls and wiring.

Standards:

- Electrical equipment generally: To AS/NZS 3760.

Electrical switchboards

Standards: To AS 2467 and AS 1851.

Requirement: Conform to the following:

- Check for hot joints and burnt insulation. At least annually and with mechanical equipment electrical loads as high as possible, scan joints and cable terminations using an infrared temperature detector or cameras and repair any joints showing high temperatures. Provide photographic records of scans.
- Rectify faults, make adjustments and replace consumable and faulty materials and equipment within 24 hours of notification.
- Inspect and maintain the assembly, including battery systems, monthly.

Evaporative air coolers

Requirement: Conform to the following:

- Inspect and maintain to AS/NZS 3666.2 or AS/NZS 3666.4 as documented.
- Conform to **Air handling systems** for the respective components of evaporative cooling systems.

Fire and smoke dampers

Requirement: Inspect and maintain to AS 1851.

Fume cupboards

Requirement: Maintain to AS/NZS 2243.8.

Gas-fired appliances

Service: Conform to AS 3814, including the recommendations for maintenance and checks of safety devices to Appendix G. Inspect each appliance for correct operation including flame fail safe valve, thermocouple, thermostat and burners.

Humidifiers

Requirement: Inspect and maintain to AS/NZS 3666.2 or AS/NZS 3666.4 as documented.

Medical gas systems

Requirement: Conform to *0755 Medical gas systems*.

Packaged air conditioning plant and room air conditioners

Requirement: Conform to the following:

- Carry out maintenance in conformance with **Air filters**.
- Carry out maintenance in conformance with **Air handling systems.**

- Carry out maintenance in conformance with **Refrigeration systems**.

Piped systems

Requirement: Conform to the following:

- Vent air from water systems, drain water from compressed air systems.
- Check equipment items for operation, calibration, performance compliance, temperature and energy consumption, and record values. Rectify defects.
- Check water drainage systems for unobstructed flow. Remove any obstructions and flush.
- Check pump seals. Rectify if defective.
- Rectify all water leaks. Clean and repair water damage.
- Check air handling and water systems for temperature, pressure, flow and leakage. Adjust if necessary and rectify defects.
- Check condition of insulation and vapour barriers for damage and repair, if necessary.
- Check water treatment systems for water condition, chemical dosage, bleed rate and make-up. Supply necessary chemicals.

Refrigeration systems

Requirement: Conform to the following:

- Check refrigeration systems for temperature, pressure including analysis of oil and refrigerant. Record results and rectify defects.
- Check refrigerant charge by measuring and recording superheat and subcooling. Adjust charge and superheat to the manufacturer's recommendations. Record amount of refrigerant added or removed.
- Hermetic compressors: Analyse refrigerant gas. Determine the acid and moisture content of the gas. Record results.
- Check refrigeration system controls and adjust if necessary.
- Check for leaks using electronic leak detector. Rectify leaks.
- Check air cooled condenser coils for fin damage, dirt or obstruction. Clean and repair.
- Carry out wet system maintenance required by AS/NZS 3666.2 or AS/NZS 3666.4, as documented.

Tanks and piping for drinking water

Requirement: Maintain to AS/NZS 3500.1.

Backflow prevention devices: Maintain to AS/NZS 2845.3.

VAV boxes

Requirement: Perform the recommended actions at the intervals recommended in AIRAH DA19.

Report: When the system has been operating for 12 months, provide a report on the condition and cleanliness of the chilled beam systems with recommendations, based on the observed condition, for future cleaning and maintenance.

Water treatment

Requirement: Conform to *0753 Water treatment*. For each water system, conform to statutory requirements, the recommendations of AIRAH DA18 and the following:

- Sample and test water for total dissolved solids (TDS), inhibitor, pH, alkalinity, corrosion products including the presence of metal compounds, scale potential and suspended solids (SS). Record results.
- Carry out total plate count to AS/NZS 4276.3.1 or AS/NZS 4276.3.2 as appropriate. Record results.
- If required, carry out Legionella analysis to AS/NZS 3896.
- Inspect and maintain to AS/NZS 3666.2 or AS/NZS 3666.3 as documented.
- Check condition and operation of water treatment equipment.
- Check water treatment systems for water condition, chemical dosage, bleed rate and make-up.
- Check that ball float valves are set for no overflow.
- Check expansion tank limit switches.
- Supply necessary chemicals.
- Adjust settings.
- If a water meter is fitted, record water consumption.

Cathodic protection system: At least six monthly, check for correct operation and recalibrate to manufacturer's recommendations.

3.4 END OF MAINTENANCE PERIOD SERVICE

General

Requirement: Within one month before the end of the maintenance period, carry out the following service tasks:

- Undertake all work scheduled to be carried out on an annual basis.
- Replace air filter media if the resistance exceeds 80% of the dirty resistance of the filter bank.
- Drain, clean and refill cooling towers, water basins and tanks, and clean screens, strainers, distribution troughs, spray nozzles and drip trays. Reinstate water treatment.
- Drain, dismantle, inspect and reinstate boilers and pressure vessels to AS/NZS 3788.
- Remove, clean and inspect water heads at heat exchangers. Clean and inspect heat exchanger pipes, pipe plates and water chests.
- Clean moisture eliminators and heating and cooling coil surfaces.
- Remove external scale and corrosion, prepare and repaint the affected surfaces.
- Provide infra-red scan of switchboards.
- Reinstate water treatment of closed water systems.
- Fill all water treatment chemical tanks.

3.5 RECOMMISSIONING

General

Requirement: To the manufacturer’s recommendations.

3.6 COMPLETION

Maintenance records

Service records: Record maintenance undertaken in the schedules in the operation and maintenance manuals.

Maintenance reports: Prepare maintenance reports as documented.

Restitution after maintenance tasks

Requirement: Restore removed, damaged, contaminated or soiled services and building elements when the maintenance task is complete, including the following:

- Replace insulation and sheathing.
- Seal vapour barriers.
- Replace access panels.
- Replace and/or clean removed ceiling tiles.
- Clean and remove any waste generated by the maintenance task.

Standard: Equal to the condition of the original installation.