WOOD & GRIEVE ENGINEERS

Leichhardt Park - Child Care

Mechanical Services Specification

Prepared by

Joshua Hii
Project No. 26687-SYD-M

Date:
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Level 6, Building B, 207 Pacific Highway, St Leonards NSW 2065
T: (02) 8484 7000 **F:** (02) 8484 7100 **E:** sydney@wge.com.au **W:** www.wge.com.au

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REVISION

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CHECKED AND APPROVED BY PROJECT ENGINEER

NAME: **Joshua Hii**

SIGNATURE:

DATE: **17 March 2015 Revision No. 0**

WOOD & GRIEVE ENGINEERS

CONTENTS

WOOD & GRIEVE ENGINEERS

PART A. PRELIMINARIES

Refer to Head Contract for Preliminaries.

WOOD & GRIEVE ENGINEERS

PART B. PROJECT SPECIFIC INFORMATION

B.1 DESCRIPTION OF THE INSTALLATION

B.1.1 General

Carry out work as detailed and in accordance with this specification and drawings, the whole of which shall be deemed to constitute one document.

Whether or not the words "supply and install" appear in the instructions, drawings and schedules of this specification, understand that, unless clearly excluded, equipment for the complete installation is required and must be supplied, delivered to site and installed.

Similarly, where the words "in an approved manner", for approval", "to approval", "approval" and the like appear, understand that the approval is by the Superintendent or their representative.

The work covered by this Specification includes for the manufacture, supply, installation, testing and commissioning of a complete operating systems of mechanical services inclusive of all minor components necessary whether depicted or otherwise.

B.1.2 Project

Wood and Grieve Engineers have been engaged to provide the mechanical services design for Leichhardt Child Care Park in Leichardt, NSW.

The proposed development is a Child Care Park located on Mary Street in Leichhardt.

The Child Care Park will have a range of spaces that will generally be made of the following:

- Playrooms
- Cot Rooms
- Programing Room
- Meeting room
- Foyer & Parents Rom
- Admin
- Dining Facilities
- General circulation spaces

B.1.3 Design Criteria

The design criteria for the Mechanical services are as follows:

B.1.3.1 External Conditions

The design temperatures under which plant will maintain internal conditions are:

Summer	:	31.1°C Dry Bulb
	:	22.7°C Wet Bulb
	:	Full Solar Load
Winter	:	7.0°C Dry Bulb
	:	80% Relative Humidity
	:	No Solar Load

Heat rejection equipment will be sized on the basis of 40°C ambient.

BCA Climate Zone: 5

B.1.3.2 Internal Conditions

Cooling : 24ºC Dry Bulb
: 40 - 60% relative humidity anticipated by virtue of cooling coil performance.

Heating : 21ºC Dry Bulb

Control Tolerance : Plus or minus 1.5ºC at the point of control for heating and cooling.

B.1.3.3 Population

As per the confirmation form the architect:

Playrooms 1 & 2:	21 people each
Director	1 person
Admin	2 persons
Dining/Craft Area	21 persons
Meeting	8 persons
Staff Lunch	2.0 m2/person
Staff Program Room	2.0 m2/person
Parent Area/Foyer	15 people
Playrooms 3 & 4:	15 people each

B.1.3.4 Ventilation

Outside Air:	7.5 L/s per person (minimum)
General Areas:	Outside air to be provided on per m2 basis to meet AS1668.2-2012
General Exhaust Areas:	5 L/s per m² (minimum) of net exhaust air flow.
Photocopy General Exhaust:	5 L/sm2 (area to be confirmed by the Architect).
Toilet Exhaust:	To meet the minimum AS1668.2-2012 requirements.

Filtration shall be by dry media deep bed type, 20% minimum efficiency at Test Dust No 1.

B.1.3.5 Lighting and General Purpose Power

Lighting/Power allowance:	20W/m2
Kitchen In Building A and C:	2kW of sensible capacity and 2kW of latent capacity load has been allowed.

B.2 EXTENT OF WORK

The extent of the Mechanical Services work includes:

B.2.1 Specific Scope:

- Supply, install and commission VRV or VRF , heat recovery, air conditioning systems to the Building complete with:
  - System to be complete with a 36 months comprehensive warranty from date of commission
  - Condensers, pipework, power and control wiring;
  - Cassette type FCUs and one Ducted in-ceiling FCU, condensate drains, power and control wiring.
  - Ductwork, diffusion equipment, temperature sensors, balancing dampers.
  - Temperature sensors, AH Push button and proprietary controller to be coiled adjacent FCU's.

- Individual control system
- R/A plenum and Filter bank to installed. (to enable full system testing). S/A ductwork and air diffusion is excluded.
- Corrosion protection to external coils and condenser housing..
- Motorised dampers
- Condensate drip trays to be drained.
- BACnet interface.

- Supply, install and commission temperature sensors (one for each FCU), and after hours push button. The location are to be selected to Architect and Engineer approval.

- Supply, install and commission provision or the new kitchen exhaust system in Building A, Qasair or approved equivalent.

- Supply, install and commission the following systems complete with all ductwork, controls and wiring.

  - Toilet exhaust systems.
  - General exhaust systems.
  - Miscellaneous ventilation systems.

- Supply, install and commission switchboards as specified.

- Ductwork, refrigeration, piping, air diffusion equipment and other minor items.

- The Mechanical Contractor is to allow for Corrosion treatment to all plant installed as part of the building works. There is a requirement that all plant be resistant to corrosion for the long term. All condensers, condenser coils, condenser casings, condenser casing screws, any fixing screws etc, fan windings, fan casings shall all be corrosion resistant. At the end of the 36 month warranty period, any items showing effects of corrosion will be required to be replaced by a corrosive resistant alternative at the contractors cost.

- Allow condensate pumps on all FCU's.

- All side duct mounted supply air grilles are to be double deflection grilles, 250mm high, length top suit the air flow, unless noted otherwise.

- All toilet exhaust grilles to be egg crate grilles mounted within the ceiling grid.

- Final location of the condensing units in the plantrooms to be determined by the mechanical contractor to the Architect, Acoustic and Engineer's approval. Refrigerant pipework route to be site checked by the contractor and proposed for approval as well.

B.2.2 General Scope:

- Complete systems of electrical power for the Mechanical Services installation.

- Complete Control System for the Mechanical Services installation.

- Complete systems of piping, valves, fittings, supports, etc.

- Complete systems of ductwork, dampers, air diffusion, supports, etc.

- Complete insulation systems for ductwork and piping in accordance with BCA Section J.

- Fire stopping of mechanical services penetrations to maintain FRL.

- Provision and installation of fire dampers where ducts penetrate fire zones.

- Overflashing of mechanical services roof penetrations.
- Flashing and sealing airtight of duct penetrations.
- Airtight acoustic seals to duct penetrations through acoustic walls.
- Provision and fixing of plinth edge surrounds.
- Flanging of grilles and registers.
- Provision of Direct Digital Control Building Management System as further specified.
- Commissioning and testing.
- Twelve months comprehensive maintenance and warranty commencing on the date of Practical Completion including 4 off quarterly / 12 off monthly preventative maintenance visits. Maintenance shall be carried out in accordance with the schedules as specified.
- Co-ordination with all other components and trades.
- Preparation of a Construction Programme of the Mechanical Services works, separate from but co-ordinated with the Project Construction Programme, submitted for approval prior to preparation of shop drawings.
- Detailed "Shop Drawings" (Scale – 1:50), "Builder's Work Drawings" (Scale – 1:50) and schedules of equipment, fully depicting the entire installation, for approval prior to equipment purchase or ductwork manufacture.
- Manufacturer's certified drawings, upon request.
- Samples, where specified, prior to placing orders.
- As-installed drawings (electronic and hard copy) as further specified.
- 3 sets of bound Operation and Maintenance Manuals incorporating as-installed drawings.
- Engineering certification by calculation of the acoustic and thermal performance of the systems relative to the specified requirements, prior to equipment ordering or manufacture.
- Painting, marking and labelling.

B.2.3 Electrical for Mechanical Services

- Supply and installation of switchboards as scheduled.

  Note: Confirm in writing to the Builder the estimated maximum demand of each switchboard before purchase of submain cables by the Electrical Sub-Contractor. If this information is not received prior to purchase of the cables then any costs incurred due to late receipt of the information shall be met by the Mechanical Services Contractor.

- All power and control wiring between switchboards, equipment and controls.
- Electrical testing and commissioning of all electrical equipment.
- Supply of wiring diagrams for approval and "As Constructed" drawings.
- Removal and termination of power and control wiring to demolition areas.

- Supply and installation of conditioner lights and wiring.

B.2.4 Automatic Controls

- Centralised HVAC control system comprising the following component parts:

  - PC complete with proprietary A/C controller software. PC to be located in approved location. Allow to install proprietary software in order to provide controls via world wide web.

  - Open Protocol Interface Panel for central control of A/C systems (touch screen control) located within staff office (location to be approved on site).

  - Modem connected to permanent telephone line.

- Centralised HVAC system to control the following:

  - Control and monitoring of air conditioning and mechanical ventilation systems.
  - Set point adjustment and control interface override at the Centralised HVAC control system head end graphical user interface panels.
  - VRV/VRF air conditioning systems.
  - Toilet exhaust systems. Control system should be capable of providing 365 day time schedules to all fans.
  - Miscellaneous works.

B.2.5 Associated Builder's Work

The following building works are associated with the Mechanical Services installation.

Prepare and supply to the Builder all necessary detailed Builder's Work Drawings fully depicting the scope of work. This information must be provided in good time for the work to be put in hand.

All Builder's Work associated with the Mechanical Services installation which is carried out by the Builder to the Mechanical Contractor's detail shall be supervised by the Mechanical Contractor to ensure that the work is completed properly and correctly.

B.2.5.1 Demolition Work

- Nil.

B.2.5.2 Builder's Work

- All bulkheads and acoustic enclosures.
- All openings in walls, roofs, ceilings and bulkheads for air ducts, outlets, grilles, pipes, etc.
- Underflashing of all roof penetrations.
- Concrete to plinth surrounds for all equipment as shown on drawings.
- Installation of door grilles.
- Supply and installation of external grilles and louvres where noted on the drawings.

- Supply and installation of ceiling access panels.
- Supply and installations of T-Bars in ceilings.
- Supply and installation of continuous perimeter "T Bar" grilles. Note: Grille supports to be at centres to suite plenum boxes.
- Supply and installation of access stairs, ladders and walkways for Mechanical Services equipment.

B.2.5.3 Hydraulic Services

- Trapped floor wastes and tundishes as shown on the drawings.

B.2.5.4 Electrical Services

- Supply and termination of electrical submains to each mechanical services switchboard.
- Provision of dedicated phone line for BMS modem.
- Participation in co-ordinated "end to end" commissioning of Electrical Services BMS points and control sequences including troubleshooting as necessary.
- Participation in review and coordination of control drawings and switchboard drawings to ensure compatibility of designs and control interfaces.

B.2.5.5 Fire Services

- Wiring from the FIB to terminals in each Mechanical Services Switchboard to initiate, control and monitor mechanical plant in accordance with the BCA and AS 1668.1.
- ON-AUTO-OFF control device on the FIP for future connection of Building A kitchen exhaust system to enable control in compliance with Clause 4.13.2 of AS1668.1.
- Participation of co-ordinated "end to end" commissioning of FIB points and control sequences including troubleshooting as necessary.
- Participation in review and co-ordination of control drawings and switchboard drawings to ensure compatibility of designs and control interfaces.

B.3 SCHEDULES OF PERFORMANCE

B.3.1 General

These Schedules of Performance have been prepared as a guide for tendering purposes only.

The Contractor shall undertake a detailed analysis of each air handling system and pipework system making due allowance for the resistance to flow of all other selected equipment prior to confirmation of fan and pump selections. Any discrepancies from the specified requirements shall be brought to the Engineers' attention prior to ordering for resolution.

Schedules of Performance shall be read in conjunction with drawings and preceding Specification Clauses.

B.3.2 Ductwork Insulation

Refer to the drawings for the extent and nominal thickness of ductwork insulation.

Cross reference the insulation nominal thickness with the minimum R values quoted in Section C of this specification.

B.3.3 Pipework

Pipework insulation shall conform to the Building Code of Australia, Section J.

The following pipework systems are to be employed:

System:	Pipe Material:	Insulation:	Test Pressure:
Refrigeration Pipework	Copper/Steel/ABS/PVC/HDPE	BCA section J	

B.3.4 Testing and Commissioning

The following specific system testes are to be carried out:

- Pressure testing of all pipework systems.
- Pressure and leakage rate testing of all ductwork.
- Pressure testing evacuation and charging of all refrigerant systems.
- Balancing of individual water quantities in each pipework system.
- Balancing of individual air quantities in each air handling system. Setting of maximum and minimum quantities for all air terminal boxes.
- ***Surveys of and recommissioning of existing air handling systems where changes, modifications or deletions to existing systems are carried out.***
- Functional and calibration testing of all electric and pneumatic control systems and components.
- Performance testing of all major plant system components.
- Performance testing of each total system under peak design conditions.

B.3.5 Painting, Finishes, and Identification

The following components of the installation are to be painted:

System:	Colour:
Major items of plant and equipment, including pre-painted items of package.	
Ductwork in a plantroom.	
Ductwork external to the building.	
Ductwork exposed to view.	
Sun covers.	
Air diffusion.	
Switchboards and control panels.	
Minor items, including brackets, hangers, frames, bases, plinths.	
Inside of air outlets grilles, openings, dampers.	Matt Black
Electroplated cadmium or zinc, or galvanised components.	
Inside surfaces of air handling rooms and air plenums.	
Bright aluminium clad pipework need not be painted. Provide colour bands at pipe markers.	
Plantroom floors.	

Paint to match adjacent surfaces, building surfaces made good.	

B.3.6 Noise

The Acoustic report shall be complied with.

The following sound levels (as per AS/NZS 2107:2000) shall be achieved as minimum:

Room Name	Satisfactory	Maximum	Recommended Reverberation Time (s)
Staff	30	40	0.6 to 0.8
Creative centre	35	40	0.6 to 0.8
Quiet/study space + training	35	40	0.6 to 0.8
Learning and reading	35	40	0.6 to 0.8
Multipurpose space	35	40	0.6 to 0.8
Meeting rooms	30	40	0.6 to 0.8
Multi-purpose	35	40	0.6 to 0.8
Staff room	35	40	0.6 to 0.8
Kitchen	45	55	-
Library	35	40	0.4 to 0.6
Utilities/store rooms	45	55	-
WC and change rooms	50	55	-
Corridor	45	50	-
Digital gallery/foyer	40	45	See note 3
Note 3 - Reverberation time should minimized as far as practicable for noise control			

B.3.7 Air Filters

UNIT NO	MAKE	MODEL	TYPE	NO. OFF	SIZE FILTER (mm)	AIR VOLUME TOTAL (l/s)	EFFICIENCY ON NO. 2 (%)	DUST HOLDING AT 125Pa (g) (DUST NO. 2)
FCU's and outside air intakes	Aust Filters or equiv.	Aust Air Max-40 or equiv	50mm Deep Disposable Pleated Panel	To suit	Sized at 1.5mls face Vel	To suit	TBC	TBC

NOTES

1. One (1) complete set of replaceable media to be provided and suitably secured in the relevant plant rooms.

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B.3.8 Fan Schedule

FAN NO.	TEF.01	CREF.1	TEF.02
LOCATION	CORRIDOR	CORRIDOR	CORRIDOR
MANUFACTURER	FANTECH	FANTECH	FANTECH
TYPE	In-Line	In-Line	In-Line
DIAMETER (mm)	200	150	315
NO. OFF	1	1	1
CAPACITY (l/s)	200	30	310
RESISTANCE (Pa)	150	75	200
MINIMUM MOTOR (kW)	0.2	0.1	0.26
MAXIMUM FAN SPEED (rpm)	2520	2460	2760
COMMENTS	Lighting switch on/off; run – on timer.	Lighting switch on/off; run – on timer.	Lighting switch on/off; run – on timer.

WOOD & GRIEVE ENGINEERS

FAN NO.	TEF.03
LOCATION	CORRIDOR
MANUFACTURER	FANTECH
TYPE	In-Line
DIAMETER (mm)	150
NO. OFF	1
CAPACITY (l/s)	50
RESISTANCE (Pa)	80
MINIMUM MOTOR (kW)	0.1
MAXIMUM FAN SPEED (rpm)	2520
COMMENTS	Lighting switch on/off; run – on timer.

NOTES

1. Key:

AA	-	Axial Aerofoil,	LC	-	Long Casing,
SC	-	Short Casing,	DI	-	Double Inlet,
SI	-	Single Inlet,	ILC	-	In Line Centrifugal,
Cent	-	Centrifugal,	DM	-	Dual Motor,
WG	-	Wire Guard,	BM	-	Bellmouth,
NRD	-	Non Return Dampers,	PPF	-	Plate mounted Propeller Fan,
FP	-	Fixed Pitch,	VP	-	Variable Pitch,
BPM	-	Bird Proof Mesh			

2. Motors to be sized to allow for 110% design air flow against the corresponding increase in the system resistance (120%).

3. Motors 0.28kW and greater are to be 3 phase/415V unless specifically excluded.

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B.3.9 Fan Coil Units

UNIT	FCU.01	FCU.02	FCU.03	FCU.04
NUMBER OFF	1	1	1	1
LOCATION	PLAYROOM 1	PLAYROOM 2	STAFF LUNCHROOM	DIRECTOR
MAKE	DAIKIN	DAIKIN	DAIKIN	DAIKIN
MODEL	FXFQ125PVE8	FXFQ100PVE8	FXFQ40PVE8	FXFQ32PVE8
SUPPLY AIR (l/s)	550	533	250	250
OUTSIDE AIR (l/s)	N/A	N/A	N/A	N/A
EXTERNAL STATIC (Pa)	N/A	N/A	N/A	N/A
MIN RUNNING CURRENT (A)	TBC	TBC	TBC	TBC
TOTAL CAPACITY (kW)	11.3	9.1	3.6	3.5
SENSIBLE CAPACITY (kW)	9.9	8.8	3.6	3.5
AIR ON COIL (°CDB/°CWB)	27.8/18.4	27.8/18.4	27.2 / 18.2	27.2 / 18.2

UNIT	FCU.05	FCU.06	FCU.07	FCU.08
NUMBER OFF	1	1	1	1
LOCATION	DINING/ CRAFT AREA	KITCHEN	FOYER PARENTS	PLAYROOM 3
MAKE	DAIKIN	DAIKIN	DAIKIN	DAIKIN
MODEL	FXFQ100PVE8	FXFQ80PVE8	FXMQ80PVE	FXFQ100PVE8
SUPPLY AIR (l/s)	533	350	533	533
OUTSIDE AIR (l/s)	N/A	N/A	113	N/A
EXTERNAL STATIC (Pa)	N/A	N/A	N/A	N/A
MIN RUNNING CURRENT (A)	TBC	TBC	TBC	TBC
TOTAL CAPACITY (kW)	9.1	7.3	9.0	9.1
SENSIBLE CAPACITY (kW)	8.8	5.6	8.6	9.1
AIR ON COIL (°CDB/°CWB)	27.8 / 18.4	25.9/18.4	28.0/18.4	28.0/18.2

UNIT	FCU.09	FCU.10	FCU.11	FCU.12
NUMBER OFF	1	1	1	1
LOCATION	MEETING ROOM	STAFF PROGRAMING ROOM	COT ROOM 1	COT ROOM 2
MAKE	DAIKIN	DAIKIN	DAIKIN	DAIKIN
MODEL	FXFQ40PVE8	FXFQ40PVE8	FXFQ25PVE8	FXFQ25PVE8
SUPPLY AIR (l/s)	250	250	217	217
OUTSIDE AIR (l/s)	N/A	N/A	N/A	N/A
EXTERNAL STATIC (Pa)	N/A	N/A	N/A	N/A
MIN RUNNING CURRENT (A)	TBC	TBC	TBC	TBC
TOTAL CAPACITY (kW)	3.4	3.4	2.3	2.1
SENSIBLE CAPACITY (kW)	3.4	3.4	2.3	2.1
AIR ON COIL (°CDB/°CWB)	27.2/18.2	27.2/18.2	27.6/18.3	27.6 / 18.3

UNIT	FCU.13	FCU.14	FCU.15	FCU.16
NUMBER OFF	1	1	1	1
LOCATION	PLAYROOM 4	COT ROOM 3	COT ROOM 4	ADMIN
MAKE	DAIKIN	DAIKIN	DAIKIN	DAIKIN
MODEL	FXFQ100PVE8	FXFQ25PVE8	FXFQ25PVE8	FXFQ40PVE8
SUPPLY AIR (l/s)	533	217	217	250
OUTSIDE AIR (l/s)	N/A	N/A	N/A	N/A
EXTERNAL STATIC (Pa)	N/A	N/A	N/A	N/A
MIN RUNNING CURRENT (A)	TBC	TBC	TBC	TBC
TOTAL CAPACITY (kW)	8.6	1.9	1.9	3.5
SENSIBLE CAPACITY (kW)	8.6	1.9	1.9	3.4
AIR ON COIL (°CDB/°CWB)	27.8/18.4	27.6 / 18.3	27.6 / 18.3	27.2/18.2

NOTES

1. External static resistance includes 125 Pa filter resistance

2. Cooling coil:

Maximum Velocity	=	Air	2.7 m/s
		Water	1.5 m/s
Maximum Pressure Drop	=	Air	250 Pa
		Water	40 kPa

Fan motors for ducted systems shall be sized to allow for 110% design air flow against the corresponding increase in system resistance (120%)

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B.3.10 Condensing Units

ITEM NUMBER	CU.01	CU.02
NUMBER OFF	1	1
LOCATION	ADJACENT TO THE OUTDOOR STORE	ADJACENT TO THE OUTDOOR STORE
MAKE	DAIKIN	DAIKIN
MODEL	REYQ24PY1	REYQ10PY1
TYPE	HEAT RECOVERY	HEAT RECOVERY
AREA(S) SERVED	FCU.01-08,FCU16	FCU.09-15
TOTAL POWER INPUT (kW)		
TOTAL COOLING CAPACITY (kW)	69.9	27.4
TOTAL HEATING CAPACITY (kW)	75.3	32.7
AMBIENT (°CDB/°CWB)	34.3/20.5	34.3/20.5

NOTES

1. Motors to be sized to allow for 110% design airflow against the corresponding increase in system resistance (120%).

2. Motors to be 3 phase/415V.

3. Face velocity of air across coil : 2.7 ms-1 maximum.

B.3.11 Vibration Isolation

EQUIPMENT	ISOLATORS	MINIMUM ISOLATION/ DEFLECTION	BASE
CHILLER SETS	Spring Isolators	95%/50mm	Steel base on Dry Plinth
FANS (CENTRIFUGAL)	Spring Isolators	98%/65mm	Inertia base on Dry Plinth
FAN COIL UNITS	Spring Isolators	95%/50mm	Steel base
PUMPS	Spring Isolators	95%/50mm	Inertia base on dry plinth
COOLING TOWER	Double Deflection Neoprene	80%/ 8mm	Steel Base
OTHER FANS	Double Deflection Neoprene or Manufacturer's Inherent Fan Isolation	80%/ 8mm	

NOTE

1. Supply and install galvanised steel edge surrounds to all dry plinths as shown on the drawings. Edge surrounds shall be of 1.6mm minimum thickness complete with bevelled edges and fixings.

B.3.12 Mechanical Switchboard Schedule

SWITCHBOARD DESIGNATION: MSSB

LOCATION: Corridor

SUPPLY TYPE: Non - Essential

Service	Area Served	No Off	kW	FLA (MCA) A	Starting Arrangement & No. Phases
FAN COIL UNITS					
FCU.01	PLAYROOM 1	1	0.12	1.0(1.5)	- / 1ø
FCU.02	A PLAYROOM 2	1	0.12	1.0(1.3)	- / 1ø
FCU.03	STAFF LUNCHROOM	1	0.07	0.2(0.3)	- / 1ø
FCU.04	DIRECTOR	1	0.07	0.2(0.3)	- / 1ø
FCU.05	DINING CRAFT AREA	1	0.07	0.4(0.5)	- / 1ø
FCU.06	KITCHEN	1	0.07	0.4(0.5)	- / 1ø
FCU.07	PARENTS&FOYER	1	0.1	0.5(0.6)	- / 1ø
FCU.08	PLAYROOM 3	1	0.07	0.4(0.5)	- / 1ø
FCU.09	MEETING	1	0.07	0.2(0.3)	- / 1ø
FCU.10	STAFF PROGRAM ROOM	1	0.07	0.2(0.3)	- / 1ø
FCU.11	COT ROOM 1	1	0.07	0.2(0.3)	- / 1ø
FCU.12	COT ROOM 2	1	0.07	0.2(0.3)	- / 1ø
FCU.13	PLAYROOM 4	1	0.07	0.4(0.5)	- / 1ø
FCU.14	COT ROOM 3	1	0.07	0.2(0.3)	- / 1ø
FCU.15	COT ROOM 4	1	0.07	0.2(0.3)	- / 1ø
FCU.16	ADMIN	1	0.07	0.2(0.3)	- / 1ø
FANS					
TEF.01	TOILETS	1	0.20		- / 1ø
CREF.A1	COPY ROOM	1	0.05		- / 1ø

TEF.02	TOILETS	1	0.26		- / 1ø
TEF.03	WC	1	0.05		- / 1ø
KEF.01	KITCHEN EXHAUST	1	1.25		TBC
CONDENSER UNITS					
CU.1	FCU.01-08,FCU16	1		(45.4)	- / 3ø
CU.1	FCU.09-15	1		(22)	

B.3.13 Schedule of Information Required

1. Previous Experience for Similar Projects.

Project: .....

Value: .....

Date Completed: .....

Project: .....

Value: .....

Date Completed: .....

2. Personnel Details:

Project Engineers: Name: .....

Qualifications: .....

Experience: .....

Project Supervisor: Name: .....

Qualifications: .....

Experience: .....

Project Foreman: Name: .....

Qualifications: .....

Experience: .....

3. Sub Contractor's Name — Section

..... — Sheet Metal

..... — Piping

..... — Insulation

..... — Painting

..... — Controls

..... — Electrical

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B.4 PROJECT SPECIFIC QUALITY ASSURANCE ITEMS

MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(SHOP DRAWINGS)

Client:
Project:
Project No:
Contractor:
Drawing No:
Contractor's Verification Signature: _____ Date:
(Project Engineers)

1.	**Equipment**		
1.1	Adequate access for equipment service and maintenance.		
1.2	Filters installed in accessible positions.		
1.3	Door grilles provided and coordinated with doors supplier.		
1.4	Selected air diffusion equipment gives adequate room coverage.		
2.	**Ductwork**		
2.1	Ductwork fits into the ceiling space less beams and lights.		
2.2	Access panels provided in ductwork where required and in ceilings as on WGE drawings or to the approval of the Superintendent.		
2.3	Sunshades provided on external ductwork.		
2.4	Work by other building trades coordinated and clashes avoided.		
2.5	Drip trays provided under all ceiling mounted fan coil units.		
2.6	Fire dampers provided through all fire rated separations unless otherwise approved by the Superintendent.		
2.7	Duct sizes are at least as large as on WGE drawings.		
2.8	Supply/exhaust/ outside air quantities as specified.		
2.9	System has sufficient dampers and is in a configuration that promotes ease of balancing.		
2.10	Static pressures for equipment calculated.		
3.	**Pipework**		
3.1	All pipework, valves and fittings required by equipment provided.		
3.2	Condensate drains run to floor wastes or tundishes and plumber informed.		
4.	**Insulation**		
4.1	All insulation as specified.		
5.	**Controls**		
5.1	Thermostats located as specified or to the approval of the Superintendent.		
6.	**Associated Electrical**		
6.1	Electrical Trade advised of the actual electrical requirements of mechanical services.		
6.2	Mechanical switchboards located as specified.		
6.3	Mechanical electrical wiring and control logic diagrams.		
7.	**Noise and Vibration Control**		

7.1 Equipment noise levels as specified or less.

7.2 All other equipment selected so as to comply with the room noise levels specified.

7.3 Vibration isolation of equipment as specified or to the approval of the Superintendent.

MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(SUPPLY)

Client:

Project:

Project No:

Contractor: _____

Equipment/System Item Identification: _____

Does the equipment meet the requirements of the specification?

YES

NO if so, why?

Contractors Signature: _____

Suppliers Signature: _____

Date: _____

MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(INSTALLATION)

Client:

Project:

Project No:

Contractor: _____

Date: _____

Has the equipment/system been installed in accordance to the manufacturer's recommendations and the requirements of the specification?

YES

NO if so, why?

Contractors Signature: _____

Suppliers Signature: _____

Date: _____

MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(PRACTICAL COMPLETION)

Client:

Project:

Project No:

Contractor: _____

All mechanical building services have been installed in accordance with the shop drawings and with the equipment as certified in the relevant Quality Assurance Certificates.

Contractor's Verification Signature: _____

(Principal or Managing Director)

Date: _____

The overall installation complies with the performance requirements of the tender documents and subsequent variations.

Contractor's Chartered Professional Engineers: _____

IE AUST. Corporate Membership No: _____

Date: _____

WOOD & GRIEVE ENGINEERS

MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(FINAL COMPLETION)

Client:

Project:

Project No:

Contractor: _____

All mechanical building services have been installed in accordance with the shop drawings and with the equipment as certified in the relevant Quality Assurance Certificates.

We confirm that:

All Mechanical Services defects brought to our attention have been rectified **YES/NO**
If no, attach details of any defects that have not been rectified.

We have recently inspected the Mechanical Services installation and it is in efficient working order. **YES/NO**

Date of inspection: _____

Mechanical Services maintenance has been carried out in accordance with the specification and we have retained copies of records of all preventative and corrective maintenance work. **YES/NO**

Contractor's Verification Signature: _____

(Principal or Managing Director)

Date: _____

The overall installation complies with the performance requirements of the tender documents and subsequent variations.

Contractor's Chartered Professional Engineers: _____

IE AUST. Corporate Membership No: _____

Date: _____

WOOD & GRIEVE ENGINEERS

MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(ENGINEERING)

Client:

Project:

Project No:

Contractor: _____

System/Sub-System Component Description:

Calculation Type: Thermofluid or Acoustic (*).

Attached are my calculations which certify that the above system/system component meets the performance requirements specified.

Contractor's Chartered Professional Engineers: _____

IE AUST. Corporate Membership No: _____

Date: _____

(*) Acoustic only when requested by Superintendent.

PART C. TECHNICAL

C.1 MATERIALS AND WORKMANSHIP

C.1.1.1 General

All materials, labour and plant are to be provided unless otherwise specified. All materials and equipment shall be new, and the best of their respective kinds and free from all defects.

Workmanship shall be carried out in a first class manner and in accordance with the true intent and meaning of this Specification and accompanying drawings, the Contract and to the entire satisfaction of the Superintendent.

All materials, equipment and work shall comply with the appropriate Australian Standard Specification or Code, or if such have not been prepared, with the appropriate British Standard. In particular, compliance with AS 3000:2000 Australian/New Zealand Wiring Rules is required.

All materials, equipment and work shall also comply with the relevant rules and regulations laid down by any Statutory Authority having jurisdiction over such work, and shall conform to the requirements of Insurance Underwriter's Codes.

Any workmanship, materials or installation, which on inspection by such authorities, is found to require modification to be acceptable to the authority concerned shall be replaced, changed, modified, or otherwise put in a form to pass the relevant regulations. Such modifications shall be at the expense of the Contractor and at no cost to the Proprietor.

Take all necessary precautions with the supply and installation of equipment specified to prevent corrosion. If, in the opinion of the Contractor, equipment specified cannot be adequately protected against corrosion, an instruction regarding the same shall be requested. Any component or accessory showing signs of rust or corrosion during the maintenance period shall be renewed or otherwise made good in an approved manner.

C.2 ENGINEERING CERTIFICATION

This document is a performance specification with equipment selected to match the performance requirements and space limitations as shown on the drawings.

The Contractor shall be responsible for the individual systems components selection such that the composite designed systems form a complete engineering package. Consequently the Contractor shall engage the services of a practitioner who has a minimum qualification of the Chartered Professional Engineers of the Institution of Engineers Australia or a NPER-3 engineer. The practitioner shall demonstrate sufficient experience and reputation for the relevant services to the satisfaction of the Engineer. The practitioner shall be responsible for the system components such that the overall installation complies with the performance requirements of this document. Calculations for the equipment selection (such as fan static, pump head, acoustic, vibration, etc) shall be certified by the practitioner and shall be made available to the Engineer on request.

The qualifications and experiences of the practitioner shall be submitted to the Engineer for approval before the practitioner carries out his duty.

C.3 QUALITY ASSURANCE

The Contractor shall produce and submit to the Engineer verified records to confirm that the specification requirements have been achieved, as follows:

Item as specified	Record	Frequency
Equipment, ductwork, insulation, pipework, controls, electrical, noise and vibration control, painting.	Quality Assurance Certificate (Shop Drawings)	For each Shop Drawing submitted. Prior to manufacturing and installation.
Equipment	Quality Assurance Certificate (Supply)	For each item of equipment. Performance information (with Contractor's signature) submitted prior to purchase and after installation.
Engineering Certification	Quality Assurance Certificate (Engineering)	For each piping, exhaust and air handling system.
Testing and Commissioning	Commissioning Records	As specified.
The Contract Works	Practical Completion Certificate	Practical completion
Maintenance	Maintenance Log-Book	As specified.

The Contractor shall note on the record where any item fails to meet the specified requirement and the planned remedial action.

If the Contractor is certified to AS/NZ ISO 9000 then the Contractor's own Quality Assurance procedures may be used in lieu but only to the Engineer approval.

C.4 OZONE DEPLETING SUBSTANCES

The handling of ozone depleting substances shall conform in every respect to the applicable authority’s environmental protection policies or legislation.

C.5 EQUIPMENT

C.5.1 General

All equipment which forms a part of the works specified herein shall be supplied, installed and commissioned by the Contractor, unless otherwise specified.

Provide equipment complying with all specified requirements, performance schedules, and the clear intent of the specification.

All materials and components shall be the best of their respective kinds, and shall be free from all defects.

Safety guards shall be fitted to all items of equipment which may cause damage or injury to personnel, or to the building and other equipment.

The Contractor shall ensure, as much as is practicable, standardisation and interchange - ability of equipment throughout the installation.

All equipment shall incorporate any access doors, access hatches, lubrication points and any other provisions required for the easy maintenance of the subject equipment.

Notes to Tenderers:

1. Where the equipment make/brand is nominated outright, or nominated "-- or **approved equivalent**", then a fully conforming base tender offer shall be submitted incorporating the **nominated** equipment brand.

   An alternative offer may be submitted presenting an "equivalent" brand offer for approval, only in conjunction with a fully conforming base tender.

2. Where equipment make/brand is nominated "-- or **similar**", the base tender offer may incorporate similar equipment that confirms to all aspects of the specification.

Ensure that the equipment offered can satisfactorily be accommodated within the available plant area and, if any equipment modifications are necessary to achieve this, these shall be allowed for in the Tender.

All equipment shall be installed to the specification and equipment manufacturer's requirements. Allow for an inspection and report to be compiled by the equipment manufacturer confirming acceptance of the installation. Any further works required by the equipment supplier shall be included. Equipment suppliers' requirements that conflict with the specification shall be brought to the attention of the Engineer.

C.5.2 Equipment Selections

The pressure and flow requirements for equipment where shown on the drawings is for Tendering purposes only. Perform a detailed analysis of each air handling system and pipework system making due allowance for the resistance to flow of all other selected equipment, prior to confirmation of equipment selections. Any discrepancies from the specified requirements shall be brought to the Engineer's attention for resolution.

Any deficiency in system performance resulting from a failure by the Contractor to comply with this Clause shall be rectified to the Engineer's satisfaction at the Contractor's cost.

C.5.3 Coils, Cooling

C.5.3.1 Construction

Cooling coils shall be of Muller, Kirby, or approved equivalent manufacture.

Cooling coils shall be of the chilled water type, with copper tubes, aluminium fins and aluminium frames. The tubes shall be expanded into plate-type fins to provide a firm mechanical and thermal bond between fins and tubes, and prevent condensate from coming into contact with the copper tubes.

Coil headers shall be of copper, with copper or screwed brass inlet and outlet stubs. Each header shall be equipped with drain plugs and manual air vents.

Cooling coils shall be designed and installed for counter flow operation. Cooling coils shall be hydraulically factory-tested to a minimum test pressure of 2000 kPa.

The maximum individual coil height shall be 1070mm.

The Contractor shall mechanically protect the cooling coils during transit and after installation, so as to prevent mechanical damage prior to commissioning. Damaged coils may be rejected by the Engineer.

C.5.3.2 Mounting

Cooling coils shall be rigidly mounted on a galvanised steel frame, to the Engineer's approval.

Coils shall be separated from mounting frames and blanking panels by approved HDPE spacing plates and neoprene gaskets, to ensure an airtight seal and prevent electrolytic action.

C.5.3.3 Drip Trays

A drip tray shall be mounted beneath each cooling coil, as shown on the drawing.

Drip trays shall be fabricated from 1.2mm copper or 1.0mm stainless steel, and shall be fully soldered (or welded) along all seams.

Drip trays shall extend a minimum of 100mm upstream, and 250mm downstream of the coil surfaces, and shall be adequately stiffened or supported. Drip trays shall extend to completely contain all coil headers and return bends.

Each drip tray shall incorporate a minimum 25mm diameter trapped drain line run to the nearest floor waste.

Drip trays shall comply with requirements of AS 3666.

C.5.3.4 Capacity

Minimum cooling capacities of all cooling coils shall be as detailed in the "Schedule of Performance" section of this Specification.

C.5.4 Coils, Heating

C.5.4.1 General

Heating coil construction and mounting shall be generally as detailed for cooling coil construction, generally as for cooling coils.

C.5.4.2 Capacities

Minimum heating capacities of all heating coils shall be as detailed in the "Schedule of Performance" section of this Specification.

C.5.5 Re-Heat Coils

C.5.5.1 Construction

Re-heat or booster coils shall be of Muller, Kirby, or an approved equivalent manufacture.

Booster coils shall be of the hot water type, with copper tubes, aluminium fins and aluminium frames. The tubes shall be expanded into plate-type fins to provide a firm mechanical and thermal bond between fins and tubes, and prevent condensate from coming into contact with the copper tubes.

Coil headers shall be of copper, with copper or screw brass inlet and outlet stubs. Each header shall be equipped with drawing plugs and manual air vents.

Booster coils shall be designed for use in reheat applications. Coils shall be hydraulically factory-tested to a minimum test pressure of 2000kPa.

The Contractor shall mechanically protect the cooling coils during transit and after installation, so as to prevent mechanical damage prior to commissioning. Damaged coils will be rejected by the Engineer.

C.5.5.2 Mounting

Coils shall be rigidly flange mounted into ductwork.

Coils shall be separated from mounting frames and blanking panels by approved HDPE spacing plates and neoprene gaskets, to ensure an airtight seal and prevent electrolytic action.

C.5.5.3 Capacity

Minimum cooling capacities of all coils shall be as detailed on the drawings.

C.5.6 Pumps - Back Pull Out Centrifugal

Pumps shall be of the centrifugal, end-suction type, of Ajax manufacture, or approved equivalent.

Pumps shall have cast iron casings, bronze impellers and stainless steel shafts.

Pump casings shall be vertically split, back pullout, with removable spool piece to provide easy access for removal of the impeller.

Pumps shall incorporate renewable shaft sleeves and casing wear rings.

Impeller assemblies shall be statically and dynamically balanced prior to assembly of the pump, and shall be designed to have non-overloading characteristics.

Pumps shall be fitted with mechanical seals.

Pumps shall be driven through approved rubber-sheathed pin type flexible couplings. Couplings and shafts shall be contained within a rigid coupling guard.

The pump, coupling and electric motor shall be mounted on a common cast iron or galvanised MS base frame.

Pump assemblies shall be mounted on rubber or spring vibration isolators, as detailed in the "Noise and Vibration Control" section of this Specification.

Pump capacities shall be as detailed in the "Schedule of Performance" section of this Specification. Pump duty point shall be selected at 95% or less of maximum impeller size. Pump motor rating shall be selected to allow pump to deliver maximum flow rate at maximum impeller diameter.

C.5.7 Pumps - In Line Centrifugal

Pumps shall be single stage, centrifugal, in-line, single head units of “Grundfoss LME” or similar approved equivalent manufacture.

Pumps shall have 304 grade stainless steel impellors.

Pump casings shall be of one piece, cast iron construction, with opposed suction and discharge ports incorporating flanged connections.

Impeller assemblies shall be statically and dynamically balanced prior to assembly of the pump, shall be designed to have non-overloading characteristics and shall be manufactured from 304 grade stainless steel.

Pumps shall incorporate maintenance free corrosion resistant mechanical seals.

Pumps shall be direct driven by an IEC-flanged three phase motor and shall incorporate proprietary, internally mounted frequency converters, PI-controllers, overloads and temperature protection devices.

Each pump assembly shall be complete with proprietary control panel to enable accurate setup of the actual flow rate via speed control of the motor.

Pump assemblies shall be mounted on rubber or spring vibration isolators, as detailed in the "Noise and Vibration Control" section of this Specification.

Each pump assembly is to incorporate a minimum 1000mm straight length of entry pipework to ensure correct water entry conditions and minimise the risk of cavitation.

Pump capacities shall be as detailed in the "Schedule of Performance" section of this Specification. Pump duty point shall be selected at 95% or less of maximum impeller size. Pump motor rating shall be selected to allow pump to deliver maximum flow rate at maximum impeller diameter.

The contractor shall include as installed pump curve data in the Operation and Maintenance manuals.

C.5.8 Fans

C.5.8.1 General

Motors and drives shall have rated power output to allow a 10% increase in air quantity against the system (duty kW x 1.35).

Fan performance requirements are also detailed in the "Schedule of Performance" section of this Specification.

Access panels shall be provided, to the approval of the Architect, in the fan casings or the connecting ductwork, to provide adequate access to the motor and impeller assemblies.

Lubrication points shall be provided external to the fan casings for periodic lubrication of bearings.

Belt driven fans shall be provided with one set of spare belts mounted in a labelled wire rack within the plantroom to approval.

Details of fan sound power levels shall be submitted with tenders.

C.5.8.2 Fixed-Pitch Axial Fans

Fixed-pitch axial fans shall be of the direct-drive, aerofoil type, of “Fantech,” “Richardson” or “Woods” manufacture with non-overloading characteristics.

Casings shall be fabricated from hot dip galvanised steel with weld seams. Casings shall have flange connections at both ends for connection of ductwork or accessories.

Impellers shall be fabricated from aluminium alloy, and shall incorporate provision for adjustment of blade pitch angle.

Impeller and shafts shall be statically and dynamically balanced prior to assembly of the fans, after adjustment of the fan blade pitch angles.

C.5.8.3 In Line Mixed Flow Fans

In-line mixed flow fans shall be of “Fantech” Mixed Vent Series or approved equivalent.

Impellers shall be injection moulded plastic, shall be of a mixed flow design and driven by speed controllable external rotor motors with integral thermal protection.

Housings shall be of epoxy coated steel with circular end flanges, integral mounting foot and designed to provide ready access to the wheel for cleaning and maintenance.

C.5.8.4 Centrifugal Fans (Polypropylene)

Fans shall be of the backward inclined centrifugal type with non overloading characteristics of 'COLASIT' or approved equivalent manufacture.

Fans shall have single thickness blades.

Fan impellers shall be moulded from polypropylene with a plastic coated metal hub and shall be statically and dynamically balanced.

Fan casings shall be fabricated from polypropylene.

Fans shall be direct or belt driven as nominated in the 'Schedule of Performance' section of this specification.

Fans shall be driven by means of a TEFC squirrel cage induction motor of ample capacity for the required duty on continuous operation and starting.

Belt drives consist of Vee belts of matched lengths of adequate cross section to transmit the power required. Motor slide rails shall be provided for ease of belt tensioning.

Each fan/motor assembly shall be mounted on an integral hot dip galvanised mild steel inertia base.

Vibration isolators shall be as detailed in the 'Noise and Vibration' section of this specification.

Fan motors and drives shall be selected to allow for an increase in volume of 10% against a corresponding increase in system resistance.

Suitable belt guards shall be fitted over the fan drives.

C.5.8.5 Roof Mounted Exhaust Fans - Single Motor

Roof mounted exhaust fans shall be of "Fantech" or similar approved manufacture.

Fan housings shall be weatherproof, shall be of moulded bonded reinforced fibreglass, be complete with integral bird screen and shall have an easily removable motor cover.

Impellors shall be backward inclined centrifugal units with a vertical shaft.

Roof extractor units shall be belt driven with a motor sized for an additional 10% increase in air flow against a corresponding increase in system pressure beyond the duty specified.

Motors shall be three-phase totally enclosed fan cooled and shall be suitable for operation in ambient air temperatures of $40^{O}C$.

Air discharge shall be vertical.

Fans serving fume cupboard or hood exhaust systems shall have all metal parts exposed to the air stream encapsulated in PVC.

C.5.8.6 Ceiling Mounted Exhaust Fans

Ceiling mounted units shall be of "Fantech Vogue VRP" series or similar approved manufacture and shall incorporate a speed controlled single phase external rotor motor, sealed for life bearings, auto reset thermal protection and an axial impellor.

Fan housings shall be of PGI construction and shall be powdercoated.

Impellors are to be of PGI construction and shall be powdercoated matt black.

All other internal components are to be matt black.

C.5.8.7 Wall Mounted Exhaust Fans

Wall units shall be totally weatherproof, constructed to enable complete servicing of all components and be of "Fantech" or similar approved manufacture.

Housings shall be galvanised steel, aluminium or moulded bonded reinforced fibreglass sufficiently stiffened to prevent vibration and shall be complete with aluminium louvre, bird screen and back draft damper.

Aluminium louvers shall be finished in accordance with "Air Diffusion Equipment Requirements".

All impellers shall be of the backward inclined or mixed flow type, of aluminium construction suitable for direct or Vee-belt drive and driven by three phase totally enclosed fan cooled motors, suitable for operation in an ambient air temperature of 40°C.

Motors shall be sized for an additional 10% air flow increase against the corresponding increase in system pressure.

Fans and motors shall be statically and dynamically balance and provided with vibration isolation either inherent to the fan design or external to the fan. Fans shall be smooth running without objectionable noise and vibration, consistent with the requirements of the "Noise and Vibration Control" section of this Specification.

C.5.8.8 Window/Wall Fans

Window/wall fans shall be of “Xpelair” or similar.

Window fans shall be from the GX range.

Wall fans shall be from the WX range.

All fans shall be complete with back draft dampers and two speed motors.

C.5.8.9 Accessories

Accessories to be supplied with each fan shall be as detailed in the "Schedule of Performance" section of this Specification.

The nominated accessories shall be supplied by the manufacturer of the related fan.

Fan performance ratings shall be selected to allow for any losses resulting from the specified accessories.

C.5.8.10 Wire Guards

Fitted to fan inlet and/or discharges, shall be fabricated from galvanised steel, and shall be of robust construction so as to provide adequate personnel protection without detracting from the rated fan performance.

C.5.8.11 Bellmouth Entries

Shall be galvanised steel construction, shall be bolted to the casing flange at the fan inlet. Bellmouth entries shall be designed to limit the total pressure loss at the fan intake to 20% of the fan velocity pressure.

C.5.8.12 Weather-Proof Discharge Dampers

Shall be fabricated from galvanised steel, and shall be designed to ensure that rain does not enter the fan casing, or penetrate below the fan blades, at any time, whether the fan is operational or not.

C.5.8.13 Isolating Switches

Shall be provided for all roof mounted fans. Isolators shall have a minimum rating of 20 Amps and shall be of weather-proof construction. Dual motor fans or dual speed fans shall be provided with two isolating switches.

C.5.9 Air Filters

C.5.9.1 General

Air filter assemblies shall have capacities and efficiencies as detailed in the "Schedule of Performance" included in this Specification.

Filter banks shall be provided with direct reading manometers to indicate air pressure drop through filters. Manometers shall be of Dwyer "Magnehelic" type of approved equivalent manufacture with a range of 0 to 500Pa and a permanent mark at 375Pa with a printed notation reading "Filters Dirty - Replace".

Provide and install replacement filters and/or media at the end of the 12 month Defects Liability Period.

C.5.9.2 Panel Type

25mm Thick Panel filters shall be of the disposable dry media type, of "Farr 30/30" or approved equivalent manufacture.

Filters shall be designed to handle the specified total air quantities for each system with a face velocity not exceeding 1.7m/s, a maximum clean resistance to air flow of 62.5 Pa and minimum AS 1324 No. 1 dust minimum efficiency of 24%.

50mm Thick Panel filters shall be of the disposable dry media type, of "Farr 30/30" or approved equivalent manufacture.

Filters shall be designed to handle the specified total air quantities for each system with a face velocity not exceeding 2.54m/s, a maximum clean resistance to air flow of 70 Pa and minimum AS 1324 No. 1 dust minimum efficiency of 24%.

Provide one complete set of replacement media for each air handling unit, mounted in a wire rack in the appropriate plantroom.

C.5.9.3 Deep Bed Type

Air filters shall be of the high-capacity deep bed type, of "Defiant" type or approved equivalent.

Filter media shall be of the disposable type - refer to the "Schedule of Performance".

Throwaway media type of filters shall have a minimum efficiency of 60% when tested to AS 1324 with No. 1 Test Dust. The filters shall have a dust holding capacity of not less than 400g for a final resistance of 250Pa for test dust No. 4.

At the design maximum air flow the effective face velocity shall not exceed 2.5m/s and the clean resistance shall not exceed 50 Pa.

300 deep pocket filters will only be accepted where 660 deep pockets cannot be accommodated due to space restrictions.

Filter media shall be supported in wire baskets, mounted in a 1.6mm PGI frame.

Filter modules shall be readily accessible and removable, and shall be securely held in position by clips of approved design.

Frames shall be mounted so as to provide an adequate seal, and prevent air from bypassing the filter media.

The entire filter assembly shall be adequately supported, to the approval of the Engineers, to prevent distortion of frames or media under all anticipated loadings.

Filter banks shall be provided with direct reading manometers to indicate air pressure drop through filters. Manometers shall be of Dwyer "Magnehelic" type of approved equivalent manufacture with a range of 0 to 250 Pa and a permanent mark at 125 Pa with a printed notation reading "Filters Dirty - Replace".

All bag filters must be supplied with a main mounting frame that does not vibrate or flap when in use or sag when the system is turned off. The bag filters must also have an inner media retaining frame that creates a positive seal between the media and the main frame to ensure no air by-pass.

Provide one complete set of replacement media for each air handling unit, mounted in a wire rack in the appropriate plantroom.

C.5.10 Air Diffusion Equipment

C.5.10.1 General

Air diffusion equipment shall be generally of the type nominated and in the location shown on the drawings.

Air diffusion equipment shall be selected to handle the scheduled air quantities at a noise level not exceeding NR35 when the areas are empty of personnel other than those engaged on the noise level tests.

External appearance and surface finish shall be subject to approval. Submit one sample of each type of fitting for such approval, prior to confirmation of orders for air diffusion equipment.

All interior parts of grilles, diffusers slots etc. shall be painted matt black.

All air diffusion equipment shall incorporate removable cores set in extruded aluminium frames, separate to the outer flange frame to enable concealment of fixings and easy removal for cleaning.

C.5.10.2 Grille Finishes

All grilles, registers, diffusers, etc., within the building shall be colour anodized, baked enamel or paint finished in accordance with the Section "Painting". Colour to match existing.

All grilles external to the building shall be anodised, baked enamel or painted to a colour to match the existing.

C.5.10.3 Ceiling Square Pattern Diffusers

Ceiling diffusers as listed in the schedule or the drawings shall be Harts type PCD or similar set to deliver the specified air quantities to the space as indicated, taking full account of spread and throw requirements.

Construction of the diffuser shall be of the highest standards of workmanship and shall be finished within satin finish enamel to approved colour.

Diffusers taken direct off duct shall have adjustable deflecting vanes or splitter dampers. Opposed blade dampers shall be fitted to all remaining diffusers.

C.5.10.4 Curved Blade Ceiling Diffusers

Ceiling diffusers shall be the curved blade type as manufactured by S. W. Hart, type “HCB” or similar set to deliver the specified air quantities to the space as indicated, taking full account of spread and throw requirements.

Construction of the diffuser shall be of the highest standards of workmanship and shall be finished with satin finish enamel to an approved colour.

C.5.10.5 Sidewall Registers

Sidewall registers listed in the drawings schedules shall be of the adjustable double deflecting type, of "Harts" RDH or similar.

The registers shall be manufactured from extruded aluminium aerofoil section blades with the front blades horizontal and the rear blades vertical. The front set of blades shall be on centres not exceeding 20mm and the rear set of blades shall not exceed 25mm centre distance.

The flange surrounds shall be extruded aluminium section with minimum flange width of 25mm. Flange corners shall be mitred with surface buffed flat and smooth. No gaps in joints will be accepted.

Registers shall be fitted with opposed blade dampers.

C.5.10.6 Ceiling Mounted Return/Exhaust Grilles (RAG)

Ceiling mounted exhaust grilles as listed in the schedule on the drawings shall be of the Harts type EG or similar.

Exhaust grilles shall comprise an easily removable, aluminium egg crate core set in an extruded aluminium flanged surround.

Grilles shall be fitted with opposed blade dampers.

C.5.10.7 Light Air Troffers

Linear slot diffusers are integral with the light fittings and shall be single-slot, single-blow or dual slot, dual blow.

The Mechanical Sub-Contractor shall provide light air troffers complete with deflectrols to suit the light fittings provided.

C.5.10.8 Blanking Panels

Non-active slots in light-mounted and ceiling mounted linear diffusers or non-active "T" bars shall be blanked off with sheetmetal blanking strips where return air flow is not required. When return air flow is required through the blanking panel light proof sheetmetal blanking strips are to be provided.

C.5.10.9 Weather-proof Louvres

Weather-proof louvres shall be supplied and installed, except where shown otherwise on the drawings.

Weather-proof louvres shall be “SW Hart” or approved equivalent complete with galvanised vermin proof mesh.

Weather-proof louvres shall be fabricated from extruded aluminium blades of robust construction, designed so as to prevent the ingress of rain or water under all operating conditions, and to prevent direct line of sight. Blades shall be of the "double stop" type with the standard blade spacing recommended by the manufacturer.

Weather-proof louvres shall provide a maximum resistance to the rated air flow of 30 Pa at a face velocity of 2.5 meters per second.

C.5.10.10 Wall and Duct Mounted Exhaust Air Grilles

Wall mounted return air grilles as listed in the schedule on the drawings shall be “SW Hart” or similar.

Return air grilles shall be fitted with an extended extruded aluminium flange surround suitable for surface mounting to the wall.

The core shall be manufactured from extruded aluminium half-chevron sections set in an extruded aluminium frame.

Grilles shall be fitted with opposed blade dampers.

C.5.10.11 Door Grilles

Door grilles shall be fabricated from extruded aluminium chevron blades arranged to prevent direct line of sight, and shall have a minimum free area of 60%.

Door grilles shall have a trimming flange to each side of the door.

C.5.10.12 Ceiling Mounted Linear Slot Diffuser boots

Linear boots complete with deflectrols shall be of the length shown, with width to match the number of slots shown, and selected for the air flow rate indicated on the drawings.

The volume control damper associated with each boot shall be accessible through the face of the grille.

Note Mechanical Sub-Contractor to provide deflectrols for installation in the linear t-bar diffusers (by others).

C.5.10.13 Jet Diffusers

Jet diffusers as listed in the schedule on the drawings shall be of the adjustable diffuser type of "Holyoake" type JD or similar.

Jet diffusers shall be manufactured from spun aluminium.

Jet diffusers shall be fitted with opposed blade dampers.

C.5.10.14 Ceiling Diffusers (SAD)

Ceiling diffusers as listed in the schedule or the drawings shall be “Dragon DCO” type or similar, set to deliver the specified air quantities to the space as indicated, taking full account of spread and throw requirements.

Construction of the diffuser shall be of the highest standards of workmanship and shall be finished within satin finish enamel to approved colour.

Diffusers taken direct off duct shall have adjustable deflecting vanes or splitter dampers. Opposed blade dampers shall be fitted to all remaining diffusers.

C.5.10.15 Ceiling Mounted Linear Slot Diffusers

"T" bars or linear grilles shall be provided by Builder.

Linear slot diffusers shall be of extruded aluminium or pressed metal sections, securely fixed into a rigid aluminium frame, so as to prevent noise or vibration at any air flow rate up to and including 150% of the specified maximum.

Linear slot diffusers shall be of the length shown, with the number of slots shown, and selected for the air flow rate shown on the drawings.

Linear slots shall provide 180^{o} of air pattern adjustment.

All joints exposed to view shall be precision machine made, and shall incorporate accurately located dowels or other approved means to ensure a smooth in-line construction.

Linear diffusers mounted in continuous plastic or gyprock ceilings shall be surface-mounted.

"T" bar mounted linear boots shall be similar in all respects to ceiling mounted linear slots and shall be suitable for mounting direct into T bars or linear grilles provided.

Linear diffusers mounted in T-bar ceilings shall be flush mounted.

Linear diffusers shall be “Ventitec”, “Dragon”, “Harts” or approved equivalent.

C.5.10.16 Light-Mounted Linear Slot Diffusers

Linear slot diffusers mounted integrally with light fittings shall be single-slot, single-blow or duel slot, duel blow linear diffusers, of similar construction to ceiling-mounted linear slot diffusers.

Light-mounted linear slot diffusers shall be generally fitted to the light fittings as shown on the drawings.

C.5.10.17 Wall Mounted Return Air Grille (RA 45)

The wall mounted return air grilles as listed in the schedule on the drawings shall be of the "DRAGON" type DWR or similar.

Return air grille shall be fitted with an extended extruded aluminium flange surround suitable for surface mounting to the wall.

The core shall be manufactured from extruded aluminium half-chevron sections set in an extruded aluminium frame.

Grilles shall be fitted with opposed blade dampers.

C.5.10.18 Sidewall Registers (DD SA R)

Sidewall registers as listed in the schedule on the drawings shall be of the adjustable double deflecting type of "DRAGON DWS” type or similar approved equivalent.

The registers shall be manufactured from extruded aluminium aerofoil section blades with the front blades horizontal and the rear blades vertical. The front set of blades shall be on centres not exceeding 20mm and the rear set of blades shall not exceed 25mm centre distance.

The flange surrounds shall be extruded aluminium section with minimum flange width of 25mm. Flange corners shall be mitred with surface buffed flat and smooth. No gaps in joints will be accepted.

Registers shall be fitted with opposed blade dampers.

C.5.10.19 Ceiling Mounted Radial Type Diffusers

Ceiling diffusers as listed in the schedule or drawings shall be "Krantz" type RA-N and RA-V, set to deliver the specified air quantities to the space as indicated, taking account of spread and throw requirements.

All non-adjustable radial outlets shall deliver high quality indoor air flow with minimum temperature gradient in the occupied zone.

All radial outlets shall be complete with short spigot, moulded visible surface and radial vanes with central fastening screw with cap.

Construction of the diffuser shall be of the highest standards of workmanship and shall be finished within satin finish enamel to approved colour.

Diffusers taken direct off duct shall have adjustable deflecting vanes or splitter dampers. Opposed blade dampers shall be fitted to all remaining diffusers.

All diffusers to be installed into T-Bar ceilings shall be complete with a proprietary Krantz 595mm by 595mm metal backing plate.

Allow to paint all diffusers and visible backing plates to a colour that will be specified by the architect during the construction phase.

C.5.11 Split Packaged Air Conditioning Units

C.5.11.1 General

Split packaged units shall be of "Temperzone", "APAC", "Daikin" or approved equivalent manufacture.

Each unit shall consist of a fan coil unit section and a condensing unit section.

The fan coil section shall consist of air filters, cooling coils, supply air fan, insulation and all necessary piping, valves and fittings.

The condensing unit section shall consist of condenser coils, condenser fans, compressors, all necessary piping, valves, fittings, ancillary equipment and built in weather proof switchboard.

Air cooled condensing units shall have passivated fins.

All split packaged units shall be provided with head pressure control unless specifically noted otherwise. Head pressure shall be regulated by cycling of condenser fan / fans via a discharge pressure controller.

The minimum capacity requirements of the split packaged equipment shall be as detailed in the "Schedule of Performance" Section of this Specification.

C.5.11.2 Wall Hung Split Air Conditioning Units

Wall hung split air conditioning units shall be of the same manufacture throughout the project.

Each unit shall consist of a wall hung or in-ceiling fan coil unit section and a condensing unit section.

The fan coil unit section shall consist of air filters, cooling coils, supply air fan, insulation and all necessary piping, valves and fittings.

The condensing unit section shall consist of condenser coils, condenser fans, compressors, all necessary piping, valves, fittings, ancillary equipment and built in weatherproof switchboard.

The minimum capacity requirements of the split air conditioning equipment shall be as detailed in the "Schedules of Performance" Section of this Specification.

C.5.12 Packaged Air Conditioning Unit Components

Housings shall be insulated internally with 25mm thick perforated sisal lined fibretex or equivalent insulation fixed to approval.

Housings shall be rigid to ensure quiet operation and freedom from vibration.

Housings shall incorporate easily removable panels to provide ready access to the interior of the units for maintenance.

Drip trays shall be fitted below each cooling coil.

Drip trays shall be insulated on the underside and shall be adequately protected against corrosion. A 25mm OD copper drain line shall be run from each drip tray to the adjacent floor waste as indicated.

Drain lines shall be trapped in accordance with the manufacturer's recommendations to positively drain the condensate from the drip tray when the unit is in operation.

The evaporator housings shall be complete with all drain piping, wiring, refrigerant piping, expansion valves and all equipment necessary for its safe and efficient operation.

C.5.12.1 Housings - Condensing Sections

Casings shall be of 1.2mm thick zinc coated steel, primed and finished with resin enamel or powder coat and shall be weather proofed, suitable for outside installation.

Casing panels shall be braced and stiffened to prevent vibration.

The compressor section of the casing shall be adequately ventilated.

Condensing sections shall incorporate compressors, condensing coils, motor contactors, refrigerant piping, valves etc all as necessary for a complete system.

Condensers in all units shall have sufficient capacity to maintain a condensing temperature not in excess of 55°C with a condenser air-on temperature of 42°C DB.

Condensers shall be selected for continuous operation with an air entering temperature of 46°C DB.

A separate refrigerant circuit shall be provided for each compressor.

Condenser coils shall be of the copper tube aluminium fin type not exceeding 550 fins per metre.

The face velocity over the coil shall not exceed 3.0 m/s.

Fans shall be of the multi-blade propeller type or aerofoil type direct driven by electric motors adequately sized for the duty.

Fans and motors shall be adequately protected against corrosion.

Fan motors shall be fully weather-proof.

Condenser fan motors shall have thermal overload protection.

Condensing sections shall be supplied complete with all internal wiring, refrigerant piping, valves, fittings, etc.

C.5.12.2 Supply Air Fans

Fans shall be of the forward curved centrifugal type, statically and dynamically balanced and mounted in approved silent bearings.

Fans shall be selected for delivering the supply air quantities against the actual system resistance, which shall be assessed by the Contractor to suit the equipment offered.

Generally, fans shall be driven by means of 3 phase T.F.F.C. squirrel cage motors of adequate capacity for the required duty on continuous operation.

Select the correct motor size and fan speed to suit the actual system resistance.

Fan drives shall be of the Vee belt type and shall consist of accurately aligned pulleys and Vee belts of matched lengths to transmit the power required.

Suitable belt tensioning devices and belt guards shall be incorporated.

C.5.12.3 Packaged Unit Compressors

Compressors shall be of the semi-hermetic or hermetic multi-cylinder type.

Compressor design condensing temperature shall not exceed 41°C with a minimum suction temperature of 7.2°C.

The compressors shall be fitted with internal relief valves and with suction and discharge stop valves.

Electric heating elements shall be installed in compressor sumps to heat oil during stand-down periods.

Compressor motors shall be of the squirrel cage type and shall be rated for continuous loading under operating conditions.

Compressors motors shall incorporate overload protection.

Compressors motor contactors shall be provided sized and selected to suit the required motor and duty.

Lockout relays shall be provided to prevent the compressors starting should the respective evaporative fan motor or the condenser fans fail to start.

High and low pressure cut-outs shall be installed for each compressor.

Compressor motors shall be started sequentially to prevent more than one compressor in any one unit starting simultaneously.

C.5.12.4 De-Ice Control

Air Conditioning systems utilizing the heat pump provision shall also be fitted with de-ice control, on each stage, to prevent ice build-up on the outside coil in low ambient conditions.

The de-ice facility shall operate in such a way as to cause as little disturbance to system operation as possible. Returning the system to the cooling mode to defrost outdoor coils is unacceptable.

In circumstances where de-ice is required the system shall continue to run in the heat pump mode. Both the evaporator fan and the condenser fan/s will de-energise, at which time a quantity of discharge gas shall be by-passed directly into the outdoor coil, via a solenoid valve, whereby defrosting the coil. In very low ambient conditions the indoor fan may be left operating giving continuous warm air flow to the conditioned space during the defrost mode only once every 30 minutes preventing the system from de-ice short circuiting.

The above system shall be offered fully integrated within the standard heat pump unit.

C.5.12.5 Refrigerant and Oil

All refrigerant and oil necessary for the purging, charging and commissioning of the refrigeration systems shall be supplied.

Provide addition refrigerant and oil should leakage occur during the Defects Liability Period.

C.5.12.6 Filters

Filters shall be as specified in the Filters Section of this Specification.

Supply and install manometers to indicate the air pressure drop through the filters. The manometers shall be "Dwyer Magnehelic" or approved equivalent or 0 to 250 Pa range marked at 125 Pa with a label inscribed "Filters Dirty Clean".

Supply and install one complete set of replacement filters for each unit in each air handling plant room or cleaners room.

Cleaning of the filter elements shall form part of the Contractor's maintenance obligations.

C.5.12.7 Cooling Coils

Cooling coils shall be of the direct expansion type.

Coils shall be constructed from copper tubes with aluminium fins.

The aluminium fins shall be tightly wound on the tubes or the tubes expanded into plate type fins to provide a firm mechanical bond between fins and tubes.

Coils with damaged fins will be rejected.

Face velocity of the air passing over the coils shall not exceed 2.5 m/s at the specified air quantity.

Coils shall have sufficient capacity to perform the required duty and shall have a minimum of 3 (three) rows.

C.5.12.8 Ancillary Equipment

Ancillary equipment shall include liquid line filter driers and moisture indicators.

C.5.12.9 Built-in Switchboards and Wiring, etc.

Each unit shall incorporate an easily accessible built-in switchboard and all necessary internal wiring, fuses, contactors, etc.

Each unit shall be fitted with a main isolating switch.

Units with motors exceeding 4kW shall include reduced voltage starting of reach motor built into the switchboard.

All wiring associated with the units shall be as specified in the "Electrical" section of this Specification.

C.5.12.10 Controls

Control equipment including operating switches is specified in Section "Automatic Controls" of this Specification.

All packaged and split packaged units shall be provided with head pressure control unless specifically noted otherwise. Head pressure shall be regulated by cycling of condenser fan/fans via a discharge pressure controller.

C.5.12.11 Electrical

All electrical work associated with the electric heater banks shall be carried out in accordance with the "Electrical" section of this Specification.

Electric heater banks shall be generally wired so as to balance the electrical load across all three phases.

Stages of heating of up to 2.5 KW capacity may be connected to a single phase.

Stages of heating exceeding 2.5 KW capacity shall be provided by multiple elements, wired so as to balance the electrical load per stage evenly across all three phases.

All fuses, contactors, relays etc. required to control the heater banks shall be located in the control panels of the related air terminal boxes or in the Mechanical Services switchboard/panel.

C.5.12.12 Variable Volume Packaged Units

Variable volume package units shall have the following special equipment:

- Interlaced coils.
- Fan drive frequency converter to provide variable speed operation of the fan motor to maintain duet static pressure.

Hot gas by-pass control shall be provided if at worst case conditions, eg. minimum air, minimum capacity step and low ambient.

The suction temperature is below $0^{O}C$. Manufactures selection data to be provided.

An ***alternative*** price can be offered for "riding" of the fan curve, the alternative shall be accompanied by a full description and engineering certification.

C.5.13 Packaged Air Conditioning Equipment

C.5.13.1 Roof Top Packaged Units

Roof Top Packaged Units shall be of A.P.A.C. or approved equivalent manufacture.

Each unit shall be complete with housing, air filters, cooling coils, supply air fan, insulation, all necessary piping, valves, fittings, condenser coils, condenser fans, compressors, all ancillary equipment and built in weather-proof switchboard.

The minimum capacity requirements of the packaged equipment shall be as detailed in the "Schedule of Performance" Section of this Specification.

C.5.13.2 Split Packaged Units

Split packaged units shall be of APAC or approved equivalent manufacture.

Each unit shall consist of a fan coil unit section and a condensing unit section.

The fan coil section shall consist of air filters, cooling coils, supply air fan, insulation and all necessary piping valves and fittings.

The condenser section shall consist of condenser coils, condenser fans, compressors, all necessary piping, valves, fittings, ancillary equipment and built in weather proof switchboard.

C.5.13.3 Vertical Packaged Units

Vertical packaged units shall be of APAC or approved equivalent manufacture.

Each unit shall be complete with housing, air filters, cooling coils, supply air fan, insulation, all necessary piping, valves, fittings, condenser coils, condenser fans, compressors, all ancillary equipment and built in weather-proof switchboard.

C.6 DUCTWORK SYSTEMS

C.6.1 Description of Systems

C.6.1.1 General

Provide ductwork and insulation systems in accordance with the requirements of this section of the specification. Read this section in conjunction with the "Insulation Systems" section of this specification.

C.6.1.2 Ductwork Types

All ductwork shall be of low pressure sheetmetal construction with the exception of the following:

- Flexible duct connections between branch ducts and cushion heads.
- Airtight masonry risers where clearly depicted as such on the drawings.

Ductwork between smoke exhaust fans and intake grilles shall be in fire rated construction.

Exhaust hoods shall be of brushed stainless steel construction and finish.

C.6.1.3 Insulation Types

Supply and Return ductwork shall be insulated.

Ductwork shown single hatched shall be internally insulated with 25mm thick perforated aluminium foil faced insulation.

Ductwork shown special double hatched shall be internally insulated with 75mm thick perforated aluminium foil faced insulation.

Ductwork shown double hatched shall be internally insulated with 50mm thick perforated aluminium foil faced insulation.

Cushion heads and air boots shall be fully internally insulated as indicated on drawings.

Build up conditioner casings shall be internally lined on all faces to 50mm thick, insulation and perforated metal facing.

C.6.2 Ductwork Requirements

C.6.2.1 General

Ductwork systems shall generally comply with or exceed the requirements of Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA) H.V.A.C. Duct Construction Standards or the Australian Building Industry Specification "NATSPEC", except as specifically varied in the drawings or detailed in the specification.

The associated mechanical drawings indicate the sizes of duct runs, registers, diffusers and the approximate position of duct runs. Actual position of duct runs shall be shown on shop drawings, designed with least interference with all other services. Where ductwork is installed above ceilings incorporating recessed light fittings, ductwork shall maintain a minimum clearance height of 200mm above the underside of the ceiling and shall provide clearance above and around light fittings and combined light/air fittings to permit servicing, removal and relocation. Where this cannot occur, the areas of concern shall be brought to the consulting engineers attention.

Check all clearances on site to ensure that the ductwork is suitably located to avoid all obstructions such as beams, columns, water and electrical services, etc.

C.6.2.2 Ductwork Dimensions

All ductwork dimensions shown on drawings are the minimum internal dimensions of the air passage eg. inside of insulation or acoustic lining where fitted.

If necessary, the duct dimensions shown on the drawings may be changed to obtain more economical sheet cutting or to avoid an obstruction, providing:

- The ductwork shall be designed to have no less a capacity and no greater total frictional resistance than that of the original ductwork.
- Design approval is obtained prior to manufacture.
- The revised duct size will not obstruct the building structure or any other services to be installed.

C.6.2.3 Design

Where ductwork is represented in a "single line" format, or not represented on drawings entirely (eg. obscured from a view), provide a complete operating system of ductwork to handle the air quantities shown and specified. In these cases the duct system shall comply with the following:

- Unless otherwise specified, where duct dimensions are not shown ductwork frictional losses shall not exceed 0.8Pa/m and branch ducts connected to air outlets or intake grilles shall have a maximum velocity of 4 m/s.
- Ducts shall have swept radius bends, tapered transitions, adjustable balancing devices at all duct branches and air outlets, all as specifically detailed elsewhere in this section.

Where ductwork is represented as single line, the required shop drawings shall be prepared from such information. Fully detailed drawings may not be made available for this purpose.

C.6.2.4 Ductwork Classification

Each duct system shall be constructed for the specific duct pressure classification indicated below. Where the requirements of one or more variables are exceeded, the classification shall be scheduled to the higher pressure classification.

PRESSURE	STATIC PRESSURE LIMIT		MAXIMUM AIR
CLASS	POSITIVE	NEGATIVE	VELOCITY
Low	500 Pa	500 Pa	Up to 10m/s
Medium	1000 Pa	750 Pa	Up to 12.5m/s
High	above 1000 Pa	750 Pa	Above 12.5m/s

C.6.3 Sheetmetal Ductwork

C.6.3.1 Materials

All ductwork as indicated on drawings shall be fabricated from hot dip galvanised sheet steel suitable for role forming, Galvabond Class Z300 or equivalent galvanized sheet steel, machine formed and free from buckles and waves.

C.6.3.2 Low Pressure Duct Construction

Ductwork construction shall generally be as set out below:

MAXIMUM SIDE or DIA	MATERIAL GAUGE (mm)	JOINT TYPE	JOINT SPACING (mm)	BRACING SIZE (mm)	BRACING SPACING (mm)
0-300	0.6	DRIVE CLEAT	2500	--	--
301-450	0.6	DRIVE CLEAT	2500	--	--
451-750	0.8	DRIVE CLEAT	2500	25x25x3 ANGLE	1250
751-1000	1.0	FLANGE 25x25x3	2500	25x25x3 ANGLE	1250
1001-1250	1.0	32x32x3	2500	32x32x5 ANGLE	1250
1251-1800	1.0	38x38x3	1200	38x38x5 ANGLE	600
1801-2500	1.0	51x51x3	1200	51x51x5 ANGLE	600

C.6.3.3 Ductwork Bracing

Support bracing shall be equally spaced between joints. The bracing spaces noted in the chart above indicate maximum distance between bracing and adjacent joint or bracing.

Angles and bracing shall be riveted to ducts and bolted joints shall be made with 8mm diameter galvanized steel bolts at 100mm maximum centres.

As an alternative to the angle braces noted above, ductwork can be manufactured using machined formed beading or cross breaking. This will be at the discretion of the Mechanical Engineer and the contractor shall seek approval prior to manufacture.

C.6.3.4 Joints

Where drive cleats are called for in the ductwork construction charts the drive cleats shall be a 'C' type cleat. The 'C' section of the cleat shall be 0.8mm thick galvanized sheet steel. Both the 'C' section and matching cleat shall be machine formed and free from buckles and waves. Corners of ductwork shall have G.S.S. corner covers inserted into 'C' sections.

Drive cleats on medium pressure ductwork shall be sealed either side of 'C' section and corners with an approved duct sealant.

C.6.3.5 Flanged Joints

Where flanged joints are called for in the ductwork construction charts, the flanged joints shall be fabricated from the nominated size of rolled steel angles, with the duct ends turned up 10mm between the joint. Approved neoprene type gaskets shall be fitted during assembly of the joints with bolts required at corners and at 100mm (maximum) centres. All flanges shall be galvanized after manufacture.

Alternative flange joint profiles may be used subject to the approval of the consulting engineer. In this instance detail of gauges, profile, supports etc. shall be forwarded, however the alternative offered shall generally confirm to NATSPEC.

C.6.3.6 Longitudinal Joints

Longitudinal joints shall be Pittsburgh Lock Seam type joints. Clip Lock joints are not acceptable.

C.6.4 Ductwork Supports

C.6.4.1 General

Supports shall be provided to fix ductwork in position with adequate allowance for expansion and contraction. Wherever possible locate supports adjacent to cross joints in the ductwork.

Ductwork supports shall not be used to support piping, ceilings, electrical cabling or the like.

Where ductwork is supported from walls or where ductwork runs vertically, the ductwork shall be supported using gallows type brackets (to approval), at the centres specified for horizontal duct runs.

Where steel hanger straps are used to support ductwork the straps shall be arranged in pairs with tangs turned 90o under the duct and secured using pop-rivets. The straps shall be bolted to the supporting member using 10mm diameter bolts.

Where steel hanger rods are used to support ductwork the rods shall be bolted to the support member or fixed to the concrete slab over by means of "Terrier" expanding plug type fixings as applicable.

Where ductwork requires vibration isolation, details of the proposed installation shall be submitted for approval. Where ductwork comes in contact with supports or building structure, 6mm thick neoprene acoustical friction material shall be fitted to isolate ductwork from structure.

C.6.4.2 Rectangular and Flat Oval Ducts

LONGEST SIDE DIMENSION (mm)	MINIMUM HANGER SIZE (mm) STEEL ROD	STEEL STRAP	ANGLE	HANGER SPACING (mm)
UP to 600	6	25x1.6	25x25x3.0	2500
601 to 750	10	40x2.5	32x32x3.0	2500
751 to 1250	10	--	32x32x3.0	2500
1251 to 2500	12	--	38x38x5.0	1200
ABOVE 2500	16	--	51x51x5.0	1200

Where more than one duct is supported by the same rod or hanger, the size shall be determined from the sum of the longest sides of the individual ducts.

C.6.4.3 Circular Ductwork

NOMINAL	MINIMUM HANGER SIZE (mm)	SUPPORT RING DETAILS

DIAMETER (mm)	STEEL ROD	STEEL STRAP	SIZE (mm)	SPACING (mm)
Up to 450	6	25x1.6	25x1.6 STRAP	2500
451 to 900	10	40x2.5	40x2.5 STRAP	2500
901 to 1800	12	--	30x30x3 ANGLE	1200
Above 1800	16	--	40x40x3 ANGLE	1200

C.6.5 Flexible Ductwork

C.6.5.1 General

Flexible circular ductwork shall be constructed of reinforced aluminium strip or reinforced fabric, wound in a continuous interlocking spiral construction. Flexible ductwork for exhaust purposes can be uninsulated unless otherwise noted. All supply and return air ductwork is to incorporate 25mm thick insulation and a suitable outer sleeve vapour seal that is compliant with the following clauses. The outer sleeve of the insulation shall be drawn over the inter sleeve and secured using worm screw type draw band, PVC tape and foil tape.

The use of flexible ductwork shall be limited to systems classified as low and medium pressure. Where ductwork is used on medium pressure systems suitable duct sealant shall be applied to the collar before fitting the duct to the collar.

Flexible duct runs shall be as short and straight as possible, with a maximum length of 6 metres. Bends in flexible ductwork shall incorporate a bend centre line radius of not less than 1.5 times the duct diameter.

Sleeves used for joining two sections of flexible duct shall be a minimum of 100mm in length and collars to which the ductwork is attached shall be a minimum of 50mm in length. Secure the flexible duct to sleeve or collar using a worm screw type draw band, or approved equivalent. If the diameter of the sleeve or collar exceeds 300mm position draw band behind a bead on the metal collar or sleeve. Seal joints with 50mm wide minimum PVC tape and cover with foil tape.

Flexible ductwork shall be hung using 25mm wide hanging straps at 2m centres with the duct extended to 90% of its full length. Hanging straps may be glass fibre reinforced hanging tape or PGI. All flexible duct shall be supported a minimum of 150mm off the ceiling.

All flexible ductwork shall comply with the BCA.

Flexible ducting shall display maximum indices of Spread of Flame, zero (0) and Smoke Developed, three (3) in accordance with AS1530.3, as referenced by AS1668.1:1998.

The Contractor shall carry out testing of flexible ducting (to AS 1530.2) in the presence of the Engineer.

Flexible ductwork (both metal and reinforced fabric type) shall comply with all requirements of AS 4254. In addition, all aspects of the flexible ductwork installation including collars, sleeves, joints and suspension systems shall comply with all requirements of AS 4254. The bulk insulation, the duct care and the duct system (the assembled final product) shall all comply with the fire performance requirements of AS 4254 when tested in accordance with AS 1530.3 and the UL 181 burning test.

Manufacturer's test certificates shall be submitted for approval as part of the equipment schedule.

C.6.6 General Details

C.6.6.1 Trimming Angles

Where ducts pass through walls, floor slabs, ceilings, blanking panels, etc., the space around the duct shall be packed with fibretex blanket and approved 1.6mm GSS trimming angles shall be installed around the ducts to effect a neat finish.

Where penetrations are in view, trim openings with galvanized sheet steel with crimped edges screwed or riveted to the duct, painted to match adjacent surfaces.

All trimming angles shall be sealed airtight with mastic.

C.6.6.2 Acoustic Flashings

Where ducts pass to or from plant rooms, to or from sound proof rooms, or through holes in slabs or walls, the duct shall be acoustically flashed.

Insulated ductwork shall be flashed with 1.2mm PGI flanges that bridge between the ductwork and the building structure. The space between the ductwork and the building structure shall be tightly packed with “Tontine” insulation, or approved equivalent, of 32 Kg/cubic metre density.

Uninsulated ductwork shall be flashed with 1.2mm PGI flanges that bridge between the ductwork and the building structure. Loaded vinyl sheet of 5mm thickness and 5kg/m^2 density shall then be applied to the ductwork and flashing.

The loaded vinyl shall extend along the ductwork, either side of the penetration for a distance equal to twice the largest ductwork dimension and shall return along the flashing onto the building structure a minimum distance of 75mm. The remaining open corners at the flashings shall be filled with additional loaded vinyl.

Acoustic flashings shall generally be as shown on the drawings.

C.6.6.3 Weather Flashings

Where ductwork penetrates roof structures and external walls and is exposed to weather, the Contractor shall make allowance for the provision of over flashings.

C.6.6.4 Dissimilar Metals

Where dissimilar metals are likely to generate electrolytic, galvanic or corrosive action separate by purpose made fittings manufactured in a suitable compatible material.

C.6.6.5 Flexible Duct Connection

Provide flexible connections wherever ductwork connects to fans and or conditioner casings, as indicated on the mechanical drawings.

Flexible connections shall be fabricated from heavy duty PVC fabric and shall provide a minimum free length of 100mm.

The flexible material shall be fixed to both attachments using galvanized steel strip or other approved methods and seal joints. Ensure that no part of the flexible connection protrudes into the air stream where such protrusion would be detrimental to air flow.

The connection shall be sufficiently slack to ensure free movement and vibration of the item of equipment under operating conditions. Misalignment between duct and equipment openings shall not be allowed.

Where flexible connections are exposed to weather, a weatherproof sheetmetal cover that will not restrain the free movement of the flexible connection shall protect the connection.

Flexible connections between smoke spill fans and wall sleeves or ductwork shall be fabricated from woven heat resisting fabric in accordance with the requirements of AS 1668 Part 1. The flexible connections shall conform to the remainder of the notes above.

All flexible connections shall be arranged to permit the easy removal and replacement of the connections without disturbing the ductwork or plant and the easy removal of the equipment without disturbing the ductwork.

Flexible material shall not be painted.

C.6.6.6 Access Panels

Provide access panels where shown on drawings or where required for access to fire dampers. Fan motors, damper motors, etc. Except where prohibited by duct dimensions access panels shall be either manholes having a clear opening of 450mm x 600mm or handholes having a clear opening of 200mm x 300mm. Where this size is not possible, access panels of the side length of which is 50mm narrower than the side of the duct in which the handhole is located, shall be provided, subject to the approval of the consulting engineer.

Access panels shall be so constructed that no part of the access panel of cover shall project into the airstream and the cover when shut shall be flush with the inside surface of the duct.

Access panel shall be made from 1.2mm thick galvanised steel sheet. Panels shall be attached to the duct with self tapping screws, or where the sealing of the panel is designed to avoid cold-bridging, wedge type window sash catches may be used.

Where the duct is insulated the panel shall be insulated to the same thickness and to the same requirements as the duct. Where the insulation is inside the duct the surface of the panel insulation shall be flush with that of the duct.

On ducts carrying cooled air, the panel and the panel seal shall be particularly designed and constructed to avoid cold-bridging which will result in condensing on the outside of the duct. In these cases the particular design shall be submitted to the Engineers for approval.

Access panels shall be provided with rubber or neoprene gaskets fixed to either panel or frame. Panels shall be airtight when latched in the closed position.

C.6.6.7 Access Doors - Ductwork and Conditioners

Provide access doors where shown on drawings, adequately reinforced to prevent distortion, hinged so that internal air pressure holds the door closed.

Doors shall be sized as shown on drawing or if not indicated shall have a clear minimum opening size of 1350mm x 500mm.

Construction of doors shall be such as to prevent cold bridging. Doors shall be provided with matching galvanized steel frames securely attached to the duct ensuring that no part of the doorframe protrudes into the air stream where such protrusion would be detrimental to the airflow.

Provide sufficient clamping type latches and handles which can be operated from both inside and outside of the door.

Mechanically fix rubber or soft neoprene gaskets to either the door or frames. The door shall be airtight when latched in the closed position where fire rating is required use woven ceramic fibre material.

C.6.6.8 Hardware

Handles, latches, hinges and the like shall generally be galvanized or electro-zinc plated except where normally exposed to view or exposed to weather in which case they shall be chrome plated.

Bolts, nuts, washers, drop rods and self tapping screws shall generally be galvanized or electro-zinc plated steel, or of stainless steel.

Rivets shall be expanding solid end type aluminium based alloy. Open head rivets shall NOT be allowed. Rivets shall be spaced at not more than 75mm centres.

Angles and bracing shall be riveted to ducts and bolted joints shall be made with 8mm diameter galvanized steel bolts at 100mm maximum centres.

C.6.6.9 Sealants Gaskets and Tapes - Ductwork

Sealants including liquid sealants shall be compatible with materials in contact and maintain an effective seal at the service pressure and have permanent elasticity and adhesion. Liquid sealants and mastic are not acceptable for sealing flange joints airtight, but may be used to make drive cleat and slip joints airtight provided the sealant or mastic is held in the joint by lapping metal surfaces or surfaces under compression.

Flange joints and other surface seals shall utilize neoprene gaskets to form an airtight seal. Gaskets shall generally be a minimum of 3mm thick adhesive backed PVC foam tape or rubber, resistant to age, fungi and the elements of weather.

The use of self adhesive tapes shall be limited to flexible ductwork spigots and joints, in which case worm screw or drawband shall also be used. Where tapes are used they shall be a plasticised pressure sensitive type PVC tape, suitably applied to provide an air tight seal and aluminium foil tape suitably applied to provide the required fire rating.

All sealants, gaskets and tapes shall be non toxic under service conditions. Details of the type of sealants gaskets and tapes intended to be used shall be submitted to the consulting engineer for approval prior to use.

C.6.6.10 Duct Bends and Turning Vanes

Where possible all bends shall have an inside radius equal to or greater than 0.75 times the duct width. Where this is not possible, bends having a smaller radius shall incorporate one or more single skin turning vanes made from 1.2mm galvanized sheet steel, with 15mm long hem on the outside of the vane. The number and position of vanes shall be in accordance with the NATSPEC Specification.

Where square bends are used they shall incorporated double skinned turning vanes made from 0.8mm galvanized sheet steel. The turning vanes shall have the following spacing and inside radius.

Duct width up to 750mm - 50mm radius and 30mm between tips.

Duct widths Greater than 750mm - 100mm radius to 60mm between tips.

Length of vanes shall be limited to 900mm. Where vane lengths exceed 900mm, two vanes, of equal length shall be fitted incorporating a suitable interim support. Where bends are internally insulated, the vanes shall incorporate an end plate to sit on the face of the insulation being fixed using suitable spacers to ensure insulation is not compressed.

Where duct velocities exceed 7.5m/s all turning vanes shall have individual vanes lined with 1mm thick felt lining, securely fixed to the vanes using an approved sealant.

C.6.6.11 Tapers, Offsets, Obstructions and Restrictions

Where possible, tapers for transitions and restrictions shall be limited to a slope of 1:4 for converging air flow and 1:7 for diverging air flows. Where a change of shape retains the same cross-sectional area, tapers on converging air streams may be increased to 1:4.

Where tapers exceed the above internal splitters shall be positioned to bisect the angle between any side and the centreline of the duct. Tapers shall not exceed an angle of 45°.

Where possible, offsets shall be angled at a maximum of 15°. Where this is exceeded, offsets shall incorporate full radius bends. Where space limits the use of full radius bends, radius bends with turning vanes or square bends with turning vanes shall be used all to the approval of the consulting engineer.

If it is impossible to offset a duct around an obstruction the obstruction may be encompassed with a two-piece streamliner provided the streamliner does not decrease the duct area by more than 20%. An obstruction may pass through a duct and be in contact with the air stream provided it does not decrease the duct area by more than 20% or be subject to cold bridging.

All built in obstruction details are to be approved by the consulting engineer.

Where ductwork is restricted by building structure or limited space, the ductwork may be locally reduced to clear the obstruction provided that the reduction or duct area does not exceed 20%.

C.6.6.12 Ductwork on Site

During installation where ductworks is left more than eight hours without further work and/or awaiting commissioning all ducts and fan openings shall be sealed.

Where ductwork is stored on site for any period of time the ductwork shall be stored in a clean, dry and protective environment. Where ductwork is damaged by weather or other means, the ductwork shall be removed from site to be re-insulated or re-placed as directed by the consulting engineer, at no additional cost to the contract.

Before starting fans, all ducts shall be cleaned inside to the satisfaction of the consulting engineer.

C.6.7 Dampers

C.6.7.1 Volume Control Dampers - Ductwork

Dampers shall generally be of the multi-leaf opposed blade type with extruded aluminium blades inclusive of rubber edge seals.

Volume control dampers shall be free of rattles, fluttering or slack movement and shall be capable of adjustment over the desired range without excessive self generated noise or the need for special tools.

Dampers shall be fitted with a visible indicator to clearly show the position of the damper.

Blades shall be secured to spindles via locking keys. Spindles shall rotate in neat fitting nylon bushes or ball bearing races.

Mechanical linkages shall be provided for operation by control devices. Such control devices shall be sized and mounted to ensure correct operation of the dampers.

The selected damper actuators shall be submitted to the consulting engineer for approval.

Actuators shall be mounted to ensure maximum mechanical advantage. Mounting of actuators shall be rigid enough to prevent flexing or distortion of the ductwork or actuator mounting during operation.

All outside air intake dampers shall incorporate separate actuators and drives to enable independent operation of the areas of the damper associated with the minimum outside air requirement and the remainder of the damper.

Manually operated dampers shall be located in an accessible position for visual inspection, maintenance and adjustment.

Locking and adjustment to any position shall be provided using a lever and quadrant or adjustment rods. Position of dampers shall be clearly and permanently marked "open" or "closed".

All volume control dampers shall operate over the entire range of positions and affect a positive shut off seal without undue noise.

C.6.7.2 Fire Dampers and Smoke Dampers

Fire dampers of an approved type shall be supplied and installed at all points where shown on the drawings.

Fire dampers shall be constructed and installed to meet the requirements of the Australian Standard Code AS 1682 and AS 1668, Part 1 and to requirements of Local Authorities. The manufacturer will be required to submit evidence that the dampers conform to the above requirements.

Fire dampers shall be 1.60mm galvanised steel in ducts up to 450mm diameter or greatest width, 2.50mm on diameters up to 900mm or greatest width, and 5.0mm on ducts above 900mm diameter or greatest width. Where multi-blade dampers are used they may be constructed of 1.20mm steel provided the individual blade is not wider than 150mm and is stiffened by formed edges.

Fire dampers shall be arranged to close automatically and remain tightly closed upon the operation of an approved fusible link, located where readily affected by an abnormal rise of temperature in the duct.

Fire dampers shall be installed with access panels located in the ductwork, arranged to provide access to the fusible link and spring locking catch for servicing and inspection.

The damper blades shall have self aligning sintered bronze bearings pivoting on stainless steel stub shafts.

Fire dampers shall be permanently, legibly and indelibly marked in accordance with Australian standard AS 1682.

A smoke damper shall be a fire damper whose closing action is initiated by the detection of smoke.

C.6.8 Conditioner Casings

Conditioner casings include all supply and return air plenum chambers, enclosures, and air passages between the air inlets, heating and cooling coils and fans.

All casings shall be arranged substantially as shown on the drawings but may be modified to the extend required to suit the particular type and size of air handling equipment offered and supplied.

All casings enclosing air handling equipment shall be installed on concrete floors or plinths or floating slabs which serve as the bottoms, as shown on the accompanying drawings. The sides and tops shall be constructed in sheet metal in accordance with the following requirements, unless specifically shown on the accompanying drawings to the brickwork or concrete.

All casings, including doors and other details, shall be of best quality Galvabond steel panels, not less than 2mm thick and rigidly braced with galvanised steel angles.

All casing sheets shall be formed into dished panels with 25mm or 50mm deep stand-up edges (whichever is necessary to fully accommodate the insulation required) and 15mm deep returns. All corners of dished panels shall be welded.

All bracing angles shall be not less than 50mm x 50mm x 50mm thick galvanised mild steel angle.

All panels shall be bolted together with galvanised bolts and nuts at not more than 150mm centres.

Casings shall be fixed to floors and walls with not less than 50mm x 50mm x 5mm thick galvanised sheet metal channel. The channel shall be bolted to the floor at not more than 300mm centres with masonry type anchors. Panels shall be fixed to the channel at not more than 150mm centres with galvanised bolts and nuts.

All joints shall be made airtight with "Tremtape" or approved equivalent sealing strips neatly and accurately installed. Caulking compound shall not be used in any visible or exposed location. Completed conditioner casings shall be airtight and rigid and in all respects satisfy the performance requirements of the specification.

Any excess deflection, rattling, flexibility or other fault shall be corrected to approval.

All necessary penetrations for wiring to the motors and lights etc. within the casing shall be provided in liaison with the appropriate electrical Sub-Contractor and made good after installation of the wiring.

All conditioner panels including doors, discharge plenums and fresh air plenums shall be insulated in accordance with the "Insulation Systems" section of this Specification.

C.6.9 Kitchen Hood Exhaust Ductwork

Hoods shall be positioned to be central over the equipment served. Exact dimensions and locations of the hoods shall be determined on site prior to manufacture.

Exhaust hoods shall generally be manufactured and installed to comply with the requirements of the "Food Hygiene Regulations, 1983", the Local Authority and AS 1668.2.

Hoods shall be built up on 50 x 50 x 9 galvanised MS angle frames or equivalent framing.

All visible hood panelling shall be fabricated from 1mm stainless steel No. 304 satin finish. Concealed surface may be fabricated from stainless steel or 1.2mm zincanneal.

Joints in exposed surfaces shall be kept to an absolute minimum.

All joints shall be of the concealed folded type, welded after assembly, ground smooth and buffed to a satin finish.

All joints shall be sealed airtight.

Badly made joints will be rejected.

Hood panels shall be cross-broken and internally braced as necessary to prevent drumming and sagging.

A suitable drain plug shall be installed in the gutters of the kitchen hood to facilitate cleaning.

The detailed design of the hoods shall be submitted to the Architect and to the Local Authority for approval prior to any fabrication.

Hoods shall be suspended from the structure above by means of 13mm MS rods.

Suitable trimming angles if required for hanging purpose shall be bolted to the structure as part of this contract.

Grease filters, as indicated, shall be fitted in the kitchen exhaust hood.

Grease filters shall be of "Continental" type GW or approved equivalent, and shall be easily removable for cleaning.

Kitchen exhaust ductwork shall be manufactured from 1.2mm GSS strictly in accordance with SMACNA recommendations and AS 1668 Part 1 and shall have easily removable access panels at 3 metre intervals and at every change of direction to facilitate cleaning of ductwork. Access panels shall be sealed airtight.

Ductwork shall be graded in the direction of airflow to drain points, drained via 25 dia copper drains to waste points.

C.6.10 Supply Air Cushion Heads

Cushion heads shall be constructed of PGI, fully externally or internally insulated to prevent cold bridging minimum internal dimension of cushion heads shall be 500 x 500 in plan, 400 high where clearance permits.

C.7 PIPEWORK, VALVES AND FITTINGS

C.7.1 Description of Piping

C.7.1.1 General

Provide complete operating pipework systems as described as follows and as shown on drawings complete with all necessary fittings, supports, sleeves, valves, etc.

Provide all minor components required for a complete installation, unless specifically excluded.

All pipework systems shall be suitable for its respective service under the actual operating conditions of temperature and pressure.

Piping shall be arranged in a workmanlike manner, true to alignment and grade. Misaligned or sagging pipes will not be accepted.

C.7.1.2 Pipework Schedule

Refrigerant Piping	Material:	Copper, type B tube
	Design Pressure:	2800 kPa
	Operating Temperatures:	-20°C to 70°C
Drains, Vents: (D, V)	Material:	Copper, type B tube
	Design Pressure:	100 kPa
	Operating Temperatures:	Ambient

C.7.1.3 Insulation and Sheathing Schedule

Insulation details are specified in the "Insulation Systems" section of this Specification.

Condenser Water, Mains Water, Drains, Vents:

- Insulation not required.

Refrigerant Piping:

- Insulate all suction pipework, on reverse cycle units insulate suction and liquid lines.

- Insulation shall be foam type, with thickness complaint with BCA section J
- Metal clad all insulation where exposed to view in plantrooms, accessways. Metal clad all valve boxes.

Drains:

- Insulation not required except in ceiling spaces.
- Insulation shall be foam type 13mm thickness.

C.7.2 Pipework Design and Installation

C.7.2.1 Design

The drawings indicate the sizes of pipes and the manner in which the various systems are to be run. They do not necessarily show all the minor pipework bends and offsets included in the contract.

The final design shall be co-ordinated with other trades and services, measured on site where possible, and ascertained from architectural and trade drawings of the project.

Where possible, the Contractor shall adhere to the piping layout indicated. Where this is not possible, due to the type and arrangement of the particular equipment to be installed, approval shall be obtained to manufacture or installation.

Pipework shall be installed to approval to suit the building structure and to avoid interference with other trades.

The piping installation shall be in accordance with best modern practice, taking into account grading, venting, safety, thermal expansion stresses, expected movement.

C.7.2.2 Refrigeration Pipework

The drawings indicate the piping routes for the various refrigeration systems. Refrigeration pipework shall be sized to suit the equipment offered allowing for pressure drops as follows:

Liquid line	0.5 degree K
Hot gas line	1.0 degree K
Suction line	1.0 degree K

Refrigerant piping, valves and accessories shall conform to the equipment manufacturer's requirements.

Isolating valves shall be provided to permit dismantling and removal of the plant without disturbing piping layouts.

C.7.2.3 Installation Drawings

Pipework installation drawings shall be prepared and submitted for approval prior to purchase of equipment, and installation of pipe systems.

Drawings shall show all minor components, drains, vents, gradients, supports, and co-ordination/interface items. All proprietary brand components shall have make/model shown. Valve schedules shall be provided with the drawings or incorporated on the drawings.

C.7.2.4 Installation

Provision shall be made for the expansion and contraction of pipes so that they will remain aligned and will not be damaged due to build up of stresses or cause damage to other equipment or structures.

Where pipes run close to walls, floors or ceilings, a minimum distance of 50mm shall be maintained between the pipes or their insulation and the nearest surface.

Pipes shall be positioned such that all valves, controls, etc. installed are readily accessible and can be easily and properly operated.

Piping shall be site stored in a manner to prevent penetration of moisture and foreign matter and shall be thoroughly cleaned of all burrs, fur and scale before erection.

All connections to equipment shall be installed with flanges or unions to facilitate installation and maintenance, and to comply with the requirements of the equipment manufacturer.

C.7.3 Pipework Types

C.7.3.1 Copper Pipework

Copper pipework shall be of "as drawn" seamless copper tube complying with the requirements of AS 1432 and AS 1571.

Pipe wall thickness to AS 1432, TYPE B tube, or greater.

Joints in copper piping, unless otherwise noted, shall be silver soldered.

Silver soldering shall be carried out with SBA 115 or approved equivalent. Flux shall be thoroughly washed off after soldering.

Fittings in copper piping shall be capillary fittings of wrought copper.

All connections to equipment on piping over 50mm diameter shall be flanged. Flanges shall be to Table E dimensions, fitted with ring gaskets.

Flanges on piping shall be of bronze and all flange bolts shall be cadmium plated. All connections to equipment on piping 50mm diameter and below shall be made using approved heavy duty compression union fittings.

All reductions in pipe shall be made using standard fittings. No reducing flanges, bushings, etc. will be permitted without approval.

Pipe branches from main lines shall be radiused into the main lines. Standard tees shall be avoided.

Pipe bends in the main plant area where limited space is available may have a throat radius equal to the pipe diameter. Pipe bends in other areas shall, where possible, have a throat radius equal to 2.5 times the pipe diameter.

C.7.4 Pipe Supports

C.7.4.1 General

Provide support systems including hangers pedestals, saddles, anchors, and guides to adequately secure and align pipes, restrain internal forces and expansion/contraction stresses.

Steel supports shall be hot dipped galvanised after fabrication. Proprietary systems of supports may be utilized. Bolts shall be galvanised for applications exposed to the weather, and may be cadmium plated for internal applications. Fabricated supports shall be detailed on the installation drawings.

Parallel groups of pipes shall be run on common supports in neat groups.

Pipework shall have spring hangers on at least the first two (2) hangers from any item of rotating/reciprocating machinery.

C.7.4.2 Support Spacings

Pipe support spacing shall not exceed:

PIPE SIZE Nominal (mm)	SUPPORT SPACINGS (mm) Copper Pipe	Steel Pipe	Non-Metallic Pipe
10 and 12:	1200	1500	800
15 to 40:	1500	2000	1200
50 to 65:	2500	3000	1500
80 to 125:	3000	4000	2000
above 125:	4000	5000	2500

Support spacing shall be sufficiently close to enable pipe systems to have continuous fall to vents/drains.

Hanger rods shall be 10mm for pipe up to 50mm diameter, 12mm for pipe up to 100mm pipe diameter and 15mm for pipe above 100mm diameter.

C.7.4.3 Compressed Air Piping

Compressed air piping shall be of galvanised, medium duty tube of quality not less than that specified in AS 1074-1989.

Compressed air piping shall have the following minimum wall thickness.

NORMAL SIZE	WALL THICKNESS
15mm to 20mm	2.65mm
25mm to 40mm	3.65mm
50mm to 65mm	3.65mm

Compressed air piping up to and including 25mm diameter shall be screwed.

Pipping 40mm diameter and over shall be fully welded.

All bends shall be long radius, short radius bends will not be permitted without prior approval.

All screwed fittings shall be galvanised heavy duty malleable iron construction.

C.7.4.4 Support Details

Where pipe lines are insulated, hangers shall be placed on the outside of the insulation. At each hanging point a suitable heavy gauge PGI sheath shall be wrapped around the insulation. Sheaths shall be 200mm long on pipes up to 63mm diameter and 300mm long on pipes 75mm diameter and over. Sheaths shall be of sufficient thickness to support the pipe and its contents without deforming. Sheaths shall be installed over any insulation or wrapping.

Where pipes are not insulated, direct contact between dissimilar metals shall be prevented by means of approved separating gaskets.

C.7.5 Vents, Drains, Minor Fittings, Sleeves

C.7.5.1 Penetrations, Sleeves

Provide pipe sleeves at all wall, floor or roof penetrations. Sleeves shall be type A copper where pipes pass outside the building, and may be 3mm thick P.G.I for internal penetrations.

Insulation shall be continuous through the sleeve. The gap between the outside of the insulation (or pipe, if bare) shall be sealed airtight with high density insulation. Where fire rating is required, high temperature mineral wool packing shall be used.

Where pipes penetrate floors, the sleeves shall extend 75mm above the floor level, for waterproofing.

Suitable trimming collars shall be installed around all pipes where they pass through walls, ceilings or concrete slabs.

C.7.5.2 Vents and Drains

Pipework shall be installed to grade to air vents and drains to enable complete pipework systems to be rapidly vented on commissioning, and fully drained for maintenance.

Gradients shall be 1:500 minimum, with pipes rising in the direction of flow where compatible with other requirements.

Provide air vents to all high points in water systems and drains at all low points so that there can be no possibility of air locks and the system can be drained easily.

Air vents shall be of the "Spirax" automatic float type. Isolation gate valves shall be installed between each air vent and the main pipe and 15mm drain lines shall be run from each vent to nearest drain point.

Drains in the water circulating systems shall consist of 20mm valved drain-offs with hose bib attachment threads.

Drain lines shall be run to waste in 20 diameter copper and shall be provided with screwed unions to facilitate cleaning.

C.7.5.3 Gauge Cocks and Thermometer Pockets

The Contractor shall supply and install all thermometer pockets and gauge cocks as shown on the drawings and as further required for adjusting and setting the controls.

Gauge cocks shall be brass bodied 13mm ball valves with stainless steel ball

Thermometer or sensor pockets in piping 38mm diameter or less shall be installed in a 300mm long expanded section of pipe shall (to avoid excessive pipe velocities around the pocket), with eccentric reducers.

Pockets shall be installed at an angle of 30 degrees to the pipe axis trailing in the direction of flow.

Pockets shall project a minimum of 44mm beyond any pipe insulation and shall be threaded to suit.

C.7.6 Pipe Testing

Piping shall be hydrostatically tested in accordance with the "Commissioning and Testing" section of this Specification before the application of any insulation.

If necessary, the piping systems shall be tested in sections as required by the progress of the work.

Ensure that all items of equipment not designed for a working pressure of the required test pressure such as pumps, automatic controls, valves, etc. are isolated from the system during pressure testing.

Test pressure shall be maintained for ten hours and all lines inspected during the test period. Any leaks shall be rectified and the pipes re-tested and re-inspected.

C.7.7 Valves

C.7.7.1 Valve Schedule

A schedule of the valves intended to be used on the project, indicating sizes, working pressure, design pressures, flow rate/pressure drop characteristics, etc, particularly control valve sizing and system pressure drop calculations shall be submitted to the consulting engineer for approval prior to purchase or installation of the respective equipment.

C.7.7.2 Refrigeration Service Valves, General

All valves shall be of FL Hudson or equivalent approved manufacture.

Valves shall be of brass construction suitable for R22, R407 or other approved refrigerant, as appropriate.

Valves shall be suitable for operation at the test pressures specified in the SAA Refrigeration Code.

C.7.7.3 Refrigeration Services Valve Types

Permitted valve types for the refrigeration services shall be as follows:

Isolating Valves -	All Sizes	Packed back seating key operated type.
Solenoid Valves -	All Sizes	Low pressure drop type.
Pressure Relief Valves -	All Sizes	Bursting disc or fusible plug type.

C.7.7.4 Refrigeration Service Liquid and Moisture Indicators

Liquid and moisture indicators shall be installed in each refrigerant system and/or prior to each expansion valve. Liquid and moisture indicators shall be of "Heldon" or approved equivalent make.

C.7.7.5 Refrigerant Expansion Valves

Refrigerant expansion valves shall be of "Danfoss" or approved equivalent make.

C.7.7.6 Refrigerant Dryers

Refrigerant dryers shall be installed in each refrigerant system.

Dryers shall be of the Hudson in line type. And shall be installed parallel to a valved bypass line to facilitate renewal of the dryer.

C.7.7.7 Refrigerant Strainers

Refrigerant strainers shall be “YK” full flow type or approved equal.

Isolating valves shall be located on either side of the strainer.

Screens shall be readily removable.

C.7.8 Underground Piping

C.7.8.1 Refrigeration Piping

Buried refrigerant lines insulated with chemically blown PVC nitrile rubber sponge insulation ("Ensolex" or similar) shall be encased in a continuous polyethylene sleeving to approval.

The polyethylene sleeving shall be installed in such a way as to form an encasement for the insulated pipe in order to prevent both the backfill material from contacting the insulation and the free movement of ground water within the sleeving.

The sleeving shall be securely held in position so as not to be displaced by the placing and settlement of the backfill material.

Care shall be taken to avoid damage to the sleeving during installation. Any damage to the sleeving shall be repaired by using additional sleeving and adhesive tape as appropriate.

The sleeving excess shall be gathered and folded tightly around the insulation.

Buried un-insulated refrigerant lines, e.g. hot gas and liquid lines, shall be wrapped in "Denso" tape to approval.

C.8 INSULATION SYSTEMS

C.8.1 Description

C.8.1.1 General

Provide complete systems of acoustic and thermal insulation where required in the drawings and other sections of this Specification.

Insulation shall be applied by skilled trades persons. Materials shall be protected from dust and moisture on site, and shall be selected to be compatible to adjacent surfaces, and shall not promote corrosion.

Insulation systems shall be protected from deterioration due to exposure to moisture and sunlight.

Services buried underground (whether insulated or uninsulated) shall be protected by wrapping with "Denso" impervious tape as a minimum.

Insulating materials used within buildings shall comply with all requirements of AS 1668 Part 1, and shall particularly have:

- A spread of flame index number no greater than 0.
- A smoke developed index number not greater than 3.

Both as determined in accordance with AS 1530 Part 3.

C.8.1.2 Extent of Ductwork Insulation

Refer "Ductwork Systems" section of this Specification for insulation requirements and thickness and refer also system drawings.

C.8.1.3 Extent of Pipework Insulation

Refer "Pipework Systems" section of this Specification for insulation requirements, thickness, and cladding.

C.8.2 Ductwork Insulation

C.8.2.1 Internal Insulation

Internal insulation shall be "Bradford Supertel" semi-rigid fibreglass batt of 32 kg/m^3 density or approved equivalent.

The insulation shall be placed on the inside of the duct with adjacent sides overlapping at all corners and with all joints tightly butted. All joints in insulation panels shall be made with a minimum 50 mm lap of foil in the direction of air flow to prevent the air stream lifting the leading edge.

All raw edges of insulation shall be covered with "Sisalation 450", wrapped around and glued on with an approved adhesive.

Insulation shall be held in position by means of studs spot welded to the inside of the ducts and plastic coated speed clips at approximately 300 mm centres. At all duct corners, insulation shall be held in position by means of longitudinal 50 mm x 50 mm x 1 mm GSS corner angles.

All joints in insulation shall be covered with a 100 mm wide strip of sisalation 450 glued on with a suitable adhesive.

The following table sets out minimum internal insulation performance:

Minimum R-Value (m^2 kW)	Nominal Thickness (mm)
0.8	25
1.0	38
1.5	50
2.0	75

C.8.2.2 External Insulation

External insulation shall be "Bradford Multitel" semi-rigid fibreglass batt of 18 kg/m^3 density or approved equivalent.

Insulation shall be fixed with adhesive to ductwork, and held in place with aluminium band strapping at 450mm centres.

Insulation shall be applied with edges tightly butted up against adjoining insulation to form a final continuous blanket around the duct. Joints shall be sealed with 100 mm wide "Sisalation 450" tape, fixed with an approved adhesive.

The following table sets out minimum external insulation performance:

Minimum R-Value (m^2 kW)	Nominal Thickness (mm)
0.7	25
1.0	38
1.5	55
2.0	75

C.8.2.3 Insulation Facing

Where nominated as **"Perforated Foil Faced"**, the insulation shall be faced with "Bradford Thermfoil HD Perf" factory bonded, double sided, fire resistant, perforated, reinforced aluminium foil or approved equivalent. Maximum air velocity: 18 m/s.

Where nominated as **"Foil Faced"**, the insulation shall be faced with "Bradford Thermfoil HD" factory bonded, double sided, fire resistant, perforated, reinforced aluminium foil or approved equivalent. Maximum air velocity: 18 m/s.

Where nominated as **"Matt Faced"**, the insulation shall be faced with "Bradford Ultraphon" factory bonded fibreglass tissue or approved equivalent. Maximum air velocity: 22 m/s.

Where nominated as **"Perforated Metal Faced"**, the insulation shall be sheathed internally with 0.6 mm thick galvanised perforated steel, securely fixed by means of approved metal clips, screws and bolts. All edges of the perforated metal shall be covered with corner angles, channels, etc. to eliminate rough edges and present a smooth surface to the air flow. Perforated metal shall incorporate 3 mm diameter holes occupying not less than 14% of the surface area

C.8.2.4 Internal Insulation - Acoustic Requirements.

Acoustic properties of the insulation systems shall be as follows:

Reverberation room method to AS 1045:

Insulation:	**Nominal Absorption Coefficients at:**				
	125 Hz	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**
Matt faced:					
- 25mm thick:	0.10	0.39	0.79	1.00	1.05
- 50mm thick:	0.30	1.01	1.31	1.20	1.05
Perforated foil faced:					
- 25mm thick:	0.12	0.28	0.68	0.94	0.81
- 50mm thick	0.23	0.71	0.99	1.09	0.97
Perforated metal clad:					
- 25mm thick:	0.14	0.29	0.71	0.99	0.81
- 50mm thick:	0.20	0.73	1.00	0.99	0.89

C.8.2.5 Conditioner Casings, Air Handling Rooms, and Masonry Shafts

Conditioner casings shall be internally insulated throughout with 25mm or 50mm thick insulation: Refer "Ductwork" section for insulation thickness and facing material.

Air handling rooms and Masonry shafts shall be insulated where specified, with 25mm or 50mm thick insulation. Refer "Ductwork" section for extent of insulation, thickness and facing material.

Insulation shall be semi-rigid fibreglass or mineral wool batts of at least 32 kg/m^3.

Batts shall be faced with either:

- Perforated metal: 0.6mm thick perforated P.G.I with 3mm holes giving 14% free area, over black scrim faced batts;

OR

- Aluminium foil faced: perforated, factory bounded, double sided, “Sisalation 450” or approved equivalent.

Note that foil faced insulation shall be lined with perforated P.G.I to a height of 1500 mm AFL to prevent mechanical damage.

Batts shall be held in place by 0.8mm thick P.G.I angles and channels. Channels shall be spaced at no greater than insulation sheet width (i.e. 1200mm or 1500mm) and shall also be provided at all edges and corners.

Foil faced batts shall be fixed with adhesive and with proprietary drive pins.

No insulation shall be fitted closer than 100mm above floor level to avoid contact with moisture.

C.8.2.6 Flexible Elastomeric Foam Insulation

Flexible foam insulation may be utilised where specifically permitted on the insulation schedule (refer "Pipework" sections).

Insulation shall:

- Be 20mm thickness, unless specified/shown as greater.
- Have closed cell construction inherently vapour sealed type.
- Be "Armaflex", "Bradflex", "Aeroflex" manufacture.
- Be slip-on style (not slit).

  Have butt joints fully glued to each face and the pipe. Adhesive shall be as recommended by insulation manufacturer. Taped joints not allowed.
- Be applied in lengths 10% greater than pipe length to allow for shrinkage.
- Have cork ferrules at supports, glued as for insulation.

Metal sheath or paint as specified for conventional insulation.

Insulation bends over short radius pipe fittings shall be made using oversize insulation, mitre cut.

Insulation run externally shall be painted and provided with sheet metal weather covers, or shall be fully metal sheathed and silicone mastic sealed.

C.8.2.7 Metal Cladding of Pipe Insulation

Sheet metal cladding shall be fabricated from either of the following materials:

- 0.6 thick or greater galvanised steel sheet, from full size standard sheets. Cladding shall be finish painted as per section "Painting and Finishes".

- 0.8 thick or greater best quality bright aluminium from full size standard sheets. Surface of aluminium need not be finish painted if clean bright finish is maintained throughout construction, and cleaned after commissioning.

Sheet metal shall be neatly cut and rolled to the required sizes with beaded transverse joints and applied to provide tight fitting jackets with not less than 30 wide lap joints. Longitudinal joints shall be staggered and faced away from view. All joints shall be made with self-tapping screws spaced at not more than 100 intervals, such that they do not impair the vapour sealing of the insulation.

Metal sheathing for pipe bends and curved equipment surfaces shall be in the form of lobster back segments joined together with self-tapping sheet metal screws spaced at frequent intervals.

All joints exposed to weather or located in moist locations, shall have all joints fully soldered or sealed with a silicone mastic of suitable grade.

Where protruding through external walls or floor slabs all metal cladding shall be double flashed with fully soldered joints.

All flanges, valves and associated pipe fittings shall be insulated as for the particular pipework system involved and shall be complete with readily accessible covers suitable for maintenance purposes, manufactured from sheet metal of the same type as that used for cladding of adjacent pipework.

Covers shall be made in two halves and shall be completely removable and fastened with quick release catches. Line with pre-formed insulation having same thickness as specified for adjacent piping and shall be completely vapour proofed where required for the system.

C.9 AUTOMATIC CONTROLS

C.9.1 General

Controls shall be generally of the electronic type, as manufactured/nominated by existing BMCS provider, or approved equivalent, interconnected by electric relay logic.

All control systems shall be designed to optimise simplicity of each control loop, and facilitate maintenance and fault-find procedures.

Controls shall in general be of one make throughout and installed in full conformance with the manufacturers' instructions.

C.9.2 Control Systems

Supply, install and commission all automatic and manual controls for the control systems listed below:

- Buildings VRV/VRF air conditioning systems.

- Toilet exhaust systems.

- Miscellaneous exhaust systems.

- Miscellaneous works.

C.9.3 Control Sequence

C.9.3.1 Single Zone Fan Coil Units

The BMCS shall allow the following controls interface from the central BMCS system via a BACNET interface.

On/Off indication

Set point adjust

Current Space Temperature indication

Fault indication

Fan speed control.

On/Off time clock control.

Run time logging.

Allow for 4 after hours push button

Motorised dampers on the outside air are to be interlocked with the FCU supply air fan.

If condensate pump is installed, it shall be interfaced with the compressor.

C.9.3.2 Toilet Exhaust Systems

Toilet exhaust systems shall operate on 365 day schedule programmable by the building control system.

C.9.3.3 Kitchen Exhaust System

Kitchen exhaust systems shall operate via proprietary push button operation. .

C.9.3.4 Temperature Indication

The following temperature sensors are required to input multi-point temperature indicator/s. The multi-point temperature indicator/s shall be mounted in the MSSB.

The following temperature indication points are required:

- Supply air temperature (off coil) for each FCU.
- Return air temperature for each FCU.
- Zone temperatures one point for each zone of each FCU in an approved location.
- Ambient temperature.
- 4 spare indication points.

C.9.4 Specific Items and Control Functions

The following specific control items and functions, together with minor components necessary to meet the intent of the Specification, shall be included in the tender.

C.9.4.1 General

- Power failure restart time delays for all plant ensuring correct sequence starting and adequate time delays between large motor starts. The time deals shall also operate when plant is restarted after a fire alarm.
- Phase failure under voltage protection relays for each switchboard.
- Kilowatt hour meters for each switchboard.
- Programmable 365 day digital 10 channel electronic time switch located in the plantroom, complete with plant initiation signals to each air handling plantroom switchboard.
- Manual-off-auto (MOA) switches for each fan coil unit , exhaust fans, etc.
- Air flow proving switch/s connected across the suction and discharge of all the supply air fans and fan coil units to provide fan "run" and "fault" status and control interlocks.
- Run and fault indicating lights to all new items of plant.
- Hour run meters for each fan coil unit and each built-up air handling plant.
- Thermostat locations are not shown on drawings. Allow for either space detectors or return air detectors. Space detectors shall be located within the controlled zone in an approved location.
- Fault indicating lights on the main switchboard MSSB to indicate a common fault/alarm from each of the plantrooms' switchboards
- Common fault\alarm signal terminal strip for connection by the electrical contractor

C.9.4.2 Single Zone Fan Coil Unit

- Electronic duct sensor connected to a controller to control the heating and cooling coil control valves sequentially.
- Two-way chilled water and heating water control valves for the single zone unit.
- Electronic room sensor connected to a controller to control the electric heater bank.
- Air flow proving switch connected across the suction and discharge of each fan, and an auxiliary starter contact as necessary to provide interlocking of the control system and electric heater elements.
- Manual reset duct safety thermostat downstream and upstream of each electric duct heater, arranged to de-energise the heater on a rise in duct temperature beyond 55°C.

C.9.4.3 Toilet Exhaust Systems

- Interlocks between the toilet exhaust system and its respective air handling plant.
- Duty selector switch for the system.
- Automatic changeover to the standby toilet exhaust fan via a differential pressure air flow switch in the event of a lead fan failure.
- Run and fault indicating lights for each system.

C.9.4.4 Temperature Indication

- Zone temperature sensors (As per drawings).
- Ambient temperature sensors.

C.9.5 Control System Components

C.9.5.1 Room Sensors

Room sensors shall be of "Satchwell" or approved equivalent manufacture. Sensors shall be supplied and installed as shown on the drawings or as specified elsewhere in this specification.

Room sensors shall be mounted 1500mm above the finished floor level. Sensors shall be tamperproof and shall be positioned clear of obstructions or heat sources to ensure an accurate space temperature is sensed

C.9.5.2 Controllers/Selectors

Controllers/selectors shall be of "Satchwell" or approved equivalent.

Controllers/selectors shall be supplied as specified elsewhere in this specification.

Controllers/selectors shall be mounted within the air handling unit switchboards.

C.9.5.3 Damper/Actuators

Damper/actuators shall be selected for the duty required and to suit the controller characteristics.

Actuators shall be "Satchwell" or approved equivalent.

Actuators shall have oven torque safety cut-out control.

C.9.5.4 Control Valves

Control valves shall be electrically operated globe or butterfly valves, generally in accordance with the "Pipework, Valves and Fittings" section of this Specification.

Control valves shall be 2 or 3 port valves, as shown on the drawings and shall be selected to maintain priority over the controlled device (eg. cooling coil).

Valves shall be fitted with motor actuators of sufficient size to smoothly modulate the valves, and provide positive closure, under any operating conditions.

C.10 ELECTRICAL FOR MECHANICAL SERVICES

C.10.1 Extent of Work

C.10.1.1 General

Supply and install all switchboards, switchgear, protective devices, control equipment, motors, wiring, cabling, cable enclosures and supports as necessary for the safe, convenient and efficient operation of the air conditioning, heating and ventilation installation.

Electrical works shall comply with Authority requirements and AS 3000:2007.

This section should be read in conjunction with the "CONTROLS" Section.

C.10.2 Power Supply

Power supply to the installation will be three phase, four wire, 440/250V, 50 Hz. All equipment supplied as part of this Contract shall be suitable for the actual voltage and frequency available.

C.10.2.1 Balance of Loads

The load on each switchboard and sub-main cable shall be balanced as far as possible over the individual phases of the supply.

C.10.3 Switchboards

C.10.3.1 General

The Contractor shall supply and install switchboards as listed in the equipment schedule.

The Contractor shall advise his switchboard manufacturer of the size of sub-mains being run to each board and whether top or bottom entry in order that adequate space and provision for termination is made.

C.10.3.2 Construction

Switchboards shall be sized to accommodate any physical restraints such as cupboard size or clearance from adjacent equipment.

Switchboards shall be of modern design manufactured using current techniques and practices.

The power distribution and control sections shall be separate compartments within the common enclosure with separate escutcheons and doors.

The power distribution section shall contain all fuses, circuit breakers, bus-bars, contractors, starter switches, relays, etc.

The control section shall contain all electric controllers, relays, gauges etc.

Essential services distribution and control equipment shall be located in a separate action of the switchboard incorporating a solid fire resistant sheetmetal barrier between the essential and non-essential sections.

Ammeters, indicating lights, hour meters, MOA switches and similar manual controls and indication equipment shall be mounted on fixed head panels across the top of the switchboard.

All sections of the switchboard except the head panels shall be provided with hinged access doors.

All switchboards shall have spare space to accommodate at least 15% additional future equipment, that is, 15% spare space shall be provided for additional power distribution equipment, control equipment and head panel equipment.

Switchboards shall be adequately ventilated.

Sheetmetal cubicles, frames, brackets, door escutcheons, etc. shall be of machine folded and welded construction, from first class quality furniture steel mounted upon a fully welded channel iron base with "toes" turned outwards.

Unless otherwise specified, all switchboards shall not exceed 2100mm in height when fixed into position on site.

All metal work shall be rigid, symmetrical and neat in appearance with all visible joints filed and ground smooth.

Doors, escutcheons and panels shall be of not less than 1.6mm and shall have double turned edges for rigidity. Cubicles and brackets etc. shall be of not less than 2mm.

All hinged panels and removable sections shall close onto resilient full hollow perimeter rubber seals to exclude dust - such seals being fixed within deep channel frames around the perimeter of all openings and arranged so as to be reasonably compressed at all points when the panel is secured.

Doors shall have lift off type 135° swing hinges and shall be fitted with lever type handles fitted with barrel locks. All locks shall be keyed alike. Hinges shall be chrome plated brass with steel pivot pins and plastic bearing washers.

Where lift-off access panels are provided they shall incorporate two lifting handles and a centrally located (on vertical centre line of panel) dowels and receptacles to assist in locating the panel on the main frame of the cubicle.

Any exposed screw fixings on front panels, doors or covers shall be terminated with chrome plated "acorn" nuts or knurled headed captive screws depending upon the necessity or otherwise for ready access.

Escutcheons shall be fitted with knurled captive thumb nuts with screwdriver slot and fibre washers and with two "D" type handles located centrally top and bottom of each escutcheon.

Cable, ducting and covers shall be fabricated and finished as for, and to match switchboard cubicles. All hardware shall be chrome plated externally and chrome or cadmium plated internally. After fabrication metal work shall be cleaned of rust, scale, oil, etc., primer etched, undercoated and painted with two coats of good quality enamel, colour to be advised upon request.

Note: Internal surfaces shall be finished in white, high gloss only.

The final finish shall be free from blemishes, orange peel effect, weld and metal finishing marks.

The Contractor shall take all necessary precautions to ensure that paintwork is not damaged.

At Practical Completion any scratches or damage shall be properly rubbed down and repainted to a finish and appearance as good as the original.

C.10.3.3 Main Plantroom Switchboard

The main plantroom switchboard shall be similar to the existing main plantroom switchboard and located adjacent with a separate incoming sub-main.

Connect to the existing plantroom switchboards' bus-bars via a bus-tie isolator to connect the bus-bars of both switchboards together in the event of loss of supply on one sub-main.

Provide castell key locking (or similar) to prevent closing of the bus-tie with both sub-mains connected. Note this requires fitting of castell key lock to the existing main switch.

C.10.4 Equipment in Air Conditioning Switchboard

C.10.4.1 Fuses

All circuits shall be protected by fuses. Fuses shall be of the HRC type, fitted with HRC fuse cartridges of the correct size. Fuses shall be "English Electric" Red Spot Series or similar approved.

Fuses shall be sized to provide discrimination.

Six spare cartridges for each fuse cartridge size used shall be provided in each switchboard in a fuse cartridge box fixed to the inside of the switchboard door.

C.10.4.2 Motor Protection and Starting

All motors shall be protected from low voltage, single phasing and overload on any phases.

This shall generally be achieved by means of motor starters with correct size thermal overloads and appropriate auxiliary contacts. Motor starters shall be Sprecher and Schuh, Telemechanique, Siemens or similar approved and shall be of one make and type throughout.

In addition all motors larger than 20kW shall incorporate thermistor type protection with thermistor sensors buried in the motor windings and connected so as to de-energise the motor if winding temperatures get too high.

Additional protection shall be provided for special motors as recommended by the equipment manufacturer (eg., 3 pole inverse time magnetic overload relays for refrigeration compressor motors).

Operation of any motor protection device shall initiate illumination of the appropriate fault indicating light.

Electric motors may be started DOL except where indicated otherwise or as required by the Supply Authority. All motors over 4.0kW shall have reduced voltage starting conforming with the requirements of Western Power.

Auto transformer starters shall be of the 2 stage closed transition Korndorfer type with definite time/acceleration control and shall be fitted with an extra time relay which shall disconnect the starter in the event of the unit failing to complete the starting sequence within a pre-set time.

Transformer windings shall be fitted with over temperature sensing units arranged to disconnect the appropriate starter in the event of the transformers over-heating.

Closed transition Star Delta starters shall be complete with transition resistors, timers, contactors and control all complying with the requirements of AS 3947.1:2001. Starters shall be rated for a minimum of 4 starts per hour and shall include anti-short cycle timers.

Part winding starters shall be rated to suit the refrigeration compressor requirements and shall incorporate the following items:

- Start-run delay timers.
- Thermistor protection to motor windings.
- Magnetic overload protection.
- Start-run changeover failure protection.
- Further safeties previously specified.

Accept responsibility for selection of the correct type and for correctly setting all motor starting and protection equipment.

C.10.4.3 Rotary Switches

All automatically operated equipment, including air handling fan, exhaust fans, pumps, refrigeration compressors and the like shall be provided with a manual-off-automatic (MOA) rotary switch on the relevant switchboards, head panel.

Rotary switches shall be Draus and Naimer, Telemechanique or similar approved.

C.10.4.4 Indicating Lights

Indicating lights shall be of the Light Emitting Diode (LED) type mounted on the switchboard head panel, colour as listed below:

Red	-	Equipment on.
Amber	-	Fault.
White/Green	-	Auxiliary functions (as specified).

All equipment supplied from each switchboard shall be provided with Red (on) and Amber (fault) indicating lights.

The amber light shall be illuminated in the event of any fault such as operation of protective devices, failure to start and the like occurring for the relevant piece of equipment.

C.10.4.5 Ammeters

An ammeter with an associated phase selection switch shall be provided for each piece of equipment rated in excess of 50kW.

Ammeters shall be of the moving iron type, 100mm square, Crompton Parkinson "Inifax" or similar approved with appropriate scale.

Ammeters shall be connected via current transformers, and shall be marked with a red line to indicate the normal maximum running current as determined during commissioning.

C.10.4.6 Time Switches (Where BMS Not Installed)

Time switches shall be of digital type, 365 day, multi-channel with at least 24 hour battery reserve, Digi Model SC150 or similar approved.

Programme the time switch to control equipment as directed.

Provide instructions for the time switch mounted in a suitable holder in the switchboard.

C.10.4.7 Wiring

The line side connections to all protection equipment shall be made with high conductivity, hard drawn copper bus-bar.

Each bus-bar shall have sufficient capacity to carry the full connected load plus 50% without exceeding a temperature of $40^{O}C$.

All bus-bar work shall comply with BSS 159-1957.

Circuit wiring through switchboards shall be contained in slotted side PVC duct.

Elsewhere PVC cables shall be neatly laid up, laced and fixed where necessary.

Cables terminating on bolts or studs shall be fitted with compression type cable lugs.

Adequate provision shall be made on all switchboards for the neat termination of all incoming and outgoing cables, conduits and troughing.

Crimp type solderless lugs shall be used for all main, sub-main and neutral cable terminations.

All main and submain connections made electrically within the switchboards shall incorporate anti-vibration "Belleville" washers or approved equal to prevent bolted connections and termination from working loose.

Switchboards shall be fitted with multi-way, neutral link bar and shall incorporate an earth bonding bar.

Switchboards shall be completely wired in the factory with outgoing and incoming control cabling terminating at a multi-gang Wieland terminal block, and with all wiring clearly identified in accordance with "as installed" drawings.

C.10.4.8 Labelling

A typewritten schedule showing the phase and number of each fuse and the equipment supplied by each shall be fitted in a clear plastic fronted metal frame fixed on or near each switchboard.

All equipment in head panels (indicating lights, rotary switches and the like) shall be identified by engraved traffolyte labels.

All remaining equipment, including motor starters, contactors and the like shall be identified with appropriately engraved traffolyte labels fixed to panels using screws.

Labelling external and internal shall be standard lettering on white background using laminated traffolyte with bevelled edges. The labels shall be fixed to the sheetmetal panels using screws. Adhesive labels are not acceptable.

Any equipment, fitting or accessory on a particular board which is energised or controlled by equipment on another board shall be permanently labelled to that effect in a approved manner.

All incoming and outgoing circuit and control wiring and cabling shall be identified WITHOUT EXCEPTION using clip-on type ferrules. Identification shall be in accordance with the final approved "as installed" wiring diagrams and/or drawings.

C.10.5 Wiring

C.10.5.1 General

All cable shall be unconditionally guaranteed and such guarantee shall cover replacement of faulty cable and full reimbursement of all costs involved.

Unless otherwise specified all cable shall have copper conductors and V75 grade PVC insulation, and sheathed where required as set out below.

TPS cables shall be used in the following situation:

- In accessible ceiling spaces.
- In underground conduits.
- In wall cavities, stud walls and door mullions.
- In skirting ducts, floor ducts and other cable duct systems.
- Where required by the Supply Authority.

In ceiling spaces, TPS cables shall be clipped to the roof structure or slab at a maximum distance of 900 between clips.

Elsewhere, unless otherwise specified, TPS or PVC insulated cable shall be installed in conduit.

In all cases every cable shall be installed in a manner such that it is replaceable at any time without damage to the building. Any wiring installed with kinks or abrasions shall be replaced. No joints shall be permitted in cables between terminations.

Cables shall be sized in accordance with AS 3008.1.1:1998 including allowance for voltage drop and derating factors as applicable.

The minimum size conductors for power supplies shall be 2.5mm^2 and for control cabling 1.5mm^2.

Groups of cables shall be installed on approved zincanneal cable trays.

C.10.5.2 Cable

MICS cable shall be used for all essential and emergency power and control cabling.

MICS cables shall be fixed by means of brass or copper clips or saddles secured by brass pins or screws which will not cause electrolytic corrosion with the cable or the support to which it is fixed.

MICS cables shall be properly dressed into neat and symmetrical runs.

Ensure that an adequate spacing is maintained between MICS and PVC/PVC cables for heat dissipation.

One full loop of MICS cable neatly formed and supported shall be provided adjacent to termination at a piece of equipment.

C.10.6 Conduiting

Generally Class B rigid PVC conduit shall be used except where exposed to mechanical damage or sunlight, such as externally and in plantrooms, where galvanised screwed steel conduit or GWP shall be used.

PVC sheathed flexible Kopex conduit shall be used to enclose final connections to equipment.

The minimum size conduit shall be 20. Except where conduit size is specified, conduits shall have capacity for one additional circuit.

Conduits, unavoidably exposed shall be run square and plumb with building lines and as directed by the Engineer.

All conduit ends and boxes shall be plugged in an approved manner until permanent fittings are installed. The Contractor shall be present at all times when concrete containing conduit is being poured.

Conduit in concrete shall be installed in accordance with AS 14800-1974 Section 5.4.

Unless otherwise specified, no conduit fittings other than deep conduit boxes, couplings and unions shall be installed in concrete.

To change direction conduits shall be set.

Flexible joints shall be made at right angles across concrete expansions joints. The ends of the conduit shall be kept 19mm apart (across the joints) and belled to form a firm sliding fit inside a larger size conduit sleeve (200mm long minimum). The sleeve shall be taped to conduits with "Scotchrap" to prevent ingress of slurry to the expansion joint. PVC accessories shall be sued wherever possible.

Unless otherwise specified all joints in PVC conduit shall be welded.

One make of conduit, fittings and welding solution shall be used throughout.

Conduit boxes shall be proprietary units with conduit access facilities.

All joints in galvanised conduits and water pipe installations shall be made waterproof by use of "Thread Seal Tape" or similar.

The ends of conduits shall be internally reamed clear of sharp edges and projections.

C.10.7 Equipment Isolating Switches

All items of equipment containing motors, including motors themselves shall be connected via an isolating switch located adjacent to the equipment in an accessible location.

Isolating switches shall be of Clipsal manufacture or similar approved.

C.10.8 Motors

All motors, unless otherwise specified, shall be three phase, squirrel cage, induction type and shall comply with AS 1359 and AS 1360.11:1980.

All motors shall be designed to operate on the power supply available and shall be suitable for operation without overloading or overheating in ambient temperatures up to 43°C.

Where motor sizes are specified herein these are minimum sizes only except where indicated otherwise.

Motors shall be MEPS certified.

C.10.9 Variable Speed Drives (VSD's)

Variable Speed Drives (VSD) shall be provided for the applications noted in the equipment schedules, sized according to motor name plate full load current and provide minimum 110% overload capacity.

C.10.9.1 General

- VSD shall be designed specifically for high efficiency speed control of fan and pump applications in Heating, Ventilation & Air Conditioning applications and not for general purpose constant torque industrial applications.
- VSD must be suitable for operation on 3 x 415 volt (+20% /- 15 %), 50/60 Hz (+/- 2Hz) supply voltage with automatic voltage compensation to enable standard IEC motors to produce rated torque, without additional temperature rise. Automatic de-rating of VSD output at loss of mains supply or mains phase imbalance must be provided.
- Manufacture must be to ISO9001 Quality Assurance standards and include factory burn-in (load) test under worst case conditions.
- VSD operating efficiency must be 96% minimum at 100% load and 92% minimum at 20% load.

C.10.9.2 Enclosure & Control Panel

- The VSD enclosure must be minimum IP54 factory type tested construction with main cooling air ducted via rear external heat sink, without the use of dust filters. The unit shall be designed for operation in –10 to +50 degrees Celcius ambient temperature and 95% relative humidity conditions. Automatic de-rating must be provided for operation in ambient conditions of 50 – 55 degrees Celcius. Ventilation fans must be thermostatically controlled to enhance operating life.

- A door mounted control panel must be incorporated with alphanumeric display and keypad for programming, status and fault diagnostics indication in plain English. The control panel shall also include:

  - Manual / Off / Auto, Start, Stop & Reset control functions.

  - Output current, voltage, frequency, kW, kWh, Hours run, heat-sink temperature reference and feedback signal indication.

  - Last event fault memory & program lock.

C.10.9.3 Electromagnetic Compatibility

- VSD must have built-in RFI filters with C-tick compliance to AS/NZS2064 Group 1, class A, with up to 100 metres screened motor cable connected (Or longer as determined by the installation). Compliance certificate must be provided on request.

- VSD shall incorporate DC link harmonic filters providing an operating power factor of typically min 0.9 at full load. Alternatively 5% AC line reactors can be utilised.

  A harmonic calculation is to be provided based on the supply transformer KVA , % impedance and interconnecting cable length / cross-section to determine additional total harmonic distortion (THD) generated by the VSD, when added to the existing THD, will not exceed the limits laid down by the Supply Authority for the installation in question. Voltage drop must be provided where AC line reactors are used.

- VSD shall comply with International Immunity standards IEC1000-4-2, 4-3, 4-4, 4-5, 4-6.

C.10.9.4 Motor Performance

- VSD shall incorporate advanced voltage vector control modulation that allows 100% power utilisation of standard IEC motors, including service factor.

  An adaptive motor tuning function together with dynamic power optimisation must be provided to precisely match the VSD to standard IEC motor and inter-connecting cable and enhance motor efficiency and energy savings.

  Alternatively the use of 1 size up high efficiency motors is allowed where the VSD cannot maintain the temperature rise of standard motors within class B temp limits.

- VSD must comply with IEC60034:17 to enhance motor insulation and bearing life. Peak voltage must not exceed 1300 V with 50 metres screened motor cable and rate of voltage increase (dV/dt) must not exceed 800 V/micro sec. Maximum shaft voltage allowed is 0.5 volts.

  Vendors must utilise suitable output filters (detailing resultant voltage drop, transient and shaft voltages after filtering) or alternatively, inverter rated motors with insulated bearings, if standard VSD design does not meet IEC60034:17 limits.

- VSD shall incorporate automatic adjustable switch frequency modulation for quite motor operation. Alternatively an audible noise suppressing filter may be used.

- Four adjustable skip frequencies shall be provided to avoid system resonance.

C.10.9.5 Protection Functions

- VSD shall incorporate the following protection functions:

- Mains transient voltage to VDE160 class W2 ,over voltage, under voltage & mains phase loss
- Output earth fault, short - circuit and loss of motor phase
- Switching on output (Alternatively control interlock to VSD allowed)
- Flying start of motor in forward or reverse direction
- Electronic motor thermal protection and motor condensation protection
- Over current / current limit with automatic ramp control
- Inverter overload / over temperature / operation without motor.

- Automatic re-start shall be available on over/under voltage and current limit trip.

C.10.9.6 Control Interface Function

- VSD must be suitable for control interface to the BMS (Or integrated in the BMS scope of supply if specified under BMS controls) and include as a minimum the following programmable EN50178 compatible Protective Extra Low Voltage galvanicaly isolated inputs / outputs:
  - 1 x 0-10Vdc, 1x 4-20mA reference / feedback analogue inputs.
  - 1 x thermistor input (10 V dc supply must be built-in).
  - 7 x standard digital inputs (EG start/stop, run permisive, safety interlock, reset, hand start, auto start).
  - 1 x fire mode operation digital input (motor thermal protection cancelled and infinite automatic reset).
  - 2 x relay output (EG: run, fault, broken belt, blocked filter).
  - 2 x 4-20mA output (EG: Amps, kW, Hz).
  - 2 zone / 2 set-point PID controller with sleep mode & boost function (24 V dc supply for field transmitter must be built-in).
  - 1 x RS485 serial communications (Compatible with BMS protocol specified. EG: Lonworks / Metasys N2 / Siemens FLN / Modbus RTU or Profibus).

C.10.9.7 Track Record & Local Support

- VSD Vendors must have a minimum 10 years continuous local experience and demonstrate local service / repair capability, including 24 hour 1800 contact support. An inspection of local facilities must be provided on request.

C.10.9.8 Approved VSD

- VSD shall be Danfoss VLT 6000 series HVAC VSD (Or approved equivalent with full supporting documentation detailing compliance with this specification).

C.10.10 Operation of Plant

Details regarding the method of automatic operation of the plant are specified in Section "Automatic Controls" of this Specification.

C.10.11 Conditioner Lighting

Provide conditioner lighting as shown on the drawings. Light fittings shall be of a weather proof type, similar to "Vandalite" or approved equivalent.

Light fittings shall be surface mounted with spacers to allow for insulation thickness.

Lighting shall be controlled via weather-proof heavy duty switches fitted with neon indicators. Each compartment door shall be provided with a switch.

C.10.12 Wiring Diagrams

Wiring diagrams for the complete installation and shop drawings for each switchboard shall be submitted to the Engineer for approval prior to any manufacture of installation.

After the installation is complete, the Contractor shall prepare "As Constructed" wiring diagrams.

The non-fading print of each wiring diagram shall be neatly backed with 9mm chipboard and framed under glass and shall be mounted in an approved position in the chiller plantroom.

Additional non-fading prints of the wiring diagram shall be provided with the Operating and Maintenance Instructions covered elsewhere in this Specification.

Wiring diagrams shall be prepared by experienced and competent draughtsmen.

C.10.13 Conformity

The standard and type of electrical work shall generally be in conformity with the electrical work carried out by the Contractor in the remainder of the building.

The Electrical Contractor employed by the Mechanical Services sub-contractor shall issue certificates covering his work independent of the general electrical contract for the building.

C.10.14 Testing

The complete installation shall be tested to ensure that it complies with the specification and that it operates correctly under normal, emergency and fault conditions.

All control, protection and indicating equipment shall be tested for correct operation.

Test the complete installation in compliance with SAA Wiring Rules "Testing of Installation" and other relevant clauses.

Such tests shall include:

- Insulation between conductors.
- Insulation between conductors and earth.
- Continuity resistance of conduit systems.
- Earth resistance of connected equipment.

The Contractor shall provide all necessary testing equipment and any costs involved shall be borne by the Contractor.

C.11 NOISE AND VIBRATION CONTROL

C.11.1 Noise Criteria & Measurement

The installation shall be supplied, installed and commissioned so as to generate noise levels not exceeding the requirements of AS/NZS 2107:2000.

When directed, noise level measurements shall be recorded and reported with details of sound pressure levels in each octave band mid frequency from 63 Hz to 4000 Hz inclusive. The locations shall be selected and approved prior to measurement. Provide calibrated measurement equipment.

Measurement of sound pressure levels shall be taken during conditions of peak equipment load when the building is unoccupied.

Noise measurements shall comply with AS 1045, AS 1081.1, AS 1469C, AS 1055, AS 1217. No measurement shall be taken closer than 1500 mm to any outlet or item of equipment, and not closer than 1000mm to any ceiling, wall or floor surface.

C.11.2 Noise Control

In order to maintain the specified noise levels, ensure that sound power levels of equipment shall not exceed the limits defined in the Schedule of Performance, and shall take all necessary precautions in the layout and installation of duct systems and air diffusion equipment to comply with the above requirements.

In addition supply and install silencers and attenuators where shown on the Drawings and as detailed in the "Equipment" and "Schedule of Performance" sections of this Specification.

C.11.3 Vibration Control

Anti-vibration equipment shall be supplied and installed as specified in this section, and in Equipment Schedule.

All reciprocating and rotating machinery (fans, pumps, compressors, motors) shall be provided with vibration isolating mounts. If not detailed to the contrary, minimum requirement shall be double deflection neoprene isolators.

Cooling towers shall be mounted on neoprene rubber pads, supported by hot dipped galvanised steel beams on concrete plinths as shown on the drawing.

Provide concrete filled inertia bases mounted on springs, if specifically nominated.

All vibration isolation mounts required for equipment, pipework, ductwork, etc, shall be as manufactured by Mason Industries or Embelton.

Make and model of vibration isolators shall be nominated on shop drawings. Static deflection required in Schedules shall be the true static deflection, measured in situ, with true load.

C.11.4 Spring Isolators

Spring isolators shall have a horizontal to vertical stiffness at rated load of between 0.9 and 1.1. Spring diameter to loaded height shall be not less than 0.8.

Deflection at rated load shall be not greater than 2/3rd of the compressed solid deflection.

Spring isolators shall incorporate a neoprene pad having a minimum of 6mm, mounted between the spring and the base plate. Provide means of levelling.

Spring isolators should not be bolted to the masonry plinths. However, where bolting is considered necessary the holding down bolts shall be isolated from the bases with neoprene washers.

C.11.4.1 Inertia Bases

Inertia bases shall be constructed from steel reinforced concrete having a minimum thickness of 150mm.

The inertia block shall be mounted to maintain a minimum of 25mm between the inertia block and the mounting plinth.

Inertia bases shall be provided as noted in the "Schedule of Performance" Section of this Specification.

C.11.4.2 Neoprene Pads

Loading of ribbed neoprene pads shall be within the manufacturer's ratings and in any case shall not be greater than 400 kPa.

C.11.4.3 Pipe Vibration Isolation

All piping in plantrooms shall be supported with pipe hangers using approved double deflection neoprene rubber vibration isolators.

Vibration isolators shall be Mason type HD or approved equivalent.

All connections of piping to pumps, chillers, condensers and cooling towers, etc, shall incorporate flexible connections in the first available horizontal section of piping.

Flexible connections shall be not less than 6 times the pipe diameter served with a maximum length of 900mm.

Flexible connections shall incorporate a control cable.

Flexible connections shall be Mason Type BRFH or equivalent approved manufacture.

C.11.4.4 Double Deflection Neoprene Rubber Isolators

Double defection neoprene, rubber isolators shall be "Mason Industries" or "Embelton" or approved equivalent.

Neoprene isolators shall have a minimum static defection of 9mm. All metal surfaces shall be neoprene covered to avoid corrosion complete with friction pads both top and bottom. Bolt holes shall be provided as required.

C.12 PAINTING, FINISHES, AND IDENTIFICATION

C.12.1 Extent of Work

C.12.1.1 General

The Mechanical Services installation where specified shall be painted to present a neat finished appearance.

Provide identification labels to all items of plant and all pipework systems.

Equipment, components and pipework exposed to the weather shall be provided with corrosion protective treatments.

All finishes shall be applied by qualified tradesmen or under their direct supervision. All paint systems shall be the products of one manufacturer wherever possible. Application shall be entirely in accordance with the manufacturer's instructions, in particular with regard to preparation and coating times. Colours are to be submitted for approval.

Items of equipment and valves shall be identified and numbered in accordance with the approved "As Installed" drawings and as scheduled in the Operating and Maintenance Manuals.

Equipment on switchboards and control panels shall be similarly labelled.

Incoming and outgoing circuit wiring shall be identified.

Main valves in the plantroom shall be identified with a label indicating the service and/or equipment controlled and the normal position of the valve (eg. NC or NO).

Pipework and ductwork exposed to view in plantrooms, occupied spaces and access ducts shall be colour coded and labelled to identify the type of service and the direction of flow.

C.12.2 Metal Components

Metal surfaces of stainless steel, chrome plated, bright aluminium or anodised aluminium shall be carefully protected and cleaned at commissioning to the original bright metal surface as the required finish.

Mild steel surfaces shall be hot dip galvanised after fabrication for locations exposed to the weather, zinc electroplated or finished in zinc rich paint finish for weather protected applications. In each case, paint these surfaces where exposed to view.

C.12.3 Painting

Surfaces to be painted shall be suitably prepared (cleaned, etched, etc.), and then given one appropriate priming coat, one undercoat and two finishing coats of paint of Dulux or approved equal manufacture.

Where necessary, surfaces shall be filled and/or lightly sanded between coats to obtain a smooth surface.

Finishing coats generally shall be of hard gloss enamel in a high gloss finish. Paint colours nominated will be in accordance with AS 2700 and AS 1345.

All services where exposed in plant areas shall have the base identification colour applied throughout the entire length.

Insulation sheathing and blanking panels in AHU rooms shall be painted with a matte finish enamel.

Ductwork, piping, etc., in roof or ceiling spaces need not be painted, other than to provide the required vapour seal.

Flexible joints in pipework and ductwork shall not be painted.

C.12.4 Colour Samples

Samples of finish treatments may be required of visually aesthetic items, e.g. grilles, air outlets, items within occupied spaces.

C.12.4.1 Identification

C.12.4.2 Labels

Generally, all labels shall be of laminated white - black - white "traffolyte" (i.e., black lettering on a white background).

For "urgent" alarms or applications, labels shall be of laminated "traffolyte" with white letters on a red background.

For fire applications, labels shall be of laminated "traffolyte" with red letters on a white background.

The minimum acceptable size for labels shall be 63mm x 12mm. The labels shall have bevelled edges. Lettering must be upper case and 4mm as minimum size.

Labels shall be screwed to sheetmetal work by means of cadmium plated screws into drilled and tapped holes. Self-tapping screws are not acceptable. Labels shall be fixed to masonry using "Rawl" fittings. Labels shall not be mounted on removable covers on the items of equipment.

Switchboard and control panel equipment identification shall be provided on the panels to which the equipment is mounted both labels preferably being fixed by means of common fixing screws and/or nuts.

Incoming and outgoing circuit wiring shall be identified using "Critchley" clip-on ferrules.

All main valve labels shall be located under the hand wheel nut, except where valves are located overhead, where labels are to be suspended on a 75mm length of brass or stainless steel chain attached to the valve spindle.

All labels shall be of non-ferrous material - preferably brass - or stainless steel - with easily identifiable 63mm minimum sized lettering - "filled" (if stamped) or otherwise engraved.

C.12.4.3 Pipe Marking

Pipe markers to indicate type of service and direction of flow shall be "SAFETYMAN" or approved equal to comply with AS 1345 (NZS 2257).

Samples of pipe markers for all services are to be provided upon request.

Pipe markers shall be installed in all plantroom areas and wherever access is available in service areas.

The maximum suitable size of pipe-markers shall be selected and applied at intervals not greater than quoted in AS 1345. At all wall or floor penetration, branch take-offs or where service access is provided, positive pipe identification must be clearly visible.

All services in plantrooms shall have the base identification colour applied throughout the entire length where exposed.

DETAILS PERTAINING TO QUALITY OF WORK MINOR WORKS

C.12.4.4 Maintenance of Fire Rating

Fire separation and integrity of the building elements shall be maintained at all times. Pipes, ducts and conduits passing through fire and/or smoke rated walls, floors, bulkheads etc. shall be suitably sealed utilising Building Code of Australia approved materials, refer to Architectural drawings for the location of all fire rated building elements.

Install fire stopping products around all service pipe penetrations through masonry floors, walls, ceilings, ducts and other fire rated elements. Product used shall be of approved manufacture compatible with materials being used in the installation.

PVC and polyethylene pipes - fire stop collars and fire wrap applicable to the type and circumstance.

Insulated pipes - sleeved through fire barrier and then filled with fire caulking product.

Metallic pipes - sleeved through fire barrier and then grouted around with fire retardant product.

Where conduits pass through a fire rated barrier they shall be metal. The metal conduit shall extend for a length 500mm clear of both sides of the barrier, provide as per metallic pipe.

C.12.4.5 Underground Conduits & Piping

Install conduits and piping 600mm below finished ground level, except where shown otherwise.

Excavate trenches straight and true and to an adequate depth to provide the required cover for conduits and piping.

Ensure the bottoms of trenches are flat and clear of protrusions such as rocks, tree roots and the like, prior to installation of conduits and piping.

Cover conduits and pipes with 150mm depth of rubble free sand and place an identification tape, 150mm above the conduit or pipe along the entire length of the installation. Use underground marking tape in accordance with AS 2648.

The following items are part of the Mechanical Services works:

C.13 TESTING AND COMMISSIONING

C.13.1 Extent

C.13.1.1 General

Carry out all testing, commissioning and air and water balancing procedures necessary to render the installation fully operational.

The Mechanical Contractor shall submit commissioning methodology statements and proforma commissioning and testing results sheets for all items of equipment, for approval by the Engineer prior to commencement.

Nominate in the Mechanical Services Construction Schedule the proposed commissioning period, with separately nominated period for verification tests required. Convey these dates to the Builder for inclusion in the main Construction Programme. Allow for delays between notification and verification by Authorities and Consultants.

Provide at least three (3) working days notice in writing to the Engineer prior to carrying any of the specified tests, or such other period of notice as may be reasonable under the prevailing circumstances.

Advise the Engineer as to the time and type of test to be carried out. The viewing of test procedures is to ensure that tests are being carried out accurately using acceptable equipment and methods.

Approval of commissioning data will not be given until results are submitted in typed form on the respective pre-approved commissioning data sheets. Two copies of each data sheet shall be forwarded for approval. After approval, copies of the commissioning data sheets shall be incorporated into the maintenance manuals.

Unless otherwise agreed, the tests shall be carried out in the presence of the Engineer. Provide all tools and equipment required to accurately confirm test readings.

All equipment used in the testing and commissioning of services shall be accurately calibrated and in good working order. Certificates of currency of calibration shall be submitted for all equipment to be used, prior to commencement of testing or commissioning.

C.13.2 Ductwork Pressure Testing

All low pressure ductwork as defined in the "Ductwork Systems" section of this Specification shall be tested by the following method:

Test Stage 1 - Use of an external supply air fan and differential pressure gauge. Prior to the installation of any ceiling structure, individual ductwork systems shall be pressurised to range of pressures - from 100Pa below to 100 Pa above

the anticipated operational static pressure. At 25Pa intervals, the supply air quantity entering the ductwork whilst the fan maintains the respective pressure shall be noted.

The noted air quantities shall then be checked to ensure that they are within the specified range of acceptable leakage.

This stage of the test shall be applied to both supply and return air ductwork systems.

If the leakage rate at the anticipated system operational static pressure does not exceed 5% of the design air flow for that system, installation of the ceilings can proceed.

Test Stage 2 - Following proportional air balance, the operational system static pressure shall be ascertained. This figure shall be checked against the figures obtained during Test Stage 1 to ascertain the exact leakage rate.

Provided the leakage rate for the supply air and return air ductwork associated with each system is within the specified range, the system will be deemed to be acceptable.

Should the actual leakage rate fall outside the acceptable range, the Contractor shall rectify the leakage to the full satisfaction of the Engineer and the Client.

C.13.3 Testing of Refrigeration Systems

Refrigerant pipework shall be pressure tested to 1.25 times the design pressure as defined in Table 10.1 of the SAA Refrigeration Code.

The gas used for the pressure test shall be an approved dry inert gas.

Detect for leaks with a film of soapy water on all joints. Eliminate all leaks and repeat process until the system sustains the test pressure for 10 hours.

On satisfactory conclusion of the pressure tests, the pipework shall be evacuated to a pressure equivalent to that not exceeding 1.7 degrees C. wet bulb temperature and then closed off for a further period of not less than 10 hours.

During this period, no sensible change in wet bulb temperature should be observed.

The whole dehydration process shall be repeated until identical readings are obtained at the beginning and end of a 10 hour shut-down period.

Finally, the whole system shall be charged with refrigerant and again tested for leaks.

C.13.4 Air Balancing

C.13.4.1 Low-Pressure Distribution Systems

Low-pressure distribution systems shall be proportionally balanced to provide minimum overall resistance to air flow - i.e. at least one terminal damper in each low-pressure system shall be fully open.

Adjustment of air flow rates shall be made using duct-mounted branch dampers remote from the air terminal.

The Contractor shall ensure that all dampers as shown on the drawings, and other dampers as necessary for adjustment of air flow rates, without generation of excessive noise levels at or from the air terminals, are provided in each system.

Acceptable methods of terminal air flow rates shall include the following:-

- Balancing hoods of approved design, incorporating an Alnor Velometer probe, or approved equivalent, in the throat section. Such balancing hoods shall be calibrated for the related air terminal types to the Engineer's satisfaction, prior to commencement of balancing.

- Slot velocity readings at the supply air slots of the air terminal, using Alnor Velometer probe or approved equivalent, subject to demonstration of calibration and repeatability to the Engineer's satisfaction.

Note: Method (a) above is preferred.

Air flow rates shall be adjusted to a tolerance of -0%, +10% of design air flow for all air terminals, air handling units and air terminals shall be balanced to -0%, +5% maximum flow rates from VAV air terminal boxes shall be adjusted to similar tolerances as necessary, based on aggregate readings from associated air outlets.

C.13.4.2 Ventilation and Exhaust Systems

All ventilation and exhaust systems shall be air balanced in general accordance with the method prescribed for low-pressure distribution systems, and within the same tolerances.

At the discretion of the Engineer, measurement methods for terminal air flow rates may include anemometer traverse.

Measurements of total air flow rates for each system shall be made by Pitot traverse, or where this is not feasible, by other methods to the Engineer's approval.

C.13.5 Control Systems Commissioning

Commission, calibrate, test and demonstrate all control equipment and systems to the satisfaction of the Engineer.

Commissioning shall comprise two distinct phases.

C.13.5.1 Controls:

This shall comprise fully comprehensive tests of all control system carried out with all motors electrically isolated. The operation of ON-OFF control devices shall be simulated with switches temporarily wired into circuit.

The operation of sensors shall be simulated with sources of voltage, etc. variable over the full operating range of the system and temporarily wired into circuit.

The Contractor shall prepare a check list of all control loops incorporated in the system for approval by the Engineer prior to commissioning of the installation.

The check list shall include columns for the title of the control loop, function, controller set-points (including all adjustment values of proportional band, bias ratio etc.), actual controlled value of the controlled variable verification of functional operation, and columns for signature by the Contractor's commissioning engineer, and by the Engineer.

- All sensors and ON-OFF control devices shall be calibrated over their full operating range against standard devices of known acceptable accuracy.

C.13.6 Performance Testing

Upon completion of commissioning, the Contractor shall fully test and demonstrate the operation of the equipment and systems specified herein, in the presence of the Engineer.

Any defects or deficiencies in the equipment or systems identified as a result of such tests shall be made good, to the Engineer's satisfaction, at the Contractor's own cost.

Performance testing shall include the following:

- Measurement of air flow rate, fan static or total pressures, fan and motor RPM, motor power consumption for each fan.
- Measurement of water flow rate, pump head, pump RPM, motor power consumption for each pump.
- Measurement of water flow rates through all equipment items.
- Measurement of air distribution and ventilation systems terminal and branch air volumes, on a sample basis, to the Engineer's satisfaction.
- Measurement of system air and water temperature.
- Demonstration of functional operation and calibration of control systems.
- Measurement of packaged plant head pressure, low pressure, air off, temperature, air on temperature, ambient temperature and condenser air on and off temperature.
- Thermal performance testing of all chilled water plant, heating water plant, and air handling units to verify compliance with the specified requirements. Such thermal testing shall take place under near-design ambient conditions for a period of up to 5 days at an appropriate during the warranty period, to be nominated by the Engineer. Provide data logging equipment to log at hourly intervals the following.
  - Ambient wet and dry bulb temperatures.
  - Internal wet and dry bulb temperatures per zone.
  - Estimates of people and lighting loads.
  - Fresh air quantities.
  - Temperature splits and flow readings for major items of plant.

C.13.7 Commissioning Records

Provide written records of the preliminary airflow, water, and performance test data, prior to the verification tests. Data shall give design quantity, site test reading and percentage deviation from design.

The Contractor shall prepare and submit to the Engineer the complete commissioning records for the installation bound in the Operating and Maintenance manuals.

The commissioning records shall contain all test and commissioning results relating to the final, commissioned installation, derived from the tests and procedures specified in this Section.

C.13.8 Equipment Statutory Inspection and Registration

Arrange inspection and registration of all plant as required by the applicable authorities or statutory body. Specifically this shall include but is not limited to:

- Chillers.
- Boilers.
- Air Compressor Receivers.

Inspection certificates are to be laminated and mounted in a rigid frame adjacent to the plant. Copies of inspection certificates are to be included within Operating and Maintenance Manuals.

Provide a re-inspection schedule as part of the operating and maintenance manual detailing the inspection period, the type of inspection required and the inspector contact details.

Pay all fees and costs associated with the inspection and registration.

C.14 OPERATING AND MAINTENANCE MANUAL

C.14.1 General

The Contractor shall provide, **before** the Practical Completion of the installation, five copies of an Operating and Maintenance Manual set out with the following headings and containing all listed information:

1.0 Index

2.0 Description of plant

3.0 List of all equipment giving manufacturer's and agent's and name plate details and parts lists.

4.0 Installation instructions.

5.0 Maintenance instructions for each item of equipment.

6.0 Certified equipment performance data, e.g., pump and fan curves, etc.

7.0 List of settings for all major control instruments.

8.0 Instructions for operating plant including starting and stopping outside of normal working hours.

9.0 Quality Assurance Certificates.

10.0 All testing and commissioning data.

11.0 "As Constructed" Wiring and Control Diagrams.

12.0 Drawing List.

The Manual shall be professionally bound in a grey vinyl ring binder with stamped blue lettering in the following format:

OPERATING AND MAINTENANCE MANUAL

FOR

MECHANICAL SERVICES

AT

.....

Engineer:
Wood & Grieve Engineers

Architect:
.....

Contractor

The spine of the ring binder shall be similarly stamped with the Job Name and the words "Operating and Maintenance Manual".

The Mechanical Contractor shall provide five copies of the "As Constructed" drawings of all plant, equipment, ductwork, etc. These drawings shall have been prepared by a competent and experienced draughtsperson and shall be folded and inserted in individual pockets with the manual.

The Mechanical Contractor shall provide a compact disc containing all "As Constructed" shop drawings in AutoCAD format.

C.14.2 As Constructed Drawings

Where the project is a "Government" project, all drawings are to be drawn to the current version of the Government's drafting standards. It is the responsibility of the Mechanical Contractor to be informed of these standards.

Drawings may be checked for conformity at Practical Completion and failure to comply may cause delays.

C.15 MAINTENANCE

C.15.1 General

The twelve month defect warranty and maintenance liability period (Maintenance Period) shall commence on the date of Practical Completion.

Provide for corrective maintenance and repair to all equipment and systems which become defective, or is found to be defective, during the Maintenance Period, including the making good of any resulting damage.

In addition, allow for preventative maintenance of the entire plant for the full duration of the Maintenance Period, in accordance with this section.

Submit to the Engineer detailed monthly service reports, including details of all preventative and corrective maintenance work carried out during the preceding month. Copies of log book entries shall also be provided.

C.15.2 Maintenance Log-Book

The Mechanical Contractor shall supply to the Proprietor at the Date of Practical Completion a Maintenance Log Book which shall be kept in the Chiller Plantroom or the Facility Manager's Office with one copy of the Operating and Maintenance Manual.

The Maintenance Log Book shall clearly identified and of a similar format to the Operating and Maintenance Manuals.

The Mechanical Contractor shall ensure that all employees, sub-contractors and other personnel shall enter all relevant details of work carried out, together with names of personnel and times of arrival and departure, in the log-book at each service visit, whether for preventative or corrective maintenance calls.

A copy of the maintenance inspection reports shall be supplied, for record purposes, to verify the maintenance. Where such records are not provided, it shall be deemed that the work was not performed. The Proprietor shall be entitled to deduct the value of such service from the final payment.

C.15.3 Preventative Maintenance

Generally, the routine preventative maintenance shall include the inspections, lubrications and cleaning of equipment, checking and adjustment of controls, refrigerant leakage test and such other checking as may be considered necessary at the time.

Notify the Facility manager on arrival and log details of all visits.

Routine maintenance shall include the following:-

C.15.4 One Monthly Services (12 off)

C.15.4.1 General

- Check all dirty components.
- Check all equipment for abnormal noise.
- Record readings on all temperature and pressure gauges.
- Record running amps for all major equipment.

C.15.4.2 Fan Coil Units

- Check and clean filters as necessary.
- Check general operation.
- Check drains for blockages.
- Visually check control operation.

C.15.4.3 Air Conditioning Units

- Thoroughly clean the condensing units twice during the warranty period at six monthly intervals.
- Casing shall be removed, all debris cleaned from the unit and using suitable detergent clean the coil and casing and wash down.
- Provide additional 'laotrol' spray as required.
- Include comprehensive instructions for ongoing maintenance in operating and maintenance instructions.
    - Check, clean and record pressure drops of filters.
    - Check general operation.
    - Check drains for blockages.
    - Check fans for vibration and excessive noise; rectify as required.
    - Check belts, bearings, wheels and pulleys for tightness on shafts.
    - Check operation of all safety controls.
    - Check system dryness and replace dryers as required.
    - Check thermostat set points and operation.
    - Clean down all equipment and touch up paint as required.

C.15.4.4 Fans

- Check for vibration and excessive noise.
- Check flexible connections.

C.15.5 Six Monthly Services (2 off)

C.15.5.1 Controls

Service by controls sub-contractor to clean, adjust, calibrate (and record settings) all controls, control valves, pneumatic relays, pressure switches, etc.

C.15.6 Twelve Monthly Service (1 off)

C.15.6.1 Electrical

- Switchboard service by electrical sub-contractor to clean adjust and check all terminals, overloads, contacts, relays, timers, switches, indicator lights, etc.

C.15.6.2 Motors

- Check motor winding continuity and insulation.

C.15.6.3 Fans

- Lubricate as necessary.
- Check motor amps.

C.15.6.4 General

- Check all wheels, pulleys, bearings for tightness on shaft.
- Check all mounting bolts for tightness.
- Check all hangers supports, etc.
- Check calibration of gauges.
- Check and clean all drain connections.
- Clean down all equipment and touch-up paint where required.

PART D. **APPENDICES**

D.1 **APPENDIX C - TENDER SUMMARY**

Tenderers shall submit a breakdown of the total tender price including administration cost and profit for each section of the works as follows:

The amounts included in the Total Tender sum including overhead costs and profit margins are as follows:

(a) Air Conditioning System:
- Air Handling Unit $ _____
- Cooling Coils $ _____
- Ductwork $ _____
- Insulation $ _____
- Grilles and Diffusers $ _____
- Motorized Dampers $ _____
- Installation of Air Conditioning Systems $ _____
- Heating Coils $ _____
- Filters $ _____
- Pipework Valves and Fittings $ _____

(b) Ventilation Systems:
- Fans $ _____
- Ductwork $ _____
- Grilles $ _____
- Installation $ _____

(c) Automatic Controls (Including Installation): $ _____
- Number of Different Points Types _____
- Cost of each Points Type Included $_____
- No. of each Points Type Included _____
- Total Number of Points Included _____

(d) Electrical:
- Switchboards $ _____
- Cabling and Installation $ _____

(e) Demolition Work $ _____

(f) Shop Drawings $ _____

(g) Commissioning and Testing $ _____
Note: shall equal or exceed 2 % of total tender

(h) Maintenance Manuals $ _____

(i) Contingency & Provisional Sums $ _____

(j) Site Allowance $ _____

(k) Maintenance during The Defects Liability Period $ _____
Note: shall exceed 1/2% of total tender value

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TOTAL TENDER AMOUNT (EXCLUDING GST) $ _____

GOODS & SERVICES TAX (10%) $ _____

TOTAL TENDER AMOUNT (INCLUDING GST) $

NAME OF TENDERER: _____

CONTRACT: _____

D.2 APPENDIX D - SCHEDULE OF CONTRACT RATES

Tenderers shall submit the following Schedule to allow assessment of variations:

Composite Rates:

The following rates shall include for the supply and delivery of all materials, transport, erection and labour to complete the installation of the following elements in the works:

Description	Unit	Cost/Unit	GST	Total/Unit
Stand-down of Works	Day			

Hourly Labour Rates (including GST):

Period	Labour 1	Labour 2	Labour 3	Labour 4	Labour 5	Labour 6
Ordinary Time						
Time and a Half						
Double time						

NAME OF TENDERER: _____

CONTRACT: _____

D.2.1 Schedule of Unit Rates

Tenderers shall submit a schedule of unit rates as shown below.

Failure to submit this scheduled information will result in the Tender being rated as informal and rejected.

NOTE: These unit rates shall be used to assess variations to the project throughout the construction period.

DUCTWORK

For supply and installation of ductwork in false ceiling spaces under average conditions, but excluding any costs for removal or replacement of ceiling tiles.

RATE PER METRE RUN

Duct Size (mm x mm)	Bare	25mm External	25mm Internal	50mm Internal
200 x 100				
300 x 200				
400 x 200				
500 x 200				
500 x 400				
600 x 400				
700 x 400				
700 x 500				
700 x 600				
800 x 600				
900 x 600				
1000 x 600				
1100 x 600				
1200 x 600				
1300 x 700				
1400 x 700				
1500 x 800				
1500 x 900				

Insulated Flexible Ductwork (per 6m length)

150 dia
200 dia
300 dia
350 dia
400 dia

AIR DIFFUSION

Unit rates for the following shall allow for work to be carried out after erection of the ceiling, but shall exclude costs for removal and replacement of ceiling tiles.

(a) Installation for an additional supply air diffuser 500/600, including connection of 4m of flexible duct and branch from main duct. $_____

(b) Relocation of a supply air diffuser including reconnection of flexible duct but excluding costs of flexible duct. $_____

PIPING

Unit rates for the following options shall allow for works to be carried out before the erection of ceilings or cladding of walls, shall include insulation and identification labelling but shall exclude painting.

Pipe Size	CHW Pipework	HW Pipework
20mm:	$ _____	$ _____
25mm	$ _____	$ _____
32mm	$ _____	$ _____
40mm	$ _____	$ _____
50mm	$ _____	$ _____
65mm	$ _____	$ _____
80mm	$ _____	$ _____
100mm	$ _____	$ _____

HOURLY LABOUR RATES

Period	Duct Installer	Electrician	Plumber
Ordinary Time:	$ _____	$ _____	$ _____
Time & Half	$ _____	$ _____	$ _____
Double Time	$ _____	$ _____	$ _____

MARK-UP

On material for items not covered by unit rates, based on trade price. % _____

D.2.2 Schedule of Technical Information

A complete Specification of the equipment offered shall be enclosed with the Tender, such details to be listed on separate sheets. In particular, tenderers are to state for each of the items offered:

Make	Outlet velocity (where applicable)
Model	Fan tip speeds
No. Off	Maximum S.W.L. Rating
Capacity	Operating Temperature
Motor HP	Refrigerant
Speed	Weight of refrigeration

Furthermore, for each item of equipment requiring separate foundations, footings or floor space, overall dimensions and weight under working conditions shall be given when submitting the above schedule.

Failure to submit this scheduled information may result in the Tender being rated as informal and rejected.

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D.4 APPENDIX F - PROJECT SPECIFIC QUALITY ASSURANCE ITEMS

MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(SHOP DRAWINGS)

Client:
Project:
Project No:
Contractor:
Drawing No:
Contractor's Verification Signature: _____ Date:
(Project Engineers)

1.	**Equipment**		
1.1	Adequate access for equipment service and maintenance.		
1.2	Filters installed in accessible positions.		
1.3	Door grilles provided and coordinated with doors supplier.		
1.4	Selected air diffusion equipment gives adequate room coverage.		
2.	**Ductwork**		
2.1	Ductwork fits into the ceiling space less beams and lights.		
2.2	Access panels provided in ductwork where required and in ceilings as on WGE drawings or to the approval of the Superintendent.		
2.3	Sunshades provided on external ductwork.		
2.4	Work by other building trades coordinated and clashes avoided.		
2.5	Drip trays provided under all ceiling mounted fan coil units.		
2.6	Fire dampers provided through all fire rated separations unless otherwise approved by the Superintendent.		
2.7	Duct sizes are at least as large as on WGE drawings.		
2.8	Supply/exhaust/ outside air quantities as specified.		
2.9	System has sufficient dampers and is in a configuration that promotes ease of balancing.		
2.10	Static pressures for equipment calculated.		
3.	**Pipework**		
3.1	All pipework, valves and fittings required by equipment provided.		
3.2	Condensate drains run to floor wastes or tundishes and plumber informed.		
4.	**Insulation**		
4.1	All insulation as specified.		
5.	**Controls**		
5.1	Thermostats located as specified or to the approval of the Superintendent.		
6.	**Associated Electrical**		
6.1	Electrical Trade advised of the actual electrical requirements of mechanical services.		
6.2	Mechanical switchboards located as specified.		
6.3	Mechanical electrical wiring and control logic diagrams.		

7. Noise and Vibration Control

7.1 Equipment noise levels as specified or less.

7.2 All other equipment selected so as to comply with the room noise levels specified.

7.3 Vibration isolation of equipment as specified or to the approval of the Superintendent.

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MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(SUPPLY)

Client:

Project:

Project No:

Contractor: _____

Equipment/System Item Identification: _____

Does the equipment meet the requirements of the specification?

YES

NO if so, why?

Contractors Signature: _____

Suppliers Signature: _____

Date: _____

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MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(INSTALLATION)

Client:

Project:

Project No:

Contractor: _____

Date: _____

Has the equipment/system been installed in accordance to the manufacturer's recommendations and the requirements of the specification?

YES

NO if so, why?

Contractors Signature: _____

Suppliers Signature: _____

Date: _____

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MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(PRACTICAL COMPLETION)

Client:

Project:

Project No:

Contractor: _____

All mechanical building services have been installed in accordance with the shop drawings and with the equipment as certified in the relevant Quality Assurance Certificates.

Contractor's Verification Signature: _____

(Principal or Managing Director)

Date: _____

The overall installation complies with the performance requirements of the tender documents and subsequent variations.

Contractor's Chartered Professional Engineers: _____

IE AUST. Corporate Membership No: _____

Date: _____

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MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(FINAL COMPLETION)

Client:

Project:

Project No:

Contractor: _____

All mechanical building services have been installed in accordance with the shop drawings and with the equipment as certified in the relevant Quality Assurance Certificates.

We confirm that:

All Mechanical Services defects brought to our attention have been rectified **YES/NO**
If no, attach details of any defects that have not been rectified.

We have recently inspected the Mechanical Services installation and it is in efficient working order. **YES/NO**

Date of inspection: _____

Mechanical Services maintenance has been carried out in accordance with the specification and we have retained copies of records of all preventative and corrective maintenance work. **YES/NO**

Contractor's Verification Signature: _____

(Principal or Managing Director)

Date: _____

The overall installation complies with the performance requirements of the tender documents and subsequent variations.

Contractor's Chartered Professional Engineers: _____

IE AUST. Corporate Membership No: _____

Date: _____

WOOD & GRIEVE ENGINEERS

MECHANICAL SERVICES

QUALITY ASSURANCE CERTIFICATE

(ENGINEERING)

Client:

Project:

Project No:

Contractor: _____

System/Sub-System Component Description:

Calculation Type: Thermofluid or Acoustic (*).

Attached are my calculations which certify that the above system/system component meets the performance requirements specified.

Contractor's Chartered Professional Engineers: _____

IE AUST. Corporate Membership No: _____

Date: _____

(*) Acoustic only when requested by Superintendent.