

**General Specification for Air-conditioning, Refrigeration, Ventilation and Central
Monitoring & Control System Installation**
in Government Buildings of the Hong Kong Special Administrative Region
2017 Edition (Incorporating Corrigendum No. GSAC01-2017)

The General Specification for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control System Installation in Government Buildings of the Hong Kong Special Administrative Region 2017 Edition (hereinafter referred to as “General Specification for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control System Installation 2017 edition”) is reviewed from time to time to ensure that requirements stipulated in the document are clear, concise and in pace with technological advancements.

Corrigendum No. GSAC01-2017 is issued to incorporate updates and revisions to the General Specification for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control System Installation 2017 edition which are highlighted in the ensuing summary of major changes.

Electronic version of the General Specification for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control System Installation 2017 edition incorporating Corrigendum No. GSAC01-2017 can be viewed on the ArchSD Internet website.

After an introductory period of 3 months, the General Specification for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control System Installation 2017 edition (incorporating Corrigendum No. GSAC01-2017) shall apply to all tenders to be invited on or after **1 April 2020**.

(12/2019)

MAJOR CHANGES IN THE CORRIGENDUM (NO. GSAC01-2017) OF THE
GENERAL SPECIFICATION FOR AIR-CONDITIONING, REFRIGERATION, VENTILATION AND
CENTRAL MONITORING & CONTROL SYSTEM INSTALLATION
IN GOVERNMENT BUILDINGS OF THE HONG KONG SPECIAL ADMINISTRATIVE REGION
2017 EDITION

Old Ref. No.	New Ref. No.	Major Changes
-	Delete C2.7	
-	Re-arrange C2.8 to C2.18	
SECTION C2	SECTION C2	-
PART A - SCOPE AND GENERAL REQUIREMENTS		
SECTION A3 - EXECUTION OF INSTALLATIONS		
A3.17.5	A3.17.5	General updates
SECTION A4 - DRAWINGS AND MANUALS		
A4.2.2	A4.2.2	General updates
A4.3.2	A4.3.2	General updates
PART B - GENERAL TECHNICAL REQUIREMENTS (INSTALLATION METHODOLOGY)		
SECTION B2 - DUCTWORK		
B2.1	B2.1	General updates
B2.3	B2.3	General updates
B2.10	B2.10	General updates
SECTION B3 - AIR HANDING AND TREATMENT		
B3.1	B3.1	General updates

Old Ref. No.	New Ref. No.	Major Changes
SECTION B5 – CENTRAL CONTROL AND MONITORING SYSTEM (CCMS)		
B5.1.2	B3.1.3	General updates
B5.3	B5.3	General updates
SECTION B6 - CENTRAL REFRIGERATION MACHINE, DIRECT EXPANSION EVAPORATORS AND HEAT REJECTION PLANT		
B6.1	B6.1	General updates.
B6.2	B6.2	General updates
B6.5.5	B6.5.5	General updates
B6.5.5(f)	B6.5.5(f)	Add new clause “The measurement and data collection details shall comply with Code of Practice for Energy Efficiency of Building Services Installation (2018 Edition)”
B6.14.1	B6.14.1	General updates
SECTION B8 – NOISE AND VIBRATION CONTROL		
B8.1	B8.1	General updates
B8.5.5	B8.5.5	General updates
SECTION B9 – PIPEWORK, VALVES, COCKS AND STRAINER		
B9.3.2	B9.3.2	General updates
B9.15.3	B9.15.3	General updates
SECTION B11 - THERMAL INSULATION		
B11.1	B11.1	Add new clause “Pre-insulated pipes shall be supported on the outside of the cladding/ outer jacket and no high density load bearing or hardwood block should be used between the service pipe and cladding.”
-	B11.2.6	Add new clause “Pre-insulated Pipes of Foam Insulation with No Ozone Depleting Substances”
B11.5.4	B11.5.4	General updates

Old Ref. No.	New Ref. No.	Major Changes
B11.6.3 (c)	B11.6.3 (c)	General updates
B11.6.4	B11.6.4	General updates
B11.6.5	B11.6.5	Amend “All pre-insulated pipe shall be pre-fabricated and pre-insulated in off-site factory. All pre-insulated pipe shall consist of (i) carrier pipe/ service pipe, (ii) thermal insulation and (iii) external jacket/ cladding. The pre-fabrication and pre-insulation system shall include pipe fittings” to “All pre-insulated pipe shall be off-site pre-fabricated and pre-insulated by foam injection machine. All pre-insulated pipe shall consist of (i) carrier pipe/ service pipe, (ii) foam insulation and (iii) outer jacket/ cladding. The pre-fabrication and pre-insulation system shall include pipe fittings”
B11.8.3	B11.8.3	General updates
SECTION B12 - UNITARY AIR-CONDITIONER		
B12.1.2	B12.1.2	<ul style="list-style-type: none"> - General updates. - Delete the clause “rated and tested in the same country of manufacture”
PART C - GENERAL TECHNICAL REQUIREMENTS (MATERIAL AND EQUIPMENT SPECIFICATION)		
SECTION C1 - AIR CLEANING EQUIPMENT		
C1.1.1	C1.1.1	General updates
C1.2.1	C1.2.1	<ul style="list-style-type: none"> - General updates - Amend “BS EN 13779:2007 Particulate Air Filters for General Ventilation” to “European Standard BS EN 16798-3: 2007 - Energy Performance of Buildings – Ventilation for Buildings” - Add “and BS EN ISO 29463-2:2018 to BS EN ISO 29463-5:2018 – High-efficiency filters and filter media for removing particles in air” - Add “European Standard BS EN ISO 16890-1:2016 to BS EN ISO 16890-4:2016 – Air filters for general ventilation”
C1.2.2	C1.2.2	General updates
C1.3	C1.3	General updates
C1.4	C1.4	General updates

Old Ref. No.	New Ref. No.	Major Changes
C1.5	C1.5	General updates
C1.6	C1.6	General updates
C1.7	C1.7	General updates
C1.8	C1.8	General updates
C1.9	C1.9	General updates
C1.10	C1.10	General updates
C1.11	C1.11	General updates
C1.12	C1.12	<ul style="list-style-type: none"> - General updates. - Amend accredited laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C1.13	C1.13	Amend accredited laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C1.14	C1.14	<ul style="list-style-type: none"> - General updates. - Amend recognised laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C1.16	C1.16	<ul style="list-style-type: none"> - General updates. - Amend independent laboratory test reports and certificates to “test reports and certificates by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C1.17	C1.17	<ul style="list-style-type: none"> - General updates. - Amend independent laboratory test reports and certificates to “test reports and certificates by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
SECTION C2 – DUCTWORK AND ACCESSORIES		
C2.3 (a)	C2.3 (a)	General updates

Old Ref. No.	New Ref. No.	Major Changes
C2.6.2	C2.6.2	General updates
C2.11.2	C2.11.2	Amend an independent laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
SECTION C3 - AIR HANDLING AND TREATMENT EQUIPMENT		
C3.1.4	C3.1.4	General updates
C3.2.1	C3.2.1	General updates
C3.2.3	C3.2.3	Add new clause “...Electronically Commutated (EC) plug fans as described in the relevant content of Section C3.14 or ...”
C3.2.8	C3.2.8	Table C3.2.8 – (1) Pre-filter - Amend “Arrestance % BS EN 779:2012” to “Minimum Efficiency Reporting Value (MERV) ANSI/ASHRAE Standard 52.2-2017 or equivalent, e.g. BS EN ISO 16890:2016” Table C3.2.8 – (2) Intermediate filter - Amend “Efficiency % BS 3928:1969 (or EN 779:2012)” to “Minimum Efficiency Reporting Value (MERV) ANSI/ASHRAE Standard 52.2-2017 or equivalent, e.g. BS EN ISO 16890:2016”
C3.3.2	C3.3.2	General updates
C3.5.1	C3.5.1	General updates
C3.5.3	C3.5.3	General updates
C3.6.1	C3.6.1	General updates
C3.6.1 (b)	C3.6.1 (b)	Amend “an efficiency of not less than 50% when tested in accordance with BS EN 779:2012” to “minimum efficiency reporting value (MERV) of 1-2; Average Arrestance \geq 50% or 65% by ANSI/ASHRAE Standard 52.2:2017 or other equivalent”
C3.6.1 (e) (i)	C3.6.1 (e) (i)	Add “Sensorless technology as an alternative will be considered subject to the approval by the Supervising Officer;”

Old Ref. No.	New Ref. No.	Major Changes
C3.6.1 (e) (vi)	C3.6.1 (e) (vi)	Add new clause “The total harmonic distortion shall be submitted to the Supervising Officer for approval”
-	C3.6.1 (h)	Add new clause “For the connection between cooling coils of fan coil unit and chilled water pipe, suitable fitting/device or methodology approved by the Supervising Officer to prevent galvanic corrosion effect of different pipe materials jointing together shall be provided.”
C3.14.2	C3.14.2	General updates
-	C3.14.6	Add new clause “Motor efficiency for the fans shall be of minimum IE4 under International Efficiency (IE) classes according to IEC 60034-30-1.”
C3.17.1 (b)	C3.17.1 (b)	General updates
C3.17.1 (d)	C3.17.1 (d)	General updates
C3.17.4 (b)	C3.17.4 (b)	- General updates - Amend a recognised laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C3.18.3 (b)	C3.18.3 (b)	General updates
C3.19 (a)	C3.19 (a)	General updates
SECTION C5 - CENTRAL CONTROL AND MONITORING SYSTEM (CCMS)		
C5.3 (a)	C5.3 (a)	General updates
C5.3 (b)	C5.3 (b)	General updates
C5.3 (e)	C5.3 (e)	General updates
C5.3 (i)	C5.3 (i)	General updates
C5.5	C5.5	General updates
C5.7	C5.7	Delete “continuous”
C5.13	C5.13	General updates

Old Ref. No.	New Ref. No.	Major Changes
C5.31	C5.31	Amend minimum profile formatting from “last 12 months” to “last 36 months”
C5.55	C5.55	General updates
SECTION C6 - CENTRAL REFRIGERATION MACHINE, DIRECT EXPANSION EVAPORATOR AND HEAT REJECTION PLANT		
C6.1	C6.1	General updates
C6.3	C6.3	General updates
C6.5.2 (g)	C6.5.2 (g)	General updates
C6.5.2 (p)	C6.5.2 (p)	General updates
C6.8.5	C6.8.5	Delete “In general, this requires the water box end to be domed rather than flat”
C6.13.1	C6.13.1	General updates
C6.13.4	C6.13.4	General updates
C6.13.10	C6.13.10	Add “The measurement and data collection details shall comply with Code of Practice for Energy Efficiency of Building Services Installation (2018 Edition)”
C6.20.2 (a)	C6.20.2 (a)	General updates
C6.20.3	C6.20.3	General updates
C6.21.1	C6.21.1	General updates
C6.21.7	C6.21.7	Add “alarm and”
C6.22.4	C6.22.4	General updates
C6.25	C6.25	<ul style="list-style-type: none"> - General updates. - Delete “The minimum coefficient of performance for direct or indirect sea water cooled chiller at peak load condition should be indicated in Particular Specification”
C6.28.1	C6.28.1	General updates
C6.28.3 (a)	C6.28.3 (a)	General updates

Old Ref. No.	New Ref. No.	Major Changes
C6.28.4	C6.28.4	General updates
SECTION C8 - NOISE AND VIBRATION CONTROL		
C8.5.2	C8.5.2	General updates
C8.7	C8.7	- General updates. - Amend an approved laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C8.9	C8.9	- General updates. - Amend an approved laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
SECTION C9 – PIPE MATERIAL, VALVES, COCKS AND STRAINERS		
C9.3.2 (a)	C9.3.2 (a)	General updates
C9.3.2 (b)	C9.3.2 (b)	Amend independent laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C9.9	C9.9	General updates
SECTION C10 – SYSTEM MONITORING INSTRUMENT		
C10.9	C10.9	Add new paragraphs on the requirements of energy metering
SECTION C11 - THERMAL INSULATION		
C11.1.2	C11.1.2	Amend laboratories accredited by HOKLAS or other laboratory accreditation bodies recognised by HOKLAS to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C11.1.5	C11.1.5	Add new clause “not inducing or leading to corrosion to pipe work and ductwork”
C11.1.6	-	Delete C11.1.6
C11.1.7	C11.1.6	- Re-arrange C11.1.7.

Old Ref. No.	New Ref. No.	Major Changes
		- Amend an approved testing laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
C11.2.1 (a) to (g)	C11.2.1 (b) to (h)	Re-arrange C11.2.1 (a) to (g)
	C11.2.1 (a)	Add new clause “Factory made phenolic foam products specification: BS EN 14314:2015”
C11.2.1 (b)	C11.2.1 (c)	Amend “Density: 40kg/m ³ ” to “ Density: 40kg/m ³ ±10%”
C11.2.1 (d)	C11.2.1 (e)	General updates
C11.2.1 (e)	C11.2.1 (f)	General updates
C11.2.1 (f)	C11.2.1 (g)	General updates
C11.2.1 (g)	C11.2.1 (h)	- Amend independent laboratory accredited by HOKLAS or other laboratory accreditation bodies recognised by HOKLAS to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved” - Add “ASTM C1371-15 with reference to”
C11.2.4 (a) to (h)	C11.2.4 (b) to (i)	Re-arrange C11.2.4 (a) to (h)
-	C11.2.4 (a)	Add new clause “Factory made flexible elastomeric foam products specification: BS EN14304:2015”
C11.2.4 (b)	C11.2.4 (c)	Amend “Density:65 kg/m ³ ” to “Density:50 to 65 kg/m ³ ”
C11.2.4 (g)	C11.2.4 (h)	General updates
C11.2.4 (h)	C11.2.4 (i)	General Update
C11.2.9	C11.2.9	Add new clause to “Foaming for Pre-insulated Pipes”
C11.2.9 (b)	C11.2.9 (b)	Amend “Density: 48 kg/m ³ ” to “Density: 48 kg/m ³ minimum”
C11.3	C11.3	Amend an approved testing laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”

Old Ref. No.	New Ref. No.	Major Changes
C11.4.2 (d)	C11.4.2 (d)	General updates
C11.4.3 (b)	C11.4.3 (b)	General updates
C11.4.3 (e)	C11.4.3 (e)	Add “Surface Emissivity (BS 5422) ≥ 0.85 (Paint, white)”
SECTION C12 - UNITARY AIR-CONDITIONER		
C12.1	C12.1	Delete the clause “rated and tested in the same country of manufacture”
C12.19	C12.19	General updates
SECTION C13 – WATER HANDLING EQUIPMENT		
-	C13.1.1 (c)	Add new clause “Motor efficiency for the pumps shall be of minimum IE4 under International Efficiency (IE) classes according to IEC 60034-30-1.”
C13.1.3 (b)	C13.1.3 (b)	General updates
C13.1.3 (c)	C13.1.3 (c)	General updates
C13.2.3 (b)(i)	C13.2.3 (b)(i)	General updates
C13.2.3 (d)	C13.2.3 (d)	General updates
C13.4.3	C13.4.3	General updates
C13.11	C13.11	General updates
C13.13	C13.13	General updates
C13.14.2 (d)	13.14.2 (d)	General updates
PART D – INDOOR AIR QUALITY (IAQ)		
D5.1.1 (d)(v)	D5.1.1 (d)(v)	General updates
D5.1.1 (d) (viii)	D5.1.1 (d)(viii)	General updates
D5.1.1 (e)(ii)	D5.1.1 (e)(ii)	General updates
D5.1.2 (a)	D5.1.2 (a)	General updates

Old Ref. No.	New Ref. No.	Major Changes
D5.4	D5.4	General updates
D5.5	D5.5	Amend independent laboratory to “laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved”
PART G – PAINTING, FINISHING AND PROTECTIVE TREATMENT		
Table G4	Table G4	General updates
PART H - INSPECTION, TESTING AND COMMISSIONING DURING CONSTRUCTION PERIOD		
H1.7 (a)	H1.7 (a)	General updates
H1.7 (e)	H1.7 (e)	General updates
H1.7 (f)	H1.7 (f)	- General updates - Amend “BS EN 60335-1:2012+A13:20147” to “BS EN 60335-1:2012+A13:2017”
H1.7 (g)	H1.7 (g)	General updates
H1.9 (b)	H1.9 (b)	Amend the cross reference clauses numbers to Testing and Commissioning Procedure for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control Systems Installation

ARCHITECTURAL SERVICES DEPARTMENT

BUILDING SERVICES BRANCH

GENERAL SPECIFICATION FOR

**AIR-CONDITIONING, REFRIGERATION, VENTILATION AND CENTRAL
MONITORING & CONTROL SYSTEM INSTALLATION**

IN GOVERNMENT BUILDINGS OF

THE HONG KONG SPECIAL ADMINISTRATIVE REGION

2017 EDITION

Corrigendum No. GSAC01-2017

(Effective from 1 April 2020)

The following clauses are amended in the above edition of General Specification for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control System Installation.

Clauses

TABLE OF CONTENTS

SECTION C2 DUCTWORK AND ACCESSORIES

C2.1	General
C2.2	Off Site Pre-Fabrication
C2.3	Specification and Standards
C2.4	Flexible Ductwork
C2.5	Ductwork for Corrosive Fumes
C2.6	Glass Fibre Ductwork
C2.7	Foam Duct Board Ductwork
C2.8	Dampers - General
C2.9	Butterfly, Bifurcating and Multi leaf Dampers
C2.10	Self-Closing (Non-Return) Dampers
C2.11	Fire, Smoke and Combined Fire and Smoke Stop Dampers
C2.12	Motorized Shut-Off Dampers
C2.13	Terminal Dampers

- C2.14 Access Doors and Panels to Ductwork, Cabinets, Cold Stores
- C2.15 Ductwork Flanges
- C2.16 Ductwork Cleaning Points
- C2.17 Test Holes
- C2.18 Transfer Ductwork

PART A – SCOPE AND GENERAL REQUIREMENTS

SECTION A3

EXECUTION OF INSTALLATIONS

A3.17 WORKMANSHIP

A3.17.5 Quality Assurance Standards

All materials and equipment shall be manufactured by factories with acceptable quality assurance procedures. Factories having ISO 9001:2015 certification are deemed to have acceptable quality assurance procedures. Other similar quality assurance standards may be accepted by the Supervising Officer on their individual merits. Details of such other quality assurance standards shall be submitted with the Equipment Schedule.

SECTION A4

DRAWINGS AND MANUALS

A4.2 INSTALLATION DRAWINGS

A4.2.2 Size of Installation Drawings

Drawings submitted by the A/C Contractor shall only be of standard sizes from A0 to A4 or B1 size as stipulated in ISO 5457:1999+A1:2010.

A/C Contractor's installation drawings and/or shop drawings shall be prepared to such scales that will clearly show all necessary details.

A4.3 AS-BUILT DRAWINGS

A4.3.2 Size of As-built Drawings

As-built drawings shall only be of standard sizes of A0, A1 or B1 size as stipulated in BS EN ISO 5457:1999+A1:2010. Smaller size (A2 to A4) is accepted for installation drawings.

PART B - GENERAL TECHNICAL REQUIREMENTS **(INSTALLATION METHODOLOGY)**

SECTION B2

DUCTWORK

B2.1 GENERAL

The zinc coating of the ducts shall not be damaged during fabrication, delivery and installation. Any damage to the galvanised finish shall be made good with three coats of aluminium zinc rich paint or other approved corrosion resisting paint to the satisfaction of the Supervising Officer, in addition to any other protective or finishing paint/coats required in the Particular Specification.

Fabrication and testing of all ductwork shall conform to DW/143:2013 - A Guide to Ductwork Leakage Testing & DW/144:2016 - Specification for Sheet Metal Ductwork published by B&ES and the requirements stipulated in this General Specification.

If insulation is applied to the pre-fabricated ductwork in the factory, leakage test of the ductwork shall be carried out before the application of insulation. Every precaution shall be made to ensure that the insulation and vapour barriers applied to the ductwork shall not be mechanically damaged before erection on Site.

Any damaged ductwork found shall be replaced. All inspection tests carried out in factory are part of the quality control process and shall in no way be treated as substitution of the field tests required on Site.

The ducting system shall be complete with all necessary supports, access doors, dampers, fire dampers, cleaning points and test holes.

All ducts shall be fabricated and installed so as to be rigid and free from swinging, drumming and movement.

All material of ductwork, gasket, flexible joints, acoustic linings and sealants shall not support bacteria growth or posing fire hazard.

B2.3 HANGERS AND SUPPORTS

All ductwork shall be securely supported by hangers, brackets and other appropriate forms of support as detailed in DW/144:2016 - Specification for Sheet Metal Ductwork published by B&ES.

All supports and hangers for air duct installed shall be rigid galvanised steel rod, angle bar or U-channel construction free from rust approved by the Supervising Officer.

All hangers shall be provided with screwed lengths drop rods with open turn buckles for adjustment of duct level. All fixings shall be provided with washers and lock-nuts and projecting ends of drop rods shall be cut off and protected with plastic caps.

All ductwork shall be securely supported so as to prevent vibrations or movements and arranged to allow expansion due to thermal stresses without distortion of the ductwork, rupture of insulation or damage to the supporting structure. Additional ductwork supports shall be positioned close to dampers, diffusers and all similar equipment which are not subjected to distortion, in addition to those hangers and supports generally required. Allowance shall be made in ductwork construction for instrument and controls connections and adequate local stiffening shall be incorporated to provide ridge mountings.

Noise and vibration shall not be transferred to the structure or any other element through hangers and brackets and in this respect the requirements of Sections B8 and C8 shall apply.

Approval shall be obtained from the Supervising Officer for hangers and support/installation/shop drawing designs before manufacture and installation. Furthermore, approval for the method design and calculation of fixing to the structure shall also be obtained as this may have structural implications.

All metal mounting and fixing brackets for air ductwork shall be pre-fabricated off-site.

B2.10 TESTING

All installed ductwork shall be tested to the "Building Energy Code". The method of air leakage test shall follow Appendix A of DW/144:2016 and to the B&ES standard DW/143:2013 and as directed by the Supervising Officer as

necessary to prove the quality of the Installations. Air leakage testing of ductwork on any section of completed Installations shall be carried out and shall be in accordance with Appendix A of DW/144:2016 and "Method of Testing" of DW/143:2013. For those items not covered in DW/144:2016 and subject to the approval of the Supervising Officer, the recommendations of the "HVAC Duct Construction Standards-Metal and Flexible":2005 and "HVAC Air Duct Leakage Test Manual":1985 issued by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) of U.S.A. shall be applied. Air ducts shall be leakage tested as necessary and any defects rectified before applying insulation and commissioning.

SECTION B3

AIR HANDLING AND TREATMENT

B3.1 GENERAL

Fans shall be installed using galvanised steel plate, supports, bolts, nuts and washers with all "as cast" bearing surfaces for bolt heads and washers counter-faced. Anti-vibration mountings shall be in accordance with Sections B8 and C8.

Fans heavier than 50 kg shall be provided with eyebolts certified by an Authorised Person (e.g. surveyor or structural engineer) for safe working load or other purpose made lifting facilities at convenient location for fan maintenance.

Fan V-belt drives shall comply with BS 3790:2006 (or related clauses of ISO 254:2011, ISO 1081:2013, ISO 1813:2014, ISO 4183:1995, ISO 4184:1992 & ISO 5292:1995) and shall be capable of transmitting at least the rated output with one belt removed. Minimum two belts per drive shall be used for motor rated higher than 4 kW unless otherwise specified. Pulleys shall be exactly aligned. The A/C Contractor shall ensure that any holding down bolts grouted in by builders are positioned to the correct alignment. Provision shall be made for positive adjustment of the tension in V-belt drives.

Fan guards shall be provided for all open unprotected intakes to centrifugal fans; for unprotected intakes to and exhausts from axial flow fans; for open unprotected and easily accessible intakes to and exhausts from propeller fans; for V-belt drives; for drive couplings and elsewhere as indicated. For full specification on motor drive guards refer to relevant clauses of Section C7.

Flexible joint shall be provided for air duct connecting to the inlet and outlet of fans.

Air flow direction, fan designation and fan number shall be clearly marked on the fan casing.

Galvanised steel or superior materials shall be used for all supports and fixing accessories and suitable paint shall also be applied in accordance with Part G.

SECTION B5

CENTRAL CONTROL AND MONITORING SYSTEM (CCMS)

B5.1 GENERAL REQUIREMENTS

B5.1.2 Compliance with Various Codes/ Standards

The Installations shall comply with the standards as described below where applicable: -

- (a) International Organization for Standardization ISO/IEC 9075-9:2016 -Information Technology - Database Languages - SQL – Part 9: Management of External Data (SQL/MED), ISO/IEC 9075-10:2016 – Information Technology – Database Languages – SQL – Part 10: Object Language Bindings (SQL/OLB), ISO/IEC 9075-13:2016 – Information Technology – Database Languages – SQL – Part 13:SQL Routines and Types Using the Java TM Programming Language (SQL/JRT);
- (b) International Telecommunication Union Recommendation V.90 – A digital modem and analogue modem pair for use on the Public Switched Telephone Network (PSTN) at data signalling rates of up to 56000 bit/s downstream and up to 33600 bit/s upstream and Recommendation X.25 – Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit;
- (c) ASHRAE Standard 135-2016 - A Data Communication Protocol for Building Automation and Control Networks (BACnet);
- (d) ANSI /CEA-709.1-B - Control Network Protocol Specification (known as Lon talk);

- (e) TIA/EIA 232-F, Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment Employing Serial Binary Data Exchange;
- (f) TIA/EIA 485-A, Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multipoint Systems;
- (g) TIA/EIA 568-1-D, Commercial Building Telecommunications Cabling Standard;
- (h) Transmission Control Protocol/Internet Protocol of Defence Advanced Research Project Agency (TCP/IP);
- (i) International Organization for Standardization ISO/IEC 1989:2014- Information Technology – Programming Languages – COBOL; and
- (j) International Organization for Standardization ISO/IEC 8802-3:2017 – Standard for Ethernet

B5.3 ELECTRICAL WIRING

The works shall be carried out in compliance with the requirements of the Electrical General Specification (See Clause A2.1) and Section B7 of this Specification and should comply with application guidelines of TIA/EIA 568.1-D / TIA/EIA 485-A / TIA/EIA 232-F whenever applicable.

The A/C Contractor shall provide all wiring work and electrical devices and material necessary to complete the Controls and Instrumentation System. Complete metal cable trays or enclosures shall be provided for conductors throughout all systems specified. Equipment and devices, which are not constructed with housings for mounting and enclosing all live parts, shall be installed in metal cabinets. All equipment, enclosures, cable trays, etc., shall be appropriate for the atmosphere and hazards encountered within their associated areas.

"Low" and "line" voltage wiring shall be done in strict accordance with the authority referred to this Section as mentioned above. Conduit shall be concealed in building construction in all finished spaces. Conduit runs exposed shall be run in a parallel manner to building surfaces. Conduit shall be supported in approved manner. Rigid conduit shall be used in all concrete pours. All connections from instruments shall terminate on terminal strips, properly tagged for ease of identification, located in control centres. No splices or junctions of wirings will be permitted in the field.

The A/C Contractor shall provide all interlock wiring required to make system operate in accordance with the drawings and specifications. All wiring diagrams, etc., required shall be provided and co-ordinated. Wiring shall begin on terminals of control device and terminate on terminals of controlled device.

The term "wiring" shall include wire, conduit, wiring device, conduit boxes/accessories and miscellaneous materials and labour required for mounting and wiring electrical control devices and services.

SECTION B6

CENTRAL REFRIGERATION MACHINE, DIRECT EXPANSION EVAPORATORS AND HEAT REJECTION PLANT

B6.1 GENERAL

In this section, refrigeration machine may refer to chiller or heat pump.

Refrigerants are classified in three flammability safety classification according to ANSI/ASHRAE Standard 34-2016: Designation and Safety Classification of Refrigerants. For refrigeration and air-conditioning system in government building projects, only non-flammable Class 1 refrigerants such as R-134a, R-407C, R-410A, R514A, R1233zd and R513A, etc. should be adopted.

Use of highly flammable hydrocarbon refrigerants under Class 3 should be prohibited and under no circumstances should they be adopted in government building projects.

Use of refrigerants under Class 2 (such as ammonia (R-717)) should only be considered under special consideration on individual project basis and subject to the conditions that such application fully complies with relevant safety procedures and standards such as ANSI/ASHRAE 15-2016 and ANSI/ASHRAE 34-2016 : Safety Standard for Refrigeration Systems, Designation and Safety Classification of Refrigerants and the statutory requirements from local authorities.

All necessary refrigerant and lubricating oil shall be supplied by the A/C Contractor during testing and commissioning and plant operation stages until the plant is accepted at the expiry of the Maintenance Period.

Each unit shall have an electronic/microcomputer control panel factory installed and tested. Full automatic control function shall be provided as detailed in Sections B4, B5, C4 and C5.

Eye wash, shower facilities and drain shall be provided by the Building Contractor and located at the exit(s) of the A/C plant room where the central refrigeration plant is installed.

Refrigerant leakage warning alarm in accordance with ANSI/ASHRAE 15-2016 and ANSI/ASHRAE 34-2016 or BS EN 378-3:2016 shall be installed if the refrigeration plant is installed in indoor environment.

The plant shall be so selected and installed with sufficient space allowed for effective heat dissipation to surrounding air, and for easy maintenance and servicing.

Appropriate corrosion resistant materials and assembly methods shall be used including isolation of dissimilar metals against galvanic interaction, etc.

Mounting and fixing details including details and dimensions of equipment bases, fixing bolts, supporting steelwork, flexible connections, vibration isolators and any special builder's work requirements, etc. shall be provided by the A/C Contractor in good time to meet the building programme.

Any damage to finishes of the equipment which may have occurred during transit, storage, installation or other causes shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Supervising Officer. Same type of paint shall be used for making good the damages.

Apart from the fixed maintenance platform provided by the Building Contractor as indicated on the Drawings, removable rigid working and service platform shall be equipped for the easy inspection and maintenance of the refrigeration plant and associated equipment. The platform shall be assembled from galvanised steel structure or fibreglass reinforced polyester with stainless steel fixing bolts, nuts and washers, and accessories approved by the Supervising Officer.

All mounting and fixing supports shall be of galvanised steel and exposed metal surface after cutting shall be treated against corrosion and painted in accordance with Part G.

B6.2 LAYOUT AND ISOLATION OF PLANT COMPONENTS

The plant layout shall be so arranged with physical division and valves such that any plant component may be isolated for servicing without completely draining the refrigerant or water circuits of the whole plant and shall follow the ANSI/ASHRAE 15-2016 and ANSI/ASHRAE 34-2016 or BS EN 378-2:2016 to BS EN 378-3:2016. All equipment shall be located within safety marking

perimeter. Clear floor safety marking in durable brilliant colour approved by the Supervising Officer shall be provided.

Motor control centre and central monitoring and supervisory console shall be installed inside a control room which is free from water pipes with double glazing window for plant viewing provided by the Building Contractor.

B6.5 AIR-COOLED PACKAGED REFRIGERATION MACHINE

B6.5.5 Installation of Energy Metering Devices

- (a) Electricity meters and thermal energy meters shall be installed to continuous measure, record and monitor the electricity consumption, energy input and output, cooling/heating power, coefficient of performance, and energy performance for each refrigeration machine. Independent electricity meters and thermal energy meters in accordance with ASHRAE Guideline 14-2014 and ASHRAE Guideline 22-2012 shall be provided by the A/C Contractor to measure the energy performance of the whole refrigeration system.
- (b) Ambient temperature sensors shall be installed to continuous measure, record and monitor the outside air temperature, outside air dry-bulb, and relative humidity for the whole refrigeration system.
- (c) The electricity meters in accordance with ANSI C12.1-2014, and ANSI C12.20-2015 or IEC 62053-22:2003+A1:2016, IEC62058-11:2012, IEC62058-21:2012 and IEC 62058-31:2012 shall be installed with 10 years certified life.
- (d) Thermal energy meters in accordance with ANSI C12.20-2015 and IEC 62053-21:2003+A1:2016, IEC62058-11:2012, and IEC62058-21:2012 shall be installed with 10 years certified life.
- (e) Type test report of the electricity meters and thermal energy meters shall be submitted to the Supervising Officer for approval prior to execution of work.
- (f) The electricity meters and thermal energy meters shall be connected to Central Control Monitoring System, if such system is provided, to optimise the operation of the refrigeration system. The measurement and data collection details shall comply with Code of Practice for Energy Efficiency of Building Services Installation (2018 Edition).

B6.14 SAFETY ANCILLARIES FOR AMMONIA REFRIGERATION MACHINE

B6.14.1 Pressure Relief Device

A pressure-relief valve connected via discharge pipe in accordance with relevant Sections of ANSI/ASHRAE15-2013(Packaged with ANSHI/ASHRAE 34-2013) or ANSI/IIAR Standard 2-2014 shall be provided at both high side and low side pressure vessels of the ammonia refrigerating system which automatically relieves pressure of pre-determined excessive pressure due to emergency conditions. A solenoid valve shall be provided in addition to the pressure-relief valve which is opened by means of a manual emergency switch. The solenoid valve shall be installed in a parallel by-pass circuit of the pressure relief valve on the pressure vessels. The required capacity of the pressure relief valves shall be determined in accordance with 2017 ASME Boiler and Pressure Vessel Code and the maximum length and size of the discharge pipe shall be determined in accordance with relevant sections as stipulated in ANSI/ASHRAE 15-2016 and ANSI/ASHRAE 34-2016.

An emergency discharge system including discharge pipeline size, length, pipe route and material, valve size, common header, pipe support, control valve box and termination diffuser, etc. shall be designed and constructed by the A/C Contractor according to ANSI/ASHRAE 15-2016 and ANSI/ASHRAE 34-2016 or ANSI/IIAR 2-2014- relevant sections. All emergency discharge pipelines shall be connected above the liquid refrigerant level on the high pressure side and the low pressure side of the system. The lines shall be pitched so as to drain the system. These lines shall extend into an emergency refrigerant control box readily accessible outside the ammonia refrigeration machine plant room. The box shall be locked and labelled with "Emergency Refrigerant Control Box - Ammonia R-717". A readily accessible stop valve labelled with "High Pressure Refrigerant Discharge Valve" and a suitable pressure gauge shall be installed on the discharge pipes within the emergency refrigerant control box. The emergency discharge lines shall be connected to a common riser for discharge to the atmosphere. At the upper extremity of the common riser, it shall be fitted with a diffuser for mixing the refrigerant with air. The discharge termination shall be within 600mm of one side of the discharge outlet of the emergency ventilation fan at roof level to ensure good mixing of ammonia/air by forced ventilation. The emergency ventilation system shall in this case operate within 1 second after the actuation of any one of the pressure relief devices or the manual discharge system.

The safety refrigerant relief discharge point shall be sited at a location away from any pedestrian access as approved by the Supervising Officer. A clear warning label shall be displayed next to the discharge point.

SECTION B8

NOISE AND VIBRATION CONTROL

B8.1 GENERAL

The A/C Contractor shall install sufficient noise and vibration control measures on the plant/equipment, the interconnected piping, ductwork and conduit so that when the installed plant/equipment are put into operation, the resulting noise and vibration levels at locations within the building and at adjacent or nearby buildings shall not exceed the acceptable limits.

Unless otherwise specified in the Particular Specification, the total noise level in occupied areas within the building, whether it be airborne, structure-borne or ductwork-borne, shall not exceed the following limits when all the plant/equipment installed by the A/C Contractor are put into operation: -

Table B8.1 Noise Control Criteria

Broadcasting and recording studios	NC 25
Concert and opera halls	NC 25
Theatres, assembly halls and churches	NC 30
Cinemas	NC 35
Hospital wards and operating theatres	NC 35
Homes, bedrooms	NC 35
Private offices, libraries, courtrooms and schoolrooms	NC 35
General offices	NC 40
Mechanised offices	NC 45
Restaurants, bars, cafeterias and canteens	NC 45
Department stores and shops	NC 45

Swimming baths and sports arenas	NC 50
Kitchens	NC 50
Factories (light engineering)	NC 65
Factories (heavy engineering)	NC 75

The specified noise criteria shall apply based on fundamental principles, such as those in ASHRAE Fundamentals SI Handbook 2017 to all areas as measured at a level of 1.2 to 1.8 m above the floor and the measuring points shall avoid exact geometric center of the room and any location within 1m of a wall, floor, or ceiling of the rooms.

The Corrected Noise Level at potential Noise Sensitive Receiver in the adjacent or nearby building, if so identified in the Contract, shall not exceed the Acceptable Noise Level stipulated in the Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites issued by the Environmental Protection Department when the plant/equipment installed by the A/C Contractor are put into operation.

B8.5 PIPEWORK VIBRATION ISOLATION

B8.5.5 Flexible Metallic Hose

For higher operating temperatures and pressures, vibrational movement generated by pumps, chillers, refrigeration machine, water towers, air handling units and other centrifugal or reciprocating vibrating equipment shall be accommodated by braided flexible metallic hoses. Allowable stress levels shall be within the units as prescribed in PD 5500: 2018+A1:2018.

The lengths of the flexible metallic hoses shall be in accordance with manufacturer's recommendation.

Since the braid is stretched taut by the pressure in the axial direction, hoses cannot accept axial motion. Therefore, the hoses shall be installed on the equipment side of the shut off valves and be installed parallel to the shaft for best performance so that the vibration movement is perpendicular to the axis of the hose. A Type 'T' pipe anchor capable of withstanding the deflection forces generated by the flexible hose shall be installed immediately after the hose in order to force the hose to flex transversely, otherwise the hose will serve little purpose.

Two hoses at right angles to each other shall be provided when major vibrational motions to be isolated exist in two planes.

SECTION B9

PIPEWORK, VALVES, COCKS AND STRAINERS

B9.3 BELLOW EXPANSION JOINTS/ANCHORS AND GUIDES

B9.3.2 Axial Movement Pattern

Axial movement bellow expansion joints on all services shall comprise thin wall multi-ply omega formed convoluted bellows of stainless steel material to BS EN 10029:2010, BS EN 10051:2010 and BS EN ISO 9445-1:2010, BS EN ISO 9445-2:2010 of appropriate type. Bellows should be argon arc welded to carbon steel end fittings utilising a stainless steel seal ring to reinforce the bellow cuff end.

The bellow expansion joint shall be provided with a close fitting stainless steel internal liner to reduce turbulent flow.

End termination to be carbon steel threaded male to ISO 7-1:1994/cor1:2007 or carbon steel flanges to ISO 7005-1:2011 Standard to suit the line pressures.

For copper or non-ferrous pipework systems expansion joints shall be manufactured in stainless steel throughout. The bellow expansion joints shall be installed with pre-cold setting to their required length to suit the temperature condition at the time of installation. The joints shall be rated suitable for the required amount of designed axial movement and shall be capable of performing the required cycles within the working life of the pipework. Mild steel outer protection sleeves shall be fitted to the bellows only when the units are open to the environment and exposed to risk of damage or when it is necessary to carry lagging over the joint.

Units should be installed in strict accordance with the manufacturers' recommendations. Manufacturers of expansion joints should be approved to ISO 9001: 2015.

B9.15 SPECIALISED HYDRAULIC SYSTEM BALANCING VALVES

B9.15.3 Construction

10 - 50 mm	Gunmetal	Working pressure up to 2 MPa (to BS EN 1982:2017)
------------	----------	--------------------------------------------------------

65 - 300 mm Cast Iron Working pressure up to 1.6 MPa
(to BS EN 1561:2011 and
ISO 185:2005)

The valve will be constructed with angled seat and valve handle complete with two plug type pressures tapping on each side of the valve seat.

Drain or vent plug valve

Valves 10 - 50 mm with screwed ISO 7-1:1994/Cor1:2007 and 7-2:2000 connections.

Valves 65 - 300 mm with flanged ISO 7005-1:2011, ISO 7005-2:1988 and ISO 7005-3:1988 connections.

SECTION B11

THERMAL INSULATION

B11.1 GENERAL

The thermal insulation works shall be undertaken by a minimum required percentage of workers who shall have a valid certificate of completing satisfactorily the thermal insulation training courses organised by the recognised association as specified in the contract. Upon request, details and particulars of these workers shall be submitted to the Supervising Officer for approval.

In general, all ductwork and equipment shall be insulated if the air conveyed within the ductwork and the air external to it have a temperature difference which may cause an unwanted condensation or heat loss either on the duct surface or within the ductwork or result in unwanted thermal exchange between the external and inside air of the ductwork.

Thermal insulation shall be applied to chilled or hot water pipework distribution systems and to components within distribution systems such as valves, storage vessels, strainer and accessories.

All insulation shall fit tightly to surfaces to be covered, and all slabs and sections shall be built up close, butting edges being mitred, chamfered or shaped as necessary. Any minor interstices left in insulation shall be filled and sealed with granules embedded in suitable and approved adhesive compound.

Insulated pipes and ducts shall be supported on the outside of the insulation, with load spreading galvanised iron or corrosion treated steel metal plates of suitable size and thickness between the insulation and supports to prevent the insulation being crushed. A higher density load bearing quality insulation or hard wood block should be used at support points as recommended by the insulation manufacturer and as directed by the Supervising Officer.

At the point of support, specially prepared blocks of hardwood or Styrofoam material must be positioned to ensure the integrity of the vapour barrier and cladding where applicable by bonding the supports to the insulation.

Pre-insulated pipes shall be supported on the outside of the cladding/ outer jacket and no high density load bearing or hardwood block should be used between the service pipe and cladding.

All materials delivered to Site shall be new, and where appropriate, colour coded and labelled at the factory to identify different grades, sizes and types. The insulation shall be protected from damage or deterioration before, during and after fixing. Damaged or compressed insulation should be replaced.

Immediately before applying insulation, clean all surfaces until these are free of rust, scale and grease, and are thoroughly dry. Under no circumstances should the insulation be applied to wet surfaces.

Any surface to be insulated, which shows any sign of rusting or damage, shall, prior to insulating, be thoroughly scrapped and wire brushed as necessary to remove all rust, scale, etc. Surfaces shall then be cleaned with appropriate solvent to remove all oil, grease and dirt prior to the application of two coats of grey epoxy primer paint and insulation. Only clean and dry insulation shall be applied in any case, and it shall be free from damage before application.

All materials including the thermal insulation itself, together with adhesives, paint, bands, sheeting, etc. shall be supplied with a reasonable margin for cutting, wastage and making good damage and loss. All materials shall be stored in a suitable manner so as to prevent them from damage or deterioration before fixing.

All insulation shall be applied so as to give a smooth, homogeneous and linear surface. All rigid sections shall be concentric, and accurately matched for thickness. Steps and undulations in the surfaces are not acceptable. Any sections or slabs having damaged ends will be rejected.

Continuous insulation shall be provided through all sleeves and insulation joints shall be staggered with respect to joints on the associated pipework or ductwork systems.

Insulation damaged for whatever reasons will be rejected.

Where thermal insulation is applied to the outside of piped and ducted services, equipment and plant used to convey, store or generate fluids or gases at temperatures lower than the design ambient dew point temperature indicated, a water vapour barrier shall be provided unless it can be demonstrated that the insulation material itself provide adequate barrier throughout its thickness to the approval of the Supervising Officer. The separate type vapour barrier where employed shall not be pierced or otherwise damaged by supports or by the application of external cladding.

Where relevant, moisture and vapour barriers, whether applied to the ductwork, hangers or projections, shall be continuous and completely provided throughout the surface of the insulation, and the insulation complete with the barrier shall be properly and firmly bound on the duct or pipe surface by appropriate fixing provisions. Such fixing provisions shall in no way impair the insulation or the vapour barrier. The A/C Contractor shall be responsible for any damages on the insulation or barrier due to improper installation and shall make good or replace the damaged insulation as appropriate and any subsequent wetting of the insulation due to improper installation or material shall be replaced by the A/C Contractor at his own cost.

Flexible connections on air conditioning ductwork shall be insulated with flexible blanket made from non-flammable material. The insulated blanket is to be wrapped with vapour barrier that conforming to Clause C11.4. The blanket shall be wrapped around the flexible connection, overlapped and secured in place by metal bands at both ends to the rigid ducts.

B11.2 TYPES OF THERMAL INSULATION MATERIALS

B11.2.6 Pre-insulated Pipes of Foam Insulation with No Ozone Depleting Substances

For pre-insulated pipes, all joints should be made using foam-in-situ (on site foaming) method after joining the service pipes.

All form-in-situ shall be limited to standard straight pre-insulated pipe joints of length below 1 m only. Same foaming chemical shall be used for all foam-in-situ.

All pre-insulated pipe joints and bare service pipes longer than 1 m should be off-site pre-insulated by foaming machine.

All pre-insulated pipes should be supported on the outside of the cladding/ outer jacket and no high-density load bearing or hardwood

block is required between the service pipe and cladding/ outer jacket to minimize thermal bridge and enable a seamless foam insulation throughout the whole pre-insulated pipe system.

B11.5 DUCT WORK AND AIR HANDLING PLANT - METHODS OF APPLICATION

B11.5.4 Pre-formed sheet insulation shall be applied with adjacent sides lapped at joints and corners to maintain a uniform thickness. The insulation shall be fixed securely with adhesives conforming to NFPA-90A:2018 and by impaling on fasteners which must be galvanised iron metal studs' split prongs, plastics studs or other approved devices fixed to the thickness and weight of the insulating materials and finishes to be applied and shall be spaced at approximately 300 mm centres. Fastenings shall be finished flush with the surface of the insulation to which they are applied. Adhesives shall be compatible with the insulation and in their dry state be non-flammable. Under no circumstances shall adhesives be used which attack or dissolve the ductwork or insulation.

B11.6 CHILLED WATER PIPEWORK AND EQUIPMENT - MATERIALS AND FINISHES

B11.6.3 Services in plant rooms and elsewhere where specified in the Particular Specification or Drawing, shall receive the following treatment in order to avoid possible mechanical damage or make necessary provision as otherwise indicated: -

- (c) Be treated with an effective high quality water based vapour barrier coating, Class 'O' surface to BS 5422:2009.

The vapour barrier coating must be non-flammable and safe to transport, store and use. Thixotropic consistency provides easy application with pinhole free, smooth finish, even when bridged over rough substrates. The dried film must be tough, flexible, washable and resistant to acids and alkalis for a long service life.

Glass fibre reinforcing mesh shall also be applied in between coat. The reinforcing mesh should incorporate a thread of 10 strands by 10 strands per 650 mm² into its construction. When tested according to ASTM D579/D579M-15, the materials should have a tensile strength warp of 50 g/mm² and fill of 50 g/mm².

B11.6.4 Outside buildings, services exposed to the weather; either of the following weather-proof covering shall be provided as indicated: -

- (a) Enclosed in fabricated sheet hammer clad aluminium casings. The casing shall be not less than 0.8 mm thick for pipework of 150 mm and above measured over the insulation and not less than 0.6 mm thick on smaller pipework;
- (b) Enclosed in roofing felt, sealed with adhesive with overlaps of at least 50 mm, wrapped with 25 mm spaced wire mesh of 1 mm thick, galvanised steel wire netting reinforcement, laced with 1 mm thick galvanised wire and painted two coats of bituminous paint or application with 15 mm thick cement plaster and paint;
- (c) Enclosed in poly-isobutylene sheet not less than 0.8 mm thick of tensile strength not less than 3.4 MN/m², lapped and sealed at all joints; or
- (d) Be treated with two coats of elastomeric polymer-based heavy duty mastic with reinforcing membrane to give a weather resistant finish.

The product shall meet the requirement of NFPA-90A:2018. The non-combustible shall be in accordance with NFPA 220:2018. Dry Film Fire Hazard requirements meet GSA and the product should be tested by ASTM E84-18b (Standard Test Method for Surface Burning Characteristics of Building Materials).

B11.6.5 Pre-insulated pipes where specified in the Particular Specification or Drawing, shall be of the following requirement or otherwise indicated:-

All pre-insulated pipe shall be off-site pre-fabricated and pre-insulated by foam injection machine. All pre-insulated pipe shall consist of (i) carrier pipe/ service pipe, (ii) foam insulation and (iii) outer jacket/ cladding. The pre-fabrication and pre-insulation system shall include pipe fittings.

B11.8 PAINTING AND IDENTIFICATION

B11.8.3 All distribution services shall be colour coded and provided with symbols for identification purposes. Identification coding for

ductwork, including thermal insulation, shall be in accordance with B&ES Standard DW/144:2016. For pipework, including thermal insulation, the basic colour and colour coding shall be in accordance with BS 1710:2014.

SECTION B12

UNITARY AIR-CONDITIONER

B12.1 GENERAL

B12.1.2 Unitary air-conditioners shall be factory fabricated and assembled. The equipment shall be rated and tested in accordance with the International Organisation for Standardisation (ISO) Standards 5151:2017 (non-ducted air-conditioners and heat pumps) or 15042:2010 (multiple split system air-conditioners and air-to-air heat pumps – testing and rating for performance) or 13253:2011 (ducted air-conditioners and air-to-air heat pumps) or 13256-1 & -2:1998 (water-to-air and water-to-water heat pumps) or other internationally recognised quality assurance standards approved by the Supervising Officer.

PART C - GENERAL TECHNICAL REQUIREMENTS **(MATERIAL AND EQUIPMENT SPECIFICATION)**

SECTION C1

AIR CLEANING EQUIPMENT

C1.1 GENERAL

C1.1.1 Particulate Filter

Particulate filters are the most commonly used air cleaning devices in buildings. They are classified into two general categories, pre-filters and final filters, according to the size of the particulate, which they catch and the energy required to circulate air through them. One or a combination of the filters shall be selected depending on the physical characteristics and levels of the dust to be removed, the capacity of the system to overcome the associated pressure drop across the filter and the degree of indoor air cleanliness required :-

Table C1.1.1 – (1) Types of Filters

Stage	Nature	Filter Type
Pre-filters	Washable	Washable Panel Filters
		Automatic Viscous Filters
	Disposable	Disposable Panel Filters
		Disposable Pleated Panel Filters
	Renewable	Renewable Panel Filters
		Automatic Fabric Roll Filters
Final Filters	Disposable	Bag Filters
		Cartridge Filters
		High Efficiency Particulate Arrestance (HEPA) Filters
	Renewable	Automatic Reclean able Filters
		Automatic Reclean able HEPA Filters

The filters shall be cleaned or replaced on a regular basis according to the manufacturer’s recommendations or when the specified maximum pressure drop is reached. To prolong service life, two stages of filtration with the minimum efficiency reporting value (MERV) by ANSI/ASHRAE Standard 52.2-2017 as shown in Table C1.1.1-(2) are recommended for buildings designed with a central air handling system to prevent premature clogging and frequent replacement of the high efficiency filter: -

Table C1.1.1 – (2) Filter Efficiency

Conditions	Pre-filters	Final filters
General occupied areas	Required	MERV 11 - 12
Heavy dirt loading areas	Required	MERV 13
Sensitive areas	Required	MERV 14

For critical clean air requirements, such as health care facilities, three filtration stages may be employed with High Efficiency Particulate Arrestance (HEPA) Filter as the third stage.

C1.2 STANDARDS

C1.2.1 Performance of Air Filter

The performance of air filters shall comply with one or more of the following standards: -

- (a) ANSI/ASHRAE Standard 52.2-2017 – Method of Testing General Ventilation Air Cleaning Device for Removal Efficiency by Particle Size;
- (b) Underwriters Laboratories UL 586:2009 – High Efficiency, Particulate, Air Filter Units;
- (c) European Standard BS EN 16798-3: 2007 - Energy Performance of Buildings – Ventilation for Buildings;
- (d) European Standard BS EN1822-1:2009 – High efficiency air filters (EPA, HEPA and ULPA) and BS EN ISO 29463-2:2018 to BS EN ISO 29463-5:2018 – High-efficiency filters and filter media for removing particles in air;
- (e) European Standard BS EN ISO 16890-1:2016 to BS EN ISO 16890-4:2016 – Air filters for general ventilation; or
- (f) Any other standards equivalent to the standards above and approved by the Supervising Officer to suit particular project requirements.

C1.2.2 Fire Property of Air Filter

The fire property of air filters and its associated accessories shall comply with one of the following standards as well as the requirements of the FSD: -

- (a) British Standard Institution BS 476-4:1970 - Non-Combustibility Test for Materials;
- (b) British Standard Institution BS 476-6:1989+A1:2009 - Fire tests on building materials and structures. Method of Test for Fire Propagation for Products, with Indices "I" \leq 12 and "i₁" \leq 6;
- (c) Underwriters Laboratories UL 900:2015 - Standard for Air Filter Units; or
- (d) European Standard DIN 53438-3:1984 - Response to Ignition by A Small Flame, Surface Ignition, Class F1.

C1.3 WASHABLE PANEL FILTER

This type of filter shall be constructed of aluminium to withstand washing by water or steam. The filter panel shall be constructed from multiple layers of expanded aluminium mesh or glass, natural or synthetic fibre, with the layers being corrugated or plain and arranged alternately at right angle at one another. Filter media shall be supported on both sides with a rigid and thicker aluminium expanded metal mesh.

Filters shall be 50, 25 or 12.5 mm thick with a rolled or extruded aluminium frame. The frame section shall be ribbed for stiffness and its inner edges treated to prevent sharpness and increase strength. Corners shall be mitred and riveted where it is necessary. Folding handles shall be applied to the short side of all washable filter panels for easy removal and cleaning. The filter support frame shall be suitable for the installation of either side.

It shall have the minimum efficiency reporting value (MERV) by ANSI/ASHRAE Standard 52.2-2017 and initial resistance at 2.5 m/s face velocity as shown in Table C1.3-(1) below, unless otherwise specified in the Particular Specification. The filter shall operate to a final resistance of 150, 100 or 75 Pa for 50, 25 or 12.5 mm thick panels respectively.

Table C1.3 - (1) MERV and Initial resistance of washable panel filter

Thickness	MERV Not Less Than	Initial Resistance Not Exceeding
50 mm	5	50 Pa
25 mm	4	30 Pa
12.5 mm	3	25 Pa

Where coated filtration media is specified, each layer of expanded aluminium shall be furnished with a thixotropic flame resistant filter coating before assembly into a pack. The adhesive shall have a flash point exceeding 180 °C Performance data for expanded aluminium filter panels oiled with a thixotropic adhesive shall have the minimum efficiency reporting value by ANSI/ASHRAE Standard 52.2-2017 and initial resistance at 2.5 m/s face velocity as shown in Table C1.3-(2) below, unless otherwise specified in the Particular Specification. The filter shall operate to a final resistance of 150, 100 or 75 Pa for 50, 25 or 12.5 mm thick panels respectively.

Table C1.3 – (2) MERV and Initial resistance of coated washable panel filters

Thickness	MERV Not Less Than	Initial Resistance Not Exceeding
50 mm	6	55 Pa
25 mm	5	35 Pa
12.5 mm	4	30 Pa

C1.4 AUTOMATIC VISCOUS FILTER

The filter shall comprise a frame or enclosure, filter plates, motor, drive and fluid tank. There shall be access to the tank containing the fluid to facilitate maintenance and the tools and containers required for the removal of sludge shall also be provided. It shall have the minimum efficiency reporting value not less than 7 by ANSI/ASHRAE Standard 52.2-2017, unless otherwise specified in the Particular Specification. The design air velocity at the face of the filter shall not exceed 2.5 m/s and operating resistance shall not exceed 125 Pa at the design air volume flow rate. To ensure that there is no carry-over of fluid from freshly wetted surfaces the rate of drive shall be suitably adjusted and set or otherwise the filter shall incorporate shielding devices.

C1.5 DISPOSABLE PANEL FILTER

The filter shall be of glass or synthetic fibres media panel type. It shall have the minimum efficiency reporting value not less than 6 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 75 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The filter shall operate to 250 Pa final resistance.

The glass or synthetic filter media shall be supported between two media retainers inside a reinforced cardboard retaining frame. The media retainers shall be suitably designed and fabricated to provide adequate support, such as combined metal mesh and grilles, throughout its whole working life, the filter element shall be bonded together with a cured resin, with a light adhesive coating, and suitably treated such that the filter media are not affected by air moisture, vermin proof and resistant to fungal growth.

C1.6 DISPOSABLE PLEATED PANEL FILTER

The extended surface pleated filter shall be of similar design for disposal panel filter but it shall be used when higher air cleaning efficiency and higher air flow rate are required. It shall have the minimum efficiency reporting value not less than 7 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 75 Pa at 2.5 m/s face velocity, unless otherwise specified in the

Particular Specification. The filter shall operate to 250 Pa final resistance. The pleated media shall be bonded to the expanded wire mesh to maintain its high efficiency and constant air flow rate.

C1.7 RENEWABLE PANEL FILTER

It shall be used for heavy dust loading condition when the maintenance cost is the main decision factor. The filter media shall be of glass or synthetic fibre with a thickness of 50 mm unless otherwise specified. The filter media shall be replaceable and held in position in permanent wire basket, which shall be designed for easy filter element replacement. It shall have the minimum efficiency reporting value not less than 6 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 75 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The filter shall operate to 250 Pa final resistance.

C1.8 AUTOMATIC FABRIC ROLL FILTER

The filter shall comprise the complete assembly of filter frame, motor, drive, filter blockage sensor and filter media. All sheet metal parts shall be of corrosion resistant galvanised steel construction. The filter media, supplied in roll form and 50 mm in thickness, shall be automatically across the face of the filter, while the used dirty media shall be rewound onto a roll drum at the other end. Each media roll shall not be less than 20 m long for sufficient service life before replacement is required. The filter shall operate automatically to maintain the design operating resistance of the filter media and the required operating efficiency. The filter shall advance the filter media automatically on the command from a pressure switch, timer, or light-transmission control device. The control circuit must operate to ensure uniform feeding of the filter media for constant dirt condition and loading. It shall not require re-calibration if the actual working condition differs from design or if the system is of variable air volume type. Visual or audible warning to notify filter media replacement shall be provided. The driving motor shall be automatically switched off when the filter media end is reached and a filter stop alarm shall be generated to alert maintenance personnel for filter replacement. The controls shall be factory wired and arranged to insure fail safe operation. The filter shall be designed and constructed to enable continuous operation during routine servicing and maintenance of the filter. The filter media shall be provided with an effective seal to minimise air bypass. A spare roll of filter media shall be provided for each unit.

The initial resistance of the filter shall not exceed 45 Pa and a mean of 85 Pa under designed operating conditions. The air velocity through the filter media shall not exceed 2.5 m/s. It shall have the minimum efficiency reporting value

not less than 6 by ANSI/ASHRAE Standard 52.2-2017, unless otherwise specified in the Particular Specification.

C1.9 BAG FILTER

The air filter shall be of high efficiency, extended area, deep pleated, disposable type. The media shall be of microfine glass fibre and reinforced by a laminated synthetic backing. It shall have a nominal thickness of 600 mm and the minimum efficiency reporting value shall not less than 13 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 100 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The air filter shall be designed for air velocity of 1.0 to 3.5 m/s and shall operate to 250 Pa final resistance.

The filter package shall be factory assembled as a complete set readily for site installation. The filter assembly shall consist of a holding frame, sealer frame, media retainer, and the disposable element.

The sealer frame shall be constructed of galvanised steel of sufficient thickness and equipped with suitable airtight sealing gasket and sealing mechanism on the sealer frame flange. The media retainer shall be designed to match the filter elements to provide sufficient support for the multiple pleats of the filter element against the direction of the airflow. The media retainer shall be suitably coated and designed to totally eliminate the possibility of oscillation and sagging. The bag or packer shall inflate fully, shall not sag or flutter or be obstructed by contact with other filter faces or ductwork surfaces when operating between 60 - 110% of design air volume flow rate for constant volume system.

C1.10 CARTRIDGE FILTER

This type of filter shall work reliably in the range of medium and high cleaning efficiency. It shall have the minimum efficiency reporting value not less than 13 by ANSI/ASHRAE Standard 52.2-2017 and initial resistance not exceeding 100 Pa at 2.5 m/s face velocity, unless otherwise specified in the Particular Specification. The filter shall operate to 250 Pa final resistance and shall consist of water-resistant media of ultra-fine glass fibres. The media shall be pleated and have suitable separators to maintain the uniform spacing between pleats. The filter assembly shall be of rigid cartridge design, which shall consist of a steel header and cell box to form a supported pleat media pack for various difficult operating conditions. The filter set shall be, unless otherwise specified, of 300 mm nominal thickness disposable extended surface cartridge type. The media shall be water resistant and shall be made of ultra-fine glass fibres formed into thin mate, which shall be supported by suitable corrugated separators and

sturdy enough to operate in a VAV system. The filter panel shall be constructed of galvanised steel sheet folded and reverted to form a rigid frame.

C1.11 HIGH EFFICIENCY PARTICULATE ARRESTANCE (HEPA) FILTER

The HEPA filter shall have minimum efficiency of 99.97% in removing small particles of sizes larger than 0.3 micrometre from air by Underwriters Laboratories UL 586:2009. This makes use of a high efficiency glass paper medium and great surface area of medium per cross-sectional area of the filter. It shall reach this rated efficiency when the velocity of the air passing through the media is 2.5 m/s. Unless otherwise specified in the Particular Specification, a normal HEPA filter of a size 600 mm square with 300 mm thickness, shall have a rated flow of 0.75 m³/s, at a pressure drop not exceeding 250 Pa, and about 23 m² of filtering media surface area. The filter shall operate to 600 Pa final resistance.

Filter shall be constructed with the media pack folded over separators to form closely spaced pleats, the whole being sealed into a casing with hard setting synthetic resin cement. This shall enable slower media velocity and increased efficiency. The media of space filter paper produced wholly from glass micro fibres, shall be inert, non-hygroscopic, vermin proof and shall not support bacteria growth. The filter media shall be treated with organic binder materials to provide binder, fungicidal and waterproofing properties.

For clean rooms and clean zones, the HEPA filter shall be selected to meet class 5 of air cleanliness by ISO Standard 14644-1:2015 – Cleanrooms and Associated Controlled Environments - Classification of Air Cleanliness by Particulate Concentration, unless otherwise specified in the Particular Specification.

C1.12 AUTOMATIC RECLEANABLE FILTER

The filter system shall include filter media, air compressor unit, air jet nozzles, controller, automatic dust collection unit, etc.

Filter media shall be made of reinforced fibre-glass or other suitable synthetic medium mounted on a rotary tube or a fixed drum. When the pre-set differential pressure between dirty and clean air sides of the filter is exceeded, the cleaning operation shall be initiated. For the rotary tube design, the carrier tube shall rotate and suction nozzle with vibrator motor shall move along the filtering surfaces. For the fixed drum design, an air valve installed at the downstream of the filter shall induce compressed air pulse-jets opposite to normal air flow direction. As a result, dirt particles will be pulsed away from the filter and collected in concentrated form inside a collection chamber, or an external

vacuum cleaner, or a central vacuum cleaning system connected outside the filter chamber.

Cleaning shall be carried out both during downtimes of the air-conditioning/ventilation system and during plant operation. It shall have the minimum efficiency reporting value not less than 14 by ANSI/ASHRAE Standard 52.2-2017. The initial resistance across the whole unit shall not exceed 250 Pa at design air flow volume rate and the final resistance shall not be more than 500 Pa, unless otherwise specified in the Particular Specification.

The internal surfaces of the filter set shall be absolutely smooth and the bottom shall be in trough form with drain so that water can be drained away in case of wet cleaning.

The construction of the service door shall be identical to the casing panel. Non-aging steel-inlaid labyrinth seal shall be integrated into the door leaf. Each door shall be fitted with at least two double lever locks with bolts. Safety cams or chains shall be provided for pressure side doors. All the surfaces of the casing shall be protected against atmospheric corrosion by plastic powder coating.

The whole cleaning cycle shall be activated and controlled by a sequence controller with the following basic operations: -

- (a) Reverse blowing by air pulses;
- (b) Allow a few minutes' time interval for the dust and other contaminant particles to settle at the collector trap;
- (c) Operation of the vacuum cleaner/central vacuum cleaning system for a few minutes; and
- (d) Actuate alarm for disposal of the contaminant particles when the collecting bag is 80% full.

The filter media shall be selected to suit wet conditions such as market areas and poultry areas.

The controller shall be provided with two operation modes, "Auto" and "Manual". Under the "Auto" mode, the filter media shall be auto-cleaned by the compressor air from the air jet nozzles whenever the pressure difference across the filter media is in excess of the pre-set value. The filter system shall be arranged to connect to CCMS system and operated in accordance with a time schedule which can be set from the CCMS.

An automatic dust collection unit shall be provided to collect dust inside the filter section after each auto cleaning operation.

All of the operation status and fault signals shall be monitored by the CCMS.

The air compressor shall be tested and certified by the laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved in accordance with relevant statutory requirements.

C1.13 AUTOMATIC RECLEANABLE HEPA FILTER

The whole unit shall be of heavy duty proprietary made air-tight construction. It shall be coated with polyester powder to protect from atmospheric corrosion and to minimise internal friction. By modular construction, each filter chamber of the unit shall be able to be isolated from the air stream without affecting the operation of the unit while cleaning or replacing the filter cartridges within a particular filter chamber. The filter cartridge shall be designed as drawers by sliding in or pulling out for replacement and repairing services from the front panel and entirely from the clean air side. There shall be no contamination on the filter unit and the environment during the replacement. At the bottom, dust collection containers shall be mounted to each filter chamber by clamps via inter-connecting funnel sections.

Automatic cleaning is conducted by using a counter-current compressed air purge sequence. Filter shall be cleaned periodically by compressed air, which is blown in counter-flow direction to the filter cells from nozzles actuated by pneumatic system from the clean air side. A digital measuring and indication device shall be provided to show the differential pressure of all filter cells in one filter chamber.

The controller shall provide two operation modes, "Auto" and "Manual". Under the "Auto" mode, the filter media shall be auto cleaned by the compressor air from the air jet nozzles whenever the pressure difference across the filter media is in excess of the pre-set value. The filter system shall be arranged to connect to CCMS system and operated in accordance with a time schedule which can be set from the CCMS.

An automatic dust collection unit shall be provided to collect dust inside the filter section after each auto cleaning operation.

All of the operation status and fault signals shall be monitored by the CCMS.

The air compressor shall be tested and certified by the laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved in accordance with relevant statutory requirements.

Filter media shall be made of reinforced fibre-glass or other suitable synthetic medium with minimum efficiency of 99.97% in removing small particles of sizes larger than 0.3 micrometre from air by Underwriters Laboratories UL 586:2009. It shall reach the rated efficiency when the velocity of the air passing through the media is 2.5 m/s. For a nominal HEPA filter of a size 600 mm square with 300 mm thickness, it shall have a rated flow of 0.75 m³/s and about 23 m² of filtering media.

The initial resistance across the whole unit shall not exceed 1500 Pa at design air flow volume rate and the final resistance shall not be more than 2400 Pa, unless otherwise specified in the Particular Specification.

C1.14 AUTOMATIC RECLEANABLE HIGH VOLTAGE ELECTROSTATIC FILTER

The automatic reclean able high voltage electrostatic filter shall be able to control odours in the conditioned space and reduce the permanent deposition of contaminants in the space served. It shall have the minimum efficiency reporting value not less than MERV 14 by ANSI/ASHRAE Standard 52.2-2017 and an initial resistance not exceeding 120 Pa at design air flow volume rate, unless otherwise specified in the Particular Specification. The whole unit shall be tested to meet Underwriters Laboratories UL867:2011 - Electrostatic Air Cleaners and of a type approved by the Director of Fire Services. It shall not be used in hazardous locations or for handling hazardous gases/mixtures.

For kitchen applications, it shall comply with the requirements of the Environmental Protection Department on the treatment of gas fired kitchen exhaust air and the unit shall be leakage proof to avoid oil dripping. It shall have oil mist removal efficiency not less than 90%, odour removal efficiency not less than 50% and an initial resistance not exceeding 120 Pa at design air flow volume rate, unless otherwise specified in the Particular Specification. Oil mist removal performance shall be verified by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved. The whole unit shall be tested to meet Underwriters Laboratories UL710:2012 - Exhaust Hoods for Commercial Cooking Equipment (for Fire and Burnout Test only). Filter performance shall be tested according to ANSI/ASHRAE Standard 52.2-2017 and equipment shall be tested to meet Underwriters Laboratories UL867:2011 - Electrostatic Air Cleaners.

The unit shall consist of an ioniser-collector section power generator, an aluminium washable panel filters section against over-spray and a washer and adhesive applicator section. All parts shall be factory assembled into a sectioned housing having an overall depth not greater than 1000 mm in direction of airflow. Each section of the galvanised steel housing assembly shall incorporate a pair of hinged, quick opening access doors permitting access for servicing of all

internal components; and a watertight, all welded, galvanised steel, drain pan having drain connections. Access doors shall be sealed against leakage by continuous perimeter gaskets of closed cell neoprene.

- C1.14.1 Each ioniser-collector section shall be furnished with the required number of one-piece or multi-piece cells of all aluminium construction. Each cell shall be fitted with stainless steel slides for mounting on the tracks, which form an integral component of the side access housing and to facilitate removal of cells for servicing. Cell support framework shall be completely open beneath the ioniser-collector cells to ensure complete drainage of wash water and excess adhesive, minimising the possibility of short circuits when high voltage power is restored following completion of the wash cycle. Cells shall be designed so that high voltage input terminals and their high volt rated insulators are located completely out of contact with the moving air-stream to avoid build-up of dirt which could permit dissipation of high voltage charge and reduce air cleaning efficiency. The high voltage bus bars and contactors shall be inherent to the design of each cell and shall permit cell removal without disconnecting any high voltage wiring. Insulators shall be fully exposed, for ease of cleaning, when cells are removed for service. Cells shall be designed for full-face ionisation and shall have completely flat collector plates to prevent build-up of residual, inaccessible dirt accumulations.
- C1.14.2 Dual voltage power packs which are designed to provide high voltage to the ioniser circuit and to the plate circuit respectively shall be connected to each ioniser-collector section. The power packs shall be of solid state design to include "fail-safe" low voltage relays to interrupt power to the ioniser circuit in the event of a malfunction in the plate circuit. High voltage connections between the high voltage output terminals and the bus bar terminals mounted on the ioniser-collector section access door shall be adequately installed. Each power pack covers shall include a circuit breaker, a manual reset button and / or automatic reset. Safety type door interlock switches, with suitable length of safety chain and wiring in series circuit for the power pack, shall be furnished to cut-off the power supply whenever the door is opened.
- C1.14.3 Each washer and adhesive applicator section shall incorporate slide-in type, perforated, galvanised steel air distribution baffles and a swing or fixed header assembly. The header assembly shall be connected to the inlet water solenoid valve and to the adhesive pump. Washer arms shall be equipped with 360 fixed washer spray nozzles against reactive force to the high inlet water pressure. The removable brass adhesive nozzles shall be mounted on a separate, fixed, vertical

header forming an integral component of the assembly. The filter adhesive shall be cold water soluble and non-flammable. A rotary gear adhesive pump with bronze impeller and sufficient adhesive for at least four reconditioning cycles shall be furnished.

- C1.14.4 The washer supply water solenoid valve, manifold drive motor, manifold limit switch and adhesive pump shall be pre-wired to an accessible, internally mounted terminal box. The washer control panel shall incorporate a status light to indicate when the reconditioning cycle is energised and the reconditioning cycle is in operation. The complete automatic cleaning by reversing the polarity of the filter element, wet washing by water spray and adhesive application shall be initiated manually or automatically through a push button actuated, internally fused, all solid state and program timer control. The controller shall be provided with two operation modes, "Auto" and "Manual". Under the "Auto" mode, the electrostatic filter shall be automatically cleaned on the timer of pre-set value and cleaning operations shall not be energised when the exhaust fan is in running status. The filter system shall be arranged to connect to CCMS and operated in accordance with a time schedule set from the CCMS.

All of the operation status and fault signals shall be monitored by the CCMS.

C1.16 ACTIVATED OXYGEN AIR PURIFIER

The air purifier shall be capable of reducing odours of bacterial, organic and chemical origin and shall also be capable of reducing airborne bacteria and particulates in the treated areas.

All components of the air purifier, which are within the air stream, shall comply with the requirement of the Fire Service Department. The air purifier shall conform to BS EN 61000-6-1:2007, BS EN 61000-6-2:2005, BS EN 61000-6-3:2007+A1:2011 and BS EN 61000-6-4:2007+A1:2011 or similar international standards on Electro-Magnetic Compatibility (EMC) compliance.

The air purifier shall have removal efficiency of not less than 95% of Total Bacteria Count (TBC) Test, 95% of airborne particulates of 0.5 micron to 2.0 micron, 95% of cigarette smoke particles, 80% of odours, and 95% of hydrogen sulphide, unless otherwise specified in the Particular Specification. Test reports and certificates by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved to show the removal efficiency of the unit shall be submitted to the Supervising Officer for approval.

The air purifier shall not generate ozone in the treated areas in excess of the safety standards as specified by the Occupational Safety and Hygienic Association (OSHA), USA or other recognised international standards. A proper control device to shut off part or the whole unit is required when excessive ozone is detected over the limit of OSHA. A site test shall be carried out to verify that the ozone level in the occupied zone does not exceed the specified level.

The air purifier shall be suitable for ductwork mounting and shall consist of a power generator and screw-in or snap-on electrodes. The power generator shall be able to operate at 220 V 50 Hz single phase supply, equipped with on/off switch, on/off indicator lamps, over load circuit breaker (fuses) and electrode tube sockets. Indication lamp for individual ionisation tube shall be provided. The side in contact to air stream of the power generator housing shall be insulated by double skin panel with proper means of thermal insulation in order to prevent condensation.

There shall be a minimum of 1 transformer for every 2 tubes. The output of the transformer shall be at 2800V whenever ionisation is being called for.

For air purifier installed in the exhaust air plenum, the plenum shall be of min. 300 mm length after the exhaust fan and using a stainless steel mounting flange provided by the manufacturer. It shall be interlocked with the respective ventilation fan so that it switches on/off with the air handling unit or ventilation fan.

Energy of each electrode tube shall be good enough for ionising 0.045 litre/s/W oxygen.

The electrode tubes shall consist of screw-in base and a glass tube. The electrode tube shall be covered with a stainless steel mesh and shall be electrically earthed by means of an earth clip or an earth screw securely connected to the power generator. The required number of electrode tubes shall be in accordance with the manufacturers' recommendation.

A control unit shall be supplied to guarantee stable and situation referred ionisation process without generating excessive ozone for this application. Ozone monitoring device shall be provided. The unit shall be able to control several purifiers by either Auto or Manual mode.

Under Auto mode, the control unit shall moderate the output intensity of the purifiers in accordance with the information concerning adaptation, total power consumption, air flow, relative humidity, VOC concentration and also ozone level for human safety. Adaptation values are depending on the application. Control signals shall be provided by relevant duct mounted sensors. Ionisation intensity can be moderated in the range of 0 to 99% in steps of 1%.

The control unit shall be able to switch off the air purifier when the air flow is below the pre-set value in the control unit in order to prevent the accumulation of ozone inside the system.

The control unit shall be able to reduce 50% and 10% intensity of the computed value when the ozone level of supply air is exceeded 30 ppb and 50 ppb, respectively. It shall stop the unit if the ozone level detected in the first supply air outlet is greater than 61 ppb.

Under Manual mode, the intensity of the purifiers shall be in accordance with the pre-set (adaptation) value at the control unit and independent of the sensor values.

The control unit shall include a LCD display or other display device as approved by the Supervising Officer for sensing values, hour counter and an error / alarm logger record of malfunction. All configuration setting shall be adjustable by using keypads and further protected by a password against unauthorised access of untrained staff.

For purposes of monitoring and remote control, the received signals from the sensors, system parameters and alarm status shall be able to be monitored and set by using the CCMS via a RS232 interface. The time interval of signals is at least 2 seconds. A dry contact for system alarm shall be provided for local / remote monitoring of system operation. Causes of the alarm shall include the failure of sensors and the air flow & humidity exceeding the pre-set values.

The air purifier shall be UL listed and tested to comply with Underwriters Laboratories UL 867:2011 – Electrostatic Air Cleaners.

C1.17 ULTRA-VIOLET (UV) STERILISING LIGHT

The UV steriliser light shall be provided to disinfect the supply air and eliminate any health hazard from the mechanical ventilation and air-conditioning system. It shall be mounted within the air handling unit, return air duct or other appropriate locations as specified in the Particular Specification.

The complete system shall consist of UV tubes, tube fitting set, electric supply unit and monitoring unit. It shall be designed for achieving a minimum bacteria removal efficiency of 90%. Equipment shall be selected on basis of UV lethal dosage requirement, not less than $5,000\mu\text{Ws}/\text{cm}^2$, for bacteria removal. Relevant selection method and test reports and certificates by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved to show the removal efficiency of the unit shall be submitted to the Supervising Officer for approval.

The UV steriliser light shall not generate substances in excess of the safety standards as specified by the Occupational, Safety & Hygienic Association (OSHA), USA or other recognised international standards.

The UV irradiation sections shall be provided with access door, inspection window and safety switch. The A/C Contractor shall ensure sufficient access space is allowed for maintenance purpose. A permanent warning notice shall be placed at the access door to alert personnel the danger of direct sight at the UV lamps.

The UV steriliser light shall be suitable for operation under supply voltage of 220V/50Hz. It shall be of high grade, non-corrosive materials. The housing shall be of high quality stainless steel and lamps shall be made from quartz glass with ceramic bases.

The electric supply unit shall be allowed to mount inside the irradiation chamber. System components exposed under moist air or condensation shall be of IP68. It shall have an implemented safety switch-off after lamp breakdown.

The working range of the electronic ballast shall be linear throughout a wide range of temperature. It shall have an implemented over voltage cut-out to improve safety and material protection. It shall not emit at a temperature above 40 °C during operation.

The UV steriliser light shall start and work properly even under unexposed, unfavourable working temperatures.

The emitter shall consist of electrodes and high quartz glass tube with ceramic bases. Each tube shall consume not more than 36W but emit pure UVC irradiation at wavelength 253.7nm of not less than 120µW/cm² measured at 1 m distances from the source after 100 hours under 25°C.

Life span shall be not less than 12,000 hours with residual output of 75 ±5% of the original output, measured after 100 hours under 25°C.

The UV output of the lamps shall be highly stable over an air temperature range of 5 °C – 25 °C and in no case the output fluctuation shall be greater than 30% of its nominal value within this temperature range. The UV output reduction shall not be any higher than 10 ±5% of its nominal value after 2000 hrs of burning in air.

The monitoring unit shall be an independent wall mounted unit installed in the vicinity of the sterilisation section. It shall be enclosed with casing of at least IP54.

The monitoring unit shall consist of any easy to reach circuit breaker, an on/off 3-way switch (auto/off/manual), a leakage current protective switch, a good visible general malfunctioning alarm lamp and shall have an indication display with at least two coloured functioning LED's for each connected ultraviolet system.

The monitoring unit shall be able to give information about used life span and lamp replacements for any connected system. It shall be able to monitor up to 42 lamps.

The monitoring unit shall be equipped with an RS 232 interface for external communication via CCMS. All of the operation status and fault signals shall be monitored by the CCMS.

The UV steriliser light shall be UL listed and tested to comply with Underwriters Laboratories UL Standards 153:2014 – Standard for Portable Electric Luminaires, UL 1598:2018 – Luminaires & UL 1995:2015–Heating and Cooling Equipment respectively.

SECTION C2

DUCTWORK AND ACCESSORIES

C2.3 SPECIFICATION AND STANDARDS

Ductwork shall comply with the following B&ES publications with additions or amendments as required by this General Specification and/or elsewhere in the Contract.

- (a) DW/144:2016
Specification for sheet metal ductwork;

C2.6 GLASS FIBRE DUCTWORK

C2.6.2 Specification and Standards

Specification and Standards for glass fibre ductwork shall comply with the recommendations of the B&ES Publication DW/191:1973 Code of Practice for ductwork made from resin-bonded glass fibre, or the "Fibrous glass Ductwork Construction Standards" issued by the Sheet Metal and Air Conditioning Contractors' National Association, Inc. USA. The flexural rigidity rating of the rigid glass fibre board

shall be 800E1 (33.7 kg/m²) as defined in the above Standards. Glass fibre ductwork shall meet with the requirements of NFPA-90A:2018 and 90B:2018 by complying with the requirements of Under-writer's Laboratories Standard for safety UL 181:2013 for Class 0 ductwork.

Glass fibre ductwork to be used shall resist fungal or bacterial growth when subjected to microbial attack described in Standard Practices ASTM G21-15(fungus test).

Glass fibre ductwork shall be easily cleanable using methods and equipment described in North American Insulation Manufacturers Association (NAIMA) Publication AH-122, Cleaning Fibrous Glass Insulated Ductwork Systems.

C2.11 FIRE, SMOKE AND COMBINED FIRE AND SMOKE STOP DAMPERS

C2.11.1 Fire and Smoke Stop Dampers

Fire or Smoke dampers shall be provided in ductwork in the following locations: -

- (a) Wherever a ductwork passes through a floor slab or a fire resisting wall which is expressly built for the purpose of preventing the spread of fire;
- (b) Other locations where requirements of compartmentalisation are stipulated in the Code of Practice for Fire Safety in Building 2011 under the Buildings Ordinance of HKSAR; and
- (c) Other locations as required by the Particular Specification and the Drawings.

Fire or Smoke dampers used singly or in combination shall have an overall fire resistance rating not less than that indicated and certainly not less than that for the wall or floor slab in which they are situated.

In all cases, evidence of fire rating in accordance with ISO 10294-1:1996/Amd 1:2014 Classification E (BS 476-20:1987 to BS 476-23:1987) or NFPA-90A:2018 with 2-hour UL fire damper label shall be provided by an independent testing organisation approved by the Supervising Officer. All Fire or Smoke dampers shall also be approved or accepted by the FSD.

Fire or Smoke damper blades of proprietary made shall be constructed to the approved and recognised testing authority and possess a rating equivalent to the fire resistance of the structure it protects.

Local made fire or smoke damper blades shall comply with the requirements of the Circular Letters issued by the FSD and the Buildings Ordinance of HKSAR. These blades shall be housed in a corrosion resistant casing constructed to avoid distortion due to stress in fire conditions. Stainless steel spring tempered flexible gasket shall be inserted between the blade and the casing for elimination of closing friction and retardation of smoke. Provision shall be made to accommodate expansion of the damper blades within the casing in fire conditions to prevent jamming and to retard the spread of smoke. A Fire or Smoke damper installation frame supplied by the same manufacturer shall also incorporate provision for expansion within the surrounding structure together with masking flange for building into the structure.

Fire or Smoke damper assemblies for installations in corrosive environments shall be fabricated from suitable materials resistant to the corrosive substances and environments indicated. Alternatively, the material may be coated with a protective finish to produce the same effect.

Power fail-safe remote electromagnet release or electro thermal link (ETL) shall be provided to explosion hazardous areas. The electromagnet shall normally not consume more than 10 mA by 220 V AC supply or 120 mA by 24 V AC/DC supply. The A/C Contractor shall be responsible for the power fail-safe fire dampers to the fire control relay at the fire service control panel.

Each Fire or Smoke damper casing shall be air tight, continuously welded and clearly marked with a permanent indication of the direction of air flow and the side at which the access/maintenance opening is located.

The folded continuous interlocked blade type of damper may be used for vertical or horizontal ductwork applications. The closing force for these types of dampers shall be provided by stainless steel spring or springs. An automatic locking device shall be provided to ensure that the blades are held in the closed position after release.

Spring actuated pivoted single-bladed or multi-bladed dampers may be used for vertical or horizontal ductwork applications.

Multi-bladed dampers shall be provided with a means to ensure that all the blades close simultaneously.

Gravity operated multi-bladed fire dampers shall not be used in vertical ductwork.

Gravity operated single bladed dampers may be used for horizontal ductwork provided means are incorporated which ensure reliable and positive closure when operating in maximum air flow rate conditions.

Locally fabricated gravity fire dampers shall be provided with a coaming or casing of the same material and shall be physically bolted to the structure through which the ductwork penetrates.

Fire or Smoke dampers shall be rated in accordance with the fire resistance rating of the wall, ceiling or floor, etc. as shown in the drawings and the Particular Specification, to the requirements of the FSD and approved by the Supervising Officer.

For locally fabricated fire dampers, the thickness of metal for the dampers shall comply with the Circular Letters issued by the FSD and the Buildings Ordinance of HKSAR.

Where gravity acting, off-centre pivoted dampers incorporate spindle bearings long term corrosion effects shall be minimised by the choice of suitable materials. Bearings shall be sealed or capped to exclude dirt and dust. Damper blades shall close to comply with the stability and integrity requirements of ISO 10294-1:1996/Amd 1:2014 Classification E (BS 476- 20:1987 to BS 476-23:1987).

For high velocity air systems, fire/smoke dampers shall provide 100% free area when damper blades are in the open position to give minimum interference to the air flow.

Unless otherwise indicated, each Fire or Smoke damper shall be held in the open position by a corrosion resistant retaining device incorporating a fusible element which shall operate at a temperature of 69oC, unless otherwise indicated.

Fire or Smoke dampers shall be located in a position and be of a type which could facilitate periodic 1 handed manual release and re-setting for test purpose.

Proprietary access doors shall be installed adjacent to each Fire or Smoke damper and, in the case of conditioned air or kitchen exhaust ductwork, the access doors shall be encapsulated and pre-insulated.

C2.11.2 Combined Fire and Smoke Stop Dampers

Combined fire and smoke stop dampers shall be tested to ISO 10294-1:1996/Amd 1:2014 Classification ES and approved by the FSD.

The dampers shall be of stainless steel, aerofoil bladed construction with the blades held in stainless steel bearings and framed in stainless steel spring tempered flexible gasket. The blades shall have trailing edges forming an interlocking metal to metal seal when the blades are closed, providing tight, low leakage closure of the air path and maximum impedance to the passage of smoke and products of combustion from either flow direction.

The blades shall be driven by externally mounted and totally enclosed stainless steel gearbox and drive mechanism providing accurate blade control with minimum torque and without accumulative backlash.

The damper casing shall be of double-skin galvanised steel construction with continuously welded corners and integral spigot connections. The dampers shall be supplied completed with the manufacturer-installed frames.

Each damper shall have an externally replaceable combination thermal actuator and fusible link completely exposed to the air stream.

In addition to the thermal actuation/fusible link, the damper shall be normally held by actuator. The damper shall be released to the closed or fail-safe position by a closure spring on loss of power supply, either by genuine power failure or by the zone fire signal actuated by the smoke detection system. The time for closing the damper shall meet the requirements laid down by the FSD.

The damper shall be automatically reset on resumption of power supply by built-in motor of 220 V AC or 24 V AC/DC.

The whole control mechanism and actuation shall be of the same manufacturer and mounted inside a totally enclosed casing for protection against airborne contamination and to ensure unique reliability.

For smoke extraction at 250 °C for 1 hour application, damper control actuator shall be totally shielded by a proprietary thermal insulation jacket. The whole damper assembly shall have undergone a high temperature operation test followed by a leakage test at 1500 Pa differential pressure and ultimately approved by the FSD.

Leakage rate shall be tested in accordance with UL555S:2014.

Fire rating shall be to BS 476-20:1987 and the whole damper assembly shall have undergone a temperature exposure test by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved in accordance with the temperature and duration as indicated in BS 476-20:1987. Test report shall be submitted to the Supervising Officer for reference.

SECTION C3

AIR HANDLING AND TREATMENT EQUIPMENT

C3.1 GENERAL

C3.1.4 Fan Construction

- (a) Centrifugal fans having dimensions over 1000 mm in any direction shall have split casing or by other means for easy removal and repair.
- (b) The shaft and impeller assembly of all centrifugal, axial flow and mixed flow fans shall be statically and dynamically balanced. All propeller fans shall be statically and dynamically balanced. Limits of vibration severity shall be in accordance with BS ISO 20816-1:2016 or another acceptable standard, such as AMCA, as appropriate.
- (c) Fan shall be equipped with self-aligning bearings suitable for the installed altitude of the fan. They shall be of the grease/oil ball and/or roller type or alternatively oil lubricated sleeve type. All bearing housings shall be precisely located in position and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be designed to prevent damage from over-greasing. For grease lubricated systems the bearings shall be provided with grease of the amount and quality as recommended by the bearing manufacturer. For oil lubricated systems the housings shall provide an adequate reservoir of oil and shall include a filling plug and be oil tight and dust proof. Systems other than total loss types shall

include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance. Extended lubricators outside the fan casing shall only be required if sealed for life bearings are not incorporated.

C3.2 AIR HANDLING UNITS (AHUs)

C3.2.1 General

Each type of AHU offered shall be the product of a manufacturer who has made similar product for a period of at least five years.

Individual components forming part of the air handling unit shall, in addition to this section, comply with the appropriate sections contained elsewhere in this General Specification.

Air handling unit shall comply with the manufacturer's own ISO 9001:2015 quality assurance standard in respect of design and manufacturing and be "type" tested to the following minimum requirements:- (i) air leakage test to HVAC Standard DW/144:2016 Class B or BS EN 1886:2007 Class L2; (ii) thickness of casing according to Table C3.2.2; (iii) conductivity of thermal insulation not greater than 0.02W/m°C rating at the operating temperature; and (iv) insertion loss through panels at 125 Hz and 250 Hz of 20 dB and 20 dB reduction respectively.

The A/C Contractor shall submit technical information of each unit together with the above "type" test certificates for the Supervising Officer's approval.

The entire construction of the AHU should have following mechanical characteristics in accordance with the BS EN 1886:2007.

Mechanical Characteristics (minimum requirement)	
<u>Characteristics</u>	<u>Class</u>
Casing strength	D2
Casing air leakage under -400 Pa	L2
Casing air leakage under +700 Pa	L2
Filter bypass leakage	F9
Thermal transmittance	T2
Thermal bridging factor	TB2

Alternatively, the entire construction of the AHU should have mechanical characteristics not lower than the above table in accordance with AHRI-1350.

C3.2.3 Fan

All fans shall be Electronically Commutated (EC) plug fans as described in the relevant content of Section C3.14 or backward curved centrifugal fans, double inlet, double width, or single inlet, single width unless alternative requirement is specified in the particular specification and/or equipment schedule. All fans other than plug fans shall be mounted together with their motors on a galvanised steel base frame isolated from the main casing by means of 98% efficient spring vibration isolators. The vibration isolators shall have a minimum deflection of 25 mm.

Other than plug fans, fan discharge shall be isolated from the casing by a flexible connection. Fan shall be direct driven or driven by at least two-belt arrangement for motor rated higher than 4kW. Selection of fan and motor shall be at their peak operating efficiency. Fan motor shall be supplied and installed by the AHU manufacturer unless otherwise specified.

C3.2.8 Air Filter

Table C3.2.8 – (1) Pre-filter

Application	Minimum Efficiency Reporting Value (MERV) ANSI/ASHRAE Standard 52.2-2017 or equivalent, e.g. BS EN ISO 16890:2016
For use where grease or moisture is prevalent	MERV 2-4 $A_{avg} \geq 65\%$ or 70% or 75%
General ventilation system suitable for sport halls, swimming pools, ice rinks, garages, plant rooms, laundries	MERV 5-6 $E_3 \geq 20\%$ or 35%
General ventilation system suitable for office, auditoria, law courts, TV	MERV 7-8

Application	Minimum Efficiency Reporting Value (MERV) ANSI/ASHRAE Standard 52.2-2017 or equivalent, e.g. BS EN ISO 16890:2016
studios, hall and lobby, kitchens, station concourses, etc.	E3 [^] ≥50 or 70%

Remarks:

*: Average Arrestance % (Aavg)

[^]: E3 is Composite Average Particle Size Efficiency (E) % in Size Range, 3.0um-10.0um

Table C3.2.8 – (2) Intermediate filters

Application	Minimum Efficiency Reporting Value (MERV) ANSI/ASHRAE Standard 52.2-2017 or equivalent, e.g. BS EN ISO 16890:2016
General ventilation system for church, hotel	MERV 11-12 E3 [^] ≥85% or 90% & E2 [^] ≥65% or 80% & E1 [^] ≥20% or 35%
General ventilation systems suitable for foyer, dressing room, bar/lounge, restaurant, library, office, building society, department store, supermarket, airport	MERV 13 E3 [^] ≥90% & E2 [^] ≥85% & E1 [^] ≥50%
General ventilation system suitable for museum/art gallery, computer room	MERV 14 E3 [^] ≥95% & E2 [^] ≥90% & E1 [^] ≥75%

General ventilation system suitable for hospital, research laboratory	MERV 15-16 E3 [^] ≥95% & E2 [^] ≥90% or 95% & E1 [^] ≥85% or 95%
-----------------------------------------------------------------------	------------------------------------------------------------------------------------------------------

Remarks:

[^]: E1 is Composite Average Particle Size Efficiency (E) % in Size Range, 0.3um-1.0um

E2 is Composite Average Particle Size Efficiency (E) % in Size Range, 1.0um-3.0um

E3 is Composite Average Particle Size Efficiency (E) % in Size Range, 3.0um-10.0um

C3.3 AXIAL FLOW FANS

C3.3.2 Fans shall be tested for air performance and sound ratings in accordance with ANSI/AMCA Standards 210-16 and 300-14, ISO 5801:2017 or equivalent recognised standards as approved by the Supervising Officer.

C3.5 CENTRIFUGAL FANS

C3.5.1 Centrifugal fans for high-velocity high-pressure systems as defined within B&ES Standard DW/144:2016 shall be of the backward bladed type.

C3.5.3 Fans shall be tested for air performance and sound ratings in accordance with ANSI/AMCA Standards 210-16 and 300-14, ISO 5801:2017 or equivalent recognised standards as approved by the Supervising Officer.

C3.6 FAN COIL UNITS

C3.6.1 General

Fan coil units shall comply with the manufacturer's own ISO 9001:2015 quality standard in respect of design and manufacturing and be type-tested to BS 4856-2:1975 or other acceptable standards, such as ANSI/AHRI, Euro vent, GB/T, etc., for thermal volumetric and acoustic performance.

Fans, filters, cooling coils, heating coils, motors, thermal and acoustic insulation shall comply with the appropriate sections of this General Specification and the following requirements: -

- (b) Air filters shall be as indicated in the relevant content of Section C1 but with minimum efficiency reporting value (MERV) of 1-2; Average Arrestance $\geq 50\%$ or 65% by ANSI/ASHRAE Standard 52.2:2017 or other equivalent;
- (e) BLDC type fan motor shall comply with the following requirements:
 - (i) The motor shall consist of hall magnetic pole sensing elements and be controlled by pulse width modulation (PWM) of modulating speed with minimum speed setting. Sensorless technology as an alternative will be considered subject to the approval by the Supervising Officer;
 - (vi) The power factor shall have performance not less than permanent split capacitor type. The total harmonic distortion shall be submitted to the Supervising Officer for approval.
- (h) For the connection between cooling coils of fan coil unit and chilled water pipe, suitable fitting/device or methodology approved by the Supervising Officer to prevent galvanic corrosion effect of different pipe materials jointing together shall be provided.

C3.14 EC PLUG FANS

C3.14.2 Fans shall be tested for air performance and sound ratings in accordance with ANSI/AMCA Standards 210-07 and 300-14, ISO 5801:2017 or equivalent recognised standards as approved by the Supervising Officer.

C3.14.6 Motor efficiency for the fans shall be of minimum IE4 under International Efficiency (IE) classes according to IEC 60034-30-1.

C3.17 TERMINAL AIR CONTROL DEVICES

C3.17.1 General

- (b) Casing of the unit shall be manufactured from galvanised steel sheet of thickness comply with DW/144:2016.
- (d) The entire unit shall be internally lined with thermal and acoustic insulation in compliance with the relevant content in Sections B11 & C11 and B8 & C8 enclosed in a galvanised perforated metal liner. The lining shall be securely fixed and shall be proof against erosion by the air flow. The acoustic and thermal insulation shall comply with NFPA-90A:2018, UL 181:2013 and BS 476-4:1970, BS 476-12:1991, BS 476-6:1989+A1:2009 & BS 476-7:1997 standards (or the related content of ISO 1182:2010 and the requirements of the FSD).

C3.17 TERMINAL AIR CONTROL DEVICES

C3.17.1 General

- (b) Casing of the unit shall be manufactured from galvanised steel sheet of thickness comply with DW/144:2016.
- (d) The entire unit shall be internally lined with thermal and acoustic insulation in compliance with the relevant content in Sections B11 & C11 and B8 & C8 enclosed in a galvanised perforated metal liner. The lining shall be securely fixed and shall be proof against erosion by the air flow. The acoustic and thermal insulation shall comply with NFPA-90A:2018, UL 181:2013 and BS 476-4:1970, BS 476-12:1991, BS 476-6:1989+A1:2009 & BS 476-7:1997 standards (or the related content of ISO 1182:2010 and the requirements of the FSD).

C3.17.4 Single Duct Variable Air Volume (VAV) Terminal Units

- (b) Unit shall be rated in accordance with ANSI/ASHARE Standard 70-2006 and Air Diffusion Council Test Code 1062R4. The performance data shall be certified by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved. The casing of the VAV terminal unit, re-heater box and multi-outlet box shall be manufactured from galvanised steel sheet of thickness comply with DW/144:2016.

C3.18 GRILLES AND DIFFUSERS

C3.18.3 Diffusers

- (b) Linear diffusers shall be constructed of extruded aluminium section and include a control damper at the rear of the vanes giving volume control down to complete shutoff and operated from the face of the diffuser. Linear diffusers for supply air shall have adjustable blades to give directional control of air flow. The linear diffuser shall be capable of maintaining a horizontal discharge pattern at a turn down ratio down to 20% of the maximum specified air volume without air dumping.

The linear diffuser shall be completed with factory fabricated plenum with suitable inlet connection for flexible ductwork. The plenum and diffuser neck shall be constructed of galvanised steel sheets internally lined with 25 mm 48 kg/m³ glass cloth faced fibreglass insulation enclosed in galvanised perforated metal liner.

The insulation shall comply with NFPA-90A:2018, UL 181:2013 and BS 476-4:1970, BS 476-12:1991, BS 476-6:1989+A1:2009 & BS 476-7:1997 standards (or related content of ISO 1182:2010).

Where linear diffusers are mounted in a continuous line there shall be means of ensuring alignment between consecutive diffusers and of equalising pressure behind the vanes. The dummy portion of the diffuser shall be internally covered by a demountable galvanised metal enclosure to block the view into the ceiling void from below.

C3.19 ENERGY EFFICIENCY AND PERFORMANCE

- (a) The efficiency of fan and motor used for all air treatment equipment shall be in accordance with Section C7 of this General Specification and Section 6.7 of the Code of Practice for Energy Efficiency of Building Services Installation (2018 Edition).

SECTION C5

CENTRAL CONTROL AND MONITORING SYSTEM (CCMS)

C5.3 RELEVANT STANDARDS

Where applicable standards exist, the products provided shall comply with the standards etc. of the relevant authorities as stated in Section A2 of this General Specification or equivalent standard, and the list below where applicable: -

- (a) ASHRAE. Standard 135-2016 - A Data Communication Protocol for Building Automation and Control Networks (BACnet);
- (b) International Organization for Standardization ISO/IEC 9075-9:2016 - Information Technology - Database Languages SQL – Part 9 : Management of External Data (SQL/MED);
- (e) TIA/EIA 485-A - Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multipoint Systems;
- (i) International Organization for Standardization ISO/IEC 8802-3:2017 – Standard for Ethernet.

C5.5 CCMS INTER-NETWORKING STANDARD

The CCMS Server, Workstations shall be inter-connected with Local Area Network (LAN) or remote communication. Each CCMS Sub-system shall be connected to the LAN through a gateway, router or remote communications.

The General Purposes Controller, Unitary Controller, Smart Actuator and Smart Devices of each Sub-system shall be inter-connected with field bus.

The LAN's physical and data link layer shall comply with ISO/IEC 8802-3:2017 standard with a minimum speed of 100 Mbps.

The Remote Communication's physical layer shall comply with TIA/EIA 232-F standard.

The field bus's physical layer shall comply with TIA/EIA 485-A standard with a minimum speed of 19200 bps.

The communication protocol of CCMS Server and Workstations with CCMS Sub-systems shall comply with BACnet Standard. The CCMS Server and Workstation shall conform to BACnet Operator Workstation (B-OWS) or Advanced Operator Workstation (B-AOWS).

The CCMS Server and Workstations shall comply with ANSI/ASHRAE standard 135-2008 - A Data Communication Protocol for Building, Automation and Control Networks (BACnet) and support BACnet/IP with BTL listed.

The communication protocol of General Purposes Controllers, Unitary Controllers, Building Controllers, Advanced Application Controllers, Application Specific Controllers, Smart Devices in field bus shall comply with either BACnet and BTL listed or LonWork standard.

General Purposes Controllers, Unitary Controllers, Smart Devices in field bus complying with LonWork standard shall conform to the LonMark interoperability guidelines.

Building Controllers complying with BACnet shall conform to BACnet Building Controller (B-BC).

Advanced Application Controller complying with BACnet shall conform to BACnet Advanced Application Controller (B-BAAC).

Application Specific Controller complying with BACnet shall conform to BACnet Application Specific Controller (B-ASC).

Smart Actuators complying with BACnet shall conform to BACnet Smart Actuator (B-SA).

Smart Sensors complying with BACnet shall conform to BACnet Smart Sensor (B-SS).

C5.7 CCMS OPERATOR WORKSTATION

The operator workstation shall be an operator's terminal and comprise the followings: -

- Computer capable to meet the requirement of the CCMS software and expandability in Clause B5.1.3;
- Mouse and keyboard;
- Minimum 21" monitor;
- Alarm printer capable of handling papers;
- A3 ink/laser printer;
- UPS capable of backup for more than 1 hour of operation for the PC, monitor, printer as well as other UPS connected equipment; and
- A 16-bit/full duplex audio system c/w speakers.

All equipment, where applicable, should have obtained a Recognition Type Energy Label under the Energy Efficiency Labelling Scheme of EMSD.

C5.13 CCMS CENTRAL DATABASE REPOSITORY

A CCMS Central Database Repository shall reside in the CCMS Server.

The database server shall use client/server technology and comply with Microsoft Open Database Connectivity (ODBC) and support ISO/IEC 9075-9:2016.

The central database repository shall maintain an image of the network configuration of every device, controllers, and router on the network. It shall be able to serve installation, maintenance, monitoring and control applications by storing the communication attributes of network variables, messages tags and other system objects.

The central database repository shall support multiple concurrent client read/write access, allowing installation and maintenance to proceed independently at any number of workstations, POTs and controllers distributed around the network.

C5.31 CCMS SOFTWARE - HISTORICAL PROFILES

The system shall provide the capability for the operator to build historical profiles through the operator's terminal and initiate the profile immediately, automatically at some future specified time of day and/or automatically on a time increment. Profile shall be displayed on the operator's terminal or printed as selected by the operator. Any averaged or totalised point shall be able to be assigned to a profile. Multiple profiles shall be able to be defined and multiple points assigned to a single profile. Unless otherwise indicated, minimum profile formatting shall be as follows: -

- Last 36 Months, by Month or accounting period;
- Last 30 Days, by Day;
- Last 24 Hours, by Hour;
- Last Hour, by Five Minute Intervals;
- Last Ten Minutes, by Minute;
- Hourly-to-Hour for Today;
- Day-by-Day for Current Accounting Period;

- Total/Average for Today, so far;
- Total/Average for Last Accounting Period;
- Total/Average for Year-to-Date;
- Total/Average for Hour, so far; and
- Total/Average for Last Ten Minutes Only.

The accounting period shall be defined by the operator through the operator's terminal.

The operator shall be able to obtain a summary of defined profiles on the operator's terminal or on the printer as selected by the operator.

C5.55 SCHEDULE OF FUNCTION FOR CCMS

Schedule of Functions monitored and / or controlled by CCMS shall be in accordance with Code of Practice for Energy Efficiency of Building Services Installation (2018 edition) and as follows: -

SECTION C6

CENTRAL REFRIGERATION MACHINE, DIRECT EXPANSION EVAPORATOR AND HEAT REJECTION PLANT

C6.1 GENERAL

In this section, refrigeration machine may refer to chiller or heat pump.

The refrigeration plant for air conditioning purposes shall generally be of the mechanical, vapour compression type.

The refrigeration machine shall be factory assembled and tested complete "packaged" units which may have reciprocating, centrifugal, screw or scroll type compressors and as specified in the Particular Specification. The testing of the cooling/heating capacity of the refrigeration machine shall be carried out in accordance with AHRI Standard 550/590(I-P/2018), BS EN 14511-1:2018 to BS EN 14511-4:2018 or other international recognised standards.

The plant shall include any accessories necessary to ensure continuous and reliable automatic operation and remote monitoring and control. Power supply voltage-dip ride-through devices shall be provided to delay the protective shut down of refrigeration machine. Fast restart to allow the refrigerant machine to restart and going to a postlude operational mode shall be required for minimising downtime.

Each unit shall be capable of running continuously at the lowest step of cooling or heating capacity provided without any adverse effect.

Compressor and motor speeds shall not exceed 50 revolutions per second for reciprocating type and for screw type. For non-oil-free centrifugal type, the motor speed shall not exceed 50 revolutions per second and the compressor speed shall not exceed 250 revolutions per second. For oil-free centrifugal type, both motor and compressor speed shall not exceed 800 revolutions per second. Energy efficient motor to optimise the system coefficient of performance shall be required. The noise level of the refrigeration machine shall comply with the requirements as specified in the Particular Specification or the relevant environmental protection ordinances whichever is more stringent. If acoustic silencer is required in order to achieve the required noise level, it shall be factory-built and shall not de-rate the machine efficiency and capacity as specified in the Particular Specification.

For non-oil-free chiller, each compressor shall form a separate oil circuit with its own oil separator, oil filter and positive lubrication oil safety control circuit equipped to ensure proper functioning of each compressor and accessories.

All units shall comply, where applicable, with the following codes: ISO 5149:2014, ASHRAE Standard 90.1: 2016, ASHRAE Standard 189.1-2017, ANSI/ASHRAE 15-2016 and ANSI/ASHRAE 34-2016; AHRI Standard 550/590(I-P/2018) Testing and Ratings; BS EN 14511-1:2018 to BS EN 14511-4:2018 Testing and Ratings and Code of Practice for Electricity (Wiring) Regulations and Code of Practice for Energy Efficiency of Building Services Installation.

Refrigerants adoption for refrigeration and air-conditioning system in government building projects shall comply with flammability safety classification in accordance with Clause B6.1 of this General Specification.

Characteristic curves shall show the energy consumption in kilowatts, pressure drop through the evaporator, chilled or hot water flow rates and temperatures, condenser fan speeds, etc., for each unit at 25%, 50%, 75% and 100% of full capacity.

Performance characteristics, Integrated Part Load Value (IPLV) and Non-standard Part Load Value (NPLV), to shown the performance rating of refrigeration system while operating at various capacities shall be measured in accordance with the latest edition of AHRI Standard 550/590(I-P/2018).

Sound pressure level characteristic curves shall be in dB measured in accordance with ANSI/AHRI standard 575:2017 for 25%, 50%, 75% and 100% of full capacity.

The testing of the cooling/heating capacity of the refrigeration machine shall be carried out in accordance with AHRI Standard 560:2000, BS EN 14511-1:2018 to BS EN 14511-4:2018 or other international recognised standards.

C6.3 COLD STORAGE REFRIGERATION

Independent refrigeration circuits shall be supplied and installed at the cold storage room and shall comprise an air-cooled refrigeration system with semi-hermetic reciprocating compressor connected to each room unit cooler. The unit cooler shall be of the ceiling type, drawn through direct expansion with distributor, heat exchanger for better efficiency, and electric defrost heaters. Requirements for cold storage facilities will be fully detailed in the Particular Specification for specific application. The cold storage refrigeration shall be factory assembled and tested in accordance with BS 2502:1979, ASHRAE 62.1-2016 and requirements of the International Association for Cold Storage Construction (IACSC) and the International Association of Refrigerated Warehouses.

C6.5 COMPRESSORS, CENTRIFUGAL TYPE

C6.5.2 For oil-free type centrifugal compressor, the following features shall be equipped.

- (g) The compressor shall be provided with Electromagnetic Interface and Electromagnetic Compatibility EMI/EMC filter upstream of the compressor power input. The EMI/EMC filter shall be approved to UL 1283 and comply BS EN 60939-2:2005 or CSA C22.2 No. 8. The rated voltage shall be up to 480V AC 50 Hz as minimum. A short, heavy, stranded conductor from the filter chassis to the main ground of the chiller unit shall be provided for grounding.

Each compressor shall provide with surge suppression device parallel to power input line for protect against electrical surge by the manufacturer. The surge protection device for chiller shall be cabled to performance under a standard test wave of 20 kV 1.5/50 μ s voltage impulse and 10kA 8/20 μ s current impulse.

Built-in voltage dip protection device shall provide for whole system, sensing instrument and devices of the chiller unit and shall be factory assembled in compliance with IEC61000-4-11:2004/A1:2017 and IEC61000-4-34:2007+A1:2009.

Each compressor circuit shall equip with a line reactor to protect against incoming power surges and reduce harmonic distortion. The line reactor shall comply with the following requirements:

- Sustain up to at least 600V 3 Phase 50 Hz,
- UL Standard 58 with dielectric strength tests at 2.2kVAC for 1 minute,
- CSA certified and CE marked or equivalent, and
- National Electrical Manufacturers Associated Insulation Class H or better.

- (p) The oil free centrifugal chiller unit shall be factory assembled and tested in the manner completed whole unit. The testing of cooling capacity, coefficient of performance (COP) and Integrated Part Load Valve (IPLV) of the chiller unit shall be carried out in accordance with BS EN 14511-1:2018 to BS EN14511-4:2013, AHRI 550/590:2012, or other international recognised standards as considered acceptable to the Supervising Officer. The characteristic curves shall show the energy consumption in kilowatts, pressure drop through the evaporator, chilled or hot water flow rates and temperatures, condenser fan speeds, etc., for each unit at 25%, 50%, 75% and 100% of full capacity.

C6.8 CONDENSERS, SHELL AND TUBE (FRESH COOLING WATER APPLICATION)

- C6.8.5 End water boxes shall be designed to provide adequate space for water movement such that there is no erosion of the tube ends. The water boxes shall be epoxy resin coated internally to prevent corrosion.

C6.13 COOLING TOWER

- C6.13.1 Cooling towers shall be of the type with induced or forced draught fans as indicated. The entering and leaving water temperatures and the water flow rate shall be suitable for peak heat rejection rate at the maximum ambient wet bulb temperature indicated in the Particular Specification. The performance of the cooling towers shall be certified by the Cooling Tower Institute (CTI) in accordance with CTI STD-201 RS:2017.

C6.13.4 Fill shall be of the film-type and vacu-formed PVC, with louvres and drift eliminators formed as part of the fill sheets. The PVC fill shall be self-extinguishing for fire resistance with a flame spread of less than 25 per ASTM E84-18b. Fill sheets shall be individually suspended from stainless steel structural tubing, or by other suitable methods, supported by the tower columns and intermediate stainless steel panels, and shall be elevated above the floor of the cold water basin to facilitate cleaning. Air inlet faces of the tower shall be free of water splash-out, and guaranteed drift losses shall not exceed 0.005% of the design water flow. All packing shall be resistant to corrosive attack by algae, fungal growth, the type of condenser water used or the chemicals used to treat the condenser water.

C6.13.10 Fans shall be of the axial type mounted to provide a vertical upwards air discharge. In circumstances where centrifugal units are required, these will be fully specified in the Particular Specification.

Particular attention must be given to the limitations on permitted noise levels, where indicated. However, where not indicated, noise levels must be restricted and must be stated with the plant offered. Plant likely to generate unacceptable noise will not be accepted.

Fan casings and impellers shall either be made of corrosion resistant material or proofed against corrosion after manufacture. Fan motors shall be totally enclosed and weatherproofed, TEFC, 1.15 service factor, mounted outside the humid interior of tower. Fan motors on induced draught units shall have suitable protective treatment as they will be mounted in the moist air stream.

Belt or gear drives shall be readily accessible but fully protected against the weather and personnel. Anti-vibration "cut-out" devices shall be provided to protect the fans drive, etc. Warning of a "cut-out" shall be wired back to the plant room in order to draw attention to any such problem.

The energy efficiency performance of cooling tower fan shall comply with Code of Practice for Energy Efficiency of Building Services Installation (2018 Edition).

C6.20 REFRIGERANT PIPEWORK

C6.20.2 For all chloro-fluoro-methane or ethane compounds: -

- (a) All pipes from up to 108 mm OD shall be of copper complying with BS EN 12735-1:2016 and BS EN 12735-2:2016 or another international recognised standard.

C6.20.3 For ammonia system: -

Steel - whatever size is technically necessary or as specified in the Particular Specification.

All materials used in the refrigerant circuit shall be suitable for use in the presence of ammonia refrigerant or lubricating oil, or a combination of both, and comply with ANSI/IIAR Standard 2-2014 ANSI / ASME Code B31.5:2016 or 2017 ASME Boiler and Pressure Vessel Code , and meet with system pressure-temperature requirement so that they will not corrode or cause corrosion when in contact with the fluids conveyed.

C6.21 REFRIGERATION PLANT ACCESSORIES AND CONTROLS

C6.21.1 Every refrigeration system shall be protected by a pressure relief device unless it is so constructed that pressure due to fire conditions would be safely relieved. The equipment provided shall comply with ANSI/ASHRAE 15-2016 and ANSI/ASHRAE 34-2016 or BS EN 378-2:2016 as appropriate and the outlet piped to discharge outside the building.

C6.21.7 A low temperature thermostat with alarm and manual reset shall be provided for each shell and tube evaporator to stop the compressor(s) if the chilled water flow temperature falls below +3 °C. For other settings as recommended by the manufacturer shall be submitted for approval.

C6.22 ROOF MOUNTED PACKAGED WATER CHILLER / HEAT PUMP PLANTS

C6.22.4 Unitary package chiller/ heat pump units shall conform to and shall have rated and tested capacity to the requirements of AHRI 210/240:2017 or other equal Internationally Recognised Standard accepted by the Supervising Officer.

C6.25 ENERGY EFFICIENCY PERFORMANCE

The refrigeration plant shall be accepted with a minimum coefficient of performance as specified in the following Tables and comply with the requirements stipulated in Code of Practice for Energy Efficiency of Building Services Installation. The values of minimum coefficient of performance shall comply with Code of Practice for Energy Efficiency of Building Services Installation (2018 edition).

For heat pump and heat recovery equipment/applications, the equipment/system coefficient of performance shall comply with Code of Practice for Energy Efficiency of building Services Installation (2018 edition).

Details of energy efficiency assessments shall be submitted before the equipment is accepted. Factory test and field test reports shall be provided to substantiate the equipment design and performance.

Ample time approved by the Supervising Officer shall be allowed for the submission in order to meet with the installation programme.

C6.28 SOLAR HEATING SYSTEM

C6.28.1 General

The Solar Heating system shall include solar collector system, water pipework system, automatic controls, water treatment system, brackets/support, access walkway system, thermal insulation, hot water storage calorifier, water circulation pumps, valves and accessories. All the components and parts shall be compatible to each other to provide best performance.

Individual components forming part of the solar heating system shall, in addition to this section, comply with the appropriate sections contained elsewhere in this General Specification. The A/C Contractor shall submit information on the make and type of each unit together with the test certificate of solar collector panels complying with BS EN ISO 9806:2017 or approved equivalent for the Supervising Officer's approval.

C6.28.3 Construction of Solar Collector

Solar collector shall be either flat plate design or evacuated-tube design.

(a) Flat Plate Type Solar Collector Panel:

The solar collector panel shall be of flat plate design. Solar collector panels shall be connected in series and/or parallel and installed on appropriate supporting framework with sufficient maintenance access facilities as recommended by the manufacturer.

A copper tube matrix that contains potable water shall be mechanically bonded to a 0.8 mm thick aluminium absorber plate or 0.2 mm thick copper absorber plate and sealed with high transference thermal paste or soldered copper to copper. The absorber plate shall be coated in black carbon surface or approved equivalent offering up to 35% absorption. The minimum solar absorptance at normal incidence shall be 0.93 where the emittance of coating at normal incidence shall ± 0.03 . The solar collector panel system shall be designed and manufactured to BS EN 12975-1:2006+A1:2010 & BS EN ISO 9806:2017, BS EN 12976-1:2017 & BS EN 12976-2:2017, AS/NZS 2712:2007 Amd 3:2014 or approved equivalent.

Each collector shall have an insulated casing that houses a copper tube matrix for transporting the collector fluid. A copper or aluminium absorber plate with appropriate coating shall be mechanically bonded or soldered to the headers. The top of the collector shall be glazed with a glass cover to prevent heat losses and protect from the adverse weather conditions.

Tempered solar glass glazing shall be used to seal the top of the collector and a high strength black casing protecting all the components. The glazing shall be minimum 3 mm thick, with glazing transmittance of 0.88 minimum and with appropriate strength to withstand high wind load and hail. The casing shall be constructed of metal with oven baked paint finish for protection against the weather and with high outdoor durability. Panel efficiency shall be minimum 65% at 30K temperature difference between average fluid temperature and ambient temperature with solar irradiation 1000W/m^2 based on aperture area.

Thermal insulation of appropriate thickness shall be provided under and around the side of the absorber plate, to prevent solar panel heat loss.

The solar collector system shall be designed for either potable water or treated water to temperature up to 99°C under normal

operating conditions. Solar collector panels shall be mounted at a tilt angle to the horizontal to achieve maximum solar gain for the application. Each solar collector panel shall produce minimum 650 W per sq. metre based on 1000 W per sq. metre irradiation and difference of average fluid temperature and ambient temperature (i.e. $t_m - t_a = 30K$) of 30K without wind. The solar collector panel shall give a yield of 2.3 kWh per sq. metre of solar collector aperture area per day calculated on a yearly average for the region.

C6.28.4 Thermal Storage Hot Water Calorifier

The thermal storage hot water calorifier (calorifier) shall be used to store up the thermal energy delivered by the solar panels. The calorifier could be provided either with electric or gas fired auxiliary heater or hooked up with heat pump system. The calorifier shall be constructed of mild steel with appropriate coating or stainless steel. The venting requirements of the calorifier shall comply with the requirements of local Water Supplies Regulations. The calorifier shall be fitted with closed circuit flow and return lines capable of receiving thermal energy from solar collectors hot water flow. The calorifier (unless open vented type) shall be fitted with pressure and temperature relief valve and in accordance with local regulations. Calorifier with immersed auxiliary heaters shall be fitted with a manual reset over temperature thermostat that is adjustable between 40-99 °C. The calorifier shall be completed with insulation of minimum 50 mm thickness mineral wool insulation or appropriate insulation as recommended by the manufacturer. The calorifier shall be completed with temperature gauge, temperature sensors, drain pipe, heating circuit in/outlet, utility circuit in/outlet, copper coil and etc.

The calorifier shall be factory designed & manufactured to comply with PD 5500:2018+A1:2018 or AS 3498:2009 or approved equivalent. Copper coil shall be designed with a maximum pressure of 10 Bars and a temperature of 200°C. Temperature sensor shall be provided for electronic controller of the solar collector system for automatic control. Manufacturer working and test pressure certificate shall be submitted for approval.

SECTION C8

NOISE AND VIBRATION CONTROL

C8.5 PIPEWORK VIBRATION ISOLATION

C8.5.2 Flexible Metallic Hose

Allowable stress levels should be within PD 5500:2018+A1:2018.

The corrugated seamless hose body shall be of the annular and close pitched type.

For all ferrous applications, the hose body and the braid shall be manufactured from stainless steel material to BS EN 10095:1999 Type X8CrNi25-21. End terminations shall be carbon steel threaded male nipples to ISO 7-1:1994/Cor1:2007 for 65 mm size and below and flanges to BS EN 1092-1:2018 Standard for 75 mm and above.

For copper or non-ferrous pipework systems, the hose body and the braid shall be manufactured in bronze throughout. End terminations shall be copper female ferules suitable for soldering.

The lengths of the flexible metallic hoses shall be in accordance with the manufacturer's recommendation.

C8.7 DUCTWORK ACOUSTIC INSULATION

Unless otherwise specified, the acoustic ductwork liner shall conform to the requirements of ASTM C1071-16. It shall be composed of glass fibres type firmly bonded together with a thermosetting resin into a rigid board of 50 mm thickness and 48 kg/m³ density. The air stream surface shall be overlaid with a fire-resistant black acrylic coating which adds strength to the product during fabrication, installation and system operation. The manufacturer's product identification shall appear on the air stream surface.

All components of the acoustic insulation including coverings and adhesive shall have a fire hazard classification with a flame spread rating of not over 25, and a smoke developed rating of not over 50. Ratings shall be as established by the tests conducted in accordance with UL 723:2018, ASTM E84-18b or NFPA 255:2006 or BS 476-4:1970. The A/C Contractor shall certify in writing, before any insulation is installed, that the products to be used meet with the above criteria.

The acoustic linings shall have the following minimum sound absorption coefficients when tested in accordance with ASTM C423-17.

Table C8.7 Minimum Sound Absorption Coefficient

Octave Band Centre Freq. (Hz)	125	250	500	1k	2k	4k
Sound Absorption Coefficient	0.12	0.67	0.99	0.97	0.91	0.87

C8.9 DUCTWORK SILENCERS

Outer casing of rectangular ductwork silencers shall be fabricated from galvanised steel not thinner than 0.8 mm in accordance with the recommended practices that specified in Clause C2.3. Seams shall be "lock-formed" and mastic filled. Each silencer shall be provided with flanged inlet and outlet. The internal baffles or splitters shall be of galvanised perforated steel not thinner than 0.5 mm and having a nominal open area of 30%.

All internal components shall be spot welded in place with welds on centres not exceeding 100 mm. All spot welds shall be treated after with anti-corrosive epoxy resin or other approved coating.

Mani folded silencers shall be provided with continuous metallic nosing crimped in place. Nosing pieces and tails shall be as per the manufacturer's design. The filler material shall be of inorganic mineral or glass fibre of a density sufficient to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin and moisture proof.

Combustion rating for the silencer acoustic in-fill shall not exceed the following when tested in accordance with ASTM E84-18b, NFPA Standard 255:2006 or UL 723:2018 or BS 476-4:1970.

- Flame Spread 25
- Smoke Developed 15
- Fuel Contributed 20

The silencer shall be leak-proof at a differential air pressure of 2 kPa.

Unless otherwise specified, ductwork silencers shall have the following minimum Dynamic Insertion Loss under forward and reverse flow conditions of 10 m/s: -

Table C8.9 - (1) Insertion Loss (dB) - for Lowest Pressure Drop Silencer

Silencer Length (mm)	Octave Band Centre Freq. (Hz)					
	125	250	500	1k	2k	4k
900	5	9	14	23	24	14
1500	7	13	21	29	39	20
2100	13	18	28	40	47	26

Table C8.9 - (2) Insertion Loss (dB) - for Low Pressure Drop Silencer

Silencer Length (mm)	Octave Band Centre Freq. (Hz)					
	125	250	500	1k	2k	4k
900	5	10	17	17	13	10
1500	8	15	28	30	21	14
2100	12	20	36	38	28	18

Table C8.9 - (3) Insertion Loss (dB) - for Medium Pressure Drop Silencer

Silencer Length (mm)	Octave Band Centre Freq. (Hz)					
	125	250	500	1k	2k	4k
900	7	12	19	23	23	18
1500	10	18	30	42	34	23
2100	14	24	36	48	44	31

Table C8.9 - (4) Insertion Loss (dB) - for Standard Pressure Drop Silencer

Silencer Length (mm)	Octave Band Centre Freq. (Hz)					
	125	250	500	1k	2k	4k
900	10	15	25	34	35	28
1500	16	22	38	45	46	41
2100	17	34	44	49	49	45

Unless otherwise specified, ductwork silencers shall have the following maximum self-generated sound power level (dB re 10^{-12} Watt) under the flow conditions of 10 m/s: -

Table C8.9 - (5) Maximum Self-Generated Sound Power Level

Silencer Length (mm)	Octave Band Centre Freq. (Hz)				
	125	250	500	1k	2k
Lowest	51	51	49	47	50
Low	52	46	43	42	45
Medium	54	52	50	47	48
Standard	69	63	64	61	63

Before ordering ductwork silencers, the A/C Contractor shall submit for the Supervising Officer's approval the proposed manufacturer's certified test data (from laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved) for pressure drop and insertion loss ratings.

SECTION C9

PIPE MATERIAL, VALVES, COCKS AND STRAINERS

C9.3 BUTTERFLY VALVES

C9.3.2 Butterfly valves in connection with wafer, full-lug, flange or grooved ends may also be accepted. The valves shall be in accordance with the following: -

- (a) Grooved ends butterfly valves shall be bubble tight complying to ISO 5208:2015 or BS EN 593:2009 +A1:2011 standard, enabling quick assembly with mechanical grooved coupling on ISO standard pipes;
- (b) The manufacturer shall provide tests for pressure rating by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved. All testing records and data shall be submitted to the Supervising Officer for approval;

C9.9 SPECIALISED CONTROL VALVES

Motorised control valves, and solenoid valves used for automatic control purposes shall be as specified in Clause C5.50 or as indicated in the Particular Specification. Mixing valves shall comply with BS EN 1287:2017.

SECTION C10

SYSTEM MONITORING INSTRUMENT

C10.9 ENERGY METERS

The calculator unit of an energy meter shall calculate and display digitally the water enthalpy consumption in kWh with an accuracy to a maximum error of $\pm 1.5\%$ throughout the range of measurement. The number of digits of accumulated enthalpy consumption display shall not be less than six. The housing protection for the microprocessor and calculator unit shall not be less than IP 54. The requirement for the temperature sensors and the flowmeter shall be as specified elsewhere in this General Specification.

Signal connection facilities to the CCMS shall be provided for displaying the energy consumption computed and the flow rate and temperature readings.

The requirements of energy metering shall comply with the Code of Practice for Energy Efficiency of Building Services Installation (2018 Edition), but not limited to the following:

A chiller, heat pump or unitary air-conditioner, of 350 kW or above cooling/heating capacity, should be equipped with continuous monitoring facilities to measure its power (kW) & energy (kWh) input, cooling/heating power (kW) & energy (kWh) output and coefficient of performance.

A chilled/heated water plant, of 350kW or above cooling/heating capacity, should be equipped with continuous monitoring facilities to measure its power (kW) & energy (kWh) input, and cooling/heating power (kW) & energy (kWh) output, such that the plant's coefficient of performance can be determined.

It is acceptable to make use of the manufacturer's curve or data indicating the chiller's flow rate and pressure drop relationship to obtain the chilled water flow rate based on its pressure drop through the evaporator, and likewise to obtain the heated water flow rate based on the flow's pressure drop through the heat pump's condenser.

In determining a chilled water plant's power & energy input, the inputs to all equipment for producing the cooling output, such as chiller compressors, circulation pumps of condensers or cooling towers, condenser fans, cooling tower fans, radiator fans etc. should be included, whereas the inputs to chilled water pumps should be excluded. Likewise for a heated water plant, the inputs to all equipment for producing the heating output, such as heat pump compressors, circulation pumps on heat input side of water source heat pumps, fans of air source heat pumps, boilers or hot water heaters etc. should be included, whereas the inputs to heated water pumps should be excluded.

The measurement parameters as stated in clauses 6.13.1 and 6.13.2 of the Code of Practice for Energy Efficiency of Building Services Installation (2018 Edition) should be trended every 15 minutes and include hourly, daily, monthly, and annual data. The monitoring facilities should be capable of maintaining all data collected for a minimum of 36 months.

For each of an air handling unit, with motor rated at 5 kW or above, being accommodated in plant room, metering devices or the provision of measurement should be provided for measurement of power (kW) consumption of the air handling unit.

SECTION C11

THERMAL INSULATION

C11.1 GENERAL

C11.1.2 Unless otherwise indicated, all thermal insulating materials used within any building shall, with fire performance of Class "O" as stipulated in BS 5422: 2009. The definition of Class "O" (national class) shall be referred to Annex E of BS 5422:2009. A class "O" (national class) material is one which: -

- (a) has a Class 1 surface spread of flame rating in accordance with BS 476-7:1997 and has a fire propagation index of (*I*) of not more than 12.0 and a sub-index (*ii*) of not more than 6.0 in accordance with BS 476-6:1989+A1:2009; or
- (b) is of limited combustibility in accordance with "Materials of limited combustibility" (E.2 of Annex E, BS 5422:2009); or
- (c) is non-combustible in accordance with Non-combustible materials (E.1 of Annex E, BS 5422:2009).

Test reports to substantiate the fire properties of the insulation material shall be issued by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved.

- C11.1.5 Insulation materials and finishes shall be inherently proof against rotting, mould and fungal growth and attack by vermin, be non-hygroscopic and in all respects not inducing or leading to corrosion to pipe work and ductwork and be suitable for continuous use throughout the range of operating temperatures and for the environment indicated.
- C11.1.6 The A/C Contractor shall bear the cost and provide relevant certificates from laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved in order to prove the physical properties of the insulation to be used in the projects are conforming to the specification.
- C11.1.7 The A/C Contractor shall prove with supporting documents or relevant test certificates from a reputable and proven manufacturer that the insulation materials are compatible with metallic elements, e.g. steel pipes and G.I sheets, and can remain constant or are stable enough throughout the working life. The Supervising Officer's approval shall be obtained before installation.

C11.2 TYPES OF THERMAL INSULATION MATERIALS

C11.2.1 Type "A" - CFC & HCFC Free Phenolic Foam Insulation

- (a) Factory made phenolic foam products specification: BS EN 14314:2015;
- (b) Temperature range: sub-zero to 120°C;
- (c) Density: 40 kg/m³ ±10%;

Except at pipe, ductwork and other support points where a higher density load bearing quality insulation shall be used in accordance with the manufacturers' recommendations. In general, phenolic foam sections with 80 kg/m³ for pipe sizes of up to 125 mm and 120 kg/m³ for pipe sizes of 150 mm or above and made to the same thickness as the adjacent pipe insulation;

- (d) Compressive Strength: 140 kN/m²(BS EN ISO 844:2014);

- (e) Thermal Conductivity: 0.022 W/m°C at 20°C mean temperature (BS EN ISO 4590:2016 and BS ISO 1922:2018 or ISO 8302:1991);
- (f) Closed Cell Content: 90% minimum (BS EN ISO 4590:2016 and BS ISO 1922:2012 or BS EN ISO 4590:2016);
- (g) Vapour Transmission: 10 micron gram meter/Nh at 38°C 88% RH (BS EN ISO 4590:2016 and BS ISO 1922:2012 or ISO 1663:2007); and
- (h) Fire Rating: shall have class "O" fire rating and test certificate from laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved.

The above properties shall be tested independent of facings which shall be factory applied Class "O" double sided reinforced foil vapour barrier for both condensation control and mechanical protection. The external side shall be of white antiglare coating and the internal side shall be of aluminium foil fully adhered to the phenolic foam. Facing with all service jackets on the outside is also acceptable. The surface emittance of the all service jackets shall be 0.7 or greater when tested with ASTM C1371-15 with reference to ASTM E408-13. In addition, the performance of both vapour barriers and all service jacket shall comply with the requirement stipulated at Clause C11.4.2.

C11.2.4 Type "D" - Flexible Closed Cell Elastomeric Insulation

Flexible closed Cell Elastomeric Insulation shall be CFC free, in continuous lengths, with factory applied talc coating or on-site applied talc coating on inner surface. Flexible Closed Cell Elastomeric Insulation shall comply with the following requirements:

- (a) Factory made flexible elastomeric foam products specification: BS EN14304:2015;
- (b) Thermal Conductivity (at 20°C mean temperature) : <0.04 W/m°C;
- (c) Density:50 to 65 kg/m3;
- (d) Water Vapour Permeability (without additional vapour barrier foil): 0.28 micron gram meter/Nh;

- (e) Maximum Operating Temperature: > 80 °C;
- (f) No putrefaction and mildew shall form on the insulation material. The water absorption properties of the insulation shall be of not more than 1.5% after 28 days;
- (g) The material, including adhesives and all accessories shall have fire properties to Class 'O' as stipulated in BS 5422: 2009. The insulation material shall be a "built-in" vapour barrier and achieve condensation control without any additional vapour barrier foil;
- (h) Smoke Visibility (ISO 5659-2:2017); and
The mean specific optical density, D_m shall be less than 500 under all test conditions. The thickness of the test specimen shall be 25 mm and the D_m shall be the maximum value of the specific optical density (D_{s10}) of the three tests computed at 10 minutes time interval.
- (i) Smoke Toxicity:
The results shall comply and in accordance with either of the following standards or equivalent: -
 - International Maritime Organisation (IMO) – International Code for Application of Fire Test Procedure: Annex 1 Part 2 – Smoke and Toxicity Test, IMO MSC 307(88); or
 - Naval Engineering Specification (NES) 713 (Issue 3) – Determination of the Toxicity Index of the Products of Combustion from Small Specimens of Material.

C11.2.9 Type "I" – Foaming for Pre-insulated Pipes

Foam insulation used shall be CFC, HCFC and HFC free.

Pre-insulated pipes should be produced in off-site factory using foaming machine by foam injection method between the service pipe and cladding/ outer jacket to ensure the foam insulation forms a strong adhesive bond to the pipe's surface resulting in a firm and seamless insulation enveloping the service pipe.

The foam insulation for pre-insulated pipe shall comply with all of the following requirements:

- (a) Temperature range : Sub zero to 80°C
- (b) Density : 48 kg/m³ minimum;
- (c) Compressive strength : 245N/m²(BS EN ISO 844: 2014); and
- (d) Thermal conductivity : 0.024W/m°C at 20°C mean temperature; and
- (e) Close cell content : 95% minimum (BS EN ISO 4590:2003 and BS ISO 1922:2012 or BS EN ISO 4590:2003)

Galvanized steel or other materials such as aluminium, stainless steel, etc. approved by the Supervising Officer shall be applied as outer jacket/ cladding of the pre-insulated pipe and acts as vapour barrier.

Approved pipe sleeves and pipe collars, and approved fire rated pipe sleeves, collars or barriers shall be provided where necessary and applicable, or the pre-insulated pipes itself having a fire penetration time not less than the structure through which it passes when tested in accordance with BS 476 – 20:1987 for all pre-insulated pipes passing through compartments, walls, floors and any structural openings in compliance with relevant regulations and code of practices. The fire barriers shall have the same fire resisting rating as the structure through which the pre-insulated pipe passes.

Pre-insulated pipes shall only be supported on the outside of the cladding/ outer jacket and high density load bearing or hard wood block is not required between the service pipe and cladding/ outer jacket. For pre-insulated pipes, cladding/ outer jacket act as a vapour barrier.

The foam insulation of pre-insulated pipe system should be seamless throughout the system and bond tightly with the service pipe and cladding/ outer jacket to minimize condensation.

C11.3 MEASURES TO PREVENT SMOKE, NOXIOUS & TOXIC FUMES PROPAGATION IN EVENT OF FIRE

When requested by the Supervising Officer, proof of fire classification, obtained from laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved, shall be provided by the A/C Contractor in order to certify that materials in compliance with Clause C11.1.

Under circumstances, where insulation materials have been permitted which do not strictly meet with the fire properties stated in Clause C11.1, the materials shall not be construed as acceptance unless for the following exceptional conditions: -

C11.4 VAPOUR BARRIERS

C11.4.2 Aluminium foil vapour barriers used for insulation of all pipework and ductwork shall conform to the following requirements: -

- (d) Water Vapour Permeance (ASTM E96/E96M-16) $\leq 1.0\eta\text{g/Ns}$;
and

C11.4.3 All joints shall be either factory or on job site fabricated. All joints shall allow for 50 mm overlap of vapour barrier and the joints shall be completely sealed using foil tape with a minimum width of 75 mm conforming to the following specifications: -

- (b) Machine and Cross Direction Tensile Strength (ASTM D882-18) $\geq 2.0\text{ kN/m}$;
- (c) Peel Adhesion to steel (ASTM D3330/D3330M-04:2010) $\geq 10\text{N/25 mm}$;
- (d) Shear adhesion (BS7116:1990): 31; and
- (e) Surface Emittance (ASTM E408-13) ≥ 0.7 or Surface Emissivity (BS 5422) ≥ 0.85 (Paint, white).

SECTION C12

UNITARY AIR-CONDITIONER

C12.1 GENERAL

Unitary air-conditioners shall include: -

- (a) Single package unit;
- (b) Packaged unit and remote condenser;
- (c) Condensing unit and blower coils;
- (d) Condensing unit with variable refrigerant volume flow and indoor fan coil units;
- (e) Multi-split system; and
- (f) Water-cooled package and water pump package.

Unitary air-conditioners shall be factory fabricated and assembled. The equipment shall be rated and tested to meet the requirements of internationally recognised quality assurance standards approved by the Supervising Officer.

The most energy efficient model in the series shall be selected for submission and shall be referred to Clause C12.19 of this General Specification.

Refrigerants adoption for refrigeration and air-conditioning system in government building projects shall comply with flammability safety classification in accordance with Clause B6.1 of this General Specification.

C12.19 ENERGY EFFICIENCY PERFORMANCE

All unitary air conditioners shall be selected aiming for the highest operation efficiency. The minimum Coefficient of Performance (COP) for Air-Cooled Unitary Air Conditioner and Water-Cooled Unitary Air Conditioner shall comply with the requirement as specified in Code of Practice for Energy Efficiency of Building Services Installation (2018 Edition).

SECTION C13

WATER HANDLING EQUIPMENT

C13.1 FRESH WATER PUMPS

C13.1.1 Type

- (c) Motor efficiency for the pumps shall be of minimum IE4 under International Efficiency (IE) classes according to IEC 60034-30-1.

C13.1.3 Standards

- (b) Impellers & Guide Rings

The impeller shall be of the enclosed type and be of stainless steel, Leaded Gunmetal to BS EN 1982:2017 or ISO 197-4:1983, keyed to the shaft. Renewable guide rings shall be bronze and shall be provided in the casing, keyed to prevent rotation.

- (c) Shaft, Sleeves and Glands

Stainless steel shall be to BS EN 10095:1999, BS EN ISO 683-3:2018 and BS EN ISO 683-4:2018, ground and polished.

Bronze sleeves shall comply with BS EN 1982:2017 or ISO 197-4:1983 and shall be provided through the sealing glands to protect the shaft from wear. The sleeves shall be keyed to prevent rotation and secured against axial movement.

C13.2.3 Standards

(b) Impeller and Shaft Sleeve

Impeller and shaft sleeve of saline water pumps shall be of one of the materials as below:-

- (i) Zinc-free bronze to BS EN 1982:2017 Grade PB1; or Grade CT1; or ISO 197-4:1983;
- (d) The shaft shall be of stainless steel to BS EN 10095:1999, BS EN ISO 683-3:2018 and BS EN ISO 683-4:2018, AISI 316, ground and polished.

C13.4 SUMP PUMP

C13.4.3 General Requirements

All bolts nuts and fasteners shall be of stainless steel and electric cable entry shall be of watertight construction.

Sump pumps for rainwater application shall generally be of materials complying with Standards as specified in Clause C13.1.3. Sump pumps for pumping other fluids shall be of materials compatible with the fluid that are being handled. If sea water is pumped, the pump materials shall comply with Standards as specified in Clause C13.3.3. The sump pumps shall operate automatically by float level control.

The guide bars and brackets for wet sump installation shall be of stainless steel to AISI 316.

Cable supports shall be of stainless steel. A safety provision shall be incorporated for automatic electrical disconnection of the supply in case of cable entry seal failure.

Pumps for flammable zones shall be equipped with flameproof submersible motor in compliance with BS EN IEC 60079-0:2018 and BS EN 60079-1:2014.

C13.11 FLANGED CONNECTIONS

Pumps shall have flanged connections conforming to the Table of BS EN 1515-1:2000, BS EN 1092-1:2018, BS EN 1092-2:1997, ISO 7005-1:2011 or ISO 7005-2:1988 as appropriate to the maximum working pressure. Taper pieces shall be provided where necessary for connection to pipe-work.

C13.13 AUTO STRAINERS

The strainer shall be completed with a motor-controlled continuously rotating inner drum or stationary drum and equipped with an automatic backwash arrangement.

The unit body shall be provided with an inspection opening for visual checking. In addition, a drain opening with drain valve shall be provided at the lower part and connected to the nearest floor drain.

The straining element /screening drum shall be of stainless steel AISI 316 and shall be of the type and size suitable for removal of captured materials as specified in the Drawing/Particular Specification. A drip proof squirrel cage motor shall drive the inner drum, if the strainer is a rotating drum design, or to drive the rotating backwash arm if the strainer is a stationary drum design, with suitable geared facilities that shall be mounted on the top of the strainer body.

The body of the auto-strainer shall be of stainless steel AISI 316 cast iron to BS EN 1561:2011, ISO 185:2005, ASTM A278 Class 40 or carbon steel to BS EN 10095:1999, BS EN ISO 683-3:2018 or BS EN ISO 683-4:2018. Body of carbon steel shall be provided with internal coating or lining recommended by the strainer manufacturer and with zinc sacrificial anodes. It houses a rotating tapered drum attached to stainless steel shaft of AISI 316 or a stationary drum with rotating arm driven by stainless steel shaft of AISI 316 and backwash mechanism. The unit shall be suitable in operation under a pressure of 1034 kPa. Auto-strainer for handling sea water shall have its body of duplex stainless steel to ASTM A240 or EN 1.4410 or austenitic grey cast iron to ASTM A436 Grade 1B, or otherwise the materials of construction as specified in the Particular Specification of the Contract.

The automatic control of backwash arrangement shall comprise a motor-controlled valve on the outlet and an adjustable timer and differential pressure switch set to a maximum pressure drop allowed to regulate the frequency of backwash. Such control shall interface with the Central Control and Monitoring System (CCMS) if available.

C13.14 FEED AND EXPANSION FACILITY

C13.14.2 Types of Cistern and Tank

(d) Connections

Connections to mild steel cisterns and tanks shall be made by means of bossed, screwed flanges or pads and studs. Connections on mild steel cisterns shall be welded before galvanising. Flanges shall comply with BS EN 1092-1:2018 or ISO 7005-1:2011, ISO 7005-2:1988 and ISO 7005-3:1988.

PART D - INDOOR AIR QUALITY (IAQ)

D5 EQUIPMENT/MATERIALS – PART C: TREATMENT AND CONDITIONING MEDIA

D5.1 Outdoor Air Pre-conditioner

All dehumidifiers specified in the Particular Specification shall comply with the minimum energy efficiency as specified in this General Specification unless otherwise specified in the Particular Specification. The outdoor air pre-conditioner system employing wasted energy recovery equipment shall conform to the followings: -

D5.1.1 Specification of Desiccant Type Outdoor Air Pre-conditioner

(d) Total Heat Recovery Wheel

- (v) The transfer media coated shall have equal sensible and latent effectiveness and the recovery efficiency shall be clearly documented through an independent test certification programme conducted in accordance with ANSI/ASHRAE Standard 84-2013 and AHRI-1060(I-P/2018) standards. The molecular sieve shall have high water pick up rate at both high and low relative humidity so as to give a constant effectiveness over the entire relative humidity range and to allow the wheel to be effective at high face velocities up to 5.5 m/s.**

(viii) The wheel shall be independently tested; shall conform with the requirements of NFPA-90A:2018 and shall have a flame spread less than 25 and a smoke developed less than 50 when both rated in accordance with ASTM E84-18b.

(e) Filter

(ii) The filter shall be listed by Underwriters laboratories as Class 2 and the filter efficiency shall be 30% to ANSI/ASHRAE Standard 52.2-2017.

D5.1.2 Specification of Paper Plate Type Outdoor Air Pre-conditioner

(a) The paper plate type outdoor air pre-conditioner shall be the product from a manufacturer holding the quality assurance standards of ISO 9001:2015 or products having equivalent functions or performance.

D5.4 Electrostatic Precipitators

Electrostatic precipitators shall comply with the FSD's requirements and shall be of the type under the FSD's approved material list. Average efficiency of the auto clean electrostatic filter shall not be less than 90% rated at ANSI/ASHRAE 52.2-2017 "Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size". Auto clean electrostatic filter shall consist of a washer/adhesive applicator section and an ioniser-collector section, with overspray filters, all factory assembled into a sectioned housing of overall depth not greater than 1 m in direction of airflow. Each section of the galvanised steel housing assembly shall incorporate a pair of hinged, quick opening access doors permitting access for servicing of all internal components; and a watertight, all welded, galvanised steel, drain pan and drain connections. Access doors shall be sealed against air leakage by continuous perimeter gaskets of closed cell neoprene.

Each ioniser-collector section shall be finished with the required number of one-piece or multi-piece cells of aluminium construction. Each cell shall be fitted with stainless steel slides for mounting on the tracks which form an integral component of the side access housing and to facilitate removal of cells for servicing. Cell support

framework shall be completely open beneath the ioniser-collector section to ensure complete drainage of wash water and excess adhesive, minimising the possibility of short circuits when high voltage power is restored following completion of the wash cycle. Cells shall be designed so that high voltage input terminals and the high volt rated glass or ceramic fill polyseal insulators are located completely out of contact with the moving air-stream to avoid buildup of dirt which could permit dissipation of high voltage charge and reduce air cleaning efficiency. The high voltage bus-bars and terminals (contactors) shall be inherent to the design of each cell and shall permit cell removal without disconnecting any high voltage wiring. Insulators shall be fully exposed, for ease of cleaning, when cells are removed for service. Cells shall be designed for full face ionisation and have completely flat collector plates to prevent buildup of residual, inaccessible dirt accumulations.

Each washer/adhesive applicator section shall incorporate slide-in type, perforated, galvanised steel air distribution baffles and a header assembly which connected to the inlet water solenoid valve and to the adhesive pump by means of copper piping and/or non-slag, expanded PVC hose with a braided polyester exterior protective cover. Washer rams, each equipped with multi-directional, 360° washer spray nozzles, shall be driven by reactive force from inlet water pressure. The removable brass adhesive nozzles shall be mounted on a separate, fixed, vertical header forming an integral component of the assembly. The filter adhesive shall be cold water soluble and non-flammable. The A/C Contractor shall supply a rotary gear adhesive pump with bronze impeller and sufficient adhesive for reconditioning cycle.

The washer supply water solenoid valve, the manifold drive motor, and the manifold limit switch shall be pre-wired to an accessible, internally mounted. Program timer control, with field adjustable timer and a timer bypass switch shall be provided to control the washing cycles. The washer control enclosure access door shall incorporate a status light to indicate when the reconditioning cycles is energised. An internal panel is to be equipped with a combination of LED status lights and display unit to indicate which part of the reconditioning cycle is in operation. The display unit is to be visible through a window in the control cover.

The power shall be of solid state design, having single or multi steps, relays for remote indication of status of the power and solid state voltage supply, and "fail-safe" low voltage relays to interrupt power to the ioniser circuit in the event of a malfunction in the plate circuit. Power pack covers shall each include neon glow lamps to indicate status of the power and solid state voltage supply. The power pack

shall also include safety provisions of a circuit breaker, a reset button, safety type door interlock switches.

D5.5 Electronic Air Cleaners

The electronic air cleaner shall be capable of removing odours of bacteria, organic and chemical origin and shall also be capable of reducing airborne bacteria and particulate in the treated area as specified.

The electronic air cleaner shall be tested by laboratories by independent regulatory/ testing bodies, independent accredited laboratories or elsewhere as approved to show the removal efficiency to be not less than 95% of airborne bacteria (total count), 95% of airborne particulate of 0.5 micron to 5.0 micron, 95% of cigarette smoke particles, 80% of odours and 95% of hydrogen sulphide.

The maximum output voltage of the electronic air cleaner shall be less than 3,000 volts.

The electronic air cleaner shall not generate ozone in excess of 0.05 part per million by volume(ppmv) of air circulating through the air cleaner according to the standards specified by the Food & Drug Authority (FDA) of USA.

A stainless steel mounting flange shall be provided for mounting the electronic air cleaner to the air plenum of the air handling equipment. The electronic air cleaner shall be interlocked with the respective blower electrically and mechanically so that it can be safely switched off when the fan of the blower stops. The electronic air cleaner shall be wired so that the units may be unplugged and removed for regular servicing. The electrical wiring shall conform to the relevant safety standards.

The electronic air cleaner shall consist of a power generator and screw-in electrode tubes. The length of each electrode shall not be less than 400 mm. The number of electrodes required shall be able to handle maximum return air of system application design.

The power generator of the electronic air cleaner shall be able to operate on the single phase mains power supply. The power generator shall be equipped with built-in regulator for output adjustment. The power generator shall also be fitted with on/off switch, on/off indicator lamps, output regulating rotary switch, overload circuit breaker and electrode tube sockets.

The electrode tubes shall consist of screw-in base and a glass tube. The electrode tube shall be protected with a stainless steel mesh and shall be earthen by means of a firmly fixed grounding wire to the power generator.

The air purifier shall be controlled in auto or manual mode. In auto mode, the electronic air cleaner shall be switched on/off at a pre-determined time period.

The electronic air cleaner shall not generate ozone in excess of 0.05 part per million by volume (ppmv) of air circulating through the air cleaner.

All materials used in the air supply stream shall not emit any harmful if case of fire and shall be tested to surface flammability test UL 94-5VA and BS 476 Part 6.

PART G - PAINTING, FINISHING AND PROTECTIVE TREATMENT

G4 SCHEDULE OF COLOURS

Colour schedule as stated below are those of BS 4800:2011 for ready mixed paints.

Table G4 – (1) Schedule of Colours

Description of Services	Basic Colour	Colour Code Indication 100 mm approx.			Basic Colour	
Pipework:						
Water	Drinking	Green	Blue			Green
	Cooling (Primary)	Green	White			Green
	Boiler Feed	Green	Crimson	White	Crimson	Green
	Condensate	Green	Crimson	Emerald Green	Crimson	Green
	Chilled	Green	White	Emerald Green	White	Green
	Mains supply, Cold	Green	White	Blue	White	Green

	Mains supply, Hot	Green	White	Crimson	White	Green
	Sea, river Untreated	Green				
	Fire Fighting	Green	Safety Red			Green
Gases	In either gaseous or liquefied condition (exception)	Yellow ochre				
Compressed Air		Light blue				
Steam		Silver grey				
Oil Lubricating		Brown	Emerald Green			Brown
Gas	Town	Yellow ochre	Emerald Green			Yellow ochre
	Natural	Yellow ochre	Yellow			Yellow ochre
Drainage		Black				
Acids & Alkaline		Violet	Black & Yellow Stripes			Violet
Equipment:						
Plant		Opaline Green				
Electrical Conduits & Ductwork		Orange				
Ductwork		White				

Table G4 – (2) BS Colour Reference

		BS 4800:2011
(1)	Basic Identification Colours	
	Green	12D45
	Silver grey	10A03
	Brown	06C39
	Yellow ochre	08C35
	Violet	22C37
	Light blue	20E51
	Black	00E53
	Orange	06E51
(2)	Safety Colour	

	Red	04E53
	Yellow	08E51
	Auxiliary blue	18E53
(3)	Code Indication Colour	
	Crimson	04D45
	Emerald green	14E53
	Yellow	10E53

PART H - INSPECTION, TESTING AND COMMISSIONING **DURING CONSTRUCTION PERIOD**

SECTION H1

GENERAL REQUIREMENTS

H1.7 "TYPE-TEST" CERTIFICATE

"Type-test" for materials and equipment, where specified, shall be carried out at the manufacturer's works, recognised institutions or accredited laboratories, or elsewhere as approved in order to demonstrate their compliance with the specified requirements. "Type-test" certificates together with the corresponding drawings, sketches, reports and any other necessary documents shall be submitted to the Supervising Officer for approval before delivery of the materials and equipment. Cases where appropriate, "type-test" certificates will be accepted are as follows:

- (a) Fans: "type-test" certificates showing fan characteristic curves (ISO 5801:2017), "type-tests" Certificates for sound power levels (BS EN ISO 5136: 2009), fan dynamic balancing test Certificates completed with a method of statement from manufacturer on testing to Grade 2.5, 4 & 6.3 on appropriate fan types in accordance with ISO 21940-11:2016 and ISO 21940-14:2012.
- (e) High voltage switchgear and motor control switchboard: "type-test" certificates for high voltage switchgear and switchboard in accordance with IEC 62271-100:2008+A1:2012+A2:2017.
- (f) Other electrical equipment, such as air heaters (but excluding thermostatic control equipment): "type-test" certificates in accordance with BS EN 60335-1:2012+A13: 2017, BS EN 60669-1:2018, BS 5733:2010+A1:2014 and BS EN 60670-22:2006.

- (g) Refrigeration plant: "type-tests" Certificates for hydraulic and air pressure testing at works in accordance with BS EN 378-1:2016, BS EN 378-2:2016, BS EN 378-3:2016 and BS EN 378-4:2016

H1.9 SITE TESTS

The A/C Contractor shall carry out site tests for all static systems during construction period for individual components and/or part of the installed works to ensure safe and proper operation of the complete installation according to the specified requirements. Such tests shall include integrity test of welds and pressure test on the hydraulic systems where applicable. Any component or equipment set to operate at or below the test pressure shall be isolated or removed prior to applying the pressure test. Site tests for electrical works in the Installations shall comply with the COP for the Electricity (Wiring) Regulations unless otherwise specified. Registered or suitably qualified workers shall be deployed to conduct site tests, where applicable, for the Installations.

Works to be permanently covered up shall be subject to inspection and testing before covering up. If the Supervising Officer or his Representative discovers any work that has been covered up before inspection and testing, this work shall be uncovered for inspection and testing to the satisfaction of the Supervising Officer or his Representative. The cost involved in uncovering the work, inspecting, testing and re-concealing the work together with any consequential losses shall be paid by the A/C Contractor at no additional cost to the Employer.

In particular, the following arrangements shall also be included:

- (b) On completion of cleaning operations described in Clauses 3.6.1 and 4.1.6.5 of the Testing and Commissioning Procedure for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control Systems Installation, each water distribution system shall be re-charged with clean water and then subjected to a hydraulic test as required by Clause 4.1.6.6 of T&C Procedure for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control Systems Installation.

Any items of equipment set to operate at or below the test pressure shall be isolated or removed prior to applying this test.