NOVOTEL AL DANA RESORT TOWERS

Gulf House Engineering **ARCHITECTURAL & ENGINEERING CONSULTANCY**
Mechanical, HVAC & Plumbing Specification

Date: January 2010
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Report Control Form

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LIST OF MANUFACTURERS / SUPPLIERS or EQUAL

SCHEDULE OF MANUFACTURERS

All the materials supplied under this contract shall be from one of the manufacturers listed below. No alternative Makers shall be accepted unless all the listed Makers are unavailable. Materials proposed form listed Makes also must fully comply with Detailed Specification. Country of Origin, where listed, must be complied.

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
HVAC			
1	Water Cooled Chillers	Trane Carrier York USA / West Europe	
2	Air Handling Units	trane York Mekar Euroclima Climatrol VTS clima USA / West Europe	
3	Fan Coil Units	Trane Mekar Climatrol Europe York Trane Carrier USA / West	
4	ERV (HEAT PIPE) Units	Trane SPC Climatrol Europe York Trane Carrier USA / West	
5	Water pumps (Condenser / Evaporator)	Graundfos KSB ITT Bell and Gossett SPP Holden & Brooke	
6	Chilled Water Pressurization Unit	Greenheck Pillinger Holden & Broke ITT Bell and Gossett	

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
7	Black Steel Pipes and Fittings (Chilled Water)	Saudi Steel Pipe (KSA) Grinnell(USA) Nippon Steel (Japan) Sumitomo van Leeuwen	
8	Automatic Chemical Treatment	Baltimore (USA) Culligan (USA) Dearborn (UK) Houseman (UK) Corodex Waterbird	
9	Valves	Crane (UK) Econosto (Holland) Hattersley (UK) Tour & Anderson (Canada) Pegler Moneywell (Germany) Griswold	
10	Strainers	Crane (UK) Econosto (Holland) Hattersley (UK) Tour & Anderson (Canada)	
11	Gauges / Thermometers	H. O. Trerice (USA) Weiss (USA) Dwyer (USA) Hunter (USA)	
12	Air Vent	Armstrong (USA) Spirax Sarco (UK) Econosto (Holland) Crane Co.	
13	Flexible Pipe Joint	Mason Weico Senior Flexonic Tozen Crane	
14	Water Hammer Arrestors	Sioux Chief (UK) Zurn (USA) Wade (UK)	
15	Rubber Copper Pipe Insulation	Aero flex Gulf flex Mobius	

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
16	Vibration Isolators	Mason (USA) Kinetics (USA) Manson (USA) Mupro (Germany)	
17	Acoustic Floating Floors	Mason (USA) Kinetics (USA) Christie & Grey (UK)	
18	Seal Expansion Tanks	Taco/ USA ITT Bell & Gossitt Holden & Brooke Pillinger	
19	Air Purification Units / Electrostatic Filters	Trion Purified Air Environ Air	
20	Close Control A/C Unit	Liebert Denco Compu Air Canatal	
21	Extract Fans (Centrifugal / Axial)	Novenco / Denmark Flakt Woods (UK) Greenheck (USA) Metrico (UK) Nu-Aire (UK) Penn Ventilator (USA) Roof Units (UK) Systemair (Germany) S & P (Spain) Dynair (Italy)	
22	Jet Fans for Car Park	Novenco –York / Denmark Wolter/Germany ELTA (UK) Dynair /Italy	
23	Air Outlets / Louvers	Tecnalco Beta Best Choice Air Master Gamma line Aldes Middle East Trox	

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
24	Volume Dampers	Gemamco Trox (UK) Safid Aldes middle east Airmaster Technalco	
25	Extract Fans (Wall / Window)	ELTA Xpelair Ventaxia Greenwood Nuair	
26	GI Sheet	Nippon / Japan South Africa Nisshion	
27	Duct Adhesive & vapour barrier	Foster Napco Mircle	
28	Silencers	Bin Air Trox (UK) Accoustic Air Technology (UK) Gmamco Prime Technologies Gulf Acoustic	
29	Fire Dampers	Ruskin Trox Airmaster Aldes middle east One of the Makes approved by Local Civil Defense Dept.	
30	Duct & Pipe Supports	Grinnell (USA) Flammco (Europe) Mupro (Europe) Weicco Grinnel ITT	
31l	Fiberglas Insulation	Kimmco (Kuwait) Isover (Belgium) Arabian Fibreglass (KSA) Knauf (USA)	
32	Elastometric Foam insulation	Armaflex Kaiman Flex Kaiflex Eurobatex	

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
33	Sound Liner	Manville Manson Kimmco	
34	Flexible Duct	Safid Thermoflex ATCO Supaflex Satflex	
35	Flexible Duct Connector	Durodyne Thermo Flex Cain	
36	Access Doors	Zest Safid Ruskin	
37	Adhesive and Duct Coating	Foster Miracle Childer Napco	
38	Copper Pipe and Fittings	Muller -USA South Africa Crane Enfield Wednesbury Yorkshire Outokumpo	
39	Co-Sensors for Car Park	Siemens SenseAir /SWEDEN Duomo /UK	
40	Thermostat	Honey well Siemens Total Line	
41	HVAC filters	Filtrotecnica / Italy	
42	Duct Heaters	Indeeco Beasch Redd Heat Eltron	
43	DX Split Units	Mitsubishi Daiya Carrier USA York USA Trane USA Daikin Japan	

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
44	Variable Frequency Drive	ABB A/C drive ITT Bell & Gossitti AC Tech Siemens Telemechanique	
45	Automatic Controls	Siemens Honeywell ABB	
46	Aluminium Fin Protective Coating	Bronz Glow Blygold Acraclad	
47	Air Curtain	National Hitachi System Air	
48	VAV Box	Semiens ENVIRO-TEC	
49	Heat Recover Wheels for AHU	Eco – Fresh Venmar CES	
50	Metering System and Billing (BTU meters)	Actaris electronic- Europe Metering SVM- Europe Acua Metro - Europe	
51	Test Points	Binder Sisco (USA)	
52	Starters, Contactors & Motor Control Centres	ABB (Germany) Dorman Smith (UK) ETA (AEG, Germany) Merlin Gerin (France) Square D (USA) Seimens (Germany)	
53	Chilled Water Circuit Balancing Valves	Crane (UK) Grinnell (USA) Hammond (USA) Hattersley (UK) Herz (Austria) Holmes (UK) Kitz (Japan) Nexus (USA) Tour & Anderson (Sweden)	

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
54	Air Filters (Panel & Bag type)	Camfil (USA) Farr (USA) Purafil (USA)	
55	In Line Centrifugal Fans	Flakt Woods Greenheck (USA) Metrico (UK) Penn Ventilator (USA) Roof Units (UK) Dynair (Italy) Systemair (Germany) S & P (Spain)	
56	Wall / Ceiling Fans	Vent-Axia(UK) Xpelair (UK) Elicent (Italy) Manrose Systemair (Germany) S & P (Spain)	
57	Fire Rated Ductwork	Cape Durasteel Flamebar Ocean Fire Promat	
58	Manual Balancing Dampers and Turning Vanes	Actionair(UK) Nailor (USA) Ruskin (USA) Trox (UK) KBE (Lebanon)	
59	Chilled Water Air Separators	Engineering Appliances (UK) Flamco (UK) ITT Bell & Gossett (USA) Spirotherm (USA) Taco (USA)	
60	Specialist Agencies for Noise & Vibration Control	Aerocoustic Engineering Gulf Acoustics Sound Research Laboratorie	

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
		PLUMBING	
1	G.R. P Sectional Water Section	Mitsubishi- Japan Bridge Lone- Japan Leader Tech- Korea INAX- Japan Sekisui-Japan Balmoral- UK	- Engineering Marketing Est. (02-6775022) - Solico Trading (02-6226441) - Leader Tech Eng. & Trading (04-2274469) - Fikree Pipe (02-6443950) - Fikree Pipe (02-6443950) - Bin Zayed Group Dubai (04-2662222)
2	Transfer, Booster and Sump Pump	Grundfos – (Denmark) KSB – (Germany) ITT BELL & COSSIT Devay- (Australia) Armstrong- UK RITY- Germany	- MEH KHORIY (02-6426566) - TONADO Trading (02-664110) - Faisal Jassim Gen. Trading (02-6219772) - Bin Moosa & Daly Ltd. (02-6424008) - Allied Arab Trading Est. (04-3405814) - Aikah Trading Est. (06-5398070)

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
3	Water Heater	Rheem – USA NIPE - Sweden O. Smith- (Northernland) Atlanta – (France) Pacific – (France) Austria Emall- (Austria)	- RAFCO (02-6720820) - Allied Arab Trading Est. (04-3405814) - Sanitary Material Company (02-6771363) - Rafco (02-6720820) - Macal Gurg (02-67171460 - Allied Arab Trading Co. (04-405814/ 02-4496476)
4	Valves (Gate, Angle, Check, etc.)	Hatter Sley- UK PEGLER – UK NIBCO – UK MUELLER – U.S.A. Seppel Fricke- (Germany) Scholosser- (Germany)	- Al Amana Trading Co. (02-6723787) - Bin Moosa & Daly Ltd. (02-6424008) - Fikree Pipe (02-6443950) – Suwaidi Eng. Group - Seppel Fricke Sanitary Line - Allied Arab Trading Co. (04-3405814 / 02-4496476)

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
5	Filtration System	Rayned – USA	- Beta Building Materials (02-6767930)
		Water Line – Italy	- DON-RITE (02-6337066)
		Brunner – USA	- Civil Co. (02-6734400)
		Culligan – USA	-Culligan International
		MAH TRADING SON - USA	- Rays International
		Pure Water – USA	- Water Treatment Solution (02-6713110)
6	UPVC Pipes and Fittings	Hepworth – UK	- Hepworth P.M.E (02-6767930)
		UPONOR/ DURA PIPE –UK	- Fikree Pipe (02-6443950)
		NPBF – UAE	- A.D. National Pipe & Bags Factory (02-5554400)
		Terrain – UK	- Bin Moosa and Daly Ltd. (02-6424008)
		Bin Mansour Plastic Pipe – UAE	- Bin Mansour Plastic Pipe – UAE (02-5511133)
		Cosmoplast – UAE	- Cosmoplast Factory Ltd. (06-5331264)

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
7	P.P.R. PIPES and Fittings	Dizayn – Germany	- ATAD International Trading (04-2633114)
		Oliver – Italy	- Allied Arab Trading Est. (02-4496476/ 04-3405814)
		Porplus System – Polska	- United Building Materials Trading (02-6221539)
		Philsatherm – Turkia	- Al akra Main Building Materials (02-6722733)
		Thermo Pipe – Jordan	- Bani Markan International Trading & Contracting Est. (02-631930)
		WEFA Therm	- Aliaxe's Company
8	P.P.R Pipes and Fittings (Gravity)	Hepwort – UK	- Hepworth P.M.E (02-6727585)
		Terrain – UK	- Fikree Pipe (02-6443950)
		Dura Pipe – UK	- ATAD International Trading (04-2633114)
		Marley – UK	- Sultaco (02-6334425)
		NPBF – UAE	- Abu Dhabi National Ppes and Bags Factory (02-5554400)
		Cosmoplast – UAE	- Cosmoplast Factory Ltd. (06-5331264

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
9	Manhole Cover	Gynwed – UK	- Majed Bukatara Building Materials (04-3371710)
		Broads- UK	- Fikree Pipe 902-6443950)
		Stanton and Stavely	- Al Mamalek Building Materials (04-2862535)
		M.A.G Aspani	- Macal Gurg (02-6717146/ 03-7211219)
		U.P.M Aspani	- United Building Materials (02-6221539)
		Falcast	- Majed Bukatara Building Materials (04-2868666)
10	Floor Trap Cover	Wade- UK	- Fikree Pipe (02-6443950)
		Galvin-Australia	- Allied Arab trading Est. (04-3405814)
		Ancon- USA	- Majid Bukatara (04-3371710)
		Dallmar- Germany	- Macal Gurg (02-6741171)

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
11	P Trap	Terrain-UK Marly- UK Hepworth-UK Dura Pipe- UK	- Fikree Pipe (02-6443950) - Sultaco (02-6334425) - Hepworth Co P.M.E (04-3371710) - Arad Int'l Trading (04-2633114)
12	Gullery	Naylor – UK Terrain-UK Hepworth-UK Kiramer- Spain	- Bin Moosa and Daly Ltd. (02-6424008) - Fikree Pipe (02-6443950) - Hepworth Co P.M.E (04-3371710) - Bin Moosa and Daly Ltd. (02-6424008)
13	Floor Cleanout and Roof outlet	Wade- UK Galvin-Australia Frost- UK Ancon- USA	- Fikree Pipe (02-6443950) - Allied Arab trading Est. (04-3405814) - Al Mamalek Building Materials (04-2862535) - Majed Bukatara Building Materials (04-3371710)

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
14	Fire Pump Set	Wade- UK Reerless- USA Ritz- Germany KSP- Germany	- Al Sagar Eng. Company (02-6444934) - Tyco Fire & Security (02-6777776) - Al Kalak Trading Est. (06-5398071) - Tornado Trading (02-6664110)
15	Galvanized Steel Pipe	Nippon- Japan Kawasaki Sumitomo Econosto- Japan	- Apex Trading Est. (02-6310152) - Majed Bukatara Building Materials (04-3371710) - Majed Bukatara Building Materials (04-3371710) - Asia Electro-Mechanic Co. (04-8818383)
16	Galvanized Threaded Fittings	Grinnell- UK Star- UK Hitachi – Japan Shield- Korea	- Al Suwaidi Group (02-6211000) - Al Suwaidi Group (02-6211000) - Nafco Dubai (04-2972343) - Majed Bukatara Building Materials (04-3371710) - Asia Electro-Mechanic Co. (04-8818383)

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
17	Grooved Fittings	Victaulic Grinnell- UK Viking Central	- Victaulic Middle East - Al Suwaidi Group (02-6211000) - Viking Arabia (02-6451711) - Naffco Dubai (04-2972343)
18	Hangers and Accessories	Victaulic Mupro P H O Tolco	- Victaulic Middle East - Al Musamdan Building Materials (02-6424471) - Metallic Building Materials (02-6344764) - Viking Arabia (02-6451711)
19	Sprinkler Heads & Accessories	Grinnell- UK Central Shield- Korea Star Sprinkler	- Al Suwaidi Group (02-6211000) - Naffco Dubai (04-2972343) - Asia Electro-Mechanic Co. (04-8818383) - Naffco Dubai (04-2972343)

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
20	Special Valves (Alarm Valve- Pre Action Valve)	Grinnell- UK Central Viking Star	- Al Suwaidi Group (02-6211000) - Naffco Dubai (04-2972343) - Viking Arabia (02-6451711) - Naffco Dubai (04-2972343)
21	Valves (OS, Andy Butterfly and Check Valves)	Grinnell- UK Central Kennedy Automatic Sprinkler Corporation	- Tyco Fire and Security - Naffco Dubai (04-2972343) - Emirates Fire Fighting Equipment Factory (02-5340300) - Al Suwaidi Group (02-6211000)
22	Firehose Reel, Firehose Nozzle, Landing Valve Cabinets	Macron Viking Walker Naffco	- Tyco Fire and Security (02-6777776) - Viking Arabia (02-6451711) - Tyco Fire and Security (02-6777776) - Dhabia Trading Est. (02-6263554)

NO.	PRODUCT	ACCEPTABLE MANUFACTURERS / SUPPLIERS	CONTACT DETAILS
23	Fire Extinguisher	Total Walter- Germany	- Tyco Fire and Security (02-6777776)
		Angus- UK	- Al Suwaidi Group (02-6211000)
		Norsen- UK	- Al Suwaidi Group (02-6211000)
		Chubb- UK	- Emirates Fire Fighting Equipment Factory (02-5340300)

Note:

- All fire-related materials e.g. Fire Dampers etc., must have Local Civil Defence Department Approval.

- The supplier for all Mechanical equipment should have local service after sales workshop in Kingdom of Bahrain.

SECTION 15010

MECHANICAL GENERAL PROVISIONS

PART 1 – GENERAL

SCOPE OF WORK

The Mechanical Works shall include the installation, commissioning and maintenance of the following systems for a minimum of one (1) year from the date of taking over certificate issued by the COMPANY.

A. Air Conditioning System to include Central Chilled Water Plants, Pumps, Control Panels, Chilled Water Piping Network, Air Handling Units, Fan Coil Units, Ducting for all the above system, insulation for all piping, necessary supports, sleeves, indicating instruments, and all accessories and spare parts and associated Civil Works, required to complete, commission and maintain to the fullest satisfaction of the COMPANY with necessary testing, warranties, factory inspections all as called for in Drawings / Specifications /Bills of Quantities / Conditions of Contract.

B. Sewerage Network to include manholes with necessary benching, GRP lining covers, ladders, piping network, gully trap, sand trap, oil trap, floor gullies, floor traps, cleanouts, access doors, vent cowls, roof drain outlets, soak away etc.

The sewerage system shall be connected to the existing city sewer mains through a lift station complete with necessary supports, sleeves, all accessories, spare parts, associated civil works to complete, commission and maintain to the fullest satisfaction of the COMPANY with necessary testing, warranties etc. as called for in Drawings / Specifications / Bills of Quantities / Conditions of Contract.

C. Fire fighting network to include fire pumps, fire mains, fire hydrants, valves, fire hose cabinet, extinguishers, fire hose reel, automatic sprinkler installation, piping network, connection to existing network, necessary supports, sleeves, all required accessories, spare parts, associated civil works to complete, commission and maintain the system to the fullest satisfaction of the COMPANY, with necessary testing, warranties etc., as called for in the Drawings / Specifications /Bills of Quantities / Conditions of Contract.

D. Storm Water Network to include piping network, collection chambers, pits, pumps, necessary supports, sleeves, all required accessories for connection to the city storm water mains, spare parts, associated civil works to complete, commission and maintain the system to the fullest satisfaction of the COMPANY with necessary testing, warranties etc. as called for in the Drawings / Specifications / Bills of Quantities / Conditions of Contract.

E. Water Supply Network to include raw & potable water mains, valves, pits, booster pump sets, water filtration units, piping network, GRP sectional potable water tank, pumps, indicating instruments, necessary supports, sleeves, all required accessories, spare parts, associated civil works, to complete, commission and maintain the system to the fullest satisfaction of the COMPANY with necessary testing, warranties etc. as called for in the drawings / Specifications / Bills of Quantities / Conditions of Contract.

F. Existing Air Cooled Chilling System (on service yard):-
The two existing Chilling System:- The same two Air Cooled existing Chiller with new two chilled water variable pumps set (same old flow with modified new pump head) and the same water expansion unit and chemical chilled water treated pot,

will be shifted on the roof of the Apartments Tower and put the old system in efficient duty. Equipment methodology or methods statement should be submitted for engineer and existing resort operator approvals. The peak and low tourism season timing period should be informed by the existing Resort operator. Contractor should coordinate with all services to relocate the old chilling system with all pipes, fittings, electrical and control cables, panels, .etc. and connected with the existing chilled water supply and return lines as per engineer approval and existing resort operator coordination's.

G. Existing Irrigation System (on service yard):-
The Gray water system:- under ground water tanks with same existing water treatment chemical dosing pumps, poly ethylene tanks and all the piping, fittings and electrical control panels shall be shifted to new water treatment room on the ground floor. The water tanks for the treated and untreated water tanks shall be under ground RCC tank just under the treatment room (our proposal is 150m3 volumes). The existing untreated and treated water tanks capacities for the Gray water should be investigated by the contractor in coordination with the client representative and the existing resort operator. The contractor should put the Gray and irrigation systems in efficient duty.

H. Existing Manholes and Pipes (on Parking Area):-
All service pipes, cables, sewage, drainage and storm water manholes shall be diverted from the site construction area, and complete as built drawings for existing services under ground the parking area and the service yard should be investigated by the contractor in coordination with the client representative and the existing resort operator. The contractor should connect the new manholes and routes to the main existing sewage and drainage network serving the existing resort buildings.

1.1 DESCRIPTION

The scope of works for all mechanical and electrical works and systems comprises engineering, supply, delivery, installation, testing and commissioning, handover, training, maintenance and warranty all as described or reasonably implied in the Sub-contract. The Sub-contractor is obliged to provide fully functioning works and systems in conformance with the requirements of the Sub-contract. In the event certain items are not fully described or indicated in the Sub-contract, but deemed essential by the Supervision Employer's Representative (in all reasonableness) for the performance of the works and systems then the provision of such items shall form part of the Sub-contractors scope of works at no additional cost to the Employer.

The Sub-contractor shall be responsible to co-ordinate the equipment and services and shall produce properly co-ordinated shop drawings to demonstrate the installation comply with the performance requirement with shop drawing, calculations and details.

Shop drawings shall take into account actual measurement and setting out dimensions/levels obtained and determined by the Sub-contractor on site, actual equipment/material used, actual routing of services, co-ordination with all installation, and site conditions/constraints.

1.2 QUALITY ASSURANCE

Comply with the current applicable codes, ordinances, and regulations of the authority or authorities having jurisdiction, the rules, regulations and requirements of the utility companies/authorities serving the project and the Employer's insurance underwriter.

Drawings, specifications, codes and standards are minimum requirements. Where requirements differ, the more stringent apply.

The Supervision Employer's Representative reserves the right to inspect and reject any part of the Works not complying. The Sub-contractor shall replace such rejected works without cost variation and delay to the Sub-contract.

Approval or acceptance by the Supervision Employer's Representative shall not relieve the Sub-contractor of his responsibilities under the Sub-contract for the quality of materials and the standard of workmanship in the Works.

No work shall be covered up or put out of view without the agreement of the Supervision Employer's Representative. The Sub-contractor shall provide/allow the Supervision Employer's Representative full opportunity for the examination and measurement of any work which is about to be covered or put out of view. Upon request by the Supervision Employer's Representative, the Sub-contractor shall expose their Works and allow/provide access to the Supervision Employer's Representative to inspect any part of the Works during the course of the manufacturing or site installation/erection.
When requested by the Supervision Employer's Representative, the Sub-contractor shall submit evidence including written certificates and full testing reports from approved/recognised testing organisation certifying that his proposed equipment or material has been tested and conform to the specified standard.

1.3 ABBREVIATIONS AND DEFINITIONS

Abbreviations:

1.	ADA	American with Disabilities Acts
2.	ACMV	Air Conducting and Mechanical Ventilation
3.	AMCA	Air Moving and Conditioning Association (USA)
4.	ANSI	American National Standards Institute
5.	ARI	American Refrigeration Institute
6.	ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers (USA)
7.	ASME	American Society of Mechanical Engineers (USA)
8.	ASTA	Association of Short-circuit Testing Authorities
9.	ASTM	American Society for Testing and Materials (USA)
10.	BMS	Building Management System
11.	BS/BSS	British Standard or British Standard Specification
12.	CAD	Computer Aided Drafting
13.	ELV	Extra Low Voltage
14.	ETL	Electrical Testing Laboratories
15.	LPC	Lost Prevention Council (UK)
16.	HVCA	Heating and Ventilation Contractors Association (UK)

17.	ICAO	International Civil Aviation Organisation
18.	IEC	International Electro technical Committee
19.	IEE	Institute of Electrical Engineers (UK)
20.	IEEE	Institute of Electrical and Electronic Engineers
21.	IES	Illuminating Engineering Society
22.	IP	Index of Protection
23.	IPCEA	International Power Cable Engineers Association
24.	ISO	International Standardisation Organisation
25.	M & E	Mechanical and Electrical
26.	NC	Noise Criteria
27.	NEC	National Electrical Code
28.	NR	Noise Rating
29.	NEMA	National Electrical Manufacturers' Association (USA)
30.	NFPA	National Fire Protection Association (USA)
31.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association Inc. (USA)
32.	SPL	Sound Pressure Level
33.	SPW	Sound Power Level
34.	UL	Underwriters Laboratories Inc.

All other notations and symbols used shall have their internally/normally accepted/used meaning.

CLIMATE CONDITIONS

The Sub-contractor shall warrant that all materials and equipment are suitable for continuous use and operation in the climatic conditions encountered on site.
All equipment and materials shall be fully tropicalised and suitable for use in the peculiar local climate and operating conditions. All equipment/system shall be suitable for operation with outdoor dry bulb temperature of at least up to 46°C and relative humidity of up to 100%.

PART 2 – PRODUCTS

2.1 EQUIPMENT AND MATERIALS

Provide products and materials that are new, clean, free of defects, and free of damage and corrosion.

Products and materials shall not contain asbestos, PCB, or any other material which is considered hazardous by the authority having jurisdiction.

Replace materials of less than specified quality and relocate work incorrectly installed as directed by the Supervision Employer's Representative.

Provide name/data plates on major components of equipment with manufacturer's name. Model number, serial number, capacity data and electrical characteristics attached in a conspicuous place.

Install materials and equipment with qualified trade people.

Maintain uniformity of manufacturer for equipment used in similar application and sizes.

Fully lubricate equipment where required.

Follow manufacturer's instructions for installing, connecting, and adjusting equipment. Provide a copy of such instructions at the equipment during installation.

Equipment capacities, ratings, etc, are scheduled or specified for job site operating conditions. Equipment sensitive to altitude shall be de-rated with the method of de-rating identified on the submittals.

Energy consuming equipment shall meet local energy ordinances and by-laws.

2.2 EQUIPMENT INSTALLED AT OUTDOOR LOCATION

For equipment and services intended to be installed at outdoor locations or exposed to external weather conditions, the Sub-contractor shall ensure that these equipment and services are properly protected by weatherproof external casing or cladding to handle expected hot, humid, salt and carbon laden atmosphere. All associated motors, terminal, and electrical components shall be weatherproof type and suitable for outdoor installation, IP 55 or greater. Weather protection shield shall also be provided for all moving parts of the equipment and associated accessories external to the weatherproof equipment casing.

All external equipment included Air-conditioning Units and Ventilating Fans on roof, Air-conditioning used for MEP areas, etc. shall be specially graded against corrosive environment.

This outdoor weatherproof requirement shall also apply to services installed in close proximity of external openings and louvers.

2.3 PANEL AT EXPOSED LOCATIONS

For all Mechanical and Electrical panels outside plant rooms and at exposed locations such as car park, services area, public space, etc. shall be provided with a lockable front door with viewing glass panel.

2.4 EQUIPMENT SELECTION

The capacities of all plant and equipment described in the Sub-contract are minimum capacities and the Sub-contractor shall take into account of the offered equipment capacities to meet the performance requirement in the Sub-contract and actual installation requirements.

Physical sizes of all plant and equipment shall suit the space allocated, taking into account the requirement for access and proper maintenance.

Any proposal to deviate from the Specification and Drawings is subject to the Supervision Employer's Representative approval at his sole discretion.

Upon approval, any necessary changes to the engineering and installation as a result of these deviations shall be the responsibility of the Sub-contractor.

Proposed equipment shall be submitted for approval by the Supervision Employer's Representative before ordering is placed. All necessary information requested by the Supervision Employer's Representative for the review of the proposal shall be submitted.

PART 3 – EXECUTION

3.1 COORDINATION OF WORK

A master programme shall be discussed and issued to the Contractor after the kick-off meeting. The Contractor to submit a detailed construction schedule level 1 within 21 days of the kick-off meeting for approval along with a list of the long lead items. Upon approval, the Contractor shall submit detailed construction schedule level 2 for approval.

Sub-contract documents establish scope, materials and quality but are not detailed installation instruction.

Coordinate work with related trades and furnish, in writing, any information necessary to permit the work of related trades to be installed satisfactorily and with the least possible conflict or delay. The time frame to answer for request of information (RFI) shall be 14 days and should be signed by the Employer's Representative.

The drawings show the general arrangement of equipment and appurtenances. Follow these drawings as closely as the actual construction and the work of other divisions will permit. Provide off-sets, fittings, and accessories which may be required but not shown on the drawings. Investigate the site, and review drawings of other divisions to determine conditions affecting the work, and provide such work and accessories as may be required to accommodate such conditions.

The locations of thermostats, switches, panels, grilles, faucets, taps, and other equipment indicated on the drawings are approximately correct. Exercise particular caution with reference to the location of panels, thermostats, switches, etc., and have the precise and definite locations accepted by the Supervision Employer's Representative before proceeding with the installation.

The drawings show only the general run of services and approximate location of equipment, outlets, panels, etc. Any significant changes in location of equipment, outlets, panels, etc., necessary in order to meet field conditions shall be brought to the determine attention of the Supervision Employer's Representative for review before such alterations are made. Modifications shall be made at no additional cost to the Sub-contract.

Carefully check space requirements with other division works to ensure that equipment can be installed in the space allotted.

Wherever work interconnects with work amongst different installation, coordinate with other trades to insure that they have the information necessary so that the Sub-contractor may properly install the necessary connections and equipment. Identify items requiring access in order that the Ceiling Trade will know where to install access doors and panels. Abortive works to other contractors or sub-contractors due to failure of providing coordination requirements with respect to access will be to the account of the MEP Sub-contractor.

Consult amongst installation so that, wherever possible, motor controls and distribution equipment are of the same manufacturer.

Furnish and set sleeves for passage of risers through structural masonry and concrete walls and floors and elsewhere as required for the proper protection of each riser passing through building surfaces. Failure to furnished sleeves in block work and structure during the construction and requiring abortive works of breaking out will be back charged to the Sub-contractor.

Provide fire stopping around all pipes, conduits, ducts, sleeves, etc, which pass through fire compartments. At locations of multi services passage through structural/concrete block work opening where masonry filling is impossible, include for complete fire stopping between services and the adjacent structural/block work opening.

Provide required supports and hangers for equipment suitably so as not to exceed allowable loading of structures.

Wherever the work is of sufficient complexity, prepare additional detail drawings to scale to coordinate the work with the work of other trades. Detailed work shall be clearly identified on the drawings as to the area to which it applies. Submit these drawings to the Supervision Employer’s Representative for review. At completion include a set of these drawings with each set of record drawings. Wherever applicable and whenever required by the Employer’s Representative, the contractor shall provide construction method of statement for approval and prior to commencement of work.

Coordinate with the local utility companies/authorities for their requirements for service connections and provide all necessary provisions, grounding, materials, equipment, labour, testing, and appurtenances.

Before commencing works, examine adjoining works on which this work is in any way affected and report conditions which prevent performance of the works. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

The Sub-contractor is responsible to any modifications required due to service not properly coordinated.

3.2 EXAMINATION OF SITE

Prior to the submitting of bids, visit the project site and become familiar with all conditions affecting the proposed installation and make provisions as to the cost thereof.

The Sub-contract Documents do not make representations regarding the character or extent of the sub-soils, water levels, existing structural, mechanical and electrical installations, above or below ground, or other sub-surface conditions which may be encountered during the work, based on the examination of the site or other information. Failure to examine the drawings or other information does not relieve the Sub-contractor of responsibility for satisfactorily completion of the work.

3.3 EXCAVATION OF BACKFILL

Provide excavation for the work of the specified installation, if required or necessary. Excavate all material encountered, to the depths indicated on the drawings or as required. Remove from the site excavated materials not required or suitable for backfill. Provide grading as may be necessary to prevent surface water from flowing into trenches or other excavations. Remove any water which accumulates. Provide sheeting and shoring as may be necessary for the protection of the work and for the safety of personnel.

Provide trenches of widths necessary for the proper execution of the work. Grade bottom of the trenches accurately to provide uniform bearing and support the work on undisturbed soil at every point along its entire length. Except where rock is encountered, do not excavate below the depths indicated. Where rock excavations are required, excavate rock to a minimum over depth of four inches below the trench depths indicated on the drawings or required. Backfill over depths in the rock excavation and unauthorized over depths with loose, granular, moist earth, thoroughly machine tamped to a compaction level of at least 95% to standard proctor density or 75% relative density or as specified by the Supervision Employer’s Representative. Wherever unstable soil that is incapable of properly supporting the work is encountered in the bottom of the trench, remove soil to a depth required and backfill the trench to the proper grade with coarse sand, fine gravel or other suitable material.

Excavate trenches for utilities that will provide the following minimum depths of cover from existing grade or from indicated finished grade as required by local authorities.

Trenches should not be placed within 3 meters of foundation or soil surfaces which must be resist horizontal forces.

Do not backfill until all required tests have been performed and installation observed by the Supervision Employer’s Representative. Comply with the requirements of other sections of the specifications. Backfill shall consist of non-expansive soil with limited porosity. Deposit in 15 cm layers and thoroughly and carefully tamp until the work has a cover of not less than 30 cm. Backfill and tamp remainder of trench at 30 cm intervals until complete. Uniformly grade the finished surface.

3.4 CUTTING AND PATCHING

Where cutting, channelling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of conduit or other equipment, layout the work carefully in advance.

Repair any damage to the building, piping, equipment or defaced finish plaster, woodwork, metalwork, etc., using skilled trade people of the trades required at no additional cost to the Sub-contract.

Provide slots, chases, openings and recesses through floors, walls, ceilings, and roofs as required. Where these openings are not provided, provide cutting and patching to accommodate penetrations at no additional cost to the Sub-contract.

3.5 SEALING OF PENETRATIONS

Air Tight Seals

All penetrations through the building fabric subject to suction or pressurization shall be sealed airtight.

Holes in Roof

Roof penetrations for passage of conduits or circular PVC and PVC Cables shall be sealed watertight using a flexible polypropylene conical sleeve manufacturer to seal the cable to the roof structure, regardless of the roof profile.

All sharp metal edges, which may come in contact with the cable, shall be suitably bushed.

Fire Rated Penetrations

Where services penetrate any fire rated barrier, the Sub-contractor shall seal the penetration with the use of an appropriate material to ensure the integrity of the fire barrier. (See Section 15500 – Fire Fighting)

The Sub-contractor shall seal the cable enclosures through fire rated barriers to ensure the integrity and rating of the fire barrier. (See Section 15500 – Fire Fighting)

Acoustic Penetrations

Where services penetrate acoustic barriers, sealant shall be supplied and installed to maintain the acoustic separation at least equal to the barrier penetration. (See Section 15500 – Fire Fighting)

Penetration through water-proof Areas

Appropriate waterproof sealing material shall be used.

At locations where MEP Sub-contractor requests opening in structural floors larger than service installed, the balance portion to be filled-in with chequered plate by the MEP Sub-contractor.

3.6 MOUNTING OF HEIGHTS

Verify exact locations and mounting heights with the Supervision Employer's Representative before installation.

3.7 WATERPROOFING

Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement walls, and the like. If such penetration is necessary, make penetration prior to the waterproofing and furnish all sleeves or pitch-pockets required. Advise the Supervision Employer's Representative and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.

Restore waterproof integrity of walls or surfaces after they have been penetrated without additional cost to the Sub-contract.

3.8 SUPPORTS

Support work in accordance with the best industry practice. Provide supports, hangers, auxiliary structural members and supplemental hardware required for support of the work.

Provide supporting frames or racks extending from floor slab to ceiling slab for work indicated as being supported from walls where the walls are incapable of supporting the weight. In particular, provide such frames or racks in electric closets and equipment room.

Provide supporting frames or racks for equipment which is installed in a free standing position.

Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members, rigidly bolted or welded together and adequately braced to form a substantial structure. Racks shall be of ample size to assure a workmanlike arrangement of all equipment mounted on them. (All supports G.I. or stainless).

Adequate support of equipment (including outlet, pull and junction boxes and fittings) shall not depend on ducts, pipe, electric conduits, raceways, or cables for support.

Equipment shall not rest on or depend for support on suspended ceiling media (tiles, lath, plaster, as well as splines, runners, bars and the like in the plane of the ceiling). Provide independent support of equipment. Do not attach to supports provided for ductwork, piping or work of other trades.

Provide required supports and hangers for equipment so that loading will not exceed allowable loading of structure. Equipment and supports shall not come in contact with work of other trades.

3.9 FASTENINGS

Fasten equipment to building in accordance with the best industry practice.

Where weight applied to the attachment points is 45 kg or less, conform to the following as a minimum:

Wood:	Wood screws
Concrete and solid masonry:	Bolts and expansion shields

Solid metal:	Machine screws in tapped holes or with welded studs

Where weight applied to the building attachment points exceeds 45 kg, but is 135 kg or less, conform to the following as a minimum:

At concrete slabs provide 60 cm x 60 cm x 13 cm steel fishplates on top with through bolts. Fishplate assemblies shall be chased in and grouted flush with the top slabs screed line, where no fill is to be applied.
At steel decking or sub-floor for all fastenings, provide through bolts and threaded rods. The tops of bolts and rods shall be set at least one inch below the top fill screed line and grouted in. Suitable washers shall be used under bolt heads or nuts. In cases where the decking or sub-floor manufacturer produces specialty hangers to work with his decking or sub-floor such hangers shall be provided.

Where weight applied to building attachment points exceeds 135 kg, coordinate with and obtain the approval of Supervision Employer's Representative and conform to the following as a minimum:

Provide suitable auxiliary channel or angle iron bridging between building structural steel elements to establish fastening points. Bridging members shall suitably welded or clamped to building steel. Provide threaded rods or bolts to attach to bridging members.

For items which are shown as being ceiling mounted at locations where fastening to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging tying to the building structural elements.

Wall mounted equipment may be directly secured to wall by means of steel bolts. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars.

3.10 IDENTIFICATION

Identify equipment with permanently attached black phenolic nameplates with 13 mm high white engraved lettering. Identification shall include equipment name or load served as appropriate. Nameplates shall be attached with cadmium plated screws; peel and stick tape or glue on type nameplates are unacceptable.

Services runs shall be properly identified as per the requirements of this contract.

See individual section for additional identification requirements.

3.11 PROHIBITED LABELS & INDENTIFICATIONS

In all public areas, tenant areas, and similar locations within the project, the inclusion or installation of any equipment or assembly which bears on any surface any name, trademark, or other insignia which is intended to identify the manufacturer, the vendor, or other source(s) from which such object has been obtained, is prohibited. (Where applicable)

Required test lab certification labels shall not be removed nor shall identification specifically required under the various technical sections of the Specifications be removed.

3.12 EQUIPMENT PADS AND ANCHOR BOLTS

Provide concrete pads under all floor mounted electrical equipment. Equipment pads shall conform to the shape of the piece of equipment it serves with a minimum 25 mm margin around the equipment 28 day, 175 kgs/square cm concrete reinforced with 15 cm x 15 cm welded wire mesh.

Trowel tops and sides of pad to smooth finishes, equal to those of the floors, with all external corners bull nose to a 20 mm radius. Shop drawings stamped UNALTERED shall be used for dimensional guidance in sizing pads. (Where applicable)

Provide galvanized anchor bolts for all equipment placed on concrete equipment pads, inertia blocks, or on concrete slabs. Provide bolts of the size and number recommended by the manufacturer of the equipment and locate by means of suitable templates. Equipment installed on vibration isolators shall be secured to the isolator. Secure the isolator to the floor, pad, or support as recommended by the vibration isolation manufacturer.

Where equipment is mounted on gypsum board partitions, the mounting screws shall pass through the gypsum board and securely attach to the partition studs. As an attached to 15 cm square, galvanized metal back plates which are attached to the gypsum board with an approved non-flammable adhesive. Toggle bolts installed in gypsum board partitions are not acceptable.

3.13 DELIVERY, DRAYAGE AND HAULING

Provide drayage, hauling, hoisting, shoring and placement in the building of equipment specified and be responsible for the timely delivery and installation of equipment as required by the construction schedule. If any item of equipment is received prior to the time it is required, the Sub-contractor shall be responsible for its proper storage and protection until the time it is required. Pay for all costs of demurrage or storage.
If equipment is not delivered or installed at the project site in a timely manner as required by the project construction schedule, the Sub-contractor shall be responsible for resulting disassembly, re-assembly, manufacturer’s supervision, shoring, general construction modification, delays, overtime cost, etc., at no additional cost to the Sub-contract.

The Contractor shall submit schedules of materials in general and specific schedules of long lead items.

3.14 TESTING OF SYSTEMS

Comply with the project construction schedule for the date of final performance and acceptance testing, and complete work sufficiently in advance of the Sub-contract completion date to permit the execution of the testing prior to occupancy and Sub-contract closeout.

Complete any adjustments and/or alterations which the final acceptance tests indicate as necessary for the proper functioning of all equipment prior to the completion date. Refer Section 15995 (Testing and Balancing) and also see individual sections for extend of testing required.

Provide a detailed schedule of completion indicating when each system is to be completed and outlining when field testing will be performed. Submit completion schedule for review within six months after the notice to proceed by Supervision Employer's Representative has been given. Update this schedule periodically as the project progresses.

Provide all miscellaneous materials including balancing loops, drain and air vent valves, connections, water, temporary power, chemicals, gas etc as required for various systems described elsewhere to complete testing and commissioning of services.

3.15 BUILDING MANAGEMENT SYSTEM AND INTERFACES

The Sub-contractor shall co-ordinate the mechanical system and equipment to interface with the Building Management System in accordance with the point schedules specified on the drawings and specified in Section 13800. All necessary interfacing works shall be included in the Sub-contract.

3.16 SAMPLES

Samples showing fabrication techniques, quality and workmanship of component parts, compatibility of accessories shall be submitted for approval, upon request by the Supervision Employer's Representative. Samples submitted shall be the property of the Employer.

3.17 MAINTENANCE

The Contractor shall maintain, replace, repair with utmost speed and at his own expense, any part of the plant or material or work performed or furnished under the contract which may prove defective in design, erection, operation, performance, workmanship or from any act of omission on the part of the Contractor that may develop under the conditions provided for by the contract and under proper use in the works or any section thereof within three hundred and sixty five (365) days after the date of practical completion.

The Contractor shall obtain and submit to the Engineer any guarantee or certificates of warranty available from the manufactures, but only as supplementary to the Contractor's own quarantine and in no way invalidating them.

If any defect as above mentioned should occur, the Employer shall inform the Contractor thereof, stating the nature of the defect and if the contractor replaces or renews any portion of the works, the provisions of this Clause shall apply to the portion of the works so replaced or renewed as if that portion had taken over on the date of replacement or renewal.

If any defects are not remedied within a reasonable time, the Employer may not do the work at the Contractor's risk and expense.

If the replacement or renewals are of such a character as may affect the efficiency of the works or any portion thereof, the Employer may, within one (1) month of such replacement or renewal give to the Contractor notice in writing requiring that tests at site be made, in which case, such tests shall be carried out as provided in details of tests upon completion earlier in this section.

These Specifications shall apply to all inspections, adjustments, replacements and renewals as well as to all test associated thereby carried out by the Contractor pursuant to the Clause.

The Contractor shall include for complete monthly rerouting maintenance checks of all plant and equipment provided by him under the contract, throughout the whole aquatinted maintenance period to demonstrate that the operation of the completed system including the automatic controls, interlocks and safety devices for the various plant and auxiliaries are in satisfactory working order.

All required checks or tests should be witnessed by the Engineer's representative. The contractor shall prepare and fill in the routine maintenance service chart carried out and the name of the Engineer's representative witnessing the test and shall submit same in duplicate to the Engineer after every check.

Until the final completion certificate shall have been issued, the Contractor shall have the right of access at all reasonable working hours at his own risk and expense by himself or his duly authorized representative whose name shall have been communicated previously in writing to the Engineer, to all parts of the works for the purpose of the working and performance thereof, for the purpose of inspecting the same and taking notes there from, Subject to approval of the Engineer which shall not be unreasonably withheld, the Contractor may at his own risk and expense make any tests which he considers desirable.

Before the termination of the Guaranteed Maintenance Period, the Contractor shall upon the request of the Engineer, assume responsibility for dismantling of any part of the plant and apparatus indicated by the Engineer. If such dismantling, however, necessitates the interruption of service of the works, such period of interruption shall not affect the extent of the Maintenance Period as provided for in this Clause.

Application for the Final Completion Certificate shall be made by the Contractor at any time after the Contractor has ceased to be under any obligation under" Guarantee Maintenance" provided that if a Taking Over Certificate has been issued in respect of any portion of the works, the Contractor may apply for a separate Final Certificate in respect of each such portion at any time after the said obligation has ceased in relation to such portion and provided also that, if by reason of the fact that it has become necessary for the Contractor to replace or renew any portion of the Works, the obligations of the Contractor under "Guarantee Maintenance" shall continue after the period first therein mentioned, the right of the Contractor to apply for a Final Completion Certificate in respect of the Works or portion thereof other than the portion so replaced or renewed, shall not be affected by the fact and after the Contractor has ceased to be under any obligation under "Guarantee Maintenance" in respect of the portion replaced or renewed, he may apply for Final Completion Certificate in respect thereof.

The Contractor shall, at the same time, furnish the Engineer with a copy of his application for such Final Completion Certificate.

A Final Completion Certificate will not be issued until the Contractor shall have fulfilled his obligations under the Contract, and shall have delivered at site and handed to the Engineer all spare parts; if any included as per of his Contract.

A Final Completion Certificate shall, save in case of fraud or dishonesty relating to or affecting any matter dealt with in the certificate, be conclusive as to the sufficiency of the work under the Contract and of the valve thereof.

3.18 WARRANTIES

The Sub-contractor shall warrant that the capacity, rating or duty of all equipment used in the installation shall not be less than the performance specified on the Drawing or in the Specification when operating under the specified conditions and in accordance with the equipment manufacturer's instructions. Any equipment/system not meeting this requirement shall be rejected.

The Sub-contractor shall also extend such warranties to cover the entire Defect Liability Period.

All manufacturers, suppliers, distributors shall submit related warranties along with submittal for approval.

All products and installation shall be guaranteed for a minimum period of 365 days from the date of practical completion against manufacturing / installation defects, and the Contractor shall be responsible to remedy at his own expense any fault or defect including spares, labor and consumables which may occur during the above period.

3.19 PROTECTION OF MATERIALS PERSONNEL AND PROPERTY

All material and goods shall be delivered to the site in new condition, properly packed and protected against damage due to handling, adverse weather or other circumstances, and be kept in packing case or under protective covering until required for use.

Any items suffering damage in transit or on site shall be rejected and replaced without extra cost and time to the Sub-contract.

In the case of equipment and materials which originate from other countries and/or different climatic conditions, all such equipment and material shall be adequately and securely packed for safe transportation with due regard to the climatic conditions encountered in transit and arrival.

The Sub-contractor shall be entirely responsible for all apparatus; equipment and materials furnished by him in connection with his works, and special care shall be taken to protect all parts thereof in such a manner as may be necessary or as directed.

Protection shall include covers, crating, sheds, stores or other means to protect the apparatus, equipment and materials from the weather, water damage, and corrosion and to prevent dirt, grit, plaster or other foreign substances from entering the working parts of machinery or equipment. Special care shall be taken to keep all opening of pipes, ducts, and etc. closed while in storage or during the course of delivery and erection/installation.

The Sub-contractor shall take precautions to avoid unnecessary damage within the M&E installation.

All precautions shall be taken for the safety of personnel on site. The Sub-contractor shall also conform to the general regulations governing personnel on the site and must keep to the working space allocated for their use.

3.20 INTERFACING WITH ALL SERVICES AND SYSTEMS

General

The Sub-contractor shall provide all necessary provisions for interfacing with other trades, services, and equipment. All necessary sensors, current/voltage transformers, voltage-free contacts, relay, auxiliary contacts, terminals, transducers, etc. for interfacing works shall be provided by the Sub-contractor.

All control/monitoring wiring from sensors, equipment, and components for the interfacing shall be terminated at a separate interfacing compartment located at the respective equipment/system's switchboard or control panel. The interfacing compartment shall be completed with all necessary connectors, terminals, and with proper identifications to allow interfacing works to be easily carried out. The compartment shall clearly indicate "Extra Low Voltage Cable Only. No Power Cable Connection". Where there is no equipment/system switchboard or control panel involved, the Sub-contractor shall provide separate interfacing panels with provisions same as the interfacing compartment as described above. The locations of the switchboard/control panels and the interfacing panels shall be properly coordinated.

For every control panel and each module of the switchboard, at least five (5) spare terminals shall be provided for future interfacing works.

Wiring and cables for interfacing with the fire alarm system and other fire protection and life safety systems shall be fire rated to comply with Civil Defence's requirements.

Unless otherwise specified or shown on the Drawings, interfacing wiring from Fire Alarm and Building Management/Automation systems shall be provided and terminated at the terminals of the interfacing compartments or panels by the Fire Alarm System and Building Management/Automation System installation respectively. The Sub-contractor shall co-ordinate the current and voltage requirements for the interfacing works/provisions. The type of provisions for interfacing signals shall be as follows, unless otherwise specified:

Digital inputs and outputs	:	voltage-free dry contact
Analogue inputs and outputs	:	4 – 20 mA or 0 – 10 Mv

All the interface provisions shall be DC operated and rated not more than 50 mA.

In addition to the interfacing requirements shown on the Drawings, interfacing provisions as described below shall also be provided and included in the Sub-contract.

Electrical Installation

The Electrical Installation shall provide the following:

Isolators and power points (fused spur units) for all mechanical equipment and systems. Where shown on the Drawings, the Electrical installation shall include direct power cable connections to the mechanical system's main motor control centers.

Earthling terminal in the Fire Command Centre and all other plant rooms for supplementary equipotential bonding of mechanical equipment and systems.

Power failure signal to the Lift System (including wiring terminations into the Lift interfacing panel in the Lift Motor Room), Fire Alarm System and the Building Management/Automation System.

Electrical bonding of all roof equipment and external metal cladding including provisions and connection of bonding cables.

Fuel day tank High/Low level alarm signals to the Building Management/Automation System.

UPS emergency power supplies to Building Management System (including all field panels), Fire Alarm System, car parking system, and all security systems.

Emergency power supplies to all fire shutters, smoke shutters/curtains, and automatic doors.

Power point in each toilet for the plumbing installation (for connection to automatic sanitary sensors and flush valve under the Plumbing and Sanitary installation).

Plumbing and Sanitary Installation

The Plumbing and Sanitary Installation shall provide the following:
Water supply connections to water tanks under other mechanical electrical installation including isolation valve.
High / Low level alarm signals to the Building Management / Automation System for all water tanks.

ACMV Installation

1. The ACMV Installation shall provide the following:

   Smoke signal from the air-handling unit return air smoke detector to the Fire Alarm System.

An emergency ventilation system panel with ON/OFF control and ON/OFF/TRIP status indications at the Main Control Centre and the two (2) sub-control centres including switches and indication lights for the following equipment and systems:

   Entire smoke extraction system including individual fans (and associated motorized dampers), individual smoke shutters/curtains, smoke damper, etc (where applicable)

All Staircase pressurization fans

All Smoke Lobby ventilation fans (where applicable)

All automatic entrance doors

Other emergency fans for fire and life safety operations

Shut down control of air-handling units by the Fire Alarm System on floor-by-floor basis.

High/Low level signals to the Building Management/Automation System for all water tanks including feed and expansion tanks.

Fire Alarm Installation

The Fire Alarm Installation shall provide the following:

All control and monitoring modules for interfacing with all other mechanical and electrical systems.

Control signals and modules for all fire shutters, smoke shutters/curtains, automatic doors and all emergency ventilation systems.

High level interface with the Building Management/Automation system

Signal to the Lift Motor Room for lift homing operation.

Signal to all electronic security systems.

Signal to shut down air-handling units on floor-by-floor basis and all gas supply systems.

Building Management/Automation System (BMS) Installation

The BMS sub-contractor shall provide the following:
All control and monitoring modules for interfacing with other mechanical and electrical systems (with the exception of those for interfacing with the Fire Alarm System).

High level interface with the Fire Alarm System.

3.21 STRUCTURAL EXPANSION JOINTS AND SETTLEMENT JOINTS

The Sub-contractor shall make adequate provisions of flexible joints/connectors and/or expansion loops where services pass through structural expansion joints. The locations of these expansion joints are shown on the Architectural/structural drawings. The provisions of flexible joints/connections shall take into account the movement allowance. Detailed calculations shall be submitted by the Sub-contractor to justify the selection of these flexible joints/connectors.

For settlement joints shown on the structural drawings or required by the construction of structural works, the Sub-contractor shall co-ordinate that any installation which passes through settlement joints shall be executed after the complete casting of both side of the joint.

The Sub-contractor shall co-ordinate to ensure that all services installed under metal roof and skylight shall have adequate provisions to take into account the movement and deflection of the roof structure and the cladding.

3.22 PAINTING

All equipment, enclosures, housings, air ducts, piping, trunking, cable trays, conduits, etc. which are exposed to view (including those in plant rooms) shall be provided with colour paint finishes.

Generally, all metal surfaces requiring painting shall be provided with two (2) coats of asphalt aluminium paint, primer coated, and two (2) coats of finished paint.

No painting shall be done on damp surfaces.

The Sub-contractor shall submit colour scheme for the entire Works to the General Sub-contractor for co-ordination and submission for approval by the Supervision Employer's Representative.

Painting requirements as stated in codes and regulations or generally required by local authorities shall also be provided.

All piping must be primed even if concealed.

3.23 SAFETY EQUIPMENT AND NOTICES

The Sub-contractor shall supply and install the following safety equipment and notices for each switchboard/control panel in the respective switch rooms and plant rooms:

Solid rubber insulated mats complying with BS 921 in front of and extending the full length of the control panel/switchboards.

Copies of all statutory safety notices, regulations and instructions for resuscitation and treatment after electrical shock.

Danger signs on the switchboards/control panels, the doors of sub-station, switch rooms and electrical riser duct rooms and elsewhere to the requirements of the Power Supply Authority.

A copy of the main single line diagram, varnished and mounted on suitable hard backing and framed (in glass panel), showing clearly the full details of the electrical and mechanical systems as supplied and installed.

Any other Notices as required by all local Authorities.

3.24 QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

The Sub-contractor shall establish a QA department for this project, based on site with adequate number of qualified personnel.

The Sub-contractor, prior to the commencement of the Works, shall submit for the Supervision Employer’s Representative approval comprehensive QA/QC plan for the installation which shall include, but not be limited to the following:

QA/QC programme of the manufacturing process of equipment;

Method statements of all site erection/installation works;

Method of protection for material/equipment during delivery, and stored on and off the site; and

Testing and commissioning programmes, procedures, etc.

The QA/QC programme and procedures shall generally be in conformance with the guidelines of ISO 9000.

All equipment, material and items incorporated in the Works under this Sub-contract are to be new and of the best quality.

Equipment/material of non-reputable make may not be accepted solely at the discretion of the Supervision Employer’s Representative.

The use of electrically dissimilar metals in contact with each other shall be avoided. If this is not possible, the contact surfaces of the two (2) metals shall be insulated from each other by an approved method.

All work under this Sub-contract shall be performed in a skilful and workmanlike manner and in accordance with best workshop practice.

All components shall be easily accessible for maintenance/replacement.

All instrumentation and equipment required for inspection, testing and commissioning shall be calibrated and maintained by the Sub-contractor. The Sub-contractor shall submit all valid calibration records from manufacturer and/or recognized laboratories and testing authorities before the use of such instrumentation and equipment.

3.25 PROGRESSIVE RECORDS/ AS BUILT DRAWINGS

During the course of the Sub-contract, the Sub-contractor shall keep progressive record drawings of all installation works.

As-built drawings shall be developed and produced during the course of the installation and, when requested by the Supervision Employer’s Representative, for substantiating of monthly progress claims.

As-built drawings shall be submitted prior to the issue of Taking over Certificate by the Supervision Employer’s Representative.

As-fitted schematic system diagrams, properly framed, shall also be provided and mounted on the wall inside each plant room.
Submission of approved “as-built” or “as manufactured” drawings shall be in the following manner:

One (1) set of special quality plastic film transparency for all drawings;

Two (2) sets of computer soft copy in CD ROM;

Five (5) bound sets of paper prints for all drawings; and

Additional set of as-built drawings in addition to the above as specified in the Sub-contract Preliminaries and reasonably requested by the Supervision Employer’s Representative shall also be provided.

3.26 AS-BUILT DRAWINGS SUBMISSIONS

As-built drawings shall be provided as required by the Supervision Employer’s Representative.

The Sub-contractor shall ensure that the submissions are made properly and in a timely fashion and will not delay the inspections and testing by the authorities. All as-built drawings shall be produced based on the latest architectural plans.

3.27 TESTING AND COMMISSIONING

The Sub-contractor shall be responsible for obtaining all necessary licences as required by all relevant authorities before operation of any equipment/system.

All testing and commissioning to enable proper operation of the Works shall be completed to the satisfaction of the Supervision Employer’s Representative in accordance with the construction programme or before the issuance of Taking over Certificate, whichever is earlier.

All final adjustments and final balancing of the equipment/system operation shall be completed before the Date of Taking over Certificate.

The complete testing and commissioning are deemed to be concluded successfully only when the installation operated properly within the specified limits of its rating continuously without failure of any kind.
The Sub-contractor shall establish the dates by which permanent utilities shall be available for testing and commissioning of equipment and take this into account in his programme, or make suitable arrangements to test and commission with temporary power based on programme.

The Sub-contractor shall arrange for all submissions to Authorities and pay the cost of statutory inspections and certificates.

3.28 ATTENDANCE TO OCCUPATION PERMIT APPLICATION

The Sub-contractor shall provide all necessary attendance to inspections by the Supervision Employer’s Representative and authorities for the purpose of Occupation Permit application.

3.29 OPERATION AND MAINTENANCE INSTRUCTIONS MANUALS

The Operation and Maintenance Instruction manuals shall be in A4 size paper and be bound in rigid covers covered and engraved with lettering giving the Employer’s name, project name, Supervision Employer’s Representative name.

Final draft manuals must be submitted for the Supervision Employer’s Representative review before Taking over Certificate is issued at least six months before completion. After acceptance by the Supervision Employer’s Representative, the Sub-contractor shall submit five (5) sets and a soft copy of this manual for record before the Taking Over certificate can be issued.

In general, each manual shall consist, but not be limited to the following section:

General

This section shall include the purpose of the manual and brief description of the manual directory.

System Description

This section shall include the following as a minimum:

Description of the overall system.

General operation of plant, starting up and shutting down procedures, location of each equipment, normal and emergency operation of systems/equipment, control settings and tolerances.

Size and capacity of all the major equipment and components of the system.

The proposed initial setting of protective devices and other adjustable components of the system. Space shall be reserved for the insertion of final commissioned and accepted settings.

Normal sequence of equipment and plant operation and alternative sequence to maintain operation of part of the total facilities during abnormal circumstances.

Technical Specification

This section shall include the technical descriptions and functions of all equipment and components and shall generally include:

Schedules of equipment showing quantities, locations, types, operating duties.

Technical description of all systems and equipment, including circuit diagrams of each printed circuit board and component layout diagram for each printed circuit board installed for this project.

Wiring diagrams.

Manufacturer’s drawings.

Equipment list, stating the make, model, serial number, accepted settings (after commissioning).

Catalogues, certificates and performance data sheets for all equipment.

Maintenance

This section shall include the required operating and maintenance procedures of all the equipment. This shall include the following as a minimum:-

Inspection manual for all system/equipment;

Operation manual for all system/equipment;

Procedure of changing components of equipment requiring regular replacement;

Maintenance instructions, calibration procedures and fault finding instructions for all systems;

Precautions when carrying out operation and maintenance procedures;

Storage and inventory systems; and

Safety

This section shall include the following as a minimum:

Proper procedure of equipment operation;

General description of plant hazards, where appropriate, including the following:

Protection against electrical hazards;

Protection against mechanical and physical hazards;

Protection against fire and explosion hazards;

Protection against chemical hazards;

Protection during fuel and chemical handling; and

First aid and accident reporting.

Directory of Suppliers

This section shall list the name of suppliers and agents of each type of equipment, materials and accessories. Correspondence address, telephone number, fax number, pager number, and E-mail address shall be included.

List of Spares

This section shall list all the spares, consumable materials, and maintenance tools that will be maintained and kept to ensure continued satisfactory operation of the equipment and systems.

Organisation of Maintenance Team

This section shall include detailed organisation of the Maintenance team deployed for the Defect Notification Period with names and CV's, of all key staff. Contact telephone or pager numbers for emergency and/or twenty-four (24) hour call shall also be included.

List of As-Built Drawings

This section shall contain a full list of all "as-built" and "as-manufactured" drawings and asset register.

3.30 TAKING OVER PROCEDURE

The Sub-contractor shall adhere to the sequence of handover described below:

The Sub-contractor shall submit the arrangement of the commissioning to the satisfaction of the Supervision Employer's Representative. The Supervision Employer's Representative reserves the right to reject any person.

The installation shall be 'practically complete' following satisfactory commissioning and the submission of final commissioning data prior to the issuance of Taking over Certificate by the Supervision Employer's Representative. It is solely the Sub-contractor's responsibility to ensure that all plant/equipment shall have their respective warranty by the respective equipment/plant supplier directly.

A joint inspection shall be held among the Employer, Supervision Employer's Representative and Sub-contractor to establish an outstanding works and defects list. All outstanding works/defects shall be completed within one month from the date when the Taking over Certificate was issued.

If, at the end of the one month's period from the date of issuing the Taking over Certificate, any defects/outstanding works mentioned in the list still exist, the Supervision Employer's Representative is empowered to appoint a body to rectify all defects/outstanding works and deduct the cost involved from the Sub-contract sum.
The Sub-contractor shall also refer to other requirements in the relevant clauses of the Sub-contract.

Before the Taking over Certificate is issued, the following must be completed:

Operation and Maintenance Instructions Manual, test data and "as-built" drawings must be submitted. Computer "soft" copies of these manuals and drawings shall also be submitted.

The Employer or his representative must be fully instructed in the operation of the system. A written acknowledgment from the Employer shall be required.

All tools and spares shall be handed over. A written acknowledgment from the Employer shall be required.

Written confirmation from the Sub-contractor to indicate the installation is completed according to Performance Requirement.

Submit and obtain approval by the Supervision Employer's Representative. Maintenance schedule for the installation during the Maintenance and Defect Notification Period.

3.31 AS NEW CONDITIONS

At the time of handover of the Works after the Taking over Certificate, the whole installation shall be in 'as-new' conditions. The Sub-contractor shall, during the course of the Sub-contract, protect all plant and equipment and shall restore/repaint as necessary before handover of the installation.

3.32 DEFECT LIABILITY PERIOD

The Defect Liability Period for Mechanical & Electrical systems shall be as defined in the Main Contract document. During the Defect Notification Period, the Sub-contractor shall provide a 24-hour 'call-out' service to repair any equipment that has broken down.

Immediately answering the breakdown calls, the Sub-contractor shall attend to such calls within a maximum time limit of 2 hours during night and 1 hour during daytime of receiving such calls.

During the Defect Liability Period, the Sub-contractor shall at his own cost remedy and make good with all faults or defects in the Works, which in the opinion of Supervision Employer's Representative, is due to faulty materials, workmanship. The Sub-contractor shall indemnify the employer and/or the General Sub-contractor against any damage or injury to the Building contents and/or occupants arising from such faults or defects.

If the Sub-contractor fails to remedy such faults or defects within a reasonable time, the Employer may proceed to do so at the expense of the Sub-contractor and without prejudice to such other rights as the Employer may have under the Sub-contract.

The Sub-contractor shall also refer to other requirements in the relevant clauses of the Sub-contract.
The MEP Sub-contract shall warrant that the complete MEP installation shall perform satisfactorily during the Defect Liability Period.

3.33 TUITION/ TRAINING

The Tenderer shall submit a schedule in the Tender submission list all works and systems for which the Sub-contractor has to provide training. The Schedule should have information include list of recommended training courses within each works/systems, location of the training courses (Bahrain/Overseas). Trainers details (from the manufacturers premises where applicable) Courses duration, unit rate of the training on a per head basis.

The Sub-contractor shall provide sufficient and proper instructions to the trainees nominated by Employer in the commissioning, operation, maintenance, servicing and trouble-shooting of the various plant and systems.

The Sub-contractor shall provide training facilities and training courses and ensure that the trainees nominated by Employer will acquire full knowledge and appreciation of all aspects of the day to day operation, breakdown and routine maintenance, and fault diagnosis of all plant, equipment, and system installed under this Sub-contract. Detailed syllabus and the timing of the training courses shall be submitted.

Trainees nominated by Employer will attend the training courses, and the Sub-contractor shall allow them reasonable access to technical information and documentation required for proper operation and maintenance. The Sub-contractor shall also explain this information and documentation to allow the trainees to become fully conversant with all aspects of the systems.

When training is required to be held in overseas facilities, all necessary costs for airfare, hotel accommodation, local transportation, food, etc., shall be included.

3.34 VERMIN PROOFING AND CLEANING

On completion of the installation, the Sub-contractor shall check and ensure that all cable entries, openings, core holes, etc. are properly sealed with fire rated material and rendered vermin proof and water tight. The floors, trenches and surroundings shall be cleaned, mopped, and left in a clean, dust free-state on completion. Building works and paint work of equipment damaged during the installation works shall be made good to the satisfaction of the Supervision Employer’s Representative.

All costs involved in the above shall be deemed to be included in each installation.

3.35 POWER SYSTEM HARMONICS

For the purpose of this provision, “PCC” means the point of common coupling being the terminals of the mechanical equipment power interfacing units at the point where they connect to the electrical distribution system. The Sub-contractor shall demonstrate the installation will be carry out to complying with current international and European Community electrical immunity and emission standards. In order to continue an interference free service to others’ installation, the Sub-contractor must comply with each of the following:

The Sub-contractor shall provide adequate measures including active harmonic filters to limit the total harmonic distortion at the PCC to 5% for voltage and less than 12% for current for all phases, in accordance with the requirements of the Institution of Electrical and Electronic Supervision Employer’s Representative Standard IEEE 519. The Sub-contractor shall take particular care in the selection of equipment that may produce harmonics including without limitation electronic ballasts, UPS, soft starters and variable speed drives, to ensure that these limits are met at all times.

The Sub-contractor shall ensure that the power factor at the PCC is equal to or better than 0.85 lagging.

The Sub-contractor shall complete the installation to meet all current international and European Community emission standards for electrical interference for light commercial buildings, including without limitation EN50082, IEC1547, CISPR11, CISPR15, CISPR16, EN55015, EN55011, EN50081, EN60555, EN61000, IEC801, IEC1000 and EN61800.

3.36 ELECTOMAGNETIC COMPATIBILITY (EMC)

The Sub-contractor shall demonstrate the installation will be carry out in the way to ensuring that all equipment supplied conforms with the requirements of relevant international standards in terms of their electromagnetic compatibility with the environment and with all equipment to be installed in the Project. All equipment used shall comply with the prevailing generic EMC requirements and EMC requirements applicable to general, scientific and industrial equipment specified but not limited to the following standards, or their equivalents:

IEC	–	International Electro technical Commission standards
CISPR	–	International Special Committee on Radio Interference Document
EN	–	European Standard
BSI	–	British Standard Institution
VDE	–	Verband Deutscher Electrotechniker

All signal and control cabling installed shall be correctly screened and earth to prevent noise and electric shock. Operation of all equipment shall not be adversely affected by radiated energy from hand held communication equipment.

All equipment that is likely to be touched by personnel and contains sensitive electronic equipment shall be protected against electrostatic discharge.

The Sub-contractor shall ensure that any static or alternating magnetic fields, generated in the environment, do no adversely affect the operation of the equipment.

Bonding shall be provided for all exposed metallic parts of the equipment and connecting them to the earthing network for meeting safety requirements and minimize noise voltage due to potential differences.

Equipment provided but the Sub-contractor shall have minimum radio interference in the frequency range 0.15 MHz to 30 MHz by means of suppression at source.

All equipment supplies, prefabricated and installed shall be, manufactured and installed to fully comply with the European Electromagnetic Compatibility Directive 89/996/EEC, the CE marking directive 93/68/EEC and the United Kingdoms Electromagnetic Compatibility regulations 1992 and 1994 and all subsequent amendments.

All equipment supplied to the site shall be either electromagnetically benign or carry the “EC” mark and be provided with copies of the relevant test certificates.

3.37 SUB-CONTRACTOR'S OBLIGATIONS FOR THE PRODUCTION OF SHOP DRAWINGS

The Sub-contractor's obligations for the production of Shop Drawings shall, in addition to other requirements specified elsewhere in the Sub-contract Documents, include the following:
Adjustments and enhancement of services as a result of space co-ordination to provide sufficient installation and maintenance access to facilitate easy future operation and maintenance.

Re-routing and re-organization of services to achieve the clear headroom/ceiling height required by the architectural works

Adjustments and enhancements to suit the construction works on site

Adjustments and enhancements to suit equipment/systems offered

Adjustments and enhancements to suit public utility connections

Adjustments and enhancements to suit existing public utilities locations for avoiding diversions of these existing utilities

Adjustments and enhancements due to coordination and interfacing with other trades (e.g. power supply, water supply, electro-magnetic compatibility, etc.)

Changes required as a result of certain construction sequence and methods.

Adjustments and modifications of the installation arrangement to suit the specified phased completion and early hand-over areas.

The Sub-contractor shall be responsible and liable for the preparation of all Shop Drawings necessary or required under the Specifications and/or for the construction of the Works. The Shop Drawings prepared by the Sub-contractor shall be based on the Sub-contract Document. These Shop Drawings shall be subject to the approval of the Supervision Employer's Representative. The size of the shop drawing shall be on a minimum A1 paper size.

During the course of the Sub-contract, the Sub-contractor shall produce and commence submission of detailed shop drawings sufficiently early for the Supervision Employer's Representative review. These shop drawings shall be submitted progressively in accordance with the construction programme. Clearance or approval of any such drawings by the Supervision Employer's Representative shall not relieve the Sub-contractor from any specified performance or material requirements, nor nullify the Supervision.

Employer's Representative Right to reject unsatisfactory works on the site. A minimum period of fifteen (15) days shall generally be allowed for the review of each shop drawing submission by the Supervision Employer's Representative. The Sub-contractor is deemed to have allowed for this 15 day review period for each submittal in his Construction Schedule. Shop drawing shall be submitted via transmittal form and not by a covering letter. The logo and check box format to be used for the shop drawing submittal shall be checked and approved by the Employer's Representative prior to submission.

Installation works carried out by the Sub-contractor before the relevant shop drawings submitted and approved by the Supervision Employer's Representative are at the Sub-contractor's own risk.

Shop drawings shall show at least the following general categories of information:

Penetrations through floors, walls, and other structural members;
Plinth details;

Equipment positions and operating weights;

Entry positions, access routes, weight of equipment or components during delivery to site;

Services access openings;

Location, details of concealed/buried conduits, inserts, and pipes;

Temporary openings in floors/walls;

Detailed workshop and manufacturing drawings;

Equipment schedules;

General layout plans and sections (1:50 scale for plans and 1:20 scale for sections);

Schematic diagram;

Support and mounting details;

Material/Component specifications;

Setting out dimensions and level; and

Interfacing details and co-ordination with Architectural, structural and all installation Works.

In preparing the Shop Drawings, the Sub-contractor shall provide all construction-related engineering input and undertake construction co-ordination, inter-facing, cross-checking, sequencing and construction detailing subject to the absolute approval of the Supervision Employer's Representative.

Shop drawings shall be constantly updated to reflect modifications and changes agreed/accepted by the Supervision Employer's Representative and to reflect changes issued by Supervision Employer's Representative instructions.

Shop drawings produced shall be properly co-ordinated with the works of all installation. Where required for proper co-ordination and to achieve required headroom, the Sub-contractor shall make modification of services layout/routing, duct aspect ratios, pipe work gradient, etc. (from those shown on the Sub-contract Drawings) and reflect all these on the shop drawings for the Supervision Employer's Representative approval.

The Sub-contractor shall co-ordinate and provide on time the details of builders works required to be incorporated into the construction works. For builder's work information has already been given on the Drawings or the Sub-contract drawings such information is to be checked by the Sub-contractor to ensure suitability and sufficiency for his works.

Supervision Employer's Representative comments and corrections made on shop drawings shall not relieve the Sub-contractor of his Sub-contractual responsibilities to comply with requirements of the Specification and Drawings.

Shop drawings shall be updated progressively to reflect "as-built" conditions.

In preparing the Shop Drawings, the Sub-contractor shall co-ordinate the information in the Sub-contract, engineering the installation and demonstrates the installation adequacy, practicality, suitability, compliance of any statutory requirements and integrity of other information in the Sub-contract Documents. The Sub-contractor shall not be entitled to any increase whatsoever to the Sub-contract Sum for the Works or any extension of time to complete the Works.

3.38 APPROVAL CODES FOR REVIEW OF SHOP DRAWINGS

"A" Approval: Means that fabrication, manufacture, or construction may proceed providing submittal complies with Employer's Representative's notations and Contract Documents. If, for any reason, Contractor shall make revisions and resubmit as described for submittals stamped "C" action.

"B" Approved as Noted: Means that fabrication, manufacture, or construction may precede providing submittal complies with Employer's Representative's notations and Contract Documents. If, for any reason,

Contractor cannot comply with notations; Contractor shall make revisions and resubmit as described for submittals stamped C action.
"C" Revised & Resubmit: Means that fabrication, manufacture, or construction may proceed; however, the submittal did not fully demonstrate the full extent of all conditions, details, or coordination with other surrounding work and, therefore, requires additional information and rework as noted. These shop drawings shall be submitted for final A or B action. Specific areas requiring additional information shall not be fabricated, manufactured, or constructed prior to re-submittal.

"D" Rejected: Means that submittal does not comply with design intent of Contract Documents. Submittals stamped "D" Action are not to be used. Contractor shall make revisions and resubmit.

3.39 PERMITS, FEES INSPECTION

A. Obtain all required permits from the Statutory Authorities to complete your work. Make all submissions in a timely fashion with due regard for the requirements of the construction schedule.

B. Pay all fees and charges levied by the authorities having jurisdiction. Arrange and pay for any permits, inspections and certificates and work carried out by the Statutory Authorities in connection with your work.

3.40 INSTRUMENTS

3.40.1 GENERAL

DESCRIPTION

Provide instruments in accordance with the Contract Documents.

3.40.2 WORK INCLUDED

Thermometers and Temperature Wells

Hydraulic Pressure Gauges

Test Plugs

Recording Instruments

3.40.3 SUBMITTALS

Shop Drawings: submit shop drawings of instrument display boards, along with other shop or field fabricated installations.

Product Data: Submit manufacturers latest published data for instrument types, materials, accessories and installation.

3.40.4 QUALITY ASSURANCE

Instruments are to be factory calibrated for the temperature and pressure of the systems in which they are installed.

Instruments to be industrial quality.

3.40.5 PRODUCTS

A. THERMOMETERS AND TEMPERATURE WELLS

Provide duct thermometers of the dial face type, 3 ½ “(90mm) diameter, liquid-filled with averaging bulb. Accuracy is to be factory calibrated to + 0.5”C, for the average temperature of the system in which it is installed.

Provide pipe insertion thermometers of the 225mm mercury red reading scale, separable socket, and adjustable angle with brass stem.

Provide the following socket lengths:

Pipe Size Inch/Millimetres	Insertion Inches	Length Millimetres
4' and 5" (100 and 125 mm)	2 ½”	(65)
6' and 8" (150 and 200 mm)	5"	(125)
10" (250 mm)	7"	(175)

Provide thermometers with ranges as follows:

Condenser Water Systems: 0-160º F(-18 TO 71.1ºC)

Acceptable Manufacturers or equivalent

Trerice

Wechsler

Ashcroft

Weiss

B. PRESSURE GAUGES

Provide gauges of the bourdon tube type with minimum 115mm dial and die cast aluminium case with black enable finish. The movement to be all stainless steel with Grade a phosphor bronze bourdon tube brazed at socket and tip. Provide accuracy of the gauge within ½ % of the scale range. The pointer will be the micrometer adjustment type re-calibrated from the front.

Acceptable Manufacturers or equivalent

Trerice

Wechsler

Ashcroft

Weiss

C. TEST PLUGS

Provide test plugs 12.5mm NPT made of brass with Nortel core. In addition, supply six (6) kits consisting of 6mm NPT pressure gauge, gauge adapter with 3mm probe and protecting shield, bi-metal thermometer range 25 deg. To 125 deg. F (-3.9 to 51.7 deg. C) with 5" (125MM) stem and 1-3/4" (55mm) diameter dial, bi-metal thermometer range 200 to 240º F (-6.7 TO 116"C) with 5" (125mm) stem and 1-3/4" diameter dial. Each kit to be provided in an impact resistant carrying case.

Acceptable Manufacturers or equivalent

Tretice

Emst

Wechsler

3.40.6 EXECUTION

Provide pipe thermometers and thermometer wells in the inlet and outlet at each of the following locations:
Water Chillers

Air Handling and Fan Coil Units

Where shown on the Contract Documents.

END OF SECTION - 15010

SECTION 15060

HANGERS AND SUPPORTS

PART 1 - GENERAL

A. Provide structural pipe support including supplemental steel channels, angles, columns, etc., necessary to complete the installation. The provision of structural supports over and above that required for the building structure is the responsibility of this section.

B. Horizontal overhead pipes shall be supported by approved pipe hangers, spaced approximately 2.5 meter apart. In all cases, spacing of hangers shall be such as to prevent sagging or the forming of pockets in the piping. Hangers shall not pass through ducts.

C. Vertical piping shall be supported by a pipe hanger within 30 centimeter of elbow.

D. Place piping in proper alignment and position prior to connection to anchors, expansion loops joints and equipment. Furnish jacking devices, temporary steel structure members and assembles structures as necessary. Remove temporary equipment and structures at the completion of the work.

E. Reinforce piping at anchor points.

F. All hangers, rods, and associated components shall be hot dipped galvanized steel. No piping shall be permanently supported by any wire, rope, wood, or other makeshift device.

G. Base flanges shall not be bolted to floor where cement coat waterproofing occurs or where membrane waterproofing would be punctured by bolt.

H. Underground piping shall be laid on solid undisturbed ground, except where crossing another trench or excavation adjacent to a building wall or foundation, and there piping shall be supported on approved foundations of concrete or brick piers or cradles as directed.

I. The Sub-contractor shall adequately support and protect underground piping so that it shall remain in place without settling and without damage during and from backfilling. Any piping so settling or so damaged shall be replaced by the Sub-contractor without cost to the Sub-contract.

K. Where piping near floor is supported from the floor, such supports shall be of pipe standards with base flange and adjustable top yoke.

L. Where piping is run above the floor and is not hung from the ceiling construction or supported from the floor, such piping shall be supported from the wall with J-hook hangers, expansion bolted to the wall.

M. Provide approved steel pipe covering protection saddles for all insulated pipes, spot welded to pipes ∅ 65mm and larger. Pipe shall be supported with load bearing calcium silicate insulation.

N. Provide all necessary support steel for installation of pipe hangers and supports.

O. Pipe supports shall accommodate spring isolation hangers as indicated in Section “Vibration

1.1 Reference

Conform to General Requirements for Mechanical Services of Division Fifteen.

1.2 Description of Work

1.2.1 This Section includes piping supports complete for all piping systems except as otherwise specified.

1.3 Quality Control

Reference Standards.

a) British Heating & Ventilating Contractors Association recommendations.

b) Relevant British Standards.
BS 3974 Specification for pipe supports

1.4 Submittals

a) All materials submittals shall include a detailed, clause-wise, compliance statement.

b) All materials submittals shall include detailed catalogues, product literature and descriptions of all equipment and fittings with selection charts, capacities etc.

c) All material submittals shall include copies of relevant standards.

d) Provide detailed shop drawings of the items of equipment being provided, indicating the dimensions, materials and characteristics.

e) Materials selection data to be submitted.

f) Shop drawings to include typical details for both vertical and horizontal pipe work including locations.

g) Contractor to submit details and calculations of how proposed loads can be safely accommodated by the structure.

2.0 PRODUCTS

2.1 Materials

2.1.1 All hangers, supports, anchors, and guides shall be in accordance with the British Standard BS 3974.

2.1.2 Dielectric Protection. Furnish acceptable protection or copper plated hangers between ferrous and nonferrous metal pipe and hangers on all water piping.

2.1.3 Horizontal Piping Hangers

Provide one of the following types of hangers for horizontal piping manufactured by one of the approved makes.

All Pipe Except Copper:

a) Provide clevis type supports. Keep the clevis nut outside the insulation.

b) Where pipe exceeds maximum loading recommended for clevis type hangers, furnish steel pipe clamps.

c) For pipes 200 mm and larger, and where provision for expansion and contraction is required, provide single pipe-roll support with two rods and adjustable sockets, or for pipe 300 mm and smaller, adjustable swivel pipe-roll with one rod.

d) Provide trapeze hangers where several pipes can be installed parallel and at the same level, and fabricate from structural steel shapes. Use roller chairs or pipe-roll stands where provision for expansion is required.

   i) Spacing shall not be farther than the closest interval required for any size pipe supported thereby, or as necessary to prevent damage or failure to the structure.

   ii) Where there is doubt of the structural capacity for concentrated loads necessary structural calculations shall be carried out and the load distributed sufficiently.

e) Copper Tubing Support.

   i) Hangers Touching Pipe; provide copper plated, split-ring extension hanger.

   Hangers on Outside of Insulation; furnish same as specified for steel pipe.

f) Floor Supports: Provide one of the following means of supporting horizontal piping from floor:

   Where bottom of piping is less than 450 mm above finished floor, furnish cast-iron pipe rests with pipe nipples to suit. Fasten to floor.

   Contractor to fabricate galvanised steel frame to suit the site conditions to the approval of the Engineer.

   g) Wall Supports. Provide one of the following means of supporting horizontal piping from wall:

Furnish steel J-hook for pipe located close to wall (up to 80 mm pipe).

For hanger suspension with 280 kg maximum loading furnish light welded-steel bracket with hole for one rod, 19 mm diameter.

For pipe-roll stand support, furnish welded-steel brackets.

The dimensions of steel members to be used for brackets shall be suitable for the supported load and to Engineer’s approval.

2.1.4 Vertical Piping Supports

a) All Pipe Except Copper:

Vertical pipe supports shall be steel extension pipe-clamps. Manufacturer's rated maximum loading for each size pipe shall be used (with minimum 50% safety factor) for spacing of supports. Bolt clamp securely to pipe, reset clamp-end extension on building structure.

b) Copper Tubing Support.

For un-insulated vertical lines, provide copper finished steel riser clamp or plastic coated steel riser clamp.

2.1.5 Beam Clamps

a) Non-"C-Style" beam clamps shall be malleable iron for 9.5 mm hanger rods, forged-steel for hanger rod up to 38mm.

b) "C-Style" beam clamps shall be adjustable hanger rod type, malleable iron with set screw, jam nut, retaining clip, FM and UL approved.

c) Where beam configuration does not allow horizontal movement of C-clamp when set screw and jam nut are positioned, retaining clips may be omitted.

2.1.6 Inserts and Expansion Bolts

a) Furnish and set inserts in concrete forms. Provide reinforcing rods for pipe sizes over 80 mm or equivalent.

b) Concrete inserts shall be as follows: Black malleable iron universal type for threaded connections with lateral adjustment for pipe sizes up to 200mm.

c) For pipes 200 mm and over or equivalent group of pipes on trapeze, use two or more inserts to prevent exceeding maximum loading.

d) As an alternative to the above mentioned inserts the Contractor may use expansion bolts. If the Contractor uses expansion bolts, the maximum spacing between supports may need to be reduced so as not to exceed the maximum loading and the expansion bolt locations shall be determined in coordination with the structural elements.

2.1.7 Shields

Provide shields where required, to protect insulation at areas of contact with hangers and supports.

2.1.8 Support Insulators

The Contractor shall provide moulded hard rubber insulators at all supports of insulated pipework to transmit pipe load to hangers (or supports) without crushing the insulation. The rubber density shall not be less than 1100 kg/m3 and operating temperature range shall be -20 deg C to 110 deg C. The thickness of insulators shall be same as the insulation, and vapour barrier (where specified) shall be continuous across the outside of the insulators.

2.1.9 Manufacturer

All supports and clamps shall be from one of the approved manufacturers as listed in Annex “G” of Volume 2 of Contract Documents.

2.1.10 All supports, clamps or frames shall be protected against corrosion by either galvanizing or two coats of suitable primer with two coats of approved epoxy paint. Supports/clamps or frames used outside the building shall be galvanized.

3.0 EXECUTION

3.1 Installation / Application / Performance / Erection

Provide hangers to support the required loads. Where necessary, supports shall be designed to permit movement due to expansion and contraction.

Support piping with hangers in direct contact with the pipe for insulated piping not requiring a vapor barrier. Size hangers to fit on the outside of insulation requiring a vapor barrier.

Hang pipe from substantial building structure. Piping shall not be hung from other piping. All rigid hangers shall provide a means of vertical adjustment after erection. Do not suspend pipe from metal roof deck.

“C” clamps shall be installed as per manufacturer's recommendations.

Where noninsulated pipes, in which vibration may occur, pass through walls, floors, or partitions, encase pipe within acoustical wall sleeves.

3.2 Horizontal Piping Support Schedule

3.2.1 Support horizontal piping on threaded, galvanised, hot rolled steel rod hangers. Threaded rod shall not be smaller than hanger thread size. Where proprietary hangers are being used, the threaded rod size shall be as required for the hanger. The maximum spacing shall be based on the load carrying capacity of the hanger, after allowing a safety factory of 50% on the insulated full pipe weights.

3.2.2 Steel Pipe

Maximum Spacing between Single Pipe Supports:

Nominal Pipe Size, mm												
15	20	25	32	40	50	65	80	100	125	150	200	250
Maximum Span Meters												
1.5	1.8	2.1	2.1	2.7	3.0	3.4	3.7	4.3	4.9	5.1	5.8	6.1
Minimum Rod Diameter, Millimeters												
6.4	6.4	9.5	9.5	9.5	95	13	13	16	16	16	19	24

3.2.3 Copper Tubing

Maximum Spacing between Single Pipe Supports:

Nominal Pipe Size, mm									
15	20	25	32	40	50	65	80	100	150
Maximum Span Meters									
1.5	1.8	2.1	2.4	2.4	2.7	3.0	3.7	4.2	

Furnish minimum rod diameters as specified for steel pipe.

3.2.4 Support steel piping 300 mm and larger at 6 m intervals or less to ensure even distribution of loading on structural members.

3.2.5 The spacing specified herein is included to limit deflection in the pipe to an acceptable minimum. Shorten intervals as necessary so as not to exceed the support manufacturer's maximum recommended safe load values in accordance with BS 3974.

3.2.6 Cast iron pipe shall be, as a minimum, supported at each hub.

3.2.7 Trapeze Hanger. Spacing shall not be farther than the closest interval required for any size pipe supported thereby, or as necessary to prevent damage or failure to the structure. Provide additional framing as required to transfer loads to adequate structure.

3.2.8 Supporting rods over 450 mm long shall be braced at every fourth hanger with diagonal bracing attached to the structure.

3.2.9 The Contractor shall select support distances such that the pre cast structure is not subjected to excessive point loads. The contractor will be required to submit calculations to demonstrate that the proposed loads can be safely supported from the structure.

3.3 Vertical Piping Support

Support vertical piping with wrought steel riser clamps. Make adequate provision for expansion, contraction, and lateral stability by using expansion joints. Also, account for vertical expansion and lateral movement of the building structures.

Support steel pipe at a minimum of every floor as required to relieve joint stresses.

END OF SECTION - 15060

SECTION 15100

VALVES

PART 1 – GENERAL

1.1 Work Included

Provide valves in accordance with the Contract Documents.

1.2 Submittals

In accordance with the Conditions of Contract, and as specified herein:

Shop Drawings and Product Data

Furnish shop drawings, product data and samples (when requested) for all valves.

Submit all valve flow rate versus pressure drop (CV) data.

Valve List: Figure numbers and catalogue cuts of proposed valves.

Product Data: Manufacturer's Latest Published data for materials, intended service and installation.

1.3 Quality Assurance

Valves and valve construction to be suitable for the pressure, temperature, and fluid quality of the service in which they are to be used.

All valves to be in accordance with ANSI, AWWA, ASTM, MSS-SP-70 & 80 Manufacturers Standardization, Society), and ASME standards and specifications.

Minimum test pressure for all valves to be 1.5 times maximum system working pressure unless noted otherwise.

Provide butterfly valves suitable for dead end service and constructed of high quality industrial design.

All gate, globe and angle valves shall be designed for repacking under pressure when fully opened and shall be equipped with packing suitable for intended service. When valve is fully opened, back seat shall protect the packing and stem threads from fluid.

Bronze gate, globe, and angle and check valves shall conform to BS 5154.

Pressure containing parts of valves shall be of material conforming to BS 5150 PN16 & PN25.

Gate valves shall conform to BS 5150.

Valve stems shall be copper silicon alloy conforming to BS 2874.

Wheel handles shall be non-heating style cast from malleable iron or commercial aluminium.

Check valves shall operate equally well in horizontal or vertical positions.
Double regulating valves shall conform to the requirements of BS 7350.

All valves shall be full line size.

1.4 Reference Standards

BS 759:	Valves, mountings and fittings
BS 1010:	Draw off tap sand stop valves for water services (screw down pattern)
BS 1010:	Draw off taps and aboveground stop valves.
BS 1212:	Float operated valves (excluding floats).
BS 1212:	Piston type
BS 1212:	Diaphragm type (brass body)
BS 1212:	Diaphragm type (plastics body)
BS 1503:	Steel forgings for pressure purposes.
BS 1968:	Floats for ball valves (copper).
BS 2456:	Floats (plastic) for ball valves for hot and coldwater.
BS 2767:	Manually operated copper alloy valves for radiators.
BS 2879:	Draining taps (screw down pattern).
BS 5150:	Cast iron wedge and double disc gate valve for general purpose.
BS 5151:	Cast iron gate (parallel slide) valves for general purposes.
BS 5152:	Cast iron globe and globe stop and check valves for general purposes.
BS 5153:	Cast iron check valves for general purposes.
BS 5154:	Copper alloy globe, globe stop and check, check and gate valves.
BS 5156:	Diaphragm valves.
BS 5157:	Steel gate (parallel slide) valves for general purposes.
BS 5158:	Cast iron plug valves.
BS 5159:	Cast iron and carbon steel ball valves for general purposes.
BS 5160:	Steel globe valves, globe stop and check valves and lift type check valves.
BS 5163:	Predominantly key-operated cast iron gate valves for water works purposes.
BS 5235:	Dial-type expansion thermometers.
BS 5353:	Steel plug valves.
BS 5433:	Underground stop valves for water services.
BS 6683:	Guide to installation and use of valves.
BS 6755:	Testing of valves.
BS 6759:	Safety valves.
BS 7350:	Double regulating globe valves and flow measurement devices for heating and chilled water systems.
BS 7478:	Guide to selection and use of thermostatic radiator valves.
BS EN 593:	Industrial valves – metallic, butterfly valves.
BS EN 837:	Pressure gauges.
BS EN 837-1:	Bourdon tube pressure gauges - dimensions, metrology, requirements and testing.
BS EN 1982:	Copper and Copper alloy-ingots and castings.
BS EN 10213:	Technical delivery conditions for steel castings for pressure purposes.

PART 2 – PRODUCTS

2.1 General

Valves for similar service: Of one manufacturer.

All valves shall be products regularly produced for the specified service and rating in accordance with the manufacturer’s catalogue and engineering data.

For flanged valves, provide companion flanges of same pressure rating-class of valve being used.

Provide valves rated at the specified working pressure unless indicated otherwise.

Provide valve materials suitable for service and temperature of respective systems, especially with respect to discs, plugs, balls, linings, gaskets (non-asbestos containing), and lubricants of globes valves, plug cocks, ball valves, etc.

Provide composition discs for bronze globes, angles or checks. Provide bronze discs for iron body brass mounted globes, angles, or checks except where otherwise specified or approved at recommendation of the manufacturer.

Valves, except check valves, shall be capable of being packed under pressure when wide open by means of bevelled back seat and bonnet.

All gate and globe valves shall have four sided stem to hand-wheel connection with self-locking unit.

Valves 150 mm and larger to be mounted seven 2 m above the floor or higher, in areas without ceiling, shall be provided with chain wheel operators.

Wheel handles to be non-heating style cast from malleable iron ASTM A197.

Mark each valve at the factory with the following minimum information, engraved, stamped or cast on each valve or metal tag permanently attached to the valve.

Manufacturer's Name.

Catalogue or Figure Number.

Size and Pressure Class.

Arrows shall indicate direction of flow on check, globe, angle, non-return and eccentric plug valves.

UL approved valves shall bear the UL label.

All valves shall have known flow rate versus pressure drop characteristics gained for laboratory testing.
Provide valves with manufacturer's name and pressure rating clearly marked on the outside of body.

Provide valves suitable for connection to adjoining piping as specified for pipe joints.

All valves to be full pipe size unless noted otherwise.

Provide all valves used for future connection with lockable handles.

All valves 50 mm and smaller shall be threaded and have bronze bodies.

All valves 65 mm and larger shall be Iron Body Bronze Mounted (IBBM) type, i.e. with bronze trim, and shall be flanged (or grooved for grooved coupling joints).

All valves 100 mm and larger mounted in excess of 2.15 m above the floor in mechanical rooms shall be equipped with chain operators. Extend chains to within 2 m of floor.

2.2 Double Regulating Valves

2.2.1 Size 50mm and smaller

Furnish bronze double regulating valve designed for minimum PN20. parabolic and slotted disk double regulating device. Screwed bonnet, rising stem, hand wheel operated with micrometer style indicator.

2.2.2 Size 65mm and larger

Furnish cast iron double regulating valve for minimum PN16. Fitted with EPDM coated regulating disk, double regulating device and indicator, flanged to BS 4504 PN16. Inside screw, non-rising copper alloy stem, back seating feature.

2.2.3 Commissioning sets shall comprise a metering station and a close coupled double regulating valve. The metering station, containing an orifice shall be fitted with test points so that the pressure drop across the orifice can be measured. The commissioning set shall provide ±5% accuracy and should be installed with a minimum of 5 times pipe diameter uninterrupted upstream length of straight pipe.

2.3 Pressure Reducing Valves

2.3.1 Domestic Water Lines

Pressure reducing valves shall be pilot controlled, hydraulically operated, diaphragm type with a low by-pass capability. The low-flow by-pass capability shall be achieved by using a balanced direct acting PRV as an integral part of the main valve. At very low flows when the main valve is almost completely closed, to percent the possibility of cavitations the direct acting valve shall by-pass the main valve and maintain flow.

PRVs shall be bronze construction including the trim. The pressure reducing valves shall be suitable for maximum working pressure that exist within the system and downstream pressure should be site adjustable between 2 and 4 bar. Refer to Schematic drawings for the minimum locations at which PRV's shall be required.

2.3.2 Fire Protection Services

Where required for installation in the Fire Protection Systems, the PRV shall be direct acting, site adjustable type, of bronze (up to

50mm) or cast iron (65mm and larger) construction. The PRV shall be UL listed and FM approved.

2.4 Solenoid Valves

2.4.1 Electrically operated solenoid valves shall be single phase 220V and shall be rated for the system pressure.

2.5 Gate Valves

All gate valves within the building shall be solid wedge type or split wedge type for 100 mm and larger. Gate valves shall be provided with painted iron wheel handles, with gland followers in stuffing boxes and shall be constructed so that they may be repacked while open and under pressure.

All gate valves 50 mm and smaller shall be bronze body and wedge, with soldered brazed or threaded ends as specified and as required by the piping system in which they are installed. Valves shall be of the rising stem type and provided with a union bonnet.

All gate valves larger than 50 mm shall be iron body with bronze or iron mounting and shall be provided with flanges ends as required by the piping system in which they are to be installed. Valves serving steam systems and all valves in mechanical rooms shall be of the outside screw and yoke type. Valves for other services and other locations can be of the no-rising stem type. All cast iron gate valves shall be provided with a bolted bonnet.

Provide the following gate valve accessories:

- Position indicators for non-rising stem valves on valve sizes larger than 50 mm.
- Provide clean outs on valves used in condenser water systems.
- For valves without full access provide extension stems to allow operation.
- Provide floor stands/operators for all valves where indicated on the drawings.
- Provide operating nuts and wrenches for all valves shown on the drawings as being lock-shield valves. Provide similar operating nuts for all valves.
- Provide gearing with protective cover on valve sizes 150 mm and greater.

Gate valves to be back seating and suitable for re-packing under pressure. Packing to be non-asbestos.

2.6 Lubricated Plug Valves

Use for throttling in water service 2½" (65mm) and larger.

Provide valves of the lubricated bolted bonnet type with resilient faced plugs suitable for water systems.

Provide port area of valves through 20" (500mm) at least 80% of full pipe area.

Valve bodies of ASTM A126 Class B semi-steel with corrosion resistant seats of 90% nickel overlay.

Furnish valves with replaceable, sleeve-type springs, washers, etc., zinc plated.

Valves through 6" (150mm) provided with an adjustable open position memory stop and level. Valves 8” (150mm) and larger equipped with a totally enclosed worm and gear operator with hand wheel and a "memory stop".

2.7 Butterfly Valves/High Performance Butterfly Valves

Provide lug style butterfly valves. Provide balancing stop on at least one valve per equipment connection and as necessary for balancing services. When manufacturer requires, valves must be installed in proper direction for shut-off and dead end service.

Butterfly valves shall be High Performance valves manufactured of carbon steel body, threaded-lug with reinforced Teflon seats, 316 stainless disc and stainless stem.

If valves are used for fuel oil, provide reinforced Teflon seats and 316 stainless disks.

Butterfly valves for bubble tight dead end shut-off shall be capable of remaining in service with downstream piping removed.

Provide the following butterfly valve accessories.

- Valves 150 mm or larger shall have gear operator with crank handle or hand wheel.
- Valves smaller than 150 mm shall have seven position lever.
- Where valves are located 2 m above floor level in equipment rooms provide chain wheel operators and chains.
- Provide a position indicator on all butterfly valves.
- For valves without full access provide enclosed extension stems to allow operation.
- Provide memory stops for valves used on balancing.
- Provide a padlock flange.

Use for stop and isolation in water systems up to and pipe sizes 65mm and larger.

Butterfly valves to have ductile iron lug body, 316 stainless steel stem with bronze bushings and aluminium bronze disc.

The stem journals will be a multiple seal design providing for completely independent seals. The stem disc assembly will be such that the need for pins, screws or bolts is not required. Positive stem retention to be provided to permit removal of handle or actuator while under full operating pressure.

The valve seats to consist of replaceable resilient elastomer.

Valves to size 150mm to be supplied with multi-position handles; size 200mm and over to be supplied with enclosed worm gear operator.

Valve body to be full-tug pattern to comply with MSS-SP-67 and be compatible with ANSI pattern flanges of appropriates pressure rating.

2.8 High Performance Butterfly Valves

Use for stop and isolation in water systems pipe sizes 21/2" (65mm) and larger.

Butterfly valves to have steel full-logged body, one-piece 316 stainless steel stem with bronze bushings and 316 stainless discs with chrome plated seating edge. Drive end of shaft to be squared to provide positive actuator connection.

The stem journals will be a multiple seal design providing for completely independent seals. Positive stem retention to be provided using solid type 316 stainless steel keys locked in place, to permit removal of handle or actuator while under full operating pressure.

Design discs with a concave face to reduce dynamic torque, decrease turbulence and maximize flow capacity.

Provide Disc-to shaft pins of stainless steel and of the tangential or compressive type. Pins shall be subject to compression forces only, no shear forces.

The valve seats to consist of replaceable PTFE seating surface with a titanium retaining ring.

Shaft bearings to be of reinforced PTFE and thrust bearing to be a combination of reinforced PTFE with 316 stainless steel.

Provide packing of multiple PTFE V-ring design with adjustable gland follower and 316 stainless gleans.

Valves to size 6" (150mm) to be supplied with multi-position handles; size 8" (200mm) and over to be supplied with enclosed worm gear operator.

Valve body to be full-tug pattern to comply with MSS-SP-67 and be compatible with ANSI pattern flanges of appropriates pressure rating.

2.9 Ball Valves

Provide full port ball valves with reinforced (glass filled) Teflon seats, seals, bearings and packing. Provide balancing stop on at least one valve per equipment connection and as necessary for balancing service. Valves on insulated piping shall have 50 mm extended stems. All ball valves shall have locking handles to allow servicing and removal of equipment.

Provide lever handle with plastic sleeve on all ball valves unless otherwise noted. Provide extension stem for all ball valves to be installed on insulated piping.

Provide soldered or threaded ends on all valves in equipment rooms and risers.

Provide memory stops on valves used for balancing.

Use for stop, isolation and as drain valves, in water systems up to 100OC and pipe sizes to 80mm.

Provide ball valves of the bronze top-entry body type, having a straight through full port flow passage. Design to permit disassembly without removing body from line.

Construct seats and all gland packing of Teflon. Lever handles to be vinyl concerned. Body to be 2-piece screwed end for steel piping and sweated end for copper piping.

Provide lever for quarter turn operation; lever to indicate open or closed position.

When used as drain valves, provide with hose thread and brass cap with chain. Cap to be rated for full system pressure.

2.10 High Performance Ball Valves

Use for stop, isolation and as drain valves, in water systems and pipe sizes to 3" (80mm).

Provide high performance ball valves of the stainless steel top-entry body type, having a straight-through full port flow passage. Design to permit disassembly without removing body from line. Body to big 2 piece screwed end.

Shafts to be constructed of 316 stainless steel with satellite-surfaced bearing areas. Shaft bearing to be ceramic filled TFE.

Construct seats of satellite faced 316 stainless steel and all gland packing of ceramic filled multiple V-ring TFE.

Provide lever for quarter turn operation; lever to be vinyl covered and indicate open or closed position.

When used as drain valves, provide with hose thread and brass cap with chain. Cap to be rated for full system pressure.

2.11 Globe Valves

All globe valves 50 mm and smaller shall be bronze body with soldered, brazed or threaded ends and as required by the piping system in which they are installed. Threaded ends shall be used on all valves in equipment rooms and risers. Provide with union bonnet.

All globe valves 65 mm and larger shall be cast iron body with bronze mounting except where otherwise required by local Authorities having jurisdiction and shall be provided with flanged ends as required by the piping system in which they are to be installed. Provide bolted bonnet.

Provide operating nuts and wrenches for all valves shown on the drawings as being lockshield valves.

Do not provide pressure tappings in globe valves for throttling applications

Globe valves to be suitable for re-packing under pressure. Packing to be non-asbestos.

2.12 Check Valves

All check valves 50mm and smaller shall be bronze body and disc, regrinding, threaded ends or as indicated in the valve schedules and as required by the piping system in which they are installed. Provide threaded cap.

All check valves 65mm and larger shall be cast iron body with bronze, brass and stainless steel trim and shall be flanged end as required by the piping system in which they are installed. Provide bolted cap and weighted lever for adjustment.

All check valves shall be spring loaded, silent or non-slam type. Swing type not permitted.

Silent Type: Use on pumps and where indicated on drawings. Valves to have cast iron body with bronze or stainless steel trim and to be of the center guide type, with flanged end.

2.13 Safety and Relief Valves

All safety and relief valves to be constructed and rated in accordance with ASME, and so stamped.

Use “pressure relief valves” for unheated liquids.

Use “safety relief valves” for heated liquids, including water boilers, etc.

Valves suitable and rated for proper temperatures; for "safety relief valves" minimum temperature rating is saturated steam temperature corresponding to pressure 10 percent higher than valve set pressure.

Valves shall have set pressure indicated on Drawings but not more than working pressure of protected equipment.

Valves shall open, under test, at set pressure, with tolerance of plus or minus 3% of set pressure.

Valves shall have capacity to relieve maximum possible generated energy while maintaining pressure in protected equipment at no more than 10 percent above vessel working pressure.

Provide multiple valves if required for capacity even though only one valve may be shown on Drawings.

2.14 Strainers

Strainers shall be full size of entering pipe size.

Pump start up strainer screens shall be used for cleaning and removed afterwards. 0.8mm perforation for size 15mm to 50mm. 1.4mm perforation stainless steel screen for above 65mm.

Provide blow-off valve on each strainer.

For clean steam and clean steam condensate, provide stainless steel.

2.15 Automatic Air Vent

Automatic air vent cocks of adequate size shall be provided at all high points on water pipe work risers or along pipeline where air lock is deemed possible.

Where such points are inaccessible, air bottles shall be provided with the vent pipe turned over and carried down to a point 1,200mm above floor level, terminating in with a vent cock.

Automatic air vents shall have gunmetal or brass body, non-ferrous or stainless steel floats and guides and non-corrodible valve seats.

Each valve shall incorporate a lockshield and the discharge pipe shall be run to the nearest agreed drain point.

2.16 Balancing Valve

Balancing valves shall be of double regulating type and shall be installed as shown on the Drawings or as required for proper balancing of the water distribution system.

For size up to 50mm, disc bonnet and body shall be of gunmetal construction. Seats rings shall be carbon filled TFE. Valve stem shall be stainless steel. Valves shall be screwed end connection to BS 21.

For size above 50mm, bonnet and body shall be of cast iron construction of high quality to BS 1452 Grade 220 or cast steel construction of high quality to BS 1504-161 Grade 480 to suit the actual working pressure of the system. Cast iron disc with bronze trim and stainless steel stem. Valve shall have flanged end to BS 4504 PN16 or PN25 in accordance with the specified and expected working pressure.

Valves shall have memory stop feature to allow valve to be closed for service and re-opened to original set position.

Precise double regulation with indicator. Pressure and water flow relationship at different pre-set graduation shall be read off from certified flow charts. Once set, the position of the regulation shall be tamper proof.

Valves shall be complete with facilities for flow measurement, regulation and isolation.

Flow measurement accuracy shall be within ±5% across complete range of flow rates from 10% to 100%.

2 sets of flow measurement instruments shall be provided and handed-over to the Employer after completion of the testing and commissioning of the water distribution system.

Valves shall be leak tight at full rated working pressure.

2.17 Automatic Flow Control Valves

Provide automatic pressure-compensating flow control valves as manufactured by Griswold, or as approved, URT Series with extended valve body and dual temperature pressure test ports. Provide performance certification of valves by an independent laboratory to the Engineer.

Valve to be manufactured in one piece and to consist of Ground Joint Union, Flow Control and Test Plugs.

All valves to be factory set to control the flow rate within 4 percent of the selected rating over an operating pressure differential of at least 10 times the minimum required for full flow conditions.

Valves to be brass and stainless steel with threaded or sweat connections.

Provide all valves with unions to allow field exchange of internal components without removing the valve body from the pipeline.

Mark all valves in a permanent manner to show direction of flow and flow rate.

Provide valves rated for a minimum of 350 psi (2415 Kpa), or as necessary to meet the design conditions of the piping system.

Provide Test plugs with dual valve cores for pressure and temperature monitoring.

Confirm the valve design flow, rate by establishing that the pressure drop is within the valves' specified pressure range.

2.18 Solenoid Valves

Electrically operated solenoid valves shall be single phase 220V and shall be rated for the system pressure.

2.19 Bib Taps

Bib-cocks shall be in accordance with BS 1010: 1973. They shall be provided with hose union nosepiece and hand wheel operated.

PART 3 – EXECUTION

3.1 Installation

Furnish and install all the valves shown on the drawings, specified herein, and/or necessary for the control and easy maintenance of all piping and equipment:

Provide valves at points shown and as required for complete isolation of equipment, risers, branches off mains, automatic valves and tanks arranged so as to give complete and regulation control of piping systems throughout the building as shown or as required for proper system operation. Install valves, with neat appearance and grouping, so that all parts are easily accessible for maintenance. Provide isolation valves reasonably required for proper maintenance and isolation even if it is not shown on Drawings.

All AHU's , FCU's and main branches shall have a double regulating balancing valve with self sealing test point for chilled water flow measurement during the balancing and commissioning stage. During commissioning the customer shall have a digital- measuring instrument furnished by the valve manufacturer to translate quickly and accurately the valve pressure drop into the corresponding chilled water flow.

Provide all equipment with shutoff valves. Provide all valve strainers, check valves, except control valves and unless specifically sized, of same size as the pipes in which they are installed unless otherwise indicated. Provide fixture stops.

Install all globe and angle valves to close against the pressure.

Position gate valves so that stems are in any suitable angle from horizontal to upright position. Install valves only in accessible locations. Do not install valves with stems pointing downwards unless specifically indicated.

Wherever possible, install valves accessible from floor level. Provide guided chain operators and chain on valves over 2 m above floor in equipment areas. Provide operating handles for all valves and cocks without integral operators. Provide adequate clearance for easy operation.

Support line valves at the valve in addition to regularly spaced pipe supports shown and specified.

Wye-type Strainers: Ahead of all automatic valves, pumps, coils, pressure regulating valves and similar devices and as shown in systems or required those are not fully protected by automatic strainer systems. Basket-type strainers: where shown or required.

Install strainers in horizontal position.
Provide gate blow-down valves and hose adapters at strainers, air separators, tanks, pipe traps, equipment drains, etc. of same size as strainer blow-off connection.

Install swing checks and gravity closing lift checks in horizontal position.

Provide discharge pipe to atmosphere from all relief and safety valves, sized with area equal to sum of outlet areas of all valves connected thereto, unless indicated larger. Extend to over approved drain receptacle with air gap.

Provide ball valves to isolate shock absorbers.

Provide open-ended line valves with plugs or blind flanges.

Install valves so that they are accessible for re-packing.

Install with stem vertical and handle up wherever possible, never with stem below horizontal position.

Install with operating clearance for handle and stem.

Install isolation valves on equipment so that valve and piping do not interfere with equipment removal or maintenance. Install unions or flanges on equipment side of valves.

Provide 1" (25mm) drain valves with threaded ends for hose connections at drain points, at Main shutoff valves, low points of piping systems, bases of vertical risers, and at equipment.

Provide all valves 8 inches (200mm) and larger having a rating of over 150 lbs. (68Kg) with a 1-inch (25mm) bypass valve of same pressure rating.

Provide required manual or automatic vent valves at high points of piping systems to facilities venting of air and to ensure quiet operation.

Provide renewable bronze seat rings and bronze spindles for cast iron body valves.

Provide chain operated sheaves and chains for all valves which are more than 8 feet (2.44m) above the floor in Mechanical Equipment Rooms.

Furnish and install other valves, check valves, cocks, etc., as required for the complete and proper valuing of the entire installation.

Install butterfly valves in horizontal piping with stem in the horizontal position so that bottom of disk lifts in the direction of flow.

Install butterfly valves in vertical piping at pumps with stem perpendicular to pump shaft.

Properly align piping before installation of valves in an upright position; operators installed below the valves will not be accepted.

Install valves in strict accordance with valve manufacturer's installation recommendations. Do not support weight of piping system on valve ends.
Install all valves with the stem in the upright position. Valves may be installed with the stem in the horizontal position only where space limitations do not allow installation in an upright position or where large valves are provided with chain wheel operators. Where valves 50-65mm and larger are located more than 4m above mechanical room floors, install valve with stem in the horizontal position and provide a chain wheel operator. Valves installed with the stems down, will not be accepted.

Prior to flushing of piping systems, place all valves in the full-open position.

Flanged valves shall be installed between flanges.

Shut-Off Valves

Install shut-off valves at all equipment, at each branch take-off from mains, and at each automatic valve for isolation or repair.

Balancing Valves

Provide balancing valves for all major equipment and at each major branch takeoff and at the discharge of each pump as indicated on drawings and details.

Calibrated Balance valves

Install where indicated on the drawings and details for balancing of hydronic systems.

Drain Valves

Provide drain valves for complete drainage of all systems. Locations of drain valves include low points of piping systems, equipment locations specified or other locations required for drainage of systems.

Safety Relief Valves

Use air pressure to clean piping prior to installation of safety relief valves.

Install relief valves in locations indicated on drawings, downstream of all pressure reducing valves.

Install valves in the vertical position, with drain holes, including those from dip pan elbows, piped to the nearest drain. Inlet and outlet piping connecting to valves must be the same size as valve

Install drip pan elbow as detailed at first vertical rise of the vent pipe. Keep pipe between safety valve and drip pan elbow as short and straight as possible. Support piping and drip pan elbow independently to prevent stress at connections to safety valves. Install vent pipe so that its weight does not rest on the drip pan elbow. Extend drain line from drip pan elbow and relief valve to nearest drain. Pipe discharge from water system relief valves to nearest drain.

Spring Loaded Check Valves

Install a spring loaded check valve in each pump discharge line where two pumps operate in parallel and no combination shutoff, check and balancing valve is being used.

Swing Check Valves

Provide swing check valves where specified, detailed. In such cases, provide isolation valves to allow repair or replacement of check valve.

Combination Shut-Off, Check, and Balancing Valves

Contractor may use combination shut-off, check and balancing valves where separate shut-off valve, check valve, and balancing valve are specified or detailed in pump discharge piping.

Pressure Reducing Valves

Provide gate valve and strainer at inlet. Provide gate valve at outlet. Install pressure gauges to indicate inlet and outlet pressure at each pressure reducing valve.

Use concentric reducers at inlet and outlet of reducing valves where connections are not the same size as adjacent piping.

3.2 Testing

Test valve bonnets for tightness. Test operate valves from closed-to-open-to-closed position while valve is under test pressure.

Test automatic valves including solenoid valves, expansion valves, water regulating valves, pressure reducing valves, pressure relief valves, safety valves and temperature and pressure relief valves for proper operation at settings indicated.

Ensure that valves are field checked for packing and lubricant and that disc is for service intended. Replace leaking packing. Service valves which do not operate smoothly and properly with suitable lubricant before placing in operation.

Test relief valves, safety relief valves, safety valves and temperature and pressure relief valves three times.

END OF SECTION - 15100

SECTION 15120

PIPING SPECIALTIES

PART 1 – GENERAL

1.1 Reference

Conform to General Requirements for Mechanical Services of Division 15.

1.2 Quality Control

1.2.1 Design working pressure to be 16 bar for all pipe work, specialties and equipment unless stated otherwise, Contractor to ensure that all components of pipe work installation are suitable for the working pressure and test pressure to be supplied.

1.2.2 All relevant British Standards.

1.3 Submittals

1.3.1 All materials submittals shall include a detailed, clause-wise, compliance statement.

1.3.2 All materials submittals shall include detailed catalogues, product literature and descriptions of all equipment and fittings with selection charts, capacities etc.

All material submittals shall include copies of relevant standards.

1.3.3 Provide detailed shop drawings of the items of equipment being provided, indicating the dimensions, materials and characteristics.

1.3.4 Materials selection data to be submitted.

1.3.5 Submittals for sample/mock up of pipe work identification required for approval by Engineer.

PART 2 – PRODUCTS

2.1 Air Vents

2.1.1 Air vents shall be installed on all coils and all other high points required for efficient operation and venting of system.

2.1.2 Air vents shall be provided at all high points in the pipework, whether indicated on the drawings or not.

2.1.3 Large diameter automatic air vents shall be provided at all primary venting positions, such as plant rooms and at the head of vertical risers.

2.1.4 Heating and cooling coils on air handling units, fan coils and ductwork systems, in addition to all high points of pipe work which require venting, shall be provided with 6 mm diameter air cocks unless some other form of venting is specified or has been indicated on the drawings.

2.1.5 For coils and similar cased appliances, the air cock shall be located for convenient operation external to the outer casing.

2.1.6 Air bottles shall be provided at all venting points.

2.1.7 Air bottles shall be formed from pipe of equal bore to the pipe being vented and of length equal to the bore plus 150 mm. Each air bottle shall be provided with a 6 mm vent pipe welded into the top and terminating in a conveniently accessible position, approximately 1.600 m above floor level, with a 6 mm lock shield needle valve. The needle valve shall be provided with a 6 mm tailpiece with mitered end.

2.1.8 Each automatic air vent shall be preceded by a lock shield pattern stop valve, and the discharge from the air vent shall be 12 mm copper pipe terminating with an open discharge in a position to be agreed over a conveniently located drain, gulley or sump.

2.1.9 The Subcontractor shall be responsible for the design and positioning of all air vents.

2.1.10 Automatic Vents

For fire protection systems (i.e. sprinklers and wet risers) the vents shall be UL listed/FM approved and approved by the Civil Defense Authority.

Vents on air separators shall be float actuated designed to purge free air from the system and provide positive shut-off at the working pressures kPa at a maximum working temperature. Vents shall be tightly sealed against loss of system water and prevent entrance of air in negative pressure situations. Vents shall be constructed of cast iron and fitted with components of stainless steel, brass, EPDM, and silicone rubber.

2.1.11 Manual Vents

The vents on coils and other mechanical equipment shall be as per approved equipment manufacturer's standards. Only these may be manual type and all other vents shall be automatic.

2.2 Expansion Compensators

2.2.1 Expansion compensators for 75 mm diameter pipe and larger shall be pack less bellow type with equalizing rings, stainless steel bellows, limit stops, internal telescoping sleeves and carbon steel beveled welding ends.

2.2.2 Expansion compensators for 65mm diameter and smaller shall be pack less bellows type with stainless steel bellows, anti-torque device, limit stops, guides and threaded pipe ends.

2.3 Flexible Pipe Connectors

The flexible connector shall be made of multi layer in nylon tire cord fabric reinforcement with EPDM cover and liner. Straight connectors shall have minimum two spheres. Connectors 50mm and smaller may have threaded ends. Larger sizes shall have baked enamel ductile iron floating flanges. There shall be a molded in ductile iron floating flanges. There shall be a molded in ductile iron reinforcing ring.

Standard duty flexible connector shall be rated for 1723 kPa at 76.6oC, and 1130 kPa at 121 oC.

Where flexible connectors are connected to unanchored piping or isolated equipment, provide control cables and rods when pressure exceeds the maximum recommended for this application by the manufacturer.

Flexible hoses shall be stainless steel braid and carbon steel fittings.

2.4 Strainer

2.4.1 Furnish "Y" type strainers throughout the job unless specifically noted otherwise. Furnish one manufacturer throughout Project.

2.4.2 Strainers 50 mm and smaller.

Furnish screwed ends, screwed bronze cap and gasket in sizes 40 mm and smaller and with a bolted cap on 50 mm size. Screens on water service shall be made of Type 304 stainless steel with screen perforation of 0.8mm. Furnish bronze strainers to BS 1400 LG2 in all piping up to 50 mm diameter.

2.4.3 Strainers 65 mm through 300 mm.

Furnish flanged ends, bolted iron cap and gasket cast iron body to BS 1452 GR 220. Screens on water service shall be Type 304 stainless steel with screen perforation of 0.6mm. Strainer shall be rated for PN16 (minimum).

2.5 Unions

2.5.1 All unions in steel pipes shall be minimum 1200 kPa malleable iron, screwed, with brass to iron ground joints.

2.5.2 All unions in copper pipe shall be cast bronze, wrought copper or wrought bronze, with threaded or solder-joint tube ends.

2.6 Pressure Gauges

2.6.1 General

Provide pressure gauges with white dial and black scale, size 115 mm dial. Locate gauges for easy reading. Install gauges as shown and on all pumps. Equip each gauge with an integral or separate siphon and connect by means of a brass rubber pipe and fittings containing a shut-off cock.

2.6.2 Water system pressure gauges shall have a range to cover pumping head as well as static head.

2.7 Thermometers

2.7.1 General

For remote thermometers, see SECTION 16170 BUILDING MANAGEMENT SYSTEM

2.7.2 Thermometers in water systems

Furnish thermometers of the bimetal dial type with brass insert. The case diameter shall be 160mm. Casing and bezel ring made of stainless steel. Window shall be of instrument glass. Thermometers shall be mounted for convenient reading. Install stems longer than pipe diameters in pipe tee. Ranges shall be as follows:

Chilled Water - 0 to 60 degrees C.
Hot Water - 1 to 116 degrees C.

2.8 Thermometer Sockets

Sockets shall be made of Brass with threaded connections suitable for thermometer stems and temperature control sensing elements in pipeline. Furnish with extension necks for insulated piping systems.

2.9 Test Wells

Test wells shall be similar to thermometer sockets except with a brass cap that thread into the inside of the test well to prevent dirt from accumulating. Secure cap to body with a short chain. Furnish with extension necks, where appropriate, to accommodate the pipeline insulation.

2.10 Insulating Couplings (Dielectric Couplings)

Provide at all interconnections between piping systems of dissimilar material and at all connections of piping systems to equipment where piping and equipment are of dissimilar materials the appropriate sizes of insulating couplings. Couplings shall be specifically designed for the purpose of electrically isolating pipelines from other piping systems or equipment.

2.11 Test Plugs

2.11.1 Provide test plugs of solid brass or stainless steel at locations shown on Drawings and as required for the efficient and proper testing and commissioning of the system. Plugs shall be capable of receiving either a temperature probe or pressure probe. Fittings shall have a valve core of neoprene suitable for temperatures to 100 deg C., and shall be rated for zero leakage for highest working pressures of M&P systems.

2.11.2 Provide two (2) test kits each consisting of a minimum 65 mm dial face pressure gauge, with pressure ranges expected within the system; 25 mm dial thermometer, -4 to 52 degrees C.; and a standard gauge adapter all contained within a carrying case. The pressure gauge and thermometers shall be capable of easy recalibration.

2.12 Duplex Filters

Where indicated on drawings install duplex filters complete with cast iron body, quick release cover for ease of basket removal without the need for tools or lifting gear, resilient cover O-seals, multiple light weight baskets for easy manhandling, sliding gate valves with positive compression seating, stepped angle basket seat for positive basket seating, robust basket support cages complete with replaceable mesh insets, external valve position indicators showing which chamber is on stream, replaceable valve seats, synchronized chain drive and external pressure equalizing valve.

2.13 Water Hammer Arrestor

2.13.1 In all open circuit water systems install water hammer arrestors in each branch connection and in particular each vertical branch or pipe run.

2.13.2 Water hammer arrestors shall be with nesting type bellows contained within casing having sufficient displacement volume to dissipate the calculated kinetic energy generated in the piping system. Both casing and bellows shall be constructed of stabilized 18-8 stainless steel.

Water hammer arrestors shall be selected for following conditions.
Maximum working pressure: 125 psi.
Maximum temperature: 300 deg. F.

2.14 Puddle Flanges

2.14.1 Where pipe work passes through the external walls of the buildings or trenches below ground level, the Contractor shall supply and cast or built puddle flanges into the structure.

2.14.2 Puddle flanges are to be manufactured from the same material as the pipework of which they form a part.

2.14.3 Each puddle flange shall comprise a length of pipe, flanged or screwed at end according to diameter with an undrilled slip on flange welded on the outside at a point where it will be located mid way in the thickness of the wall. The puddle flange is to be painted externally with two coats of bituminous paint before being built into the structure.

2.15 Flow Sensing Devices

Contractor shall provide all flow sensing devices as per indicated on the drawings. Proper schedule indicating the flow rate that is to be sensed, the type of flow sensing device, and the permanent pressure loss at the design flow rate shall be submitted for approval of the Engineer.

The flow sensors shall be one of following types:

PITOT TUBE FLOW SENSORS: Multi-port averaging type flow sensor designed to sense the velocity of a fluid flowing in a pipe and produce a pressure output that is proportional to the fluid velocity

VORTEX SHEDDING FLOW SENSORS: Wafer type, unit with an analog output.

2.16 Water Meters

Meters shall meet local regulations and BS and/or ANSI/AWWA Standards.

2.17 Piping Specialities Identification

Refer to Section 15010 Mechanical General Provisions

2.18 Backflow Preventers

2.18.1 Unless otherwise required by BS Standards and Codes, backflow preventers shall be of the double check valve type incorporating resilient elastic and positively tight seals designed to permit water to flow in one direction only.

2.18.2 Backflow preventers shall be suitable for installation in horizontal or vertical position. They shall be pressure rated for 16 bar and BS kitemarked.

Construction shall be:

Body	- Bronze
Check valve	- Brass
Drain valve	- Brass
Seals/Membrance	- Nitrile : NBR Rubber
Springs/bolts/Nuts	- Stainless steel

3.0 EXECUTION

3.1 Preparation

Piping and Fittings. Ream all pipes to full inside diameter after cutting and thoroughly clean before erection.

3.2 Installation/Application/Performance/Erection

General:

Provide valves at each piece of equipment to isolate equipment from its connected system. Locate strainers and valves as necessary to provide easy isolation and cleaning of strainers.
Strainers shall be installed ahead of all automatic valves and elsewhere as indicated on Drawings. Provide a ball valve and 1.5 m of rubber hose in the blow off opening of each strainer.

Unions shall be provided adjacent to each screwed type valve and shall be on the outlet side of the valve.

Install thermometers and gauges for easy reading.

Furnish piping accessories where shown and as necessary for complete installation of Mechanical Work.

3.3 Thermometers

3.3.1 Stem type

Install in piping systems as indicated on the drawings and/or details using a separable socket in each location.

3.3.2 Thermometer Sockets

Install at each point where a thermometer or temperature control sensing element is located in a pipeline.

3.4 Test Wells

Install in piping systems as indicated on the drawings and/or details wherever provisions are needed for inserting a thermometer at a later date.

3.5 Pressure/Temperature Test Plugs

Install in piping systems as indicated on the drawings and/or details. Do not insulate over test plugs.

3.6 Pressure Gauges

Install in locations where indicated on the drawings and/or details, including any gauge piping, with scale range appropriate to the system operating pressures.

3.7 Pressure Snubbers

Install in gauge piping for all gauges used on water services.

3.8 Coil Siphons

Install in gauge piping for all gauges beside vibrating equipment.

3.9 Gauge Valves

Install at each gauge location as close to the main as possible and at each location where a gauge tapping is indicated.

3.10 Expansion Loops

Install where indicated on the drawings or details, locating anchors and guides as detailed.

3.11 Expansion compensators

3.11.1 Provide expansion compensators for the expansion and contraction of all pipes. Install expansion compensators to have sufficient flexibility to prevent end thrust and movements caused by thermal expansion or contraction causing detrimental distortion or damage of connected equipment. Provide offsets between mains and equipment of sufficient length to safely absorb the expansion of the main. Provide guides as necessary.

3.11.2 During operation, the chilled water supply temperature will be 60C. If expansion compensators in chilled water lines are installed at a time when the ambient air temperature is above 300C, they shall be pre-compressed in accordance with manufacturer's installation instructions. Expansion compensator shall have sufficient number of corrugations to absorb the expansion between anchors in the pipe plus not less than 25% safety factor for the temperature range between 40 C to 500 C.

3.11.3 Provide one expansion compensator between every two rigid supports for all chilled water risers. Provide guides at distances of 4 pipe diameters, 14 pipe diameters and at 3 meter intervals after that, from the expansion compensator.

3.11.4 Provide expansion compensator for all pipes crossing building expansion joints.

3.12 Flexible Pipe Connectors

Provide flexible connectors at all air handling units, pumps, and chillers.

Provide flexible hoses for all fan coil units.

Install units as per manufactures printed installation instructions.

Support pipes and equipment such that connector carries no weight.

3.13 Strainers

Install all strainers where required or indicated on the project details, allowing sufficient space for the screens to be removed. Rotate screen retainer where required by the installation so blow down can remove accumulated dirt from the strainer body.

3.14 Backflow Preventer

Provide back flow preventer at connections to all laundry and kitchen equipment, water coolers and as required by BS 6700.

3.15 Air Vents

3.15.1 Manual Key Type Vents

Install at all high points where air may collect and not be carried by the system fluid. Use a soft Type L copper "pigtail" so the vent can be positioned for venting and collecting any water that might escape.

3.15.2 Manual Ball Valve Vents

Install on air handling coils and where indicated elsewhere as shown on drawings and details.

3.15.3 Automatic Vents

Install on the top of air separators on systems using bladder type expansion tanks. Install at other locations as indicated on the drawings or details. All locations to have a ball valve installed upstream of the vent for maintenance purposes.

3.16 Suction Diffusers

3.16.1 Install at each pump suction connection for end suction pumps where shown. Provide sufficient space for removal of the strainer. Install a capped drain valve in the blow down connection. Install support below the suction diffuser so the weight of the suction piping does not rest on the pump suction connection.

3.16.2 Install a pressure gauge across the suction diffuser, valve so that a single gauge can be used to read the inlet pressure and the outlet pressure across the strainer. Use gauge valves as specified with the gauges. This gauge can be the same one used to read pressures across the pump. Select gauge range appropriate to the system pressures.

3.16.3 Open the drain valve and blow down the strainer after system cleaning and again after 30 days of operation. If the unit is furnished with a fine mesh startup strainer, remove this strainer after the system has been flushed and cleaned.

3.17 Flow Sensing Devices

3.17.1 Pitot Tube Flow Sensors:

Install where indicated on the drawings and details for flow sensing in hydronic and/or steam piping systems. Butterfly valves installed at the location of a flow sensing device are to have a memory stop.

3.17.2 Vortex Shedding Flow Sensors:

Install where indicated on the drawings and details for flow sensing in hydronic and/or steam piping systems. Do not install close to elbows, valves, or other piping specialties which might affect the reading of the sensor; follow manufacturer's installation instructions. Butterfly valves installed at the location of a flow sensing device are to have a memory stop.

3.18 Water Meters

Install water meters on makeup water line to hot water and chilled water systems ahead of water pressure reducing valve.

3.19 Drain Points

3.19.1 Adequate provisions shall be made for emptying sections of all services as required for maintenance purposes whether indicated on the drawing or not.

3.19.2 Particular attention shall be paid to the requirements of the Civil Defence and the NFPA regulations with respect to the provision of drain taps on fire service pipework systems.

3.19.3 All cylinders, coils and pumps together with all low points of pipework within plant rooms shall be provided with drain cocks.

3.19.4 All other low points shall be provided with drain taps.

3.19.5 Drain taps shall also be provided on the flow and return of all sub-circuits provided with isolating facilities and shall be located on the isolated side of the valves.

3.19.6 Drain cocks shall be in accordance with BS 2879 : 1980

3.19.7 Schemes involving external distribution mains below ground level are to be provided with ample sized dirt pockets to which the drain cock shall be provided. Underground mains shall be provided with a 54 mm gland cock with hose union outlet at the lowest position for the purpose of flushing out.

3.19.8 The Contractor shall be responsible for the design and positioning of all drain points.

3.20 Testing of Pipe Work and Pipe Work Specialties

3.20.1 Refer to Section 15950 TESTING ADJUSTING AND BALANCING

3.20.2 Unless specifically indicated otherwise, Contractor shall apply following general procedures.

3.20.3 All pipe work shall be tested hydraulically after assembly on site and before any insulation is applied or pipe work made inaccessible by building cladding, to a pressure equal to twice the working pressure. If the working pressure is greater than 600 kPa the test pressure may be one and a half times the working pressure. The minimum test pressure for water pipes shall be 700 kPa.

3.20.4 Hydraulic pressure tests shall be carried out by means of a purpose made test pump, which shall be locked after the desired pressure is obtained.

3.20.5 The test pressure shall be registered at the lowest part of the system being tested and maintained for a period of two hours during which time all parts must remain completely watertight and no pressure loss is indicated on the test gauge. In the case of Fire Mains wet risers and Hose reel supplies, the pressure test shall be maintained for 24 hours. Any leakage must at once be made good and the pressure test repeated until the desired test conditions are maintained. During this period all welds on steel pipe shall be well hammered. Any defects shall be made good and the relevant section shall be re-tested all at the Contractor's expense.

3.20.6 Chillers, Heat exchangers, Water Heaters, Boilers, Cylinders, Pumps and any other ancillary items of equipment which may be liable to damage by the test pressure, shall be isolated or suitably protected during the test, and all necessary precautions shall be taken. Any damaged equipment shall be replaced.

3.20.7 In order not to delay the building operations sections of the pipe work may be pressure tested independently as the work progresses. All necessary plugs, caps or blank flanges shall be provided for testing and these shall be removed after the pressure tests have been approved.

3.20.8 A test certificate shall be issued for each section of the pipe work tested satisfactorily.

3.21 Adjustment and Cleaning

Valves and Specialities

All valves and specialities shall be adjusted to operate smoothly and without binding or leaking. All vents shall be tested and proven to open freely for passage of air.

Locate strainers as necessary to allow easy cleaning.

END OF SECTION - 15120

SECTION 15240

SOUND AND VIBRATION CONTROLS

PART 1 - GENERAL

1.1 Work Included

This purpose section provides for vibration isolation for the "equipment" as listed below. This specification is part of the general conditions for the HVAC Contract.

The work in this section includes the following:

Vibration isolation elements for equipment.
Equipment isolation bases.
Piping flexible connectors.

Comply with SECTION 15010 MECHANICAL GENERAL PROVISIONS and all documents referred to therein.

The contractor shall supply, deliver and install all noise control equipment, for supply and return air ductwork to and from the package units to reduce the airborne equipment noise in all the conditioned areas as stated elsewhere.

The sound attenuators shall in general be constructed from galvanized steel casing with drilled galvanized external flanges of rectangular cross section. The splitter and sidewall linings shall be of resin-bonded mineral wool faced with woven glass fibre material, which prevents the mineral wool being eroded into the air stream. The splitters shall be held in pre-galvanized steel frames. All as specified hereinafter.

Whenever possible, attenuators, to be installed in plant rooms, shall be installed at a point where the distribution duct leaves the areas. Attenuators shall be mounted hard up against the plant room wall to prevent the possibility of high plant room sound pressure levels re-entering the duct system on the 'quiet' side of the silencer. If attenuators cannot be installed in this position, the ductwork on the 'quiet' side of the attenuator shall be lagged externally up to the plant room wall with acoustic insulation to prevent flanking transmission.

Definitions

The term EQUIPMENT will be used throughout this specification. It includes ALL non-structural components within the facility and/or serving this facility, such as equipment located in outbuildings or outside of, the main structure on grade within five feet of the foundation wall. Equipment buried underground are excluded but entry of services through the foundation walls are included.

Below is a partial list equipment for reference, equipment not listed are slag included in this specification.

AC Units		Transformers	Conduit
Air handling		Generators	
Chillers	Ductwork	Piping	
		Pumps (All Types)	
	Fans (All types)	Rooftop Units	Var. freq. Drivers
	Heat Exchangers	Tanks (All types)	

Life Safety Systems Defined

All systems involved with fire protection including sprinkler piping, fire pumps, hockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems.

All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all circuits to fire protection, smoke evacuation and/or emergency lighting systems.

All medical and life support systems.

Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.

Provide all labour, materials, products, equipment and services to supply and install the sound and vibration control devices indicated on the Drawings and specified in this Section of the Specification and in the Particular Specification.

Retain the services of an independent Acoustical Employer's Representative to confirm selections of the noise and vibration attenuating devices. This company shall be independent from the mechanical supplier.

The Sub-Contractor shall commission a full report prior to procurement of the acoustic equipment which addresses the following:

Noise breakout between plant and adjacent spaces

Ambient Noise levels at the specified site boundaries

Schedule of Sound Power levels used to size attenuator
Schedule of Attenuators with tabulated design and actual insertion values

Noise Levels under plant rooms and next to AHU Plant rooms

Confirmation of selection of vibration equipment

Expected room noise levels where fan-coil units are used.

1.2 References

Unless otherwise specified, acoustic and vibration control equipment, material, methods and processes and equipment identification shall be in accordance with the following standards:

BS REF	Title
BS6472	Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)
BS4718	Methods of test for silencer for air distribution
BS4800	Schedule of paint colours for building purposes
ASHRAE	ASHRAE Equipment and Systems hand books
DW/144	Standard for Duct Constructions

1.3 Noise Design Criteria

Adequately isolate all equipment to maintain acceptable noise levels in the occupied areas of the building as specified below. Take measurements over the complete audible frequency in each of the occupied zones, under, above and beside mechanical equipment rooms and where indicated by the Employer's Representative. Submit a report accordingly. Refer to the following acceptable room criteria levels:

	RC (N)
General Office	35
Dining/Banquets	40
Bed rooms	30
Restaurants	40
Corridors	40
Services Cores	40
Commercial Kitchens	45

Where a room is not shown in this table utilize ASHRAE recommendation (lower range).

1.4 Quality Assurance

A. Provide vibration isolation and duct attenuators from a single sound and vibration control manufacturer, whose responsibilities shall include, but not be limited to:

1. Supply of all vibration and sound isolation equipment necessary to meet the performance requirements

2. Coordination throughout the project with all provided equipment to ensure adherence to performance criteria

3. Determination of equipment, pipe and duct mounting arrangements

4. Field supervision and inspection to assure proper installation and performance

5. Allowance for expansion and contraction when selecting and applying isolation materials

6. Coordination of any silencer provisions with sound power levels of fans specified elsewhere in this Specification

B. Ensure the provision of adequate vibration and sound control equipment for all fans, pumps, ducts, pipes, Fan Coil Units, VRV Units and other mechanical equipment.

C. Ensure that no ducts and pipe installation transmits vibration to the walls and floors through which they pass.

D. Provide equipment, pipe and duct mountings non-resonant with equipment operating and building structure natural frequencies.

E. All vibration isolation equipment shall be met the seismic requirements of the installation area.

1.5 Submittal Requirements

A. Submit Shop Drawings of sound and vibration control components including all calculations.

B. Submit Shop Drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, all bases including necessary concrete and steel work and vibration isolation devices, and all required hanger bolts and other appurtenances necessary for proper installation of the equipment.

PART 2 – PRODUCTS (VIBRATION CONTROL)

2.1 General

A. Furnish and install all vibration and noise control devices, materials and related items.

B. Co-ordinate with other trades to avoid through their related activities any rigid contact with the building that will degrade the noise and vibration with 'following-work', such as plastering or electrical, to avoid any contact which would adversely affect the vibration isolation.

C. Provide vibration isolators of the appropriate size and capacity to meet the specified deflection and noise control requirements and shall follow the instructions from the manufacturer or vendor of these products.

D. Vibration isolators shall be produced by a reputable, established manufacturer. A single, approved manufacturer shall supply all vibration isolators.

E. The resonant frequency of the isolation system shall be lower than any operating speed and in no circumstances shall coincide with the natural frequency of any component of the equipment.

F. Vibration systems shall be selected to suit the environment in which the equipment is to be located. For example, weatherproof, non-rusting, etc.

G. All vibration isolators shall have either known un deflected heights or calibration markings so that, after adjustment, when carrying their load, the deflection load can be verified.

H. All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer, and must be linear over a deflection range of not less than 50% above the rated deflection.

I. Overloading of any isolators during installation or servicing shall require isolators to be fitted with overloading restraints.

Overloading of equipment due to service connections shall not occur.

When assessing the values for vibration control of all mechanical plant either in motion or used as carrier the values indicated in the following table shall apply:

Vibration Isolation Efficiencies

Description	Vibration Isolation Efficiency
Pumps <2.2 kw	94%
Pumps > 2.2 – 3.75 kw	96%
Pumps > 3.75 kw	98%
Air Handling Plant	98%
All other Plant	98%

The vibration amplitude:

Shall not exceed curves ‘4’ given in BS6472 “Evaluation of Human Exposure to Vibration in Buildings (1 Hz – 80 Hz)”.

Not of magnitude which causes the noise criteria to be exceeded.

Not having T & R values which exceeds 1% of operating speed or 7.5% of run up speed.

T = Dynamic force transmitted
R = Weights of the rotating equipment

2.2 Spring Isolators

A. Spring type vibration isolators shall preferably be constructed from suitably treated and finished steel or steel alloys. They shall be equipped with 2 layers of neoprene 'acoustic pads' to prevent transmission of high frequencies.

B. Spring type vibration isolators shall be free-standing and laterally stable, without any housing. All mounts shall have levelling bolts. The spring diameter shall not be less than eight-tenths of the compressed height of the spring at rated load and springs shall be capable of 'additional travel to solid' for another 50 percent, as a minimum before becoming fully compressed.

C. Springs shall be selected so that the ratio of horizontal stiffness to vertical stiffness ranges between 0.9 and 1.1.

D. Restrained spring isolators shall have vertical travel limit stops to control extension of the spring when the weight is removed or to provide wind resistance in outdoor locations and to prevent excessive movement as the machine speed passes through the resonant frequency of the mounting system.

E. Where restrained spring isolators are to be used, minimum clearance of 13mm shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stop shall be out of contact during normal operations. Mountings used out of doors shall be painted, hot dipped galvanised or neoprene coated.

F. Spring isolators shall be selected to support the required loads with the specified minimum deflection but not being compressed solid or exceeding the maximum rated capacity of the spring.

G. Weight distribution of equipment, pipes, dynamic load due to fluid flow shall be considered in the spring selection.

2.3 Neoprene “IN-Shear” Isolators

A. The active element of the isolator shall be bonded to mild steel or steel alloy plates, sleeves, pressings or forging. Both element and bonding agent shall be resistant to lubricating oil and water suited to the operating temperature.

B. The location of the fixing bolts shall not be in such a way that creates unnecessary stress in the elements.

C. The dynamic deflection and damping coefficients of the active material, at the operating speed of the supported equipment, shall be used in calculation of isolation efficiencies. Alternatively, certified isolation efficiency charts may be used.

D. Mountings whose stiffness varies with direction of deflection shall be mounted with orientation marks for use during maintenance and installation.

E. Neoprene-in-shear mounts shall only be used where a deflection with less than 8mm is required.

2.4 Vibration Isolation Pads

A. Waffle-pattern or ribbed neoprene pads shall be made of 40 to 50 durometer neoprene. Where required these shall be adhesively cemented to 1.6mm steel plates of similar area so as to form a sandwich.

B. Pads may be bolted through (where necessary) with bolts isolated from the machine by neoprene grommets. Alternatively 'waffled' neoprene pads can be used without holding down bolts where the vibration is minimal and the weight of machine is such that the resultant friction is adequate and the machine unlikely ever to move.

C. The area of pad to be used and number of layers shall be determined for each application in accordance with the manufacturer's recommendations. Where multiple-layer pads are selected to increase the static deflection the layers are to be separated by steel shims as recommended by manufacturers.

2.5 Double Deflection Pads

A. Double deflection pads shall be of 40 to 50 durometer neoprene and sized so that deflections do not exceed 15 percent of the pad's thickness.

B. All metal surfaces shall be neoprene covered to avoid corrosion and have friction pads both top and bottom.

C. Bolting down holes shall be provided for applications where bolting down is required.

2.6 Pipe Hangers and Supports

Piping connected to vibration-isolated equipment shall be installed so that it does not strain or force vibration isolators supporting the basic equipment out of alignment. Pipes shall not restrict such equipment from floating freely on its vibration-isolation system.

Springs in series with neoprene pad hangers shall contain a steel spring that is set in a neoprene cup manufactured with a projecting brushing that passes through the hole in the hanger box or is otherwise isolated from the hanger housing to prevent short-circuiting of the hanger rod against the hanger box.

The neoprene cup should have a steel washer manufactured to distribute the load properly on the neoprene and prevent its extrusion.

Spring diameters and the lower holes of the hanger boxes shall be large enough to permit the hanger rod to swing through a 30°C arc before touching the edge of the hole.

Springs should have a minimum additional travel to solid equal to 50 percent of the rated deflection and diameters equal to no less than eight-tenths of the compressed height of the spring. Minimum deflection shall be 25mm.

All pipe supports shall incorporate a neoprene or felt gasket.

General:

Hanger isolators shall be installed with the hanger box hung as close as possible to the structure (without touching).

Hanger rods shall not short circuit the hanger box.

TYPE L hangers may be substituted for all other hangers listed below.

Ceiling supported piping outside shafts connected to rotating or reciprocating equipment and pressure reducing stations whether the equipment is isolated or not shall be isolated as follows:

Water pipe larger than 50mm shall be hung with TYPE F isolators. The first three supports for piping connected to isolated equipment shall have deflection equal to the equipment isolators up to 50mm deflection; all supports thereafter shall have 19mm deflection isolators.

Floor supported piping outside shafts connected to isolated rotating or reciprocating equipment and pressure reducing stations shall be isolated as follows:

Horizontal floor or roof mounted water piping 32mm to 50mm and all steam piping larger than 25mm shall be hung with TYPE P isolators with 7.5mm deflection.

Water pipe larger than 50mm shall be supported by TYPE B isolators with a minimum of 19mm deflection.

Control air piping and vacuum piping from compressor discharge to receiver shall be suspended by TYPE E isolators with a minimum of 7.5mm deflection or supported by TYPE P isolators with a minimum 7.5mm deflection.

All ductwork over four square feet face area located in the mechanical equipment room(s) shall be supported by TYPE C hangers with a minimum of 19mm deflection.

Emergency generator exhaust shall be isolated with TYPE C isolators with a minimum of 19mm deflection (all neoprene components shall be omitted).

Vertical riser supports for pipe 100mm diameter and larger shall be isolated from the structure using TYPE K guides and anchors.

Install TYPE FC-1 flexible connectors at all connections of pipe to pumps, chillers and other isolated equipment as shown on drawings. Where they are not installed on isolated equipment, insert spool pieces on the equipment side of shutoff valves.

Install FC-2 or 4 type connectors only at locations which exceed temperature limitations of FC-1 or service requires stainless steel or bronze construction flex. (Such as gas, fuel oil, steam or refrigerant).

2.7 Pipe Work General

All supports or hangers horizontally or vertically installed shall incorporate felt or neoprene gaskets of minimum thickness 6mm.

When a pipe passes through the plant room wall, a minimum 25mm clearance shall be provided between the pipe and the penetration in the wall. The pipe shall be supported on either side of the hole, so that the pipe does not rest on the wall. The clearance space shall be stuffed with fibrous fill or material and sealed both sides with non-setting or non-hardening fire stop material.

All piping within plant rooms or other specified areas shall be resiliently supported from the building structure with spring in series with neoprene hanger.

Pipe work connections to pumps shall include minimum 300mm straight flanged sections for insertion of flexible connections at a future date if necessary.

Where pipes pass through cored holes, core diameters to be a maximum of 50mm larger than pipe O.D., including insulation. Cored holes must be packed with resilient material or fire stop as specified in other sections of this specification and/or state and local codes. No additional horizontal seismic bracing is required at these locations.

Non-isolated, constant temperature pipe risers through cored holes require a riser clamp at each floor level on top of the slab attached in a seismically approved manner for vertical restraint.

Non-isolated, constant temperature pipe risers in pipe shafts require structural steel attached in a seismically approved manner at each floor level and a riser clamp at each floor on top of, and fastened to the structural steel. The riser clamp and structural steel must be capable of withstanding all thermal, static and seismic loads.

Isolated and/or variable temperature risers through cored holes required Type K riser resilient Guides and Anchors installed to meet both thermal expansion and seismic acceleration criteria. Each floor level must have either a riser clamp that does not interfere with the thermal expansion/ contraction of the pipe or a riser clamp/cable assembly (also non-interfering) capable of supporting the weight of the pipe between floors in the event of pipe joint failure. Riser guides and anchors must also be selected to serve as seismic restraints.

Isolated and/or variable temperature risers in pipe shafts require Type K resilient riser guides and anchors installed on structural steel to meet both thermal expansion and seismic acceleration criteria. Each floor level must have a riser clamp/cable assembly that does not interfere with the thermal expansion/contraction of the pipe capable of supporting the weight of the pipe between floors in the event of pipe joint failure. Riser guides and anchors must also be selected to serve seismic restraints.

Chimneys, stacks and boiler breeching passing through floors are to be bolted at each floor level or secured above and below each floor with clamps.

Lay-in ceilings in compliance with seismic zone requirements may use earthquake clips or other approved means of positive attachment to secure fixtures such as panel light and diffusers to bar structure.

All non-isolated floor or wall mounted equipment and tanks shall use RESTRAINT TYPE III or V.

Where base anchoring of equipment is insufficient to resist seismic forces, restraint TYPE III shall be located above the unit's center of gravity to suitable resist “G” forces specified.

Vertically mounted tanks and up-blast tubular centrifugal fans tanks, or similar equipment, may require this additional restraint.

Exclusions

Exclusions which DO NOT apply for Life Safety equipment regardless of governing code.

Piping

Fuel oil, gasoline, natural gas, medical gas, compressed air or any piping containing hazardous or corrosive materials 1” nominal diameter and larger.

All piping less than 2-112” diameter.

All clevis or trapeze supported piping suspended by hanger rods less than 12 inches in length (6 inches or less for fire sprinkler piping) with positive attachment to structure.

PVC or Fiberglas suspended waste or vent pipe 150mm diameter or smaller

Ductwork

Smoke evacuation duct or fresh air make-up connected to emergency system. Exclusions for equipment in areas governed by BOCA Code.

Curb mounted mushroom, exhaust and vent fans with curb area less than nine square feet are excluded unless specifically detailed in the schedules or drawings.

Rectangular, Square and Oval air handling ducts less than six square feet in cross sectional area.

Round air handling duct less than 28 inches in diameter.

Duct supported at locations by two rods less than 12 inches in length from the structural support to the structural connection to the ductwork with positive support to the structure.

2.8 Duct Hangers And Supports

A. All ducts between the AHUs, fans and other equipment and the duct flexible connectors shall have resilient mounts having same static deflection as the AHU or fan.

B. Hangers used for vibration control shall consist of spring in series with neoprene.

C. Isolators shall be protected from overloading by external containment or metal to metal restraints. No permanent deformation to the spring shall result under 150 percent of the rated maximum loading.

D. The hanger cage shall be capable of carrying five times the maximum rated normal service load without permanent distortion. The drop rod arrangements shall allow 30° movement without metal to metal contact.

2.9 Flexible Connectors / Expansion Joints

All connectors shall be installed on the equipment side of shutoff valves, horizontal and parallel to equipment shafts whenever possible. Piping shall be supported and/or anchored to resist pipe movement beyond the allowable movement of the flexible connector. The manufacture’s submittal package must detail the design precautions included and/or the installation precautions required.

TYPE FC-1: Elastomer Connector

Manufactured of nylon tyre cord and neoprene, both molded and cured in hydraulic presses.

Straight connectors to have two (2) spheres.
Rated at 14 Bar at, dropping in a straight line to 12 Bar at 1200OC for sizes 40mm to 300mm.

Sizes 250mm & 300mm at 14 bar and greater operating pressure, to employ control rods with neoprene and fittings isolated from anchor plates by means of 15mm bridge bearing neoprene bushings.

Connectors shall be installed pre-extended per manufacturers recommendations to prevent elongation under pressure.

Minimum safety factor of 3:1 at maximum pressure ratings.

Connectors boiled to victaulic type coupling or gate, butterfly or check valves to have, a minimum 15mm flange spacer installed between the connector and the coupling flange

Flexible neoprene connection shall be used on all equipment as indicated on the Drawings or the equipment schedule. They shall be manufactured of multiple ply of nylon type cord fabric and neoprene both bonded and cured in hydraulic rubber presses. Where flexible pipe connections are required, they shall have a length that is approximately 6 to 10 times the diameter. Twin sphere connectors shall be used.

The axis of the connectors shall be perpendicular to the direction of vibration. Alternatively, where the Supervision Employer’s Representative allows, the connectors may be formed into 90° bends.

Where expansion joints are required to achieve vibration isolation, the tie rod system fixings shall be constructed in such a way to prevent metal to metal contact throughout the normal range of movement of the joint.

Where service pipes are joined to equipment incorporating flexible connections the first 3 service supports after the flexible connection shall have vibration isolation mounting with minimum 25mm static deflection or one-half the static deflection of the mounting system used for the equipment whichever is greater.

2.10 Inertia Bases

A. Concrete inertia blocks shall be formed of stone-aggregate concrete (2400kg/m3) cast within a reinforced steel frame made by bolting or welding formed or structural channels or beams. Inertia block shall be reinforced with 12mm diameter steel bars at 150mm centres.

B. Inertia blocks shall have a minimum depth equal to one tenth of the longest dimension of the base but not less than 150mm deep. Minimum 50mm clearance between bottom of inertia block and supporting slab shall be allowed.

C. The weight of the inertia base is to be determined by the inertia base/equipment mass ratio as recommended below:

D. Fans:min. 2 x unit weight
Pumps electric: min. 2 x unit weight

E. Electrical connections to the equipment motors shall be made with long floppy length of flexible cables and piping resiliently supported.

2.11 Equipment Mounting

A. Submit catalogues of proposed equipment complete with manufacturer's specification to the Supervision Employer’s Representative for review.

B. Mechanical equipment with operating weights substantially different from installed weights (such as pumps) and equipment subject to wind loads (such as roof top equipment e.g. cooling towers, chillers) shall be mounted on spring isolators with travel limit stops.

C. The installed and operating heights of the vibration-isolation equipment shall be identical. Maintain a minimum clearance of 10mm around restraining bolts and between the housing and the spring to prevent interference with the spring action. Keep travel limiting stops out of contact with isolator top plate and bolts during normal operation.

D. Unless otherwise specified, all floor-mounted equipment shall be set on concrete plinth.

1. All fans and motors shall be isolated with spring isolators complete with double-layer neoprene pads separated with 1.6mm steel shims.

2. Each AHU shall rest on spring isolators of minimum 25mm static deflection with two layers of 8mm thick neoprene waffle pads. There shall be no significant casing radiation due to such installation. All pipes connected to AHU's shall have flexible pipe connectors.
3. Vibration isolation equipment shall also comply with chiller manufacturer's recommendations.

E. All pipe work between chillers and associated equipment shall be resiliently supported. All water pipes shall be isolated with 13mm thick felt or resilient pads under the pipe strap or clamp. Piping to chiller shall include flexible connectors.

F. Fan coil units shall be suspended with two layers of 8mm thick neoprene hanger. All pipes connected to fan coil units shall be isolated with rubber isolation sleeves.

G. Pumps shall be mounted upon raised concrete plinth (150mm) and incorporating an inertia block 2 times the total weight of pump and motor. System resonant frequency shall be lower than the pump blade passage frequency or motor rpm whichever is lower. In-housed type spring (minimum 50 mm static deflection) in series with 2 layers of 8mm thick neoprene pads shall be used to support the pump and inertia block.

2.12 Other Associated Equipment and Non-Vibration Equipment

A. All other mechanically and electrically associated equipment that is capable of causing undue vibration and noise shall be vibration isolated with 25mm static deflection spring and neoprene 2 layers of isolators.

B. To short-circuit noise and vibration transmitting paths, all non-vibrating equipment shall be isolated with neoprene friction pad.

C. It is the responsibility of the Sub-contractor to include the cost of such work in his Sub-contract price.

PART 3 – PRODUCT (ACOUSTIC REQUIREMENTS)

3.1 General

A. The total noise level arising from all simultaneously operating mechanical and electrical plant as well as regenerated aerodynamic noise, whether it be ductborne, structurally transmitted, or airborne, shall be limited to specified limits.

B. Acoustic treatment shall be applied to all ductwork and equipment by all means such that the noise level is maintained at all times.

C. The noise level shall be measured at 1.5m above the floor level, except next to the AHU room or other plant rooms where the measuring points shall be 1.5m from the room walls.

D. Provide acoustic products of the appropriate size and capacity to meet the dynamic insertion loss and self noise requirements and is required to follow the instructions from the manufacturers or vendors of these products.

E. Acoustic products shall be produced by a reputable, established manufacturer. A single, approved manufacturer shall supply all sound attenuators.

F. All self-noise and dynamic insertion loss data shall be in accordance with the applicable portions of ASTM E477-80 to the latest revision.

G. Unless otherwise specified, perforated galvanised steel sheet shall have 2.4mm diameter holes at 4.8mm staggered centres.

H. Carry out noise level test in the factory or approved testing laboratory for AHU, FCU, fan, VAV terminal according to ASHRAE Standard 36 or BS 4856 Part 4.

3.2 Sound Attenuators

A. All silencers shall be completely pre-fabricated of non combustible materials and shall have a minimum insertion loss to suit equipment and required terminal noise levels.

B. Submit certified data of pressure drop, insertion loss and generated noise of silencers. Data shall be certified by a qualified independent testing laboratory. The test method used by the independent testing laboratory certifying the attenuator data shall be fully described.

C. Sound attenuators shall consist of an outer casing of 18 gauge thick galvanised sheet steel, sound absorbing materials and internal baffles, splitters and supports. Casings shall be tested to 2 kPa and shall show no more than 2% leakage or distortion in this condition. Seams shall be lock formed and mastic filled. End flanges shall be made from galvanised mild steel or rolled steel angle, as determined by the Supervision Employer’s Representative. Attenuators shall be fitted to ductwork using neoprene gaskets between bolted flanges. The geometry of selected attenuators shall not result in requirements for sharp transformation in adjacent ductwork, shall not interfere with adjacent services or with the aerodynamic performance of the system or encourage regeneration of noise local to the attenuator, all to the satisfaction of the Supervision Employer’s Representative.

D. The size of the attenuators shall not be less than the cross sectional area of the duct.

E. Sound absorbing materials shall be fibreglass or mineral wool held in place with at least 5% compression to prevent voids due to settling. Absorbing material density shall be minimum 48 kg/m3 faced with minimum 0.8mm perforated galvanised steel sheets.

F. Acoustic infill and sound absorbent materials shall be tested to withstand air velocities of 20m/s without evidence of material breakdown, migration or dusting.

Where noise attenuators are located at a position not immediately adjacent to the noise source, ductwork between equipment and attenuator must be constructed from sheet metal of minimum thickness 1.2mm and internally lined with 50mm thick 48 kg/m3 acoustic lining. Where sound attenuators are to be located close to a turning elbow, the minimum separated distance shall be 3D, where D is the duct diameter or equivalent diameter.

The construction of attenuators, conforming to the recommendations of the ASHRAE, SMACNA and or HVAC Publication DW 143, shall apply to the construction of rectangular attenuators. The casing and end flanges shall be manufactured from high quality pre-galvanized mild steel sheet. Flanges drilled to standard.

G. The acoustic splitters shall be made separately before assembly in the casings and the acoustic lining materials shall be enclosed in a pre-galvanized, perforated, mild steel sheet frame.

The design shall incorporate half splitters on the side walls of the attenuator to minimize flanking problems and to ensure that the quoted test performance is not reduced as a result of unequal distribution of sound energy across the face of the attenuator. The Eurolon acoustic infill material from which the splitters and half splitters are made shall be totally inorganic and incombustible having a class I rating for the surface spread of flame with a minimum density of 26.00 kg per cubic meter

H. Air velocity through sound attenuators shall be no more than 7.5 m/s and have a pressure drop not exceeding 75 pas.

I. All acoustic infill and materials shall have Class 1 Surface Spread of Flame and Class ‘O’ rating testing to BS 746.

J. Where attenuators are used for kitchen extract and similar systems, where regular cleaning of ductwork internal surfaces take place, then a polyester or similar facing shall be placed between the splitter acoustic fill and the perforated sheet. The acoustic effect of the facing shall be allowed for in the selection of the attenuator performance.

3.3 Acoustic Duct Lining

All acoustic lining shall comply with the National Fire Protection Association Standard NFP 90A UL 181 Class 1 Requirements.

All acoustic lining shall have a thermal conductivity rating of not more than 0.036 W/m K at a mean temperature of 24oC and shall be of the semi rigid batt type manufactured from mineral wool or fibre glass, having a density of not less than 48kg/m3.

Insulation shall comprises 25mm or 50mm thick semi rigid butts faced with perforated foil laminate sheet similar to “Sisalation 450” or approved equivalent or 0.6mm thick perforated zincanneal sheet as itemised below having a free area of approximately 10%. Alternatively for velocities less than 10 metres per second, perforated foil may be deleted and replaced with neoprene coating and perforated aluminium foil. Insulation shall be adhered to the ducts with an approved type adhesive and fastened with welded pins and speed clips located at not more than 400mm centres.

All joins between insulation butts shall have the surface layer lapped and adhered together or pop riveted as appropriate in the direction of the air flow.

All end pieces shall be complete with sheet metal nosing and all corners shall be firm with angles formed from galvanized sheet steel.

Acoustic lining shall have sound absorption coefficients of not less than following:

	Frequency (hertz)				
Thickness (mm)	125	250	5000	1000	2000
25 (foil laminate)	.01	.19	.43	.71	.73
50 (foil laminate)	.22	.52	.73	.94	.94
25 (performated zincanneal)	.10	.14	.37	.75	.92
50 (performated zincanneal)	.18	.38	.73	.90	.88

Acoustic lining in masonry ducts shall be as for sheet metal ducts as previously specified except that pressed 1mm thick galvanized steel “Z” sections shall be located at approximately 1000mm centres to support the full weight of the butts in a horizontal direction.

The galvanized steel “Z” sections shall be firmly attached to the masonry wall with expanding type masonry anchors or at not more than 450mm centres.

Pins and speed clips shall be used as for ductwork except that approved cement type fixings shall be used for direct and firm attachment of pins to the masonry wall in lieu of welded type.

3.4 Acoustics Panels

A. Acoustic panels shall be 100mm thick and constructed of 0.8mm perforated and 1.2mm solid galvanised steel sheet for the interior and exterior facings.

B. Acoustic infill shall be 48 kg/m3 fibreglass or mineral wool.

C. Internal panel reinforcement shall be a minimum of 1.2mm galvanised steel and spaced so that span does not exceed 600mm. Perimeter and internal reinforcement and panel steel shall be welded and riveted to form a rugged metal-sheathed acoustical panel. Spot welds shall not exceed 75mm on centres.

D. The sound transmission loss (STL) and sound absorption coefficients of the panel when tested in accordance with ASTM E90-61T and ASTM C423-65T respectively shall be as follows:

Octave Band Centre Freq. (Hz)

	63	125	250	500	1K	2K	4K	8K
STL (dB)	20	21	17	38	48	58	58	58
Absorption	-	0.89	1.20	1.16	1.09	1.01	1.03	-

3.5 Acoustic Enclosure

A. Acoustic enclosure shall be provided to equipment as indicated on the Drawings or required to meet the specified noise criteria.

B. Acoustic enclosure shall be constructed of 2 layers of 13mm plaster board/cement board and 50mm thick 48kg/m3 fibreglass insulation.

Access door shall be of solid construction of the same acoustic insulation proportion as the enclosure.

Ducts specified with external lagging (where shown on drawings) shall be encased with minimum 25mm thick 48kg/m3 fibreglass and two layers of 13mm plaster board/cement board.

3.6 Noise Break-In / Break-Out

A. Where ductwork, piping and services pass through walls, floors or ceilings the penetration shall be acoustically sealed in the following manner.

B. A 12-20mm clearance all around the duct shall be filled with acoustic infill either rock wool or fibreglass of high density. Acoustic infill to be tightly compressed and mastic caulking applied to provide airtight seal over all exposed infill.

C. Ensure that all pipes and duct penetrations are well sealed acoustically and that there is no noise leakage through the penetrations and no vibration or vibration-induced noise due to the mechanical installation is noticeable in any part of the building.

PART 4 – EXECUTION

4.1 Floor Mounted Equipment

Erect floor mounted equipment on 150 mm high concrete pads over complete floor area of equipment. Mount vibration eliminating devices and concrete inertia blocks on housekeeping pads.

4.2 Vibration Isolation Systems

A. Have vibration isolator manufacturer determine mounting sizes. Install in accordance with manufacturer's instructions.

B. Installed vibration isolation system for each floor or ceiling supported equipment shall have a maximum lateral motion under equipment start-up or shut down conditions of 6 mm. Restrain excess motions by approved mountings.

4.3 Mounting Systems Exposed

A. Protect mounting systems exposed to weather and other corrosive environments with factory corrosion resistant coatings. Hot dip galvanized metal parts of mountings (except springs and hardware). Cadmium plate and neoprene coat springs. Cadmium plate nuts and bolts.

4.4 Water Cooled Chillier & Packaged Air Handling Units Mounting

A. Mount packaged units which are not internally isolated directly on stable bare steel spring isolators. Where units to be mounted are furnished with internal structural frames and external lugs (both of suitable strength and rigidity), or without any severe overhangs, no additional structural frame provided beneath unit. Integrally mount motor on slide rails.

4.5 Pipe Support

A. Support piping as follows:

1. Resiliently support all suspended piping connected to isolated equipment.

2. Provide resilient diagonal mountings or other approved devices to limit piping motion due to equipment start-up or shutdown, to a maximum deflection of 3 mm.

4.6 Expansion And Contraction

A. Allow for expansion and contraction when selecting and applying isolation materials.

4.7 Noise Levels

A. Isolate equipment to attain the noise criteria (NC) levels as specified in the Particular Specification.

B. After systems have been balanced, take sound measurements throughout the complete range of audible frequencies from 63 Hz through 8000 Hz, in each occupied area above, below and beside each Mechanical Equipment Room and where directed. Plot readings on noise criteria NC curves.

C. Modify, as required and at no additional cost to the Sub-contract, the fan distribution and other mechanical systems to achieve the specified noise criteria.

Submit a report, including sound curves, to substantiate that equipment has been isolated adequately, and that acceptable noise levels have been attained. Provide a list to indicate equipment in operation at time of readings taken.

Make sound measurements in accordance with the American Standard Method for the Physical Measurement of Sound, ANSI S1.2.

Sound measuring equipment shall be Type 2 Class I in accordance with ANSI Standards S1.4 or S1.11.

Noise levels resulting from the air-conditioning system shall be tested with a sound level meter with an octave band analyzer to record sound pressure levels against the mid frequency of each octave band. In octave bands centred on 250Hz and above, three random measuring stations shall be taken, none closer than 2 meters from the outlet and none closer than 1 meter to any room surface. In octave bands centred at 63Hz and 125 Hz, this random measuring station shall be taken as above. The design criteria levels shall then meet the arithmetical average of the random readings and be no more than 2dB over the specified curve and no more than 3 dB over at 125 Hz and 5 dB over at 63 Hz.

After commissioning of the completed installation, and in the final stages of fitting out of the buildings, the Contractor shall provide the services of the attenuator manufacturers' test engineer to carry out site measurements in accordance with the requirements outlined above, and shall submit to the Engineer signed test sheets giving details of all noise levels recorded during the period of the test.

Verification of the proposed attenuator performance data shall be provided by the supplier before materials are delivered to site. The acoustic performance shall be measured with reverberation chamber technique, as recommended by the HVRA. Tests shall be carried out on all units to ensure their complete suitability for satisfactory operation of the system.

END OF SECTION - 15240

SECTION 15255

MECHANICAL INSULATION

PART 1 – GENERAL

1.1 Reference

Conform to General Requirements for Mechanical Services of Division Fifteen.

1.2 Description of Work

Extent of mechanical insulation is specified in this section.

1.3 Quality Assurance

Insulation material shall comply with the following British Standard:

BS 476 (Part 4, 6, 7)
BS 874
BS2972
BS3958 (Part 4,5)
BS 5422
BS6676 (Part 1)

1.4 Submittals

Product Data: Submit manufacturers technical product data and installation instructions for each type of mechanical insulation, submit schedule showing manufacturer's product number, k-value, thickness and furnished accessories for each mechanical system requiring insulation.

Submit samples for each types of mechanical insulation.

Provide mock up installation before progressing with work.

1.5 Delivery, Storage and Handling

Protect insulation from moisture and dirt by inside storage and enclosure and polythene wrapping in accordance with the manufacturer's recommendations.

1.6 Maintenance Data

Submit maintenance data for each type of mechanical insulation. Include this data, product data, and certifications in the maintenance manual.

2.0 PRODUCTS

2.1 Materials

2.1.1 Insulating materials shall have thermal conductivity values not more than those listed hereafter:

MATERIAL	TYPE	THERMAL CONDUCTIVITY. W/M/DEG.C
Mineral wool	Sectional	0.04
Mineral wool	Slabs	0.04
Fibre Glass	All	0.034
Closed Cell	All	0.016
Polyurethane	Sectional	0.025
Styrofoam	Rigid	0.026

All conductivity figures are rated at an average temperature of 24 deg C.

2.2 Lagging Adhesive

Adhesive shall be a flexible, fire resistive compound suitable for vapour sealing insulated ducts and pipes.

Adhesive shall be suitable for indoor and outdoor use and in high humidity environments.

Water vapour permeance shall not exceed 0.05 perms at 0.030 inch dry film thickness when tested in compliance with ASTMF 1249.

When tested for surface burning characteristics in compliance with ASTM E84, flame spread shall be 10 and smoke developed 15.

Adhesive shall be UL classified and shall meet or exceed the requirements of NFPA 90A and 90 B 25/50.

2.3 Fungicidal Protective Coatings

Fungicidal protective coatings shall be applied over external surfaces of chilled water & refrigerant pipes and interior and exterior surfaces of ductwork.

Coating shall be a polyacrylate copolymer emulsion specially formulated for long term fungicidal activity with no loss of activity on aging. It shall prevent the spread of molds and odour causing bacteria on the applied surface.

Coating shall meet the requirements of NFPA 90A and 90B.

2.3.1 Fungicidal Protective Coatings for indoor applications:

As manufactured by Foster or approved and equal shall be applied to all indoor ductwork and pipe work as specified. The properties shall be as follows:

Coating should be a white color, fire resistive, tough, washable, abrasion-resistant indoor coating for thermal insulation. It should also used as a lagging and lap adhesive for canvas and glass lagging cloth. The coating should have excellent brushing characteristics, which will result in better coverage, and more uniformly coated surfaces. It should present a neat white finish, and will not yellow or become discolored with age. The surface can be washed free of grease, oil, soot, and other dirt accumulation.

Coating should be provides a protective finish for insulation on air conditioning ducts and cold water piping when applied in 2 coats with reinforcing fabric embedded between coats. When relative humidity exceeds 75% for continuous periods, or where the insulated piping or equipment contains chilled water, brine or refrigerant, additional vapor barrier protection should be applied.

Compatible with polystyrene and polyurethane foam insulations. Conforms to current requirements regarding use in meat and poultry processing areas under federal inspection.

Coating should be produced under the classification and follow-up service of Underwriter’s Laboratories, Inc. and meets NFPA 90A requirements.

Vapour Sealing Terminal Points and Interruptions in Insulation

A suitable Fosters' Sealant shall be applied to butt all longitudinal insulation joints.

Contains no asbestos, lead, mercury, or mercury compounds.

Coverage Range: (Subject to the type of surface being coated.) Wet coverage for smooth non-porous surfaces. Porous or rough surfaces may require higher gallonage to attain required dry thickness.

Properties:

Coating : (1.0-1.7 m2/l) per coat
Thickness per coat : (1.0 to 0.6 mm)
Drying Time at 73ºF (23ºC) 50% RH
Set to Touch: 2 Hours
Dry Through: 15 Hours
Service Temperature Limits (Temperature at coated surface)
0ºF to 180ºF (-18ºC to 82ºC)
Surface burning characteristics:
Flame Spread: 10
Smoke Developed: 15

2.3.2 Fungicidal Protective Coatings for Outdoor applications:

As manufactured by Foster or approved and equal shall be applied to all outdoor ductwork and pipe work as specified. The properties shall be as follows:

White color coating should be a tough flexible fire-resistive elastomeric finish for protection of outdoor thermal insulation. It should contain rubber so that the coating shall have excellent vapor barrier for low temperature insulation on tanks, pipe work, vessels, ductwork, and fittings.

Coating should be provides sufficient weather barrier protection, showing good color retention, excellent chemical resistance, and durability. It has excellent resistance to UV and sunlight. Also Coating should provide excellent weather barrier and vapor barrier protection for sprayed polyurethane foam in outdoor locations. It shall be one-component, high film strength product, to be applied in two coats with standard airless spray equipment or with brush coating.

Coating should be produced under the classification and follow-up service of Underwriter's Laboratories, Inc.

Coating meets NFPA 90A and 90B 25/50 requirements.

Coating contains no asbestos, lead, mercury, or mercury compounds.

Properties:

Coverage Range: (Subject to the nature of material coated.) Wet coverage for smooth non-porous surfaces. Porous or rough surfaces will require higher gallonage to attain required dry thickness.

Dry Thickness: 0.032 inch (0.8 mm)
Equivalent Wet Coverage: 0.096 inch (2.4 mm)
6 gal./100 sq. ft. (2.4 l/m2)

Drying Time:
Set to touch: 3-4 hours
Dry Through: 24 hours
Service temperature limits: (Temperature at coated surface)
-50ºF to 220ºF (-46ºC to 104ºC)
surface burning characteristics
Flame Spread: 10
Smoke Developed: 15

2.4 Application

2.4.1 Ductwork Insulation

a) Concealed indoor supply & return for air condition system, fresh air system and (exhaust air ducts passing through air conditioned area).

Unless otherwise indicated insulate all ductwork with 25 mm thick, 24 Kg/M3 density aluminum foil faced fiberglass duct insulation. Fasten the insulation with adhesive on 200 to 250 mm centers. Butt all joints tightly and seal all breaks and joints by adhering a 75 mm Aluminum foil vapour barrier tape or sheet with a fire retardant adhesive.

Insulate flexible connections and connections to diffusers with 25 mm thick, 24 Kg/M3 density reinforced aluminum foil faced flame resistant flexible fiberglass insulation. Overlap onto adjacent insulation and seal with adhesive duct tape to give good closure.

Where ductwork is installed in ceiling voids and masonry shafts, which are not used as return air plenums insulate with 50mm thick rigid board, 48 Kg/M3 density aluminum foil faced rigid fiberglass duct insulation.

Finish all duct insulation with a 20x20 (thread/inch) woven glass cloth cover adhered between two coats of fire resistant fungicidal protective lagging adhesive.

b) Exposed supply, return for air condition system, fresh air system and ducting inside plant room

For ducts exposed inside conditioned spaces, insulate as described above for concealed air ducts using 25 mm thick aluminum foil faced fiberglass boards with density 48 kg/m3.

Then apply a 20 x 20 (thread/inch) woven glass cloth cover adhered between two coats of fire resistant fungicidal protective lagging adhesive.

Exposed ductwork within conditioned areas shall be clad with plain aluminum sheet 0.9 mm or thicker if required by the Engineer.

For ducts exposed in non air conditioned areas, insulate using the method described for concealed ducts, but using insulation with a minimum thickness of 50 mm, 48 Kg/M3 density rigid fiberglass insulation. Then apply a 20x20 (thread/inch) woven glass cloth cover adhered between two coats of fire resistant fungicidal protective lagging adhesive.

Then cover with plain sheet Aluminum, 0.9 mm or thicker.

All ductwork exposed externally to the building, installed on roof and within plant rooms is to be clad with plain aluminum, 0.9 mm or thicker.

Where ducts penetrate the building shell, the duct shall be flashed and waterproofed before any insulation is applied.

2.4.2 Chilled Water Pipe Work Insulation

Pipes shall be generally insulated with rigid sections of aluminum foil faced glass fiber insulation with density of 64 Kg/m3 having a thermal conductivity factor of 0.035 w/m.k at 10 deg. C.

Internal chilled water pipes (inside buildings) shall be insulated by 40mm thick rigid insulation for pipes up to 40 mm dia. and 50 mm for pipe sizes 50mm dia and above.

External chilled water pipes (on roofs and in chiller plant room) shall be insulated by 50mm thick rigid insulation for pipe sizes up to 40 mm dia and 75 mm for 50 mm dia and above.

For both internal and external pipes the insulation shall be finished with a water proof 20x20 (thread/inch) woven glass cloth cover painted with two coats of approved anti fungal lagging adhesive.

Where insulated pipe work is run on roof, in plant room, chillers yard and tunnels it shall be clad using an outer covering of plain aluminum sheet of 0.7mm or thicker.

Where exposed, insulated pipe work runs through occupied or public areas it shall be clad using an outer covering of plain aluminum sheet of 0.7 mm or thicker.

2.4.3 Refrigerant pipe work insulation

Refrigerant pipe work shall be insulated with closed cell synthetic rubber foam insulation, 19 mm thick and finished as described for chilled water pipes.

2.4.4 Condensate drain pipe work

Condensate drain pipe works shall be insulated with 25mm thick, 24 kg/M3 density fiberglass or rubber insulation finished with a water proof 20x20 (thread/inch) woven glass cloth cover painted with two coats of approved anti fungal lagging adhesive.

2.4.5 Diesel Engine Exhaust Pipe

Diesel engine exhaust pipe and muffler shall be insulated with 100mm thick calcium silicate.

2.4.6 Water Pipes Insulation

a) Hot water pipe insulation

Hot water pipes embedded in block walls shall be polythene coated copper tubes. The polythene coating shall have a profiled inner surface to trap air which forms a thermal barrier.

In all other areas, hot water pipes shall be insulated with preformed sections of aluminum foil faced rigid fibre glass insulation, minimum density 65 Kg/M3, and covered with 20x20 (thread/inch) woven glass fibre cloth. Cloth shall be thoroughly soaked in fire resistant, fungicidal protective sealer prior to application and applied whilst still wet.

Insulation thickness shall be as follows:

Pipe Size MM	Insulation thickness (MM)
Up to 28	25
35 to 50	40
Above 50	50

All insulated pipe work installed on roof, within plant room and wherever exposed to view shall be cladded with plain aluminum sheets at least 0.7mm thick.

b) Cold water pipe insulation

Cold water services pipe work installed on roof shall be insulated in a similar fashion described for hot water pipes.

All insulated pipe work installed on roof, within plant room and wherever exposed to view shall be cladded with plain aluminum sheets at least 0.7mm thick.

2.4.7 Drainage Pipes Insulation

The following drainage piping shall be insulated:

First 3m of vertical rainwater vertical rain water leader closest to the roof drain plus exposed portion of roof drain.

All horizontal drainage pipe work within false ceiling and all elbows connecting this pipe to vertical stacks.

Waste pipes from urinals to closest branch or main.

Condensate drains lines.

Any piping specifically noted.

Drainage piping insulation shall be 25mm thick 48 kg/m3 glass fibre preformed, pipe insulation complete with vapour barrier jacket.

3.0 EXECUTION

3.1 The whole of the insulation work shall be carried out by an approved specialist insulation Contractor. All allowances shall be included for arranging a specialist subcontract accordingly and for informing the specialist Sub-contractor of all conditions relating to the Contract and for coordinating his works with the remainder of the works.

3.2 All adhesives, mastics, coatings, sealers and primers shall be classified as Class 1 surface spread when tested in accordance with B.S. 476, part 7. They shall not in any way attack the insulation or the surface to which the insulation is being applied and shall be suitable for the working temperatures.

3.3 The Contractor is to allow in his price for the removal and replacement of two sections of each type of insulation. If, however, defects are revealed, further sections shall be cut out for inspection, and all cutout sections shall be replaced at no cost to the Contract.

If further defects are revealed then the Company shall have the right, when in its opinion it is necessary, to issue instructions for any part or the whole of the insulation to be removed and replaced. The replacement with new insulation shall be to the satisfaction of the Company and the cutting out and replacing shall be at no cost to the Contract.

3.4 Particular attention shall be paid to the finished appearance of all thermal insulation which must present a neat and symmetrical appearance running true in line with pipe layouts, etc.

3.5 Any rough, irregular and badly finished surfaces shall be stripped down and re-insulated to the Company's satisfaction.

3.6 All systems are to have been tested and approved by the company prior to installation of insulation.

3.7 The insulation, in sizes indicated shall be applied over clean, dry surfaces. Adjoining sections of insulation should be butted firmly together with the longitudinal seam of the jacket located on the bottom half of the pipe.

3.8 Insulate and finish valves and fittings in the same manner and same thickness as piping in which such items are installed. Moulded, factory shaped sectional pipe covering, factory- or job-fabricated may be used subject to satisfactory visual checking by the Company.

3.9 Direct contact between pipe and hanger shall be avoided. Hangers shall pass outside of the sheet metal protection saddle, which shall cover a section of high density insulation, of sufficient length to support the pipe without crushing the insulation. The vapour barrier shall be lapped over the saddle and securely cemented to it. Minimum thickness of metal saddle is 1.5 mm.

3.10 The insulation shall be installed in accordance with the manufacturer's printed instructions.

END OF SECTION - 15255

SECTION – 15400

PLUMBING

PART 1 – GENERAL

GENERAL REQUIREMENTS

1. All general provisions contained within this, or any other, section of the specification shall be fully applicable to each and every other section.

2. All installation work shall be carried out in a neat, efficient and workmanlike manner, to provide for proper operation, maintenance and repair. The work shall be in accordance with the requirements of these Specifications, and shall fulfill their true intent and meaning. No deviations from these Specifications and/or Drawings shall be made without written approval of the Engineer.

3. These Specifications and associated drawings form a composite set of documents, intended for the complete cold and hot water, drainage and sanitary plumbing, works having a general and specific characteristics as detailed.

4. Unless otherwise specifically stated, the installation shall complete, tested and ready for operations in all respects, fully integrated and coordinated with all other works.

5. The contractor, upon the request of Engineer shall submit proof that the materials, appliances, equipment or devices that furnishes and installs under this contract meet the requirements of BS, DIN Standard, GCC code and Uniform Plumbing Code.

PART 2 – CODES AND STANDARDS

1. The work under this contract shall be executed in the manner set out in this specification.

2. The work shall be carried out in strict accordance with the latest/current applicable standards, codes published and specification, as follows:

   a. British Standard

   b. Din Standard

   c. Uniform Plumbing Code

   d. GCC Code

3. The contractor shall include all items of material and labor required to comply with such standards and codes.

4. In the event when quantities, sizes or other requirement indicated on the drawings or specified there in are excessive of the Standard or Code requirements then these specification/drawing shall govern.

5. Where requirement of any such regulations conflict with the requirement of this specification, the Contractor shall refer to Engineer prior to commencement of work.

PART 3 – TYPE & TESTS AT MANUFACTUER'S WORKS:

The contractor shall submit test certificates of all equipment, machinery and materials showing compliance with relevant British Standards and with any other test specified; as and when asked for by the Engineer,

The Test Certificates shall be supplied from the manufacturer.

TESTS AT SITE

1. After completion of any portion of works the test shall be conducted in the presence of the Engineer.

2. The contractor shall give 7 days notice after which he will be ready for test in the Engineer, the Contractor shall be required to complete all the outstanding items of works to the satisfaction of the Engineer before the tests can be made.

3. All test equipment such as pumps, gauges, instruments etc., and personnel necessary for the test shall be arranged by the contractor at his expense and he will make all provisions for removal of test equipment after completion of tests.

4. If, in the opinion of the Engineer, the tests are being unduly delayed, the Engineer may be notice in writing, call upon the contractor to make such tests within ten days form the receipt of said notice and the Contractor shall make the said test on such a day within the said ten days as the contractor may fix and of which he shall give notice to the Engineer.

5. If any section of the works fails to pass the tests, tests shall be repeated within a reasonable time with the same terms and conditions. All the expenses to which the Engineer may be put by the repetition of such tests shall be borne by the Contractor.

TESTS ON COMPLETION

The following tests shall be carried out:

Pump

1. Flow Rate

2. Total Head (Pressure) developed

3. Motor Current drawn/ overload setting

4. The test data shall be recorded on the pumps graph for future reference.

Electrical Motors

1. Speed –RPM

2. Current drawn/overload setting

3. Power Input – KW

PART 4 - DEMONSTRATION

The contractor shall provide all attendance necessary during commissioning of all plant, equipment and apparatus under the Contract.

The contractor shall conduct training in the operation of the system to the owner's representative which shall include setting of controls, adjustments, sequence of operation, interlocking, functioning of safety and protection devices.

The contractor shall hand over full and comprehensive operating and maintenance instruction to Engineer/Employer.

2. SCOPE OF WORK

2.01 The scope of work shall include detailed design, supply, installation, testing and commissioning of plumbing and sanitary system ready for use in accordance with the drawings and specifications in compliance with the local plumbing code of the Bahrain/GCC, British Standards on Plumbing and Sanitary installations and uniform Plumbing Codes.

2.02 The complete plumbing and sanitary works includes but not limited to the following:

A. The plumbing Contractor is required to refer to all architectural, structural, mechanical, fire protection and electrical plans and investigate all possible interference and conditions affecting his work.

B. Tapping from service water main distribution system to include supply and installation of main water meter, isolation valves, pipes and fittings, and valve boxes.

C. Supply and installation of water storage tanks including booster pumps.

D. Water supply and distribution system to include booster pumps, pipes, valves, fittings, hangers and supports.

E. All building sanitary drains, waste and venting system including floor drains and air conditioning condensate drains.

F. Sewage collection and disposal system up to the existing main sewer including modification of the existing lines to suit the new layout.

G. Building storm drainage system including deck and scupper drains, roof drains, area drains and catch basins up to the existing main storm drainage system.

H. Supply and installation of plumbing fixtures trims and accessories.

I. Excavation and back filling of underground piping including sand and gravel beddings and concrete saddles.

J. Testing for leakage of all drains, waste, sewer and venting system plus pressure testing and disinfection of the water supply and distribution system.

K. Testing for leakage and disinfection of water tanks.

L. Preparation of technical submittals, shop drawings and as-built drawings.

M. Electrical power wirings from control box to all motor requiring the same, including conduits, fittings and supports.

3. QUALITY AND WORKMANSHIP

GENERAL

1. Novotel Al Dana Resort Towers has been designed as a dwelling fit for human habitation with a minimum life period of twenty-five years in the climatic conditions of GCC. Notwithstanding any reference to design in the Contract Documents the Contractor shall in addition satisfy himself that all aspects of such design are adequate for the above purpose and shall as soon as he becomes aware of any fault or omission in such design either before or during the construction and maintenance of each works immediately inform the Engineer direct in writing in order that any such fault or omission may be duly examined and corrected by mutual agreement.

2. In addition the Contractor shall satisfy himself that all materials, products and workmanship are of a sufficient standard to ensure a safe and habitable human environment within each completed project in GCC. For this purpose the Contractor shall obtain from the manufacturer and supplier of each material and product and shall submit for the approval of the Engineer written details of the specification, guaranteed and expected life in GCC.

3. Instructions for use for each such material and product. No material or product shall be purchased or used by the Contractor until the above written details have been approved in writing by the Engineer.

4. In the event that any works may be subject to harsh environment hazards the Contractor shall examine the effect of such hazards on such house or any part thereof and on any material or product used in the construction of such house and shall inform the Engineer in writing of any such effect prior to the commencement of construction or prior to the purchase of such material or product.

5. The Contractor shall submit to the consultant within seven (7) calendar days after receipt of the letter of award/intent list of all equipment and materials intended for the project including technical specifications that may be required. No materials shall be procured or delivered to the jobsite without the prior approval of the consultant.

6. Any equipment and materials found not in accordance with the specification and without prior approval by the consultant shall be rejected and shall be removed from the jobsite immediately after receipt of non-compliance report.

7. When so required by the consultant, samples of materials are to be provided at the Contractor's expense. Samples must be labeled bearing the name of material, intention of use, manufacturer's name, contractor's name, date of submission and specification reference.

8. The Contractor may submit alternative material for Consultant's approval in cases wherein the approved/specified materials is not available in the GCC.

9. Alternative material must be of the same quality with that of the specified material.

10. If alternative material proves to be acceptable but there is an inferior quality or value, a suitable price reduction will be made, however if there is an increase in quality and value, no adjustment shall be made in the contract cost. Any delays and losses incurred due to the Contractor's failure to provide the specified material will not relieve the Contractor of his responsibility and obligation under the Contract.

11. The Contractor shall be responsible to ensure that all the imported equipment and materials arrive on site in sufficient time to adhere to the project schedule.

12. It is the responsibility of the Contractor for the transporting, unloading storing and safekeeping of his equipment and materials in an approved manner protect from damage and exposure to weather or dampness during transit and after delivery to the site.

13. The Contractor is to provide all labor, materials and transport that the Consultant's Representative may require in carrying out tests and checks on materials and workshop.

14. The Contractor must submit to the Consultant with seven (7) calendar days upon receipt of the notice of award, the following:

    - Project Organization Chart
    - Work Schedule including manpower requirement, material procurement and deliveries, and cash flow schedule.

    The Contractor must submit updated work schedule and accomplishment report every first Saturday of each month or as directed by the consultant.

DESIGN CRITERIA

Provide equipment fixtures, water piping, connections to special equipment, and connections to site utilities as shown on the drawings. Pipe sizing and equipment selections shall be as required by British Code and standard and as required by recognized engineering methods. Water pressure at point of connection to site utilities, is anticipated to be approximately 2.0 Bar

4. CONTRACTORS RESPONSIBLILTIES

NO EXTRA PAYMENT WILL BE ALLOWED FOR ANY EXTRA WORK CAUSED BY MISSING INFORMATION / DETAILS, ANY ALTERATION OR MODIFICATION AND ANY DISCREPANCY.

SECTION 1

GENERAL

1. The Tender drawings are prepared essentially so that, in conjunction with specification, a correct engineering interpretation may be put on the design scheme for the works and estimate of cost prepared.

2. And also, the Engineer for guidance purposes has calculated the Static Resistance stated in the equipment schedule only. The contractor is obliged to check and recalculate the resistance of the system taking into consideration the pressure drops of all the equipment to be installed as well as the pressure drops in the domestic water pipe line runs.

3. The contractor shall include all parts and materials necessary to make the installation complete in all respects and ready to operate whether such items are specified or not.

4. The contractor shall be responsible for coordinating all other engineering services in order to avoid any work conflict.

5. All water supply and plumbing installation work in connection with the contract shall be executed in strict accordance with the valid edition of British, DIN Standard, and National Plumbing Code, and any supplements, addenda or published revisions thereto up the date of submission of the contractor's Tender. The contractor shall keep a copy of the said regulations supplements etc. on site at all times during the continuance of the contract.

6. The contractor to check and re-route the services if required to have a proper coordination before submitting working drawing for the approval of the Engineer. The spaces available within the false ceiling and false floor can be worked out from the relevant architectural and structural drawings. All the pipes, ducts, cables, cable trunking etc., shall be so routed as to fit within the space but without any interference or conflict.

7. The contractor shall be responsible for the coordination of all his subcontractors and their installation work on site. All subcontractors concerned with the works will be required to co-operate with the Contractor and Engineer as well as others to plan the installation before commencement of the work and to ensure correct installation to the design the course of construction.

8. Services installed in duct shall be so arranged to permit maximum access along the duct and all services equipment and plant shall be readily accessible for maintenance.

9. Whether or not shown on the drawings, equipment shall be installed in such as manner that equipment, operating and control devices etc. are readily accessible for servicing and adequate access spaces/clearances are maintained. Adjacent units, building structure etc., shall not disturb with the proper operation and service of the equipment.

10. The position of points and equipment as indicated on the Tender drawings may require variation to suit site conditions. The exact positions of points and equipment must be checked and shown on detailed working drawings to be submitted for approval to the Engineer prior to commencement of installation.

11. The contractor shall install the works as closely as possible to the layout shown but make without additional costs any changes in routing of piping o meet the job conditions as the Engineer may direct.

12. Should any points or equipment shown on the drawings be missing in schedules or vice versa, the contractor shall assume that these points are to be installed. Discrepancies of the nature shall be immediately brought to the attention of the Engineer at the time of Tender.

13. All other schedules attached to the specification duly filled as required.

14. Overall schematic wiring diagram of the plant including size and rating of circuit, breakers, switch fuses, cables and other accessories, interlock protection and instrumentation and a description of the sequence of operation shall be submitted. The drawing shall be complete with a legend explaining the symbols used.

15. Any other information or samples that may help in evaluating the offer shall be submitted.

16. The Engineer shall ask for any other information required in the particular specification.

17. All civil work for making, enlarging or making good of all openings in walls, floors and roof, equipment foundations, plant room floors and trenches shall be provided by the Contractor, and all the above said work shall be made to match the design of the building.

18. The Contractor shall include in his price for drilling, raw bolting, plugging, screwing and nailing of all brackets, hangers, for all pipe work, ductwork, conduit, cable tray, cable trunking and cable supports. The contractor shall also include for supplying all brackets, hangers and support as necessary.

19. Unless otherwise noted on the drawing, the Contractor shall supply, fabricate and fix all steel structures required for the support of plant, equipment, piping ducting and all services.

20. All such structure shall be constructed of rolled steel sections of adequate strength, bolted or welded together and painted with two coats of lead primer. Structures shall wherever possible be entirely self-supporting and suitable for bolting to the floor of the building.

21. The contractor shall take care and protect all works, whether complete or in the course of completion form the ingress of dust or moisture or form damage by any other means.

SECTION 2

1. COORDINATION

a. The Contractor shall be held solely responsible for the proper co-ordination of all phases of the work and timely delivery to the site of all equipment and materials for proper execution of the Work.

It is the sole responsibility of the Contractor to fully co-ordinate the Work with all or any other disciplines and to ensure proper phasing of the Work to ensure continuity of all works under this Contract. If it becomes necessary to remake any part of these Works or that of any other discipline of trade as a result of poor or badly timed co-ordination, then all costs associated with remaking those works will borne by the Contractor.

b. The Contractor shall take into consideration all statutory and local requirements issued by the Supply Authority, Local Authority, Central Government, Broadcasting Authority, Telephone and Telecommunications Authorities along with any other requirements to be considered for the correct and legal operation of the electrical and telecommunication.

c. Contractor shall be responsible to co-ordinate different services, systems and builder works accordingly, and any discrepancy found shall be brought to the Consultant's attention in writing, failing which the Contractor will rectify the systems or services, as per Consultant's, requirements at no extra cost. Installation or equipment connected to the installation as part of this Contract.

2. ACCESSIBILITY

All work shall be so installed as to be accessible for operation, maintenance and repair. Deviations for the drawings may be made to accomplish this, but no change shall be made without written approval from the Engineer. The Engineer shall approve access door locations before work is commenced.

3. STORAGE OF MATERIALS AND EQUIPMENT

All material and equipment, fixed or unfixed, shall be protected against corrosion, deterioration and ingress of foreign matter. All equipment shall be kept clear of the floor of ground by means of wooden bearers or other means, and shall be protected against weather.

4. FIRE AND SAFETY PRECAUTIONS

The whole of the works shall be carried out with care and so arranged as to minimize the risk of fire and extent of damage resulting form outbreak of fire.

5. CLEANING DOWN

The contractor shall allow in his tender for the final cleaning down and painting of all scratched or damaged electrical apparatus, panel boards, cubicle panels, distribution boards and transformers.

6. SPECIAL TOOLS

The Contractor shall supply as part of this contract all special tools required for equipment maintenance.

7. LABEL AND IDENTIFICATIONS

All pipe work; valves, controls and equipment on the project shall be identified as per BS 1710 or specified herein. All marks of identification shall be easily visible from the floor or usual point of vision.

a. Equipment

All equipment, except in finished rooms shall be identified by stenciling. The position of the letter shall be clearly visible from the floor. The letters shall be made with black paint and shall be not less than 50 mm high.

b. Piping

The letter shall be 25mm high on small pipe size and 50 mm high on large pipe sizes and the flow arrows shall be at least 150mm long.

c. Control Panel

All control panels shall be identified by Engraved name plates. The engraved nameplates shall be engraved on "LAMACOID" or approved equal plastic, which will be black and show white letter when engraved. Letter shall be 15mm high.

8. SIGNS AND NOTICES

a. All signs and notices shall be in Arabic and English with the Arabic version being above or to the right of the English version.

b. A schedule of all signs and notices with proposed Arabic translations shall be approved by the Engineer prior to manufacture.

9. MATERIAL SUBMITTALS AND DOCUMENTS

MATERIALS

a. The letters ‘BS’ shall mean the British Standard Specification current at the date of Tender, Where a material is required to be in accordance with a BS the Engineer may at his discretion accept materials in accordance with other standard specifications (eq. ASTM) if the quality is equivalent or superior to the BS.

b. The letters ‘CP’ shall mean the British Standard Code of Practice current at the date of Tender.

c. Unless otherwise specified, all materials shall be of the best quality available and in accordance with the relevant British Standard current at the time of Tender and workmanship shall not be inferior to that laid down in the relevant British Standard Code of Practice, current at the time of Tender, or similar.

d. The Contractor shall fully demonstrate in detailed documentation that he has investigated all local on-shore GCC manufacturers of all products and materials listed in this Specification. Preference must be given to on-shore GCC produced materials and products. In the event that the correct quality of cost margins are not met these shall be brought to the attention of the Consultant prior to rejection. The Engineer reserves the right to direct Contractors to purchase locally produced materials where all other factors are equal.

APPROVAL OF MATERIALS

1. It is conditional to the Contract that written approval must be obtained for all products and materials prior to use in the works. Approval of products or material does not in any way relieve the Contractor of his full responsibilities under the Contract.

2. Certain materials and components are specified on the Drawings using proprietary names in order to identify the standard and quality required by reference to an example. The Contractor may submit for written approval details of any alternative which meets the

3. Said standard and quality.

4. The Contractor shall submit samples and full relevant manufacturer's literature for all material proposed for the project, in accordance with the requirements of the relevant sections of this specification.

5. No order shall be placed until the Contractor has obtained full written approval of the relevant material from the Engineer.

6. The Contractor shall submit a sample of the exact make, model and finish for each Material required.

7. Manufacturers performance data and certified factory drawings giving full information pertinent to the adequacy of the relevant equipment shall be submitted for approval.

8. Submittal shall be made in a manner to ensure complete information regarding what is being offered in a manner that facilitates easy filing and ready access to all data.

9. Where data, certified drawings or other required information is not available until after orders have been placed, the Engineer may give provisional approval until all requested drawings and information have been supplied to the Engineer and approved by him. It is the Contractor's responsibility to ensure that all necessary information is supplied to the Engineer in accordance with that progress of work.

10. Should the Engineer give provisional approval due to lack of complete information, and should the missing information not eventually meet with approval, the Engineer shall not be held responsible for any delay or additional expense incurred. For equipment where delivery from the manufacturer is like to be prolonged, it is essential that the Contractor provided, the submittals at the earliest possible, so as to ensure approval and orders in complete conformity with the progress of the works.

11. Contractor shall submit work schedule and material flow sheet before end of every calendar month or otherwise instructed in a format approved consulted by the consultant. Approval of materials and equipment does not relive the contractor from his contractual obligation.

10. DOCUMENTS

Maintenance literature: Prior to the final acceptance of the installation the Contractor shall submit to the Engineer manuals for all equipment supplied under the Contract. The manuals shall be A4 size bound in loose-leaf binders or booklets suitably enclosed and including the following:

1. Commissioning and operating instructions.
2. Trouble shooting procedures
3. Maintenance instructions including schedules for preventive maintenance.
4. Complete recommended spares list including manufacturers name and catalogue number.
5. Name of manufacturers local authorized representative and service agent.

11. SHOP DRAWING AND AS BUILT DRAWINGS

The Contractor shall submit in duplicate (or as agreed), shop drawings of all services / installations for Engineer's approval before the commencement of site works. Shop drawings shall be fully co-coordinated with all other services and trades together with architectural and structural elements. Individual services drawings (i.e. piping, ducting, drainage etc.) commented or approved, shall not be deemed appropriate for construction purposes, until and unless fully co-coordinated M+E drawings in color are submitted and approved by the consultants for construction. Digital copy of the shop drawings in an approved format shall also be submitted if required by the consultants.

Approved “As Built Drawings” shall be completed within 15 days after completion of works and before the issue of the substantial completion certificate. Three prints and one set of negative prints of approved "As Built Drawing" of the completed installation shall be submitted to the Engineer. Digital copy of the “As Built Drawings” in an approved format shall also be submitted within the above period.

Three sets of “Approved Operation and Maintenance” manuals of all equipment installed shall also be submitted in an agreed format to the Engineer within the above period.

12. PIPING SYSTEMS

GENERAL REQUIREMENTS

- Piping and fittings shall be first class and comply with the requirements of the relevant British Standards, ISO or DIN Specification.

- All piping, run in floor construction, suspended ceiling space or roof space, shall be run parallel with the lines of the building unless otherwise shown or noted on the drawings. Water supply pipes where practicable shall be placed at same elevation and hung on suitable hangers.

- Insulated pipes shall be so installed that there will be not less than 15mm clear space between them.

- Except as otherwise specified, hangers shall be spaced as per relevant codes.

- Vertical lines shall be adequately supported at each floor and at their bases by a suitable hanger placed in the horizontal line near the riser. Also vertical lines shall be adequately braced to vertical walls, etc.

- All pipe connections with fittings shall be made hydraulically tight with approved materials.

- All pipe work shall be thoroughly cleaned to remove dirt and grease or oil. The inside of pipe work shall be thoroughly flushed with fresh water.

- Fittings i.e. stopcocks, valves, flexible connectors, bends, etc., shall be provided where necessary and in accordance with good engineering practice.

- Main valves and switches on pipe works shall be stenciled to indicate their use.

- All piping shall be tested before used as described in the specification.

- Fittings on chromium plated brass pipe shall be cast brass, malleable iron pattern, finished and chromium plated.

- A friction wrench shall be used on plated pipe and fittings. Cut, dented or bruised pipe will not be allowed, and if found installed, shall be removed by the Contractor.

- All ends of pipe shall be reamed and filed and all burrs removed from the interior of it.

- All hot and cold-water piping shall be installed so as to pitch to drain to accessible locations.

- Generally, all piping shall be run concealed in chases or pipe spaces adjoining fixtures or shall otherwise be concealed in walls, unless otherwise indicated.

- Air chambers, set 800mm high full size of branch shall be installed at the end of all hot and cold water supplies to fixtures. Shock arrestors shall be provided for all water lines to equipment with quick opening and closing valves.

- All exposed piping valves and fittings in toilets shall be chromium plated. All exposed pipe work elsewhere which is not chromium plated, shall be covered according to the specifications.

- All ends of pipes, including those extending above roof, drains, and fixtures shall be closed with caps or plugs so as to prevent dirt or building material from getting into pipes or traps, during erection.

- Dielectric fittings shall be used to connect nonferrous pipe and equipment to ferrous pipe and equipment.

- All metal pipe work conveying water shall be protected from electrolytic action by the installation of non-conductive or fiber type nipples to mechanically separate copper pipes (*if used*) from galvanized tanks or galvanized steel pipe work. Where the water is acidic, approval shall be obtained of the solution to avoid possible corrosion due to electrolytic action.
- In areas where certain water or soil conditions could cause dezincification on brass fittings, valves, etc., then the gunmetal type shall be used throughout.

- Approval shall be obtained prior to ordering materials, which may be affected by dezincification, and the correct materials shall be used throughout the system.

- Ample provision shall be made for expansion of pipe work and expansion loops constructed from steel pipe and fittings. Purpose made expansion joints and anchor points shall be provided on the drawing or as directed by the Consultant or his representative.

- All expansion loops or breaks shall be 'cold stressed'. All pipe runs shall be approved by the Consultant, before installation.

- All pipe work passing through walls, ceilings and floors shall be provided with sleeves of suitable size to allow free movement of the pipes, and be constructed of a similar material to that of the pipe.

- All vents, stacks and in general any pipes within the building extending to outdoor under direct sunlight should be made of P.P.R. with joint protection (the portion extending outdoors), PVC is not allowed on all cases to be used.

- Sleeves shall be of sufficient length to finish flush with finished face of wall or ceiling and 13mm proud of the finished face of all floors except where shown otherwise on the drawings. Sleeves shall be retained in position before making good by lugs or plates.

13. INSTALLATION OF UNDERGROUND PIPING

TRENCHING

Trenches shall have shape and dimensions as shown in typical details according to the diameter of pipes that will be laid in.

The excavated material should be placed on one side of the trench at a safe distance. Stones and rubble should be gradually removed to avoid the possibility of their falling accidentally on the pipes. When the excavated material is made up entirely of stones and rubble (when excavating in rocky areas) it has to be removed from the neighborhood of the trench before any attempt of laying the pipes.

The bottom of the trench should be leveled so that the full body of the pipe rests on even bed. Big stones and rocky protrusions must be removed very carefully

PIPE LAYING

All precautions shall be taken to protect the pipes, and prior to installation all pipes shall be checked for soundness and cleanliness. Any material found to be defective shall be marked and removed from the trench in such manner that neither the pipe nor the trench will be damaged or disturbed and so as to prevent earth or debris from falling onto the previously prepared pipe bed. Under no circumstances shall water main materials be dropped or dumped into the trench. Particular care must be taken to prevent scratching or otherwise damaging the surface of the pipe.

Pipes and fittings shall be laid and jointed according to the manufacturer's instructions to give a watertight structure, true to line and grade.

At times when work is not in progress, open ends of pipe and fittings shall be securely and satisfactorily closed with caps supplied by the Contractor as recommended by the pipe manufacturer so that no water, earth or other substance will enter the pipe or fittings.

All pipes must be inspected and approved by the Consultant before they are covered.

PIPE BEDDING AND SURROUND

All pipes shall be bedded and surrounded in accordance with the drawings.

Bedding and surrounding shall be granular material free from rocks as specified.

GENERAL

The granular bedding and fill shall be carried out the depths and positions as shown on the Drawing.

The bedding material shall be carefully placed on the bottom of the prepared trench; hand tamped and shaped to fit the lower portion of the pipe barrel, all to the minimum thickness shown on the drawings. Care shall be taken to ensure that the pipe will be uniformly supported on the bedding material and under no circumstances shall large stones, rock projections or other hard objects be permitted to come in contact with the pipe.

When pipe has been laid on its bedding, additional bedding material shall be placed and thoroughly compacted by hand in successive layers not exceeding 150 mm thickness up to the top of the pipe. The material shall be placed on both sides of the pipe simultaneously and shall completely fill the spaces between the pipe and the trench wall and under the haunches of the pipe.

In all cases it is essential to properly compact the bedding around the sides of the pipe. Care shall be taken to ensure that the alignment and grade of the pipe is not disturbed during the operation. Couplings should be left exposed until the line has been tested.

BACKFILLING OF TRENCHES

Following successful testing of each length of pipe the remaining surround material shall be placed and backfilling commenced. The first layer shall consist of selected material from the excavation not containing material larger than 50mm sieve size. Heavy mechanical compactors shall not be used.

All the unsuitable material i.e. soft materials, asphalted chunks, stones larger than 60mm, organic materials, metal, debris etc. shall not be used for backfilling and shall be removed from the site. Where unsuitable material is encountered in excavation it shall be replaced for backfilling purposes with selected granular material from approved sources and shall consist of good hard granular screened desert fill within the following grading limits:

B.S. Sieve Size	% By weight passing
63.5mm	100
37.5mm	85-100
20mm	60-80
10mm	40-65
5mm	30-50
2.36mm	20-40
600 Microns	10-25
75 Microns	0-10

When the trench is excavated below the level of the base, the excess excavation shall be filled and tamped, in the same manner as the base at the Contractor's expense.

COMPACTION

Compaction of the backfill shall be carried out in layers not exceeding 150mm thick after compaction using vibrating plate compactors or rollers.

Mechanical compaction shall not be carried out below a minimum distance of 300mm from the crown of the water pipe, where only hand tapping (compaction) is allowed.

The backfill material shall be deposited and spread in uniform, parallel layers not exceeding 150mm thick after compaction. Before the next layer is placed, each layer shall be compacted as required so as to obtain a thoroughly compacted mass to at least 95% maximum Dry Density at optimum moisture content.

Where instructed by the Consultant, the Contractor shall carry out at his expense such tests as are required to confirm that compaction has been carried out in accordance with this Specification.

10. HOT AND COLD WATER SYSTEM

Hot and cold water pipes and fittings shall be PPR or approved equal complying with British Standards. But all cold main underground water pipes feeding the garden and buildings shall be polyethylene or as mentioned on the drawing.

The Engineer on the site can change the type depending upon the necessity and situation.

PE –X WATER PIPES

1. Pipes shall be made from cross linkable molding mass manufactured on the basis of high density polyethylene (Pe-x).

2. Pipe ends should be cut as square as possible to the pipe axis. Pipes shall be free from any blisters and irregularities (including foreign matter) which could affect their performance. Pigmentation shall be uniform throughout.

3. To ensure the pipe pliability and easy removal/replacement, it is necessary to follow the instruction listed hereunder.

   a. When laying pipes on floor, small bend (might be S OR C shape) must be done with out exaggeration to allow for expansion and contraction of the pipes.

   b. Bending of the pipes must be performed with the attention not be reach the critical angle which might damage the pipe. The minimum bending radius is eight times the outside diameter of pipe. All bends from floor to wall must be done using bend former.

   c. Protect the pipes from the exposure to the direct sun rays, these pipes not to be used externally.

   d. Protect the pipes from the exposure to the direct sun rays, these pipes not to be used externally.

   e. Do not heat the pipe with naked flame or any other heating sources.

PIPE, VALVES AND FITTINGS (UNDERGROUND)

1. Pipes shall be made from cross linkable molding mass manufactured on the basis of high density polyethylene (Pe-x).

2. Pipe ends should be cut as square as possible to the pipe axis. Pipes shall be free from any blisters and irregularities (including foreign matter), which could effect their performance. Pigmentation shall be uniform throughout.

3. To ensure the pipe pliability and easy removal/replacement, it is necessary to follow the instructions listed hereunder:

   a. When laying pipes on floor, small bend (might be S or C shape) must be done without exaggeration to allow for expansion and contraction of the pipes.

   b. Bending of the pipes must be performed with the attention not to reach the critical angle, which might damage the pipe. The minimum-bending radius is eight times the outside diameter of the pipe. All bends from floor to wall must be done using bend former.

   c. Protect the pipes from the exposure to the direct sunrays, these pipes not to be used externally.

   d. Protect the pipe and the sleeve from any possible damages.

   Do not heat the pipe with naked flame or any other heating sources.

POLYETHYLENE PIPES (HDPE)

High Density Polyethylene Pipes and fittings shall conform to B.S. 1972, 1967 (as amended 1977). Pipe shall be tube type and the class of pipe shall be D (173 PSI).

Pipe and fittings shall not be stored in conditions where ambient temperatures may cause distortion or damage.

uPVC PIPES

uPVC pipes shall conform to B.S. 3505 Class 'E'.

COMPRESSION FITTINGS FOR POLYETHYLENE PIPES

Fittings for HDPE Pipes shall be Gunmetal to B.S. 1400 Grade LG2, including liners, and be purpose designed for use with the pipe specified. The size of the fittings shall be designated by the nominal size of the pipes stated in B.S. 1972.

Cold Water Pipe & Fittings

Cold water pipe fittings shall be conforming to British Standard.

Piping Joints - Capillary

Fittings shall have solder ring. Any other or additional joint shall be made with lead free solder. The following assembly shall always be made:

a. Select the correct size of tube and fitting. Ensure that the ends of the tubing are cut square.

b. Clean outside of tube and socket of fitting with fine "sand paper" or steel wool.

c. Apply adequate but not excessive, flux to both the outside surface of the tube and inside surface of the fitting.

d. Insert the tube into the fitting until it reaches the tube stop and wipe off any excess flux.

e. Heat the fitting and tube, continuing until a complete ring of solder appears at the mouth of the fitting.

f. Allow the joint without disturbance.

g. Clean the joint thoroughly.

Compression Joint

a. Select the correct size of tube and fitting. Ensure that the ends of the tubing are cut square. With a fine-toothed hacksaw remove burr inside and outside and check that tube is free from reeds, deep scratches or other surface imperfections. Insert the tube up to the tube stop in the fitting.

b. Tighten the compression nut by hand.

c. Complete the joint by tightening the nut (a "Kuterlite" spanner is recommended). In sizes up to 28mm 1 to 1 1/4 turns of the nut are required to key the ring on to the tube. Above this size, experience will indicate how much additional tightening is necessary to ensure the ring firmly grips the tube. An arrowhead is stamped on each nut as a guide to how far it should be tightened.

Bending

Wherever used and approved by the supervisor the bending shall be made as follows: -

- For the installation for plain tube between 12mm and 22 mm, table X tube can be easily bent either on a bending machine or with approximately sized bending springs. The spring bending shall consist of an external and internal bending.

- For the installation of all sizes of the plastic covered tubes and for plain tubes over 22mm a bending machine shall be used with appropriate size, fitted with accurately machined, matched formers and guides, which should always be used in matched pairs.

Piping Supports

All pipes shall be supported from the building structure in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on trapeze type hangers. Vertical risers shall be supported at each floor line with steel pipe clamps. The use of wire or perforated metal to support pipes or Hanging pipes from other pipes will not be permitted.

Intermediate supports should be provided for long lengths of pipe where necessary in accordance with the following table:

NOMINAL INTERVALS SIZE IN	NOMINAL BORE OUTSIDE DIA.	MAXIMUM INTERVALS FOR VERTICAL RUNS	MAXIMUM FOR HORIZ. RUNS
MM	MM	METRES	METRES
12	12	1.2	1
15	15	1.8	1.2
20	22	2.4	1.8
25	28	2.4	1.8
30	35	3.0	2.4
40	45	3.0	2.4
50	54	3.0	2.7
65	67	3.0	2.7
75	76.1	3.6	3

Piping Supports

All pipes shall be supported from the building structure in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on trapeze type hangers. Vertical risers shall be supported at each floor line with steel pipe clamps. The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes will not be permitted.

Intermediate supports should be provided for long lengths of pipe where necessary in accordance with the manufacture’s recommendations.

VALVES

1. Float operated ball valves shall be of the gunmetal 'Portsmouth' type up to 20mm diameter to BS 1212 and shall be of the low, medium or high pressure type to suit operating conditions and shall be stamped accordingly. They shall be complete with a rubber or similar washer and have a copper float to BS and a gunmetal float arm.

   Valves above 20mm shall be the gun metal piston type to BS 1212 of gun metal construction complete with a synthetic disc and piston bucket and a gun metal float arm and a copper ball float BS. All ball valves to be fitted with a silencer discharge tube.

2. Stop-Valves shall be gunmetal screw down pattern to BS 1010 marked with manufacturer's name or trademark, the size and BS number. The stopcock used on the cold water feed pipe to the water heater shall be to the following specification, such as supplied by Yorkshire Imperil Fittings No. 222 or equal and approved by the Engineer, plug stopcock, copper X male thread with back nut, full round bore suitable for low pressure water services and capillary solder joint to pipe work.

3. Automatic Air Vent shall be made of bronze.

4. Pressure relief valve shall be of bronze.

5. Drain Valves for water tanks shall be same model as the water services stop cocks.

STORAGE TANK

The capacity of the tanks will be as shown on the drawings, and should be one of the followings materials:

a. Glass fiber cold water storage tanks

Shall be of the capacity and shall comply with the general requirements of BS 4994 and shall be of approved manufacture. They shall be white flow finish and be produced by a closed mould process such as vacuum-assisted resin injection so as to give an ex-mould surface both internally and externally. They shall be fitted with a GRP dust cover with an approved locking mechanism. Sufficient vertical plane surfaces shall be incorporated to allow fixing of all inlet and outlet pipe work.

The water tanks and pipes shall be provided with gate valve non return valve, ball valve, globe valve, overflow and drain pipe, 'Y' strainer, stopcock, float switches and low level alarm switch together with respective wiring. Place tanks on 200mm reinforced concrete base (the concrete surface should be smooth finish) with 18mm marine plywood platform.

b. GRP sectional tanks

GRP Sectional Tanks are manufactured to the requirements of EN 13280-2001 and incorporating the quality control requirements of BS 4549 Part 1, and panel laminate structural requirements of BS 4994. All internal panel surfaces to be isophthalic gel-coated to improve resistance to bacteriological growth. Resin shall be top grade orthophthalic and pigmented to BS 4800 color 10.A.07 and shall be resistant to ultra-violet attack. Reinforcement glass to be 'E' glass type and to be long stranded (40mm minimum). The proportion of resin to glass shall be no less than 30% w/w. The bracing system shall be designed to maintain the tank structure under fluctuating loads and must not exert point loads on the tank panels. All internal bracing components shall be in stainless steel to grade 18/8 BS 970. All external supports to be hot dip gallivanted to BS 729 part 1 and must not exceed the gross external tank dimensions by more than 50 mm.Full height division, when incorporated in a tank, shall be supported by the same method as the side walls of the main tank structure, and provide individual leak tight compartments. (All wetted internal bracing parts to be in stainless steel). The tank shall be supported in accordance with the tank manufacturer's recommendations and tolerances. Connections and provision for connections to be factory fitted in positions as indicated on the contract drawings and within the panel laminations. 1000mm square access man ways shall be provided in positions adjacent to ball valve entries in each compartment. Internal stainless steel and external MS galvanized ladders shall be fitted to tanks in excess of 1.8 meters depth upon request. Screened overflows, warning pipes and cowl vents shall be fitted to comply with the water requirements.

c. Polyethylene (PE) vertical or horizontal tanks

The polyethylene material tanks should be complying with the **FDA (F**ood & **D**rug **A**dmins**.)** requirements:

- The PE tanks should especially design with a smooth inner layer that resists growth of algae and bacteria.

- It should be leak proof and one piece, molded body has no joints and absolutely maintenance free.

- The polyethylene granules used in the construction of the tanks ensure it is strong, durable and free from corrosion.

- It is designed for easy handling, mobility and installation.

- A special, threaded cover ensures that the tank and its contents cannot be tampered with.
- Strong membrane ribs that counter “hoop stress” help reinforce the tank.

- The tanks should be suitable for overhead and underground applications, adaptable to a variety of application: in house hold, water supply schemes, and agricultural farms.

- Tanks exposed to weather should be constructed of four layers (UV protector, Sun shield, Thermal insulator & Portability enhancer)

Physical Properties for Polyethylene tanks

Melt index	5.0g/10 min.
Vacant softening	115 celsius
Density	0.935g/cubic cms
Bulk density	0.420g/cubic cms
Tensile strength @ yield	2600 psi
Tensile elongation yield @ break	700%
Flexural strength	2800psi
Flexural modulus	105000psi
Environmental stress-crack resistance	50-300 hr.
Toxicity	free from toxic
Water absorption	0.20%

AUTOMATIC ELECTRIC WATER HEATERS

The Heaters shall be of western type body of corrosion proof steel finished in white stove enamel with heavy orange high pressure copper tank insulated by non-hygroscopic and fire resisting glass fiber equipped with factory built thermostat. The internal surfaces of the water heaters exposed to water shall be glass-lined with an alkaline borosilicate composition fused to steel. Heaters shall have a maximum working pressure of (10 Bar) with a separate 20mm tapping for relief valve installation and a rigidity supported anode rod for maximum cathodic protection. Electric heating element shall be zinc plated copper sheath. Screw in design. Element operation shall be double element, non simultaneous (or a single element). The controls shall include a thermostat with each element and a high temperature cutoff. The jacket shall provide full size control compartments for performance of surface and maintenance through front panel openings and enclose the tank with foam insulation. The drain valve shall be located in the front for ease of servicing. Outer jacket shall be baked enamel finish. Heaters shall have 6 year limited warranty for residential operation, I year for commercial installation, as outlined in the written warranty. Fully illustrated instruction manual to be included. Heaters shall meet the minimum energy factor required by comply with British Standards, UL standards, tested and approved. Any change as per the availability in the market can be done and approved by the Engineer.

Unit to bear Underwriters' Laboratories label of approval.

MANUFACTURERS OR APPROVED EQUAL:

A.O Smith	(USA)
Johns Manville	(USA)
St. Gobain	(France)
Fiberglass Ltd.	(U.K)
Rheem	(USA)

TRANSFER PUMPS

a. Provide intermittent duty stainless steel pump set, the pump set to be self-contained, fully automatic package unit complete with control panel and all related accessories. The quantity and duty of the pumps set shall be indicated on the drawing.

b. The pumps shall be totally enclosed couple centrifugal pumps with Class E insulation with auto-changeover panel for stand-by running operations and suit the power supply. In the case of three phase pumps the starters shall be provided with thermal overload and single-phase protection. The pump set shall be provided with two equal duty pumps controlled by pressure switch/timer control.

c. The pump set shall include all piping, valves, strainers, manifold, and auto-charger panel suitable for electrical connection to ED regulations.

BOOSTER PUMPS

a. Provide stainless steel pump set with pressure vessel. The duty of the pump set shall be indicated on the drawing.

b. The pump shall be totally enclosed couple centrifugal pump with Hydro scan control panel. In the case of three phase pumps the starters shall be provided with thermal overload single-phase protection. The pump set shall include all piping, valves strainers, manifolds, control panel and suitable for electrical connection to ED regulations.

DISINFECTION OF WATER SYSTEM (WATER SUPPLY)

1. Upon completion of all tests and necessary repairs or replacements, all water piping systems shall be subjected to a disinfections procedure as herein specified.

2. The systems to be disinfected shall include hot, cold and recirculation water piping and any other systems that may be connected to the same supply source. The disinfection shall be applied to all piping included in the contract from the main cut-off valve through pumps and other appurtenances connected thereto.

3. These systems shall be thoroughly flushed with water to remove sediment. Following this flushing, they shall be disinfected in accordance with one of the following methods:

   a. The systems shall be filled with a solution containing 50 parts per million of available chlorine. The solution shall be retained in the systems for not less than four (4) hours and then drained.

   b. The systems shall be filled with a solution containing 100 parts per million of available chlorine. The solution shall be retained in the systems for not less than two (2) hours, and then drained.

   c. After the systems are drained, they shall be thoroughly flushed with chlorinated water and to submit a certificate from Ministry of Health or independent body confirming the appropriateness of water supply system for general use, before returning the system to service.

CENTRAL WATER FILTRATION SYSTEM

1. Tendered is to allow for supply a central filtration system as specified including installation, testing, commissioning and maintenance period.

2. The system shall be connected to the main plumbing by a "by pass".

3. Tendered is to allow for all plumbing, civil and electrical works associated with the filtration system.

4. Catalogues and Schematic diagrams must be approved prior to installation.

   a) The filtration system shall control and eliminate the following:

      Provide Sand filter, GRP Composite tank Dia as per dwg. For sediment and turbidity removal, filter rating 10 micron., fully automatic backwash system via a rayned control valve.

   b) The System Shall be of 2 Nos. filters of the size & Dia as per dwg Height and to be installed in parallel

   c) The system shall be installed after the filter booster pump set in between the raw water tank & filtered water tank

   d) Provide Duplex Water Softener, GRP composite tank Dia x Height as per dwg consisting of two softener units, each softener shall be capable of providing a continuous flow rate of : as per dwg and total flow rate of as per dwg, utilizing Resin as the primary layer for the removal of calcium and magnesium (hardness),

   e) 1 No. Stainless Steel 316 Ultraviolet sterilizer complete with time meter and lamp failure, for the flow of as per dwg. to be installed after the supply water line for the top floors

   f) 3 Nos. Stainless Steel 316 Ultraviolet sterilizer complete with time meter and lamp failure, for the flow of as per dwg to be installed after the supply gravity line for complete building.

5. Filter Booster pump set (1 Duty + 1 stand-by) complete with full accessories, control panel, skid & float switch, matching the flow rate of filter.

6. The system shall operate completely automatic and trouble free. All filters shall employ automatic backwash via automatic control valve time clock, to automatically backwash and rinse on periodic basis in order to clean and reclassify the filter media.

7. All filters shall be of heavy duty fiberglass construction of 150 psi working pressure.

11. SOIL WASTE AND DRAINAGE SYSTEM

DESCRIPTION OF THE SYSTEM

All soil and waste from various fixtures and fittings shall be conveyed through pipes as shown on the drawings.

PIPES AND FITTINGS

1. All above ground soil, waste and vent pipes and fittings 75mm and above shall be uPVC pipes to BS 4514.

2. All above ground waste and vent pipes and fittings 50mm and below shall be uPVC pipes to BS 5255.

3. All underground gravity soil and waste pipes and fitting shall be uPVC pipes according to BS 4660.

4. Floor/ceiling cleanouts shall be provided for all drainage piping as shown on the drawings and or as required.

5. All horizontal drainage piping shall have a minimum slope of 1: 50 except as otherwise noted on the drawings.

6. All pipes and fittings shall be as supplied by Caradon Terrain **or equal approved**.

THERMAL EXPANSION

Where piping is installed in such a way as to prevent slight movement a seal ring shall be used between the fixed points.

Where boss or branch connections are made into the stack the maximum distance between those entries and the nearest fixed point shall not exceed 510mm (20 ins). For all other support and fixing centers see table hereafter.

Where pipe work penetrates fire barriers, the pipe work must be fire stopped but capable of thermal movement.

The fixed points on the stack are the drain connections and the WC branch on the first floor. Provision for thermal movement must be made between these points. Where there are no ground floor connections a "key Terrain" number 132 or number 133 caulking bush should be used for the drain connection.

Where a sink or other connection is made to this stack, it is preferable to use a 'key Terrain' number 111 expansion coupling above the connection (if access is required use a 'key Terrain' A4 with a number 134 caulking ring on the foot of the stack). The WC branch should be fixed to ensure stability at this point. The vent pipe above the bossed connections shall be provided with:

a. Expansion coupling above the highest boss on the stack, or

b. Seal ring adaptor fitted to the lowest socket of the offset.

FIXING OF PIPEWORK

The fixings used shall comply with the following minimum requirements:

1. The wall thickness of fixings manufactured from uPVC shall in no case be less than that of the pipe with which they are to be used.

2. In the case of eared fixings the centre-to-centre dimension fixing of the holes should be such as to avoid damage to the pipe when installing the system with the pipe in position.

3. When assembled the pipe and fixing should provide a secure installation.

4. Every length of pipe shall be independently supported. Intermediate supports shall be provided for long lengths of pipe where necessary in accordance with the following table:

Nominal size	Nominal Outside	Maximum Support Distance		Maximum exp. Joint distance vertical and horizontal
		Vertical	Horizontal	
mm/inch	Dia. mm	Meters/Feet	Meters /Feet	Meters / Feet
30 1 1/4	36.35	1.2 4.0	5 1.7	1.8 6.0
40 1 1/2	43	1.2 4.0	.9 1.7	1.8 6.0
50 2	56	1.2 4.0	.9 3.0	1.8 6.0
75 3	82.6	1.8 6.0	.9 3.0	3.6 12.0
100 4	110	1.8 6.0	.9 3.0	3.6 12.0
150 6	160	1.8 6.0	1.0 3.3	3.6 12.0

5. Any metal fixing shall be suitably protected against corrosion.

6. Screws for use in brickwork, concrete or masonry should be non-corrodible, not less than 45mm (2 inches) long and of minimum size No.12.
7. Pipe shall be fixed at a minimum distance (from the outside of the barrel of the pipe) of 25mm from walls.

8. Seal ring expansion joints shall be provided on fittings by means of a seal ring adaptor so that thermal movement between fixed points can be taken up.

9. Care must be taken to anchor each unit of pipe work to prevent accumulative movement or escalation, which in extreme cases can lead to pulling out of joints.

10. Seal ring joints shall be used between fixed points if they are more than 900mm (3 ft) apart.

11. In suspended horizontal pipe work the brackets at expansion points must be braced to ensure fixed points. Suitable brackets are available as proprietary items or can be purpose made. It is essential that the width of the clamping ring should not exceed 22mm (7/8 inch) for size number

160mm (6") socket and 15mm (5/8 inch) for number 110mm (4") or number 75mm (3") socket.

MANHOLE

1. All manholes shall be constructed strictly in accordance with the specification and requirements of Bahrain Municipality.

2. Manhole shall be provided at every point at which a sewer changes either its direction or its gradient and elsewhere so as to ensure that the maximum distance between manholes does not exceed 20 meters.

3. Manhole shall be of sufficient size to allow access to the drain for Roding. Shallow manholes (less than 1000 mm deep) shall normally be 800 mm x 800 mm.

4. Deeper manholes shall be not less than 1200 mm long and 900 mm wide or have an internal diameter not less than 1000 mm when it is circular.

5. Manhole shall be constructed of concrete brickwork; in site concrete or precast concrete sections in such manner as to exclude all subsoil water and surface water. The concrete brickwork, in situ concrete or concrete sections shall be carried up to ground or floor level and shall have a concrete roof slab and be provided with a double sealed manhole cover of suitable duty to DIN or approved equivalent standard.

6. Covers for shallow manholes shall have a clear opening of not less than 600mm by 450mm. Covers for deeper manholes shall have a clear opening of not less than 600mm by 500mm. The minimum thickness of concrete brickwork shall be 200mm.

7. Benching shall be formed above the level of every drainage channel in a manhole and fall towards the channel at a gradient of1 in 2.

8. The benching of every manhole shall be rendered with cement mortar to provide a smooth and impervious surface.

9. Every drainage channel in a manhole shall have a diameter not less than that of the largest drainage inlet into, and not more than that of the outlet from manhole or inspection chamber.

10. Every drainage inlet into a manhole shall discharge into the drainage channel therein with properly made bends constructed within the benching of the manhole, such that the flow travels in a similar direction to that in the channel.

11. The manhole cover shall be as manufactured by Glynwed B.B.I. UK or equal approved.

12. Manholes should be coated with one coat of approved epoxy paint.

FLOOR DRAINS / CLEAN-OUTS

All floor drains and floor clean-outs shall be of appropriate type as supplied by WADE U.K (or approved equal) and shall be series of VARI-LEVEL with nickel bronze grating and cover with cast iron body.

INSPECTION CHAMBERS

Inspection chambers may be performed of M.D.P.E. and shall be the same as those complying with Agreement Certificate 83/1135 supplied complete and suitable for use with 110 mm diameter UPVC pipes or 100 mm diameter sleeve-jointed vitrified clayware pipes.

INSPECTION CHAMBER COVERS

Inspection Chamber Covers and frames shall be coated cast iron complying with B.S. 497 and double seal as detailed on the Drawings or plant, frame and cast iron cover as suitable with pre-formed inspection chamber.

SEPTIC TANK /SOAKPIT

Septic tank and soak pit shall be constructed with the Government standard as shown on the drawing, the quantity of the septic tank shall be shown on the drawing.

GENERAL NOTES ON SEWERS

1. All materials and workmanship shall comply with the relevant British Standard or Code of Practice except as amended herein and should apply equally to insitu and precast concrete.

2. The Contractor shall submit to the Engineer samples of all materials proposed to be used for the works, together with a list of suppliers to be employed. The Engineer's consent in writing shall be obtained to all such samples and sources of supply before concreting work is put in hand No changes shall subsequently be made without the Engineer's approval. The Engineer shall have access to all sources of supply for the purpose for inspecting and taking samples.

3. Concrete mixes indicated assume no adverse ground conditions or impure constituents in the concrete. All relevant tests shall be carried out prior to construction and the results presented to the Engineer for approval. Precautions shall be taken where necessary under a further specification prior to any works proceeding.

4. All concrete work shall be in accordance with relevant concrete work specifications.

5. The Contractor shall check any levels of existing sewers, and manholes, before any sewerage work is commenced and shall notify. The Engineer immediately if the declared levels prove to be inaccurate.

6. The bottoms of all excavations shall be trimmed and consolidated to the correct levels. Unauthorized excavations below the required levels shall be filled with concrete of the same composition as for sewer beds or approved sand at the Contractor's expense. Where the bottom is insufficiently firm the Contractor shall excavate until, in the Engineer's opinion, a firm bottom is obtained and the level shall be made up with concrete of the same composition as for sewer beds. Care shall be taken not to undermine the foundations of buildings and, if so directed by the Engineer, earthwork support shall be left in or other means adopted to protect the foundations. Particulars of such additional work shall be agreed with the Engineer before the work is covered up, otherwise no claim in this respect will be entertained.

7. Sewers shall be laid truly straight and to line and gradient and the full bore shall be unobstructed.

8. All sewers passing through walls or concrete shall have sleeves of sufficient size to allow a clearance round the sewer, packed with polystyrene as detailed on the Drawings.
9. All pipes laid shall have grade ratio of 1:50.

10. Necessary traps shall be provided for all the sanitary-ware and fixtures.

11. All pipes in the building shall be provided with proper venting.

12. Necessary clean out shall be provided to allow for future maintenance.

13. All floor drains shall be provided with traps.

UPVC PIPES & FITTINGS

1. Pipes and fittings are to be approved UPVC and shall conform to BS 4660 (unplasticized PVC underground sewer pipes and fittings). The pipes and fittings shall have a minimum softening point of 81 degrees C and 79 degrees C respectively) when measured in accordance with the vacate deformation temperature test specified in method 102J of BS 2782 (Methods of Testing Plastic).

2. Identification markings giving the Manufacturer's mark and the nominal size shall be stamped on to each of the fittings. In addition each pipe shall have an adhesive label bearing the B.S. kite marking referring to B.S. 4660 and the Agreement Board identification mark incorporating the number of the certificate. If a supplier is unable to supply pipes and fittings with the above markings the Contractor shall obtain from him a letter of guarantee that this material conforms to the above requirements and shall furnish the same to the Engineer for his written approval.

CONCRETE BEDS AND SURROUND

Concrete beds for sewer shall be used if there is less than 600mm cover to the pipe and shall be a minimum of 150mm thick surround to the pipes and finished to the correct gradients. After testing, the sewer shall be haunched up on both sides in concrete to half the diameter of the pipe or shall be surrounded with concrete 150mm thick as detailed on the drawings.

12. INSPECTION TESTS AND ADJUSTMENTS

The Contractor shall test all of the equipment installed under this specification / contract and demonstrate its proper operation to the Consultant. No final inspection and test results will be accepted without the prior formal notice, by letter or fax to the Consultant and his presence or representation during the test is deemed necessary:

- The Contractor shall furnish all necessary labor, fuel, water and appliances required for the tests and shall meet all expenses of said tests.
- The Contractor shall also furnish the electricity (generator or otherwise) required for the testing of all the equipment under this subcontract.
- The Contractor shall take all necessary measurements for the safe execution of the tests and shall bear all the responsibility for any damages or losses, which might be the result of his actions.
- If tests show that the work is in any way defective or at variance with the specification requirements the Contractor shall immediately make all changes necessary to correct the same and remedy defects to the satisfaction of the Consultant. In the event the Contractor does not remedy all defects and make all changes demanded by the Consultant within a reasonable time, the right is reserved to have defects remedied or charges made and to charge the cost of it against the account of the Contractor.
- All piping that is to be painted shall be thoroughly cleaned to remove dirt and grease or oil. All piping shall be flushed out prior to testing of equipment and all strainers shall be cleaned.
- All soil / waste / vent/ condensate piping, above the ground floor line must have the openings plugged where necessary and be filled with water to the level of the main roof or tops of vent pipes. The water shall be allowed to stand at least 30 minutes for inspection, after which, if the lines prove tight, the water is to be drawn off the fixtures connected.
- All below ground soil/waste pipe work shall be tested in accordance with BS 8301.
- Any water-piping run in chases in walls, or in any way concealed by structural work must be tested and proved tight before the pipes are concealed.

  All HDPE or uPVC series 5 pipes and fittings must be hydrostatically tested to a pressure of 100 meter head of water.

13. RAIN WATER / STROM WATER DRAINAGE SYSTEM

Rain water / Storm water drainage system piping shall be provided with suitable slope to facilitate water drainage from roof with direct drain outlet at ground level. The layout and sizes of pipes shall be as indicated on the drawings. Contractor to take note of screed slops required on the roof and should allow for it in his price.

PIPING

Above ground and belowground 160mm and below shall be uPVC pipe and fittings to BS 4660.

ROOF DRAINS

Roof Drains shall be as manufactured by WADE or equal and approved.

14. TESTING AND COMMISSIONING

Prior to the completion of all the works described herein or shown on the drawings the Contractor shall prepare and submit to the Consultant Engineers a program and necessary data for the testing and commissioning of all the services and installations.

The contractor shall submit those data in a tabular form and graphs shall be drawn by the contractor as agreed with the Consultant Engineer.

After the consideration of the above by the Consultant Engineer, the Contractor may be directed to execute adjustments or modifications on the system until its performance satisfies the design intent. Testing and Commissioning of all electrical and mechanical services should be carried out in accordance with the relevant British or International Standards together with rules and regulations:

1. Access shall be afforded at all times to the Engineer to enable him to inspect the A/C Equipment.

2. Tests shall not commence before the schedule of test has been approved and such other tests as may be required by the Engineer shall be included within the schedule or tests.

3. The Contractor shall give to the Engineer in writing at least ten days notice of the date by which he will be ready to make the specified tests on completion of installation. Unless otherwise agreed the tests shall take place within seven days after the said date on such day or days as the Engineer shall in writing notify the Contractor.

4. The tests shall as far as possible be carried out under normal working conditions to the satisfaction of the Engineer and shall extent over such periods as may direct.

5. The Contractor shall provide all skilled labor, supervision, apparatus and instruments required for testing and commissioning and within a reasonable time thereafter furnish to the Engineer a total of six certificates of all tests performed and accepted, signed by the Contractor, or an authorized person acting on his behalf, as prescribed in the appropriate regulations and specifications.

6. Each completed system within the installation shall be tested as a whole under normal site operating conditions to ensure that each component functions correctly in conjunction with the rest of the system.

7. The Contractor's Particular attention is drawn to the requirements of the specification in regard to testing, commissioning and handover of the works.

A. TESTING REQUIREMENTS

1. All tests shall be carried out in the presence of the Engineer.

2. Not withstanding the above, the testing requirements shall be endorsed by the specific requirements set out in the Specification for specialist installations, and to the particular performance standards therein.

3. The following tests shall be carried out, as appropriate or when required by the Engineer.

4. Where modifications and alterations on existing system and installations are to be undertaken then the Contractor shall carry out all necessary tests to establish the integrity of such systems and installations before any modifications and alterations are commenced and again when such modification and alterations are completed.

5. All sewers must be tested in accordance with the appropriate BS by means of an air test and by a water test should the air test nor be passed.

6. Inspection Chambers must be tested by an internal hydrostatic test.

7. All Sewer lines are to be flushed clean.

15. MAINTENANCE AND WARRANTIES

1. The Contractor shall maintain, replace, repair with utmost speed and at his own expense, any part of the plant or material or work performed or furnished under the contract which may prove defective in design, erection, operation, performance, workmanship or from any act of omission on the part of the Contractor that may develop under the conditions provided for by the contract and under proper use in the Works or any section thereof within three hundred and sixty five (365) days after the date of practical completion.

2. The Contractor shall obtain and submit to the Engineer any guarantee or certificates of warranty available from the manufactures, but only as supplementary to the Contractor's own quarantine and in no way invalidating them.

3. If any defect as above mentioned should occur, the Employer shall inform the Contractor thereof, stating the nature of the defect and if the contractor replaces or renews any portion of the works, the provisions of this Clause shall apply to the portion of the works so replaced or renewed as if that portion had taken over on the date of replacement or renewal.

4. If any defects are not remedied within a reasonable time, the Employer may proceed not do the work at the Contractor's risk and expense.

5. If the replacement or renewals are of such a character as may affect the efficiency of the works or any portion thereof, the Employer may, within one (1) month of such replacement or renewal give to the Contractor notice in writing requiring that tests at site be made, in which case, such tests shall be carried out as provided in details of tests upon completion earlier in this section.

6. These Specifications shall apply to all inspections, adjustments, replacements and renewals as well as to all test associated thereby carried out by the Contractor pursuant to the Clause.

7. The Contractor shall include for complete monthly rerouting maintenance checks of all plant and equipment provided by him under the contract, throughout the whole aquatinted maintenance period to demonstrate that the operation of the completed system including the automatic controls, interlocks and safety devices for the various plant and auxiliaries are in satisfactory working order.

8. All required checks or tests should be witnessed by the Engineer's representative. The contractor shall prepare and fill in the routine maintenance service chart carried out and the name of the Engineer's representative witnessing the test and shall submit same in duplicate to the Engineer after every check.

9. Until the final completion certificate shall have been issued, the Contractor shall have the right of access at all reasonable working hours at his own risk and expense by himself or his duly authorized representative whose name shall have been communicated previously in writing to the Engineer, to all parts of the works for the purpose of the working and performance thereof, for the purpose of inspecting the same and taking notes there from, Subject to approval of the Engineer which shall not be unreasonably withheld, the Contractor may at his own risk and expense make any tests which he considers desirable.

10. Before the termination of the Guaranteed Maintenance Period, the Contractor shall upon the request of the Engineer, assume responsibility for dismantling of any part of the plant and apparatus indicated by the Engineer. If such dismantling, however, necessitates the interruption of service of the works, such period of interruption shall not affect the extent of the Maintenance Period as provided for in this Clause.

11. Application for the Final Completion Certificate shall be made by the Contractor at any time after the Contractor has ceased to be under any obligation under" Guarantee Maintenance" provided that if a Taking Over Certificate has been issued in respect of any portion of the works, the Contractor may apply for a separate Final Certificate in respect of each such portion at any time after the said obligation has ceased in relation to such portion and provided also that, if by reason of the fact that it has become necessary for the Contractor to replace or renew any portion of the Works, the obligations of the Contractor under "Guarantee Maintenance" shall continue after the period first therein mentioned, the right of the Contractor to apply for a Final Completion Certificate in respect of the Works or portion thereof other than the portion so replaced

or renewed, shall not be affected by the fact and after the Contractor has ceased to be under any obligation under "Guarantee Maintenance" in respect of the portion replaced or renewed, he may apply for Final Completion Certificate in respect thereof.

12. The Contractor shall, at the same time, furnish the Engineer with a copy of his application for such Final Completion Certificate.

13. A Final Completion Certificate will not be issued until the Contractor shall have fulfilled his obligations under the Contract, and shall have delivered at site and handed to the Engineer all spare parts; if any included as per of his Contract.

14. A Final Completion Certificate shall, save in case of fraud or dishonesty relating to or affecting any matter dealt with in the certificate, be conclusive as to the sufficiency of the work under the Contract and of the value thereof.

WARRANTIES:

All products and installation shall be guaranteed for a minimum period of 365 days from the date of practical completion against manufacturing / installation defects, and the Contractor shall be responsible to remedy at his own expense any fault or defect including spares, labor and consumables which may occur during the above period.

END OF SECTION - 15400

SECTION – 15405

DRAINAGE

PART 1 - GENERAL

1.1 Reference

Conform to general requirements for Mechanical Services of Division fifteen.

1.2 Quality Assurance

1.2.1 Manufacturer Qualification

Firms regularly engaged in manufacture of floor drains, cleanouts and roof drains of types and sizes required, whose products have been in satisfactory use in the similar service for not less than 5 years.

1.3 Submittals

1.3.1 Product Data

Submit manufacturers' technical product data, installation instructions and dimensioned drawings for each type of items.

1.4 Maintenance Data

Submit maintenance data as per manufacturer recommendations. Include this data, product data, and certification in maintenance manual.

PART 2 - PRODUCTS

2.1 Materials

2.1.1 Floor Drains

a) Floor traps: HDPE with rodding eye (110 dia top inlet, 82 dia outlet) with minimum water seal of 7 cm.

b) Floor drain: Cast iron body with heavy duty 150 x 150mm nickel bronze gratings and covers. The open area of strainer shall be at least two third of the cross sectional area of the drain line to which it connects. Note wherever floor drain is indicated it shall be connected to floor trap unless other wise indicated.

c) Funnel floor drain where specified shall include a nickel bronze funnel secured to the grating.

d) Flower bed drain where specified shall be heavy duty, dome type drain coated cast iron body with bottom outlet complete with combination membrane flashing clamp/gravel guard, low silhouette dome and stainless steel mesh screen over dome, no floor trap is required.

e) Floor trap with trap primer shall be normal floor drain as described above but with trap primer connection.

2.1.2 Roof Drains

Rain water outlets shall be epoxy coated cast iron body and dome, wide serrated flashing flanged, flashing clamp device with integral gravel stop. Rain water outlets shall be selected to suit the type of roof where installed and shall be provided with a no hub outlet for mechanical jointing to rain water pipe.

2.1.3 Clean Outs

a) Floor type: Cast iron body with square or round adjustable, secured, nickel bronze top with 3mm tile recess.

b) Wall type: Cast iron body with square nickel bronze smooth wall access cover and frame, 150 x 150mm.

c) Clean out at high level shall be HDPE screw cap and washer.

2.1.4 Manholes/Gully Traps Covers

All covers shall be ductile iron with black bitumen coating.

Manhole covers shall have clear opening of 600 x 600 mm.

All manholes and gully traps shall be vented as per drainage department requirements.

Gully trap covers shall have clear opening of 300 x 300 mm.

All manhole covers and frames shall comply with BS 497:1976 part 1.

a) Internal Manholes:

All internal manhole covers shall be bolt down air tight double seal recessed type, they shall be insitu concrete filled with surface finish to match surrounding floor. Covers shall be medium duty, locking and sealed.

b) External Manholes:

Covers in paved areas shall be medium duty, double seal, and recessed type. They shall be insitu concrete/pavement filled with surface finish to match surrounding floor.

Covers subject to vehicular traffic shall be kite marked heavy duty, single seal, non-rock with square push fit seal plate complete with lifting key-holes.

2.2 Applicable Standards

Generally roof drains and floor drains shall be in compliance with ANSI standard A 112.21.2 and A 112.21.1 M respectively.

3.0 EXECUTION

3.1 General

3.1.1 All roof and floor drains shall be installed with water proof membrane extended up to and within the drain, and flashed to prevent any water penetration through the drain. Water proofing shall be carried out as recommended by the manufacturer and as approved by the company.

3.1.2 Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Maintain integrity of water proof membrane where penetrated.

3.1.3 Position roof drains and floor drains for easy access and maintenance.

3.1.4 Unless otherwise mentioned provide traps at each drain to stop seepage of sewer gases into occupied spaces.

3.1.5 Provide transition piece with mechanical joint connectors to couple drains to pipes specified.

3.1.6 Install floor drains at low points of surfaces to be drains, set grates of drains flush with finish floor or as indicated.

3.1.7 Clean outs shall be installed at change of direction of drainage pipes inside building and where indicated on the drawings. Clean outs shall be not more than 15m apart in horizontal lines for pipe diameters of 100 mm and smaller, and 30 m apart for larger pipes.

3.1.8 A clean out shall be provided at the foot of each vertical waste or soil stack and at each floor, the clean out shall be at 0.6 m height from finished floor level.

3.1.9 Clean outs on concealed piping shall be extended through and terminate flush with finished wall or floor. Pits or chases may be left in walls or floors provided they are of sufficient size to permit removal of clean outs plug and proper cleaning of the system.

3.1.10 Where it is necessary to conceal a cleanout plug, a heavy duty stainless steel covering plate 200 x 200 mm shall be provided which permits ready access to the plug.

3.1.11 Cleanouts shall be of the same nominal size as the pipes up to 100 mm pipe diameters and not less than 100 mm for larger piping.

3.1.12 Cleanouts shall be so installed that there is a clearance of not less than 450 mm for the purpose of rodding and cleaning.

3.1.13 Protect cleanouts during construction period to avoid clogging with dirt and debris and avoid damages from traffics and construction works.

END OF SECTION - 15405

SECTION – 15500

FIRE FIGHTING

PART 1 - GENERAL

1.1 CONTRACTOR'S RESPONSIBILITIES

The Contractor is responsible for the quality and the satisfactory operation of the installations entrusted to him, as well as for compliance with the performance stipulated in this document.

Consequently, for his own account and under his own responsibility, he must carry out all calculations and select the necessary materials and equipment.

Apart from the required performance definitions, this document and the relevant drawings also provide many indications resulting from the studies carried out by the Engineer.

The Contractor shall review these studies and check the corresponding indications.

The same applies to equipment selection, for which the information given in this document must be deemed as indicative, only and defines only the minimum requirements.

Scope Description

The Contractor shall furnish all labour, materials, tools, supplies, equipment, transportation, supervision, technical, professional and other services, and shall perform all operations necessary and required to satisfactorily complete all the necessary engineering, procurement services, construction work and commissioning for the fire protection systems and equipments for the project.

Basic Design Criteria

Refer tender Drawings and Documents.

Codes and Standards

All the systems shall be designed and installed in accordance with the applicable Bahrain Civil Defense Codes and Standards. They shall be particularly in accordance with the following NFPA /BS EN/Vds standards:

NFPA 10, Standard for Installation of Portable Fire Extinguishers

NFPA 13, Standard for the Installation of Sprinkler Systems

NFPA 14, Standard for the Installation of Standpipe and Hose Systems

NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection

NFPA 22, Standard for Water Tanks for Private Fire Protection

NFPA 24, Standard for the Installation of Private Fire Service Mains and their Appurtenance

NFPA-25, Standard for Inspection, Testing, and Maintenance of Water Based Fire Protection Systems

NFPA-70, National Electric Code

NFPA 72, National Fire Alarm Code

NFPA 92A, Standard for Smoke Control Systems

NFPA-101, Life Safety Code

NFPA-110, Standard for Emergency and Stand by Power Systems

NFPA-170, Standard for Fire Safety Symbols

NFPA 204, Standard for Smoke and Heat Venting

NFPA-220, Standard for types of Building Construction

NFPA-221, Standard for Fire Walls and Fire Barrier Walls

NFPA 780, Standard for the Installation Lightning Protection Systems

NFPA-2001, Standard on Clean Agent Fire Extinguishing Systems

NFPA 5000, Building Construction & Safety Code

OSHA, Code of federal regulations, Title 29, Part 1926

BS EN 54 Standard for installation of Fire Alarm System.

2. SCOPE OF WORK

This specification covers the supply, delivery and complete installation on site and in full working order of the equipment specified in this document and/or shown on the drawings.

Full particulars, performance curves and illustrations of the equipment, complying as closely as possible with this specification, shall be provided with the tender, but any deviations from the specification must be fully and clearly indicated in the tender submission schedules.

The Contractor shall provide and install:

The complete fire pumping station, including the firewater pumps (pumps, diesel engines drive, engines drive controllers, skid, diesel underground storage & pump), the jockey pump (pumps, electric drive, electric drive controllers), the piping & hanging, the valves, check-valves, relief valves, fittings, the instrumentation, the storage fire water tanks and feeding controllers (valves & controllers).

The firewater mains (sprinkler, standpipe & hydrant), including the piping, the fittings, the hanging, the block-valves & the hydrants.

The wet sprinkler systems, including the control valves, the piping, the hanging, the heads, the instrumentation.

The hose reels (standpipes, hose connections, external hose streams).
The portables extinguishers

Clean agent fire suppression system for the rooms mentioned in the drawings.

The marking of all the safety equipment

The Contractor shall be responsible for all the following aspects of the provided systems:

The checking of the tender drawings and any calculations supplied with the drawings. The Contractor shall check each drawing and satisfy himself that the design is correct for the equipment offered and will meet all applicable rules and regulations

The provision of any additional information required by the Contractor's installation engineers which are particular to the equipment being supplied e.g. fabrication drawings, equipment data sheets, commissioning instructions etc.

The provision of drawings and equipment data related to the systems as required by the Engineer.

The supply of all required equipment and other fixtures associated with the systems

Painting

Shop testing of equipment and provision of inspection facilities

Certification

The provision and fittings of suitable wall boxes, transits and plates where pipe work or cable passes through walls, etc., as well as fire rating reinstatement materials

The supply of as built drawings and as built calculations

The provision of scaffolding, ramps and any other equipment required to enable the systems to be installed, tested and commissioned correctly

A demonstration to key personnel in the use and testing of the systems and equipment supplied

Operating and maintenance manuals.

3. MATERIALS

The Contractor shall supply all materials necessary to make up effective and operable fire protection, detection and alarm systems, voice alarm system and emergency & exit lighting systems for the facilities indicated in the drawings and in the present specification, and particularly :

All the necessary pipe work, valves, equipment and instrumentation required for the facilities.

All electrical cable between panels, junction boxes, sensors, call points, pressure switches, alarm bells, flashing lights, and generally all the cable (and their supports) required for the facilities. Cables passing through fire walls shall not modified the fire rating of the wall (reconstitution of fire rating with approved sealant materials by the Contractor)

Local alarms indicating actuation of the systems

All detectors, fire signalling and alarm cabling shall be installed by the Contractor using materials in accordance with international standards.

All emergency lights, exit lights with directional arrow marks & pictograms as required,central battery panels, addressable monitoring panel, interface modules, phase monitoring relays and interconnecting cabling shall be installed by the contractor using the materials in accordance with International standards.

The main electrical supply to the Contractor's equipment will be by others.

All instrumentation and electrical equipment will be enclosed to suit the Hazard Class of the area. The Hazard Class of each area is indicated on the Hazardous Area Layouts.

Hazardous Area Certificate will be required for each item supplied within the Hazardous Area.

The Contractor shall define in the quotation the full specification of every system proposed (pipe work, cables, equipment).

3.1 Quality of Materials

Only materials of first-class quality shall be used and all materials shall be subject to the approval of the Engineer.

Wherever applicable, the system and material is to comply with the relevant International Standards of NFPA codes or British Standards /Vds /LPCB specifications.

All Materials shall be of UL listed or FM Approved/ LPCB Approved/ BSI Kitemark/Vds approved and approved by the Bahrain Civil Defense.

Approval Listing of Materials

The equipment shall have been tested and, where applicable, shall have been granted a certificate of approval or listing for the intended service. UL listed ,FM approved,BS Kite mark,Vds approved equipment shall be used where possible. Where equipment is offered without the above approval or listing, these items shall be listed with the type of certificate or approval granted indicated.

The Contractor shall supply only proven and established equipment which is suitable for the duty.

The Employer reserves the right to call for either substitute or alternative units, or to nominate manufacturers or models for any class of equipment.

4. Submittals

The installing contractor shall submit the following design information and drawings for approval prior to starting work on this project:

A) Product Data: submit manufacturers technical product

Field installation layout drawings having a scale of not less than (1:100m) detailing the location of all equipments, pipe runs including pipe sizes and lengths, controls and other accessories.

Auxiliary details and information such as maintenance panels, door holders, special sealing requirements and equipment shutdown.

Separate layouts, or drawings, shall be provided for each level, (i.e.; room, under floor, and above ceiling) and each system for mechanical and electrical work.

A separate layout or drawing, shall show isometric details of clean agent storage containers, mounting details and proposed pipe runs and sizes.

Electrical layout drawings shall show the location of all devices and include point-to-point conduit runs and a description of the method(s) used for detector mounting.

A complete sequence of operation shall be submitted detailing all alarm devices, shutdown functions, remote signaling, and agent discharge for each system.

Submit drawings, calculations and system component data sheets for approval to the local Fire Prevention Agency, and all other Authorities Having Jurisdiction before starting installation. Submit approved plans to the Architect/Engineer for record.

5. Drawings

5.1 Shop Drawings

The Sub-Contractor shall provide shop drawings for each system floor wise in detail as required by the engineer in charge and Authority having jurisdiction. It is the contractor responsibility to co-ordinate with other services while preparing the shop drawings and obtain approval from the engineer in charge.

5.2 As Built Drawings

Upon completion of each system, the installing contractor shall provide four (4) copies of system "As-Built" drawings to the owner. The drawings shall show actual installation details including all equipment locations as well as piping and conduit routing details. Show all room or facilities modifications, including door and/or damper installations completed. One (1) copy of reproducible engineering drawings shall be provided reflecting all actual installation details.

These drawings shall be as accurate and complete as possible.

6. Commissioning and Testing

Discharge tests shall be carried out on Site at the discretion of the Employer.

All tests shall be carried out in the presence of the Employer’s insurers or their nominated representatives.

The Contractor shall provide all the necessary tools and equipment for testing and commissioning activities.

6.1 Protection Systems Approval

It is the responsibility of the Contractor to submit the protection systems design, to obtain the Authority approval prior to the commencement of work and to implement the Authority requirements. The Contractor shall also submit the ‘As Built’ drawings to the Authority and make necessary arrangements for Final Inspection & testing and obtain the Final NOC and approval from the concern Authorities.

FIRE FIGHTING

1.0 FIRE EXTINGUISHERS

Fire extinguishers shall comply with NFPA-10 for installation.

The classification of fire extinguishers shall consist of a letter that indicates the class of fire on which a fire extinguisher has been found to be effective, preceded by a rating number (Class A and Class B only) that indicates the relative extinguishing effectiveness.

The distribution of fire extinguishers shall comply with the prescribed requirements of NFPA-10, as shown on the drawings and the specific requirements of the local Civil Defence Authorities.

Cabinets housing fire extinguishers shall not be locked.

Portable fire extinguishers shall be maintained in a fully charged and operable condition, and kept in their designated places at all times when they are not being used.

Definitions

The type of extinguisher needed depends on the right type of fire that may occurs in the room or building.

According to NFPA 10, several classes of fire have been defined:

Class A Fires: Fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.

Class B Fires: Fires in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.

Class C Fires: fires that involve energized electrical equipment where the electrical non-conductivity of the extinguishing media is of importance. (Where electrical equipment is de-energized, fire extinguishers for class A or B fires can be used safely.)

Class D Fires: Fires in combustible metals, such as magnesium, titanium, zirconium, sodium, lithium, and potassium.

Class K Fires: Fires in cooking appliances that involve combustible cooking media (vegetable or animal oils and fats.)

Building presenting class B or C fire hazard shall be equipped with a regular number of class A extinguishers dedicated to the building protection, and shall also be equipped with adding class B or C extinguishers.

According to these definitions, all parts of the buildings shall be equipped with class ABC type extinguishers. In the meantime, rooms such as Storages, Workshops and other rooms housing electrical equipments, shall be equipped with adding class C extinguishers.

1.1 ABC Dry Powder Fire Extinguisher

ABC Dry powder fire extinguishers shall be manufactured in accordance with BS EN 3 standards and shall be operated by means of a lever operated valve provided with a safety pin which shall allow a controlled partial discharge. The cylinder shall have minimum working pressure of 14bar. The temperature shall range from -20 to 60 degree. The extinguisher must have a plastic base. It must be coated inside by electrostatic PVC resin to resist corrosion. The cylinder shall be made special cold rolled steel sheet with Argon/CO2 welding process and the suction tube shall be made of PVC material. All extinguishers shall carry instructions for use in English and Arabic.

The Dry powder fire extinguishers shall have LPCB approval/KITE mark approval and having Bahrain Civil Defense approvals.

Multipurpose Dry Chemical Extinguishers (Class A, Class B, and Class C Fires).

The capacity of the extinguisher shall be 4Kg and shall have a fire rating of 21A and 113B Rating as shown in the drawings.

1.2 Carbon Dioxide Fire Extinguisher

Carbon dioxide fire extinguishers shall be manufactured in accordance with BS EN 3 standards and shall be operated by means of a lever operated valve provided with a safety pin which shall allow a controlled partial discharge. The cylinder shall be made of high grade seamless steel and shall have high gloss polyester finish. The cylinders shall be tested to 250 bar.

The temperature range for safety operation shall range from -20 to 60 degree. The extinguisher shall be electroplated PVC resign coated to resist corrosion. The suction tube shall be Aluminum. The CO2 fire extinguisher capacity shall be of 2 Kgs and the rating shall be 55B as shown on the drawings. All extinguishers shall carry instructions for use in English and Arabic.
The Carbon dioxide fire extinguishers shall have LPCB approval/KITE mark approval and or manufactured complying with BS EN3 standards and having Bahrain Civil Defense approvals.

Typical applications are electrical & electronic equipments, food preparation areas, laboratories, and printing or duplicating areas, telephone equipment Rooms, Engine Rooms, Control Rooms, Paint spray Booths, Flammable liquid storage areas etc,. Since the agent is discharged in the form of a gas/snow cloud, it has a relatively short range of 3 ft to 8 ft (1 m to 2.4 m).

This type of fire extinguisher is not recommended for outdoor use where windy conditions prevail, or for indoor use in locations that are subject to strong air currents because the agent can rapidly dissipate and prevent extinguishment. The concentration needed for fire extinguishment reduces the amount of oxygen (air) needed for life safety when the discharge is in a confined area (space).

Carbon dioxide fire extinguishers shall be manufactured in accordance with BS EN 3 standards and shall be operated by means of a lever operated valve provided with a safety pin which shall allow a controlled partial discharge. The cylinder shall be made of high grade Aluminium Alloy AA6061 and shall have high gloss polyester finish. The cylinders shall be tested to 250 bar.

The temperature range for safety operation shall range from -20 to 60 degree. The extinguisher shall be electroplated PVC resign coated to resist corrosion. The suction tube shall be Aluminum. The CO2 fire extinguisher capacity shall be of 2 Kg - rating 34B & C or 5 Kg – Rating 55B as shown on the drawings. All extinguishers shall carry instructions for use in English and Arabic.

The Carbon dioxide fire extinguishers shall have LPCB approval/KITE mark approval and or manufactured complying with BS EN3 standards and having Bahrain Civil Defence and Fire & Rescue Department approvals.

Typical applications are electrical & electronic equipments, food preparation areas, laboratories, and printing or duplicating areas, telephone equipment Rooms, Engine Rooms, Control Rooms, Paint spray Booths, Flammable liquid storage areas etc,. Since the agent is discharged in the form of a gas/snow cloud, it has a relatively short range of 3 ft to 8 ft (1 m to 2.4 m). This type of fire extinguisher is not recommended for outdoor use where windy conditions prevail, or for indoor use in locations that are subject to strong air currents because the agent can rapidly dissipate and prevent extinguishment. The concentration needed for fire extinguishment reduces the amount of oxygen (air) needed for life safety when the discharge is in a confined area (space).

EXECUTION

1. Fire extinguishers shall be conspicuously located where they will be readily accessible and immediately available in the event of fire. Preferably they shall be located along normal paths of travel, including exits from areas.

2. Fire extinguishers shall not be obstructed or obscured from view.
3. Portable fire extinguishers other than wheeled types shall be securely installed on the hanger or in the bracket supplied or placed in cabinets or wall recesses. The hanger or bracket shall be securely and properly anchored to the mounting surface in accordance with the manufacturer’s instructions. Wheeled-type fire extinguishers shall be located in a designated location.

4. Fire extinguishers having a gross weight not exceeding 40 lb (18.14 kg) shall be installed so that the top of the fire extinguisher is not more than 5 ft (1.53 m) above the floor. Fire extinguishers having a gross weight

greater than 40 lb (18.14 kg) (except wheeled types) shall be so installed that the top of the fire extinguisher is not more than 31/2 ft (1.07 m) above the floor. In no case shall the clearance between the bottom of the fire extinguisher and the floor be less than 4 in. (10.2 cm).

Fire extinguishers shall be installed in a 1.2 mm thick, stainless steel, polished finish cabinets where required in finished rooms / office areas and as shown on the drawings and shall be confirmed with the Architect.

STANDPIPE AND HOSE SYSTEMS

FIRE HOSE REELS: Automatic Type

The hose reel drum shall be made of stainless steel with the cabinet supported with reinforced support arm, which shall be chrome plated and swing through 180 degrees. Welding of any part on cabinet front shall not be allowed. The reels shall comply with BS EN 671 and comprise a reinforced rubber hose, 25mm. diameter x 30m long, coiled on a revolving drum. The outer end of a hose shall be fitted with a “jet / spray / shut-off” control nozzle. The inner end of the hose shall be connected through the reel to the water supply.

The reels shall incorporate a valve that automatically turns on the water supply when more than approximately 3 mtr of hose is unreeled, and shuts off again when the hose is re-wound onto the reel. A manual shut-off valve of the wheel type shall also be installed on the service pipe to each hose reel.

The hose nozzle shall be, (JET/SPRAY/SHUT OFF) type nozzle.

Each hose reel shall be installed and tested to BS 5274 and shall deliver not less than 0.4 l/s when the two top-most reels are in use simultaneously providing a jet of approximately 6 mtr. in length. Pressure reducing devices shall be provided whenever necessary to limit the pressure as per local athority remotest point requirenment.

An instruction plate shall be supplied with each reel indicating the method of use in English and Arabic.

The hose reels shall be of a make, approved by the Ministry of the Interior Civil Defense Department, and shall be supplied through an authorized agent.

Brief operating instructions should be clearly displayed on or by each hose reel in both English & Arabic languages. e.g.

TO OPERATE
RUN OUT HOSE
TURN ON LOCK AT NOZZLE

The hose reels shall be suitable for working pressures up to 4.5 bar (65psi) and shall be installed in accordance with the manufacturer’s instructions.

LANDING VALVES

Landing valves shall be of a type acceptable to the Fire Brigade use inside buildings as shown on the drawings. Landing valves shall be UL listed and FM approved or should have a BSI KITE Mark , install built in pressure reducing landing valve where the pressure exeeds the 12 bar, with 65mm diameter bore fitted with 65 mm. instantaneous female coupling to conform to BS 336 and a blank cap secured by a suitable length of chain.

The valve shall be of brass / Gunmetal construction with approved finish.If the landing valve is Ul listed then the outlet coupling must be quick instantanious with local fire services and should have BSI Kitemark.The installation of the coupling should be done by an certified installer.

Landing valves shall be installed inside the cabinet as shown in the drawing, at a height above floor level between 750 mm and 1100 mm. The outlet shall be installed to give clearances of not less than 150 mm on both sides and below the valve and not less than 200 mm clearance above the hand wheel.

FIRE HOSE & NOZZLE

Fire Hose and Nozzles and shall be of UL / FM approved or should have BS Kitemark.

Fire hose shall be of synthetic re-inforced rubber lined, 65 mm diameter and 30 m long equipped with brass chrome plated male coupling for the connection with the landing valve, and female coupling for the connection 65 mm chrome plated adjustable diffuser nozzle. The fire hose unit shall include the landing valve specified above, and shall have minimum working pressure of 12 Bar and bursting pressure of 35 Bar.

FIRE HOSE CABINETS

Cabinet shall manufacture by ISO9001 manufacturing company and duly certified e.g. LPCB,UL and others.

Fire hose cabinets, valves, hose and accessories shall be approved by and shall be conformance with the requirement of the Authority Having Jurisdiction and provided where shown on the drawings in accordance with this Specification.
The Fire Hose Cabinet back box shall be made of 2mm thick electro-galvanized sheet for recessed type cabinets and shall be made of 2mm thick stainless steel , door shall be wood to steel finish and architrave shall be made of 2mm thick stainless steel, Stainless steel shall be polish finish type, the finish of the polish shall be decided upon the approval of the Architect.

The cabinet shall be either wall-mounted type or recessed type as shown on the drawings.

The fire hose cabinet in different locations of the building shall include the following of the specified hereafter. The contractor shall furnish a certificate from the original manufacturer of reel and cabinet.

Automatic Fire Hose Reel
Landing Valves, Fire Hose and Nozzle
2 kg CO2 Fire Extinguisher
9 Ltrs Water Fire Extinguisher

INLET BREECHING VALVE

The unit shall be of UL listed / FM approved make or shall have BSI kitemark approvals.

The inlet breeching piece shall be of horizontal pattern having a 150 mm flanged outlet and four 65 mm instantaneous male inlets complete with blank caps and chains. A non-return (check) valve shall protect the inlet. The coupling shall comply with BS 336. The inlet connections shall be of suitable type of local fire brigade department / Bahrain Civil Defence .

The breaching piece shall be equipped with a 25 mm drain valve to drain the riser. The valve should be kept strapped and padlocked closed.

All parts including valve body, chain and caps shall be brass/gunmetal, polished chrome plated finish.

INLET BREECHING VALVE CABINET

Cabinet shall manufacture by ISO9001 manufacturing company and duly certified e.g. LPCB,UL and others.

The inlet breeching unit shall be housed in an approved 2 mm stainless steel polished finish/Mild steel powder coated, type, flush box with wired glass glazed front panel and:

Conspicuously indicated by the words: “FIRE BRIGADE – “SPRINKLER SYSTEM” or STANDPIPE SYSTEM INLET” in block letters on the inner face of the glass, both on English and Arabic.
Fastened only by means of a spring lock, which can also be operated from the inside without the aid of a key after the glass has been broken.

Made large enough for hose to be connected to inlets even if the door cannot be opened and the only means of access is by breaking the glass.

The box shall be built into the structure with a fall of one in 12, from the rear of the base to the front of the base. Construction material for the cabinet shall be polished finished stainless steel.

EXECUTION / INSTALLATION

Standpipe and hose systems shall be installed in accordance with NFPA-14 and Authority having jurisdiction requirements and as shown on the drawing.

The Fire protection contractor shall be responsible to co-ordinate his work with all other trades and shall be completely familiar with and shall make allowance for conditions which affect the fire protection installation.

The Fire hose cabinets shall be mounted securely in the concrete block walls, shimmying the back box and mortaring tightly in place.

Provide a pressure guage with a isolation cock with inspectors test plug on top and bottom of the each stand pipe risers.

Chrome plated nipples shall be provided in between the landing valve and hose connection. Chrome plated escutcheons shall be provided where pipes penetrate the cabinet.

A waterflow switch shall be provided in each standpipe riser and interfaced to fire alarm system for monitoring and to locate the section of waterflow during fire fighting operation.

A drain valve and piping, located at the lowest point of the standpipe piping downstream of the isolation valve, shall be arranged to discharge water at an approved location.

CLEANING AND TESTING

Tubes and all items of equipment shall be delivered, stored and maintained in closed storage with their open ends effectively plugged, capped or sealed. All fittings, valves and sundry items shall be stored in clean bins or bagged and stowed in suitable racks. All such stored items shall be maintained under weatherproofed cover to be supplied by the MEP sub-contractor until they are ready for incorporation in the works. Particular care shall be taken to ensure that electrical equipment and components are kept clean and dry.

Before installations are handed over or subjected to the inspection and tests, the entire installation shall be thoroughly cleaned, both internally and externally.

All fire protection installations shall be flushed out with clean water. During the flushing out, provision shall be made to exclude any items of plant, which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Engineer.
The fire protection system shall be tested in accordance with the NFPA codes and the relevant standards, with particular reference the requirements set forth in this section.

All testing shall be performed under the work of this section. All services required for testing shall be a responsibility of the work of this section. The MEP sub-contractor shall notify the Engineer of all tests, 48 hours prior to testing.

If the systems are tested in sections, the connection to the previously tested section shall be included.

All tests that may be required by the local fire authorities shall be performed under the work of this section, in the presence of their representative, if so required.

All leaks shall be corrected and the system re-tested until no leaks are found, at no cost to the client.

Functional tests of all water flow alarms are a responsibility of the works of this Section.

When the various systems are completed, operation tests shall be run on all equipment to demonstrate proper operating conditions. These tests shall be run under the observation of the inspector and the client's operating engineer. The client's operators shall be instructed during this period. Operation tests shall be performed under the work of this section.

Should any piece of equipment or apparatus of any material or work fail in any of these tests, it shall be immediately removed and replaced by a perfect material, and the portion of the work replaces shall again be tested under the work of this Section.

SPRINKLER SYSTEM

1.1 Hazard Classification

The sprinkler system shall be designed as per NFPA-13 Installation of Sprinkler System requirements. Spacing of sprinklers shall suit the hazard of the occupancy as shown in the drawing.

1.2 Submittal Data

Submitted system layout drawings, component shop drawings, specification and hydraulic calculations for consultanta review prior to commencing installation.

Submitted data shall be certified correct and bear the contractor engineers certification prior to submission to the consultant.

Upon completion of installation, modify the system calculation and submit hydraulic design data base on as built system.

Obtain all the approvals before proceeding with the work.

All sprinklers shall be of UL listed / FM Approved. The sprinkler heads shall be of the spray pattern installed in an upright position or pendant position as may be required. Sprinkler in false ceilings shall be concealed to ceiling and to architects' approval.

The design Criteria for all sprinklers such as K-factor, type and operating temperature shall be submitted for approval.

A set of spare sprinkler heads shall be provided and located in a cabinet in the fire pump room together with sprinkler spanners for use in removing and installation of the heads as recommended in NFPA-13 and local authority requirements.

The sprinklers and lines shall not be spaced too close together in order to prevent an operating sprinkler from wetting and hereby delaying operation of adjacent sprinklers.

In locations where sprinkler heads are liable to be operated or damaged by accidental blows, stout metal guards should protect them; care being taken to ensure that the normal operation of the sprinkler head in the event of fire is not thereby impeded.

The contractor shall supply set of spare sprinkler heads in each type/temperature range and located in a cabinet in the fire pump room together with sprinkler spanners for use in removing and installation of the heads as recommended in NFPA-13 and local authority requirements.

Finish of sprinklers shall be to the approval of the architect.

1.3 SPRINKLER CONTROL VALVES

ALARM VALVES

It should be UL 753 listed conforming to NFPA-13. Retarding device of approved design to obviate false alarms due to mains pressure variations where necessary or where indicated.

Alarm valves shall be complete with Water Motor Alarm Gong, all required auxiliary valves and drains and with pressure switch for wiring into the building electric alarm system.

Alarm check valves shall be iron body bronze trim for minimum175psig(12bar) working pressure complete with electric pressure switches, test and alarm bell connections. Pressure gauges and all other ancillaries.

1.4 WATER MOTOR ALARMS

The sprinkler system shall be fitted with an approved water motor alarm, which shall be located at a distance not exceeding 21m from the alarm valve, and at a height not to exceed 6m above the alarm valve.

The pipe work and fittings used shall be galvanized and to the sizes determined by the NFPA-13.

The pipe work shall be arranged to drain through a fitting having an orifice not exceeding 3 mm in diameter. The orifice plate may form an integral part of the fitting but shall be manufactured from a non-ferrous material to prevent the hole from becoming blocked by corrosion or foreign matter.

A 15 mm test valve shall be installed on the installation side of each alarm valve.

1.5 ELECTRIC ALARM PRESSURE SWITCHES

The electric alarm pressure swithch should be UL 753 Listed.It shall be installed in the system as per NFPA 13 and they shall be mounted on a vertical branch pipe at least 300 mm long.
The pressure switch may be of the diaphragm bellows operated type, and shall be sufficiently sensitive to operate when only one sprinkler is discharging. The pressure switch shall be provided with volt free contracts to facilitate monitoring by a Building Management System, and wired to the main fire alarm panel.

1.6 PRESSURE GAUGES

Pressure gauges shall be fitted to meet the requirements of the LPC. Pressure gauges shall conform to BS 1780 or equivalent International Standard. The maximum reading of the scale shall be 150% of the maximum system pressure and each scale shall have divisions not exceeding 0.2bar.

1.7 AUTOMATIC ZONE CHECK (ZONE CONTROL VALVE)ASSEMBLY

A zone control valve set shall UL, FM Approved and it is to be provided for each sprinkler system zone as shown on the tender drawings, and shall comprise:

Butterfly valve shall have UL 1091 .It shall be fitted with factory installed UL/Fm apporved tamper switch.

Flow alarm switch shall be UL listed and FM approved for the size of the pipe in which it is installed as a paddle type water flow indicator. Shall be fixed after the butterfly valve, on the main supply pipe and before any connection is taken off.

Inspector test and drain connections.

Dial pressure gauges suitable for the water pressures shall be fitted so arranged that it can be easily removed for testing and checking without shutting down the water supply.

Provide UL listed automatic zone check assembly to support monitoring, controlling, inspection, testing & maintenance of each zone in sprinkler system, where shown in the drawing as sprinkler zone control valve assembly or automatic zone check assembly:

They consist of following:

Re-circulating Pump.
Two sets of valve, elbows and pipes to facilitate the circulation of the water around water flow monitoring switch.
Vane-type water flow monitoring switch (WFMS).
Electrical box enabling control of motor and monitor of WFMS, local/remote as required.

When actuated they shall perform the following:

Test mode actuation: When activated in test mode, the pump shall circulate the water, within the sprinkler riser, around WFMS to stimulate the flow of one sprinkler head in operation. The electrical box shall control and monitor, motor and WFMS respectively, as required.

Fire mode actuation: When fire occurs, the sprinkler burst and water starts flowing to control / extinguish the fire. This leads to flow equal to or more than one sprinkler through the WFMS actuating it. The fire alarm panel / flow monitoring panel performs monitors / controls required in the fire condition when the WFMS actuation signal reach them.

They shall have following features in the system:

Insure the testing of WFMS as per the requirements of BS5306 Part-2 & NFPA 25 without activating the fire pump and opening of test/drain valve.

Installed in such a way that the test shall be conducted from a central control room, through single push button and the individual WFMS status can be read from main fire alarm panel or separate flow monitoring panel.

Have the future (contacts and relays) facilitating the connection to BMS, for automatic actuation, once in 3 months which records the status as required.

1.8 ISOLATING VALVES OS & Y TYPE

Isolating valves shall be UL 262 Listed and shall be fitted to the installation in order to shut the valve, the spindle must turn clockwise. The hand wheels of all stop valves shall be clearly marked to indicate which direction the wheel is to be turned to close the valve.

An indication shall also be provided which shows whether the valve is open or shut.

Each main stop valves shall be installed with a tamper / supervisory switch and interconnected to the building fire alarm system or secured open by a padlock or riveted strap.

1.9 DRAIN LINES

All drain lines from test valves, drain down points etc., shall discharge over suitable and proper drain vent. Each drain vent shall be connected to a 50 mm galvanized steel drain line, which shall discharge over a suitable gully.

All drain-vent, pipe fittings, and support clips used for the drain lines shall be galvanized.

EXECUTION / INSTALLATION

The “Protection Area of Coverage” per sprinkler (As) shall be determined as the multiplication of the distance between sprinklers upstream and downstream, and the perpendicular distance between a sprinkler and another on the adjacent branch line.

Installation for hydraulically calculated system with concealed pendent and upright sprinklers shall be, according to NFPA 13 latest edition and local authority requirements.

Complete Sprinkler system shall be installed in accordance with NFPA-13 and Authority having jurisdiction requirements and as shown on the drawing.
The Fire protection contractor shall be responsible to co-ordinate his work with all other trades and shall be completely familiar with and shall make allowance for conditions which affect the fire protection installation.

The Zone control valve assembly locations and access panels shall be mounted securely and provided with proper sign boards.

Provide a pressure guage with a isolation cock with inspectors test plug on top of the each sprinkler pipe risers.

CLEANING AND TESTING

Tubes and all items of equipment shall be delivered, stored and maintained in closed storage with their open ends effectively plugged, capped or sealed. All fittings, valves and sundry items shall be stored in clean bins or bagged and stowed in suitable racks. All such stored items shall be maintained under weatherproofed cover to be supplied by the MEP sub-contractor until they are ready for incorporation in the works. Particular care shall be taken to ensure that electrical equipment and components are kept clean and dry.

Before installations are handed over or subjected to the inspection and tests, the entire installation shall be thoroughly cleaned, both internally and externally.

All fire protection installations shall be flushed out with clean water. During the flushing out, provision shall be made to exclude any items of plant, which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Engineer.

The fire protection system shall be tested in accordance with the NFPA codes and the relevant standards, with particular reference the requirements set forth in this section.

All testing shall be performed under the work of this section. All services required for testing shall be a responsibility of the work of this section. The MEP sub-Contractor shall notify the Engineer of all tests, 48 hours prior to testing.

The fire protection piping System shall be tested hydrostatically for not less than 2 hours and at one time of the system pressure without any leaks or as directed by the local fire department.

If the systems are tested in sections, the connection to the previously tested section shall be included.

All tests that may be required by the local fire authorities shall be performed under the work of this section, in the presence of their representative, if so required.

All leaks shall be corrected and the system re-tested until no leaks are found, at no cost to the client.

Functional tests of all water flow alarms are a responsibility of the works of this Section.

When the various systems are completed, operation tests shall be run on all equipment to demonstrate proper operating conditions. These tests shall be run under the observation of the inspector and the client's operating engineer. The client's operators shall be instructed during this period. Operation tests shall be performed under the work of this section.

Should any piece of equipment or apparatus of any material or work fail in any of these tests, it shall be immediately removed and replaced by a perfect material, and the portion of the work replaces shall again be tested under the work of this Section.

Cost to repair any damages to the building construction occasioned by pipe leaks or defective materials shall be become under the works of this section, at no cost to the client. All. corrective work shall commence immediately after damage occurs.

PIPES, FITTINGS AND SUPPORTS

Piping

Pipes and fittings shall be in conformance with the following specifications unless specified otherwise by the Authority having jurisdiction. Obtain approval of local Authorities before proceeding with the work.

Pipe shall be seamless, galvanized steel to ASTM A 53 grade B, schedule 40.

When pipes are assembled by screwed fitting or by « cut-grooved » groove, the minimum thickness for a pressure up to 20.7 bar.

Steel pipes must have galvanised internal and external surfaces. The threaded extremities must be treated to prevent corrosion.

Diameters

Minimum diameter is DN25

Pipes Bendings

Schedule 40 Steel pipes bending is allowed if bending are executed with no defaults, no diameter reduction and no significant deviation in the pipes circle symmetry.

The bending minimum radius must be:

6 pipe diameters for a diameter < 2 '', and
5 pipe diameters for a diameter > 2 ½ ''

Pipes Marking and Identification

Firewater pipes in galvanised steel shall be marked to indicate it's destination.

Pipes Drainage

For sprinkler system, pipe drainage shall be accomplished by sloping pipe to low point with auxiliary drain as per NFPA13.

Special Requirements

Full flanges or plugs, according to the diameter shall be installed on the collector's extremities to flushing rinsing of the pipes

Pipe Fittings

1. Fittings for piping 50mm and small shall be UL listed and FM approved threaded galvanised ductile iron with 300 psi pressure rating or cast iron fittings, ANSI B 16.4 or galvanised ductile iron fittings, complying with ANSI B 16.3

2. Fittings for piping larger than 50 mm shall be galvanised mechanical grooved fittings and mechanical joints. Fittings, gaskets and mechanical

couplings shall be UL listed and FM approved. The fittings shall be suitable for 300 psi working pressure.

3. Pipes welding shall not be carried out on site.

4. The galvanised steel fittings shall be Ul Listet and Fm approved.

5. Unions and Couplings

Screwed unions shall not be used for pipe grater than DN40. For pipes above, flanges will be used.

6. Reducers and male/female reducers

A one-piece reduced fitting must be used for each pipe diameter change.

Reduced sleeve for the pipe continuity, and;

Male/female reducer for a direction change with reduction (T shape + reducer)

Supports

1. Pipe hangers and supports must be in accordance to NFPA13.

2. Pipes supports shall be designed to maintain their integrity in case of fire exposure.

3. All underground piping/valves shall be supported with Concrete Anchor Thrust blocks as recommended by the manufacturer. Provide calculation for the Engineers approval.

4. All Above ground piping/equipments hangers, supports and sway braces shall be fabricated in accordance with ANSI B 31.1. The Hangers, rod supports and supporting devices and accessories shall be capable of supporting at least twice the live loads of the product being supported. All hangers, supports and accessories shall be UL listed and FM approved make.

5. Hangers shall be adjustable clevis type, of yoke and lower U strap design with cross bolt and manufactured from galvanised steel. Cross bolt shall have a double locking nuts. Vertical adjustable supporting rod shall have a load nut below the yoke and a locking nut above the yoke.

6. Concrete anchors shall be factory made cadmium plated alloy steel expansion shield type.

7. Concrete inserts shall be factory made galvanised malleable iron, poured in place type, screwed or toggle style.

8. Riser clamps shall be galvanised steel bands shaped to tightly fit O.D. of the pipe, secured with bolts and nuts.

9. Piercing of load supporting system is not permitted.

10. The supporting structure can be directly attached to equipments if the equipment supplier certifies this supporting feasibility.

11. The welding of pipes on the supports on the pipes is not permitted.

12. Pipes supporting system must be reinforced in order to reduce any movements resulting from nozzles reaction and therefore preserve the system performance and integrity if battering ram is used.

13. The maximum length for a non-supported DN 25 pipe is 0.8 meter.

14. When possible, loop-type clamps will be used.

15. If spring hangers are used, they shall be installed and located in accordance with NFPA 13 specifications.

16. The Contractor shall take into account the problem of dilatation (of his systems but also of the buildings) and shall make the coordination with the others Contractors to solve the support problems.

FIRE WATER PUMPSETS

General (2 PUMP SETS, EACH PUMP SET CONSISTS OF):

1 Electric Main Fire pump
1 Diesel Stand By Fire pump
1 jockey pump
The pump capacity (for the resedential Tower) is :

- 1250 gpm each Main & Stand by pumps at the maximum pressure of 13 bar
- 50 gpm each jockey pump at the maximum pressure of 13 bar
- The pump capacity (for the Hotel Tower) is :
- 1000 gpm each Main & Stand by pumps at the maximum pressure of 13 bar.
- 50 gpm each jockey pump at the maximum pressure of 13 bar.

Each system shall be designed to ensure the maximum pumping capacity even if 1 pump fails.

The total supplying of all the necessary equipment for the firewater production (including pumps, engines driven, controllers, instrumentation, piping, valves, relief valves) is included in the Contractor's scope of work.

The supplying and installation of the day fuel tank of the engines is included in the Contractor's scope.

The fuel tank (and all the fuel installation) shall be in accordance with NFPA standards & Environmental legislation of Bahrain.

The air supply system of the diesel engines drive (automatic opening, venting panels) is included in the Contractor's scope.

The fire pumps, motor, engine and controllers shall be UL listed or FM approved, built in the country where the agreement is made.

The fire pumps and engine driven shall be in accordance with NPFA 20 (curves, starting, protection).

The problem of surge (hammer effect) shall be taken into account in the design. A surge analysis shall be conducted and specific surge pressure control system shall be installed.

Over-pressure system shall also be installed.

The contractor shall provide fully certified hydraulic calculations for exact sizing of the pumps.

The pumps shall be furnished with a full set of bench test certificates proving acceptability for the design points of this installation.

7.0 PRODUCTS

A. FIRE PUMPS

Fire pumps shall be UL or ULC listed and FM approved and manufactured by an approved manufacturer. Each pump shall have a capacity as shown in pump schedule, adjusted as necessary to suit the hydraulic calculations.

The pumping unit shall be listed by Underwriters' Laboratories Inc., and shall be fully approved by the Associated Factory Mutual Fire Insurance Companies. The pumping unit shall meet all requirements of the National Fire Protection Association Pamphlet No. 20.

The pumps shall also deliver not less than 150% of rated capacity at a pressure of not less than 65% of rated pressure. The shutoff pressure shall not exceed 140% of the rated pressure at rated capacity.

Fire Pumps Type

Each fire pump shall be of horizontal split case centrifugal single stage or multistage construction, specifically labeled for fire service and capable of proving the required flow and pressure of the entire development. The pump shall be connected to the combined sprinkler/standpipe system. The suction supply for the fire pump shall be from a storage tank at a maximum pressure of 20 kPa and a minimum pressure of 0 kPa. The pump casing shall be cast iron and rated to withstand twice the working pressure.

Pump Construction

The pump construction shall be cast iron casing, Bronzr impeller, Stainless Steel shaft and gland packing.

Note: The pump shall also deliver not less than 150 % of the rated capacity at a pressure of not less than 65 % of the rated pressure. The shut off pressure shall not exceed 140 % of the rated pressure at rated capacity.

Pump Discharge & Head

The pump discharge & head shown on the drawing schedule is an estimate. The fire protection contractor shall select a pump discharge and head to satisfy the fire protection system requirements resulting from the system hydraulic calculations.

Fire Pump Accessories

The Fire and Sprinkler Pumps shall include the following accessories, as required by NFPA standards:

1. Flow Metering Device, shall be of the Venturi type. Pilot and annubar devices will not be acceptable- One metering device shall be provided for each pump. or as shown on the drawings. Pipe water back to the storage tank.

2. Discharge tee.

3. Necessary isolating valves with supervisory switches.

4. Air release valve and fittings.

5. Discharge pressure gauge.

6. Main relief valve, pilot operated, enclosed relief valve overflow cone and discharge tee with elbow (diesel drive only).

7. Main relief valve with discharge pipes to water tank.

8. Pump casing relief valve.

9. Pressure recorder as required by NFPA 20.

B. ELECTRIC MOTOR DRIVE

On installations where the Fire Pump is to be operated electrically, the electric motor shall be a horizontal, open drip-proof type, wound for 380 V, 3 phase, 50 Hz (cycle) current The motor shall be of such capacity that 115% of the full-load ampere rating shall not be exceeded at any condition of the pump load for UL Listed fire pump.

With an ambient temperature not exceeding 40 deg. C, the motor shall be designed for a temperature rise not exceeding 60 deg. C when carrying fully rated-load continuously, and shall be capable of operating continuously with an overload of 15% without stress or excessive rise in temperature. The locked rotor current shall not exceed the values specified in NFPA Pamphlet No. 20.

Bearings shall be anti-friction ball or roller type.

CONTROL EQUIPMENT FOR ELECTRIC DRIVE

The Fire Pump motor control shall be UL listed and FM Approved. It shall be completely assembled, wired and tested by the control manufacturer before shipment from factory, and shall be labeled 'Fire Pump Controller".

The controller shall be located as dose as practical and within sight of the motor, preferably mounted on the pump skid.

The controller shall be so located or protected that it will not be injured by water escaping from the pump or connection. The controller shall be of the combined manual and automatic auto transformer type. and shall be complete with:

1. Disconnect switch - externally operable, quick-break type.

2. Circuit breaker - time delay type with trips in all phases set for 300% of the motor full load current-

3. Motor starter, capable of being energized automatically through the pressure switch or manually by means of an externally operable handle. Motor starter shall be of the autotransformer type.

4. Pressure switch, of adjustable type.

5. Running period timer - set to keep motor in operation, when started automatically, for a minimum period of one minute for each 10 HP motor rating, but not to exceed 7 minutes.

6. Pilot lamp - to indicate circuit breaker closed and power available.

7. Ammeter test link and voltmeter test studs.

8. Alarm relay - to energize an audible or visible alarm through an independent source of power to indicate circuit breaker open or power failure.

9. Manual selection station - a two position station shall be provided on the enclosure marked "Automatic" and Non-automatic".

10. Means shall be provided on the Controller to operate an alarm signal continuously while the pump is running.

11. Provisions for power supply at 220 V for diesel pump battery chargers.

12. Control equipment shall meet all requirements of NFPA No. 20.

13. Tank Accessories

C. DIESEL ENGINE DRIVE

Diesel engine shall be UL listed and FM approved for fire protection service.

The engine shall be of the self contained open type, mounted on a suitable base with the following minimum plus any others that may be necessary by NFPA-20 and local CD requirements.

Dual battery set sized to NFPA -20 requirements with electrolyte shipped in separate containers, rack and cables.

Dual battery charger of proper type for batteries used (included in UL Listed / FM Approved controller). Power to battery charger shall be supplied from electric pump control panel. Wiring from control panel to battery chargers shall be by the contractor.

Electric starter with suitable generator and voltage regulator

Engine water pump

Heat exchanger cooling system

Water cooled or ceramic blanketed exhaust manifold

Lubricating oil pump and filter

Speed governor

Fuel injection system

Air cleaner

Driveplate

Fuel Pump

Proper instrument panel, complete with engine run warning light, water temperature gauge, oil pressure gauge, ammeter, totalizing type tachometer and hour meter.

Residential Grade Muffler

Cooling water line for the engine heat exchanger assembly

Flexible exhaust connectors

All engine wiring for automatic operation shall terminate in a proper junction box to permit connection to control panel.

D. FUEL SYSTEM

A suitable fuel system for the diesel engine shall be furnished. It must be in accordance with NFPA Pamphlet No.20 and shall include above surface day storage tank, flexible hose connectors, combination vent, flesh arrestor and fill cap.

E. SILENCER (MUFFLER)

The silencers shall be Silex series JA. The silencer shall be for turbo-charged engines, sized and selected to accommodate the allowable pressure drop of the engine.

The silencer shall provide an average attenuation of 20-25 Db (a).

The silencer shall be designed by HEAVY DUTY APPLICATIONS OR APPROVED EQUAL, with noise attenuation across the entire audible range of the frequency spectrum 63 through 8000 Hz. The silencer shall consist of a series of chambers connected by non-resonant tubes. The entire silencer shall be manufactured from plate steel and be of a completely welded design. The heavy plate ensure longer silencer life and better resistance to damage. The heavy plate shall prevent shell radiated noise. There shall be no spot welds or press fits used.

Silencer inlet and discharge shall be flanged, manufactured from minimum 10mm thick plate and drilled to ANSI 70 kg. Silencers shall be either and in/end out and side in/end out configurations to suit installation.

Provide 12mm drain connections. Prior to shipping, the silencers shall be thoroughly cleaned and coated in a high temperature 650ºC aluminium paint.

F. DIESEL ENGINE DRIVE CONTROLLER

Automatic Diesel Drive Engine Control Panel : The automatic engine control panel shall be approved for fire pump service and shall meet the requirements of NFPA Pamphlet No. 20. The panel shall be of the floor mounted type, and enclosed in a moisture and dust tight housing. A combination manual and automatic type controller with “Manual-Off-Automatic” selector shall be provided and a 240 volt single phase power failure relay or a pressure switch, which will (when the system pressure drops) activate all electric circuits to automatically start the engine.

Should the engine fail to start after the required cranking cycles, the controller shall disconnect the starting circuit and activate an alarm system using lights and buzzer or bell. “Low oil pressure” and “high jacket-water temperature” shall also be indicated by a suitable alarm system. The engine shall not shut down if either of these conditions occurs during an operating cycle.

The engine shall be started automatically by the Controller at least once a week, adjustable, and operate a minimum of 30 minutes (adjustable). An appropriate timing arrangement shall determine the day and hour of this test.

Starting the engine by fire alarm relay, deluge valve relay or remote push-button station shall be included in the Controller circuit.

A remote alarm panel shall be furnished as per NFPA Pamphlet No. 20.

Pressure recorder (7 day drive) shall be provided within the control panel.

Fire Pump Controller shall be a diesel engine type, Controller approved and listed by the Underwriters Laboratories for fire pump service, carry the labels of both UL and CSA and meet the requirements of the National Fire Protection Association Standards No. 20, as presently required by UL.

The controller shall be a Bulletin #500 diesel engine fire pump controller Model FPD, as manufactured by Tornatech Inc., or approved equal, wired and tested by the manufacture, rated for (12 or 24) V.D.C., with 240 volts, 50 Hz AC Input and supplied in a floor mounting EEMAC 12 enclosure, complete with dripshield suitable for pump room environment.

The controller shall incorporate the following :

1. Each charger shall be completely independent of the other charger and equipped with its own individual power transformer, rated for a maximum continuous charge current of 10A. The charger shall be of solid state electronic design, with semi-conductor type rectifier, and include the following supervisory and safety features :

    1. Current limiting in every charging mode
    2. Over current shut-off
    3. Automatic selection of bulk or charge by sensing battery voltage
    4. Trickle charge limited to less than 500MA
    5. Reverse voltage shut-off
    6. Dead cell detection
    7. Over and under voltage alarm

In case of battery failure, the charger shall initiate an alarm and provide a signal to prevent the use of the defective battery during the start attempt cycle.

2. Relays : All relays shall be equipped with manual test buttons, status “ON” – “OFF” indicators, be of the plug in type and shall meet all voltage and current requirements.

3. Remote Alarm Circuit : A total of five (5) standard alarm contacts, rated at 10 A, 125 V shall be provided and wired to the field terminal block, to indicate the following engine conditions :

    a. 2 SPDT contact : Engine Running
    b. 1 N/O contact : Contact shall close when main switch in Auto-position
    c. 1 N/O contact : Contract shall close when main switch is in OFF or Manual position.
    d. SPDT contact : Engine trouble. This shall be a common alarm contact indicating the following conditions. Engine overspeed, engine fail to start, low oil pressure, high coolant temperature.

4. Description of Operation : A four positions main switch shall provide selection of three starting method and one OFF position.

    1. OFF position shall shut down engine and alarms under any condition.

    2. AUTO position: a water pressure switch mounted inside the controller shall provide the engine start on water pressure drop. The automatic starting circuit shall alternate the two storage batteries after each start attempt. The attempt to start cycle shall consist of six cranks and five rest periods of 15 seconds duration. In the event of one battery failure, the starting cycle shall lock itself to the remaining battery. In case of engine failure, the controller shall stop any

further cranking and energize the ENGINE FAIL TO START alarm. A manual stop pushbutton shall enable engine shut down, but only after all starting causes have returned to normal. The automatic Weekly Exercise cycle shall also be operational in the auto-position. This cycle shall be programmed on the 7 day time clock. A short opening of the water solenoid valve shall create a momentary pressure drop and cause automatic engine start. At the end of the programmed Exercise cycle, engine shall shut down automatically. A manual test switch located on the time clock shall allow for manual test operation of the weekly exercise cycle. The 7 day time clock shall hold its time on A/C power failure and not require resetting.

3. TEST Position: Engine shall start in the same manner as the above exercise cycle start. Turning main switch to Auto or Off position shall shut down engine.

4. MANUAL Position: Start pushbutton “Battery 1” or “Battery 2”, shall override all automatic starting circuits, and allow for direct manual engine start.

5. Safety Shut Down: Engine overspeed condition shall shut down engine without time delay and lock out until manually reset.

   The controller shall provide the following additional safety features: Engine shut down in case of low oil pressure or high coolant temperature during exercise, test or optional AC failure operation only.

G. ANNUNCIATOR AND OPERATOR CONTROL PANEL

A central annunciator and operators control panel shall be provided on the inner door located behind a breakable glass cover. This control panel shall incorporate all alarm and status pilot light indicators, voltmeters and ammeters for battery chargers and the 4 positions main switch, manual start pushbuttons, the combination Lamp test / Charger Reset Pushbutton and the optional “NORMAL-SILENCE” selector switch for pump room alarms.

1. Annunciator : The annunciator panel shall feature extra long life light bulbs, rated at 14 V for a 12 V and 28 V for a 24 V system.

   The following annunciating points shall be provided with the basic controller package : Charger 1 failure; Charger 2 failure; Battery 1 failure; Battery 2 failure; AC power on, Exercise cycle; Engine high coolant temp.; Engine low oil pressure; Engine fail to start; Engine overspeed; Engine run; Main switch auto and Pressure switch failure. Manual lamp test shall be provided.

2. Engine Connections : All circuit provided for engine interconnection shall be rated at 10 A.

3. Enclosure : The enclosure shall be lockable EEMAC 12/NEMA 12 heavy duty 14 gauge steel enclosure, dust tight, moisture resistant and drip proof, complete with gasketted window to allow emergency access to the operators control panel, for wall/floor mounting.

The controller shall be supplied including the following options :

Option No.1 AUTOMATIC LOW LEVEL STOP after minimum water level in the fire tank is reached.

Option No.2 SEQUENCE START TIMER (adjustable) operation to delay operation of diesel pump for a maximum of 60 seconds.

Option No.3 PROVISION FOR REMOTE AND DELUGE VALVE START CIRCUIT RELAY. Remote contacts to be N/C and must open for start signal (Fail safe circuit).

Option No.4 SILENCE SWITCH AND COMMON ALARM CONTACT STOP for the following :

LOW FUEL LEVEL
WATER RESERVOIR LOW
WATER RESERVOIR EMPTY & PUMP SHUT DOWN

H. JOCKEY PUMPS

The Jockey pump capacity and pressure shall be as indicated in the pump schedule on the drawings.

Pump shall be constructed as follows:

Type	: Vertical submersible motor driven, multi-stage
Rotation	: Counter-clockwise, viewed down
Motor	: NEMA Submersible, water lubricated
Motor bracket	: Cast type, connecting motor to pump
Strainer	: Square mesh type, locked against rotation
Diffuser cases	: Pressure containing, flow directing
Impellers	: Single suction
Pump shell	: Stainless steel, seamless type
Shaft, bowl	: Stainless, spline type
Bearings, bowl	: Sleeve type water lubricated
Pump discharge	: Diffuser type, threaded connector with guide bushing
Pipe	: Threaded
Mounting plate	:Drilled for discharge tee and motor lead connections
Submersible	: Three wire neoprene type
Control	: Definite purpose type, magnetic starter

In NEMA I enclosure, with reset button

Pump controller shall be factory pre-wired and tested. Pressure switch shall sense low pressure in the fire pump system. Set cut-in pressure 5 PSI above main fire pump cut-in pressure. Set cut-out pressure at system pressure. Provide minimum run timer to operate the pump for a minimum of 3 minutes.

Across the fine start, H-O-A selector switch.

Control panel to contain a fusible 3-pole disconnect switch, magnetic motor contractor and thermal overload relays with external reset Enclosure to be wall mounted with hinged door.

I. ELECTRONIC WATER LEVEL INDICATOR

Electronic water level indicator shall provide remote reading of water level into the pump control panel. An alarm facility shall be provided for connection to the fine pump control panel to indicate low water level and to provide a signal to shut down the pumps if the tank is empty.

Fire pump (Diesel and electric) shall have performance; as indicated on the drawings.

8. EXECUTION

1. The fire pumps shall be provided with a supervised isolating valve, flow meter and throttling valve on the test piping. Test piping shall discharge water to the fire water tank through a galvanized steel diffuser pipe.

2. Each pump, whether diesel or electric driven shall be complete with suction and discharge pressure gauges, circulation relief valve, dosed relief cone, automatic air release valve, drain valves coupling guard and its own control 'panel.

3. Provide remote annunciation panel for each pump which shall be located in the Managers office and shall provide the following features: diesel and electric pump status indicating rights and trouble tight for each pump. Wiring between control panel and remote control panel shall be by division 15 installed in conduit as described in section 16434.

4. Batteries shall be furnished in a dry charge, condition with electrolyte liquid in a separate container. Electrolyte shall be added and the battery given a conditioning charge at the time that the engine is put into service. Batteries shall be located so as to be readily accessible for servicing and at least 300 mm above floor level.

5. The electric motor driven unit shall have the pump. electric motor and control panel mounted on a common base. The entire unit will be factory tested prior to shipping.

6. The automatic engine control panel and the electric motor driven unit control panel shall be specifically designed for fire pump service. All wiring between pump, pump devices and controller shall be factory wired and tested. Wiring between controller and the building fire alarm system shall be by Division 16. Power wiring for the electric fire pump will be by Division 16.

7. The control panels shall be securely mounted in an enclosure which will protect the equipment against mechanical injury and fading drops of water. All switches required to keep the controller in the "automatic" position shall be within the locked cabinet. Emergency access to the switch shall be by breaking the glass panels.

8. A wiring diagram shall be provided and permanently attached to the inside of the each enclosure showing exact wiring for the controller, including a legend of identifying numbers of individual components. AH wiring terminals shall be plainly marked to correspond with the wiring diagram furnished.

9. Wiring elements of the controllers shall be designed on a continuous-duty basis. All wiring leading from the panel to the engine and to the batteries shall have adequate carrying capacity. Such wiring shad be protected against mechanical injury by metal conduit

10. Each operating component of the controllers shall be marked to plainly indicate an identifying number referenced to the wiring diagram. The markings shall be located so as to be visible after installation.

11. Complete instructions covering the operation of the controllers shall be provided and conspicuously mounted on the controllers.

12. Prior to shipment, the electric pumps and control panels shall be thoroughly shop-tested as a unit by the pump manufacturer. A characteristic curve showing the pump performance based upon the results of the shop test shall be submitted to the Consultant prior to shipment, and shall include the performance of the pump and engine at the set-governor's speed. Absence of these test reports, indicating that the complete unit has been tested in the factory by the driver, will be ample grounds for the rejection of the equipment. The contractor shall include in his price the cost and expenses of having one representative of the Owner from Bahrain witness the complete factory test prior to shipment

CONTROL

1. The electric fire pump shall be the lead fire pump. The other diesel fire pump shall be backup fire pump and will only operate if the lead fire pump cannot maintain system pressure.

2. The Jockey pump shall maintain the system pressure.

FIELD ACCEPTANCE TESTS

1. The field acceptance test results shall be as good as the manufacturer's certified shop test characteristic curve for tha pump being tasted within the accuracy limits of the test equipment.

2. OVERHEATING: The pump shall operate at peak load conditions without objectionable heating of the bearings or of the prime mover. The operating pump speed shall be the speed at which the pumping unit would be expected to operate during a fire.

3. The engine shall not show signs of overload or stress and its governor shall properly regulate the speed.

CONTROLLER

1. The automatic controller shall be put through not less than ten automatic and ten manual operations.

2. A running interval of at least five minutes at full speed shafts is allowed before repeating the starting cycle.

3. Automatic operation of the controller shall start the pump from all the provided starting features, such as pressure switches, valves, etc.

4. The pump shall be in operation not less than one hour (total time) during the foregoing tests.

The pump, driver, and all controls and necessary attachments, specified herein, shall be purchased under a unit contract Field wiring of remote panels, installation and wiring of water level indicators and fuel piping and wiring from the main storage tank to the local tank shall be provided by the Contractor. The pump manufacturer shall assume unit responsibility and shall provide the services of a qualified Engineer to supervise the installation and alignment of equipment Field tests shall be conducted in the field to satisfy Local Authorities having Jurisdiction of satisfactory operation of pump driver and controller. The pump manufacturer's engineer shall be at the job site, supervising the test. The control manufacturer shall have their representative at the Job site to train operators in the use of the controls.

Spare parts and tools necessary for two years operation, as recommended by the manufacturer, shall be provided as a part of the contract for the engine. A list of these spares shall be included in the offer.

Provide and install water relief valve and test discharge piping and all discharging water back; to the fine water tank.

Provide and install all water cooling piping, valves, controls for the engine, silencer and gear box cooling heat exchangers.

Contractor shall provide exact head calculations based on shop drawings before final selection of pumps.

9.0 CLEAN AGENT FIRE SUPPRESSION SYSTEM

(FM-200 / HFC-227ea)

GENERAL CONDITIONS

A. SCOPE

This specification outlines the requirements for a “Total Flood” Clean Agent Fire Suppression System with automatic detection and control. The work described in this specification includes all engineering, labor, materials, equipment and services necessary, and required, to complete and test the suppression system.

B. APPLICABLE STANDARDS AND PUBLICATIONS

The design, equipment, installation, testing and maintenance of the Clean Agent Suppression System shall be in accordance with the applicable requirements set forth in the latest edition of the following codes and standards:

1) NFPA No. 2001 - Clean Agent Fire Extinguishing Systems
2) NFPA No. 70 - National Electrical Code
3) NFPA No. 72 - Standard For Fire Alarm System
4) Factory Mutual Approval Guide
5) U.L Listings
6) Requirements of the Authority Having Jurisdiction (AHJ)

The standards listed, as well as all other applicable codes and standards, shall be used as "minimum" design standards. Also to be considered are good engineering practices.

REQUIREMENTS

The HFC-227ea Suppression System installation shall be made in accordance with the drawings, specifications and applicable standards. Should a conflict occur between the drawings and specifications, the specifications shall prevail.

INCLUSIONS / EXCLUSIONS

The Specialist contract shall include the following materials/works in their scope but not limited to:

Design & Engineering of clean Agent fire suppression system;
Prepare workshop drawing and technical submittals;
Perform Flow calculation;
Clean Agent gas storage cylinders filled with gas and all hardware accessories;
Gas cartidge actuators and release interface modules .
Cylinder Manifold and discharge piping;
Discharge Nozzles;
Gas low pressure switch & Gas discarge pressure switch;
Fire Detection and Alarm system c/w Ionisation smoke detectors, optical smoke detectors, manual release, Auto / Manual selector switch, Abort unit, First stage Alarm bell, second stage Alarm sounder, strobe horn, Gas discharge warning sign and associated cabling etc;
Gas release control panel;
Interlock wiring and conduit for shutdown of HVAC, dampers and/or electric power supplies, relays or shunt trip breakers.
Providing Drop curtains for any permanent openings;
Integrity Test and Functional test;
Training to the client representatives;
Provide As Built drawings and Operation & Maintenance Manuals.

The work listed below shall be provided by others, or under other sections of this specification:

1) 120 VAC or 208/220 VAC power supply to the control panel.

2) Connection to local/remote fire alarm systems, listed central alarm station(s) or sprinkler preaction/deluge valve actuation;

3) Sealing of openings to maintain the protected room enclosure as Air tight.

10. QUALITY ASSURANCE

A) MANUFACTURER

1) The manufacturer of the Suppression System hardware and detection components shall have a minimum of 10 years experience in the design and manufacture of similar types of suppression systems and who can refer to similar installations providing satisfactory service.

2) The name of the manufacturer, part numbers and serial numbers shall appear on all major components.

3) All devices, components and equipment shall be new, standard products of the manufacturer's latest design and suitable to perform the functions intended.

4) All equipment shall be U.L listed and/or FM approved.

5) Locks for all cabinets shall be keyed alike.

B) INSTALLER

1) The installing contractor shall be trained by the supplier to design, install, test and maintain Suppression Systems.

2) When possible, the installing contractor shall employ a NICET certified special hazard designer, level 2 or above, who will be responsible for this project.

3) The installing contractor shall be an experienced firm regularly engaged in the installation of automatic Clean Agent, or similar, fire suppression systems in strict accordance with all applicable standards.

4) The installing contractor must have a minimum of eight (8) years experience in the design, installation and testing of Clean Agent, or similar, fire suppression systems.

A list of systems of a similar nature and scope shall be provided on request.

5) The installing contractor shall maintain, or have access to, a Clean Agent recharging station. The installing contractor shall provide proof of his ability to recharge the largest Clean Agent system within 24 hours after a discharge. Include the amount of bulk agent storage available.

6) The installing contractor shall be an authorized stocking distributor of the Clean Agent system equipment so that immediate replacement parts are available from inventory.

7) The installing contractor shall show proof of emergency service available on a twenty-four hour, seven-days-a-week basis.

C) SUBMITTALS

1) The installing contractor shall submit the following information for approval to the local Fire Prevention Agency, owners Insurance Underwriter, Architect/Engineer, and all other Authorities Having Jurisdiction before starting installation:

a) Field installation layout drawings having a scale of not less than 1/8" = 1'-0" or 1:100m detailing the location of all agent storage tanks, pipe runs, including pipe sizes and lengths, control panel(s), detectors, manual pull stations, abort stations, audible and visual alarms, etc.

b) Auxiliary details and information such as maintenance panels, door holders, special sealing requirements and equipment shutdowns.

c) Separate layouts, or drawings, shall be provided for each level, (i.e.; room, underfloor, and above ceiling) and for mechanical and electrical work.

d) A separate layout or drawing shall show isometric details of agent storage containers, mounting details and proposed pipe runs and sizes.

Electrical layout drawings shall show the location of all devices and include point-to-point conduit runs and a description of the method(s) used for detector mounting.

Internal control panel wiring diagram shall include power supply requirements and field wiring termination points.

Graphic Annunciator wiring schematics and dimensioned display panel illustration shall be provided (optional device).

Complete hydraulic flow calculations, from a U.L. listed computer program, for all engineered Clean Agent systems. Calculation sheet(s) must include the manufacturers name and U.L. listing number for verification. The individual sections of pipe and each fitting to be used, as shown on the isometrics, must be identified and included in the calculation. Total agent discharge time must be shown and detailed by zone.

Provide calculations for the battery stand-by power supply taking into consideration the power requirements of all alarms, initiating devices and auxiliary components under full load conditions.

A complete sequence of operation detailing all alarm devices, shutdown functions, remote signaling, damper operation, time delay and agent discharge for each zone or system.

System component datasheets.

11. CLEAN AGENT SYSTEM REQUIREMENTS

11.1 SYSTEM DESCRIPTION AND OPERATION

A) The system shall be a Total Flood Clean Agent Suppression System supplied & installed by an Authorised by the manufacturer.

B) The system shall provide an HFC-227ea minimum design concentration of 7.2 %, by volume, in all areas and/or protected spaces, at the minimum anticipated temperature within the protected area. System design shall not exceed the NOAEL value of 9.0%, adjusted for maximum space temperature anticipated, unless provisions for room evacuation, before agent release, are provided.

C) The system shall be complete in all ways. It shall include all mechanical and electrical installation, all detection and control equipment, agent storage containers, HFC-227ea agent, discharge nozzles, pipe and fittings, manual release and abort stations, audible and visual alarm devices, auxiliary devices and controls, shutdowns, alarm interface, caution/ advisory signs, functional checkout and testing, training and all other operations necessary for a functional, U.L. Listed and/or F.M. approved HFC-227ea Clean Agent Suppression System.

D) Provide two (2) inspections during the first year of service. Inspections shall be made at 6 month intervals commencing when the system is first placed into normal service.

E) The general contractor shall be responsible for sealing and securing the protected spaces against agent loss and/or leakage during the 10 minute "hold" period.

F) The system(s) shall be actuated by a combination of ionization and/or photoelectric detectors installed at a maximum spacing of 250 sq. ft. (23.2 sq. m) per detector, in both the room, underfloor and above ceiling protected spaces. If the air flow is one air change per minute, photoelectric detectors only shall be installed at a spacing not to exceed 125 sq. ft. (11.6 sq. m) per detector. (Ref. NFPA No. 72 - current edition)

G) Detectors shall be wired in Sequential Detection method of operation, standard Cross-Zoned detection, or Single Detector Release, using either a Class "A" or Class "B" wiring arrangement. No other detection / wiring arrangements will be acceptable.

H) Automatic operation of each protected area shall be as follows:

1) Actuation of one (1) detector, within the system, shall:

a) Illuminate the "ALARM" lamp on the control panel face.

b) Energize an alarm bell and/or an optional visual indicator.

c) Transfer sets of 5 Amp rated auxiliary contacts which can perform auxiliary system functions such as:

1) Operate door holder/closures on access doors.
2) Transmit a signal to a fire alarm system.
3) Shutdown HVAC equipment.

d) Light an individual lamp on an optional graphic annunciator.

2) Actuation of a 2nd detector, within the system, shall:

a) Illuminate the "PRE-DISCHARGE" lamp on the control panel face.

b) Energize an predischarge horn or horn/strobe device.

c) Shut down the HVAC system and/or close dampers.

d) Start time-delay sequence (not to exceed 60 seconds). System abort sequence is enabled at this time.

e) Light an individual lamp on an optional graphic annunciator.

3) After completion of the time-delay sequence, the HFC-27ea Clean Agent system shall discharge and the following shall occur:

a) Illuminate a "SYSTEM FIRED" lamp on the control panel face.

b) Shutdown of all power to high-voltage equipment

c) Energize a visual indicator(s) outside the hazard in which the discharge occurred.

d) Energize a "System Fired" audible device. (Optional)

4) The system shall be capable of being actuated by manual discharge devices located at each hazard exit. Operation of a manual device shall duplicate the sequence description above except that the time delay and abort functions SHALL be bypassed. The manual discharge station shall be of the electrical actuation type and shall be supervised at the main control panel.

11.2 MATERIALS AND EQUIPMENT

A) GENERAL REQUIREMENTS

The Clean Agent System materials and equipment shall be standard products of the supplier's latest design and suitable to perform the functions intended. When one or more pieces of equipment must perform the same function(s), they shall be duplicates produced by one manufacturer.

1) All devices and equipment shall be U.L Listed and/or FM approved.

B) CLEAN STORAGE AND DISTRIBUTION

Each system shall have its own supply of clean agent.

1. The system design can be modular, central storage, or a combination of both design criteria.

2. Systems shall be designed in accordance with the manufacturer's guidelines.

3. Each supply container shall be located within the hazard area, or as near as possible, to reduce the amount of pipe and fittings required to install the system.

4. The clean agent shall be stored in Agent Storage Containers. Containers shall be super-pressurized, with dry Nitrogen, to an operating pressure of 360 psi @ 70° F. (2482 kpa at 21° C). Containers shall be of high-strength alloy steel construction and conform to NFPA 2001.

5. Containers shall be actuated by Gas Cartridge Actuator (GCA) wired to a Agent Release Module (ARM), located at each agent container.

6. Each container shall have a pressure gauge and low pressure switch to provide visual and electrical supervision of the container pressure. The low pressure switch shall be wired to the control panel to provide an audible and visual "Supervisory" alarm in the event the container pressure drops below 288 psi (1986 kpa). The pressure gauge shall be color coded to provide an easy, visual indication of container pressure.

7. Each container shall have a pressure relief provision that automatically operates when the internal temperature exceeds 150°F. (66°C).

8. Engineered discharge nozzles shall be provided, within the manufacturers guidelines, to distribute the clean agent throughout the protected spaces. The nozzles shall be designed to provide proper agent quantity and distribution.

    a) Nozzles shall be available in pipe sizes 3/8" thru 2.0" (BPS 10mm thru 50mm). Each size shall be available in 180° and 360° distribution patterns.

    b) Ceiling plates, can be used with the nozzles to conceal pipe entry holes through ceiling tiles.

9. Distribution piping, and fittings, shall be installed in accordance with the manufacturer's requirements, NFPA 2001 and approved piping standards and guidelines. All distribution piping shall be installed by qualified individuals using good, accepted practices and quality procedures. All piping shall be adequately supported and anchored at all directional changes and nozzle locations.

a) All piping shall be reamed, blown clear and swabbed with suitable solvents to remove burrs, mill varnish and cutting oils before assembly.

b) All pipe threads shall be sealed with Teflon tape pipe sealant applied to the male thread ONLY.

C) ELECTRICAL REQUIREMENTS

CONTROL PANEL

The control panel shall be a SHP (Single Hazard Panel) Control Panel.

The SHP Control System, and its components, shall be UL listed and FM approved for releasing service and be suitable for clean Agent release service.

The SHP Control System shall perform all functions necessary to operate the system detection, actuation and auxiliary functions, as outlined.

The SHP Control System shall be capable of providing 7AH or 18AH battery standby power supplies.

The SHP Control System shall be microprocessor based with hardware and software integration designed to guarantee reliability.

The SHP Control System shall support Cross Zoned, Sequential, Single Detector Release and Manual Release detection/actuation methods.

The SHP Control System shall provide the following capabilities and functions:

a) Three (3) Class B (Style Y) indicating appliance circuits rated for 2.0 amps @ 24 VDC.

b) Four (4) Class B (Style A) initiating circuits

c) Optional Class A (Style D) module for initiating circuits

d) Eight (8) Status LEDs plus alpha-numeric display for troubleshooting: AC normal; alarm; pre-discharge; release; supervisory; trouble; alarms silenced and system abort.

e) Programmable pre-discharge and discharge timers

f) Resettable and continuous auxiliary output power

g) Five (5) optional Abort types

h) Intelligent Transistor protection to prevent noise spikes and microprocessor failure from inadvertently activating release outputs

i) A dedicated Disarm switch for release outputs

j) Dedicated alarm and trouble contacts programmable for alarm, trouble, pre-discharge, discharge, abort, supervisory or waterflow functions, depending on panel configuration.

k) Two (2) Form “C” relays, rated at 5 amps, are provided on the SHP™ panel board. Installation of the optional SRM4 Relay Module (P/N 10-2176) will provide four (4) additional 5 amp relays.

l) Multiple input power source - 120 VAC or 208/220 VAC @ 50/60 Hz

m) 2.6 amp @ 24 VDC power supply to operate high current draw horns and strobes. Capable of allowing expansion to 8 amp external power supply for a total of 10.6 amps of available power.

n) Available in either Red or Gray finish

D) DETECTORS

The detectors shall be spaced and installed in accordance with the manufacturer's specifications and the guidelines of NFPA No. 72 – current edition.

a) Ionization Detector

The ionization fire and smoke detector shall continuously measures the products of combustion in the air, and gives a proportional output. It shall meet the requirements of EN54 part 7.

The detector shall be a dual-chamber type fully compensated for temperature, humidity and barometric changes. The radioactive source shall be less then 1 micro-curie of Americium 241, and shall comply with all Atomic Energy Agency requirements.

A light emitting diode (LED) on the base must illuminate when a detector is in alarm.

b) Optical Smoke detector

The optical smoke detector shall continuously measures the smoke level in the air, and gives a proportional output. It shall comply with the requirements of EN54 part 7.

The detector shall be an optical light scattering type sensitive to visible smoke and be stable under all environmental conditions. The internal test and calibration circuits shall use the same optical elements as the smoke sensing circuits, to ensure reliability.

A light emitting diode (LED) on the base must illuminate when a detector is in alarm

E) MANUAL RELEASE (Electric)

The electric manual release switch shall be a dual action device which provides a means of manually discharging the Suppression System when used in conjunction with the Fire SHP Control System.

The Manual Release switch or Manual Pull station shall be a dual action device(s) requiring two distinct operations to initiate a system actuation.

Manual actuation shall bypass the time delay and abort functions, shall cause the system to discharge, and shall cause all release and shutdown devices to operate in the same manner as if the system had operated automatically.

A Manual Release switch shall be located at each exit from the protected hazard and shall have an advisory sign, provided at each location.

F) ABORT STATION

The optional Abort Station shall be the "Dead Man" type and shall be located next to each manual switch.

The Abort Station shall be supervised and shall indicate a trouble condition at the SHP Control Panel, if depressed, and no alarm condition exists.

"Locking" or "Keyed" abort stations shall not be permitted.

The Abort Station shall be located adjacent to each manual station.

G) AUDIBLE and VISUAL ALARMS

Alarm audible and visual signal devices shall operate from the SHP Control Panel.

The Alarm Bell, Alarm Horn and Horn/Strobe devices shall operate on 24 volts Dc power to allow supervision of the circuit wires.

The alarm bell and horn shall deliver a minimum sound level of 92 decibels at a distance of 3m.

Horn and strobe light are to operate simultaneous from one power supply with flash rate of 1-3 flashes per second minimum over the listed input voltage range.

A Strobe device shall be placed outside, and above, each exit door from the protected space. Provide an advisory sign at each light location.

H) MANUAL ACTUATOR

Manually operated actuator shall be provided for independent means of operation of clean agent system. The unit shall activate the system without the need for external power or stored energy, therby providing a fail safe method of activation.

I) LIQUID LEVEL INDICATOR

The liquid level indicator shall be installed in the clean agent storage container to provide means of verifying the weight of agent in a container without having to remove the container and weigh it on a calibrated scale. The device shall enable the inspector to determine the weight of agent with the container safely secured in its installed position.

J) CAUTION and ADVISORY SIGNS

Provide signs, as required, to comply with NFPA 2001 and the recommendations of the equipment supplier:

Entrance sign: (1) required at each entrance to a protected space.
Manual Discharge sign: (1) required at each manual discharge station.
Flashing Light sign: (1) required at each flashing light over each exit from a protected space.

K) SYSTEM and CONTROL WIRING

All system wiring shall be furnished and installed by the contractor.

All wiring shall be installed in electrical metallic tubing (EMT), or conduit, and must be installed and kept separate from all other building wiring.

All system components shall be securely supported independent of the wiring. Runs of conduit and wiring shall be straight, neatly arranged, properly supported, installed parallel and perpendicular to walls and partitions.

The sizes of the conductors shall be those specified by the manufacturer. Color coded wire shall be used. All wires shall be tagged at all junction points and shall be free from shorts, earth connections (unless so noted on the system drawings), and crosses between conductors. Final termination's between the SHP control panel and the system field wiring shall be made under the direct supervision of a factory trained representative.

All wiring shall be installed by qualified individuals, in a neat and workmanlike manner, to conform to the National Electrical Code, Article 725, and Article 760, except as otherwise permitted for limited energy circuits, as described in NFPA 72 - current edition. Wiring installation shall meet all local, state, province and/or country codes.

The complete system electrical installation, and all auxiliary components, shall be connected to earth ground in accordance with the National Electrical Code.

L) SYSTEM INSPECTION and CHECKOUT

After the system installation has been completed, the entire system shall be checked out, inspected and functionally tested by qualified, trained personnel, in accordance with the manufacturer's recommended procedures and NFPA standards.

All containers and distribution piping shall be checked for proper mounting and installation.

All electrical wiring shall be tested for proper connection, continuity and resistance to earth.

The complete system shall be functionally tested, in the presence of the owner or his representative, and all functions, including system and equipment interlocks, must be operational at least five (5) days prior to the final acceptance tests.

a) Each detector shall be tested in accordance with the manufacturer's recommended procedures, and test values recorded.

b) All system and equipment interlocks, such as door release devices, audible and visual devices, equipment shutdowns, local and remote alarms, etc. shall function as required and designed.

c) Each SHP control panel circuit shall be tested for trouble by inducing a trouble condition into the system.

M) TRAINING REQUIREMENTS

Prior to final acceptance, the installing contractor shall provide operational training to each shift of the owners personnel. Each training session shall include system SHP Control Panel operation, manual and abort functions, trouble procedures, supervisory procedures, auxiliary functions and emergency procedures.

N) OPERATION and MAINTENANCE

Prior to final acceptance, the installing contractor shall provide complete operation and maintenance instruction manuals, four (4) copies for each system, to the owner. All aspects of system operation and maintenance shall be detailed, including piping isometrics, wiring diagrams of all circuits, a written description of the system design, sequence of operation and drawing(s) illustrating control logic and equipment used in the system. Checklists and procedures for emergency situations, troubleshooting techniques, maintenance operations and procedures shall be included in the manual.

O) AS-BUILT DRAWINGS

Upon completion of each system, the installing contractor shall provide four (4) copies of system "As-Built" drawings to the owner. The drawings shall show actual installation details including all equipment locations (i.e.: control panel(s), agent container(s), detectors, alarms, manuals and aborts, etc.) as well as piping and conduit routing details. Show all room or facilities modifications, including door and/or damper installations completed. One (1) copy of reproducible engineering drawings shall be provided reflecting all actual installation details.

P) ACCEPTANCE TESTS

1) At the time "As-Built" drawings and maintenance/operations manuals are submitted, the installing contractor shall submit a "Test Plan" describing procedures to be used to test the control system(s). The Test Plan shall include a step-by-step description of all tests to be performed and shall indicate the type and location of test apparatus to be employed. The tests shall demonstrate that the operational and installation requirements of this specification have been met. All tests shall be conducted in the presence of the owner and shall not be conducted until the Test Plan has been approved.

2) The tests shall demonstrate that the entire control system functions as designed and intended. All circuits shall be tested: automatic actuation, solenoid and manual actuation, HVAC and power shutdowns, audible and visual alarm devices and manual override of abort functions. Supervision of all panel circuits, including AC power and battery power supplies, shall be tested and qualified.

3) A room pressurization test shall be conducted, in each protected space, to determine the presence of openings which would affect the agent system concentration levels. The test(s) shall be conducted using the Retro-Tec Corp. Door Fan system, or equivalent, with integrated computer program. All testing shall be in accordance with NFPA 2001.

4) If room pressurization testing indicates that openings exist which would result in leakage and/or loss of the extinguishing agent, the installing contractor shall be responsible for coordinating the proper sealing of the protected space(s) by the general contractor or his sub-contractor or agent. The general contractor shall be responsible for adequately sealing all protected space(s) against agent loss or leakage. The installing contractor shall inspect all work to ascertain that the protected space(s) have been adequately and properly sealed. THE SUPPRESSION SYSTEM INSTALLING CONTRACTOR SHALL BE RESPONSIBLE FOR THE SUCCESS OF THE ROOM PRESSURIZATION TESTS. If the first room pressurization test is not successful, in accordance with these specifications, the installing contractor shall direct the general contractor to determine, and correct, the cause of the test failure. The installing contractor shall conduct additional room pressurization tests, at no additional cost to the owner, until a successful test is obtained. Copies of successful test results shall be submitted to the owner for record.

5) Upon acceptance by the owner, the completed system(s) shall be placed into service.

Q) SYSTEM INSPECTIONS

The installing contractor shall provide two (2) inspections of each system, installed under this contract, during the one-year warranty period. The first inspection shall be at the six month interval, and the second inspection at the 12 month interval, after system acceptance. Inspections shall be conducted in accordance with the manufacturer's guidelines and the recommendations of NFPA 2001.

Documents certifying satisfactory system(s) operation shall be submitted to the owner upon completion of each inspection.

R) WARRANTY

All system components furnished, and installed under this contract, shall be guaranteed against defects in design, materials and workmanship for the full warranty period which is standard with the manufacturer, but in no case less than one (1) year from the date of system acceptance.

12.0 SPECIFICATIONS FOR FIRE HYDRANTS

12.1 FIRE HYDRANTS

Hydrants shall be of the wet barrel type with 150 mm (6”) barrel. Each hydrant will be equipped with two, two and half inches instantaneous couplings with caps and chains to suit local fire brigade requirements. Each hydrant will be fitted with a stop valve in the supply pipe from the main.

12.2 LANDING VALVES

Single outlet landing valves shall be installed in the stair wells, control and service areas.

The landing valves shall be complete with valved outlets, caps and chains to suit local fire brigade equirements.

12.3 HOSE AND EQUIPMENT CABINETS

Free standing or wall mounted fire hose and equipment cabinets shall be provided at each hydrant, of a size suitable for the contents detailed below.
Wall mounted cabinets shall be provided at each internal landing valve.

The cabinets shall be constructed of GRP. The floor shall be suitably strengthened to support the load. Alternatively they may be constructed of galvanized steel at least 1.2 mm thick. With reinforcement where necessary. The cabinets shall be red in color.

The cabinets shall be provided with doors fitted with stainless steel encapsulated hinges and door fasteners with facilities for fitting a wire and lead seal.

The doors shall be fitted with a neoprene, or similar, seal to minimize the ingress of dust, sand and moisture. Air vents, with fine mesh screens, shall be provided to prevent the build-up of condensation.

The cabinets shall be marked in white lettering 150 mm high to read.

END OF SECTION -15500

SECTION 15650

REFRIGERATION EQUIPMENT (HVAC)

PART 1 -PLANT SEQUENCE OF OPERATION

1.1 DESCRIPTION

Brief Plant Description and sequence of operation:

The proposed system comprises of 4 no's of air cooled screw chillers to generate the required chilled water for the two towers. Each two chillers group is dedicated to certain tower and is connected to common inlet and outlet header. 2 no's of primary variables chilled water pumps are connected to the common header to maintain the desired water flow for each tower. The primary chilled water supply loop with variable frequency drives on the pumps controlled from differential pressure, which is reset incrementally to operate at the lowest speed and pressure possible to satisfy the current load. The Chiller Controller controls chiller functions and set points and same to be monitors number of points through the local interface (BMS).

The various sensors shall be connected to the system include flow sensor, temperatures, pressure switch and valve actuators.

Wiring Layout

The two chillers for each tower will be connected to each other via- a 3-wire network in a daisy chain arrangement for communication with Chiller Supervisor Manager. Recommended Communication Cable is Beldon 8772/Bacnet I.P protocol or approved equal.

Chiller Plant Controller (supervisor)

Chiller plant controller shall have dedicated microprocessor based system to closely monitor the chilled water inlet and outlet temperature optimize the chiller utilization based on the best operating condition as available at operating site.

Chiller plant controller uses one or a combination of following alternative control scheme to optimize the chiller load and performance to run the chillers in energy efficient way:

Chilled water common header supply Temperature.

The chiller Amperage as a percentage of Rated Load Amps (RLA)

The chillers shall be started and stopped by the controller based up on a time schedule, system demands optimized start/stop and/or via operator command. On initiation of a chiller to run the primary chilled water and condenser water, 2-way, 2 position, butterfly valves shall open on the lead chillers, the chilled water pumps shall start and flow proven.

The primary chilled water pumps and chillers will be programmed for optimized running through sequencing and automatic Fail change over. The automatic re-sequencing of the units will take care of equal usage of the available healthy equipment to maintain smoothly plant operation without any physical intervention and delay.

The chiller plant controller shall be equipped with local microprocessor controller with local display units. Chiller controller is in turn connected to a PC for graphical representation of data, logging trend data, keeping history log, smoother & automatic plant operation and monitoring through a custom designed graphical user interface to make the plant operation very easy and user friendly.

A Chiller Plant controller system shall be included with the chillers to provide coordinated chiller plant operation, optimize energy efficiency, equipment protection and alarm requirement of a chilled water plant. The chiller plant controller shall be furnished by the chiller supplier, complete with a monitor and printer.

The chiller plant controller must be a micro-processor based programmable controller and be capable of specific chiller plant control, chiller interface and must have a local LCD display.

The chiller plant controller shall control the chiller plant using Direct Digital Control (DDC). The controller outputs must be capable of modulating / positioning valves and pump speed. Output quantity shall be, minimum of 24 outputs for primary pumps. Chiller start/stop shall be done over the network.

The chiller plant controller must have an RS 232 C data port /BACNET and IP protocol based port for communication to a printer terminal or PC. The data port must use standard industry ASC II communication protocol to 9600 Baud asynchronous communication speed. The controller shall have translator capability that shall transfer all chiller inputs, alarm conditions, and safety / cycling information to the building management system. The translator shall be capable of receiving commands and top change set points, alarm points, on status of the chillers, maximum demand of each chiller and parameters as recommended by the chiller supplier.

The chiller plant controller must have a display panel for human interface, on site access to chiller plant operating data, enunciation of system alarms and messages and changes in chiller plant control. The operator display shall be built in.

The chiller plant controller system display shall be built in display of at least 50 alphanumeric characters and must be capable of displaying system temperatures, pressures, flows, calculated values, equipment status, valve position, system alarms and messages in both metric or imperial.

The chiller plant controller software must be capable of accumulating historical data and equipment logs. The controller must have sufficient memory to store at least 48 hours of chiller logs and weekly chiller plant management reports.

The chiller plant controller must interface to a smart modem and be capable of auto answer and auto dial, for remote access and equipment alarm.

In the event of power failure, all equipment shall remain off for a select period of time. Equipment shall than be sequentially started to minimize KW peak demand. If a chiller or its auxiliary equipment fails to start or shuts down on safety failure, the next chiller and its associated auxiliary shall be started.

The chiller plant controller shall recognize and enunciate chiller, pump and fan failure by means of positive proof feed back and/or safety failure circuit. An alarm message shall be displayed and beeper/horn sounded.

The chiller plant controller must be capable of summing pump KW and chiller KW. It shall also sum cooling KWh (and ton hours) provided by each chiller.

The chiller plant controller system must be capable of displaying chiller plant alarms and messages. Minimum requirement shall include: Chiller failure alarms, pump failure alarms and high/low temperature alarms.

The chiller plant system shall be capable of accumulating and displaying the chiller plant data, historical chiller logs and reports. Minimum report requirement shall include: chiller historical KWH, chiller run times, historical cooling load and total chiller plant estimated power use. Minimum chiller log requirement shall include: all chiller plant operating temperatures and pressures, chiller KW. All chiller logs must be available for the previous 48 hours, in 1 hour increments.

The chiller plant controller shall have facility to communicate with BMS / BACNET I.P protocol. The program shall cover the following:

Optimized Start/Stop:

To minimized equipment energy usage, automatic scheduling of chillers, pumps and also individual control for optimum start time and stop time of all equipment. The compressor start/stop time is controlled based on the stating-up and shut down time requirement of other components and water temperature. In no case will a single contactor shutting down all components simultaneously be accepted.

Automatic Sequencing:

Start up the lead chiller first based on the varied load condition. The schedule shall be operator selectable or can be automatically selected. The chiller supervisor controllers automatically select optimum equipment combination based on energy efficiency, load requirements equipments alarm status and the day of the work.

Optimum Load Distribution:

The chillers shall be automatically loaded to optimize energy consumption.

Chilled Water Temperature Reset:

To control the leaving chilled water temperature based on the any one the following:
Constant supply Temperature.
Constant return Temperature
Variable supply Temperature based on the Ambient.

The set points and reset limits are operator selectable subject to the proper access based on the based on the user password.

Low Load Prevention:

None of chillers shall be runs below the desired load limit. The limit is operator selectable. In case of one chiller requirement the system will decide the efficient way to run the chillers.

Auto Start after Power Failure:

To control the start up of the equipments one by one to control the maximum starting load requirements.

Demand Limit:

The gradual loading of the chillers is over a span of the time period after the start-up of the unit to minimize the peak starting load requirement.

Reports and Logs:

System generated reports and logs to minimize the manpower involvement and eliminate human error. The history data shall be available to analyze the plant health.

Better Chiller Diagnosis:

The operational code and fault code helps to immediately find out the plant operational status and fault status. Hence reduce time required to identity and rectify the same. Typically the codes are covers the followings.

Operation Codes:

No abnormal Condition
Unit Switch in off position.
System Switch in Off position
Lock-Out
Chiller Fault
System Fault
Remote Shutdown
Daily Schedule Shutdown
No Run Permissive
No Cool Load
Anti-Coincidence Timer Active
Anti-Recycle Timer Active.
Manual Override
Suction Limiting
Discharge Limiting
Demand Limiting

Fault Codes:

No fault
115 VAC under voltage
Low Water Temperature
High Discharge Pressure
Low Oil pressure
Low Suction pressure
Low Motor Current
Liquid Line Solenoid Valve not on

Warning Low Battery
High Motor Current etc.

Inputs:

The chiller plant controller system shall not be less that the following excluding system requirement.
Outside Air Temperature
Outside Air Humidity
Leaving chilled water temperature – each chiller.
Entering chiller water temperature – each chiller.
Evaporator pressure
Condenser pressure
Oil pressure
Entering condenser water temperature – each chiller
Leaving condenser water temperature - each chiller
Amperage
Chilled water set point that the micro panel is controlling to
Current limit set point that the micro panel is controlling to
Evaporator saturation temperature
Condenser saturation temperature
Discharge temperature
Oil temperature
Operational mode (remote or local)
Vent solenoid
Oil pump

Outputs:

The chiller plant controller system shall be able to command:
Chiller on / off
Current limit set point
Leaving chilled water set point

Safety Shutdown Codes:

No shut down.
Low evaporator pressure
Low oil pressure
High condenser pressure
Evaporator transducer error
Motor controller
High discharge temperature
High oil temperature
Power failure
Oil pressure transducer
Starter malfunction detected
High motor temperature
Replace battery – reprogram
Discharge probe failure
Oil temperature probe failure

Cycling Shut Down Codes:

No shut down
Low water temperature
Flow switch
System cycling
Multi unit cycling
Internal clock
Remote stop
Power failure
Vane motor switch open
Anti-recycle
Motor controller
Power fault
Pressure run switch to start

Chiller Sequencing

HVAC contractor has to provide for engineer approval; full electrical and mechanical operation sequence for each chillers group with the pumping chilled water system and FCU's, AHU's & ERV/s, also actual full hydraulic pressure head losses for the pumps, pipes, fittings, evaporators, FCU/AHU/ERV coil pressure drops.

The chillers shall be sequenced based on the cooling load requirement. The cooling load requirement can be calculated from the flow and temp difference. The chiller can also be programmed based on the chilled water supply header temperature sensor reading (say T1) should be greater than current chilled water set point. The lead/lag sequencing of the chillers will be carried out by the Chiller Controller. A time sequence can also be implemented for conditions when no cycling of chillers/pumps will take place due to load condition.

At any time of operation if it is desired to add another chiller manually, the operators can “Forced Add” a chiller-set from the PC Workstation.

The Chiller Controller will first start the chilled water pumps; open the respective chiller and pump butterfly (isolation) valves. Once the flow through the evaporator and condenser is proven then only the chiller will commanded ON. During shut down first the chiller will be commanded off; then the valve will be closed and pump will be commanded off. In the case of not receiving the run feedback form chiller /pump within a stipulated time, the equipment will be assigned a fault status and the next available healthy equipment in the sequence will be started.

Subtract logic

The de-coupler allows the pumps to operate at different flow rates. This is necessary because the primary pumps are variable speeds. Only on special occasion will the primary pump flow and the demand water flow be equal. The primary flow is based on the load in the building. Specifically, the primary flow rate is produced to maintain the necessary system pressure differential. Any excess primary water flows through the de-coupler to the return side and back to the chillers. Modulating control valve in the de-coupler with flow meter on the main return line are needed (refer to page 26, Feb. 2002 ASHRAE Journal)

If the chiller plant is running in the Auto mode of operation & the load is decreasing, the system will look to reduce (subtract) a running chiller set.

The subtract logic of the chiller-set is based on the de-coupler flow in the bypass line in the plant. The system will constantly measure the flow through the de-coupler, and the when the flow through the bypass is greater than 110% the nominal flow of chiller, a subtract request becomes active, thus ensuring that when the set is disabled, the system will continue to operate in positive flow in the de-coupler.

If subtract request for the next chiller remains active as per the following condition for a pre-determined time interval, and there is no co-existing add request, only then a chiller will be subtracted.

$Q_b \geq 110\%$ of Q_c.
Q_b : Measured actual flow in the bypass line
Q_c : Nominal flow through the chiller
At any time of operation if it is desired to subtract another chiller manually, the operator cans “Force Subtract” a chiller-set from the PC workstation.

Control Sequence

Chiller Plant controller shall not be limited to dedicated only the control of its respective system.

The chillers shall be furnished with a factory controls package. The controller Lead lag selector to allow any of the chillers to act as the lead machine.

Individual Chiller –set start-stop logic: Once chiller is enabled (either locally or through the chiller supervisor controller), the chiller controller will:

Open the dedicated evaporator valve.
Start the chilled water primary pump.
The flow has to be confirmed through the hardware interlocked DP switch (in the outlet of each chillers evaporator) with chiller.

Once the evaporator flow has been established, the chiller will then start through its own safety check.

Once the chiller-set is disabled (either locally or through the chiller plant manager), the CSM will:
Disable the compressor of the chiller.
Stop the corresponding condenser fans.
After a certain lag time, stop the corresponding chilled water pump & close the evaporator valve.
If status is not confirmed off for both series chillers in that delay time, the chiller shall be marked as failed and the pump shall remain on.

Cooling program (ENABLE/DISABLE)

Enable or Disable the Chiller supervisor program is by the software through the operator interface. The point acts as the ON/OFF switch. Enabling the program allows the chiller supervisor to take control of the chiller plant. If cooling active is NO, no action is taken. If cooling active is YES, Chiller supervisor will assume active control.

Disabling the program halts chiller supervisor control of the system. All chillers are left in their last commanded states (running or stopped). When enabled, the chiller supervisor resumes operation based on current operating condition.

Chiller Start/Stop Sequencing Modes (Rotation)

Rotation based on chillers service runtime hours. The chillers rotate to equalize service runtime, once per week at a configured time and day. When the chiller supervisor cooling active is ON, the chiller supervisor start the lead chiller based on the current start sequence. When the chiller is sequence is enabled by the controller, it will allow the lead chiller to “Pull Down” the chilled water loop temperature for a configured pull down time. Pull down time allows the lead chiller to cool the building’s water loop and prevents the starting of unnecessary additional machines. After the pull down time elapses, the Additional Cooling Required (ACR) Algorithm determines when lag chillers should be started.

ACR Criteria is as follows:

The Average Chiller Load of all running chillers should be greater than ACR set point.

The chilled water supply header temperature sensor reading T1 should be greater than current chilled water set point.

The above criteria to be valid for a lag start delay time.

While ACR conditions are met, the ‘ACR conditions True’ maintenance point will display ‘Yes’. If the ACR conditions are not met, the ‘ACR CONDITIONS’ point will display ‘No ’.

After ‘Time to Start Chiller’ expires, the chiller supervisor starts chiller # 2 (the next chiller available to start). If it reads back a ‘Running’ status before the ‘Start Fault’ has elapsed, the chiller supervisor will not try to start another chiller.

When the system load decreases, the chiller supervisor determines when to stop a chiller based on the Reduced Cooling Required (RCR) Algorithm.

RCR Criteria is as follows:

1. The average chiller load of all running chillers must be less than or equal to the RCR Set point.

2. The selected current chilled water temperature value is less than the current chilled water set point value + (set point delta T).

3. The above conditions must be true for the Lag stop Delay time. The specific lag chiller to be stopped is dependent on the current sequence.

   ‘RCR conditions True’ will display ‘Yes’, then RCR will decrement pre configured timer to Stop Chiller and keep checking to verify that Conditions 1 and 2 are still true. After the configured Lag Stop Delay Time has elapsed, the next chiller will be stopped. The specific lag chiller to be stopped is dependent on the current sequence.

Butterfly Valves Control Logic (Chilled Water Circuits)

The Butterfly valve will be interlocked with the chiller. When the chiller is enabled by the chiller supervisor, the chiller will send signal to the BFVs (CHILLED WATER CIRCUIT) to open. The limit switch contact of BFVs is the signal for controller (Module/DDC) to start the chilled water pump (CHILLED WATER CIRCUIT).

When the chiller is disabled by the controller (Chiller supervisor), the chiller will stop the “OPEN” signal to the BFVs and directly the (Module/DDC) will stop the respective chilled water pumps.

Primary Chilled Water Pumps (Chilled Water Circuit)

The Primary chilled water pumps sequence is selected based on the time and alarm- handling programs.

Using a Relay to output volt free signal, the chilled water pump contact output is hard wired to (Module/DDC) controller. The (Module/DDC) controller will then use this signal to send a command to MCC Panel to start the respective Primary Pump according to the sequence logic.

Upon receipt of signal from (Module/DDC) controller (activated by BFV limit switch), MCC will start the primary chilled water pump. In the event of the receipt of an alarm on the primary chilled water pump; the faulty pump shall be kept as a last priority until the fault is rectified.

There are 1 running and 1 duty for each chiller group. Variable speed pump driven by frequency drive that will be controlled by two analogue output signal from the (Module/DDC) controller, based on the system differential pressure which is sensed by the differential pressure sensor located **at far end** of the longest chilled water line. The (Module/DDC) controller shall signal the pump variable speed drive as dictated by the system differential pressure reading and shall also monitor the actual pump speed, in addition to the pump trip status and the A-O-H switch position.

The (Module/DDC) Controller will monitor the following signals for each pump generated from the MCC panel serving the pumps: During initial start up of the first pump, the (Module/DDC) controller shall signal the frequency converter to start its minimum speed 30% (recommended), and shall increase the speed of the first pump until it reaches its maximum (100%). If one pump at full speed is not sufficient to maintain the required differential pressure (set point), the (Module/DDC) controller shall give the signal to start second pump with half speed. In the same time (Module/DDC) controller will give the signal to the first pump to reduce the speed at half, so both pumps shall run with same speed and both gradually will run faster in order to maintain required system differential pressure. When there is a load demand and the pressure decreases, the speed of the pumps shall be increased at the same rate until they reach 100%.

The following is a further clarification:

Pump 1 running:

A. The pump shall start at minimum 30% and increase up to maximum (100%).

B: In case there is no load demand, when 1 pump is running the controller shall signal to the pump to decrease the speed. The speed will be decreased down to 50%. If the speed has be decreased more, controller will send signal to stop one running pump and in the same logic, a signal will be given to the running pump to increase speed to 100% of the nominal speed to mach the necessity.

2.0 References for this section 15650

A. Air Conditioning & Refrigeration Institute (ARI):

1. ARI 550/590-1998: Standard for Water Chilling Packages Using the Vapor Compression Cycle.

2. ARI 575: Standard for Method for Measuring Machinery Sound within an Equipment Space.

B. American Society of Heating, Ventilating, and Air Conditioning Engineers (ASHRAE):

1. ASHRAE 15: Safety Code for Mechanical Refrigeration.

2. ASHRAE 30: Methods of Testing Liquid Chilling Packages.

C. American Society of Mechanical Engineers (ASME):

ASME Unfired Pressure Vessel Code, Section VIII, Division 1.

D. American National Standards Institute (ANSI):

ANSI B31.1: Code for Pressure Piping - Power Piping (Current Edition)

3.0 AIR COOLED CHILLER

System Description

Design Requirements

Chiller manufacturer is responsible for selection, design and performance of components provided.

A. Chilled Water Media

1. Circulating chilled Water media: Entering and leaving chilled water temperatures are provided in the data sheet.

2. On site performance testing is required.

B. Performance Requirements

1. See Part 3 of this Specification Section for performance requirements at design conditions.

2. Chiller manufacturer is responsible for the performance of all components.

3. On-site performance test is required for each chiller provided

4.0 Submittals

A. Contractor to comply with the specification document and the specified values in the submittal sheet.

B. Product Data: The following information shall be submitted.

1. Manufacturer's specifications and technical data including performance, construction and fabrication.

2. Submit product data for each manufactured component.

    a. Control Panel

    b. Refrigerant Management System

3. Wiring diagrams. Complete wiring diagrams of the system to be provided. Marked-up drawings of manufacturer’s typical drawings will not be acceptable.

4. Sound power levels for each of the 8 octave bands (63 Hz through 8,000 Hz).

5. Factory Certified witness **test reports** indicating compliance with specified performance requirements.

    a. Chiller performance on Project scheduled operating conditions.

    b. Chiller part load performance for 25%, 50% and 75% capacity at design conditions as specified in the chillers data sheet.

6. List all exceptions to the specification.

7. Complete information on heat gains to the surrounding space from machines and equipment.

8. Completed data sheets.

9. Detailed factory test procedure proposed and with factory two persons visit.

Shop Drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, including specific requirements indicated.

Submit shop drawings on the following items:

a. Electrical requirements for power supply wiring to units.

b. Ladder wiring diagrams for interlock and control wiring, clearly differentiating between portions of wiring that are factory-installed and portions to be field-installed.

c. Submit Shop Drawings for each complete system or assembly of shop-fabricated, field fabricated and manufactured components.

d. List of any hardware required to be provided by other than the vendor in order to make the equipment run.

C. Quality Control

1. Source Quality Control submittals as specified in Part 2 of the Section.

2. Field Quality Control submittals as specified in Part 3 of this Section.

D. Contract Closeout

Operating and Maintenance Manuals

1. Testing, cleaning and maintenance instructions

2. Personnel operating instructions

3. Maintenance Materials List

4. Parts List/Diagram

5. Service Organization

6. Provide a list of spare parts required for each chiller on an annual basis and the cost of these parts as a separate line item with the bid. Spare parts to include gaskets, seals, etc.

5.0 DELIVERY

A. Delivery of equipment and materials shall include the cost of freight and handling from the manufacturer’s plant to the job site. All rigging and unloading shall be by the contractor.

B. Chillers shall be able to be stored at temperatures of 50°C.

6.0 WARRANTY

A. The manufacturer shall guarantee the performance of the equipment and shall include guarantees and performance data from manufacturer's vendors for equipment that is part of the chiller package.

B. Chiller manufacturer shall warranty all equipment, including parts and labor, for five years after acceptance by Owner.

C. Manufacturer to replace without cost any lost refrigerant exceeding 5 percent of the system charge for up to one year after acceptance by the Owner.

7.0 PRODUCTS

7.1 Performance Guarantee & Criteria

A. Chillers shall be guaranteed to operate at an outdoor temperature of 115°F (46°C).

B. Select chiller components based on performance criteria scheduled and as specified herein.

C. Chillers to be constructed in accordance with ARI Standard 550/590 or EN 14511 and as modified in this specification.

D. Efficiency: Chiller input not to exceed 0.78 kilowatts per ton of refrigeration (kW/ton) at the zero tolerance conditions described herein. In order to establish the actual kW/TR correctly, the cooling load imposed by the heat emission of chiller's open motors (in Tons) shall be subtracted from the total chillers capacity output.

E. Minimum efficiency acceptable according to ASHRAE STD 90.1 according to ARI 550/590 test procedure:

2.3 COP (full load Coefficient of performance) @ 46 Cdeg.

7.2 Refrigerant

Provide a full charge of refrigerant and lubricating oil with each chiller. Acceptable refrigerant is R-134a (any other refrigerant is as per Engineer approval). Refrigerant shall be shipped with chiller in suitable containers. Provide labor, materials and equipment for charging the chillers at the job site after installation is completed.

The manufacturer shall certify that chiller components, such as seals, o-ring, motor windings, etc, are fully compatible with the specified refrigerants.

HFC-134a shall be supplied with single or multiple reseating types, spring-loaded relief valve.

7.3 Special Tools

The chiller manufacturer shall furnish two sets of each type of special tool used for all maintenance and equipment service.

7.4 Capacities

Provide capacities as described in the data sheet.

7.5 Compressors / Motors

A. General

1. Chillers equipped with two or three semi hermetic screw compressors and two independent refrigerant circuit.
2. Capacity control by pre-rotation vanes on each stage of compression to modulate unit capacity for a stable cooling operation from 15 percent to 100 percent of design load.
3. Starter panel, IP55 enclosure, single source power supply, with disconnect switch.
4. 19mm expanded rubber foam insulated shell and tube evaporate assembly
5. Condenser coil of copper tubes with factory epoxy coated aluminum fins, TEAO direct drive condenser. fan motors having class F insulation and tropicalized IP55 protection.
6. Microprocessor based unit control module
7. Weather proof tropical paint to withstand 500 hr's of salt spray test.
8. under/over voltage production.
9. Flow switches, discharge valves and neoprene isolators.
10. Full operating charge of refrigerant and oil.
11. Compressor acoustic jacket, chiller coil guards to protect the condenser coil and evaporators area.
12. Chiller plant manager to control the chillers and related pumps.
13. External anti vibration mounts and acoustic treatments.

B. Sound Pressure Level

1. Maximum 85 dba while operating under full load conditions.
2. Levels are measured 10 meter from compressor, condenser, and evaporator.

Manufacturers shall submit details for all utility and/or auxiliary requirements for oil coolers, motor coolers, etc, including, but not limited to the following:

1) Water flow rates

2) Entering/leaving temperatures

3) Pressure drops

4) Coordination requirements with the motor starter, etc.

Motor Load Limiter: Provide a sensing and control system, which will limit maximum load current of compressor motor to a manually selectable percentage of 40 percent to 100 percent of full load current. System shall sense compressor motor current, overriding other controls in their ability to increase loading, but not overriding their ability to reduce loading.

2. All motors shall conform to the applicable requirements detailed in the **electrical sections of this specification.**

3. Semi Hermetic motor requirements:

Refrigerant cooled.

Hermetic motor shall have a continuous duty service factor of 1.0 based on the guaranteed input kilowatts at the zero tolerance performance specified, but shall be capable of testing at 125% of name plate rated power.

Motor surge pressure that is set at 95% of compressor RLA that will automatically unload the compressor to prevent an over current trip. One protector is required for each compressor and indicating light shall also be provided.

Motor: Compressor motor furnished with the chiller shall be in accordance with the chiller manufacturer and the electrical specification. Starting torque of the motor shall be suitable for the driven chiller machine.

4. Open Drive Motor Requirements

a. Stator winding temperature rise shall not exceed 125ºC (measured by RTD) when motor operates at full load at service factor 1.0.

b. Motors shall be complete with space heaters, contactor and separate terminal box.

c. Open Type motor shall have a minimum continuous duty service factor of 1.05 based on the guaranteed input kilowatts at the zero tolerance performance specified.

E. Couplings

1. Couplings shall be provided for coupling the compressor and open type electric motor. The couplings shall be high performance type of forged

alloy steel dynamically balanced; oil or grease lubricated gear type, provided with puller holes and shrouded bolts for low noise operation.

2. The couplings shall be provided with spacers to allow coupling removal without disturbing train component alignment or removal.

3. Couplings shall be precision bored and half couplings shall be mounted by the individual component manufacturer. Couplings shall be keyed and locked on the respective shaft. Dry disc type coupling on the high speed shaft may be allowed.

4. Low speed couplings shall have limited end float.

5. Removable coupling guards shall be provided.

6. A one year supply of lubricant shall be provided with grease lubricated coupling types.

7. Approved manufacturers:

   a. Renk, Germany

   b. Kopflex, USA

   c. Zurn, USA

7.6 Evaporator / Condenser

A. Selection Information

   1. Tube Fouling Factors: Selection based on a minimum scale factor of 0.00025 ft2 hr ºF/BTU for the evaporator.

   2. The design tube side water velocity shall not exceed 8.0 fps (2.4m/s) nor be less than 3.5 fps (1m/s), unless determined and verified by the factory to be acceptable for unit performance.

   3. Maximum allowable pressure drop to be no more than indicated in the schedule at the end of this section.

B. Design Requirements

   1. Heat exchangers: Shell and tube construction; with integrally enhanced tube design.

   2. Refrigerant in the heat exchanger shell and water in the tubes.

   3. Construct in accordance with ASME Code, U stamp, ASHRAE 15/ANSI B9.1 for mechanical refrigeration and ASME B31.5 Refrigeration Piping Code.

   4. Refrigerant components: Pressure test to 1.5 times design working pressure for hydrostatic tests. Pressure test to 1.25 times design working pressure for pneumatic tests.

   5. Evaporator tube side (water) components: 150 psig design working pressure.

C. Tubes

Individually replaceable tubing mechanically expanded or rolled into the tube sheets and with intermediate supports. Intermediate supports shall be spaced to eliminate tube sagging and vibration.

1. Seamless internally and externally enhanced non-ferrous copper alloy material and rolled into tube sheet.

2. Evaporator Non-ferrous copper alloy

3. Tube thickness 0.028 inches minimum at fin root for evaporator.

4. Tubes shall be externally plain at all tube supports and the tube sheets

7. Tubes shall be roll expanded into grooved tube end sheets holes, as well as at all intermediate tube supports.

D. Water Boxes

Design working pressure same pressure as specified for evaporator water side components. ASME 150 psig working pressure.

1. Condenser water box shall be internally coated with GRP or ceramic coating for protection against sea water.

2. Evaporator: Water boxes of the nozzle in head type.

4. Evaporator water connections shall be grooved for Victaulic coupling connections.

5. Each water box shall include threaded or flanged connection on the bottom for drainage connection and the top for vent connection. Minimum size is 1” for vent and 2” for drain connections.

6. Furnish ASME Code safety liquid relief valves to protect the water side of the evaporator.

   Relief valves to be field installed by piping contractor.

E. Insulation

Thermal insulation to be furnished and installed by the Contractor in the field. Chiller manufacturers to provide drawings and specifications for all insulation indicating location and minimum thickness.

Insulation: Evaporator, suction piping, compressor, and all other parts subject to condensation shall be insulated with // 20 mm (3/4 inch) // 40 mm (1.5 inch), minimum thickness of flexible-elastomeric thermal insulation, complying with ASTM C534.

7.7 Control Panel

A. General

Dedicated factory mounted and tested panel for each chiller compressor. Each control panel shall contain a microprocessor based control system with non-volatile memory which shall maintain all data even when power is cut off. Panel operable in multiple modes that allow local and remote control, programming, and service/diagnostic capabilities. Face of panel contains keypad and 40 character alphanumeric display. For chillers with two compressors/circuits, chiller shall have two individual control panels with one panel designed for control of entire chiller and the second panel used to monitor second compressor-refrigerant system.

1. Manufacturer shall incorporate all appropriate and necessary safety controls to assure proper and safe operation of the chiller.

2. Provide an emergency shut-off switch for each chiller that to shutdown the entire chiller. Switch should be located for easy access by the operators.

3. Provide control transformer.

4. All internal heaters, pumps, etc shall be factory wired.

5. Provide MODBUS Micro gateway communication interface card to be able to provide interface with Plant Control System (PLCs). Card shall provide seamless integration between chiller protocols and MODBUS network. The interface shall expose all data in the chiller control panel in a consistent, organized and definable fashion. Coordinate chiller control and monitoring with Plant Control System Integrator.

B. Control Panel Indication: LCD display for the following minimum quantities in English or Metric units:

1. Chiller operating mode and diagnostic information.

2. Entering and leaving evaporator chilled water temperature.

3. Entering and leaving condenser air temperature.

4. Chilled water leaving temperature set-point.

5. Operation hours

6. Evaporator flow

7. Provide for each compressor – refrigerant circuit.

   a. Compressor discharge temperature.
   b. Differential oil pressure.
   c. Compressor oil sump temperature.
   d. Electrical current limit set-point.

e. Evaporator refrigerant pressure.
f. Condenser refrigerant pressure.
g. Motor current percentage.
h. Number of compressor starts.
i. Alarm history file.
j. Phase currents
k. Phase voltage.
l. Motor winding temperatures
m. Motor bearing temperatures.
n. Compressor bearing temperature.
o. Input power (Watts).
p. Purge unit status and cycling frequency (for R-123 machines).

C. Manual Reset Safety Cutouts: Protective limits which require manual reset and cause an alarm message informing the operator which condition caused the shutdown. Provide for each compressor- refrigerant circuit:

1. High compressor discharge temperature.

2. High oil temperature.

3. Low oil pressure.

4. Low evaporator pressure.

5. High condenser temperature.

6. High condenser pressure.

7. Motor controller over or under load.

8. Starter fault.

9. Refrigerant over-pressure protection.

D. Automatic Reset Safety Cutouts: Protective limits which require automatic reset and cause an alarm message informing the operator which condition caused the shutdown.

1. Low leaving evaporator temperature

2. Interlocks

3. Loss of evaporator water flow

4. Power failure

Chilled Water Control

1. Set point accuracy of 0.5 degrees F.

2. PID control algorithm.

3. Remote chiller reset controls. Provide capability for each chiller to accept a 4-20 milliamp input signal to reset the chilled water leaving temperature.

4. Communications capability with industrial protocol such as ModBus, Profibus, DeviceNet, etc.

Controls: Chiller shall be furnished with unit mounted, standalone, microprocessor-based controls in NEMA 12 enclosure, hinged and lockable with variation of +/-10% of design flow per minute, chiller shall be able to maintain +/- 0.5 degrees F leaving water temperature control. The chiller must be able to withstand a +/- 30% change in flow rate per minute without unit trip. Variations in the primary flow allow for optimal system efficiency, but the chiller must be able to maintain temperature control to help ensure occupant comfort.

The chiller control panel shall provide +/-0.5 degrees F leaving water temperature control during normal operation. The chiller shall provide multiple steps leaving chilled water temperature controller to minimize part load energy use and optimize leaving chilled water temperature control. If manufacturer is unable to provide at least several steps of unloading, hot gas bypass shall be required to minimize loss of leaving water temperature control.

7.8 Pressure Relief

Design Requirements

1. Refrigerant evaporator to have factory set safety relief valves and rupture discs.

   All rupture disks shall be piped in series with safety relief valves.

2. Rupture disc device with vacuum support sized to meet requirements of ASHRAE 15 Safety Code for Mechanical Refrigeration.

3. ASME Section VIII safety relief valves labeled and tagged in accordance with ASME safety codes. Provide redundant safety relief valves manifold across an approved double seated service valve. The double seated service valve is intended to allow for repair or replacement of safety relief valves without removing refrigerant and without isolating both relief valves at any one time.

4. Pressure gauge with shutoff valve connected between each rupture disc and safety relief valve set.

5. Chillers operating with Refrigerant 134a shall be provided with dual self seating safety relief valves sized in accordance to ANSI / ASHRAE 15 safety code for Mechanical refrigeration.

6. All Safety relief valves shall be connected by the installing contractor for venting to the exterior, vent lines sized in accordance to latest edition of ASHRAE 15v code.

7.9 Flow Switches

A. Switch Type

1. Differential pressure type flow switches for verification of chilled water flow. Paddle type flow switches are not allowed.

2. Provide switches for chilled water piping for each chiller.

3. Chiller manufacturer to select pressure range and sensitivity suitable for low pressure drop through evaporator flows as per data sheet.

4. Acceptable Manufacturers or equal:

   a. Mercoid

   b. Approved equal

7.10 Auxiliary Motors

A. ½ hp and Above

1. Type: Totally enclosed fan cooled (TEFC), and squirrel cage induction motor in accordance with NEMA.

2. Ratings: 415, 3-phase, 50 Hz, continuous duty, 1.15 Service Factor.

3. Insulation: Class F.

4. Bearings: Greased lubricated ball bearings.

B. Below ½ hp:

1. Type: Open drip proof (ODP), permanently lubricated.

2. Ratings: 240 volts, single-phase, 50 Hz.

2. Signs/Identification: Provide permanent sign securely attached to the Building with the following information:

   a. Name and address of installer

   b. Refrigerant number and amount of refrigerant

   c. Lubrication type and amount

   d. Field test pressure applied

8.0 QUALITY CONTROL

A. Factory Performance Test witness: Provide Factory performance test for one chiller with associated equipment installed, regardless of capacities, in accordance with the latest edition of ARI-550/590-1998, but with the following modifications: The design conditions for this project are beyond the Scope of the standard ARI performance criteria. The test shall be modified as shown to account for actual project conditions. Equipment failing to meet the specified KW/Ton shall be modified and retested at the manufacturer's expense. The performance test shall be run with clean tubes in accordance with ARI 550/590-1998 to include the following:

1. A downward temperature adjustment per Section A7.3 shall be made to the design leaving evaporator temperature to adjust from the design fouling to the clean tube condition.

2. An upward temperature adjustment per Section A7.3 shall be made to the design entering water temperature to adjust from the design fouling to the clean tube condition.

3. Test temperature adjustments shall be verified prior to test. There shall be no exceptions to conducting the performance test with clean tubes and with temperature adjustments in paragraphs 1 and 2 above. The manufacturer shall clean tubes, if necessary, prior to test to obtain a test fouling factor of zero.

4. The factory test instrumentation shall be per ARI Standard 550/590 and with the modifications as shown. The calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology (formerly NBS).

5. Tests will be run for a minimum of 3 hours at steady state conditions before are readings taken. Readings to be recorded every 15 minutes for a test run of 3 hours.

6. Test shall be **witnessed by Engineer as well as Owner representative.**

7. A certified test report shall be submitted to the Engineer and Owner. Report shall include specified tolerance and actual test results. If the equipment fails to perform within allowable tolerances specified, that manufacturer will be allowed to make necessary revisions to his equipment and must retest as required. In the event that these revisions do not achieve submitted performance, the following penalties will be imposed:

   a. Capacity Test: For each ton below the nameplate capacity as set forth from testing, $1500 per ton multiplied by the total capacity of all chillers to be provided for this project will be deducted from the contract price.

   b. Allowable capacity = ((1 - tolerance) x nameplate design capacity); tolerance per modifications shown.

   c. Power Consumption Test: The power consumption penalty for all load points shall be based upon the tolerances set forth. The power consumption penalty (P.C.P.) will be calculated based on the following formula:

      P.C.P. = (Measured KW - (Measured tons x allowable KW per ton)) x $3,000 per KW.

d. Allowable KW per ton = ((1 + tolerance) x design KW per ton); tolerance per modifications.

e. Total Performance Penalty: The total performance penalty will be the sum of the capacity penalty and power consumption penalty for all chillers provided for this project failing to meet the test.

f. Equipment manufacturer shall not request payment for the chillers until successful completion of the performance test or acceptance of penalty deduction from the contract.

g. The tolerance for Capacity Test shall be ±3%.

h. The tolerance for Power Consumption Test shall be minus two percent (-2% or –0.02) and plus zero percent (+0% or +0.00).

i. ARI tolerance of +/- 5% is not acceptable

j. Leaving chilled water temperature allowance and entering air tolerance allowed ±0.5°F of adjusted for fouling allowance values. Water flow tolerance ±5%.

k. All tests shall be conducted under the supervision of the manufacturer's Service Engineers.

8. Part Load Tests

a. The chiller shall be tested for part load performance with constant entering condenser air flow at 100% design conditions and a constant temperature of 94 ºF.

b. Each part load test to include 25%, 50%, and 75% of the full load capacity as testing points with constant condenser air flow (100% condenser air flow).

c. All tests to include minimum of 1 hour operation at constant load before readings are recorded and new load condition is established.

9. Special Load Test:

a. Chiller shall be tested at its maximum load capability with the evaporator at maximum design flow and with leaving temperature at 4.45 ºC while using condenser air at design flow with entering condenser air temperature at 46 ºC.

b. All tests to include minimum of 1 hour operation at constant load before readings are recorded and new load condition is established.

c. Provide one hour testing with readings recorded and capacity calculated for each 15 minute-interval.

d. Field performance test: See Field Quality Control section below.

e. Factory Sound Pressure Test: One of the chillers shall have a sound test conducted at the factory prior to shipment in order to confirm the Sound Pressure Levels submitted. All data must be measured and presented in strict accordance with ARI Standard 575-87.

1. Sound data: The chiller sound pressure level (SPL), in decibels (dB), with a reference pressure of 20 micro-Pascal, shall not exceed 87 dB ("A" scale weighted) at 100%load. The sound test shall confirm and certify this level is achieved. All ratings shall be in accordance with ARI Standard 575-87, "Method of Measuring Machinery Sound within Equipment Rooms"

   No reduction of entering condenser air or rising of leaving chilled water temperatures will be allowed in the SPLs. Making such a temperature adjustment does not represent the loudest operating condition the chiller will experience while on the job. A minimum of 75 percent of the sound data points along the length of machine shall be taken, and established as the minimum percentage of total possible points used to determine sound levels.

2. In the event that a chiller does not meet the submitted dBA sound pressure level, the manufacturer shall, at the manufacturer’s expense, provide sufficient sound attenuation to any and all machines to meet the submitted value. This sound attenuation shall be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller.

3. If the unit cannot be modified to meet the submitted SPL levels, funds will be deducted from the purchase price to provide materials and labor for job-site sound attenuation to bring the sound levels to the specified level.

4. Should sound attenuation be required, submit sound tests taken after the sound attenuation has been applied to confirm effectiveness of sound attenuation.

e. Factory Vibration Test

   One of the chillers shall have a vibration test conducted at the factory prior to shipment to confirm the vibration levels submitted.

a. Unit shall be run in manufacturer's shop at the required design speed.

b. Vibration measurements shall be taken at critical bearing locations in the horizontal, vertical and axial directions, where possible.

c. Factory report shall indicate:

1) Measured peak displacement, velocity, and acceleration amplitudes at critical frequencies and RPM's.

2) Range of acceptable displacement, velocity, and acceleration amplitudes at critical frequencies and RPM's.

9.0 EXECUTION

9.1 Shipping

A. Each chiller must be protected at the factory to prevent damage during transit and to prevent the entrance of dirt, moisture and contaminants.

B. The refrigerant side shall be evacuated to remove moisture and replaced with a dry nitrogen gas charge for the refrigerant side. The pressure of the nitrogen is minimum 5 psig with a pressure gauge with shut off valve reading 0-50 psig. Because the ambient air temperature at the factory may be substantially lower than the design temperature in the **Kingdom of Bahrain**, the manufacturer must account for the pressure rise because of change in temperature.

1. R123 chillers have a rupture disk and safety relief valve setting of 15 psig gauge and the intent is to maintain a positive nitrogen pressure without bursting the disk. Design temperature in **Kingdom of Bahrain** is 46 Deg.C and should be used as the possible temperature at the project site.

2. R134a chillers have a higher relief valve setting and therefore must maintain a minimum of 5 psig pressure at all times. Provide a pressure gauge and valve that will indicate clearly the status of the factory nitrogen charge during transit.

C. The water boxes for the evaporator must include pipe plugs for all vent and drain connections as well as for any instrument connections on the inlet and outlet nozzles and the water box itself.

D. All water circuits after factory testing shall be drained thoroughly, air dried and closed.

E. Skids mount equipment as required, protecting component parts during shipment.

F. Control panels shall be over crated for protection in transit.

G. Provide plastic “heat shrink wrap” minimum of 20 mils thickness over compressor and motor, control panels, purge system and liquid refrigerant and oil pump system. Provide protective covering for cables, exposed valves etc. to prevent damage during shipment.

H. The manufacturer shall inspect chiller unit before and after covering and shall provide a minimum of 6 digital photos of the chiller from all sides before and after wrapping. The photos and a written report indicating the conditions of the unit and the name of the person making the observation shall be dated and sent to the Engineer prior to shipment from the factory.

I. The manufacturer shall inspect each chiller unit again at the ocean port before it leaves the country of manufacture. Digital photos and information same as at the factory shall be obtained and sent to the Engineer prior to shipment overseas. All chiller units shall be stored below ship decks during the entire transit period from the ocean port of manufacturer’s country to the port of entry to **Kingdom of Bahrain**.

J. The manufacturer shall inspect each chiller unit again at the ocean port of entry into the **Kingdom of Bahrain** before it leaves the port of entry. Notify the Owner within 10 days of the arrival in the port in **Kingdom of Bahrain** to allow the Owner to witness the condition of the chiller at the port of entry before shipment to the project site. Digital photos and information same as at the factory shall be obtained and sent to the Engineer and Owner prior to shipment to the project site.

K. The Owner’s representative, the Engineer, the contractor and the manufacturer shall make a final inspection prior to installation to insure that the unit is in the same condition as it left the factory. Digital photos and information regarding the condition shall be submitted to the Engineer.

L. Severe penalties will be imposed for failing to prevent intrusion of corrosion or foreign matter within the components and connections. During any phase of the shipment, should there be evidence of damage or loss of nitrogen charge, the Engineer will be notified to make recommendations as to the remedy of the reported problem. Should the Engineer determine that the damage is severe and not repairable at the point of discovery, the unit shall be returned to the manufacture’s plant for replacement or repairs as required at no cost to the Owner.

M. All equipment shall be arranged for bellow deck ocean shipment.

9.2 Installation

A. Install in accordance with manufacturer's recommendations.

B. Chiller must be installed with level-adjusting, spring type vibration isolator with non-skid pads sized for one inch deflection.

C. Electrical Specification provides power wiring to compressor motor starter cabinet.

D. Provide refrigerant relief vent piping system from all chillers, pump-out units and purge units as required to safely discharge vent products to outside atmosphere.

E. Also included in this contract:

1. Control wiring differential pressure sensors, and other safety points required to operate the chiller.

2. Miscellaneous piping, wiring, valves, fittings and all required auxiliaries in accordance with manufacturer's recommendations and as indicated on the drawings.

3. Provide all interfaces, configuration, interconnection, control devices and instrumentation as specified in section 16170 building management system to meet the control and monitoring points and sequence of operations.

9.3 Start-Up and Operating Instructions

A. Furnish refrigerants and lubricants necessary to put the chillers into service. Manufacturer to replace without cost, any lost refrigerant exceeding 5 percent of the system charge for up to 1 year.

B. At a time set by the Contractor and agreed to by the Owner, place the water chiller into operation. At such time the chiller manufacturer shall provide the services of a competent, factory-trained and certified representative to assist in start-up and in proving satisfactory operation.

C. The manufacturer's representative shall take data during this period of initial operation and instruction which will serve to indicate the proper performance of the installation.

D. Provide written operation and maintenance instructions to the operating personnel in the proper care and operation.

E. Provide manufacturer technician's time during start-up, including travel, lodging and subsistence for each chiller to provide start-up and operating instructions.

F. Prior to training:

1. Submit written outline of what will be covered in the training sessions to the Owner.

2. Submit the Operations and Maintenance Manuals.

G. Training

1. Provide class room style (on-site) instruction for a minimum of 4 people. Attending will be Hotel operator, operating and maintenance personnel, and control system technicians.

2. Training shall be for minimum of 16 hours.

3. Provide copies of all required reference materials.

4. Minimum topics to be covered:

a. Chiller Operation

b. Chiller Maintenance

c. Sensor and Transducer Recalibration Procedures

d. Use of Programmed Software

e. Operator Interface

5. Upon completion of Owners' training, submit Owner's Verification of Training Completion Form signed by Owners Representative.

9.4 Field Quality Control

A. Start-up to include supervision during erection of the equipment.

B. A satisfactory unit performance at the factory alone without performance duplication on site will not guarantee equipment acceptance.

C. Manufacturer/supplier shall prepare and submit site performance test procedure in accordance with the latest ASHRAE / ARI standards to prove fulfillment of guarantees and conformance with the specification for full load capacity, efficiency, and proper mechanical and electrical operation. Manufacturer shall take all corrective actions required to ensure that site performance test will be within ARI defined tolerance. In case of failure, the same penalty described above shall be applied.

D. Manufacturer/supplier shall successfully perform and document site performance test.

9.5 Chiller Schedule

REFER TO THE CHILLER SUBMITTAL DATA HVAC SHEET(S).

9.6 Refrigerant Process Conditions and Performance

9.7.1 PERFORMANCE

Leak detection refrigerant monitors shall be capable of sensing down to one part per million (ppm), compound specific, and calibrated for R-134a.

Monitors shall continuously measure and display the specified gas concentration.

Three levels of alarm shall be provided. Each level may be independently adjusted.

1. Caution – First stage (factory set point at approximately 9 ppm) for early leak detection and indication. Verification that the refrigerant ventilation system is operating in the low-speed "occupied" mode. If not, refrigerant ventilation system shall be enabled.

2. Warning – Second stage (factory set point at approximately 29 ppm), before TLV-TWA refrigerant toxicity is exceeded, to enable

refrigerant ventilation system into high-speed operation for emergency ventilation. Alarms are also enabled.

3. Alarm – Third stage (factory set point at approximately 700 ppm) to indicate that the room is not safe to occupy or enter without the proper personnel protective equipment.

Monitors shall communicate with emergency ventilation and HVAC systems through three alarm levels by annunciating alarms, starting emergency ventilation, and shutting down HVAC equipment.

Monitors shall have all software, gateways, and integrators for a complete, fully functional system. Although combustion equipment is not employed, the monitoring system shall have the capability to automatically shut down the combustion process in the event of a refrigerant leakage if other acceptable conditions are not specified.

9.7.2 System Configuration:

The system shall consist of a sample draw monitor/readout unit including the following:

A. Wall-mounted, NEMA 4 type enclosure with brackets.

9.7 Final Assembly, Testing, and Start-Up

PART 1

Mechanical Contractor shall be responsible for performing onsite calibration, testing, pre commissioning, and commissioning of the equipment supplied. Coordinate all startup and commissioning services with the Chiller Manufacturer. Under the supervision of the Mechanical Contractor; the factory authorized chiller service agency shall be responsible for providing training and orientation on the operation of the equipment to the Owner’s plant staff.

PART 2

The Chiller Manufacturer shall identify a recognized service center for the supplied equipment. The service center must be capable of responding to service requests within 24 to 48 hours.

9.8 Signs/Identification

Provide permanent sign securely attached to the building with the following information:

a) Name and address of installer

b) Refrigerant number and amount of refrigerant

c) Lubrication type and amount

d) Field test pressure applied

10.0 Related Work

Section 15010, MECHANICAL GENERAL PROVISIONS
Section 15540, ACVM PUMPS
Section 15240, SOUND AND VIBRATION CONTROL
Section 15510, ACVM PIPEWORK
Section 15910, DUCT WORK ACCESSORIES.
Section 16090, ELECTRIC MOTOR CONTROLLERS
Section 16100, MOTOR STARTERS

Definition

A. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.

B. BACNET: Building Automation Control Network Protocol, ASHRAE Standard 135.

C. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.

D. FTT-10: Echelon Transmitter-Free Topology Transceiver.

E. LonMark: An association comprising of suppliers and installers of LonTalk products. The Association provides guidelines for the implementation of the LonTalk protocol to ensure interoperability through Standard implementation.

F. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication.

G. LonWorks: Network technology developed by the Echelon Corporation.

H. SCBA: Self-Contained Breathing Apparatus.

Quality Assurance

A. Refer to Paragraph, QUALITY ASSURANCE, in Section, BASIC METHODS AND REQUIREMENTS (MECHANICAL), and comply with the following.

B. Refer to PART 3 herein after and Section 15995, TESTING AND BALANCING for test performance.

C. Comply with ARI requirements for testing and certification of the chillers.

D. Refer to paragraph, WARRANTY, Section 15010, MECHANICAL GENERAL PROVISIONS, except as noted below:

   1. A 5-year motor/transmission/compressor warranty shall be provided based upon the RPM of the compressor as follows:

Compressor RPM	Warranty Term
0-5000	1 year from start up
5001-10,000	5 years from start up
10,001 and above	5 years plus annual oil analysis

2. A 5-year parts and labor warranty shall be provided on any reciprocating compressor.

E. Refer to OSHA 29 CFR 1910.95(a) and (b) for Occupational Noise Exposure Standard.

F. Refer to 42 CFR—Public Health, Part 84, "Approval of Respiratory Protective

G. Devices," Subpart H—"Self-Contained Breathing Apparatus," 1998.

H. Refer to ASHRAE Standard 15, Safety Standard for Refrigeration System, for refrigerant vapor detectors and monitor.

Applicable Publications

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. American Refrigeration Institute (ARI):

210/ 240-03 Unitary Air Conditioning and Air-Source Heat Pump Equipment
370-01 Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
495-99 Refrigerant Liquid Receivers
550/590-03 Standard for Water Chilling Packages Using the Vapor Compression Cycle
560-00 Absorption Water Chilling and Water Heating Packages
575-94 Methods for Measuring Machinery Sound within Equipment Space

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

15-02 Safety Standard for Mechanical Refrigeration Systems
3-96 Guidelines for Reducing Emission of Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems

D. American Society of Mechanical Engineers (ASME):

1998 ASME Boiler and Pressure Vessel Code, Section VIII, "Rules for Constructive Pressure Vessels"

E. American Society of Testing Materials (ASTM):
C 534-03 Preformed, Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
C 612-04 Mineral-fiber Block and Board Thermal Insulation

F. National Electrical Manufacturing Association (NEMA):
250-03 Enclosures for Electrical Equipment (1000 Volts Maximum)

G. National Fire Protection Association (NFPA):
70-05 National Electrical Code

H. Underwriters Laboratories, Inc. (UL):
1995-99 Heating and Cooling Equipment

Submittals

A. Submit in accordance with Specification Section 01340, SHOP DRAWINGS, and PRODUCT DATA AND SAMPLES.

B. Manufacturer's Literature and Data.

1. Air cooled chillers, including motor starters, control panels, and vibration isolators, and remote condenser data shall include the following:

a. Rated capacity.

b. Pressure drop.

c. Efficiency at full load and part load without applying any tolerance indicated in the ARI 550/590/Standard.

d. Refrigerant

e. Fan performance (Air-Cooled Chillers only.)

f. Accessoires.

g. Installation instructions.

h. Start up procedures.

i. Wiring diagrams, including factor-installed and field-installed wiring.

j. Noise data report. Manufacturer shall provide noise ratings. Noise warning labels shall be posted on equipment.

k. Self-contained breathing apparatus (SCBA).

l. Refrigerant vapor detectors and monitors.

C. Maintenance and operating manuals for each piece of equipment in accordance with Section 15010, MECHANICAL GENERAL PROVISIONS.

D. Run test report for all chillers.

E. Product Certificate: Signed by chiller manufacturer certifying that chillers furnished comply with ARI requirements. The test report shall include calibrated curves, calibration records, and data sheets for the instrumentation used in factory tests.

F. Provide seismic restraints for refrigeration equipment to withstand seismic forces.

G. Factory-mounted purge unit, complete with necessary, piping, operating and safety controls and refrigerant service valves to isolate the unit from the chilling unit. Purge unit shall be air, water, or refrigerant cooled. When in operation, purge system shall function automatically to remove, water vapor, and condensable gases from refrigeration system and to condense, separate, and return to system any refrigerant present therein. Purge system shall be manually or automatically started and stopped, and shall be assembled as a compact unit. As an option, a fully automatic purge system that operates continuously while main unit is operating may be furnished. Such purge system shall provide a means to signal operator of occurrence of excessive purging indicating abnormal air leakage into unit. The purge system shall be of high efficiency in recapturing the refrigerant at all load and head conditions and with capability to operate when the chiller is off. The purge unit shall be UL listed.

END OF SECTION - 15650

SECTION 15800

SPLIT / MULTI-SPLIT AIR CONDITIONING

PART 1 – GENERAL

1.1 Work Included

A. Comply with Division SECTION 15010 MECHANICAL GENERAL PROVISION and all documents referred to therein.

B. Provide all labour, materials, products, equipment, accessories, services and tests necessary to complete, make ready, and set to work all fans indicated on the Drawings and specified herein.

1.2 Reference Standards

The indoor unit (fan-coil unit) shall be wall-mounted type, with decorative cabinet. Out-door unit (condensing unit) shall be designed for outdoor installation. Condensing unit shall be capable to operate without tripping at summer ambient temperature up to 125 °F.

Unit shall be quite in operation consisting of centrifugal fan, cooling coil & filter. Cooling coil shall be copper tubes mechanically bonded to aluminium fins. Fan motor shall be of three-speed winding controlled by 3-speed fan switch, wireless remote controller. Wireless remote controller shall be lightweight adopting advanced microprocessor with LED display of set temperature and room temperature.

The air discharge from the wall mounted type indoor unit shall be through the lower chamfered face. The cold air can be evenly distributed in a room. Unit shall be equipped with swing flow louvers.

The unit should be equipped with an inner drying function, after the power is turned off, the dry operation starts inside the air conditioners. This prevents the growth of bacterial inside the air conditioner

The unit shall include compressor, condenser coil, fan and motor charging valves, all controls and holding charge of R-410a.

The compressor shall be of the welded hermetic reciprocating type with refrigerant gas, cooled inherently protected motor with internal vibration isolators and shall be located in an isolated compartment of the unit to reduce the noise level. The compressor shall be equipped with safety devices like crank case heater, thermal and current sensitive overload devices.

Condenser coil shall be copper tubes mechanically expanded into aluminium fins. Casing shall be protected against extreme weather conditions, placed on raised concrete base with anti-vibration mounts.

Condenser fan shall be direct driven propeller type and arranged for horizontal /vertical discharge. Fan hub shall be designed to protect motor shaft, bearing and winding. Fan motor shall be factory lubricated and inherently protected. The whole unit shall be housed in a weather proof cabinet.

The condenser coils to be provided with pre-coated anticorrosion, which should withstand salt spray test for above 300 hrs.

Split / Multi-split-type AC units to be standard products, selected from approved manufacturers.
Fan ratings to AMCA for sound and air delivery performance

Fans shall be factory balanced, statically and dynamically to AMCA Standards.

Cooling coils shall be ARI certified.

1.3 Submittal Data

Submit manufacturer's latest published data for dimensions, materials, accessories and installation details.

Submit full technical rating data (electrical, capacity, etc.). Include piping and electrical connection drawings.

Operational and Maintenance Manual: Manufacturer's instruction for operation and maintenance.

1.4 Performance Requirements

A. Refer to Equipment Schedule and Drawings for sizes, arrangements and capacities.

1.5 Quality Assurance

Acceptable Manufacturers: Firms approved and whose products have been in satisfactory use in similar services in GCC/(Bahrain).

Standards Compliance: Comply with requirements of applicable local codes and the standards outlined in the General Notes.

1.6 General Requirements

These specifications describe requirements for a self-contained, factory-assembled split / multi-split-type AC unit.

The manufacturer shall confirm all equipment to be fully compatible with heat dissipation requirements of the room.

PART 2 - PRODUCTS

2.1 Split/Multi-Split Type A/C Unit

A. General

Air conditioning units shall be of the air cooled split type and shall be standard products of approved manufacturers.

The units shall be designed for quiet operation with all moving parts mounted on anti-vibration mountings and carefully balanced to ensure minimum vibration.

Each unit shall be of standard design and construction, having refrigerant of an approved non-toxic, non-flammable type, and shall incorporate accessory items set out below. Allowance shall be made for the provision of all these items if these are not provided in the manufacturer's standard equipment.

The indoor fan coil units shall consist of fans, cooling coils and associated pipe work and controls equipment. The outdoor air-cooled condensing units shall consist of compressors, condenser coils and fans, associated pipe work and control equipment.

Each unit shall have compressor(s) quantity as indicated in the Equipment Schedule and each compressor shall have its independent refrigerant and electrical circuit.

Cooling capacities shall be as stipulated in the Equipment Schedule and certified by ARI.

B. Casing

Casings shall be constructed or folded and reinforced zinc anneal sheet or a structural steel frame clad in zinc anneal sheet to support all items of equipment, and shall be treated for prevention of corrosion. Casings for outdoor installation shall be of weather proof finish with galvanised or special coating finish with zinc chromate and a finish coat.

Casings for housing coils and supply air fan shall be internally lined with 25mm thick fibreglass or mineral wool insulation in rigid form faced with aluminium foil.

Casings for housing compressors shall be acoustically treated to achieve the specified acoustic level.

Removal panels shall be provided for access to all internal components to facilitate convenient installation and maintenance.

C. Compressors / Controls

Compressors of fully hermetic or accessible hermetic type with suction gas cooled motor shall be complete with all necessary accessories and controls for safe and efficient operation and shall include:

Starters complying with the requirements of power supply authorities.

High refrigerant pressure safety cut-out for unit with a cooling capacity over 13 kW.

Low refrigerant pressure safety cut-out for unit with a cooling capacity over 13 KW.

Oil pressure (manually reset) safety cut out for accessible hermetic compressor with a cooling capacity over 40 KW.

Positive lubrication.

Service valves at suction and discharge of each compressor.

Liquid moisture indicator sight glass.

Compressor crankcase heaters for unit with a cooling capacity over 13 KW.
Pump down control for unit with a cooling capacity over 40 KW (A tight-closing solenoid valve in the branch of each evaporator required).

Individual compressor fault indication

Time delay relay for compressor

D. Evaporator Coils

Coils shall be constructed of seamless copper tube complete with mechanically bonded and chemically treated aluminium fins.

For units with multiple compressors, all compressors shall have an independent coil with its own expansion valve and solenoid valve.

Heavy gauge insulated galvanised drip trays shall be provided under each evaporator coil.

E. Fans

Fans shall be of centrifugal type and shall be adequately rated to provide the air quantities specified.

Fans shall be full double width, double inlet, forward curved, multi-blade fans statically and dynamically balanced. Fan wheels shall be mounted on an adequately size shafts with 20,000 hours bearing.

Fans shall be direct drive type with field adjustable speed tap or driven by a vee belt drive correctly aligned with pulleys capable for replacement as necessary to achieve the air quantities specified.

The exact fan speed and fan motor size shall be determined by Sub-Contractor having regard to the resistance of all elements of the air conditioning systems to be provided and installed, including ductwork and fittings with a 20% safety factor for motor sizing.

F. Air Cooled Condensers

Air cooled condensers shall be constructed with copper tubes and chemically treated chemically treated aluminium fins. Fans shall be of propeller type.

Each compressor shall be connected to its independent condenser coil amply sized to dispose the heat rejection.

Condensers shall be provided with spring loaded pressure relief valve and line valves.

Condensers shall be designed for suitable refrigerant working pressure.

G. Air Filter

All units shall be complete with washable aluminium filters and thermostat controls.

H. Refrigerant Piping

Refrigerant piping shall be of soft copper coil to equipment manufacturer's standard.

The suction line shall be insulated with 20mm closed cell elastomeric thermal insulation ("Armaflex" Class 1) suitable for service temperatures up to 125oC.

The refrigerant piping shall be adequately sized.

PART 3 – EXECUTION

3.1 Installation of Split/Multi-split Type Air Conditioning Units

General

Install the split/multi-split-type air conditioning units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

Electrical Wiring

Install and connect electrical devices furnished by manufacturer but not specified to be factory mounted.

Piping Connections

Install and connect devices furnished by manufacturer but not specified to be factory mounted.

Field Quality Control

Start up mainframe coolant units in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements.

END OF SECTION-15800

SECTION 15850

AIR HANDLING UNITS

PART 1 - GENERAL

Provide factory assembled air handling unit in configuration as indicated and scheduled on drawings. Unit shall include all specified components installed at the factory. Field fabrication of units and their components will not be acceptable.

Units shall be modular, factory built for shipping and field assembly for field erection by experienced manufacturer of large custom air handling units that maintains experienced engineering and production staff. Coordinate shipping split with field restrictions.

All air side equipment and chilled water piping must be designed and selected using the chilled water temperatures specified. Designing coils at 1°C higher design supply temperature than stated in the AHU's & FCU schedules the drawings and with higher temperature differentials is prudent to allow for coil fouling over time. Particular attention must be given to selecting the cooling coils with delta T specified. The fan coil units shall be of particular concern as they need to be properly selected with deeper rows (minimum 4) so as to achieve the delta T desired.

The system are designed around a variable flow chilled water system using two way equal percentage control valves for all air handling units (AHU's) and fan coil units (FCU's). All AHU's & FCU'S shall have modulating equal percentage type. Correct sizing of actuators and valves to achieve adequate close off capability is essential.

Control valves must be interlocked with the fan to shut off when the associated AHU/FCU shuts off.

Cooling coils must be piped counter flow.

End of line 3 way valves should be avoided except where essential to allow for the minimum pump flow. They should not be provided at the end of remote circuits to avoid chilled water stagnation. The number of AHU's and FCU's that using 3-way control valves should not exceed a maximum chilled water flow of 10% of full design flow. The bypass on the three-way valve should have a double regulating valve for proper balancing and shut off the bypass whenever the system requires it. The contractor should indicate location and piping arrangement for these units.

General manufacturing/sub contractor considerations shall include the following:

Steel construction shall be G-90 galvanized steel. All galvanizing shall conform to ASTM-525.

Coils shall be arranged so that space between coils is a minimum of 24 inches, unless specifically shown otherwise on the drawings.

Fan compartment shall be arranged such that the space between the fan inlet(s) and the housing is a minimum of one fan diameter.

Arrangement of components shall be such that the coil face velocity distribution shall not vary more than 20% from the average coil velocity. Maximum air face velocity through coil shall not exceed 2.54 m/sec unless otherwise specified or accepted to the Supervision Employer's Representative.

Coil assemblies shall have provisions to facilitate total or partial removal from coil bank. Removable panels shall be provided on both sides of the unit.

Multiple coil banks shall have coils independently supported. All coil pipe connections shall be extended through the unit wall casing by the unit manufacturer. No field pipe penetrations are allowed.

Outdoor and return air mixing boxes shall be arranged to minimize stratification. Air blending devices or mixing columns shall be provided as detailed on the drawings.

Housing shall be manufactured to minimize through metal construction in order to eliminate external water vapour condensation. Housing shall be manufactured to minimize air and water vapour leakage.

The unit manufacturer shall be responsible for the complete manufacture of units, all components, complete shop and field erection of units and all components, operation and performance of units under manufacturer's nameplate.

The Sub-contractor shall be responsible for coordination of the delivery of all units in compliance with construction schedule; provision of all necessary external piping, ductwork and miscellaneous connections required to complete the installation of the units in cooperation with and as recommended by the unit manufacturer.

The unit manufacturer shall be responsible for provision of casing, fans, dampers, sound attenuation measures, electrical components, and all other unit and plenum components as specified in this section or other sections of this division and performance as shown in schedules or on drawings.

Provide necessary appurtenances to perform as specified, whether or not expressly required by the Sub-contract Documents mentioned herein in conformance with good trade practice, as determined by the Supervision Employer's Representative.

Provide services of experienced field Sub-contractor employed by the manufacturer to supervise installation, testing and troubleshooting of units.

Provide all interfaces, configuration, interconnection, control devices and instrumentation as specified in section 16170 building management system to meet the control and monitoring points and sequence of operations.

QUALITY ASSURANCE

The equipment manufacturer shall strictly adhere to following standards & Specification:

(1) ISO 9001 certificate required.

(2) Equipment shall be Euro vent – Certificate to be submitted by AHU manufacturer.

(3) Air Handing Unit manufacturer shall strictly adhere to CEN standards (Committee European de Normalization). Air handing units shall meet the EUROPE CERTIFICATION requirements of:

(a)	Casing Strength	to Class 2A
(b)	Casing air leakage minus 400 Pa	to Class A.
(c)	Casing air leakage plus 700 Pa	to Class A.
(d)	Thermal Transmittance	Class T4.
(e)	Thermal bridge factor	Class TB3.

(4) AHU panel insulation shall be fibreglass or polyurethane foam Units shall be produced by a recognized manufacturer whose manufacturing process is ISO-

9002 certified. Their quality control procedures must be thoroughly documented to ensure a consistently high quality product.

Provide proof of credentials of manufacturer's staff as required by the Supervision Employer's Representative. Provide evidence satisfactory to Supervision Employer's Representative that the manufacturer has supplied units to prestigious projects in the last ten years.

Certify conformance with performance requirements specified and shown on Drawings.

Local service shall be available either directly from the factory or through the local certified factory representatives.

Major components shall be products of recognized manufacturers regularly engaged in production of such equipment and whose products are in compliance with industry standards.

The following parameters shall establish the selection criteria and shall be as specified: airflow rates, external static pressures, and water flow rates. The following are to be as specified or improved: coil and filter face velocities, cabinet air leakage rate, inlet/discharge/radiated sound power levels, and internal static pressures/brake horsepower.

TESTING

Test to ensure structural integrity, suitability under simulated operating conditions, system operation and minimum vibration levels as specified. Certify that the unit complies with design intent and Sub-contract Documents.

Following tests shall be performed:

Pressure test water coils.

Air pressure test with fans operating at shut-off pressures to ensure tight housing construction and integrity.

Unit operation and vibration analysis. Operate fans at design rpm, set fan drive and conduct complete vibration spectrum as specified. Fan, motor, drive and base assembly vibration shall be brought to within specified levels. Check motor and drive vibration with fan as assembly.

Energize electrical devies to ensure operational integrity prior to shipment. Replace non-functioning items.

Submit casing panel acoustical, structural and physical properties performance test data before shipment from independent recognized test laboratory.

Casing leakage shall be less than 1 % of design airflow at 1.25 times the design static pressure or 1.1 times the fans peak static pressure at design RPMs.

Fans shall conform to AMCA standards regarding testing and construction. Fans shall bear the AMCA certified rating seal for sound and airflow.

Heating and cooling coils shall be ARI certified.

Filter media shall be ULC listed.

Units with factory wiring shall be CSA or ETL approved for electrical safety.

OPERATION AND MAINTENANCE DATA

Include instructions for lubrication, filter replacement, motor and drive adjustment and replacement, spare parts lists, and wiring diagrams.

DELIVERY, STORAGE AND HANDLING

Units shall be shipped with all openings securely covered with wood and/or nylon reinforce plastic wrap and be water-tight.

Accept products on site in factory applied protective wrapping, and factory installed lifting lugs. Inspect for damage. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish.

Environmental Requirements

Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

Approved Manufacturers

Company specializing in manufacturing the products specified in this section with minimum ten years documented experience, who issues complete catalogue data on total product.

SUBMITTALS

Submit manufacturers Quality Assurance Manual.

Submit shop drawings and product data. Shop Drawings shall be subject to approval of the Supervision Employer's Representative.

Shop drawings shall be clear and legible with an index format to identify different sections. Provide a cover page for each air handling unit, showing the project name, Sub-contractor, tagging information, revision if applicable, and submission date, leaving adequate space for approval stamps.

Provide all technical information relevant to the product being provided, including but not limited to all the information shown in the schedules of the specification. It is the responsibility of the supplier to highlight any variances his equipment has with the requirements of this specification.

Shop drawings shall include appropriately scaled CAD drawings. Drawing files shall be available through the Internet or as hard copies on disk. Provide website or e-mail address to obtain electronic documents.

Product data shall include dimensions, weights, capacities, component performances, electrical characteristics, construction details, required clearances, field connection details, proposed test descriptions and sample reports, pressure drops, vibration isolation, gauges and finishes of materials.

Submit fan manufacturer's published performance curves, based on tests in accordance with current AMCA standards and in AMCA approved laboratory, to define sound power levels (PWL), re: 10-12 W for each of eight frequency band.

Submit fan manufacturer's published sound power level data based on actual test on fan sizes being furnished in accordance with current AMCA Standards.

Provide fan performance curves depicting the operating point described on the schedule for each individual fan.

Provide copy of vibration Nomograph showing test results.

Provide coil selection data sheets, clearly showing input data with proper consideration for altitude, air density, as well as clearly indicating the selected coils' output data.

Provide details showing condensate drain connection height and required P-trap height.

Provide filter information, including initial air pressure drop, final air pressure drop, and dust spot efficiency, final dust holding capacity, filter media description, filter frame details, filter replacement details, and filter gauge details if applicable.

Submit air handling unit inlet, discharge, and radiated sound power levels at nominal capacity.

Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring; clearly indicating factory installed and field installed wiring and accessories.

Submit material thickness and finishes details

Submit filter details with performance characteristics

Submit damper details including housing and linkages.

Submit manufacturers recommended installation instructions.

Omission of any of the above information will cause submittal package to be immediately returned without review.

PART 3 – PRODUCTS

3.1 ENERGY RECOVERY UNIT (HEAT PIPE APROUCH)

3.1.1 GENERAL

Supply and install as indicated in the schedule of equipment, packaged modular Air Handing Units of Double Decker Type, (as Shown on drawings) each capable of the duty as mentioned in the Schedule of Equipment. The space available for the unit shall be confirmed with the civil and architect proposal of the main contract and sizes of units shall be selected top fit into the spaces available. Where necessary the units may be built on site, Subject to acceptance of the finished units for warranty purposes by the original supplier and his local agent.

Unless otherwise stated, the air-handling units shall be of sectionalized constriction with pre – filter, bag filter, chilled water-cooling coil and supply air fan. For fresh Air recovery, AHU shall be additional with heat recovery wheel, necessary empty sections with access doors; Liquid coupled heat exchanger, return air fan. As indicated in the schedules, the unit configuration should suit the ducting arrangement as shown on the drawings viz. double deck constriction.

Unit Construction

The unit casing shall be of double-skinned panels. Casing shall assemble with self-supporting modular panel elements with an integrated base frame made of zincated steel and sections along upper sides of the units.

Sheet metal thickness shall be not less than 1.5 MM for the inner skin and 0.8 MM for the outer skin and shall be made from zincated steel sheets. The outside of the outer skin shall be plastic coated to a thickness of 0.18 mm for additional protection. Inside and outside of panel walls shall be completely smooth. The overall heat thermal transmittance (Heat Transfer Coefficient) shall not exceed K=0.59 W / m 2

All Casing panels shall be insulated glass fibre layer of 50 mm thick (pressure injected foam will not be acceptable). Incombustible with class of in flammability:

A1 in accordance to DIN 4102
O in accordance to ISO 1182.2

The base frame of the units shall be made from sendzimir galvanized sheet metal for size with largest dimensions up to 2500 MM , and hot dip galvanized U – profile for larger units. Service doors shall be provided with special gasket and locking device. Access doors 400 MM and larger shall be provided with hinges and handles for external and internal opening.

Access doors with width smaller than 400 MM shall be removable type fitted with quick release flap turn lock with spring pressure arrangement. Sealant between panels shall be an anti fungicide sealant material.

All air-handling units installed outdoors shall be fitted with aluminium weather canopy.

The AHU manufacturer shall guarantee that no condensation shall take place on the exterior of panels. In the event that any condensation problems appear after installation, the contractor shall undertake all remedial measures to rectify and to the satisfaction of the consultants. Any Stacked or double height coils shall separate drain pans to reduce carry over.

Acoustical insulation through the panel:

HZ MID FREQUENCY OCTAVE BAND						
125	250	500	1000	2000	4000	8000
14	25	28	27	29	31	34

Vibration Isolation

The Air Handling Unit shall have internal vibration isolation system fan, motor and drive assembly on spring isolators. The fan discharge shall be connected to the air-handling unit casing through canvas connection to prevent vibration transfer. In addition to the above, the entire unit shall be mounted on additional vibration isolators.

Filter Section

Filter cells shall be of standard sizes and shall be obtained from European manufacturer. The filter shall be sealed against the filter frame using a permanently elastic gasket to a standard compatible with the filter efficiency.

Pressure drop tapings shall be integrated into the frame to allow a manometer or filter monitor to be fitted. Filter materials shall be flame – retardant, incombustible, non – odorous and offer no sustenance to vermin. Each filter section has to be provided with manometer.

The filter material shall be pleated to provide a large effective area. Filter section should be provided with an inspection door.

The contractor shall supply one set of all filters per AHU as spares for replacement after testing and commissioning and prior to handing over of the installation.

Pre Filter

The Pre filter material shall be glass fibber, of standard readily available sizes. The filters shall be clamped against the frame using a cam-locking bar. The filter class should be E U 7 as per Euro vent 4/5 or G7 as per EN 779.

Chilled Water Cooling Coil Section

Cooling Coils shall be fabricated from heavy gauge copper tubing expanded into Aluminium fins. Return bends shall be die-formed. Headers shall be heavy section seamless copper tubing with connections made in steel pipe with anti corrosion protection paint and with external screw thread. All joints shall be silver brazed. Fittings shall include plugged vent and drain taps for each section.

The coil shall be tested to 21 bar and designed to operate at 16 bar NP.

The Coil shall be mounted on guide rails for side withdrawal. Header Connection through the unit casing shall be sealed with plastic grommet.

Drain pans shall be stainless steel either integrated in the base or placed under the coil within the coil section. Drain pans shall have drain connection to the service side.

Fan & Fan Motor

Fans supply and extract shall be double inlet, double width, and backward curved centrifugal airfoil with galvanized steel casing. Fans shall be tested in accordance with AMCA 300-58. Every individual fan shall be run before delivery to check bearing condition and vibration. Fan shafts shall be mounted in taper sleeve bearing designed for continuous operation and a mean useful life of 200,000 hours. Backward curved impeller should be coated with 60 micron epoxy of high quality.

The fan shall be connected to the outlet opening by means of an airtight flexible connection. Fans shall not exceed a maximum outlet velocity of 15m/sec.
The degree of protection shall be IP54 with mounting method B3 and class F insulation.

Fan bearing shall be re–lubricated type with extended lube lines to terminate outside the fan section. The bearing shall be selected for life of 200,000 Hours operation .Fan drive shall be rated at 150% of the maximum motor power of the units and shall be fitted with adjustable belt tension arrangement.

Belt guards of screen protection door in fan section shall section shall be provided in accordance with CEN Standard.

The fan motor shall be suitable for operating 415V, 3PH, 50Hz electrical power supply the fan motor shall be wired to the safety isolation switch or connection box.

The Contractor shall select power input and speed of the fan subsequent to ascertaining system static pressure in accordance with pressure drop calculations to the approval of the engineer.

The fan shall meet the safety requirement of the CE.

The fan and motor assembly shall be isolated from the casing by means of spring anti vibration mountings selected to suit the speed of the fan and designed for 90% isolation.

Rotary Heat Exchanger (Thermal Heat Wheel), (if illustrated on HVAC drawings)

The wheel shall be made of layers of corrugated and intervening flat aluminium foil of uniform width to ensure smooth surface. This wheel material is bonded together to form a rigid transfer medium forming a multitude of narrow channels thus ensuring a laminar flow. The rotary heat exchanger shall be of hygroscopic type for the transfer of sensible and latent heat. The whole rotor shall be chemically treated by controlled corrosion process to produce hygroscopic layer on aluminium foil. The Chemically attached layer should have high affinity to moisture. Pre – Coated aluminium foil should not be used.

Rotor shall be mounted in a sturdy casing with an access door and sealed against casing by means of wear resistant, adjustable seal. The casing shall be equipped with purring sector. The wheel shall be cleanable by spraying its surface with compressed air, low temperature steam, hot water or by vacuum cleaning with out affecting its latent heat recovery properties. The casing shall be equipped with adjustable brush seals which minimize carry – over to max. 0.5 – 0.2% the wheel shall be belt driven along its perimeter. A constant speed drive motor shall be used. The motors shall be mounted on a self adjusting base to provide correct belt tension.

The rotary wheel should confirm to ASHRAE 84 – 78 EN 29001 and BS 7550.

For one piece rotor, Hub and spoke shall be in aluminium. On sector zed rotor, Hub made of steel, painted with anti – corrosion paint, galvanized sheet steel spokes.

The direction of airflow through the rotor should be reversing continuously to give excellent self-cleaning effect. In order to prevent fouling and clogging of the rotor, a standard EU-4 filter (Synthetic Washable) should be in position and the rotor should always be rotating when the fans in the system are running. A double glass inspection window should be provided in this section.

The heat recovery wheel shall be constant speed .The HRW shall be provided with speed detector.

Enthalpy Wheel

The ERV enthalpy wheel contains parallel layers of a polymeric material that are impregnated with silica gel (desiccant). The wheel is located in the entering (intake) air and exhaust air streams of the ventilation equipment. As the wheel rotates through each air stream, the wheel surface captures sensible and latent energy. In the heating mode, the wheel rotates to provide a constant transfer of heat from the exhaust air stream to the colder intake air stream. For applications that do not need to recover energy during mild outside weather conditions, an option is provided to stop the wheel from rotating, thereby providing cooling with energy recovery.

Run Around Coil (IF APPLICABLE)

Coil shall be rated as per ARI 410 and it shall be made of CU tubes and plate type AL fins. Each cooling coil assembly shall be placed above a condensate drain pan made of stainless steel. Drain pan shall be slopped in the direction of drain connection to ensure complete removal of drainage. Cooling coil shall be selected with a maximum water resistance of 45 kPa. Chilled water cooling coil shall be provided with plastic eliminator plates to avoid any moisture carry over of the air stream. Pre cooling & re heating coils shall be connected with water circulating pumps (working & standby) at site by the contractor.

3.2 AIR HANDLING UNIT (MORE THAN 5000 CFM)

A. GENERAL

Provide factory assembled air handling unit in configuration as indicated and scheduled on drawings. Unit shall include all specified components.

Casing – Side and Roof Panel Construction

Housing side and roof panels shall be separate frame and panel or integral frame and panel construction of galvanized steel.

Fasteners in steel housings shall be stainless steel screws with stainless steel washers and neoprene grommets.

Fasteners in aluminium construction shall be closed end aluminium rivets.

B. All side and roof panels shall be constructed of minimum 50 mm thick double wall thermal acoustic panels. They shall have a minimum 50 mm wide cross section completely filled with 48 kg/m density fibreglass insulation. The wall liner shall compress the insulation by 6 mm to provide sturdy and uniformly insulated panels.

Panel skin thickness, stiffener and frame spacing and thickness, and core density shall be manufactured to eliminate panel pulsation and to limit maximum deflection to 1/200th of any span at design positive and negative pressures. Operating/working pressures shall be equal to 1.5 times fan static pressure, at fan shut-off pressure.

Exterior wall panels shall be a minimum of 16-gauge solid G-90 galvanized steel. The inner wall shall be a minimum of 20-gauge G-90 galvanized steel. Exterior panels exposed to outdoors shall be treated as follows:

Galvanized steel exterior panels shall be treated for painting and shall be epoxy painted.

All paint systems shall consist of one prime coat and two finish colour coats shop applied to properly prepare surfaces.

Paint finish shall be protected from damage during shipment and field assembly. Any field touch up shall be completed to Supervision Employer's Representative satisfaction.

Aluminium or stainless steel components need not be painted.

All panels shall be internally fastened together with intermediate adjoining T-elements and externally sealed with a heavy bead of polyurethane caulking compound to provide a visible assurance of seal. Units must be suitable for pressure differentials up to 2,000 pa static pressure.

The insulation media shall have long resilient inorganic glass fibres bonded with a thermosetting resin. Insulation shall be NFPA 90A rated and shall a density of minimum 48 kg/m3. High strength plastic film (Tedlar or Mylar) shall completely encapsulate the insulation to preclude fibre entrainment in air stream.

The acoustic performance of the panels shall have been tested by an independent laboratory per ASTM C423, mounting Type A and E795-93. The sound attenuation characteristics shall be the following:

Acoustical Performance for Both Airborne Noise Transmission and Radiated Noise Transmission								
Octave Band Frequency (Hz)		125	250	500	1000	2000	4000	
50 mm Panels	Absorption coefficient	0.92	0.92	1.04	1.07	1.06	1.00	1.10 NRC
	Transmission loss (dB)	22	30	44	53	57	63	38 STC

Base Construction

Base shall either steel beams or channel or formed galvanized steel. The minimum base height shall be manufactured to allow minimum of 150 mm from centreline of drain connection(s) to the bottom of the base. Provide minimum 6 mm thick steel lifting lugs at corners of each module.

Steel base shall be steel beams or channel for direct bearing support for components in casing. The unit base shall be cleaned and shall be painted with primer and exterior enamel.

Galvanized formed base shall be constructed from heavy gauge formed galvanized steel around the perimeter of unit, with intermediate formed galvanized channels located at regular intervals.

To minimize thermal conductivity and prevent condensation, the entire perimeter frame shall be uniformly insulated.

Floor shall be minimum 10 gauge carbon steel diamond plate or minimum 10 gauge aluminium tread plate.

Steel floor plate shall be welded to the unit base. The floor shall be fabricated such that it is recessed two inches forming pan type construction. No drive screws, bolts, or fasteners shall penetrate the pan/floor assembly. Caulked seams in the pan/floor assembly are not acceptable.

Aluminium tread plate floor shall be installed on the base. The floor shall be recessed 50 mm, reinforced from below, with all seams broken upward to form a watertight assembly. Base shall be provided with lifting lugs, a minimum of four (4) per unit section.

The base shall be insulated with minimum 50 mm 48 kg/m3 density fibreglass insulation with foil vapour barrier, held in place with weld studs and clips. Joints between insulation board sections shall be sealed with tape and mastic sealer. Bottom of base shall be underlined with an 18-gauge galvanized steel liner and sealed watertight at all joints and penetrations. Voids between this closure and rigid insulation shall be filled with fibreglass batts to full depth of joists.

All service penetrations in the floor shall be fully sleeved and sealed at floor and sub-floor. A fully welded 50 mm sleeve extension above the floor shall provide water drainage protection.

All duct connections or control dampers in the floor of the unit shall be covered with painted heavy gauge steel bar grating bolted in place, to prevent people and large objects from passing through the unit floor into the ductwork. Bar grating shall be manufactured for a maximum deflection of 6 mm under a concentrated load of 100 kg at mid span.

Provide auxiliary drains in fan sections downstream of cooling coils.

All drain connections on floor mounted air handling units shall terminate at the side of the unit. Condensate drain pan connection shall be located to accommodate minimum 150 mm condensate trap height.

Access Doors, Panel and Safing

Access doors shall be double wall with skin thickness, stiffeners and insulation specified for the panels.

Provide dual pane inspection windows. The windows shall be made of two 6 mm thick tempered glass panes separated by an air space. A desiccant pouch shall be placed in the air space to absorb any moisture.

Door frames shall be made from 16-gauge galvanized steel with the outside of the door flush with the unit. The corners of the frame shall have a 75 mm radius and shall include self-gripping automotive gasketing to ensure appropriate air tightness and durability.

Each door shall have two (2) "Ventlock®" latches operable from either side of door and two (2) heavy-duty pin hinges. Hinges shall be zinc coated. Doors shall be removable by pushing the pins out of the hinges. Doors must open against the high pressure side.

Provide removable access panels or doors, for removal of coils, fan and motor. Panels shall be bolted in place. Panels shall be factory sealed, air-tight without visible caulking on casing exterior.

Blower Section

Fan assemblies shall be completely isolated with structural steel spring vibration isolation bases.

Fans shall be backward inclined, airfoil wheels. Fan wheels shall be constructed to next higher class when the operating speed at specified condition is within 15% of corresponding maximum class speed.

Fan performance shall be based on tests conducted in accordance with AMCA standard test code for air moving devices. The fans shall have quiet and stable operation under all conditions. The fan manufacturer shall provide sound power ratings in the eight octave bands which shall be based on AMCA standards. Sound power ratings shall be in decibels referenced to 10-12 watts. The fan shall bear AMCA seal for Air and Sound performance.

Fans shall be dynamically balanced. An IRD or PMC analyzer shall be used to measure velocity and the final reading shall not exceed 2.5 mm per second filter in at design operating speed and maximum 5 mm per second with filter out at 30%, 50% and 100% of the operating speed. The vibration level shall be recorded on the fans as proof of the final dynamic balance at the factory.

Fan and motor shall be mounted on all welded, structural steel, prime coated integral structural steel bases.

Fans shall be constructed of low carbon steel and painted with an approved coating. Each fan shall receive a documented inspection by a qualified inspector. The inspection shall include welding, dimensions, bearings, and overall workmanship.

Wheel diameters and discharge areas shall be in accordance with the standard sizes adopted by AMCA. Inlets shall be fully streamlined and housings shall be suitably braced to prevent vibration and pulsation. Housings shall be constructed of heavy-gauge steel and shall be continuously welded throughout. The standard coating shall be durable and heat resistant up to 260oC. Fan shafts shall be solid and keyed to fan wheels. They should also be keyed to the sheaves for positive wheel to shaft interlock.

The first critical shaft speeds shall be at least 125 % (Class I and II) and 142 % (Class III) of the fan's maximum operating speed. Bearings shall be manufactured for heavy-duty service with minimum L-50 life of 200,000 hours in accordance with AFBMA Standard 9 and 11. Bearing ratings are to be based on the fans' maximum catalogued operating speed and horsepower. Pillow block bearings shall be either single row ball or double row spherical roller type. Bearing bars shall be rigidly fixed to the base (bearing supports mounted to the inlet funnel are unacceptable). Bearing supports shall consist of two or more full-length structure uprights.

Acoustic Performance

Air handling unit components shall be selected and/or manufactured to meet or exceed the acoustical performance requirements as specified for the entire operating range. It shall be the option of the manufacturer to provide a quieter fan(s), adequate fibreglass acoustical lining, baffles, aerodynamically manufactured and acoustically treated inlet to and discharge from fans in order to comply with the sound power levels specified. For units arrangement refer to equipment schedules and drawings.

The Sub-contractor shall require that the unit manufacturers ensure that the unit's dimensions conform to the space requirements and access of the same into the building. Units will not be accepted that do not readily conform to the space and access conditions. Space limitations make unit's physical dimensions critical and must not exceed those indicated on the drawings. Manufacturers are required to meet the details of these specification requirements without exception.

Motors and Drives

Furnish high-efficiency totally enclosed fan cooled (TEFC), standard NEMA frame, squirrel cage induction, single speed, single winding, continuous duty, variable torque suitable for operation in vertical, horizontal or angular position, rigid ball bearing type motors. Bearing shall be selected for a minimum of AFBMA L-10 life of 20,000 hours life. Horsepower as shown on the schedule are minimum allowable.

All motors rated for use with variable frequency drive (VFD) shall be "inverter duty" or "drive duty" motors, compatible with the drive to which it is connected. Use of motor with a VFD shall not adversely affect the operation, useful life, or warranty of the motor.

Motors shall have Class "F" insulation.

Motor windings shall be spike resistant to withstand 1,600 peak volts.

Motors shall have shaft grounding system to protect bearings from induced voltage. Shaft grounding system shall have very low drag, less than ½% of motor kW, and shall operate for a minimum of three (3) years without periodic adjustments. All consumables of the shaft grounding system shall be replaceable without a shutdown of the motor or VFD.

The motor shall be mounted on an adjustable slide rail motor base. The fan motors shall be factory wired to an external junction box with flexible conduit of adequate length so that it will not have any effect on the vibration isolation.

Motors shall be supplied in accordance with electrical/mechanical specifications and schedules. They shall be mounted on slide bases for proper alignment and belt tension adjustment.

Provide V-belt, cast-iron sheaves, and reinforced rubber belts (minimum of 2 belts per drive). The belts and drives shall be selected for minimum 150 % of the motor nameplate horsepower. Fixed motor sheaves shall be provided for all drives 15 kW and above on final balancing. Belts shall be of matched sets and factory pre-tensioned for normal operation.

Belt drive types and service factor shall be in accordance with the general mechanical specifications.

Provide a metal belt guard having sides and face of galvanized steel with openings for fan tachometer readings. Belt guard shall be sized to allow either sheave to be increased by two sizes.

Vibration Isolation

An integral all welded structural steel, prime coated, vibration isolation base shall be provided for the fan and motor. Unpainted or galvanized, bolted together fan/motor bases are not acceptable. The base shall be tailored to accommodate the fan assembly, motor slide base, and space saving isolator mounting brackets. Minimum beam height-to-length ratio is 10% but the height shall not be less than 150 mm. Base shall be free- floating on all four corners, on spring type isolators.

Spring isolators must be sized to support the final fan assembly (inclusive of the base) weight. The fan assembly shall be isolated from the cabinet by steel spring isolators. Fan thrust restraints shall be provided, to, prevent the spring isolator system from grounding against floor, walls, or tearing fan flexible connections. The minimum mounting deflection of spring isolators shall be as follows:

Lowest Operating Speed (RPM)	Min deflection (mm)
300	90
500 and greater	50

Water Coils

Coils shall be fully enclosed within the section and shall have double wall galvanized floor construction consistent with the unit casing construction.

Piping connections shall extend to the outside through rubber grommets.

Coil(s) shall include galvanized steel blank off sheets to hold coil(s) rigid and prevent air from bypassing the coil(s).

Removable 50 mm thick access panels shall be provided on both sides to remove coils through casing wall, normal to the direction of airflow, without disturbing other coil sections.

Coils shall be housed in factory fabricated frame independent of unit casing and shall be individually removable. Multiple coils shall be mounted on independent support structure. Directly stacking coils using coil casing as structural support for other coils is not acceptable.

Drain pans shall have a double slope for positive drainage, constructed of 16-gauge – 304 stainless steel and continuously welded. Drain pipe connections shall be 37.5 mm copper sweat fittings.

Each coil tier shall have double slope drain pans extending at least 150 mm in the direction of air flow, constructed of 16-gauge – 304 stainless steel and continuously welded. Intermediate drain pans shall have 25 mm drains flowing into the unit's main drain pan. Pans must be fully cleanable without removing the coil.

Floor drain hubs shall be recessed in the pans to ensure complete drainage.

Provide Cost-Gard condensate drain seal, to be shipped loose with unit together for field installation. Unit manufacturer shall coordinate required piping connections and condensate drain seal size on basis of condensate flow rate and internal negative pressure within the drain pan section.

Coils shall be tested and rated in accordance with air conditioning and refrigeration institute (ARI) standard 410.

The complete coil core shall be tested with under warm water and be suitable for operation at the specified working pressure. Water coils shall be circuited for drain ability without removing individual plugs from each tube.

The primary surface of all coils shall be round seamless copper tubes. The secondary surface shall consist of rippled aluminium plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous cover over the entire tube surface for maximum heat transfer. The tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire fin length.

Water coils shall have copper headers, steel male pipe connections, a vent connection at the highest point, and a drain connection at the lowest point.

Coil construction materials shall be as follows:

Coil Copper header thickness: 1.2 mm minimum wall thickness, brazed joints.

Tube material & thickness: Seamless copper tube 0.6 mm minimum wall thickness.

Tube bend: Brazed replaceable return bend of 0.8 mm wall thickness.

Fin material & thickness: Aluminium, 0.24 mm thick, not closer than 11 fins/inch.

Coil casing material: Hot dip galvanized steel type 304 stainless steel for chilled water, coil side plates shall be of reinforced flange type construction.

Air Filter

Frame:

Filter bank framing shall be 16 gauge galvanized steel or extruded aluminium rack.

Aluminium framing members shall be at least 2.2 mm thick. Frames shall be suitable for upstream or downstream filter servicing, cut to size and pre-punched for easy assembly into modules of size to suit the AHU.

Framing shall be permanently gasketed to prevent bypass of unfiltered air. If required, provide suitable aluminium vertical support members to prevent deflection. Vertical supports shall not interfere with installation or operation.

Framing system shall incorporate factory installed positive sealing device for each row of filters, to facilitate installation and removal of cartridges while preserving seal between gasketed filter elements while the bank is in operation.

Pre-Filter

Pre-Filter shall be provided and as specified in the Filter Section of this Specification.

Filter shall have with welded steel wire grid support.

Filter shall not unload or collapse under high velocity or static pressure.

Pre-filters shall be front loading where access is available upstream of the filter section, unless otherwise indicated on the drawings.

Final Filter

Final Filter shall be provided and as specified in the Filter Section of this Specification.

The enclosed filter frames shall be constructed of galvanized steel. It shall be constructed and assembled in such a manner that a rigid and durable enclosure for the filter pack is affected. The periphery of the filter pack shall be continuously bonded to the inside of the enclosing frame thus eliminating the possibility of air bypass. The enclosing frame shall be equipped with protective diagonal support members on both air entering and air exit side of the filters.

Provide factory fabricated and assembled walk-in front access filter frames. The frames shall be constructed of not less than 16 gauge galvanized steel. They shall incorporate, extruded aluminium tracks and universal holding frames manufactured to accommodate the filters specified herein before. Provide for front access to filters with clips to hold filters in place.

Filter Gauges

Provide and flush mount Dwyer Magnehelic 2003 AF dry air filter gauge, with a scale of 0 to 50 mm w.g.

Static pressure tips, shut off valves and tubing with adjustable signal flag suitably marked to indicate need to change filter shall be provided and installed by the AHU manufacturer.

One Magnehelic gauge shall be provided for each filter bank.

Smoke Detector

Smoke detector shall be provided at the return air duct and interfaced with fire alarm and BMS.

CO2 Detector

Provide CO2 detector at the return air duct of all AHU's and interfaced with fire alarm, motorized damper and to be interfaced with BMS system.

3.3 AIR HANDLING UNITS (FORM 3000 CFM UP TO 5000 CFM Flow Rate)

3.3.1 GENERAL

The Contractor shall supply and install single zone air handling units(s) as shown on the Drawings. Capacities are indicated on the Drawings.

Each unit shall consist of fan, motor, V-belt drive, cooling-coil, heating coil (when specified), drain pan, filters and necessary controls.

The unit shall be either mounted on a suitable base, or hung from the ceiling. In all cases, approved vibration eliminators shall be provided. The Contractor shall submit details of bases, mountings and connections to the Engineer for approval.

The unit(s) shall be of the draw thru Low/Medium pressure type.

The minimum air flow thru the electric heating coil should not drop below 350 fpm (1.8 m/s) based on the face area of the cooling whenever the electric coil is energized.

The Contractor shall provide the supply and return with sound attenuators (if indicated in the drawings), the attenuators specification shall be as per the specifications.

The Contractor shall confirm to the Engineer the total static pressure of the fan after the Engineer's approval on the air handler and after preparing the shop Drawings.

3.3.2 CONSTRUCTION

Air handling unit shall be constructed of heavy gauge galvanized steel with removable panels for accessibility to all internal parts.

Unit(s) shall be factory insulated internally with fibreglass 20mm. thick or approved equivalent and finished with oven dried grey finishing coat.

Units installed in special rooms shall be of the double skin type factory insulated with fibreglass 20mm. thick or approved equivalent and finished with oven dried grey finishing coat.

3.3.3 FAN SECTION

The fan section shall be constructed of heavy gauge sheet steel properly reinforced and braced with steel angle framework. It shall be provided with suitable angle flanges for connecting it to the coil section.

Fan shall be centrifugal type with multi-blade forward curved or air foil type, mounted on a common shaft with enclosed housing. The fan motor shall be statically and dynamically balanced to eliminate noise and vibration.

Fan bearings shall be grease lubricated ball type with grease lines extending to the outside surface of the casing. Average life of bearing shall not be less than 200,000 hours.
Fan shall conform to the design fabrication of the AMCA.

Fan shall be mastic coated and have galvanized steel wheel and high grade steel shaft.

Fan shall be driven by V-belt of variable pitch type. Belt guards of removable type shall be provided on the fan and motor shafts.

The electric motor starter and controllers shall be in accordance with Electrical section of these Specifications.

3.3.4 COOLING COIL

The coil shall be suitable for chilled water application.

The coil shall be of seamless copper tubing, having aluminium fins mechanically bonded to the tubes.

The headers shall be of seamless copper with supply and return connections. Each header shall be provided with drains and vents.

The coil shall be tested at not less than 250 psig. (1725 Kpa).

The face velocity shall not exceed 550 FPM (2.8 m/s).

The coil shall be accessible for service and shall be removable without dismantling the entire unit.

The cooling coil shall comprise of 4 row min., number of fins shall be 12 - 14 fin/inch max., the contractor allowed to select the number of fins and rows within the specified number indicated above so that the size & noise of units shall be within the space limitation available.

3.3.5 FILTER SECTION

The air filter section shall consist of a rough 50 mm thick aluminium mesh. Pressure drop in the filter when dirty shall not exceed ½" WG (125 pa). Filters shall be easily removable for cleaning and replacement.

The rough filter shall be part of the mixing box section.

Filters shall be provided with rigid self supporting corrosion resistant steel frames and clamps, casketed and sealed to prevent air bypass.

3.3.6 DRAIN PAN

An insulated drain pan shall be provided in each unit under both the fan and the coil section.

Drain pans shall have drain connections on both sides and a deep seal trap on the drain pipe.

Drain pan shall be suitably connected to the drainage system

CONTROLS

Each air handling unit shall be equipped with:

A control panel as detailed on the drawings. The panel shall include but shall not be limited to the following: circuit breakers, motor starters, pilot lights, on/off push button, temperature controller, control power transformer, as applicable, to limit control voltage to 240 volts maximum, and all control wiring, no phase to neutral voltage shall be required.

A 2-way modulating motorized valves, isolating valve double regulating valves, strainer and all accessories as detailed on drawings.

Comply with section 15010 mechanical general provisions and all documents referred to therein.

Provide all labour, material, and services to supply and install all air handling units and primary air handling units as indicated on the Drawings and specified in this Section of the Specification.

EXECUTION

Use all factory provided lifting lugs to rig the units or modules. Ensure that spreader bars are used to prevent damaging the cabinets.

Lift modules in an upright position.

Ensure housekeeping pads or mounting bases are level and in accordance with approved dimensions. Air handling units shall be installed with metal and waffle sandwich pads, Mason Industries type WSW or approved equal between unit base and housekeeping pad or mounting bases.

The Sub-contractor shall provide and install adequately factory furnished Cost Gard Condensate drain seal for all condensate pipe connections. Pipe condensate drain to nearest floor drain or condensate pump as indicated on plans.

Remove gussets, hold-down bolts and shipping fasteners.

Remove fans' shipping restraints and level spring isolators. Adjust thrust restraints.

Assemble modules together according to the installation manual.

On completion of installation provide services of factory trained service Sub-contractor inspect and supervise the start-up and checkout of the equipment. Do not start up equipment until the following operations are complete.

Automatic temperature control.

Power connection to equipment.

Shipping materials and shipping restraints have been removed.

Unit levelled with isolators under the perimeter frame.

Spring isolated components are off shipping supports and levelled.

Filtration media is installed.

Piping and duct connections are complete.

Leak checks are complete on all water piping.

Electrical interconnections are complete on multiple section units.

Check fan motors for rotation and amp draw for each phase. Record information on the start-up data sheets

Belt drives should be adjusted for tension and alignment.

Execute start-up, complete report and send to the air handling unit manufacturer for verification and as acknowledgment of warranty commencement.

3.3.7 FAN COIL UNITS

SCOPE OF WORK

Supply, installation, test and commission chilled water fan coil units as shown in the drawing.

Codes and Standards

Fan Coil Units shall be designed, manufactured, rated and tested in accordance with the following codes and standards:

Air Conditioning and Refrigeration Institute

Underwriters Laboratories

National Fire Protection Association

SUBMITTALS

Submit manufacturer's latest published data for dimensions, material specifications, accessories and installation detail.

Submit full technical rating data based on tests in accordance with current publication of Air Conditioning and Refrigeration Institute (ARI). Include manufacturer's certified fan performance curves and certified sound power ratings.

PRODUCTS

GENERAL

Fan coil units shall be horizontal blow-thru type as specified in the schedule and or as shown in the drawing.

BASIC UNIT

The horizontal basic unit shall include insulated galvanized steel casing, chilled water cooling coil, controls, main drain tray, centrifugal fan, three speed motor filter housing and thermal insulation.

Duct collars shall be provided where ducted connection is required.

The condensate tray located under the coil shall be of one piece construction and shall have sufficient slope for positive and efficient drainage of condensate under all conditions. The trays shall be of 1.2 mm (minimum) hot dipped galvanized steel sheet and adequately insulated with fire retardant thermal insulation.

Coils shall be of aluminium fins mechanically bonded to seamless copper tubes and tested with compressed air up to 2000 kPa under water. Face velocity through coils shall not exceed 2.25 m/s to prevent moisture carries over.The number of fins shall not exceed 400 per meter and all fins shall be continuous. Coils shall be three rows unless indicated otherwise and be provided with air vents at high points, with drain lines extended to drain pan. The capacity of the coil shall be based on 6.5 deg C chilled water entering temperature with a temperature difference of 5+_ 1 deg. C.

Coil connections shall be female threaded and compatible with steel pipe connection.

Unit shall be internally insulated with minimum 25 mm, 32 kg/cubic meter density thermal and acoustic insulation.

Filter shall be aluminium washable type, 50 mm thickness.

EXECUTION

INSTALLATION

Install unit as per manufacturer's instruction.

FAN COIL UNIT EXPOSE TYPE

The Fan Coil Unit shall be the factory assembled decorative type, integral fan type with chilled water-cooling coil and shall be made for exposed mounting. The unit shall be complete with decorative grill.

The Fan Coil Unit shall be of the factory assembled, integral fan type with chilled water-cooling coil and shall be made with concealed mounting. The capacities of the FCU will be as per the enclosed schedule. And also the unit should have access panel in the lower part of the unit to facilitate all routine maintenance operation. The FCU shell also have washable filter, filter shall be 15mm permanent cleaning aluminum mesh and the drain pan shall be integral and an auxiliary drain pan shall be provided to cover the valve package.

Units shall be ARI rated.

Air Filters: Shall be accessible by dropping down bottom panel of the filter back. Filter shall be 15mm permanent, clearable aluminum mesh.

Valves: The control valve and piping package shall be factory built, installed and tested. Each fan coil units shall be provided at least with one isolating and one balancing valve at outlet and one isolating at inlet.

Thermostat (Fan Speed & Temperature Control)-The wall mounted type thermostat with remote sensor shall be off slick design, complete with fan speed control switch (high –medium-low-off).

Sound Levels: Units shall be tested in accordance with ARI standard 443-66. Standard for sound Rating of Fan Coil Air Conditioners. Manufacturer shall submit Octave Band analysis showing sound pressure level not exceeding NR 35 based on high speed in a medium hard room.

Plenum and Air Filters: the fan coil units shall be supplied with factory built acoustically treated supply and return air plenum boxes. The filters shall be accessible by dropping down bottom panel of the filter back.

FCU to be selected at Medium Speed

PART 4 - SEQUENCE OF OPERATION

4.1 Air Handling Units/FCU (Common Area)

A. System Descriptions

The Air Handling Units or FCU's shall provide constant temperature to the common areas. The system consists of single speed AHU motor, cooling coil, 2- way modulating valve, air filters, supply air and return air temperature and humidity sensor, Indoor air quality (IAQ)/ CO2 sensor, air measurement device and modulating fresh and return air damper. The system shall be controlled with the combination of VLC controller and its sensors.

B. The Mode of Operation

Occupied Mode/ Normal/On mode Operation
Unoccupied Mode /Off mode Operation
Fire mode

C. System On

The system shall start and stop based on the time schedule automatically or BMS override command or through manually from starter panel.

D. System Off

The system shall be stopped automatically based upon the time schedule or BMS override command or through manually from starter panel.

E. Occupied Mode/ Unoccupied Mode of Operation

The system can be on occupied or unoccupied mode based on the time schedule. The time schedule of the system shall be configured by the BMS operator.

F. Occupied Mode

When the common areas AHU will be on occupied mode, the BMS DDC controller will check the following:

AHU- Selector (H-O-A) switches position.
AHU Healthy status.

If both are positive, BMS DDC controller will give an open command to AHU fresh air intake damper to open its minimum position for preset level. After a time delay it will give a start command to AHU supply air fan VFD.

G. Humidity (Option)

Fresh air and Return Air humidity and temperature is monitored by BMS DDC Controller through humidity sensors and the same will be used to calculate inside and outside Enthalpy. The difference in inside and outside Enthalpy will initiate free cooling operation of AHU.

H. Temperature Control

In the common areas AHU supply return and fresh air temperatures will be continuously measured by the duct mounted temperature sensor; which is installed in AHU supply air, return air and fresh air duct respectively.

The temperature difference between the supply and the supply air temperature set point value will generate the cooling demand. The control loop within the controller will perform the mathematical calculations and compare the measured value and current set point value. If the measured value is more then the set point value, cooling loop will be initiated. The voltage level from sensor is converted into a number, which the sensor will scale into degree centigrade. The loop will then generate a proportional control output designed to reduce the error to the actuator fitted on the 2- way modulation valve and chilled water is allowed to enter the Coil.

The above action results in the cooling and dehumidification process, thereby reducing the dry- bulb temperature and the moisture content of the air entering the room. The cooling is achieved by removing the sensible/ latent heat from the air.

If the supply air temperature is lower than the set point the control loop shall modulate the valve up to 0% for less cooling and thereby reducing the level of reduction in the dry bulb temperature.

I. CO2 or Fresh Air Quantity Control/ Indoor Air Quality

In the common areas AHU CO2 concentration level will be measured by CO2 sensor installed in critical place where presumed more occupancy. (The concentration level ranges of 400 to 1200PPM or 700PPM above outdoor air). The BMS DDC controller will compare the measured value of CO2 concentration and set value. If the measured value is higher then the set value, DDC controller will generate the proportional control output to the fresh damper to open more and return air damper to close more so that more fresh air will come and CO_2 concentration level will go down.

J. System Unoccupied / Off Mode Operation

When the system will be in unoccupied mode, DDC will switch off the AHU. It will close the all dampers and also close the 2- way control valve fully.

K. Fire Mode Operation

Once the DDC controller has received the fire alarm signal, the system will go to off mode condition. After clearing the fire alarm or after the fire alarm is reset the system will automatically restore to the previous mode of operation.

L. Alarm Monitoring

AHU supply air fan failure alarm is generated whenever the supply fan differential pressure switch fails to respond to its start - stop command, within 30 seconds or the trip signal from the starter panel. In case of supply fan failure , the cooling valve will go to fully closed position.

Dirty filter alarm will also be generated through the differential pressure Switches installed across the filters.

BMS DDC will continuously monitor the AHU healthy status. If AHU trips, it will generate an AHU Trip Alarm.

BMS DDC will be continuously monitored the AHU intake/Fresh AHU supply and return air temperature through temp Sensor installed in duct. If these sensor values will be more or less than the specified value, it shall generate a high or low temperature alarm.

Duct mounted smoke detector in supply and returns main duct sensing the event of fire and give signal to Fire alarm panel, Fire alarm controller shut off the FAHU.

Fire alarm will be generated whenever the fire signal is received by Fire Alarm System which is indicated on BMS via fire alarm software integration.

4.2 FRESH AIR HANDLING UNIT (ENERGY RECOVERY UNIT)

A. System Descriptions

The Fresh Air Handling Units shall provide constant temperature fresh air to the tenant's area like space units, anchor and semi anchor, retail shops, cafes, cinemas using the outside fresh air. The system will consists of supply and return air fan with single speed motor, air filters, 2 way cooling coils, On/off damper, temperature sensor for supply air and return air, humidity sensor for supply and return air, heat recovery wheel and VLC DDC controller. The system will be controlled with combination of VLC DDC controller and sensors.

B. The Mode of Operations

Occupied Mode of Operation
Unoccupied Mode/ Off Mode of Operation
Fire Mode

C. System On

The system shall start and stop based on the time schedule automatically or IBMS override command or through manually from starter panel.

D. System Off

The system shall be stopped automatically based upon the time schedule or BMS override command or through manually from starter panel.

E. Occupied Mode/ Unoccupied Mode of Operation

The system can be on occupied or unoccupied mode based on the time schedule. The time schedule of the system shall be configured by the BMS operator at the head end. The system can be also start/stop by BMS override command.

F. Occupied Mode

When the Fresh air AHU (ERCU) will be on occupied mode, the BMS DDC controller will check the following:

AHU Selector (H-O-A) switches position.
AHU Healthy status of both fan

If both are positive, BMS DDC controller will give an open command to AHU intake fresh and discharge air damper. Then after a time delay it will check the status for fully open. After confirmation of open status of damper, it will give a start command to AHU supply fan and after a delay return fan and Enthalpy and sensible wheel.

The fresh air initially shall be cooled down through heat wheel (enthalpy wheel) by using return air and further this fresh air will be cooled down up to the set point level through cooling coil then cooled air pass on sensible wheel.

G. Temperature Control

The BMS DDC controller will continuously measure the supply and return air temperature and humidity through temperature and humidity sensors, which are installed in AHU supply and return air duct. And also it measures the humidity and temperature after enthalpy wheel.

The temperature difference between the supply and the supply air temperature set point value will generate the cooling demand. The control loop within the controller will perform the mathematical calculations and compares the measured value and current set point value. If the measured value is more then the set point value, cooling loop will be initiated. The voltage level from sensor is converted into a number, which the sensor will scale into degree centigrade. The loop will then generate a proportional control output designed to reduce the error to the actuator fitted on the 2- way modulation valve and chilled water is allowed to enter the Coil.

The above action results in the cooling and dehumidification process, thereby reducing the dry- bulb temperature and the moisture content of the air entering the room. The cooling is achieved by removing the sensible/ latent heat from the air.

If the supply air temperature is lower than the set point the control loop shall modulate the valve up to 0% for less cooling and thereby reducing the level of reduction in the dry bulb temperature.

H. System Unoccupied / Off Mode Operation

When the system will be in unoccupied mode, DDC will perform the following as below:

First it will switch of the supply fan, return fan and enthalpy and sensible wheel.
Close the fresh and discharge air damper.
Close the 2- way cooling valve.

I. Fire Mode Operation

Once the DDC controller received the fire alarm signal, the system will go to off mode condition. After clearing the fire alarm or after the fire alarm is reset the system will automatically restore to the previous mode of operation.

J. Alarm Monitoring

FAHU supply and return air fan failure alarm is generated whenever the supply fan differential pressure switch fails to respond to its start - stop command, within 30 seconds or the trip signal from the starter panel. In case of supply fan failure , the cooling valve will go to fully closed position.

Dirty filter alarm will also be generated through the differential pressure Switches installed across the filters.

BMS DDC will continuously monitor the AHU healthy status, if FAHU will trip, it will generate an FAHU Trip Alarm.

BMS DDC controller will continuously monitor the enthalpy and sensible wheel healthy status, if it will trip, it will generate a Heat Wheel Trip Alarm.

The BMS DDC controller will continuously measured the supply and return air temperature and humidity through temperature and humidity sensor, which are installed in FAHU supply and return air duct. If these sensor values will be more or less than the specified value it will generate a high temperature/humidity alarm or low temperature alarm.

Duct mounted smoke detector in supply and returns main duct sense in the event of fire and gives signal to Fire alarm panel, Fire controller shut off the FAHU.

K. Fire alarm will be generated whenever the fire signal is received.

4.3 AIR HANDLING UNIT (MANAGEMENT AREA)

A. System Descriptions

The Air Handling Units shall provide constant temperature to common area & variable volume air to the management area. The system consists of supply fan with the VFD, cooling coil, 2 way modulating valve, air filter, supply air and return air temperature and humidity sensor, supply air duct static pressure sensor, air quality/ CO2 sensor, air measurement device and modulating fresh and return air damper. The system shall be controlled with the combination of VLC controller and its sensors.

B. The Mode of Operation

Occupied Mode
Unoccupied Mode
System Operation
System Operation in by pass mode.

C. System On

The system shall start and stop based on the time schedule automatically or BMS override command or through manually from starter panel.

D. System Off

The system shall be stopped automatically based upon the time schedule or BMS override command or through manually from starter panel.

E. Occupied Mode/ Unoccupied Mode of Operation

The system can be on occupied or unoccupied mode based on the time schedule. The time schedule of the system shall be configured by the BMS operator.

F. Occupied Mode

When the AHU will be on occupied mode, the BMS DDC controller will check the following:
AHU supply and return fan Selector (H-O-A) switches position.
AHU supply and return fan VFD Healthy status.

If both are positive, BMS DDC controller will give an open command to AHU fresh air intake damper to open its minimum position. After a time delay it will give a start command to AHU supply air fan VFD.

G. VFD Operation **(if illustrated on HVAC drawings)**

The fan speed will gradually increase through the VFD to its preset speed. The BMS DDC controller will monitor the duct pressure through Static Duct Pressure sensor located at 2/3rd distance down stream of the supply duct in management area of supply ring. Then DDC controller will compare the lowest measured duct pressure value and duct pressure set point value. If the measured value is less than the set point value the DDC controller will generate the proportional control output designed to reduce the error to the VFD .

The return fan VFD will start automatically after getting the air flow confirmation of supply fan (monitored by differential pressure switch installed across the supply fan). Then within 90 seconds both the VFD shall ramp up to the same speed.

H. High Pressure Trip

If these static pressure sensors will measure the abnormal rise of pressure in the duct, the BMS DDC controller will switch of the fan and generate a high pressure trip an alarm.

I. Humidity

Fresh air and Return Air humidity and temperature is monitored by BMS DDC Controller through humidity sensors and the same will be used to calculate inside and outside Enthalpy. The difference in inside and outside Enthalpy will initiate free cooling operation of AHU.

J. Temperature Control

In the AHU supply return and fresh air temperatures will be continuously measured by the duct mounted temperature sensor; which is installed in AHU supply air, return air and fresh air duct respectively.

The temperature difference between the supply and the supply air temperature set point value will generate the cooling demand. The control loop within the controller will perform the mathematical calculations and compare the measured value and current set point value. If the measured value is more then the set point value, cooling loop will be initiated. The voltage level from sensor is converted into a number, which the sensor will scale into degree centigrade. The loop will then generate a proportional control output designed to reduce the error to the actuator fitted on the 2- way modulation valve and chilled water is allowed to enter the Coil.

The above action results in the cooling and dehumidification process, thereby reducing the dry- bulb temperature and the moisture content of the air entering the room. The cooling is achieved by removing the sensible/ latent heat from the air.
If the supply air temperature is lower than the set point the control loop shall modulate the valve up to 0% for less cooling and thereby reducing the level of reduction in the dry bulb temperature.

K. CO_2 or Fresh Air Quantity Control

In the AHU CO2 concentration level will be measured by CO2 sensor installed in the management office and related with common area. The BMS DDC controller will compare the measured value of CO2 concentration and set value. (The concentration level ranges of 400 to 1200PPM or 700PPM above outdoor air). If the measured value is higher then the set value, DDC controller will generate the proportional control output to the fresh damper to open more and return air damper to close more so that more fresh air will come and CO2 concentration level will go down.

L. System Unoccupied / Off Mode Operation

When the system will be in unoccupied mode, DDC will switch off the AHU. It will close the all dampers and also close the 2 way control valve fully.

M. Fire Mode Operation

Once the DDC controller has received the fire alarm signal, the system will go to off mode condition. After clearing the fire alarm or after the fire alarm is reset the system will automatically restore to the previous mode of operation.

N. Free Cooling Mode

The BMS controller will continuously measure the outside and AHU return air temperature and humidity. Based upon the temperature and humidity, the DDC controller will calculate the enthalpy of outside air and return air. It compares the both values and if the outside air enthalpy is below the return air enthalpy, DDC controller will fully open the fresh air damper and close the return air damper and cooling valve respectively. In this mode AHU utilizes the outside air to cool the management and its related common area.

O. System Bypass Mode

The BMS controller will monitor the VFD status. If the VFD will be put in the bypass mode, the BMS will give a fully open command to the entire VAV units and then it will give a start command to AHU to run on full speed.

Note: Smoke damper open/close position shall be monitored by fire alarm system.

P. Alarm Monitoring

AHU supply/Return air fan failure alarm is generated whenever the supply fan differential pressure switch fails to respond to its start - stop command, within 30 seconds or the trip signal from the starter panel. In case of supply fan failure, the cooling valve will go to fully closed position.

Dirty filter alarm will also be generated through the differential pressure Switches installed across the filters.

BMS DDC will continuously monitor the AHU healthy status. If AHU trips, it will generate an AHU Trip Alarm.

BMS DDC will be continuously monitored the AHU intake/Fresh AHU supply and return air temperature through temp Sensor installed in duct. If these sensor values will be more or less than the specified value, it shall generate a high or low temperature alarm.

BMS DDC will continuously monitor the AHU supply air duct pressure through the duct static pressure sensor. If the duct static pressure sensor reading is abnormally high, then DDC will switch off the AHU and generate a high pressure trip alarm.

Duct mounted smoke detector in supply and returns main duct sense in the event of fire and gives signal to Fire alarm panel, Fire controller shut off the FAHU.

Fire alarm will be generated whenever the fire signal is received by Fire Alarm System which is indicated on IBMS via fire alarm software integration.

END OF SECTION-15850

SECTION 15865

FANS

PART 1 - GENERAL

1.1 Work Included

A. Comply with section 15010 mechanical general provisions and all documents referred to therein.

B. Provide all labour, materials, products, equipment, accessories, services and tests necessary to complete, make ready, and set to work all fans indicated on the Drawings and specified herein.

1.2 Reference Standards

A. Fans to be standard products, selected from published literature of manufacturer.

B. Ratings to AMCA for sound and air delivery performance.

C. Fans shall be factory balanced, statically and dynamically to AMCA Standards.

1.3 Submittal Data

Submit manufacturer's latest published data for dimensions, materials, accessories and installation details.

Submit full technical rating data based on tests in accordance with current

AMCA standards and in an AMCA approved laboratory. Include manufacturer's certified fan volume-pressure performance curves, from shutoff to free delivery and certified sound power ratings. Correct all ratings and curves for altitude and temperature where applicable.

Operational and Maintenance Manual: Manufacturer's instruction for operation and maintenance.

1.4 Performance Requirements

A. Refer to Fan Schedule and Drawings for fan duties, type and capacities.

1.5 Quality Assurance

Acceptable Manufacturers: Firms regularly engaged in manufacture of fans of the types and materials, sizes and capacities specified herein and on the drawings, whose products have been in satisfactory use in similar service for not less than 5 years, as approved by the Supervision Employer's Representative.

Standards Compliance: Comply with requirements of applicable local codes and the standards outlined in the Section 15010 (Mechanical General Provisions).

Construct all fans to comply with the requirements of the latest editions of the Air Moving and Conditioning Association (AMCA) Standards and Bulletins. Certify these fans by AMCA for performance ratings and provide the AMCA Performance and Construction Seal when requested by the Supervision Employer's Representative.

1.6 General Requirements

MECHANICAL VENTILATION / PRESSURIZATION SYSTEM:

The scope of work includes supply, install, commission complete ventilation & pressurization systems in accordance with this specifications including but not limited to followings, all as described herein and as shown on the drawings and in any case to comply with ASHRAE, BS, SMACNA, and DW 142.

The systems including all necessary fans, motors and automatic controllers, ductwork, grilles, registers, dampers, diffusers, insulation, filters, and all required auxiliaries all as required for proper operation of the system.

The systems shall include the following

A. Toilet exhaust, general exhaust systems

B. Stair pressurization system

C. Smoke extracts system (smoke fan extraction fans)

PART 2 - PRODUCTS

2.1 CENTRIFUGAL FANS

A. Scroll Type

Provide single width single inlet (SWSI), or double width double inlet (DWDI), to meet the duties of the fan as specified on the Drawings, enclosed in scroll shaped fan housing. Fan scroll shall have airfoils and non-overloading characteristic.
Weld or securely rivet fan blades to the hub plate and rim.

Fan housings are to be heavy duty gauge, continuously welded construction. Housings shall be suitably braced to prevent vibration or pulsation. Fan housings shall have spun, aerodynamically manufactured inlet cones or inlet ventures for smooth air entry into the wheels. All fan wheels shall have tapered spun wheel cones or shrouds providing stable flow and high rigidity.

B. Tubular Type

Provide backward inclined or airfoil fan wheels to meet the fan duties as indicated on the Drawings, in a cylindrical housing, with integral inlet venturi and airflow straightening vanes, arranged to impart unidirectional air flow.

Weld fan blades to the hub plate and rim. Backward inclined blades may be securely riveted to the hub plate and rim. Precisely cast aluminium fan wheels and machine finish.

Match the wheel inlet ring to a close tolerance with integral deep spun aerodynamic venturi inlets.

Provide radial air flow straightening vanes at the fan discharge.

C. Cabinet Type

Provide scroll type centrifugal fans, factory installed within a cabinet enclosure, and comply with the requirements of Scroll Type Centrifugal Fans.

Internally isolate fan and motor assemblies from the cabinet.

Provide gasketed access doors and panels for inspection and routine maintenance of the internal components.

Provide solid state variable speed controllers for small ceiling mounted direct driven exhausters and transfer fans.

2.2 AXIAL FANS

A. Smoke Axial Fans

Extract fans shall be AXIAL two speeds reversible type, made of hot dipped galvanized steel, shall completely surround both the impeller and motor. The terminal box shall be mounted on the casing and pre-wired at the works.

Fan impeller shall be Aerofoil, Die cast in aluminum alloy and X-ray inspected to ensure flawless castings. Impellers shall have a range of blade angels and impeller solidity for flexibility of air duty. Impeller blade angles shall be set and fixed at works.

Fan motor shall be totally enclosed squirrel cage. Motor case shall be constructed of aluminum alloy or cast iron dependent upon the temperature of operation. The grade of motor insulation shall be suitably selected to meet the requirements of high temperature smoke venting. Motors shall have a safety margin of an average of twice the expected survival times.

Fans shall be driven by electric motors directly coupled to the shaft (Direct Driven) on which the impeller is mounted.

SMOKE AXIAL & car park fans shall be provided with motors suitable for removal of smoke rated up to (300°C/2Hr.) with Class "H" insulation.

Fans with impeller shall be fully tested and complied with Motor bearings and greases shall be selected to provide long life at normal ambient temperature and still survive the emergency condition during this life time.

Smoke fans shall be provided with automatic shutters / dampers to be activated prior to the fan operation.

Smoke fans shall be approved by civil defense authority. Control panel for supply and extract fans to be provided in control location.

B. Propeller Type

Include propeller type impellers, complete with motors, and panel or ring mountings.

Vary fan blades in camber and twist from base to tip.

Construct impellers of die formed steel or aluminium attached to a central hub mounted on the fixed drive shaft.

Rotate fun hub on the fixed drive shaft using sealed ball bearings.

To eliminate overhang load on belted units, apply belt load to the hub in the same plane as the bearings.

Direct drive fans are only acceptable where belt driven units do not meet the performance criteria or direct drive is specified.

Provide panels or rings with spun venturi inlets suitable for wall mounting and structural angle supports of welded steel construction.

Provide basket type fan guards for exposed inlets and discharges.

Provide TEFC motors on all fans.

C. Vane Axial Fixed Blade Type

Include impeller, motor, drive and cylindrical housing.

Construct fan blades, airfoil cross section, varying in camber and twist from base to tip, of die-formed steel or aluminium.

Fixed pitch fans shall have form impeller blades and hub in a single casting, or precision weld blades to the hub assembly.

Mount impeller directly on the drive shaft and secure in place with locking keyway assembly. Motor and impeller shall be removable from the inlet side of the fan.

Cross brace motor support base on direct drive fans to the fan housing for structural rigidity to prevent motor misalignment.

On belt drive fans protect belts and bearings from the air stream in an air insulated enclosure. Apply belt loads to the hub in the same plane as the bearings to eliminate overhang load.

Construct cylindrical fan housings of heavy gauge hot rolled steel with continuous weld seams.

Provide venturi inlet bell and discharge diffuser accessories of the same gauge and material as the fan housing.

Fan used for kitchen exhaust system shall be bifurcated with motor out of the air stream.

Fan shall be suitable for either vertical or horizontal mounting as shown on drawing.

Fan shall have factory mounted, rolled steel ring for flanged duct connections.

D. Vane Axial Adjustable Blade Type

Include impeller and hub, guide vanes, motor, drive and cylindrical housing.

Construct fan blades of die-formed aluminium, sized for the fan diameter. Blades cut down from longer sections will not be acceptable. Provide double thickness blades with airfoil cross section and profile, varying in camber and twist, from base to tip.

Provide fans designated as adjustable pitch fans with blades which can be individually manually adjusted in the field. Provide pitch indicators at the base of each blade. Secure blades in place with set screws or locking adjustment nuts.

Direct drive unit shall have impeller mounted on the drive shaft and secured with locking keyway assembly. Motor and impeller shall be removable from the inlet side of the fan.
Provide an aerodynamic spinner cap over the hub face of impellers, to protect and conceal blade adjustment bearings.

Construct guide vanes of heavy gauge material and match the camber and twist of the impeller blades.

Cross brace motor support base and motor bearing on direct drive fans to the fan housing for structural rigidity to prevent motor misalignment.

On belt driven fans, protect blades and bearings from the air stream in an air insulated enclosure. Apply belt loads to the hub in the same plane as the bearings to eliminate overhang load.

Construct cylindrical fan housings of heavy gauge hot rolled steel with continuous weld seams.

Provide venturi inlet bell and discharge diffuser accessories of the same gauge and material as the fan housing.

Provide factory mounted heavy duty back draft dampers manufactured by the fan manufacturer at discharge or inlet of fan as appropriate to avoid interference with routine maintenance and motor removal.

Provide companion flanges to receive sheet metal duct or flexible connectors. Companion flanges shall be of the same thickness as the fan flanges and provided by fan manufacturer.

Axial fan used for kitchen exhaust system shall be bifurcated with motor out of the air stream.

Fan shall be suitable for either vertical or horizontal mounting as shown on drawing.

Fan shall have factory mounted, rolled steel ring for flanged duct connections.

2.3 Roof Exhaust Fans

Provide roof exhaust fans of the centrifugal, belt-driven type. Construct fan housing of heavy gauge aluminium.

Construct all spun parts with a rolled bead for added rigidity and spun so as to seal the pores of the aluminium providing greater resistance against oxidation and deterioration.

Provide all aluminium fan wheel of the centrifugal blower type backward inclined blades and a tapered inlet shroud. Statically and dynamically balance wheels.

Provide inlet cone of aluminium centrifugal blower type.

Enclose motor and drives in a weather-tight compartment, separate from the air stream. Provide air for cooling the motor to the motor compartment by way of an air passage from an area free of contaminated exhaust fumes.

Provide motors of the heavy duty, permanently lubricated, sealed ball bearing type. Size drives for 165% of motor horsepower capabilities and of the cast iron type, keyed to the fan and motor shafts. Provide variable pitch drives.

Construct fan shaft of steel construction, turned, ground and polished to precise tolerances in relationship to the hub and bearings.

Provide drive belts of the oil-resistant, non-static, non-sparking type with life expectancy of over 24,000 hours.

Provide bearings flanged and of the permanently lubricated, permanently sealed ball bearing type.

The entire drive assembly and wheel removable shall be a complete unit from the support structure without disassembling the external fan housing. Mount the complete drive assembly on rubber vibration isolation.

Provide direct drive units of identical construction as belt drive units, except for drives, belts, and fan shaft bearings.

Construct all belt drive units interior and exterior parts, including wheel, wheel hub, supporting posts, fan shaft, drive assembly, and all outside fasteners, of aluminium or non-ferrous material. Include a five-year warranty.

2.4 Utility Sets

A. Provide utility sets with fan characteristics and performance similar to those described for centrifugal fans. The bearings on these fans, however, may be of the light duty, single row, sealmaster type, pillow block arrangement, foot mounted. Mount the fan sheave in the overhung position, so that both sheaves and bearings may be changed if required, without dismantling the unit.

B. Equip utility sets with belt guards and drain holes.

2.5 Domestic Ventilators

Domestic ventilators include small capacity, low-noise fans of, ceiling-mount, duct fans, compact size axial and mini-sirocco type.

Provide high-performance blades, totally enclosed powerful condenser motor, automatic oil circulation system, automatic shutters, decorative louvers, turbo fan, and all required accessories.

Electrical characteristics shall be single phase.

PART 3 - EXECUTION

3.1 Installation

Install fans in accordance with manufacturer's recommendations and as known on the Drawings. Follow SMACNA and AMCA recommended procedures for fan installations, belt guards, duct connections, etc.

Provide flexible connections as described in specification Section 15910 Ductwork Accessories to provide sufficient separation of ductwork from fan assembly to prevent metal-to-metal contact.

Unless noted otherwise, provide discharge direction and drive arrangement to suit space conditions and conform as closely as possible to the layouts shown on the Drawings. Deviations from overall dimensions of specified fans will not be accepted without written permission. Confirm before ordering, that equipment can be accommodated within space provided, indicating allowance for required service clearances.

Wherever required provide fans that are quiet operating and non-overloading over the entire range of operation.

Provide fan motors, starters, and controllers in accordance with Section 16090 and 16100 – Motors, Starters, and Control Centres. Size motors to drive its respective fan when the fan is operating at a speed 5% in excess of that required to meet the scheduled fan performance. Do not select motors within the service factor for this range.

Statically and dynamically balance fan wheels/impellers at the factory and certify balance.

Provide precision self-aligning bearings manufactured to prevent leakage of oil or grease. Provide cups, oil chambers, lubrication fittings in accessible locations for ease of lubrication. Provide heavy duty split pillow block bearings with tapered, double-row spherical roller assemblies. Provide bearings with AFBMA L-50 service life in excess of 200,000 hours at maximum catalogued fan operating conditions unless noted otherwise.

Provide copper lubrication leads, for lubrication of internal motors and bearings, extending to a capped termination point external to the fan casing.

Extend wire leads on fans driven by direct motor drive from the motor junction box in air tight rigid walled conduit, to a junction box mounted external to the fan casing.

On fans drive by belt drive, provide standard “V-groove” type belts and sheaves suitable for the service intended. Fan sheaves are non-adjustable type with removable machined bushings. For motors up to 3.7 KW, provide adjustable pitch type motor sheaves with double locking feature, to 10% above and below the rated fan speed. For motors larger than 3.7 KW, provide the necessary drive changes to adjust fan speed at operating capacity. Dynamically balance sheaves with over three grooves. For fan motors over 7.5 KW, provide at least two belts. Provide multiple belt drives capable of carrying the entire load with one belt broken. Provide perforated expanded metal or sheet metal belt guards, with grommeted tachometer ports at the fan and motor shafts, for all exposed sheaves and belts. Provide adjustable motor bases.

For motors in the air stream, provide TEFC type motors.

Provide solid hot rolled steel drive shafts, accurately turned and polished to a close tolerance where in contact with bearings. Secure fan wheels/impellers to the drive shaft by a key and keyway assembly. Shafts shall be sized for first critical speed and at least 1.43 times maximum speed for fan class.

Manufacture fans of materials and finishes suitable for the service intended.

Construct wheels/impellers exposed to normal atmospheres of mild steel, hot dip galvanized, and finished with two layers of factory applied non-scaling paint.

Construct fans exposed to corrosive atmospheres of corrosion resistant materials suitable for intended use, and factory finished with epoxy or other approved corrosion resistant coatings.

Provide fans exposed to elevated temperatures with components rated for high temperature service. Do not use belt drive assemblies exposed to the air stream. Use direct drive motors certified for high temperature service.

Construct fans used to convey flammable vapours of non-sparking (non-ferrous) materials, and use explosion proof motors.

Electrically ground fan and drive to prevent accumulation of static charge.

Completely house fan assemblies exposed to weather in weatherproof enclosures including motor and drive.

Fan wheel/impeller and casing shall be relieved of residual stress produced in forming process.

Provide fans used to exhaust grease laden vapours with motor drive and bearings completely external of air stream.

Provide housings with integral inlet and discharge flanges, complete with bolt holes for duct connections.

Where required or specified, provide variable speed drive as specified.

Provide gasketed access doors to permit routine maintenance and inspection of motor and internal components. Equip fan housing with drain holes and plug.

Equip fans connected to common duct or shaft with back draft dampers unless motorised dampers are provided.

Provide manufacturers certified sound power ratings with an octave band analysis. Make one set of these curves available to the supplier of sound and vibration control.

All fans outlet/inlet that is without connection to duct or plenum shall be provided with bell mouth and complete with protective screen at the opening.

Install fans and motors with proper support and vibration isolation as specified in Section 15240 – Sound and Vibration Control.

Provide sufficient clearances around fans for access and servicing of components. Install fans such that access doors, motors, belts, lubrication lines, electrical connections, etc. are readily accessible and not obstructed by other installations or structures.

Bump start fans to check that fan wheel/impeller rotation corresponds to the desired direction of air flow. Correct fans found to be rotating in a direction opposite to that desired.

Tighten belt drives, taking into account the service factor and any other operating requirements of the drive. Exercise care not to over tension belts.

Check all bolts and fasteners to ensure proper tightness. Do not over tighten nuts and bolts.

Check bearings and motor for proper lubrication, taking care not to over lubricate.

Use only lubricants recommended by the manufacturer.

Provide a drain at the bottom of the housing for fans discharging upward from the roof. Pipe drains from housings of interior fans discharging directly up through the roof indirectly to a floor drain. Pipe drains from housings of kitchen grease exhaust fans to a grease interceptor.

Provide reinforced galvanized steel inlet and discharge guard screens for all floor fans without inlet or discharge ductwork.

Fan supplier shall provide static pressure calculations for all fans based on actual shop drawing for Supervision Employer's Representative review before final selection of fans.

Provide all the installation accessories as per the manufacturer recommendation/ proper system operation such as horizontal plate, High-Temperature Flexible connection, Steel Hub, Duct spigot land, Inlet cone for land, back draft dampers .. etc.

3.2 Start-up and Testing

Have manufacturers check out installed equipment for proper alignment and lubrication at time of start-up.

END OF SECTION-15865

SECTION 15885

AIR FILTERS

PART 1 – GENERAL

Supply and install air filters wherever shown on the Drawings and/or wherever specified, of the sizes and type indicated.

Provide temporary filter elements in the filter banks of supply systems used during construction prior to using the system.

Temporary filter elements shall be throw-away type with frames taped air-tight.

Immediately prior to test and balance operations, replace temporary filters with a new set of specified filter elements.

After final acceptance, a new set of filter elements shall either be delivered to owner or installed to replace "Test" filters, as directed by Owner.

1.1 Work Included

A. Comply with section 15010 mechanical general provisions and all documents referred to therein.

B. Provide all labour, materials, products, equipment and services to supply and install all air filters indicated on the Drawings and specified in this Section of the Specification.

1.2 Related Work

This Section includes providing all materials as hereinafter specified or shown on the Drawings for the cleaning and filtering of the air system.

Particularly related sections:

SECTION 15850	AIR HANDLING & FAN COIL UNITS
SECTION 15940	AIR TERMINALS
SECTION 15995	TESTING AND BALANCING

1.3 Provision Requirements

A. Meet filter arrangement and type specified.

B. Provide sufficient filter media and size filter banks:

1. To limit maximum face velocity across filters to 2.54 m/s or less to meet manufacturer's recommendations

2. To ensure filters occupy maximum face area within unit enclosures

3. To limit initial filter pressure drops to specified values

Use manufacturer’s standard modular size wherever possible.

1.4 Quality Assurance

Manufacturer shall have experience of supplying filter to similar project of not less than 5 years.

All filter performance rating (pressure drops and efficiency) shall be rated to the latest relevant ASHRAE standard.

Flame spread rating shall comply with the requirement of NFPA and local Civil Defence requirements.

PART 2 - PRODUCTS

A. Throw Away Filters:

Provide 2" (50 mm) thick fiberglass media contained in rigid frame with a supporting maze across both entering and leaving faces of Media. Minimum average 10% NBS efficiency with atmospheric dust. Maximum 0.17" WG. (42 pa) initial resistance at 500 FPM (2.5 m/s) face velocity

Provide throw-away filters of thickness to fit frames of unitary equipment.

B. Cleanable Filter

Provide 2" (50 mm) thick aluminum media, contained in aluminum frame. Filter shall have an average efficiency of 60 % and it shall be capable of being completely cleaned by flushing with tap water. Holding frames shall be provided with polyurethane seals and stainless steel spring latches.

C. Pre-Filters

1. Provide 50 mm thick pleated media disposable type filter consisting of non-woven cotton polyester fabric media, media support grid and enclosing frame.

2. Do not exceed 25 Pa initial resistances at 2.54 metre/second approach velocity.

3. Meet average efficiency of 25% to 30% per ASHRAE Test Standard 52-76 with average arrestance of 90% to 92%.

4. Provide welded wire grid media support, 96% free area, bonded to the media and formed to effect radial pleat effect.

5. Provide enclosing frame, constructed of rigid heavy duty high wet strength beverage board with diagonal support members bonded to air entering and leaving side of each pleat.

6. Filters shall be listed by UL as Class 2.

7. Pre-filters shall be provided for all kitchen make-up fans, all outdoor air supply fans, all primary air-handling units, all air-handing units, all car park intake fans, and all other supply air fan for mechanical ventilation systems.

D. Final Filters

1. Provide 600 mm deep, high holding capacity bag filters (after the pre-filter) for all primary air-handling units and air-handling units

2. Do not exceed 88 Pa initial resistances at 2.54 metre/second approach velocity.

3. Meet average efficiency of 70% to 80% per ASHRAE Test Standard 52-76, with average arrestance of 97%.

4. Filters shall be listed by UL as Class 2.

E. Bag Filters

Provide for AHU wherever specified Minimum 550 mm long, high efficiency bag filters having an average atmospheric dust spot efficiency of 60% minimum as measured to EUROVENT 4/5 (i.e. Grade EU7). The fibre shall be bonded by resins and backed by scrim to prevent erosion of particles.

F. Filters for Indoor AC Units and Fan Coil Units

Provide 8 to 10 mm thick synthetic fibre media air filters and install throughout the entire surface area allocated for the air filter at the back of the indoor AC unit and fan coil units.

Meet average arrestance of 75-80% per ASHRAE Test Standard 52-76.

Initial filter pressure drop shall not exceed 25Pa at 2.54 metre/second approach velocity.

Coordinate closely with indoor AC unit and fan coil unit manufacturer to ensure that air flow performance is not hampered by pressure drop/resistance rating of the air filter.

For decorative type indoor unit and fan coil unit, provide filter as per manufacturer's standard.

G. Holding Frames

1. Provide 75 mm deep galvanized holding frames, with gaskets, four holding clips per filter per frame, inter-frame seals and frame stiffening bars for upstream servicing only.

   Provide filter housing for side or bottom access constructed of 1.61 mm galvanized steel with two access doors, extruded aluminium tracks, individual Universal Holding Frames and static pressure taps upstream and downstream of filter stages.

   For ceiling-concealed, ducted-type indoor AC units, provide the necessary stiffeners and frames for the specified filter media.

   Filter access shall be either right or left for AHU to facilitate future maintenance based on actual site conditions and installation arrangements. Similarly, filter access for FCU shall either be right, left or bottom. The location of access shall be confirmed to the manufacturer prior to order.

H. Air Filters Gauges

1. Provide across each air handling unit and primary air handling unit filter installation, an inclined manometer type draft gauge kit, similar to Dwyer 250-AF Series. Include static pressure tips and three port vent valves.
2. Provide 0 to 500 Pa range.
3. Not required for indoor AC units and fan coil units.

PART 3 - EXECUTION

3.1 Installation

A. Filters shall be properly packed in plastic bags and store in dry locations on site prior to installation into the system. Handle filter with care while installation to avoid damaging of filter frames and media material. Cover filter section before fan system is turned-on for testing and commissioning.

B. Arrange filters for upstream servicing or side access, to suit air handling/Fan Coil unit installation.

C. Take all necessary precautions including blanket filter media coverage over the entire filter installation for protection during construction and start-up.

D. The pressure drop across filters (in a ‘dirty’ filter condition) shall be considered as an internal pressure drop of the AHU.

E. Initially install one (1) set of filters during testing and commissioning. Then replace filters immediately prior to acceptance. Finally, turnover one (1) set of spares to Employer during project handover.

END OF SECTION-15885

SECTION 15890

SHEET METAL

PART 1 - GENERAL

1.1 Work Included

Comply with Division 1, General Requirements and all documents referred to therein.

Provide all ductwork required to make the various air conditioning, and ventilating systems complete and ready for operation in accordance with the Contract Documents.

Provide all labour, materials, products, equipment and services to supply and install the sheet metal and ductwork systems as indicated on the Drawings and specified in this Section of the Specifications.

The specialist ductwork company selected shall have sufficient expertise, organizational ability, drawing office production capacity and site erection capability to deal with a project of this size within the proposed construction programme.

Works Include:

General Ductwork
Duct Accessories
Outdoor Duct
Belt Guards
Access Doors
Flexible Connections
Air Chambers
Plenums
Louvers
Drain Pans
Duct Sealant

1.2 Reference Standards

A. Meet Standards described in the latest ASHRAE Handbook and SMACNA DW/144.

B. Duct dimensions shown on Drawings are net, inside insulation and acoustic duct lining.

Fire dampers shall be UL listed and labelled, and meet requirements of NFPA-90A, or Equivalent International Standard acceptable to the Supervision Employer's Representative.

Meet the latest editions of the following standards:

NFPA 92A - Recommended Practice for Smoke Control System
NFPA 92B - Guide for Smoke Management Systems.
NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
ASTM - A-525

Construct ductwork accordingly to the pressure-velocity classifications established by SMACNA, and as called for on the duct drawings.

Construct ductwork in accordance with Table 1-5 of the 1985 SMACNA Manual for 2" (0.5 Kpa) static pressure ductwork and Table 1-6 of the 1985 SMACNA Manual for 3" (0.75 Kpa) static pressure ductwork, with the exception that tie rods may not be utilized in ductwork 72" (180mm) wide and smaller.

Provide flexible duct assembly listed as Class 1 air duct by the Underwriters Laboratories under UL-181 "Standard for Factory – Made Air Duct Material and Air Duct Connections" at a flame spread of not over 25 and a smoke developed rating of not over 50 complying with NFPA Standard 90A.

Flexible air ducts to have a heat loss per foot of duct as measured by Air Diffusion Council Flexible Air Duct Test Code FD 72-RI and be UL listed as Class 1 under UL-181.

Construct flexible connections of canvas for low pressure systems, of vinyl-covered fiberglass (or neoprene) for medium and high pressure systems and of heavy noncombustible, material such as Thermafab by DuroDyne for kitchen exhaust 'fans or lab exhaust fans. Flexible connections must not contain asbestos and are to be suitable for the operating pressure and temperature of the system in which they are installed.

Flexible connections to be approximately 6 inches (150mm) long. After installation is complete, hold securely in place with heavy metal bands to prevent any leakage. Align ductwork and fans to be plumb prior to connection. Allow at least 1 inch (25mm) of slack.

Provide flexible connection in ductwork connected to the inlets and/or outlets of all air handling unit, fans, etc. except fan air handling units with internal isolators and flexible fan connection. Overlap ends of fabric 2" (50MM) and glue.

Sewing or stapling will not be permitted. Allow at least one inch slack in all flexible connection installations to insure that no vibration is transmitted.

1.3 Submittals

Shop Drawings

Submit sheet metal-shop details for approval before any duct layouts are submitted for review. Shop drawings will not be acted on before shop details have been reviewed.

Submit layouts of all ductwork drawn to a scale of 1:50mm for approval.

Submit drawing of location and size of sleeves for openings in floors and walls prior to ductwork fabrication.

Submit to the Engineer for review, complete certifications and data (in the English Language), on all sheet metal materials manufactured outside the United States.

Sheet metal ductwork drawings serve as the base sheets for the Contractor Coordination drawings specified in as specified in section 15010 Mechanical

General Provisions. Submit ductwork shop drawings for review as specified in Section 15501.

Samples

Submit samples of flexible ducting and special materials as required by the Engineer.

PART 2 - PRODUCTS

2.1 Ductwork

Ductwork shall be constructed of ASTM A-525 G90 galvanized steel sheet gauges specified in SMACNA Tables 1-4 to 1-9, unless otherwise called for on the drawings and having a minimum coating of 242 gm/m2. All duct dimensions indicated are net clear inside dimensions. Any conversion from the given shape shall be made without increasing air velocity or friction losses.

Construct sheet metal ductwork of galvanized iron of gauges specified in SMACNA Tables 1-4 to 1-9, unless otherwise called for on the drawings.

The ductwork on this project falls into classifications as indicated below. Each classification has positive and negative requirements as shown:

Table 1

Ductwork	Pressure Classification "W.G."/Pa	Velocity Classification	Seal Class
Toilet exhaust ductwork on the building side of the volume damper on floor	+2"/500 & -2/500	1500-2500	A

Table 2

Ductwork	Pressure Classification" W.G."/Pa	Velocity Classification	Seal Class
Toilet exhaust and kitchen exhaust ductwork, risers, and run outs to the volume damper on each floor.	-2"/500	1500-2500	A
Stair pressurization ductwork	+4"/1000	4000	A

Comply with the pressure class, seal class and velocity class listed for the construction in each classification. Cross-break or use mechanical transverse beading on rectangular ductwork 300mm and wider and install as indicated on the Drawings and as specified. Make beading at least 27900mm deep at the center of the, bead and a maximum of 7950mm wide at the base of the bead.

Where tie rods are utilized, provide a fender washer and jam type lock on each side of the sheet metal. Reinforce ductwork in accordance with Table: 1-10 Construct ductworks over 2400 mm wide with T-24 type flanged transverse joints with bolted corners. In lieu of using tie rods, this ductwork may be constructed as follows for the size ranges listed if carefully coordinated with all physical space limitations.

Table 3

Dimension of Longest Side of Duct mm	Supply of Exhaust	Sheet Metal Gauge	Min. Reif. Size mm	Max. Reif. Spacing mm
2450-2800	Supply	18	50	750 CC
2875-4100	Supply	16	100	600 CC
4125 – 4600	Supply	14	150	500 CC
4625 and larger	Supply	14	200	450 CC
*16 gauge 'Z' bar or 12 gauge angle				

Table 4

Dimension of Longest Side of Duct IN/MM	Supply of Exhaust	Sheet Metal Gauge	Min. Reif. Size mm	Max. Reif. Spacing mm
2450-2800	Exhaust	16	50	600 CC
2875-4100	Exhaust	14	100	500 CC
4125 – 4600	Exhaust	12	150	400 CC
4625 and larger	Exhaust	12	200	350 CC
*16 gauge 'Z' bar or 12 gauge angle				

Fasten reinforcing to ductwork on 300mm centers by bolting or welding reinforcing to the ductwork.

Install duct connected grilles, registers and ceiling diffusers shown on the drawings. Exact dimensions of openings must await approval of registers and diffusers. Submit exact locations for approval. Do not cut joints for the installation of outlets.

Where possible fabricate all ductwork in such a manner that seems and/or joints will not be cut for the installation of grilles, registers, or ceiling outlets. If cutting of seams or joints is unavoidable, properly reinforce the cut portion to original strength.

For low pressure ductwork provide air extractors in branch ducts at connection to main ducts

Unless otherwise indicated or specified construct all sheet metal ductwork in accordance with the HVAC DUCT CONSTRUCTION STANDARDS – METAL AND FLEXIBLE, First Edition, 1985, published by the Sheet Metal and Air Conditioning Contractors, National Association, Inc., and herein referenced as the SMACNA Manual. Various page numbers, table numbers, plate numbers, detail, numbers, and figure numbers herein cited refer to this edition of the SMACNA Manual. Install all ductwork in accordance with the arrangements and sizes shown on the Drawings and as specified herein.

Construct low pressure ductwork of "lock forming quality" galvanized steel of the gauge thickness listed in Tables 1-5 and 1-6 for the pressure class indicated of the 1985 SMACNA Manual with gauge tolerances as listed in Appendix A-1 of the 1985 SMACNA Manual. Comply with ASTM A-525 for all steel with a hot dipped galvanized coating weight that complies with the G90 section of ASTM A-525 and ASTM 90.

For rectangular ductwork, use radius elbows without vanes with centerline radius equal to 1-½ times duct width. Where space is limited, use either curved elbow with single vane and with centerline radius not less than width of duct, or use square varied elbow. For square elbows, use single thickness vanes for ducts up to 18 inches wide and double thickness airfoil vanes in ducts over 18 inches wide. Hold vanes in runners. See SMACNA Detail Fig. 2-3 and 2-4 of Standards. Construct turning vanes of the same material as the ductwork in which they are installed.

Alternative Joining

At the Contractor's option, ductwork may be joined at the transverse joints with prefabricated galvanized Ductrnate-35 sections, or with fabricated TDF or TDC T-24 type flanged transverse joints with bolts corners, gaskets, and sealants, constructed in accordance with SMACNA Manual (1985), Table 1-12. Submit the joint packing material and joint construction details using this method and a 300mm x 300mm x 300mm long duct sample to the Engineer for review. Plastic joint clips are not acceptable. Do not join flanged and prefabricated joints by different manufacturers.

Install Duct mate system according to manufactures instructions. Tables 12 and 13 of the installation instructions of September 1986 regarding the fastening of Duct mate angles must be observed. Bolting of Corners is required.

Duct Sealant

Seal all joints and seams on medium ductwork with an oil soluble elastomer sealant.

Sealant to be fast curing to a firm rubbery seal and have gap filling properties with smooth easy calling characteristics.

Sealant to the gray in color.

Acceptable Manufacturers or equal:

3M Fast bond 900

Foster 32-14

MEI 44-50

Hard cast Sure Grip 404

Fabricate ductwork from galvanized sheet metal unless other materials are specifically named. Duct installation shall conform to the following:

1. Ductwork shall be smooth on the inside and free of obstructions, vibration and rattle.

2. Fabricate ductwork, except as described in the next item, according to the following classifications (where applicable):

   a. Low Pressure: Velocities less than 10 m/s and static pressure in duct less than 500 Pa, positive or negative.

   b. Medium Pressure: Velocities 10 m/s and greater and static pressure in duct from 500 Pa positive or negative to 750 Pa positive or negative and up to 1500 Pa positive.

   c. High Pressure: Velocities 10 m/s and greater and static pressure in duct over 1500 Pa positive up to 2500 Pa positive.

3. Also comply with the following ductwork construction specification:

   a. Ductwork associated with all air-handling units shall be of medium pressure construction.

   b. Ductwork used in smoke exhaust/control, smoke purging, pressurization and all other emergency ventilation system shall be of high pressure construction. Minimum thickness of ductwork sheet metal shall comply with the local Fire regulations.

4. Provide duct transformation with expansion fittings having slopes not exceeding 1 to 7 and contraction fittings having slopes not exceeding 1 to 4.

5. Provide full radius tees, bends, and elbows for changes in direction except where square elbows are required due to space restrictions. Provide DuroDyne double thickness 0.8 mm turning vanes assembled in top and bottom rails in square elbows.

6. Provide balancing dampers free to move in either direction without binding and rattling. Construct dampers in low and medium pressure ductwork from 1.2 mm galvanized sheet metal. Use manual quadrants on small ducts. On dampers longer than 375 mm use push rods with ball joints. Use two push rods on ducts wider than 600 mm.

7. Isolate equipment with neoprene 0.8 mm thick flexible connectors with finished fabric width not less than 150 mm. Flexible connectors shall have the same fire/temperature rating as the connecting ductwork.

8. Provide 50 mm insulated sheet metal blank off panels behind unused portions of exterior louvers.

9. Proprietary made duct joints such as “Ductmate” or approved equivalent shall be used. Seal all joints in low, medium and high pressure ductwork with Transcontinental MP for low and medium pressure or duct sealer for high pressure. Joints shall be sealed to conform to SMACNA standards as follows:

Table 5

Seal Class	Sealing Required	Static Pressure Construction Class
	All transverse joints, longitudinal seams and duct wall penetrations.	90 Pa and up
	All transverse joints and longitudinal seams.	500-744 Pa
	Transverse joints	Up to 500 Pa

Construct round ductwork to meet high pressure duct standards and as follows:

1. Provide welded slip joint construction round duct fittings. Wipe pipe and fittings with duct sealer before assembly. Secure joints with self-tapping screws, and then brush again with thick coat of duct sealer.

2. Provide die formed round elbows through 200 mm dia. constructed from 1.1 mm galvanized steel. Provide 5 section construction for larger elbows.

3. Provide conical round tees.

Flexible Ductwork:

1. Provide Flexmaster Triple Lock Aluminium, flexible ductwork upstream and downstream of air terminal control units and/or other locations indicated on the Drawings.

2. Construct ductwork from a tape of soft annealed aluminium sheet, spiral wound into a tube and spiral corrugated to provide strength and flexibility. Provide a triple mechanical lock to form a continuous secure air joint without the use of adhesives for pressures up to 2000 Pa.

3. Conform to the requirements of NFPA 90 and Underwriters Laboratories classification for round duct to specification 181 and comply with local Fire Authority requirements.

Provide flexible ductwork in minimum lengths of 1500 mm and maximum lengths of 3600 mm for low pressure systems. For medium pressure systems restrict minimum and maximum lengths to 1200 mm.

Provide kitchen exhaust ductwork as follows:

1. Meet NFPA Standard No. 96 and the requirements of the local governing authority.

2. Submit construction drawings and detail drawings when required by the governing authority.

3. Provide duct access doors at 3m intervals for inspection and cleaning purposes.

4. Provide 3mm steel duct with liquid tight continuous welded joints.

Provide fire cladding materials for smoke exhaust/control/purging ductworks installed outside fire-rated shafts as required by local Fire Authority. All smoke exhaust/control/purging ductwork shall be of 1.2mm galvanised steel.

Provide stainless steel ductwork for dishwater exhaust. Construct from Type 304, 1.52mm material. Seal joints and seams water tight.

Provide fire rated duct as follows:

Fire rated material shall be of approved type with acceptable tested fire rating by Civil Defense.

The material shall have adequate thickness and the same fire rating properties as the structure in which they are installed through.

Provide galvanised steel support channels at 600mm centres. The spacing between the fire resistance board and metal duct shall be packed with mineral wood.

The complete assembly shall be non-combustible.

Fire resisting board shall have zero indices for ignitability, spread of flame and smoke development, in accordance with BS 476 and as approved by Civil Defense.

Fire rated duct shall be supported independently by galvanised hangers.

Provide fire rated duct for duration 120 minutes in the following location:

The entire ducting work for extract system of car park B1 & B2.
Ducting work for supply air system inside of car park B1 & B2.
The entire ducting work for smoke extraction system.
The entire ducting work for Pressurization system of stair cases.

Outdoor Duct

Duct works installed outdoors or exposed to weather shall be galvanized and protected by one coat of mordant solution or calcium plum bate primer finished by two (2) coats of bituminous paint.

Ensure that all ducts penetrating though outside walls and roofs be fitted with weather proofing materials to avoid water and dust entering the building structure

2.2 DUCT ACCESSORIES

Provide duct accessories such as volume dampers, splitter dampers, fire dampers, vanes, etc. as shown in the contract documents or as required by the Engineer.

Volume Dampers shall be opposed blade type, with formed channel or structural frame and a minimum 18 gauge blades. Dampers shall be complete with damper lock and shaft extension for easy adjustment.

Fire Dampers shall be provided as per the requirements of the governing codes of Bahrain, NFPA, U.L., SMACNA, or B.S. standards. Fire resistance rating shall be at least the same fire resistance as the wall or floor through which the duct passes bit not less than 2 Hours.

Auxiliary Drain Pans

A. Construct drain pans of 16 gauge galvanized steel with all joints brazed. Construct pans watertight with hemmed edges.

B. Provide drainpipe connections of at least 20mm, or as shown on the Drawings.

Screens

Furnish and install all wire mesh screens indicated in the Construction Documents.

Fabricate frame of extruded aluminum with mitered reinforced corners.

Provide non-rewire able frame with permanently secured screen mesh.

Provide mesh of 15mm square, 0.16mm intercropped aluminum wire

2.3 ACCESS DOORS

Provide access doors for galvanized ductwork using 0.7 mm galvanized material with galvanized mounting frame and 25 mm rigid insulation between panels. Provide fastening devices to give tight closure.

Provide access doors for stainless steel ductwork using 0.61 mm stainless steel with stainless steel mounting frame and 25 mm rigid insulation between panels. Provide fastening devices to give tight closure.

Provide access doors for aluminium ductwork of 0.61 mm aluminium with aluminium mounting frame, and 25 mm rigid insulation between panels. Provide fastening devices to give tight closure.

Provide access doors and removable panels in plenums and casings of 1.31mm galvanized material with 50 mm thickness fibreglass insulation. Equip doors with handles and hinges to open from either side (without risk of injury).

.Provide access doors not smaller than 18 inches (450mm) by 18 inches (450mm). Ducts smaller than 18 inches (450mm) are to be provided with access doors 2 inches (50mm) smaller than the width by 18 inches (450mm) long. Provide access to all fire dampers as required by code and local authorities.

Here removable hung ceiling panels are installed below access doors, provide markers showing the access door location clearly.

Construct all access doors with double panels.

Provide neoprene gaskets securely formed into door frames around the periphery of all duct access doors.

Equip door frames for plenums and casings with hollow tubular gaskets. Provide all doors complete with 300 mm x 300 mm viewing ports.
Provide access doors at all fire dampers. Gasket used shall be of high temperature rating. Servicing volume dampers and servicing of motors on fans and air handling units. Access doors shall be provided with sponge rubber gaskets around the entire perimeter.

Hang access doors in ductwork in separate frames and attached to duct with aircraft type cable. Provide "Ventlok No. 100" cast zinc latches one (1) per side. Install hinged walk-in type casing access doors where required and indicated on the Drawings. Construct casing access doors 1450mm x 600mm wide where possible and be complete with heavy duty hinges, hardware, and Ventlok # 260 latch handles. See figures 61 1 and 6-12, and Table 6-2 of the 1985 SMACNA Manual.

2.4 Acoustic Duct Lining

A. Rectangular Duct Liner: Permacote Linacoustic meeting ASTM C 1071 with air surface coated with acrylic coating treated with EPA registered anti-microbial agent proven to resist microbial growth as determined by ASTM G 21 and G 22.

1. Noise Reduction Coefficient: 0.70 or higher based on Type A mounting and tested in accordance to ASTM C 423.

2. Adhesive: Meeting ASTM C 916.

3. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.

B. Round Duct Liner: Permacote Spiracoustic, rigid performed round liner, or Spiracoustic Plus with air surface coated with acrylic coating treated with EPA register anti-microbial agent proven to resist microbial growth as determined by ASTM G 21 and G 22.

1. Noise Reduction Coefficient of 0.70 as per ASTM C 423. (Type A mounting)

2.5 Field Assembled Plenum and Casing Construction

A. Provide metal partitions, plenums and casings of not less than 1.61 mm galvanized sheet metal suitably reinforced with rolled angle sections.

B. Provide metal partitions, plenums and casings with adequate strength for all operating conditions. Fabricate each sheet of material as a panel. Join panels by 40 mm standing seams on outside of casings and secure with bolts at 300 mm centres.

C. Provide closure baffles around banks of coils, filters and other inline components.

D. Provide 25 mm minimum size rolled structural steel angles where casing meets floor. Caulk joints to prevent air and water leakage.

E. Flange and bolt casings on 150 mm centres to coils, blank off panels and filler panels.

Incorporate adjustable directional flow baffles into mixing plenums, to ensure complete mixing of outdoor and return airstreams with stratification not to exceed +2 deg C across the coil face at winter outdoor design temperature.

2.6 Insulated Plenums and Casings

A. Provide insulated metal sandwich panels for all exterior intake and exhaust air plenums consisting of prefabricated 18 gauge galvanized sheet metal panels and 50 mm rigid fibreglass insulation with interlocking joints securely fastened.

B. Provide steel supports, joiner sections, floor channels, opening frames and sealing materials. Provide 1.31 mm minimum channel stiffeners at not greater than 800 mm centres.

C. Connect corners and butt joints with 1.61 mm galvanized sections. Seal all joints with rubber mastic. Use angle joints to attach panel edges to walls.

D. Construct entire plenum to resist deflection and seal sufficiently to avoid air leakage when subjected to a pressure differential between inside and outside of up to 2500 Pa.

E. Provide access doors suitable for personnel pass through.

2.7 Fire Dampers

Provide curtain type dampers to maintain fire rating integrity of membrane being pierced. Minimum rating to be 1-1/2 hours with 71 deg C fusible link. Provide multiple dampers where sizes exceed code limitation. All fire dampers shall be approved by Civil Defence and must be UL listed.

Curtain blades under normal operating conditions shall be totally out of the air stream.

Fire dampers shall have the same fire rating as the compartment wall or slab.

Select dampers with air flow resistance not exceeding 13 Pa at design flow rates.

2.8 Combination Fire and Smoke Dampers (UL listed, Civil Defense approved)

Provide Class I dampers to maintain fire rating integrity of membrane being pierced. Minimum fire rating shall be 2 hours.

Provide parallel blade type dampers, suitable for horizontal or vertical mounting.

Provide multiple dampers where sizes exceed code limitations.

Select dampers with air flow resistance not exceeding 13 Pa at design flow rates.

2.9 Smoke Dampers (UL listed, Civil Defense approved)

Provide Class I smoke dampers where indicated on the Drawings.

Provide parallel blade type dampers, suitable for horizontal or vertical mounting. Provide multiple dampers where sizes exceed code limitations.

Select dampers with air flow resistance not exceeding 13 Pa at design flow rates.

2.10 Back Draft Dampers

A. Provide counter-balanced heavy duty back draft dampers suitable for use in temperatures from 10 deg C to 93 deg C.

B. All back draft dampers shall be heavy duty grade/type suitable to be installed close to discharge side of the fan with high static pressure. Frames shall be 6063T5 extruded aluminium. Blades shall be formed aluminium. Bearings shall be moulded synthetic and linkage 12 mm tie bars. Blade edge seals shall be extruded vinyl. Dampers shall be equipped with adjustable counter-balance weights attached to rear of blades.

Refer to Drawings for locations, mounting direction and air flow direction.

2.11 Insulated Ductworks Inside the Building

Please refer to Mechanical Insulation Section 15255 for Specification.

2.12 Duct Mounted Smoke Detectors

Duct mounted smoke detectors are provided by Division 16 and installed by Division 15. Locate such mounted smoke detectors in the ductwork in accordance with the manufacturer's recommendations, the requirements of NEPA, and the authorities having jurisdiction.

PART 3 - EXECUTION

3.1 Sheet Metal Installation

Where necessary in order to attain the specified noise level criteria, provide acoustic insulation on all discharge side of fans and attenuators as follows:

1. 3000 mm for straight duct run box or

2. 1500 mm downstream of 1st elbow or

3. 1500 mm for each branch downstream of 1st tee

Provide final duct connections to all fume hoods and other individual canopies or hoods provided by others where required.

Frame and install motorised dampers. Unless shown otherwise, attach each motorised damper module to the channel framing.

Provide frames in ductwork for airflow stations.

Provide test openings in all ducts entering and leaving air handling equipment. Install test openings at 150 mm intervals across the long dimension of rectangular

ducts, and at 90 degree intervals around circular ducts. In insulated surfaces, provide extension to suit insulation thickness. Provide additional test ports in ductwork where required for air balancing. Submit drawings to indicate proposed locations.
Make provisions in ductwork and plenums for installation of duct type smoke detectors and other control devices.

Provide a stainless steel skirting around kitchen exhaust ductwork between hood-connection and ceiling line where top of hood is below ceiling.

Provide a sheet metal protection for leading edge of acoustic insulation.

Slope ductwork down to exhaust hoods and other equipment connections. Provide drains at low points and pipe to nearest floor or funnel drain.

Provide neoprene isolation gaskets and nylon bolts at connections required for dissimilar metals.

Seal water tight all longitudinal and transverse joints in ductwork for swimming pool and change room systems.

Seal water tight bottom and sides of intake and exhaust ducts connected to exterior louvers as follows:

1. Intake - from Louver to air handling unit or fan.

   Exhaust - from Louver to 2 metres upstream of Louver.

3.2 Duct Sealant

A. Clean and dry all surfaces thoroughly prior to application.

B. Apply with caulking gun, trowel or spatula.

C. Join surfaces to be sealed immediately after application of sealant.

D. Follow manufacturer's instructions carefully for application, storage and cleanup.

E. Do not use sealant which is beyond manufacturers recommended shelf life.

3.3 Installation of Fire Dampers, Smoke Dampers and Combination Fire and Smoke Dampers

Install dampers in approved manner suitably anchored to building structure in locations indicated on the Drawings.

Install fire dampers complete with sleeve and full perimeter steel angle on both sides of barrier being pierced. Provide manufacturers recommended minimum clearance between masonry or non-combustible frame and sleeve. Sleeve shall accept actual size of damper with blades pocketed outside of air stream.

Divide openings into smaller openings using fire resistant structures where openings to be protected require dampers larger than maximum UL listed sizes.

Install dampers in a matter approved by Civil Defense

3.4 Testing

Duck leakage tests shall conform to Section 15995.

3.5 Clean Up

A. Vacuum clean the inside of all air handling systems, including fans, plenums, ducts, coils and terminal units to ensure that they are free from debris and dust.

END OF SECTION-15890

SECTION 15910

DUCTWORK ACCESSORIES

PART 1 – GENERAL

All work shall be subject to the General Conditions or shall comply with the requirements of the contract.

Provide duct accessories as indicated in the drawings or as required by the Engineer.

Requirements of Section 15010 (Mechanical General Provisions) shall also govern work specified together with all applicable paragraphs of other Division 15 sections.

Provide all interfaces, configuration, interconnection, control devices and instrumentation as specified in section 16170 building management system to meet the control and monitoring points and sequence of operations.

1.1 Related Work

Section 15240 – Sound and Vibration Control

Section 15255 – Mechanical Insulation

Section 15910 – Ductwork Accessories

Section 15995 – Testing and Balancing

1.2 Section Includes

Turning vanes

Volume and splitter dampers

Damper regulators

Fire and Smoke Dampers, Fire Dampers and Smoke Dampers

Low leakage pressure relief/ pressure regulating dampers

Back draft dampers

Duct access doors

Access door hardware

Blanking plate

Blanking panel

Perforated plate

Duct test openings

Flashing

Bird screens

Drip pans
Equalizing Grid

Miscellaneous

1.3 Reference Standards

NFPA 90A - Installation of Air Conditioning and Ventilating Systems. Fabrication testing and installation to be in compliance with U.L., NFPA and local authorities. Fire dampers to be U.L. labelled for 1½, or 3 hour rating as indicated on the drawings. Refer to architectural drawing for fire ratings of slabs and partitions being penetrated.

SMACNA - Low Pressure Duct Construction Standards. Comply with sheet Metal and Air Conditioning Contractors National Association (SMACNA) Details and details as shown on the drawings.

UL 33 - Heat Responsive Links for Fire-Protection Service.

UL 555 and UL 555S - Fire Dampers and Smoke Dampers.

ADC 1062 - Certification, Rating and test Manual.

AMCA 500 - Test Method for Louvers, Dampers and Shutters.

ASHRAE

British Heating and Ventilating Contractors Association Code of Practice

1.4 Submittals

Submit shop drawings and product data under provisions of General Conditions and Division 1 as applicable.

Provide shop drawings for shop fabricated assemblies indicated, including volume control dampers, duct access doors and duct test holes. Provide product data for hardware used. Show all duct accessories on ductwork shop drawings. Submit samples of dampers as requested by the Engineer.

Submit complete manufacturers data on all dampers required by this section, including sizes, location, and quantity and construction details.

Submit manufacturer's installation instructions under provisions of General Conditions and Division 1 as applicable for fire dampers.

Submit schedule of air outlets and inlets indicating type, size, static pressure and noise levels and location.

PART 2 – PRODUCTS

2.1 Materials (Where Applicable)

A. Flexible Duct Connections:

General: Flexible duct connectors shall be made of approved flame retardant fabric with flame spread rating of not over 25 and a smoke developed rating of less than 50. Connectors shall not exceed 10 inches in length. Temperature rating shall be the same as the associated ductwork.
Flexible ducts shall be provided wherever shown in the drawings and a required. The flexible duct shall be constructed from tight gauge aluminium metal. Helical wound with lock seam to form a corrugated duct capable of being bent or set by hand without spring back and without deforming the circuit section.

The ducts shall be pre-insulated with 25-mm thick fibreglass insulation. The duct supports shall be as per manufacturer's recommendations.

Jointing shall be done by special clamps, stealth etc. to eliminate any chance of air leakage.

The flexible duct connector shall meet UL 214 - Tests for Flame Propagation of Fabrics and Films, and Federal Test Standard 181 for abrasion, leakage, radiation resistance, tear and tensile strength.

Flexible duct connectors shall meet the following requirements as outlined in Table below:

Service	Indoor	Outdoor	High Temp.
Continuous Temp. Range	-40ºC to 80ºC	-30ºC to 120ºC	-60ºC to 260ºC
Abrasion Resistance	15,000 cycles	500 cycles	125 cycles
Leakage Resistance	350	250	400
Minimum Radiation Resistance of Fabric	19x106	19x106	19x106
Tear Strength	100/100	12/12	50/40
Tensile Strength	240/220	225/300	200/150
Model - (Duro Dyne as standard)	MB6X	MF6D	MF6T

B. Turning Vanes:

Same material as the ductwork in which they are installed.

Three inch and lower pressure classification systems: SMACNA-HVAC Duct Construction Standards 1985, except as noted. Also refer to drawings for short radius elbows.

Single width turning vanes with 19mm trailing edge and 50mm radius, Type Y blades for ducts 915 mm or less in width; type Z blades for ducts greater than 915 mm wide.

Three inch and higher pressure classification system: SMACNA-HVAC Duct Construction Standards 1985, except as shown.

C. Small Double Thickness Vanes with 2-inch Inside Radius

Vane length not to exceed 915 mm. Provide separate equal size sections for greater lengths.

D. Volume Control Dampers/Automatic Dampers/Splitter Dampers:

Volume Control Dampers as required for balancing the airflow should be multi-leaf opposed blade pattern made from galvanized steel complete with hand locking quadrant.

The volume control dampers shall be of the opposed multiple blades, 100% shut-off type, suitable for the static pressure shown on the drawings.

The damper frame shall be 2mm zinc-coated steel and shall be provided with mounting holes. The frame shall be roll-formed, interlocked and welded at corners. The frame shall be 100mm width.

The damper shall have dual blade linkage concealed in the jambs and connected with steel rods. The blades shall rotate on 12mm diameter pivot assembly in permanently lubricated bearings. Blades shall be capable of opening to a full 90o and linkage shall incorporate positive 90o opening stop. Operation shaft shall be suitable for motor operation.

The damper and damper frame shall be installed dead level in both directions. The blades shall not touch any adjacent material throughout the full travel of the blades.

The damper and damper frame shall be installed so that there is no torsion or twist in the frame to prevent smooth operation of the damper.

Pressure drop through the damper shall not exceed 5mm W.G. at 2.5m/s velocity based on the face area.

Whenever required the ductwork shall be provided with the splitter dampers at its branch off. The position of the splitter shall be adjustable and lockable

For ductwork with pressure classification 500 pa or higher or Seal Class A regardless of pressure class, penetrations shall be provided with sealed assemblies, end bearing or approved equal. For insulated ducts provide proper assembly, with 50 mm handle extension for externally insulated ductwork.

Damper blade shall be 13 mm smaller in each dimension than the size of duct in which they are installed.

Damper and damper frame may be made in one section up to 1200mm in width and 300mm height. Larger sizes shall be made in sections.

Blades shall be constructed of 2mm roll-formed zinc-coated steel not to exceed 150mm in depth and shall be formed with double 90o bends to insure positive air lock and maximum strength. Blades shall be felt tipped to ensure tight closure and noiseless operation.

After installation, the linkage of the automatic damper shall be adjusted to the airflow quantities shown on the drawings.

The damper and linkage shall be cleaned of all construction dirt. Any debris or dirt that could cause binding shall be thoroughly removed.

The damper, damper frame and linkage shall be the product of a manufacturer regularly engaged in the production of high quality dampers.

Fabricate all damper blades, axles, and frames of the same material as the ductwork in which they are to be installed.

E. Steel Construction:

Hat shaped, galvanized, sheet steel channels, minimum of 1.6 mm thick, with mitred and welded corners; Axles 13 mm round minimum or hexagonal stock; Galvanized steel tie-bars and brackets; roll formed galvanized steel blades.

F. Aluminium Construction:

Hat shaped, 2.5 mm thick minimum aluminium sheet channels or extruded aluminium channels with mitred and welded corners; Non-ferrous axles 13 mm round minimum or hexagonal stock; Galvanized steel tie-bars and brackets; roll formed 2.5 mm inch thick minimum aluminium sheet blades or 1.2 mm thick minimum extruded aluminium blades.

Bearings: Moulded synthetic material or bronze oilite, spacing 1220 mm maximum.

G. Concealed Volume Damper Operator:

Provide concealed volume damper operator for all volume dampers located above inaccessible ceilings and where indicated on the drawings. Regulator shall be embedded in the finished ceiling or wall material so that the unit shall be flush with the finished ceiling. Cover plate shall not exceed 20 mm diameter. Provide complete workable system as required for damper operation.

H. Low Leakage Pressure Relief/ Pressure Regulating Dampers

The low leakage pressure regulating dampers shall be purpose made from Aluminium extrusions and include a balanced blade mounted in an installation frame.

The damper shall provide automatic pressure regulation without the help of any external power sources.

The operating pressure range for the damper shall be 18 Pa-65 Pa adjustable to any required point.

The damper shall be supplied in standard finish with white polyester powder coating.

The damper shall be fitted with fixing flange to mount into angle iron frame prepared in the opening.

2.2 Fire and Smoke Dampers, Fire Dampers and Smoke Dampers:

A. General

All fire dampers shall be UL listed. They shall comply with the following specification or local building regulations, whichever is more stringent.
Dampers operating with blades closing in any direction other than by gravity pull shall be assisted in closing by a heat resistant, reel-type stainless steel spring.

Combined fire and smoke damper installation or independent smoke and fire damper installation is required for all ductwork which penetrates fire rated walls, floors and ceilings. Smoke dampers are required in all smoke rated partitions. In accordance with NFPA and COP. All dampers guaranteed by the manufacturer to close against air flow.

Provide locking closure, UL listed spring assembly. Bear UL label as dynamic damper.

Provide dampers for rectangular, oval and round duct connections as required. Fire dampers shall be provided as shown on the drawings and as required elsewhere. Generally fire separation is to be floor to floor in vertical traverse or wall to wall in horizontal traverse.

Provide duct access panel at each fire and smoke damper, and smoke control damper suitably sized and located for inspection and resetting. Coordinate ceiling or wall access doors as specified in Section 15010.

Dampers shall be installed in accordance with SMACNA fire damper guide and manufacturer's instructions.

Dampers shall be tested in accordance with the most recent edition of UL-555. They shall be classified for dynamic closure to a minimum 12 m/sec and 1000 pa static pressure for horizontal air-flow, air flow up and air flow down.

Dampers shall be marked with a UL classified rating and maximum velocity/pressure rating for each horizontal and vertical installation.

Use multiple sections where the largest single section available is not large enough.

B. Curtain Type Fire Dampers

Dampers shall be approved fusible link self-closing spring loaded type. Fusible link shall be of appropriate melting temperature. Blades shall be out of air stream (damper in open position), and shall not reduce the net free area of duct below that shown on drawings.

Damper construction shall be of same material as the ductwork in which the damper is installed.

Frame shall be fitted with angle iron stop and stainless steel spring latch, and shall be securely fastened to building construction.

Dampers shall be suitable for use in dynamic and static systems as applicable. Dampers for active smoke control systems shall be dynamic rated.

Damper shall be rated 1 ½ hour minimum unless otherwise noted, bear UL- Fire Damper Label and shall be constructed and installed as required by UL555.

Each damper shall include sleeve and retaining angle furnished by the damper manufacturer.

C. Smoke Dampers:

Frame shall be a minimum of 16 gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement.
Bearings shall be stainless steel sleeve turning in an extruded hole in the frame.

The blades shall be airfoil shaped double skin construction with 14 gauge equivalent thickness. Blade edge seals shall be silicone rubber and galvanized steel mechanically locked in blade edge (adhesive or clip fastened seals not acceptable) and shall withstand temperature up to 250°C.

Jamb seals shall be stainless steel flexible metal compression type. Blade action must be opposed.

D. Combination Fire Smoke Dampers

Same specification as smoke dampers plus additional clauses below.

Each combination fire smoke damper shall be 1 1/2 hour fire rated under UL Standard 555, and shall further be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same.

E. Fire and Radiation Ceiling Dampers:

1/2x1/2 x12 gauge steel channel welded frame; No. 16 gauge, maximum 150 mm wide blades with heat retardant blanket secured to blade with rivets.

The closure assembly shall use a stainless steel torsion spring closure spring assembly. The damper shall meet UL classified as a three hours heat stop.

For lay in diffusers, manufacturer shall provide a ceramic thermal blanket which shall lay over the diffuser between the fire damper and ceiling tile with a 50 mm minimum overlay.

F. Back Draft Dampers:

Gravity back draft dampers, size 460 x 460 mm or smaller, furnished with air moving equipment, may be air moving equipment manufacturer's standard construction for low leakage.

Steel Construction: Back draft dampers shall have 12 gauge galvanized steel channel frame with 14 gauge press formed steel sub frame and 16 gauge reinforced galvanized steel blades with edge seals and synthetic bearings. Dampers shall be manufactured for velocities up to 17.5 m/sec.

Aluminium Construction: Frames shall be 6063TS extruded aluminium, 2.25 mm wall thickness and mitred corners. Blades shall be formed aluminium of 0.6 mm thickness with extruded blade seals and synthetic bearings. Linkage shall be concealed in frames. Dampers shall be manufactured for velocities up to 17.5 m/sec.

Damper shall be low-leak, counter balanced, parallel blade type. Dampers shall be counter-balanced to begin opening at 7 pa static pressures and full open at 25 pa static pressure differential.
Dampers shall not have leakage rate exceeding 7 m3/hour per square foot of face area at 125 pa pressure.

2.3 VAV TERMINAL UNITS:

Furnish and install variable air volume fan powered terminals of the sizes and capacities shown on the plans. Space limitations shall be reviewed carefully to ensure that all terminals will fit the available space.

Terminals shall be certified under the ARI Standard 880-94. Certification program and carry the ARI seal.

The terminal shall be designed, built, and tested as a single unit including motor and fan assembly, primary air damper assembly, electric heating coils, and accessories as shipped. All electrical components shall be UL listed and installed in accordance with the National Electric Code. Electrical connection shall be single point. All electrical components, including low voltage controls, shall be mounted in sheet metal control enclosures. The entire terminal shall be ETL or UL listed as a complete assembly.

The terminal casing shall be minimum 20 gauge galvanized steel, internally lined with non porous, sealed liner which complies with UL 181 and NFPA 255 (25/50). Insulation shall be minimum 1.5 lb. Density. Exposed insulation shall be non fibrous or fibreglass insulation shall be sealed from the airstreams with a solid metal lining. The terminal shall have a round duct connection and a rectangular discharge suitable for flanged duct connection. The casing shall be designed for hanging by sheet metal straps.

The terminal casing shall have a bottom access panel which allows removal of fan and servicing of terminal without disturbing duct connections.

The fan shall be constructed of steel and have a forward curved, dynamically balanced wheel with direct drive motor. The motor shall be suitable for 240 volt, 50 cycle, single phase power. The motor shall be of energy efficient design, permanent split capacitor type, with integral thermal overload protection and permanently lubricated bearings, and specifically designed for use with a SCR (Silicon Control Rectifier) for fan speed adjustment. Fan assembly shall include an anti-backward rotation device, torsion-flex tuned spring steel suspension and isolation between motor and fan housing.

The terminals shall utilize a manual SCR (Silicon Control Rectifier) which allows continuously adjustable fan speed from maximum to minimum, as a means of setting fan airflow. The speed control shall incorporate a minimum voltage stop to ensure that the motor cannot operate in a stall mode.

The terminals shall include a gasketted back draft damper at the fan section discharge to prevent primary air from flowing back through the fan section into the return air plenum.

The primary air damper assembly shall be heavy gauge steel with shaft rotation in bronze oillite self lubrication bearings. Shaft shall be clearly marked on the end to indicate damper position. Stickers or other removable markings are not acceptable. The damper shall incorporate a mechanical stop to prevent over stroking, and a synthetic seat to limit close off leakage.

The terminals shall be equipped with pressure independent direct digital controls. The contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware, and methods, as well as wiring and piping diagrams for each application identified by unit tag per the schedule in the drawings. Controls shall be compatible with pneumatic inlet velocity sensors. The sensor shall be multi point centre averaging type, with a minimum of four measuring ports parallel to the take off point from the sensor. The sensor shall provide a minimum differential pressure signal of 0.03" wg. at an inlet velocity of 500 fpm.

Controls shall be field set by the contractor for the scheduled minimum and maximum flow rates. Flow measuring taps and flow curves will be supplied with each terminal for field balancing airflow. All pneumatic tubing shall be UL listed fire retardant (FR) type. Each terminal shall be equipped with labeling showing unit location, size and scheduled flow (cfm).

The contractor shall provide a Class II 24 Vac transformer and disconnect switch. Actuator shall be direct connection shaft mount type without linkage. All control shall be installed in approved NEMA1 sheet metal enclosure.

Provide all interfaces, configuration, interconnection, control devices and instrumentation as specified in section 16170 building management system to meet the control and monitoring points and sequence of operations.

2.4 CONSTANT AIR VOLUME (CAV) UNITS

The CAV units shall be pressure independent type, having low pressure loss, low sound level to provide constant air flow with a percentage deviation not exceeding 2.5%.

Units shall be galvanized steel sheet construction with casing leakage rate to Class II in accordance with DIN 24194. Damper blades shall be of aluminium with neoprene seals, aerofoil profile to control air flow. Damper spindle shall be supported on self lubricating nylon bearings.

The CAV unit shall be equipped with a factory installed "Flo-cross" type averaging and signal amplifying air flow sensor to maintain constant airflow even with irregular duct approach.

Units shall be complete with factory installed DDC controllers. Units shall be preset at factory for the scheduled airflow. It shall also be possible to carry out field resetting of airflows when necessary. Units shall be selected so as not to exceed specified noise levels for the respective zone.

2.5 MOTORIZED SHUT OFF DAMPERS

The Contractor shall furnish and install, control dampers as required for the proper functioning of the system.

All control dampers shall be opposed blade.

Casing shall be in galvanized sheet steel to BS 2989 Z2 G275 M.

Blades shall be of natural anodized extruded aluminium to BS 1474.

Blade tip seals silicon rubber, temperature resistant upto 200 deg. C.

Side seals shall be stainless steel to BS 1449 Grade 302-525.

External blade linkage shall be stainless steel to BS 970 304-S 15.

Blade spindles shall be in stainless steel to BS 970 304 S11 supported in plain brass bearings.
Shut off dampers shall have a leakage rate not exceeding 200 M3/hr/M2 at 1000 Pa.

2.6 DUCT THERMOMETERS

Provide duct thermometers wherever required for proper system operation of AHU, duct thermometers shall be as follows:

90 mm diameter metal case of dust-tight construction
Black pointer
White face with black lettering
Range normally 0 to 115o C for heated supply air, 0 to 80o C for cooled supply, mixed and return air and 0 to 90o C for outside air but range shall suit maximum and minimum temperature of location and shall be shown on shop drawings.

Temperature marking in 1oC increments

Liquid filled 1.5 m minimum length copper averaging bulb with bronze braided armour.
Accuracy ±1% of range span.

Thermometers for remote reading shall be similar to duct thermometers specified above but with armoured extension capillary and bulb with separable well for pipelines or flanged duct connection for averaging bulb, as required.

2.7 DUCT ACCESS PANELS/DOORS

Provide proper pressure and leakage rated, gasketed, duct mounted access panel/doors. In insulated ducts, access doors/panels shall be insulated double wall, thermally equivalent to ductwork insulation. Gauges of door material, no. of hinges, no. and type of door locks shall be as required by SMACNA Duct Construction Standards.

Unhinged doors shall be chained to frame with minimum length of 150 mm to prevent loss of door.

For seal Class A, hinged, screwed or bolted doors are not acceptable. Access doors shall be leakage rated neoprene gasketed UL 94 HF1 listed.

Door metal shall be same as the attached duct material.

For grease and high temperature ducts, door assembly shall be rated for at least 2.5 times of the carrying fluid temperature.

The minimum sizes shall be 450 x 450 mm unless restricted by the duct size, otherwise agreed by the Supervision Employer's Representative where smaller size is more practical to meet space constraints.

Access covers shall be provided for the inspection and servicing of plant and equipment as described elsewhere.

Frame duct opening for each door with a continuous 25 mm by 25 mm by No. 12 gauge sheet metal angle, of the same material as the duct in which installed, riveted to the exterior surface of the duct opening.

Lap inner face of door over duct opening, a minimum of 6.5 mm on all four edges of the free duct opening.

For thermally insulated duct the frame of access door or cover shall be extended beyond the face of the duct by a measurement equal to the thickness of insulation and be so arranged that the insulation and finish can be dressed into the frame ensuring that the opening is not concealed and that the edges of the insulation are protected from accidental damages.

Provide all doors with a 20 mm wide sponge rubber or felt gasket, around all four sides of duct opening.

Wherever possible, install doors so that air pressure differential tends to keep door closed.

On doors of systems where fan is scheduled for 1000 pa S.P. or greater, provide painted signs appropriately worded as follows:

"CAUTION – DOOR CLOSES WITH AIR PRESSURE"
"CAUTION – DOOR OPENS WITH AIR PRESSURE"

Blanking Plate: 16 gauge galvanized sheet metal, painted matt black cut to size as required.

Blanking Panel: Construct from 18 gauge galvanized sheet metal sandwich with 25 mm thick rigid board fibreglass insulation. Attach insulation to metal with adhesive fasteners and edge tape. Overlap front and back metal plates and tack weld at 75 mm centres.

Perforated Plate:Construct from 16 gauge galvanized steel with circular holes equally distributed and equally sized to achieve the free area required. Galvanized after perforating.

Duct Test Openings:

Cut or drill temporary test holes inducts as required. Cap with threaded metal caps.
Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap.
Provide extended neck fitting to clear insulation.

Flashing:

16 gage minimum ducts through roof, material to match duct material soldered watertight, flashed and counter-flashed, and provided with storm collars to secure watertight construction.

Bird Screens:

No. 14 gauge,12.5 mm galvanized wire mesh set in galvanized steel frame. Stainless steel wire mesh and frame when exposed to outdoors.

Drip Pans:

18 gage, stainless steel 50 mm deep, solder-jointed, with drain piped to nearest air gap waste, unless specifically shown otherwise. Extend coil drip pans under coil valving. Provide suitable dielectric gasket to connect dissimilar metals.

Equalizing Grid:

75 mm thick aluminium honeycomb grid with 10 mm openings securely fastened inside a 16 gauge galvanized steel duct section 150 mm long.
Grid and casing in outside air intake duct 304 stainless steel

Spin Collars:

For each flexible duct connection off of a main or branch duct to a ceiling diffuser and for each outlet off the ventilation ductwork to the plenum air provide a spin collar with a positive locking balancing damper.

Miscellaneous

All the accessories such as louvers, dampers, grille etc., shall be provide with wall/duct mounting frame, gaskets, nut bolts, screws etc.,

PART 3 - EXECUTION

3.1 Installation

Install ductwork accessories as specified herein and in accordance with the manufacturer's printed instructions.

Turning Vanes: Where centreline radius is less than 1.5 times the duct width (on supply, return and exhaust ductwork), elbows shall be radius throat with radius heel and full length splitter vanes when required. When centreline radius (r) divided by duct width (w) is less than 1.5, provide the following number of splitter vanes:

(r/w)Centreline radius/duct width	No of vanes
1.49 < (r/w) < 0.7	1
0.69 < (r/w) < 0.6	2
0.59 < (r/w) < 0.55	3

Flexible Connections: Provide ductwork connected to air-handling equipment and fans unless the fan is internally isolated, with flexible fabric connections and all necessary transformation pieces as required. Do not use flexible connections on life safety smoke exhaust fans. Coordinate with requirements of section 15240 Sound and Vibration control.

For round duct connection, install fabric connectors a minimum of 75 mm in length for ducts having a maximum diameter of 450 mm and a minimum of 125 mm in length for duct diameters over 450 mm in size.

Secure fabric connectors tightly to fans, casings and ducts as follows:

Secure round connectors with No. 12 US gage by 25 mm wide galvanized steel draw bands. Secure bands with bolts and nuts.

Secure rectangular connectors with 25 mm by 3 mm thick flat galvanized steel bars, with screws or bolts on 200 mm centres maximum, or with sheet metal slip joints. Tightly crimp fabric into sheet metal joint and secure complete joint with sheet metal screws on 150 mm centres maximum.

Allow at least 75 mm slack in connections.

Fabric connectors may be factory pre-fabricated pre-assembled units, with minimum No. 24-gage metal edges, secured to fabric with double lock seams.

Do not paint fabric connectors.

Provide flexible connector in ducts spanning structural expansion joint.

Volume Dampers:

Provide manual adjustable volume dampers, with extended mount indicating and locking quadrants:

On each supply, return and general exhaust take-off.

At each take-off to register, grille or diffuser. (Not all are shown on drawings).

Note: All required volume dampers may not be indicated on Drawings, but dampers shall be provided as necessary for system balancing.

Duct Access Doors: In addition to access doors required for inspection, maintenance and adjustment provide access doors every 15 m to facilitate duct cleaning.

Volume Dampers:

Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts and at each take-off to register, grille or diffuser. All required volume dampers may not be indicated on drawings, but shall be provided as necessary for system balancing.

Fire and Smoke Dampers:

Provide fire and smoke dampers, smoke dampers or fire dampers as appropriate at locations where ducts and outlets pass through fire rated components.

Fire dampers must be included at all floor changes; at entry and take-off at shafts in all supply, return and exhaust ductwork.

Install with required perimeter mounting angles and sleeve. Sleeve depth shall be a minimum total of 150 mm larger than wall or floor thickness to allow 37.5 mm on each side for angle attachment, plus additional 25 mm on each side for breakaway duct connections.

Dampers shall be installed per SMACNA with breakaway connections and nosing on duct liner. Refer to SMACNA HVAC Duct Construction Standards.

Provide access panels at each location of sufficient size to repair internal link as previously specified under access door/panel section. Demonstrate re-setting of fire dampers to authorities having jurisdiction.

All damper openings in drywall assemblies shall be framed.

Back draft Dampers: Provide back draft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated. .

Provide duct test holes where indicated and required for testing and balancing purposes.

Provide galvanized wire mesh screens on all indoor duct openings that do not contain grilles or access panels, and stainless wire mesh screens behind all intakes and exhaust louvers.

Flashing:

Match ductwork material soldered watertight. Solder side seams at least 300 mm from bottom. Provide suitable dielectric gaskets to join dissimilar metals.

Drip Pans:

Provide drip pans under piping running over electrical equipment, ceiling hung air conditioning or air handling units with drain piped to nearest air gap waste.

Combination fire smoke dampers: Division 15 shall furnish and install. Coordinate with control associated with fire alarm systems and for control connections by BMS system.

Automatic Dampers:

Install automatic damper as shown on Drawings, and as specified. Provide proper sealed wall penetrations.

END OF SECTION - 15910

SECTION 15940

AIR TERMINALS

PART 1 – GENERAL

1.1 Reference

Conform to General Requirements for Mechanical Services of Division 15.

1.2 Description of Work

1.2.1 Furnish and install air outlets as indicated on drawings.

1.2.2 Types of air outlets and inlets required for project include the following:

Ceiling air diffusers
Wall registers and grilles
Louvers

1.2.3 Refer to section 15910 for ductwork and duct accessories required in conjunction with air outlets and inlets.

1.2.4 Refer to section 15995 for balancing of air outlets and inlets.

1.3 Quality Assurance

1.3.1 Manufacturer’s Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

1.3.2 Codes and Standard:

1.3.3 ARI Compliance: Test and rate air outlets and inlets in accordance with ARI650 “Standard for air outlets and inlets”

1.3.4 ASHRAE Compliance: Test and rate air outlets and inlet in accordance with ASHRAE 70 “Method of Testing for Rating the Air flow Performance of outlets and Inlet”.

1.3.5 ADC Seal: Provide air outlets and inlets bearing ADC certified rating seal.

1.3.6 AMCA compliance: Test and rate louvers in accordance with AMCA 500 “Test Method for Louvers, Dampers and Shutters”.

1.3.7 AMCA Seal: Provide louvers bearing AMCA Certified rating seal.

1.4 Submittals

1.4.1 Product Data: Submit manufacturer’s technical product data for air outlets and inlets including the following:

Schedule of air outlets and inlets indicating drawings designation, room location, number furnished, model number, size, and accessories furnished.

Data sheet for each type of air outlet and inlet, and accessory furnished, indicating construction, finish, and mounting details.

Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.

1.4.2 Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, weight loadings, required clearances, construction details, and field connection details.

1.4.3 Submit mock-up installation for company approval before final selection.

1.5 Product Delivery, Storage and Handling:

1.5.1 Deliver air outlets and inlets wrapped in factory fabricated fiber board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

1.5.2 Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

2.0 PRODUCTS

2.1 General

2.1.1 Select all diffusers to provide uniform air coverage without overlap. Air velocity up to a height of 6' (1.8m) above the floor shall be 25 to 50 fpm (0.13 to 0.25 m/s).

2.1.2 Noise generated by outlet or inlet at peak volume shall be such that room sound pressure level does not exceed noise criterion 26 with an 8 Db. Room attenuation; the sound power level reference to 10-12 power watts.

2.1.3 All volume and air pattern devices shall be fully adjustable from the face of the diffuser, register or grille.

2.1.4 Size of all round flexible or rigid duct connections to diffusers shall be the same size as diffuser inlet diameter.

2.1.5 Diffusers, registers and grilles shall be arranged for flush mounting in lay-in type ceilings and over lap mounting in plaster, mineral tile and similar ceilings, with concealed fixings unless otherwise directed.

2.1.6 Grilles, register and diffuser locations shall be adjusted to suit reflected ceiling drawings, or site instructions. It is recommended that all grilles, registers, diffusers, louvres be from one manufacturer.

2.1.7 All diffusers, grilles and registers shall be supplied completely factory powder coated. Finish colour shall be to the approval of the COMPANY. The interior of all grilles and diffusers is to be factory painted matt black.

2.1.8 All supply grilles and diffusers will have opposed blade balancing dampers. All will have foam rubber sealing band around the edge to seal to the structure. All pivots will be round section, not of formed sheet, and not relying on a spring steel locking wire.

2.1.9 Unless otherwise specified basic grilles and diffuser materials shall be Aluminum extruded sections. Sections in the airstreams shall be carefully selected to minimize turbulence.

2.1.10 All grilles and diffusers supplied on this project shall be tested and rated in accordance with ASHRAE Standard 70-72, ADC Test Code 1062-GRD and ISO 3741.

2.2 Linear Bar Grilles

Linear bar grilles shall be fabricated from aluminum, with 6.4mm wide bars on 12.5mm centers pressed into a notched steel retaining bar. The core can be either welded into the cuter frame, or, where the grille is used in a sill application, held in the outer frame by spring clips fixed to the core retaining bar.

The outer frame shall be 35mm deep and shall have a visible flange 25.4 mm wide. Mitred end caps shall be welded to give a near invisible joint.

The grill shall be complete with an opposed blade damper painted matt black, and shall be fixed with universal mounting brackets. Both the damper and the fixing brackets shall be accessible through the face of the grille.

Continuous grilles shall be provided with positive alignment strips, which fit into special keyways extruded into the frame of the grille to ensure clean unbroken lines.

2.3 Four-Way Ceiling Diffusers

Ceiling Diffusers shall be multi cone giving 4 way horizontal discharge.

The three centre cones of the diffuser shall be manufactured from pressed aluminum, with the remaining cones and the outer frame fabricated from extruded aluminum welded at the corners to give near invisible joints.

The core shall be removable without the use of special tools, but for safety, shall be fixed to the outer frame by a small length of chain.

The diffuser shall be complete with an opposed blade damper painted matt black. All supply air diffusers shall be provided with an equalizing grid.

2.4 Perforated Face Ceiling Diffusers

Perforated ceiling diffusers shall be (aluminum, flush face), for supply and return. The return models shall have the same face and border construction as the supply models for harmonious appearance in the room. Diffusers shall have a perforated face with 3/16" diameter holes on ¼" staggered centers and no less than 51% free area. Perforated face shall be aluminum. The back pan shall be one piece stamped heavy gauge steel of the sizes and mounting types shown on the plans and outlet schedule. The diffuser neck shall have 11/8" depth for easy duct connection.

Diffusers must discharge a uniform horizontal blanket of air into the room and protect ceiling against smudging. Pattern controllers in the supply models shall be mounted on the back of the perforated face and must be field adjustable to allow the discharged air to enter the room in either vertical or 1,2,3 or 4-way horizontal jets. The perforated face must be easily unlatchable from the back pan to facilitate removal of the face for pattern controller adjustment or to access damper.

Damper shall be constructed of heavy gauge steel. Damper must be operable from the face of the diffuser by unlatching the diffuser face. The diffuser must be designed such that complete removal of the face is not required during damper adjustment.

The contractor shall provide published performance data for the perforated diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE standard 70-1991.

2.5 Wall Registers

Wall registers shall be double deflection fabricated from aluminium, the front vanes being horizontal, the rear vanes vertical. This grille shall be complete with an opposed blade damper painted matt black and adjustable from the face of the diffuser. Both sets of vanes shall be fully adjustable without the use of special tools.

2.6 Eggcrate Grilles

Eggcrate return or extract grille shall be provided with a steel lattice core of 12.7mm x 12.7mm openings, giving a free area of 90%.

The core shall be fixed into an extruded aluminum frame, with welded corners and a 25mm face flange.

The grille shall be complete with wire mesh and an opposed blade damper painted matt black and adjustable through the face of the diffuser.

2.7 Circular Ceiling Diffusers

Circular ceiling diffuser shall be of aluminum construction with two concentric inner spinnings.

The diffuser core shall be fully adjustable for vertical or horizontal air discharge, and shall be removable without the use of special tools.

A flap damper shall be provided in the neck of the diffuser which is adjustable from the diffuser face.

2.8 Linear Slot Diffusers

Linear Slot diffusers shall provide unobtrusive continuous air diffusion with a pleasing aesthetic appearance. Hairline butt joints shall ensure clean unbroken linear runs for active and dummy sections.

The diffusers shall be complete with pattern control blades, fully adjustable from face of diffuser through 180 degrees and shall be fitted with end caps at each end.

The diffuser members shall be constructed from high quality aluminum extrusions to BS 1474 while the pattern control blades shall be of black rigid PVC.

2.9 Exhaust Disc Valves

Exhaust valves shall be manufactured from high quality sheet steel spinnings protected by a stove enameled or powder coated paint finish. Flanges shall be fitted with sealing gaskets. The valves shall be installed with the aid of a mounting ring and air flow adjusted by rotating the central disc. Finish of valves shall be to the COMPANY's approval.

2.10 Extract Air Louvers

Louvers shall be extruded Aluminum frame with Aluminum blades of not less than 2 mm thickness, and shall be firmly fixed so as not to vibrate. Unsupported blade width shall not exceed 1800 mm.

Behind each louver shall be an insect mesh screen 76 x 6 mm made from 2 mm diameter stainless steel wire. The screen will be clamped by a 20 mm frame and will be firmly fixed to the outer edges of the louver. The frame shall be hot dip galvanized after fabrication.

The connection to the louver shall be flexible and shall ensure no duct load is transmitted to the louver.

Louvers shall be provided with powder coated finish to the approval of the COMPANY.

2.11 Sand Trap Louvre for Air Intake

Sand trap louvers shall have a double deflection inlet passage to separate sand from incoming air by means of centrifugal forces.

Separation efficiency particle size 350-700 shall not be less than 90% at a face velocity of 1M/Sec and not less than 70% at a face velocity of 2M/sec. Sand trap louver shall be of aluminum construction, self cleaning and maintenance free. The base of the louver shall have self-emptying sand holes. Pressure drop at 2 M/Sec average face velocity shall not exceed 120 pascals. Stainless steel insect mesh shall be included. Sand louvers shall be provided with powder coated finish to the approval of the Engineer.

2.12 Jet Diffuser or Nozzle

Jet nozzles shall be used in applications where large quantity of supply air from the diffuser has to travel a long distance to the required air conditioned area.

Many factors could effect the direction and length of this air stream such as air velocity from the nozzle, the temperature difference between the supply air and the room, and local convection effects or draughts within the room.

Jet diffuser shall be designed to be manually adjusted up to 35° upwards, and up to 35° downwards in order to minimize these factors, and direct the supply air to the desired location. Normally the jet nozzles should be adjusted upwards.

Jet nozzle should be well-designed, aerodynamically efficient shape results low noise characteristics which allow the utilization of these jet nozzles in critical areas.
The jet nozzle should be consists of square plate, with several centric cylinders. All are made of aluminum, and colored with the approved color. Jet nozzles

should be installed in the side walls. Easily by screwing or riveting the plate on plenum box, or directly onto the duct.

3.0 EXECUTION

3.1 Examination

3.1.1 Verify inlet/outlet locations.

3.1.2 Verify the size of air terminals to achieve proper air pattern.

3.1.3 Verify ceiling and wall systems are ready for installation.

3.1.4 Ensure the noise generated by air terminals is within the permissible range.

3.1.5 Coordinate beginning and completion of installation with other works.

3.2 Installation

3.2.1 Install all Air Inlets and Air Outlets as indicated on project drawings and in accordance with the manufacturer's installation instructions.

3.2.2 Where electrical reheat coils are provided with air terminal boxes, provide duct access doors in ductwork upstream and downstream of reheat coil. Duct accesses doors shall be of the necessary dimensions to access and replace reheat coils.

3.2.4 Paint ductwork visible behind air outlets and inlets matte black or as per architectural specifications.

3.2.5 Interface with other products. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

3.3 Cleaning

3.3.1 Protect all Air Inlets and Air Outlets against entry of foreign matter during construction works.

3.3.2 Remove all dirt and foreign matter from the entire duct system and clean diffusers, registers and grilles before operating fans.

3.3.3 Provide temporary capping to prevent entry of foreign matter during construction.

3.3.4 Clean duct systems, Air Inlets and Air Outlets with high power vacuum machines. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

3.4 Identification

The identification shall be as detailed in standards, listed in this Section as well as per Section 15010 Mechanical General Provisions

3.5 Testing, Balancing and Commissioning

Coordinate adjustment of Air Inlets and Air Outlets with procedures of Testing, Balancing and Commissioning as detailed in standards listed in this Section as well as per Section 15995 Testing and Balancing.

END OF SECTION -15940

SECTION 15990

CONTROL CENTRE INTERFACING

PART 1 – GENERAL

1.1 Work Included

Comply with section 15010 mechanical general provisions and all documents referred to therein.

Provide all labour, materials, products, equipment and services to supply, install and test the operation of the smoke control systems and all emergency ventilation system interfaced to a central control panel located in each building component's Security Room and the Fire Command Centre.

Refer to Electrical Specs. for wiring of all smoke control devices and to ensure that sequences are implemented to meet all applicable codes and requirements of authorities having jurisdiction.

Provide all interfaces, configuration, interconnection, control devices and instrumentation as specified in section 16170 building management system to meet the control and monitoring points and sequence of operations.

Control panel shall be provided in accordance with the Specification. The contractor shall supply, install and set to work the control panels described below and on the Electrical section of this specification.

Furnish and install adjacent to air distribution system, a control panel. The panel shall be of the cabinet type of steel construction, with proper bracing of rigid wall or floor mounting. All main floor mounted control panels. Mount on this panel all associated temperature controls, relay, switches, air gauges, duct or immersion thermostat and thermometers with points of measurement within the Mechanical Equipment Room, except as otherwise specified.

Each control device on the panel shall be marked with nameplates describing its function and cross-referencing it to control diagrams shown on the panel.

The controls panels shall be manufactured in accordance with the details give in the (Electrical services), together with the requirements listed below. Submit shop drawings of each panel for approval before fabrication.

The cabinets shall be folded mild steel sheet having a minimum thickness of 2.5mm or of stiffened proprietary construction.

The control panels shall be Zintex coated to be a BS 4800 color to be specified by the Consultants at a later date.

The panel of all equipment contained therein shall comply with all current regulations and standards. Particular attention shall be paid to the B.S.E.D Regulations for Electrical Installations earth leakage requirements

The supply system will be 400V 3PH 50HZ 4Wire.

Control circuit voltage shall not exceed 110VAC or DC. The supply cables to the panels will be excessively large and special facilities must be provided for termination and connection.

Main isolators shall be interlocked with the panel doors, which shall be lockable. All isolators shall be capable of making and breaking under fault conditions.

Molded case circuit breakers and miniature circuit breakers shall be used for over current/shot circuit protection.

Each motor drive circuit, main supplies to individual items of plant shall each be supplied through and M.C.B or M.C.C.B of suitable rating equipped with auxiliary contracts which will isolate the individual drives control circuit. Each of the control circuits shall be supplied through on M.C.B.

Where miscellaneous circuits are controlled by means of relays, these shall be formed in to small logical groups of about eight each group being protected by an M.C.B.E.L.V circuits to thermostats, valve controls, instruments and similar items of equipment shall be formed into small logical groups of about six, each group being protected by an M.C.B.

All starters motors rated at 1KVA and above shall have separate compartment within the panel.

Motor starters shall be provided with a manual pre-set thermal overload incorporating single phasing protection.

Relays will generally be 110V 11pin plug type, low voltage relays will generally be 8 ping plug type, and a suitable color code shall be used to indicate the voltage applied.

Control switches shall be provided close to the incoming supply point.

Wiring within the panel shall be carried out in PVC insulated cable of the appropriate cross sectional area, minimum size 1.5 mm and phase color. Extra low voltage A.C wiring will be colored white.

All wiring shall be carried on the front surface of the mounting plate plastic cable trucking. Cable conductor sizes will be noted to take into account all grouping and enclosing factors.

ll outgoing electrical cables shall be terminated at a numbered terminal strip at the top of the panel. The terminals shall be fully numbered in consecutive order and sized to cater for long runs, where voltage drops may necessitate increased cable cross sectional area.

All components shall be identified with an engraved label.

One spare 30 Amps rated M.C.B shall be provided on each bus bar.

PART 2 – PRODUCTS

2.1 Interface Hardware

A. Provide an Emergency Ventilation System control panel in the Security Room and Fire Command Centre to remotely control and monitor all emergency ventilation systems.

B. The following equipment and shall have control and status monitoring facilities in the control panel:

Smoke control/exhaust/purging fans, staircase/lobby pressurization fans and all other emergency ventilation fans shall be able to be switched On/Off with operating and trip status indications.

Lower ground and ground level service area and loading/unloading areas mechanical ventilation fans shall be able to be switched On/Off, control of fan speed (if multiple speed fans are provided) with operating and trip status indications.

On/Off control and status indications for all smoke curtains, main entrance automatic doors associated with the smoke control/exhaust/purging systems.

Open/Close control and status indications of all automatic dampers associated with the smoke control/exhaust/purging systems.

2.2 Metering System and Billing

2.2.1 Description

The Tenant metering system is intended to provide Complete Energy consumption Monitoring, Billing, Planning, and Commercial Control. For the Chilled Water Cooling Energy Consumption for Each Tenant (only large retail areas and anchors which are indicted with "BTU" symbols on the drawings for chilled water piping system).

The Given Facility also should have the suitability and ability to be extended with minimal changes and additions to be part of global billing System.

The Energy Metering should consist of the Most Updated Intelligent Industrial standard internationally recognized Hardware and Software Components, with high accuracy.

The Measurement devices shall meet the site requirements for the installation and operation with Minimal adjustments.

Equipment shall have the suitable rating and working conditions of the given Buildings.
The Meters shall be with the suitable output reading output.
The Main reading and communication language is only English.

The Communication Network should be such that the Transferee of Data will be safe and unable to be interrupted by other communication networks, and such that long life with minimal maintenance and spare part backup requirements.

The Installation and terminations shall be of nature that can be easily extended and can accept variety of communication systems implemented by addressable means of plug and Play Provisions which enables open protocol addressable signal communication facility.

2.2.2 Quality Assurance

A. Manufacturers: Firms regularly engaged in manufacture of meters and gauges, of types, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Compliance: Comply with applicable BS standards pertaining to meters and gauges.

C. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.

2.2.3 Submittals

A. Product Data Meters and Gauges: Submit manufacturer's data on meters and gauges including, but not limited to, scale range, ratings and calibrated performance curves, for the Engineer's approval.

2.2.4 Product Delivery, Storage And Handling

A. Deliver and store meters and gauges in factory-wrapped packages which protect units against weather, dirt and damage. Store in clean dry place and protect from construction traffic.

B. Handle meters and gauges carefully to avoid damage. Do not install damaged units; replace and return to manufacturer.

2.2.5 Central Billing Facility

To be suitable to be expanded with minimal changes to the given facility, and by additional provisions for future expansion.

Also to be capable of shifting and upgrading the given facility to meet the global billing and metering future demands.

2.2.6 Customer’s Services

To be of complete addressable data transferee and monitoring to each individual customer, easy for analyzing, past historical record for the long terms records, and planning capability with direct access to the customer data from the remount location.

2.2.7 Security

The Billing Security shall be the priority to the satisfactory requirements and future planning of the company.

2.2.8 Meter Level

The BTU meters (referred as BTU in the drawings) shall be of wear free ultrasonic type with high measuring accuracy and long term stability. The meter should have no moving parts with a measuring range of 1:100.

The ultrasonic flow sensor should employ microprocessor based technology and use ultrasonic measuring techniques. The flow sensor should be able to withstand an overload twice the nominal range. The flow meters calculator should be able to cater to the medium temperature between 15 deg. to 50 deg. The flow sensor should comply with

DS/EN1434 class C specifications for EMC & Environment conditions. The flow sensor should have a supply voltage of 3.6 VDC, powered by a Lithium battery with battery life of 10 years. The flow sensor should have an integral super capacitor to eliminate operational disturbances due to short term power cuts. The electronic display unit shall be mounted directly on the supply/return flow tube or on the wall with minimum distance of 1.5 meters. The BTU meter should have 2 temperature sensors (Pt500 or Pt 100 –EN60751), one mounted along with the flow sensor and the other on the supply/return path as applicable. The BTU meter should have a temperature of 2-130oC with display resolution of 0.01K. The BTU meter should comply with DS/EN1434 standards.

The BTU meter EEPROM shall be updated at least hourly with all the accumulated values, thus ensuring minimum loss in the even of total power loss (concurrent failure on backup and primary supply). The meter should be equipped with an optical interface/transmitter for communication to a hand held terminal. The meter shall as a minimum display the energy, volume, operating hours, temperatures (supply/return & differential), flow rates etc and instantaneous values. In addition it should also be able to display alarms such as failure of primary supply, battery back-up, temperatures above or below the measuring range etc.
The protection class should be IP54.

2.2.9 Communication Level

The communication protocol should be Hard Wired M-Bus. M-Bus components such as Master/Concentrator/Repeater/Modems are capable to work with a baud rate of 9600. All components should be as per EN1434 standards. Outputs from the master level converters should have a proper out put such as modems, TCP/IP, RS232, RS485 or any proper output according to the final design.

2.2.10 Reading Software Level

The software should be capable to read any M-Bus component and has a manual and auto install facility regardless of the manufacturer of the M-Bus component manufacturer. The software should have the capability to read all the details of the meters such as flow, energy, temperatures, temperature differences instantaneous flow and alarms generated by the system. The software has the capability to view the readings in different views such as physical, logical and geographical with the ability to schedule the tasks for periodical readings. The software should have the ability to read the total number of meters in the system. The software should be capable to produce a proper file type to be exported to the billing software for billing purposes. The software should have the ability to be used by different clients and also to manage the client's authorities.
The software has a log for all the events in the system which includes the time and date and the address of the user.

2.2.11 Billing Software

The billing software should be tailor made as per EMPOWER requirements. The billing software should comply with Empower Financial software. The Billing software should be capable to handle at least 100000 tenants bill for future purposes. The billing software should comply with UAE standards and EMPOWER requirements.

2.2.12 Payment Collection Facility: (To be considered in the BILLING Software)

Payments through web sites.
Payments through counters.
Payments through machines.
Payments Through bank accounts.
Payments through Ethicality facilities such as sums or any other payment facility.

All the above requirements are main requirements and we are ready to accept any other suggestions from the engineering consultants firms.

We are looking for your reply of interest to set a meeting to discuss the suggestions and procedures of the project.

The quotations will be submitted after the meetings required finalizing the design as per Empower requirements.

2.2.13 System Objectives

The required system will be a fully automated metering system which will be used to measure the AC Energy consumption of each tenant at the Al Nagfa Hotel Project, following are highlights of the overall project objectives the system will periodically read consumption information from the meters and send it to the main server. The main server will process the collected data on monthly bases and issue a separate bill for each tenet according to the level of his consumption. Printing, folding and insertion of the bills will be automatic. The system will provide multi levels of security according to a predefined set of roles. The system will use an open architecture, which allows future expansion and development. The system will provide different interfaces for registering bills payment such as a cashier module, e-Payment module or payment. The system should provide an audit trail for the transactions done by the users. The tenants should be able to see there bills and payment history on line.

2.2.14 System Administrators

The system administrator will be responsibilities as follows:

Ensuring the Availability of the system and Client machines linked to it.

Ensuring the data transmission between clients and the server is running smoothly.

Ensuring the automated billing process is running without any problems

Updating master data such as Tenets, Meters, Tariffs, and Fees etc.

2.2.15 System Users

The system users should have multiple roles; following are some of the suggested more roles can be added upon the request of the client.

2.2.16 Customer Service Role

The system will provide customer service screens which will provide information about the tenants, bills payment history, or even record customer complain.

2.2.17 Back Office Employees

One person should do the office and managerial work, such as extracting cutoff reports, financial reports, outstanding dues audit trail reports and taking actions on issues like non paying the dues, this person will also be responsible to report to the higher management with the latest collected vs. outstanding repots.

2.2.18 Tenants

Tenants can see access their bills and payment history, in this proposed solution payment using the internet was kept optional because of the financial overhead it imposes. 12.0 Software.

2.2.19 Functional Requirements

Meter reading
Filtering data
Scheduling of data reading
Transmitting data
Issuing bills
Accepting payments
Bill enquiry
Payment history enquiry
Audit trail
Registering / updating customer account(s) inserting, updating and deactivating master data
Customer complain processing (optional)

2.2.19 Non-Functional Requirements

System Security
Availability
Folding and Inserting

2.2.21 Hardware Requirements

Servers
Backup Tape
Firewall
USB
Printers
Folding and Inserting Machine

2.2.22 System Topology

Each apartment will be equipped with a meter, meters at the same floor will transmit the reading on demand to the repeaters, all the repeaters will be linked to a central concentrator which resides at each building, the concentrator will be attached to a PC with modem connection to establish a dial-up connection with the main server.

A Special software provided by the meter vendor will be installed on the client PC, this software will help automating the process of detecting the installed meters, filtering the data and schedule the reading process, All the data read from the meters will be stored in a local database and later on transmitted to the main server where it will be saved to the main database.

PART 3 – EXECUTION

3.1 Interfacing Requirements

All interfacing works shall be provided such that the following can be achieved at the Main Control Centre and the two (2) Sub-control Centres:

ON/OFF control and status/trip indications of all emergency ventilation fans
UP/DOWN controls and status of all smoke curtains
OPEN/CLOSE controls and status indications of all automatic opening doors
Speed control of all pressurisation fans
OPEN/CLOSE controls and status indications of all automatic dampers

3.2 Testing

A. Provide all labour and materials required to complete the testing of the remote control and indication functions. Ensure that required smoke control systems and components are functional, and ensure that smoke control systems operate properly.

B. Perform tests in the presence of authorities having jurisdiction.

C. Repeat tests as often as necessary to demonstrate acceptable operation of the systems.

END OF SECTION - 15990

SECTION 15995

TESTING AND BALANCING

PART 1 – GENERAL

1.1 DESCRIPTION

Provide testing, adjustment and balancing for all water and air systems in accordance with the Contract Documents.

1.2 Submittal Requirements

Submit the following information to the Supervision Employer's Representative at least six (6) months prior to the execution of testing:

Complete brochure of proposed independent certified balancing firm, listing previous installations successfully balanced length of time in business, names and qualifications of employees who will be assigned to the project, and list of instruments, equipment and elapsed time schedule to be used on the project. Procedures and recording forms for testing and adjusting each system and each item of equipment. Documentation of instrumentation calibration including date of calibration

List of proposed instruments, meters and devices to be used for this project:

Outline of methods proposed for testing, adjusting and balancing.

The name and qualifications of the testing and commissioning Supervision

Employer's Representative who will certify the report, and the names and qualifications of all personnel who will be assigned to this project. Use of other personnel will be grounds for contract termination.

Submit the following within two (2) weeks of completion of testing and adjusting. Submit six (6) certified copies of each complete testing and adjustment report to the Engineer for review and send two (2) copies of the report to the Owner. The Contractor shall submit individual testing and adjustment reports for each individual air distribution system, each return and exhaust system, and each pumping system within two (2) weeks after completion of the testing and adjustment of each system

A listing of project references including project names, Supervision Employer's Representative, Contractor and Employer references with telephone numbers and contact persons.

Note:The Employer/Supervision Employer's Representative reserves the right to request an independent test and balance Specialist or Agency to be engaged by the Contractor if it feels the proposed Supervision Employer's Representative and Testing and Balancing Team personnel are lacking qualification and necessary instruments required for the intended job.

1.3 Work Included

A. Comply with section 15010 Mechanical General Provisions and all documents referred to therein.

B. Provide all labour, materials, products, equipment and services to test, adjust and balance all air and refrigerant systems to verify conformance to specified quantities and to the design intent of the mechanical system.

C. Make final adjustments to best suit building conditions prior to and immediately after Substantial Performance. Include overtime costs for conducting final balance in unoccupied hours.

For specified/ required test openings. Provide additional openings required for pivot tube traverses. After balancing, close openings with removable gasketted plugs.

Pressure testing of new piping and new duct systems.

Preliminary and final adjustment of all new water systems.

Preliminary and final adjustment of all new air systems.

Temporary pipe and duct connections, pipe caps, duct caps, tees, valves, dampers, etc.

Performance testing of all HVAC systems.

This section covers general duct, pipe and equipment testing. Additional specific equipment tests are conversed in individual sections.

Operation of mechanical systems as required for testing by other trades.

Provide data register as required.

Provide system report.

1.4 STANDARDS

Testing

SMACNA – 1983 Testing, Adjusting and Balancing.
ANSI/ASME B31.9 – 1982; Chapter VI Part 937.
ANSI/ASME B31.1 – 1986; Power Piping Code.
CIBSE Code C; Automatic Controls
Local Codes

Balancing

AABC 1989 National Standards; Air and Hydraulic.
BSRIA AG 2-89-2; Commissioning of Water Systems
CIBSE Code W 2003; Water Distribution Systems
NEBB 1983 Fourth Edition of the Procedural Standards for testing, adjusting and balancing of Environmental System.
SMACNA – 1983 Testing, Adjusting and Balancing
CIBSE Code A 1996; Air Distribution Commissioning

During the progress of the work, make tests as specified herein and 1 as required by authorities having jurisdiction, including local authorities' Inspection Department, Owner, Owner's Insuring Agency, or The Engineer .Tests shall be conducted by the Mechanical contractor as part of the work of this Division.

Include all qualified personnel, equipment apparatus, and services required to perform the tests.

Calibrate all instruments used for testing and adjusting within a period of six (6) months prior to testing and/or balancing. Certify instrument calibration as specified.

PART 2 – PRODUCTS

Supply and Turnover to Employer One (1) Complete Set of Testing and Balancing Instrument as Follows

Air balancing instrument – “Shortridge” air velometer set complete with measuring hoods and accessories similar to the following:
Air Data Multimeter model ADM-850 complete with Airflow Measuring base assembly, battery charger, carrying case.
Fire top kit (2”x2”, 2”x4”, 1”x5”, 3”x3”)
Pilot tube 18” long
Temprobe (ADT 442”)
Temperature netractile cord. 6’ long (TRC-16)
Temperature extension wand, 19” long (TEW-19)
Two A-303 static pressure tips.
Neoprene tubing set, two 5” long and one 10” long.

Self-Balanced Dampers (Constant Air Flow Regulators) and Grilles

In lieu of manual balancing dampers, self-balanced dampers or constant airflow regulators and grilles can be provided for certain applications subject Supervision Employer’s Representative approval. With airflow controlled at preset value, these dampers eliminate adjustments/balancing on site and greatly facilitate the task of the Balancing Contractor.

Pressure and Temperature Sensing Taps

Provide 15mm pressure and temperature test plugs on the entering and leaving piping at all heat exchangers and as indicated in the details on the drawings.

PART 3 – EXECUTION

3.1 Calibration of Testing Equipment

Calibrate equipment immediately prior to commencement of the work and check at regular intervals to ensure that calibration is maintained. Provide calibration certificate when requested by Supervision Employer’s Representative showing dates and method of calibration.

Verify permanently installed meters and devices by calculation and calibration or by independent measurement of the same flowing medium with calibrated devices.

3.2 Preparation Work

Before starting balancing, the Contractor shall make sure that each operation listed below, whichever is applicable, has been satisfactorily completed. Physical installation of air and piping systems as specified. Examine approved submittal data of system and equipment.

Examine design data, system descriptions, statement of design conditions and system output and philosophies about system and equipment controls.
Examine system and equipment installations to verify that they are completed and that commissioning specified have been performed.

Examine ACMV system and equipment installations to verify that indicated balancing devices such test ports, gauge cocks, thermometer wells, flow control devices, balancing valves and fittings, manual volume control dampers are properly installed and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

Provide a complete set of approved mechanical and electrical shop drawings to the balancing contractor.

Perform all tests required by Codes, Ordinances, and as specified herein, as well as demonstrations of operation for, all equipment. Each final test to be witnessed by the Owner or Owner's designated representative. Give a minimum of seven (7) days written notice before performing tests.

Install all temporary and permanent equipment and instruments required for tests, as well as additional thermometer wells, gauge and instrument connections, at no additional cost to the Owner.

Perform preliminary tests and repair all leaks before notifying the Owner of final tests.

Repair leaks, damage, or defects discovered during or resulting from tests or replace to a like new condition. Remove leaky pipe joints, ductwork, etc., and replace with acceptable materials. Retest systems repaired.

Maintain a logbook of all tests, preliminary and final, showing dates, personnel, observers' initials, description of tests, and test status. Provide updated log to Owner each month throughout the construction period. Initial log submitted to include listing of all anticipated tests.

Testing, balancing, and adjusting will not relieve the Contractor of the warranty requirements.

Furnish all fuel, water, and electricity required in performing the testing, balancing and adjustment of mechanical systems.

Clean all piping and ducts before testing.

Use calibrated test gauges with at least 41/2" (115mm) diameter dial. Gauge range not to be more than three (3) times test pressure.

Provide and demonstrate operation of all test equipment and apparatus required for the complete testing and inspection of all systems at such time and locations as may be directed by the Engineer and/or by the authorities having jurisdiction.

All tests shall be successfully completed and approved prior to the application of insulation and prior to the concealment of any portion of the system being tested.

Examine AHU equipment to ensure clean filters have been installed, bearings are greased both and both are aligned, and equipment with functioning controls are ready for operation.

Examine terminal units such as FCU's, etc to verify they are accessible and their controls are connected and functioning.

Examine strainers for clean screens and proper perforations.

Examine control valves for proper installation and for their intended function.

Examine equipment for installation and for properly operation safety interlocks and controls.

Examine heat transfer coils for correct piping connections.

Report deficiencies discovered before and during testing and balancing procedures.

Pressure and leak testing of air and piping systems as specified. All testing will be witnessed by the Supervision Employer's Representative.

Air plenum ceilings have been properly constructed and sealed.

Equipment is in operable condition, with all accessories installed.

Proper thermal overload protection is in place for electrical equipment.

Linkages and equipment have been serviced and lubricated and tested for proper operation.

Duct systems are clean of debris.

Final filters are clean of debris.

Coil fins have been cleaned and combed.

Fire and volume dampers are in place and open.

Refrigerant piping systems have been flushed and vacuum-dried.

Proper strainers are clean and in place.

Service and balance valves are open.

Temperature control systems are installed complete and operable.

Control valves and dampers are in proper working order and have been positioned for full flow through equipment.

Prime movers such as fans and pumps, have been operated, at specified loads and checked for misalignment, imbalance, excess vibration, improper rotation or motor overload. Correct all deficiencies prior to balancing.

Prepare procedures for of testing and balancing for all systems under Division 15.

Prepare procedures for balancing of all hydronic systems.

Prepare procedures for balancing of primary and secondary chilled water systems. (Not Applicable)

Pipework

Before covering or enclosing piping of various systems, all piping must be tested tight for 24 hours. The maximum test pressure not to exceed 3450 kPa. Tests may by witnessed by the Engineer if he so desires, and pronounced satisfactory before pressure is removed.

Note: Equipment must be valued off or removed during the test is the pressure rating of equipment is not as high as the test.

Mix water for each hydrostatic test with Nalco 2572 or approved equal to a ratio of 189 Litres of Nalco 2572 to 37,850 Litres of water, or a higher concentration if recommended by the chemical manufacturer. At least sixty (60) days prior to the start of hydrostatic leak testing submit a 600mm long length of the typical piping installed on the project to Nalco or another chemical manufacturer acceptable to the Owner, to determine the composition of the internal pipe coating. Provide injection pumps, water meters and coupon racks to control and monitor the concentration. After leak testing and a sufficient time period to allow the interior of the piping to be chemically coated to prevent rust formation, drain the piping system until empty.

Test piping within conduit prior to encasement of joints.

Hydrostatically test water piping at 1.5 times actual maximum working pressure

Ductwork

Maximum system leakage shall not exceed 5% of system design capacity. When testing individual segments of a total system, prorate allowable leakage as follows:

Maximum Leakage = (Surface Area of Test Section) x 0.027 x (system pressure Pascals) P0.65

Test recording form to include above calculation. When all sections of a system have been tested, submit confirmation that the sum of individual section surface area is equal to the total system surface area.

Pressure tests shall be performed with a test blower. Rig with orifice plate. Test ducts/casings with positive pressure on the discharge side of the system fan and under negative pressure on the suction side of the system fan. Include testing of flexible run outs.

During construction, individually test each completed riser, each completed horizontal distribution section and each filed erected casing/plenum, as required below.

Test ductwork as follows:

Low Pressure Ductwork (from -50mm to + 50mm H20 inclusive): H20

Exposed or accessible: Visual and audible check for leaks that can be heard or felt under normal operating conditions.

Concealed (i.e., within shafts and above sheetrock ceiling): Pressure test at 50mm H20 (pos. or neg. as required).
Medium Pressure Ductwork below -50mm and above +50mm H20: Pressure test at system pressure classification.

EQUIPMENT AND SYSTEMS

Take vibration and alignment field measurements on every pump, fan and chiller over 10 HP. Readings shall include shaft alignment equipment vibration, bearing housing vibration and foundation vibration. Building structure vibration shall be tested when directed by the Engineer. Readings shall be made using portable IRD (or as approved) equipment capable of filtering out various unwanted frequencies. Maximum vibration at any point listed above, or where specified, shall not exceed 2 mils on air handling units and individual fans, and 2 mils on pumps, unless other wise specified. Equipment manufacturers shall certify in writing that the field readings, which do not exceed the maximum specified, are acceptable to them.

Take sound level readings at locations in the building as selected by the Engineer. Take the readings on an Octave Band Analyzer in a manner acceptable to the Project Acoustical Consultant and/or the Engineer. Submit the test equipment data and reporting forms to the Engineer for review at least three (3) months prior to the field testing. In order to reduce the ambient noise level, take the readings at night. Perform all tests in the presence of the Owner, Project Acoustical Consultant, and / or the Engineer, of they so desire.

When each mechanical system is complete and functional, prove the capacity and performance of each item of equipment (i.e., fans, pumps, cooling towers, heat exchangers, etc.). Operate each item of equipment for a minimum of four (4) hours and record all associated operating data every 30 minutes (i.e., temperatures, flows, pressures, amps, volts, etc.). Verify all integral and external equipment controls and safeties are in proper working order. Complete system testing and demonstration to be done for both normal and emergency modes of operation. Owner or Owner's representative may witness final tests.

Demonstrate to Owner or Owner's representative, the proper operation of each control, monitor and alarm function of the building Management System, and/or control system, along with all software routines. These functions and routines will be demonstrated from the front. End and local panels under both normal and emergency power. Proper operation of battery backup and downloading of software from the front end to the remote microprocessor panels will be verified.

Provide operation of all mechanical equipment required for systems testing by other trades (i.e., fuel oil systems, smoke exhaust systems, etc.)

3.3 Procedures for Balancing of Air Systems

Initiate air balances by accurate fan capacity tests including for each fan, a pitot tube traverse, static pressure across fan, fan kW Bhp and RPM. Crosscheck each set of readings with manufacturer's fan curves. Take into account condition of filters and, if necessary, adjust fan speed to suit system design requirements.
Balance air systems with outside air dampers in their normal minimum operating position.
Operate fan systems for as long a time as will be necessary to test air flow from openings, make necessary damper and other adjustments until even distribution is obtained, throughout the various systems, with the air quantities required at each outlet or inlet as shown on the drawings. Make noise level measurements

for the operation of mechanical equipment selected by the Engineer in order to determine if the equipment produces excessive noise in occupied areas of the building.

Following this, perform the required number of distribution air balances and adjust in order to obtain required terminal airflows with plus/minus 5%. Perform at least one additional fan capacity test as described above, after the distribution balance has been completed.

Provide air flow measurements to assist in set-up of supply and return fan tracking controls.

Where similar or typical conditions exist, submit for review, simplified checking procedures for portions of the balancing work. These procedures may be accepted if proposed procedures do not decrease the quality of the air balance.

Before any air balance work is done, test the system for duct leakage, check for correct fan rotation and equipment vibration, check automatic dampers for proper operation, and verify that all fire dampers are open.

Fans to be adjusted to deliver above system requirements to compensate for duct leakage.

Preliminary adjustment may be made prior to completion of systems; however, final balancing must be done with all system completely installed and operating.

Traverse main supply air ducts, using a pilot tube and manometer. Calibrate the manometer to read two (2) significant figures in all velocity pressure ranges. A main duct defined as any of the following:

A duct serving five (5) or more outlets
A duct serving two (2) or more branch ducts.
All exhaust risers

The intent of this operation is to measure by traverse the total air quantity supplied by the fan and to verify the distribution of air to zones.

Submit data in support of all supply fans deliver by the following three (3) methods:

By summation of the air quantity readings at outlets.
By-duct traverses of main supply ducts.
By plotting revolutions per minute and static pressure readings on the fan curve. Air density corrections must be indicated.

For exhaust fans, the second and third methods listed above (b & c) can be omitted.

Inspect fan scrolls and remove objects or debris. Verify that all fire dampers are open and control dampers are in their proper position.

Record the following design requirements for fans and fan motors from the design drawings and reviewed shop drawings:

Manufacturer, model and size.
Air quantities – cubic feet per minute

Approximate fan speed – revolutions per minute.
Fan static pressure (total or external) – inches of water.
Outlet velocity – feet per minute.
Fan brake horsepower
Motor horsepower
Volts, hertz, amperes and service factor at design conditions.

Record the following data from fans and fan motors installed at the project:

Manufacturer, model and size
Motor horsepower, service factor and revolutions per minute.
Volts, hertz, full load amperes and service factor.
Motor starter and heater size.
Equipment location

Completely adjust fans and duct systems by the adjustment of sheaves, dampers, and other volume and diverting control devices, to obtain the air quantities indicated in the contract documents. Adjust final air quantities within 5% of the design requirements. Balance air outlet with air pattern as shown on the drawings.

Record the following test data for data for fans and fan motors installed at the project at final balanced conditions:

Fan speed – revolutions per minute.
Fan suction, discharge and total static pressure (external or total) – inches of water.
Static pressure drops across filters, dampers, coils washers and eliminators in the supply fan casings in inches of water.
Motor operating amperes and voltage per phase at operating conditions.
Fan cubic feet per minter as required above.
Calculated brake horsepower.

Prepare single line diagrams of duct systems indicating terminal outlets identified by number. List on data sheets all such outlets denoted by the same numbers, including the outlet size, "K" factor, location, litres per second and jet velocity. Submit this data for supply, and exhaust air systems.

The air-balancing subcontractor shall visit the project site as often as necessary prior to the start of balancing procedures to verify that the duct systems have been properly installed complete with all grilles, dampers, and ducts. The air balancing subcontractor shall submit a written report to the Engineer and Owner within one (1) week after each visit.

After the garage supply and exhaust, all smoke supply and exhaust, toilet exhaust, and other exhaust air systems have been installed complete with all ductwork, grilles, dampers, fans, and other items as hereinafter specified, make adjustments, as required to deliver the volumes of air at each inlet or outlet within 10% of design flow.

After all miscellaneous ventilation systems have been installed complete with all duct, grilles, louvers, dampers, fans, and other items as hereinafter specified, make adjustments, as required to deliver to volumes of air, or differential static pressures in the case of the pressurization fans, at each air inlet and/or outlet within 10% of design flow.

3.4 Testing Requirements

General

Carry out all commissioning and testing necessary for the safe, reliable and satisfactory operation of the system and equipment installed.

The Works shall be commissioned and tested in accordance with manufacturer's instructions, the appropriate ASHRAE commissioning codes, local Government requirements, and this Specification.

At least two month's prior to testing or commissioning any system, furnish the following information for each system or process to the Supervision Employer's Representative for review.

Testing procedure and details as well as the relevant report forms to the Supervision Employer's Representative for approval.

Type of instruments to be used

Manufacturer of instruments

Calibration methods for instruments

Operating instructions for instruments

Accuracy and tolerances of instruments

Complete schedule and programme of all testing and commissioning activities.

All instruments and labour necessary for testing and commissioning shall be provided by the Contractor.

All instruments shall have been recalibrated within six months of the start of commissioning or testing. Calibration of all instruments shall be certified by the instrument manufacturers or an approved calibration agency.

Should the results of any test show that any plant, system or equipment fails to perform to the efficiencies or duties as given in this Specification, the Contractor shall adjust, modify and if necessary replace the equipment without further payment in order that the required performances be obtained.

Should it be necessary for the Contractor to modify or replace any item of plant as described above, he shall be responsible for the cost for making good of any damage or deterioration to the building or other services consequent on such modifications.

Allow in the Contract Price cost for returning to site during the first year of operation from the date of Completion Certificate issued by the Supervision Employer's Representative to test systems under maximum design conditions. Be aware that such tests may need to be carried out after normal office hours as required by the Employer.
All equipment sites testing and commissioning shall be carried out by manufacturer's qualified field Supervision Employer's Representative.

Factory Tests

1. The following items of equipment shall be tested at the manufacturer's works or elsewhere as appropriate prior to installation. In all cases, test certificates shall be submitted in triplicate.

   a. Fan

      1) `Type-test' Certificates showing fan characteristic curves, and Type Test Certificates for sound power levels.

   b. Pumps

      1) 'Type-test' Certificates for head discharge, speed and power input.

   c. Electric Motors

      1) `Type-test' Certificates. For motors of 40 kW output and above, routine individual test certificates shall also be submitted.

   d. Starters and Control Gear

      1) 'Type-test' Certificates. For control panels as a whole, routine (individual) high voltage test.

Cooling Towers (Not Applicable)

Cooling towers shall be type-tested to the published water cooling capability or performance before the towers are delivered to site. The whole test procedure shall conform to that as laid out by the Cooling Tower Institute, Palo Alto, California, United States of America (hereafter referred to as CTI) and/or Japan Cooling Tower Institute, the relevant ASME or JIS standards.

All instruments, test equipment and consumable materials, and expenses incurred including certification by an independent authority shall be included in the Contract.

The more important measurements required shall be: Wet Bulb temperature, cold/hot water temperature, circulating / makeup / blow-down water flow rate, tower pumping head, fan driver power input, and noise levels.

Any tower found not up to performance shall be rejected and the Contractor shall provide additional features to enhance its performance at his own expense before another acceptance test shall be carried out. Failing which the Contractor shall replace the equipment with other brands complying to the above requirements.

Air Handling Equipment and DX Air-Conditioning Units

Manufacturer's standard 'Type-test' certificates shall be submitted.

Hydrostatic or pressure testing certificate for each equipment shall be submitted.

Factory Hydrostatic or Pressure Tests

1) Each of the following equipment shall be individually tested to at least 1.5 times of the maximum anticipated system working pressure.

All cooling coils
Pumps
Cooling towers
Water-cooled packaged units

Switchboard and Electrical Equipment

1) All 'Type-test' certificates as specified in the Division 16 of this Specification shall be submitted.

Factory Witness Test

Performance test to ARI standard for a typical air-cooled chiller shall be conducted in the manufacture factory or testing facilities. This performance test shall be witnessed by representatives of the Supervision Employer's Representative and Employer and all cost (including travelling and hotel accommodation cost) shall be included in the Contract price.

Site Testing

Execution of Tests

The plant shall be inspected and tested during and after installation on site as set out below for compliance with the performances, and ratings as specified.

All tests shall be witnessed by Supervision Employer's Representative at site with at least seven days' notice given prior to any test.

All tests shall be executed and, if not satisfactory, repeated to the satisfaction of the Supervision Employer's Representative at no extra cost.
All DX/VRV system shall be commissioned and tested to the recommendation of the manufacturers.

Preliminary Commissioning Check

Ensure that all equipment included under this Contract is thoroughly cleaned, lubricated and checked for serviceability immediately before setting to work. Particular attention is drawn to the removal of building debris from the air systems, motors, fan bearings and pipework.

All pipework shall be thoroughly flushed and chemically cleaned to ensure that all foreign matter is removed and internal surfaces are degreased. During all preliminary flushing, plant shall be isolated by means of bypasses to avoid dead-legs, and the systems shall be completely isolated from any existing systems to ensure contamination cannot occur.

Further flushing and chemical treatment shall be carried out on isolated systems by connection of temporary diesel driven pumps to circulate water and dosing chemicals. Allow for cross-connection of flow and return pipework at the extremities.

All automatic controls and safety devices shall be inspected and checked for serviceability before the working fluid or electricity is applied to the system.

All ductwork shall be thoroughly cleaned internally. Temporary filter shall be installed.

Air Handling Equipment & Ductwork

All the commissioning procedures shall comply with those set out in the current edition of the ASHRAE Standard or CIBSE Guide Commissioning Code Series A or DW/143 standards.

Allow for balancing all air diffusers and grilles by means of the regulating dampers provided. Air quantities shall be set to within +5% - 0% of the design value.

The following data shall be recorded on the commissioning sheets:

On coil and off coil dry and wet bulb temperatures

Dry and wet bulb temperatures within each occupied space, at various locations within same space as required

Temperatures at each main supply and return air duct

Fresh air supply flow rate to each air handling unit

Air flow, total fan head, and resistance across each main plant item, e.g. filter, cooling coil, silencers, etc.

Air flow at each supply and exhaust duct, and at each supply, return and exhaust air grille and diffuser.

All fan and motor speeds.
Starting and operating current for each motor.

Noise and vibration levels in plantroom and occupied space.

The following ductwork system shall be tested for leakage rate in accordance with:

ASHRAE SMACNA requirements: (Where applicable)
All VAV and AHU system ductwork
All medium and high velocity ductwork

All smoke extraction system and pressurisation system ductwork:

Perform all tests as specified herein and in accordance with the procedures and rest criteria established by the local authorities having jurisdiction. The mechanical, fire protection, fire alarm, electrical, controls subcontractors and the General Contractor shall be present and participate during the entire testing procedures.
The Mechanical Contractor shall include all costs associated with the required demonstration tests, including smoke bombs, instrumentation, etc.

Test the stairway pressurization systems after the stair shaft way has been checked for leaks, crakes, door seal function, etc. activate smoke bombs in the stairway to verify tightness of enclosure. The maximum differential pressure at any point between the stairway and building not to exceed 50 Pa with all doors closed. The minimum differential pressure at any point between the stairway and the building is not to be less than 38 Pa with all doors closed. The pressurization system shall provide a minimum air velocity of 1.52 m/s through the open door farthest from the pressurization source, with three other open doors at the center of the shaft.

All kitchen and fume exhaust system ductwork

All smoke extract and control system ductwork:

Verify and record that the quantity of air indicated on the drawings is exhausted at the smoke removal inlet; verify and record the quantity of air flowing through the exhaust fan. Test shall demonstrate the proper sequence of the fire safety ventilation systems, the activation of the smoke detection system, smoke exhaust system, operation of smoke dampers and fire/smoke dampers and makeup air from the outside air and stairwell systems. Performance test the smoke management systems installed in this project in accordance with the requirements of the authorities having jurisdiction and the Fire Department. Conduct the demonstration tests and repeat until they are accepted and approved by the authorities having jurisdiction.

Pipe and Water Systems

All the commissioning procedures shall comply with those set out in the current edition of the ASHRAE Standard or CIBSE Guide commissioning Code Series W.

All water pipework, coils and other fittings shall be hydraulically tested to 1.5 times the maximum anticipated working pressure but in no case less than 14 bar. The pressure shall be maintained for a period not less than 8 hours within ±2%

Where any section of pipework or equipment of the plant is unable to withstand the maximum pipework test pressure, it shall be isolated during the pipework tests, then, that section of pipework or equipment shall be re-tested at the appropriate test pressure.

Before finally charging, the chilled and condenser water systems shall be thoroughly flushed and all strainers, filters, etc. cleaned.

All chilled and condenser water systems shall be adjusted and balanced for the correct duty by the regulation valves provided.

The following data shall be recorded on the commissioning sheets:

Circulation pump motor speed

Suction and discharge heads for all the pumps, and flow rates as checked against pump curves.

Water flow rates in main branches and through major equipment

Supply and return water temperatures of each water coil

Starting and operating current of each pump motor

Water pressure drop across each item of hydraulic equipment, e.g. cooling coils, control valves, strainers, etc.

Noise and vibration level of pumps

Control System

Include all thermostatic and automatic controls to be commissioned and tested by the control manufacturers Supervision Employer's Representative. Generally, the commissioning procedures shall comply with that set out in the current edition of ASHRAE Standards or the CIBSE Guide Commissioning Code Series C.

Calibrate all thermostats, humidistat and pressure-stats, set the modulating range and set points on all automatic valves and dampers as required to ensure that operating conditions are correct. The time and control sequence shall also be tested and verified.

Interlocking circuit and safety devices shall be tested to ensure safety operation of the plant.

Other site tests as specified in the Control Section of this Specification shall also be performed.

Electrical Test

After erection of the switchboard on site, the following tests shall be performed in the presence of the Supervision Employer's Representative.

Inspection of switchboard including wiring, electrical and mechanical connection

Mechanical Test

Continuity and dielectric tests

Power frequency pressure test

Functional checks

Earth electrode resistance test

Primary and secondary injection tests, commission and calibrate all measuring, protection and control circuits and associated components.

On completion of the above tests, commission the switchboard on no-load and perform the following tests:

- Voltage test for phase to phase and phase to neutral
- Phase sequence tests on every outgoing circuits

The following tests shall be carried out in full compliance with the IEE Regulations by the Contractor in the presence of the Supervision Employer's Representative:

- Insulation resistance test of all power and control cables
- Insulation resistance test of all motor windings
- Test of conductor continuity

- Test of effectiveness of earthing
- All thermal overload relays and starters
- Sequence of operation
- Flick test of motors

All other site tests as specified in Division 16 of this Specification or as required by relevant local authorities shall also be carried out.

Cooling Towers

The following shall be checked / tested on site:

Full load and free cooling capacity
External ambient dry bulb and wet bulb temperatures
Condenser water in / out temperature and flow rates
Fan speed and full load current
Noise level and vibration level at location agreed with the engineer.
Fan speed

Miscellaneous Measurement and Testing

Room temperature, humidity and noise level (at each octave band mid-frequency from 63Hz to 8,000Hz) shall be measured to ensure design conditions are achieved. Measuring instruments shall be located 1500 above floor level at points away from the influence of draughts or hot or cold surfaces. Such measurements shall not be carried out when weather or other environmental conditions are likely to cause undue influence to the results.

Sound and vibration testing shall be carried out to ensure that equipment are operating within the specified maximum sound and vibration levels and that there is no transmission of objectionable vibration or through the building structure. Sound levels shall be measured with and without the plant in operation.

Final Adjustments and Commissioning

When the entire installation works are completed and all the above checking and testing have been properly carried out, the Contractor shall set to work, regulate and calibrate the entire installation. Particular attention shall be paid to the following:

All valves, traps, dampers, switches, controls, etc. are regulated to operate properly in accordance with the specified performance. All valves shall be able to be shut off totally at the maximum anticipated system working pressure.

All equipment are silent and meeting the specified noise and vibration levels.

All instruments are correctly calibrated and read accurately.

All air-handling and ventilation plants are operated properly and are able to deliver the correct air-flow rate to each individual space.

All control systems are functioning correctly and are properly sequenced, interlocked, and interfaced with other services.

All major plant to be fully commissioned by the respective Manufacturer's qualified field testing and commissioning Supervision Employer's Representative.

Be aware that the commissioning may need to be carried out after the Completion Certificate is issued and after normally office hours, as required by the Employer.

Handing Over

The following procedure shall be adopted prior to handing over the installation:

All preliminary testing, checking, adjusting and balancing of the installation shall be carried out before forwarding notification that the installation is considered to have reached Practical Completion.

After inspection by the Supervision Employer's Representative, the plant shall be finally commissioned and Installation prior to handover to the Employer. Manuals together with as-built drawings shall be provided as specified.

Completion Certificate will be issued only after the plant has been inspected and approved and the above requirements fulfilled.

PART 4 – REPORTS

Submit progress reports at least three times during the work upon Supervision Employer's Representative request. Include preliminary recommendations, and advise Supervision Employer's Representative of any situation which may adversely affect end result of balancing.

Demonstrate to the Engineer and Owner, prior to acceptance by the Owner, that all systems and/or equipment have been balanced and adjusted properly, and that the system and/or equipment comply with the Contractor Documents.

Submit four copies of the final typewritten report at the completion of the work. Print reports on letter quality paper and enclose each in hard cover binders.

Include the following in each report:

Cover sheet identifying project name, address, Employer name, Contractor name(s).

Balancing company, address, name of balancing technician(s), date and time of test, description of test equipment and ambient conditions at time of test.

Complete equipment identification data and location, including manufacturer and model, size, arrangement, discharge, class, motor type, kW, voltage, phase, frequency and FLA, belt size/model number and sheave size.

Suction and discharge pressure gauge readings and water flow rate (l/s) for each pump.

Pump curve for each pump showing plotted design conditions, and field conditions.

Air on and off temperatures and pressure drops at each major piece of equipment such as cooling coils.

Detailed summary of velocity traverses and calculated air quantities for each fan.

Actual fan and system curves for each fan showing plotted design and field condition.

Static pressure readings across filter bank, coil banks of each air handling system, showing design and actual readings.

Measured suction, discharge and total static pressure for each fan using pitot tube measurement.

Summary showing design and actual air quantity from each low pressure outlet complete with description of the method used to obtain same upon request. Submit area factors and velocity correction factors for all outlets, diffusers, registers and grilles for Supervision Employer's Representative review prior to first balance and include in report submissions.

Summary showing inlet static pressure and l/s capacity of each variable constant air terminal control unit under simulated maximum and minimum conditions as previously described.

Temperatures of outside air return air, mixed air, air off cooling coils and terminal supply air for each air handling system.

Rated and actual motor current, in amperes, of every motor at full load conditions.
Schematics for all systems with all terminals identified.

Provide separate test forms for each air and water system.

Submit with the report, a summary listing of recommendations for Supervision Employer's Representative review

Certify all reports by the Balancing Supervision Employer's Representative and balancing technician before submitting for Supervision Employer's Representative review.

ATTACHMENT – A

Contents of Mechanical Completion Checklist

CONTRACTOR shall develop Mechanical Completion Checklists for the following INSTALLATIONS, as a minimum. The checklists shall be suitable for the particular INSTALLATION and subject to acceptance by THE ENGINEER.

General Procedure (All Equipment)
Concrete Pouring Release
Structures
Buildings (2 Sheets)
Civil
Tanks and Vessels
Internals of Tanks and Vessels
Insulation release
Pumps
Compressors, Expanders, Turbines
Air Fin Coolers
Exchangers
Lifting Equipment
Miscellaneous Equipment

Underground Piping
Above ground Piping
Instruments
Relief Valves
Safety Equipment
Fire and Gas Detection Equipment
Underground High Voltage Cable
Switchgear and Transformers
Grounding, Lightning Arrestors, Battery Chargers and Bus Ducts
Low Voltage Wiring
Motors
Conduit and cable trays
Cement Fireproofing

Mechanical Completion Inspection Forms

CONTRACTOR shall develop Mechanical Completion Inspection Forms for the following equipment and installations. The forms shall be suitable for particular installation and subject to acceptance by THE ENGINEER.

Mechanical completion checklist (responsibilities) - Sample

ITEM NO.	ACTIVITY	RESPONSIBILITIES	
		CONTRACTOR	Engineer
1.0	GENERAL PROCEDURES (ALL EQUIPMENT)	X	I
1.1	Install equipment in accordance with P&IDs, approved drawings and project specs	X	I
1.2	Check that equipment name plate data are in accordance with technical data sheet	X	I
1.3	Remove temporary supports, bracing, etc. that were installed to prevent damage during transit, storage and erection	X	I
1.4	Mark equipment with owner's equipment number which is legible from 15 meters, for instruments, from 5 meters	X	I
1.5	Remove rust preventatives	X	I
1.6	Install lubricants per manufacturer's recommendation. Provide lubrication list	X	W
1.7	Install thermal insulation per project specs	X	I
1.8	Paint per project specs	X	I
1.9	Clean area of scaffolding, tools and debris	X	I
1.10	Obtain vendor representatives for technical assistance as required	X	R

LEGEND:

I = Inspect
R = Review
W = Witness
X = Perform Work

ATTACHMENT B

Contents of Ready for Commissioning Checklist

CONTRACTOR shall prepare ready for Commissioning Checklists for all INSTALLATIONS. The checklists shall be suitable for the particular INSTALLATION and subject to acceptance by THE ENGINEER

1.2.1 General (Checklist)

1.2.2 Instruments and Control (Checklist)

Instruments
Relief Valves
System Control Panel

1. 2.3 Piping (Checklist)

Under Ground Piping
Above Ground Piping

1.2.4 Mechanical Process Equipment (Checklist)

Tanks
Pressure Vessels and Drums
Internals of Tanks, Drums and Vessels
Exchangers
Air Cooled Exchangers

Rotating Equipment (Checklist)

Centrifugal Compressor
Centrifugal Pump

Safety System (Checklist)

Fire and Gas Detection and Protection Equipment
Safety System Equipment

Miscellaneous (Checklist)

Heating, Ventilation and Air Conditioning

Commissioning Checklist (Responsibilities)

Responsibilities of the Contractor and the Engineer after Mechanical Completion

Work Permits are required for activities authorized by The Engineer. This checklist assumes that all CONTRACTOR construction activities have been completed (Refer to Mechanical Completion Checklist)

	To be arranged and/or provided by

		Contractor	
A	General Procedures		
1.	Planning/Scheduling		
	- Commissioning planning	X	
	- Maintenance planning	X	
	- Start-up planning	X	
2.	Tightness Tests		
	- Conduct all operational tightness	X	
	- Repair any leaks	X	
3.	Inspection		
	- Arrange for any special pre-start-up inspections such as required by insurance or governmental agencies.	X	
	- Provide and remove scaffolding upon completion of commissioning.	X	
4.	Operating Supplies and Chemicals		
	-Install in equipment as required all chemicals and inert packing materials (CONTRACTOR to provide labour + temporary equipment).	X	
5.	Lubricants		
	-Maintain lubrication after initial charge	X	
6.	Rotation and Alignment		
	-Operate equipment for test	X	
	-Make vibration checks (uncoupled and coupled), trip checks, governor checks, safety device tests and adjustments as required.	X	
	-Perform hot alignment and any doweling required.	X	
7.	Packing and Seals		
	-Make adjustments and replacements to mechanical seal, packing and accessories.	X	
8.	-Flushing, Blowing and Chemical Cleaning (insofar as not executed prior to Mechanical Completion		
	-Turn system over to the ENGINEER free of construction debris (including mechanical cleaning)	X	
	-Operate equipment where required for testing	X	
9.	Temporary Screens, Strainers and Blinds		
	-Provide, install and clean strainers as required during flushing operations/run-in and remove if warranted	X	
	-Install and remove all blinds required for flushing/run-ins and other operations	X	
	-Maintain a record of blinds installed	X	
10.	Purging		
	-Install temporary start-up purge connections if required.	X	
11.	Maintenance		
	-Provide routing maintenance for equipment, including cleaning of strainers (normal wear	X	

		To be arranged and/or provided by	
		Contractor	
	and tear).		
	-Provide breakdown maintenance CONTRACTOR to arrange VENDOR support and spare parts.	X	
B.	Specific Procedures		
1.	Instrument Systems / Telecom / Information Techno-logy		
	-Install orifice plates after completion	X	
	-Isolate or remove in-line components for flushing	X	
	-Operations and reinstall them on the completion of such operations.	X	
	-Confirm adequacy of system/VDU display configuration and make necessary adjustments.	X	
2.	Piping		
	-Check pipe hangers, supports, guides and pipe specialties for hot/cold settings and make the necessary adjustments.	X	
	-Check and record position of all locked valves	X	
3.	Vessels , Tanks		
	-Final inspection and boxing-up (CONTRACTOR to provide labor and temporary equipment)	X	
4.	Pumps, Compressors and Turbine Drivers (see also DGS-MU-011)		
	-Clean seal oil and lube oil systems as specified (if not executed prior to Mechanical Completion).	X	
	-Charging of the seal oil and lube oil systems including bearing housings.	X	
	-Circulate for cleaning purpose seal oil, lube oil and cooling systems.	X	
	-Provide assistance from the VENDOR's service engineer for start-up	X	
	-Make vibration tests when driver is coupled	X	
	-Operation of compressors, pumps and turbines to carry out tests if process and mechanically practical in the commissioning mode	X	
5.	Water Systems (Cooling Water, Firewater, Freshwater Systems etc.)		
	-Flush, drain and clear (if not executed prior to Commissioning.	X	
	-Clean permanent screens/filters	X	
	-Operate fire pumps for simulation run.	X	
	-Fill reservoirs, tanks, etc.	X	
	-Install all moveable fire protection equipment such as hoses, fire extinguishers and related equipment.	X	
	-Establish water treating program	X	

		To be arranged and/or provided by	
		Contractor	
	-Operating test (functional test of spray systems; checking flow rate; distribution functional test of fire water main flow and pressure drop).	X	
6.	Waste Treatment		
	-Operating test. CONTRACTOR to arrange VENDOR support	X	
7.	Building Accessories		
	-Test heating, ventilating and air-conditioning units and make all adjustment	X	
8.	Electrical Power and Lighting Systems		
	-Provide THE ENGINEER with all completed inspection/test forms (refer to Field commissioning of Electrical Installation and Equipment, DGS-EU-020)	X	
	-Provide THE ENGINEER with local Authority approvals.	X	
	-System acceptance of PRE-COMMISSIONING inspection/test forms	X	
	-Energize the Electrical system check phasing, interlocks and auto-changeover.	X	
9.	Security Systems		

ATTACHMENT C

Contents of Ready for Start Up Checklist

CONTRACTOR shall prepare ready for Start Up Checklists for all INSTALLATIONS. The checklists shall be suitable for the particular INSTALLATION and subject to acceptance by THE ENGINEER.

1.3.1 General (Checklist)

1.3.2 Electrical (Checklist)

General
Switchgear
Transformer
Earthing
Motors
Batteries and Battery Charger
Cable and Cable Trays
Distribution Board and Lighting
Motor Control Center
Generators
Motor Operated Valves
Uninterrupted Power Supply System (U.P.S)

1.3.3 Instruments and Control (Checklist)

Instruments

Relief Valves
System Control Panel

1.3.4 Piping (Checklist)

Under Ground Piping
Above Ground Piping

1.3.5 Mechanical Process Equipment (Checklist)

Tanks
Pressure Vessels and Drums
Internals of Tanks, Drums and Vessels
Exchangers
Air Cooled Exchangers

1.3.6 Rotating Equipment (Checklist)

Centrifugal Compressor
Centrifugal Pump

1.3.7 Safety System (Checklist)

Fire and Gas Detection and Protection Equipment
Safety System Equipment

1.3.8 Miscellaneous (Checklist)

Heating, Ventilation and Air Conditioning
Cathodic Protection

ATTACHMENT D

Contents of Test Run Procedure

CONTRACTOR shall prepare for the entire INSTALLATION a TEST RUN procedure which shall be agreed upon CONTRACTOR and ENGINEER. The procedure shall, as a minimum, cover the following:

1.4.1 Agreement with THE ENGINEER regarding location and frequency of measurements and samples to be taken during TEST RUN to verify all process warranties and systems.

Agreement with THE ENGINEER regarding procedures for:

Data collection
Calculating results
Average results from charts, analysis and samples
Instrument calibration
Independent tests on equipment which cannot be operated at capacity during TEST RUN
Interpretation of TEST RUN results if feed varies from specification
Completion of TEST RUN if it is interrupted
Remedies if the TEST RUN is unsuccessful

1.4.2 Availability of:

Product (sewage and water)
Product storage
Manpower
Representatives of CONTRACTOR and SUBCONTRACTOR(S) including Licensors and SUPPLIERS/VENDORS
Spare parts
Calibrated measuring equipment
Laboratory staff and equipment
Operating log sheets for data collection

Verification that:

Punch list items are cleared
Blinds removed
Car seals installed
Final alignments performed
Rotating Equipment dowelled
Vibration check completed
Noise survey completed

END OF SECTION-15995