SECTION 4

Chilled Water Installation

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DIVISION 15

MECHANICAL WORKS

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CHILLED WATER INSTALLATION

4.01 GENERAL

The chilled water installation shall comprise the complete installation as depicted on the Drawings. It shall be commissioned in accordance with the manufacturers code of requirements and C.I.B.S.E. Commissioning Code and handed over in a fully reliable working condition.

4.02 CHILLED WATER PLANT

The central chilled water plant shall include two air cooled packaged water chillers located external at site.

The chillers shall be installed in positions as shown on drawing and arranged such that adequate air is circulated for proper heat rejection.

In order to reduce the transmission of vibration, each chiller shall be mounted on spring anti vibration mounts selected for a minimum static deflection of 50mm. The contractor shall also count for the compatibility of the multiple mountings systems of all other chillers..

Each chiller shall be provided with a constant flow primary pumps. The primary circulating chilled water pumps shall be of direct driven type. Each pump shall be interlocked with its respective chiller.

The primary chilled water pumps shall deliver water at supply temperature = 7° and return temperature = 13° and controlled to maintain a supply flow that exceed the total secondary chilled water flow.

The primary chilled water pipes shall feed the main feeding low pressure loss header. The header shall feed the various A.H.U. Plant and fan coil units secondary chilled water pumps.

A low loss pressure header shall be installed in the primary circuit for connection of secondary circuits. The primary and secondary chilled water temperatures have been selected to ensure that the primary flow exceed the secondary flows.

Primary pumps operations shall be under the control of the total secondary circuits flow meters, such that to maintain continuous excess of primary water flow to secondary water flow. The primary chilled water pumps shall be mounted on inertia bases fitted with spring antivibration mountings.

4.02 CHILLED WATER PLANT (CONT'D)

Closed type expansion tank set shall be provided to maintain the system pressure and supply makeup water for the whole chilled water system.

The secondary chilled water system are splitted and categorized into two independent circuits :-

1- Circuit I

This circuit is to serve all air handling units.

A Package of three variable speed secondary chilled water pumps (two duty and one standby) shall be installed to serve all units. Each pump is capable to deliver 50% of the total design capacity of all air handling units. This was considered taking in considerations the geometry of the building, the diversity of occupations and lighting considerations. A by pass connection with a differential pressure valve shall be fitted between the supply and return pipe. This is to allow for a minimal permissible by pass flow of the pumps. The estimated by pass flow as per one of the pumps manufacturers is 10%, the contractor shall check with the pump manufacturer the need to install the bypass connection.

The flow temperature shall be	7 C .
The return temperature shall be	14 C .

The secondary pumps shall be under the control of the multiple secondary differential pressures sensors, which shall be installed at 70% of the total distance from the pump and the most remote AHUs. At least two different differential pressure sensors shall be installed for this circuit at different zones. Pump flow control shall modulate the speed based on the maximum demanding zones

2. Circuit II

This circuit is to serve all fan coil units.

A package of two variable speed secondary chilled water pumps (one duty and one standby) shall be installed to serve all units. Each pump is capable to deliver 100% of the total design capacity of all the fan coil units. This was considered taking in considerations the geometry of the building, the diversity of occupations and lighting considerations.

A by pass connection with a differential pressure valve shall be fitted between the supply and return pipe. This is to allow for a minimal permissible by pass flow of the pumps.

An injection circuit shall be fitted to increase the flow temperature of this circuit in order to reduce the formation of fan coil units condensations.

The secondary chilled water circuit will serve the two port valves of the fan coil units .

4.02 CHILLED WATER PLANT (CONT'D)

The flow temperature shall be 9 ºC .
The return temperature shall be 14ºC .

The secondary pumps shall be under the control of the secondary differential pressures sensors, which shall be installed at 70% of the total distance from the pump and the most remote FCUs. At least two different differential pressure sensors shall be installed for this circuit at different zones. Pump flow control shall modulate the speed based on the maximum demanding zones

4.03 CHILLERS

The design, construction, materials and finishes of all units shall be suitable for outdoor use in the locations, climatic and operating conditions indicated in this specification and drawings. The units shall be started on site by the Manufacturer's qualified technical staff.

The size of the chiller plant shall be such that it can brought into the position and sufficient space for access and manufacturers recommendations space for serving shall be maintained

The units shall be packaged and fully factory assembled complete with operating and safety controls and all customary auxiliaries deemed necessary by the manufacturer for the safe, controlled automatic operations of the equipment.

Manufacturer shall provide efficiency of their equipment per each refrigerant along with a list showing all requirements needed to replace the R22 by 134a.

Compressors shall be of screw rotary serviceable construction serviceable hermetic construction oil separator system with filter(s), drier(s), crank case heater(s), suction and discharge valves and all necessary auxiliaries, copper flexible connector to be fitted at the discharge of the compressor.

The Compressor shall have automatic capacity control equipment which will have a multi stage capacity. The compressor shall not be enabled to start unless in the fully unloaded condition.

The lubrication system shall be arranged by using a flanged oil separator ensure adequate oil level switch at all bearings as the compressor starts. A replaceable or cleanable filter shall be positioned within compressor.

A device shall be fitted to prevent the pressure differential across the compressor causing backward rotation at a normal or emergency stop by check valve.

Each compressor shall be provided with the following ancillary equipment items fully connected:-

4.03 CHILLERS CONT'D)

- Service stop valves on refrigerant suction and drop.

- Suction and discharge refrigerant pressure gas glycerin filled, minimum 50mm diameter with pressure and saturation temperature scales in bar and °C oil reservoir level sight glass.
- Oil pressure gage 50mm Diam. With isolating device.

- Low pressure switch or flow switch

- Light oil temperature cut-out with hand reset.

- Refrigerant suction gas strainer.

- The machine shall be fitted with anti recycle timer and all other safety devices necessary for operation in a totally fail safe manner, All devices shall be pre-set by manufacturer at works.

  Compressor units shall be suitable for continuous and automatic operation and be free of vibration. Noise level restrictions are shown on the Equipment Data Sheet. A full noise spectrum shall be provided.

a) Controls

The operating and safety controls shall include:

1. Motor temperature winding (Inherent motor protector) protection by embedded ambient insensitive solid state sensor and discharge gas temperature sensor for each motor to open all three phases in the event of overloading on any one phase,

2. High and low refrigerant pressure safety devices.

3. Neciprocating.

4. Antishort cycling timer,

5. Crank case heater control.

6. Chilled water safety thermostat (antifreeze protaction). By Microprocesser.

7. Flow Switch interlock.

8. A command control micro processor which shall be built-in each chiller and shall control capacity cycling of the compressors and unloaders to satisfy the dictates of a leaving water temperature sensor and a return water temperature compensation sensor. All sensors shall be of the thermistor type providing inputs to the micro processor. The micro processor shall recycle the capacity control to the unloaded condition following plant shut down. The microprocessor controller shall afford simple interface with other control systems such as BMS .

4.03 CHILLERS (CONT'D)

The microprocessor shall be capable to perform self diagnosis of the chiller and shall report the fault on a built-in LCD .

9. Fan cycling head pressure control,
10. Automatic pump down control on shut down, of chiller.
11. Sequence selection switch for compressor operation (manual).
12. Abnormal conditions alarm lights.
13. Controlled pull down limits for compressor loading on start up, (Reduced starting load part winding motor or star delta starting).
14. Hours Run Meter.
15. Remote Start Stop Control.
16. Common Alarm Volt Free Control.

A weatherproof and dust tight housing shall be provided with lockable tight sealed door(s) all factory wired controls and instrumentation that will be IP55 rating. The chiller will be equiped with pressure and temperature gauges for refrigerant, field power and control circuit terminal blocks, circuit breakers, motor starter control relays and disconnect switches.

b) Motor Starting

1. The motor starting equipment shall limit the starting current of each motor/compressor unit to 2 ½- 3 times the full load running current,
2. With multi compressor units each compressor must run up to its full speed before the next compressor can start,
3. Compressor starts shall be limited to (6) per hour,
4. Starters shall incorporate thermal overload devices on each phase with single phasing protection,
5. The units shall be capable of starting under all ambient and water temperature conditions likely to occur.
6. Compressors shall be part winding started .

c) Evaporator

The evaporator shall be of the direct expansion shell and tube design with removable heads and multi refrigerant circuits one circuit per each compressor Constructed to ASME and tested to a pressure of 1030 K.P.A. water side and 1800 K.P.A. refrigerant side with a water side fouling factor of 0.00009 m2 dec. C/W.

4.03 CHILLERS (CONT'D)

Construction shall be seamless copper tubes expanded into tube sheets.

The evaporator shell shall be insulated to a minimum thickness of 38 mm: (K=0.28 w/m °C) with closed cell insulation suitably protected against weather and mechanical damage.

Gland type drain valve with hose union connection shall be provided.

d) Air Cooled Condenser

Air cooled condenser coil(s) shall be of non ferrous construction with fins mechanically bonded to tube to ASME U I standards.

Coils shall be constructed of seamless copper tubes with aluminum fins having a maximum of 470 fins/meter.

Sub cooling circuits and liquid accumulators shall be provided where required.

Provision for purging non condensable shall be made.

Fans shall be direct or belt driven propeller type, statically and dynamically balanced having permanently lubricated ball bearings. Fans shall be aluminum or zinc plated steel with zinc plated steel hubs and the motors shall have inherent over current protection.

Motors shall be weatherproof and protected and all bearings shall be capable of operating in dust laden atmosphere.

All motors shall be selected with service factor to N.E.M.A. standards.

Fans shall be fitted for low noise levels.

Coil(s) and fans shall be fitted with protective safety guards.

All fan/motor assemblies shall be mounted on vibration isolators.

The condenser and sub cooler shall be factory leak tested under water to 1034 k.p.a and pressure test to 3100 k.p.a.

e) Casing

The shassies shall be constructed from 6 mm. thickness weld steel chassies.

Panels and access doors shall be constructed from 2.0 mm. galvanized sheet steel, bonderised and given a special tropicalised (epoxy) heat reflecting, corrosion resistant finish to withstand the climatic temperature, humidity and atmospheric dust conditions indicated in this Specification to provide a fully weatherproof enclosure for components.

4.03 CHILLERS (CONT'D)

Coil panels, safety guards and where necessary top panels shall be removable for inspection.

Coil shall be robust in construction and shall not flex or vibrate during operating of fans and compressors.

Lifting eyes or facilities for lifting tubes in base frames and sling spreaders if necessary shall be provided to avoid damaging the equipment during Site lifting activities.

Each Chiller shall also incorporate the following :-
Oil Pressure Gages.
Refrigerant Pressure Gages.
Compressor Isolating Valves
Condenser Coil Wind Baffles
Compressor Muffler.
Condenser Coil Protection Guards
Corrosion Resistant Coated Coils.
Low Noise / High pressure Condenser Fans. 750 RPM.
Compressor Attenuating Enclosures.
Power Supply Isolator.

f) Noise & Vibration

Based on the selected chillers the sound reduction shall be to the following criteria :-

Frequency (HZ)	63	125	250	500	1000	2000	4000	8000
Estimated Chiller transmission	99	96	97	97	95	91	87	81
Sound Reduction Indices	5	5	7	12	18	21	16	16

To reduce noise levels at source the chillers shall be fitted with low noise, high efficiency fan and compressors shall be enclosed in acoustic housings. To reduce the noise each chiller shall be mounted on spring anti vibration mounts selected for a minimum static deflection of 50mm. If individual compressors are also mounted on springs the compatibility of the two mounting systems shall be verified.

A complete and detailed analysis shall be carried out by the contractor, taking in consideration the adjacent buildings and the close guest rooms.

4.04 CHILLERS PLANT CONTROLLER

The chiller plant shall include a central microcomputer controller to control and optimize the operation of the chillers and the primary pumps through the built-in chillers microprocessors and pump modules controllers.

The plant control system shall sense and monitor all control variables that govern the operation of each chiller, the current draw, evaporator temperature, condenser temperature... etc.

4.04 CHILLERS PLANT CONTROLLER (CONT'D)

The plant controller shall be able to maintain the operation of the chiller by making the corrective steps automatically without the need to shut down the chiller, if one of the variables has reached its limit condition.

The plant controller shall optimize the total chillers power consumption.

The plant shall be fully compatible and interfaced to the BMS system via modules, which shall be supplied by the plant manufacturer ready for direct connection to BMS, and shall provide all sensed parameters, such as leaving water temperature, capacity stage, water flow, number of operating compressors and chillers...etc.

The plant shall be fully compatible and interfaced to each chiller microprocessor controller .

The plant controller shall incorporate CRT for monitoring and setting up instructions.

All control points of the chillers and primary pumps shall be commanded by the controllers. And only the status of pumps and chillers shall be monitored by the BMS.

The Plant Controller shall be capable of rescheduling the chilled water temperature to achieve the required mixed flow temperature under part Load operating conditions.

The Plant controller shall be able to control the following functions of the chilled water system:

1- System Start-up
2- Chillers Start Sequence.
3- Primary Chilled water Pumps starting sequence
4- Logic control of the set point and actual temperatures.
5- Operation scheduling.
6- Soft Start of the chillers.
7- Unloading at starts.
8- Failure Detection and Recovery.
9- Failure Reset
10- Operator Override.
11- Electrical Demand Limit Controlling.
12- Chiller Plant Reporting & Logging.

4.05 SPLIT D/X COOLING UNITS

4.05.01 Description

A. Scope: Supply and install split D/X cooling units complete in accordance with the requirements of the Contract Documents. This section relates to the supply and installation of split D/X cooling units for the HVAC installation.

4.05 SPLIT D/X COOLING UNITS (CONT'D)

4.05.02 Quality Assurance

A. Regulatory Requirements

a. Test and rate split D/X cooling units of 35kw capacity or over in accordance with ARI 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment".

b. Test and rate split D/X cooling units of 35kw capacity or over in accordance with ARI 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment", and provide certified rating. Sound test and rate units in accordance with ARI 270 "Standard for sound rating of outdoor unitary equipment", and provide certified rating.

4.05.03 Submittals

A. Product Data : Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights, furnished specialties and accessories and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearance, methods of assembly of components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring for split D/X cooling units. Submit manufacturer's ladder type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field-installed.

4.05.04 Product Delivery, Storage and Handling

A. Handle split D/X cooling units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged units or components; replace with new.

B. Store split D/X cooling units and components in clean dry space. Protect from weather, dirt, fumes, water construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading split D/X cooling units, and moving them to final location.

4.05 SPLIT D/X COOLING UNITS (CONT'D)

4.05.05 Special Project Warranty

A. Warranty on Compressor: Provide written warranty, signed by the manufacturer and/or supplier, agreeing to replace/repair, within warranty period of five years, compressors with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling installing, protecting, and maintaining units shave been adhered to during warranty period. Replacement is not limited to component replacement only, and it does include labour for removal and reinstallation.

4.05.06 Split D/X Units

A. General: Provide factory-assembled and tested split D/X units as indicated, designed for roof, slab or floor mounting consisting of compressors, condensers, evaporator fans, refrigeration and temperature control, filters, and dampers. Provide capacity and electrical characteristics as scheduled.

B. Casing : Provide manufacturer's standard casing construction, corrosion protection coating, and exterior finish. Provide removable panels and/or access doors for inspection and access to internal parts. Insulate casing with 1" thick minimum thermal insulation. Provide knockouts for electrical and piping connections. Provide condensate drain connection, and lifting lugs.

C. Evaporator Fans : Provide forward or curved, centrifugal, belt-driven fans with adjustable sheaves and permanently lubricated motor bearings.

D. Condensor Fans: Provide propeller-type, direct-driven fans with permanently lubricated bearings.

E. Coils: For evaporator and condenser, provide non-ferrous construction with aluminum plate fins mechanically bonded to seamless copper tubes; with brazed tubing joints. Circuit evaporator to provide full active face on minimum cooling step 470 F/meters max for condenser coil and 393F/meter for evaporator coil.

F. Compressors: Provide serviceable, semi-hermetic, or hermetic compressors for less 20 KW compressors. Provide vibration isolators, and crankcase heaters which de-energize during compressor operation.

1. Provide cylinder unloaders for capacity control, with minimum steps as scheduled.

2. Provide thermal expansion valves, filter dryers, sight glasses, compressor service valves, liquid line service valves; and provide minimum of 2 refrigerant circuits for units having 2 or more compressors. Provide fan-cycling control for low ambient control to 45°F (7°C).

4.05 SPLIT D/X COOLING UNITS (CONT'D)

G. Safety Controls : Provide the following controls:

1. Low pressure cutout, manual reset.
2. High pressure cutout, manual reset
3. compressor motor overload protection, manual reset.
4. Anti-recycling timing device
5. Adjustable low-ambient lockout.

H. Refrigerant Piping and Fittings

1. Refrigerant pipes installed in the field shall consist of copper tubing and recessed solder joint fittings. Tubing shall be in accordance with ASTM Specification B 88-61 type 'k' hard drawn. fittings shall be wrought copper or tinned cast brass. where required for connection to gauges and control devices, tubing not larger than 3/8 inch. O.D. may be type 'k' soft (annealed) with flared tube or double ferrule compression fittings suitable for high pressure. On all joints in refrigeration piping flux and solder which is recommended by solder type fittings manufacturer shall be used. Tubing shall be protected against oxidation during silver soldering by use of dry nitrogen flowing through the tubing.

2. Refrigerant stop valves shall be of the back seating, key operated seal cap type. Valves which must be opened and closed in regular operation shall have hand wheels and shall be of the backless type. Valves connected to copper tubing shall have solder type ends or flanged ends and soldered flange adapters.

3. Accessories for field assembled refrigerant piping systems such as oil separators, liquid receivers, heat exchangers, driers, expansion valves, refrigerant strainers, sight glass etc., shall be in accordance with instructions of the units manufacturers standard practice and specific recommendations.

4. Drain line shall be of copper pipe type "L" fitted with dielectric fitting to drain pan.

I. Filters: Provide filter section consisting of 2" thick fiberglass throwaway filters in filter rack, with maximum face velocity of 300 fpm.

J. Automatic Temperature Control System

Provide combination thermostat and fan switches to control the room temperature automatically, provide factory fabricated unit of the same manufacturer of DX-Split unit having sensor, 4-position push button or lever operated manual switch for control of fan compressor interlock and control transformer as an integral part of the unit.

K. Electrical: Provide 400V convenience outlet, separately fused, with relay, contactors, indicator lamps, overload switches for unit service. Provide means for unit power connection through unit cabinet.

4.05 SPLIT D/X COOLING UNITS (CONT'D)

L. Accessories: Provide the following accessories;

1. Anti-Recycling Control: Provide controls to automatically prevent compressor restart for 5-minutes after shutdown.
2. Time Guard: Provide time guards to prevent short cycling of compressors.

M. Examine areas and conditions under which split D/X cooling units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

N. **Installation of Split D/X Cooling Units**

1. General: Install split D/X cooling units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in approved locations, and maintain manufacturer's recommended clearances.

2. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal.

O. **Start - Up**

1. Start-up split D/X cooling units, in accordance with manufacturer's start-up instructions. test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

2. Balance split D/X unit systems to verify its capacity and balanced delivery of air for each space.

P. **Grounding**

1. Provide positive equipment ground for split D/X cooling unit components.

4.06 ENERGY METERS

(Not included in this Contract)

Chilled water Energy and flow metering installations shall be installed to provide feed back to the building management systems, it shall comprise the following items:

a. Electro-magnetic manufactured from stainless steel suitable for insertion between pipe flanges.

- Fluid to be measured : Chilled water
- Nominal Pipe Bore:

1- ∅ 80mm x 1
2- ∅100mm x 1

4.06 ENERGY METERS (CONT'D)
(Not included in this Contract)

3- ∅125mm x 1
4- ∅150mm x 2
5- ∅200mm x 1
6- ∅300mm x 1

- Plate Thickness : To suit
- Static Pressure : 350 psig maximum

4.07 WATER TREATMENT

The Contractor shall include for the following water treatment to be carried out by a firm specialized for such works to be approved by the Engineer.

a) System Pre Cleaning

Immediately after pressure testing the system shall be thoroughly flushed in order to remove any extraneous matter. This flushing operation shall be carried out using line size drains, flanges etc. to ensure adequate water velocity is achieved for complete flushing. During subsequent refilling a non acidic dispersant, anionic polyelectrolyte (DIS TECH LQ206) shall be added via. the Magmove separation unit. The water shall be circulated as determined by the specialist for physical removal of debris. The completion of this operation shall be determined by the water treatment specialist firm based on results of monitored tests, and submitted to the Engineer for approval.

b) System Passivation

Following the above procedure, the system shall be passivated by the addition of the a Nitrite based inhibitor (CORRO TECH 41400). This shall be added via the Magmove separation unit at a rate of 25 litres per 2000 litres system water.

In order to inhibit growth of micro organisms a biocide (BIO-TECH LQ200) shall be added at the rate of 1 litre per 1000 litres system content.

c) Magmove Separation Unit

The water treatment specialist shall supply and install in a suitable location a Magmove separation unit of adequate capacity. The Contractor shall include for connection into the system as detailed and for all interconnecting pipework, valves, drains etc.

4.07 WATER TREATMENT (CONT'D)

d) Service Agreement

The Contractor shall include for the water treatment specialist firm to provide a monitoring and treatment program during the periodical working period. This shall include visits and the cost of all materials. A detailed report on the analysis and treatment carried out shall be provided following each visit, and submitted to the Engineer.

4.08 DOSING POT

In the location shown on the Tender Drawings, the Contractor shall supply and install a chilled water dosing pot size 1 LP/WM as manufactured by the water treatment specialist.

The dosing pot shall be connected into the system as detailed by the manufacturers complete with all interconnecting pipe work and isolating cocks.

4.09 DIFFERENTIAL PRESSURE VALVES

Chilled water Differential Pressure Valves shall be installed on the sub circuits to limit the maximum pump pressure imposed on two port terminal units valves at locations as shown on drawing, it shall comprise the following items :

a. Field mounted differential pressure reducing valves with transmitters being complete with a barton bellows differential pressure unit, all used to provide an electrical output.

•	Electrical Output	:	4: 20 mA
•	Square Root Extractor	:	Fitted with 10% cut off
•	Differential Pressure Range	:	To be determined during installation
•	Maximum Static Pressure	:	500 p.s.i.
•	Body Material	:	Brass
•	Electrical transmitter power supply units		
•	Output	:	0 10 mA DC
•	Number of Outputs	:	One
•	Mounting	:	Surface

4.10 PUMPS

A) General Requirements

- All pumps shall be provided from the factory complete with their motors.
- Pump and motor base shall be mounted on an isolated reinforced concrete foundation of an adequate construction and dimensions via vibration isolators, as detailed on the drawings.
- All pumps shall be located in accessible locations for ease of repair and maintenance.
- All pumps shall be constructed of materials having a pressure rating not less than 10 bars at 85°C.
- All pumps shall be provided from the factory with plugged connections for casing vent, drain and suction and discharge pressure gauges.
- Each pump shall be tested at the factory to provide detailed performance data and to demonstrate its compliance with the specification.
- Each pump shall be hyrostatically tested by the manufacturer for a pressure not less than 10 bars at 85°C.
- Piping shall be supported independent of pumps nozzles to prevent piping weight or stresses from bearing on or being transmitted to the pump nozzles.
- Drains from base plate, pump, relief valves, etc. shall be piped to the floor drain located in pump room.
- All conduits for electrical works in pumps room shall be heavy gauge galvanized steel.
- All pumps that are installed under shade or in roof plant rooms shall be protected by additional l weather proofing for specially considered for exposed pumps.

B) Documents

The following documents of all pumps, shall be submitted to the Engineer for approval, prior to shipment from the factory.

- Certified performance curves showing job number, customer order number, date of manufacture, model number, pump size, impeller diameter, impeller type, rpm, flow-head characteristic curve, consumed horsepower curve and pump efficiency curve.

4.10 PUMPS (CONT'D)

- Pump cross-sectional drawing showing major components with parts numbers and parts list.

- Pumps outline dimensional drawing showing overall dimensions, location of foundations bolts holes and size, location and rating of suction and discharge nozzles of pumps.

- Recommended spare parts list for 2 years operation.

- Detailed wiring diagrams of pumps controllers, and any other electrical devices of accessories.

- Installation, operation and maintenance instruction manuals.

C) Pump Motors

The motors of all pumps shall be of squirrel cage induction type and rated for continuous operation at ambient temperature not less than 40°C.

The motors shall be totally enclosed fan cooled type with insulation class F and IP 54 protection.

The motor shall be designed for:

- Direct On Line (DOL) start for motor capacities less than 10 horsepowers.

- Star-Delta start for motor capacities less grater than or equal 10 horsepowers.

The motor speed shall not exceed 1450 RPM ;unless otherwise stated.

The locked rotor current of the motor shall not exceed approximately six times the full load current. The motor shall be sized so that the full load ampere rating will not be exceeded.

All motor terminals shall be marked in accordance with NEMA Standard MG1- Part 2.

All motors shall be provided with nameplates in accordance with NFPA 70.

Motor power factor shall not be less than 0.85.

The horsepower rating of the motor driving the pump shall be of such magnitude as to ensure non-overloading of the motor throughout the capacity range of the pump for the impeller size selected.

4.10 PUMPS (CONT'D)

D) End Suction Centrifugal Pump

1) Foundation and Setting

The pump and motor shall be mounted on a common cast iron or steel base plate adequately reinforced against deflection and provided with drip rim and bolt holes.

The pump shall be directly connected to the motor through a heavy duty flexible coupling and provided with heavy gauge coupling guard from the factory. The base plate shall be securely supported on the foundation in such a way that proper pump and motor shaft alignment will be assured.

Horizontal split pumps shall be of a single stage volute type , with cast iron body, fully bronze fitted, double suction inlet, bronze impeller, flanged suction and discharge connections.

The base plate, with pump and motor mounted on it, shall be set level on the foundation and secured with proper size anchor bolts and completely grouted in to provide a rigid non deflating support. Pump and motor shall be aligned at the factory.

Realignment is required after grouting in of base plate and after connecting piping.

2) Pump Construction

The pump casing shall be of high tensile strength close-grained cast iron fitted with bronze wearing rings.

The impeller shall be bronze of the enclosed type and fitted to the shaft with stainless steel key. The impeller shall be dynamically balanced at the factory.

The shaft shall be stainless steel amply sized to carry all axial and radial thrust. The shaft shall be protected by stainless steel sleeves.

The pump rotating element shall be supported by heavy duty grease lubricated ball bearings mounted in a heavy iron housing. The bearing shall be lubricated by screw type grease cups.

The pump shall be fitted with mechanical shaft seals which shall be easily removable from the stuffing boxes without disturbing motor and pump alignment.

The pump shall be provided with back pull-out casing for maintenance purposes.

4.10 PUMPS (CONT'D)

The pump shall be provided from the factory with mating flanges for suction and discharge connections. the pump shall be provided with nameplate.

The pump shall be furnished with grease lubricated outboard bearings provided with drain plugs and fittings suitable for in service lubrication.

Mechanically; sealed condensing and chilled water pumps shall be provided with balanced seals.

Mechanically; sealed heating and hot water pumps shall be provided with John Crane Code Xp1d1 Type 1 unbalanced seals. Pumps provided with seals shall be provided with bronze or stainless steel shaft sleeves and stainless steel Cyclo-clean filters.

Packed pumps shall be fitted with stainless steel shaft sleeves heat treated or metallized to brinell hardness 500.

Stuffing box shall designed to accommodate a minimum five rings of packing plus spacer ring and shall be suitable for conversion to grease or water sealing. Packing shall be suitable for service scheduled in accordance to the pump manufacturer's recommendations.

3) Operating Characteristics

The pump shall be selected so that the operating point of specified flow and head falls near the point of maximum efficiency as obtained from the manufacturer published data. The pump shall never be selected to operate near the end of its curve.

The pump shall deliver not less than 150 percent of rated flow at a pressure not less than 65 percent of rated pressure. The shutoff pressure shall not exceed 120 percent of the rated pressure.

The impeller size shall not exceed 90% of the maximum size available for pump casing.

A pump satisfying the specified flow and head characteristics but with smaller impeller size will be rejected. A large pump with a smaller impeller shall be selected to satisfy the specified flow and head.

4.10 PUMPS (CONT'D)

4) Pump Instrumentation

a) Relief Valve

The pump shall be provided with a relief valve set below the shutoff pressure to provide circulation of sufficient water to prevent the pump from overheating when operating with no discharge. A 20 mm. relief valve shall be used.

Provision shall be made for a discharge to drain.

The relief valve shall be located between the pump and pump discharge check valve.

b) Automatic Air Release Valve

Each pump shall be provided with float operated air release valve not less than 15 mm. size, to automatically release air from the pump.

c) Pressure Gauges

A pressure gauge shall be connected to the discharge and suction side of the pump casing.

d) Valves and Fittings

- Gate valves shall be installed on the suction and discharge piping of the pump.
- Globe valve shall be installed on the discharge bypass piping of the pump.
- Check valve shall be installed on the pump discharge piping.
- Strainer Y-type shall be installed on the suction piping of the pump.
- Flexible connections shall be installed on the suction and discharge piping of the pumps.
- All valves, strainers and fittings shall be of the same size as the pipe which they are installed.
- All power cabling, flow switches and the connection to the BMS.

E) In Line Centrifugal Close Coupled Circulating Pump

The Contractor shall supply and install circulating pumps as shown and detailed on the drawings, for installation in vertical position, capable of being serviced without disturbing piping connections

4.10 PUMPS (CONT'D)

The pump shall be inline close coupled single suction centrifugal type. The pump shall have suction and discharge flanges of the same diameter and on the same centerline.

The pump motor shall be of squirrel cage induction type rated for continuous operation at ambient temperature not less than 50°C.

The motor shall be totally enclosed fan cooled type with insulation class F and IP54 protection. or it shall meet NEMA specifications

Motor shall have heavy duty grease lubricated ball bearings, completely adequate for the maximum load for which the motor is designed.

Pump volute shall be of Class 30 cast iron or bronze. The impeller shall be of cast bronze, enclosed type, dynamically balanced, keyed to the shaft and secured by a locking capscrew.

The liquid cavity shall be sealed off at the motor shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225 Deg. F. A bronze shaft sleeve shall completely cover the wetted area under the seal.

Pump shall be rated for minimum of 10 Bar working pressure at 85°C.

Volute shall have gauge tappings at the suction and discharge nozzles and vent and drain tappings at the top and bottom.

Impeller sizes shall not exceed 80% of maximum size available for pump casing.

Each pump shall be factory tested per Hydraulic Institute standards. It shall then be thoroughly cleaned and painted with at least one coat of high grade machinery enamel prior to shipment.

Pump Instrumentation

a) Pressure Gauges

A pressure gauge shall be connected to the discharge and suction side of the pump casing.

b) Valves and Fittings

- Gate valves shall be installed on the suction and discharge piping of the pump.
- Globe valve shall be installed on the discharge by-pass piping of the pump.

4.10 PUMPS (CONT'D)

- Check valve shall be installed on the pump discharge piping.
- Strainer Y-type shall be installed on the suction piping of the pump.

Note:-

- All valves, strainers and fittings shall be of the same size as the pipe which they are installed.
- All power cabling , flow switches and the connection to the BMS.

4.11 PACKAGED VARIABLE SPEED PUMPS

All secondary and tertiary chilled water pumps shall be of packaged variable speed pumping set. The package pump set shall include:

1. Pumping Skid
2. Pump Control Panel
3. Adjustable Frequency Drive
4. Sensor Transmitters

4.11.1 SUBMITTALS

A. Submittals shall include the following:

1. System summary sheet
2. Sequence of operation
3. Shop drawing indicating dimensions, required clearances and location and size of each field connection
4. Power and control wiring diagrams
5. System profile analysis including variable speed pump curves and system curve. The analysis shall also include pump, motor and AFD efficiencies, job specific load profile, staging points, horsepower and kilowatt/hour consumption.
6. Pump data sheets

B. Submittals must be specific to this project. Generic submittals will not be accepted.

4.11 PACKAGED VARIABLE SPEED PUMPS (CONT'D)

4.11.2 QUALITY ASSURANCE

A. The pumping package shall be assembled by the pump manufacturer. Any assembler of pumping systems not actively engaged in the design and construction of centrifugal pumps shall not be considered a pump manufacturer. The manufacturer shall assume "Unit Responsibility" for the complete pumping package. Unit responsibility shall be defined as responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.

B. All functions of the variable speed pump control system shall be tested at the factory prior to shipment. This test shall be conducted with motors connected to AFD output and it shall test all inputs, outputs and program execution specific to this application.

C. Contractor shall comply with all sections of this specification relating to packaged pumping systems. Any deviations from this specification shall be bid as a voluntary alternate clearly defined in writing..

4.11.3 MANUFACTURED UNITS

A. The control system shall include as, a minimum, pump & motor assemblies, the programmable logic pump controller, adjustable frequency drive(s), suction and discharge piping and additional equipment as specified and shown on drawings. Furnish field installed remote sensor transmitters as indicated on the plans.

C. System shall require only suction and discharge connections and a single point power connection. Field connection of remote sensor/ transmitters and connection to Building Automation System shall also be included..

D. All components shall be mounted on a structural steel base suitable for grouting. The base shall be large enough to support the system's pumps, piping and control panel. All welded pressure bearing piping must be fabricated with full penetration welds. Qualification of the welding procedures and performance of the welders shall comply with the requirements of ANSI/ASME B31.1 and ASME code, Section IX.

E. Provide pumps as indicated on the pump schedule. Pumps and motors shall be furnished as specified in respective sections of this document.

H. Pressure gauges shall be furnished for system supply and return headers. Gauges shall be installed to be clearly visible from front of control panel.

4.11.4 COMPONENTS

A. Pump Logic Controller

1. The controller shall meet Part 15 of FCC regulations pertaining to class A computing devices. The controller shall be specifically designed for variable speed pumping applications.

4.11 PACKAGED VARIABLE SPEED PUMPS (CONT'D)

2. The controller shall function to a proven program that safeguards against damaging hydraulic conditions including:

   motor overload
   pump flow surges
   hunting
   end of curve

3. The pump logic controller shall be capable of accepting 4 analog inputs from zone sensor/transmitters indicated on the plans. The controller shall scan each analog input a minimum of once every 500 milliseconds. It will then select the analog signal that has deviated the greatest amount from its setpoint. This selected signal will be used as the command feedback input for a hydraulic stabilization function to minimize hunting. Each Input signal shall be capable of maintaining a different set point value.

4. The pump controller shall be capable of controlling all pumps in parallel.

5. The hydraulic stabilization program shall utilize a proportional-integral-derivative Control function. The proportional, integral and derivative values shall be user adjustable over an infinite range.

6. The pump logic controller shall be self prompting. All messages shall be displayed in plain English. The operator interface shall have the following features:

   a. Multi-fault memory and recall
   b. On-screen help functions
   c. LED pilot lights and switches
   d. Soft-touch membrane keypad switches.

7. The readout shall be brightly lit fluorescent characters capable of displaying the following values:

   a. Differential pressure in kPA
   b. Pressure in kPA
   c. Flow in L/S
   d. Temperature in degrees F or C
   e. Differential temperature in degrees F or C
   f. KW Ref. calculation
   g. Kilowatt consumption
   h. Tons per hour calculation
   i. Wire to water efficiency calculation

4.11 PACKAGED VARIABLE SPEED PUMPS (CONT'D)

8. The following communication features shall be provided to the BAS:

   a. Remote system start / stop
   b. Failure of any system component
   c. Process variable
   d. AFD speed

B. Adjustable Frequency Drive

1. The adjustable frequency drive(s) shall be six-step variable voltage (VVI) type, microprocessor controlled design.

2. The AFD, including all factory installed options, shall have UL & CSA approval.

3. Enclosure shall be NEMA 1 ventilated for wall mounted installation. Drive shall be equipped with an input disconnect switch and electronic ground fault protection. A hand-off-automatic switch and speed potentiometer shall be mounted on the front of the enclosure.

4. Three phase input line reactors shall be provided in the AFD enclosure. The drive shall comply with FCC rules and regulations Part 15, subpart J. Line noise shall be no greater than 3% harmonic distortion and no more that 16,400 volt-microsecond commutation notch area, in compliance with IEEE standard 519-1981.

5. AFDs utilizing PWM technology shall not be acceptable unless furnished with inverter duty motors. An inverter duty motor shall be defined as a motor with cast iron housing and class F insulation.

6. The following customer modifiable adjustments shall be provided:

   a. Accel time: 3 to 280 seconds
   b. Decel time: 3 to 280 seconds
   c. Minimum frequency
   d. Maximum frequency
   e. Variable overload
   f. Output frequency (50 or 60 HZ)
   g. Output voltage (208, 230,380, 415, 460, and 575 VAC)

7. Speed reference signal shall be customer selectable for:

   a. 4-20 mA
   b. 0-5 VDC
   c. 0-10 VDC

8. The AFD shall be suitable for elevations to 3300 feet above sea level without derating. Maximum operating ambient temperature shall not be less than 104 degrees F. AFD shall be suitable for operation in environments up to 95% non- condensing humidity.

4.11 PACKAGED VARIABLE SPEED PUMPS (CONT'D)

9. The AFD shall be capable of displaying the following information on the door mounted operator interface:

   a. Percent speed
   b. Percent load
   c. Run
   d. Reverse
   e. Fault identification

10. All AFDs shall be warranted for a period of 18 months after shipment. This warranty shall cover parts and labor. A factory start-up shall be available. Factory start-up shall extend warranty to cover parts & labor for a period of 36 months after date of shipment.

C. Sensor / Transmitters

1. Provide (1) field mounted differential pressure sensor transmitter for each pump. Unit shall transmit an isolated 4-20mA dc signal indicative of process variable to the pump logic controller via standard two wire 24 DC system. Unit shall have stainless steel wetted parts with two 0.25" male NPT process connections. It shall be protected against radio frequency interference and shall have a watertight, NEMA 4 electrical enclosure capable of withstanding 2000 PSI static pressure With a 0.5" NPT conduit connection. Accuracy shall be within 0.25% of full span.

   Provide field mounted 3-valve bypass to facilitate removal of sensor/transmitter.

2. Provide one field mounted flow sensor transmitter for each pump. Unit shall transmit an isolated 4-20 mA dc signal indicative of Process variable to the pump logic controller via standard two wire 24 VDC system. Unit shall consist of an insertion probe and separately mounted transmitter. The unit shall be accurate to within 1% of flow rate from 1 to 30 fps and shall withstand a static Pressure of 200 PSI with negligible change in output.

D. Sequence of Operation

1. The system shall consist of a Technologic pump logic controller, duty pump(s) / AFD set, one standby pump/AFD set, with duty-standby pump selection, automatic alternation and automatic transfer to the standby pump.

2. The pumping system shall start upon the closure of customer's contact when the pump logic controller Mode of Operation selector switch is in the REMOTE position.

4.11 PACKAGED VARIABLE SPEED PUMPS (CONT'D)

3. When the pump logic controller selector switch is in the LOCAL position, the pumping system shall operate automatically.

4. Sensor/transmitters shall be provided as indicated on the plans.

5. Each sensor/transmitter shall send a 4-20mA signal to the pump logic Controller, indicative of process variable condition.

6. The pump logic controller shall compare each signal to the independent, engineer/user determined set points.

7. When all set points are satisfied by the process variable, the pump speed shall remain constant at the optimum energy consumption level.

8. The pump logic controller shall continuously scan and compare each process variable to its individual set point and control to the least satisfied zone.

9. As the worst case zone deviates from set point, the pump logic controller shall send the appropriate analog signal to the AFD to speed up or slow down the pump/motor.

10. The redundant variable speed system shall be started through the pump logic controller.

11. In the event of a system differential pressure failure due to a pump or AFD fault, the pump logic controller automatically initiates a timed sequence of operation to start the redundant pump/AFD set in the variable speed mode.

12. In the event of the failure of a zone sensor/transmitter, its process variable signal shall be removed from the scan/ compare program. Alternative zone sensor/transmitters, if available, shall remain in the scan/compare program for control.

13. The zone number corresponding to the failed sensor/ transmitter shall be displayed on the operator interface of the pump logic controller.

14. In the event of failure to receive all zone process variable signals, the AFD shall maintain 100% speed, reset shall be automatic upon correction of the zone failure.

15. PUMP or AFD fault shall be continuously scrolled through the display on the operator interface of The pump logic controller until the fault has been corrected and the controller has been manually reset.

4.12 PRESSURIZATION SET

This type of unit shall only be used for pressurizing the main and secondary chilled water systems & heating system.

The Contractor shall provide a permanently connected apparatus for initial water filling an d water make up including a break tank and an electric pump. The tank shall be fitted with a ball valve and connection for cold water supply.

A high pressure switch and a low pressure switch shall be provided both wired in series with the cooling generating plant controls to shut down the plant and to give a continuous audible warning when a dangerous condition arises.

The units shall comprise but not necessarily be limited to the following:

- Break tank
- Expansion vessel
- Pressurization Pump
- Valves and fittings
- Controls and instrumentation

a) Expansion Tank

The expansion tank shall be of the closed type, sealed, pre-charged expansion vessel, steel shell divided into two sections by a flexible removable diaphragm. One section contains system water, the other, air or an inert gas such as nitrogen. All valves and other devices should be connected and included with the tank as mentioned on drawings.

- Isolating valves
- Pressure regulating valve
- Relief valve
- Pressure gauge and Air or Nitrogen filling connection
- Automatic air vent valve
- Working temperature should be up to 165 C

b) Pressurization pump

The Contractor shall provide a close coupled centrifugal pump bolted to a base on a vibration isolation pad. The capacity of the pump shall be as recommended by manufacturer to suit the applicable pressure.

The pump casing shall be of close grained cast iron with gun metal impeller and hard coated mechanical seals or packed glands.

The motor shall be of the drip proof squirrel cage induction type.

c) Valves and fittings

The Contractor shall provide the following valves and fittings:

- Pump suction strainers
- Pump isolating gate valves on suction and discharge

4.12 PRESSURIZATION SET (CONT'D)

- Pump discharge non return valves
- Adjustable setting pressure reducing valve
- Suction flow control valve
- Air purger/separator
- Automatic air vent with isolating valve

d) Base frame

All components shall be mounted on to a mild steel folded and welded base frame complete with lifting eye bolts.

The base frame shall be primed and undercoated with epoxy paint finish.

e) Vibration isolators

1. The unit shall be mounted on anti vibration isolators.

2. Non ferrous braided flexible pressure hose connections on interfaces with pipework system shall be provided.

3. Final electrical connectors shall be made with armored flexible conduit.

f) Control Panel

The pressurization set shall include control panel to operate the pressurizing pump and monitor the low and high level switches, and low and high level pressure

Final electrical connectors shall be made with armored flexible conduit.

The unit shall be complete with all power cabling, flow switches and sensors and shall be connected to the BMS.

4.13 TWO PORT CONTROL VALVES

The two port valve authority (pressure drop over the valve when it is fully open divided by the pressure drop when it is fully closed) has been designed between 0.3-0.5 based on the maximum systems pump pressure and based on equal percentage or modified parabolic characteristic .

However; and in order to achieve acceptable levels of the control and to minimize the required pump pressures, the valve authority and sizes shall be determined by contractor in coordination with the control valve manufacturer after the final units selection and based on the pressure drop calculation of the network .
This shall ensure the system operates effectively.

4.13 TWO PORT CONTROL VALVES (CONT'D)

The contractor shall advise the engineer the required size of the valve based on:-

Valve authority

Valve rangeability which shall not be less than 50:1.

Valves tolerances as defined in the VDE 2173.

Valve actuators torques which shall be sufficient to open and close valves against 150% of the out balance pressure across them.

4.14 DIFFERENTIAL PRESSURE REGULATING/REDUCING VALVES (DPRV)

The differential pressure regulating valves, reducing or relief valves, shall be fitted where shown on the secondary sub-circuits to limit the maximum pump pressure imposed on two port terminal unit valves.

The valve shall be of self acting pilot operated diaphragm type of upstream and down stream pressures as per the control valves manufacturer recommendations

The contractor shall allow for the installation of the required numbers of the DPRV based on the recommendations of the control valves manufacturer. The contractor in coordination with manufacturer shall submit complete schematic drawings showing locations, sizes and upstream and down stream pressure and shall adjust the Δp settings at high load conditions to the ranges of acceptable valve authority as recommended by the two port control valve manufacturers.

4.15 DRAINAGE AND FLUSHING OF SYSTEM

On the dead side of isolating valves, the Contractor shall supply at all low points of pipework systems, except where pipes dip under floors or doors suitably sized key operated cocks with hose unions to ensure complete drainage. Where pipes dip under floors or doors a suitably sized tee with plugged outlet shall be fitted.

The Contractor shall provide scale or dirt pockets where indicated on piping system at the lowest point, which shall generally be adjacent to the plant or equipment.

Scale or dirt pockets shall be of equal cross section as the connecting pipe, 150 mm. minimum length or depth. For pipe-work 65 mm. and above they shall terminate with welded on flange and bolted down blank companion flange arranged to allow easy removal for cleaning. Companion flange shall be tapped and fitted with a 25 mm., tight shut off valve with hose union connection.

For pipework 50 mm. bore and below the dirt pocket shall terminate by means of a screwed cap unless otherwise indicated.

4.15 DRAINAGE AND FLUSHING OF SYSTEM (CONT'D)

Capped flushing valves shall be installed in the following positions and additionally where indicated on the Drawings:

a) At the base of all vertical risers and droppers

b) At the ends of all horizontal run outs

c) On the system side of valved connections to equipment located at other than roof plant room level.

d) At all other low points in systems

The valves shall be line size up to 40 mm. and not less than 50 mm. for line size 50 mm. and above.

Capped branch connections shall be installed suitable for fitting flexible hoses for dynamic flushing, at the following locations on each system and additionally where indicated on the Drawings.

a) Inlet and outlet of all strainers and on strainer side of isolating valves.

b) Suction and discharge side of all pumps and on pump side of isolating valves for system pumps used for flushing system.

c) System side of system pump discharge valve when portable pumps are used to flush systems.

d) System side of inlet isolating valves and equipment and system side of all cooling coils of air handling units, evaporators, exchangers.

Isolating valves shall be fitted on branch flushing connections located on the system side of the equipment isolating valves and at other positions where indicated on the drawings.

The branch connections sizes shall be as follows unless practical limitations dictate otherwise:-

Connection Size (mm)	Line Size (mm)
Line size	Up to 50 mm.
65	65 to 150 mm.
80	150 to 200 mm.
100	300 to 450 mm.

Pipework between flushing tanks and system connections may be flexible material, to suit operating pressures.

Overflow and/or warning pipes shall be provided to the feed and expansion tanks and automatic air relief valves.

4.15 DRAINAGE AND FLUSHING OF SYSTEM (CONT'D)

The guiding principles determining the provision and positioning of drain points shall be that all sections of the pipework installation must be capable of being completely drained with the isolating valves closed on the section to be drained.

The Contractor shall install horizontal drain lines to fall at a rate of not less than 25 mm. in 6 m. (1:240), and provide ample, easy access rodding facilities with union or flanged joints for cleaning, inspection and dismantling.

The following shall be arranged to discharge into tundishes connected to drains lines run to convenient drains or sumps. This shall include where pressure or suction conditions exist, cleanable traps with water seals of the required depth.

Drip points from pumps, one tundish being provided for each pump.

4.16 ANTI VIBRATION PROTECTION

The inlet and outlet from each chiller and pump shall be provided with a line sized anti vibration flexible connection capable of absorbing all vibration prior to any pipework bracketing.

Chillers and pumps should be seated on anti vibration mountings to prevent vibrations being transmitted to the structure.

4.17 STRAINERS

Line size strainers shall be fitted before each item of the equipment and prior to each 3 port control valve, and where shown on Drawings.

4.18 ISOLATING AND COMMISSIONING VALVES

Control regulation and isolation valves shall be installed in the following positions on the chilled water installations, and where shown on Drawings.

Isolation valves shall be provided for each chiller, pump, three port control valve and air handling plant cooling and heating coils. In addition isolation and regulating valves shall be provided the mains and submains and at valve stations as shown on the Drawings and as necessary whether indicated in Drawings or not. Double regulation and orifice valves shall be installed across all pumps and items of heat exchange equipment.

4.19 PIPE FLEXIBLE CONNECTORS

Shall be of the bellows type and shall be suitable for a minimum working pressure of 10 bars at a maximum temperature of 80 °C. They shall be able to withstand a test pressure of 15 bars at 80 °C.

The bellows and inner sleeves shall be stainless steel to B.S. 1449, 321 S 12 .

The tube ends shall be carbon steel flanged to match connected equipment.

4.20 ENERGY TECOVERY SYSTEM

The Contractor shall supply, install, test and commission energy recovery system to suit the application as shown on the drawings. It shall be of rotary wheel heat exchanger type.

END OF SECTION