PART III OF TECHNICAL SPECIFICATION PACKAGE 3A: SCREW TYPE WATER COOLED MACHINE

1.1. SCOPE

This chapter describes central Air-conditioning plant with Supply, installation, testing and commissioning including Lifting, shifting & positioning of factory assembled & tested chilling units comprising of screw compressor, direct driven with electric motor, water cooled condenser, chiller, water flow switches at inlet and outlet of condenser and chiller, water drain and air purge valves wherever required, connecting refrigerant plumbing, microprocessor based safeties and controls, Variable frequency Drive including first charge of refrigerant & compressor oil. **The Chilling machine shall be minimum ECBC Compliant.**

1.2. SCREW TYPE COMPRESSOR

- The screw compressor shall have a rotary mono / twin screw, and may be of open / Semi hermetic type. It shall be using refrigerant R410a/R134a.
- The mono/ twin rotary screw shall be manufactured from forged steel. The profile of screws shall permit safe operation upto a speed of 5000 RPM for 50 Hz operation. The compressor shall unload from fully loaded to the minimum capacity by means of hydraulically actuated slide valve positioned over the screw rotor.
- The compressor housing shall be of high grade cast iron, machined with precision, to provide a very close tolerance between the rotor(s) and the housing.
- The rotor(s) shall be mounted on antifriction bearings designed to reduce friction and power input. There shall be multiple cylindrical bearings to handle the radial and axial loads.
- There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent backspin during shut down.
- There shall be oil pump or other means of differential pressure inside the compressor for forced lubrication of all parts during startup, running and during shut down. An oil sump header shall be provided.
- The open type compressor shall also have a suitable shaft seal, to prevent leakage of refrigerant.
- The units shall be complete with automatic step less capacity control mechanism, to permit modulation between 25% to 100% of capacity range.
- The driving motor shall be squirrel cage type Semi hermetic/ open type as required, protected against damage by means of built in protection devices.
- Compressor motor.

  a. The electrical motor driving the compressor shall be squirrel cage induction motor class 'F' insulation, Open dip proof for open type unit and totally enclosed (refrigerant cooled) for hermetic/ semi-hermetic unit.
  b. The motor shall be suitable for operation on 415 ±-10% volts, 3 phase, 50 HZ alternating current supply, unless otherwise specified.
  c. The motor synchronous speed shall not exceed 3000 r.p.m.
  d. Continuous BHP rating of the motor shall not be less than the maximum power requirement of the compressor and drive under specified design conditions.

- Motor starter
  The starter shall be mounted on the main electrical control panel / unit mounted/ self-

mounted as specified. The starter for the motor shall be Star Delta close transition type with VFD. Starters shall be rated for intermittent duty. Starting current should not exceed two times the full load current.

The following protective devices will be factory mounted and wired to the starter:

a) 3-leg sensing electronic overloads with indicating lights and reset button
b) Phase rotation protection circuit and indicating light
c) Single-phase failure protection circuit and indicating light
d) High temperature safety protection system with indicating light and reset button
e) Hinged access door with lock and
f) High and low line voltage protection.

The following convenience items will be factory mounted and wired to the starter:

a) Auxiliary 1-1/2 KVA transformer
b) Digital Elapsed Time Meter
c) Power Fault Protection , Electrical lugs
d) 3-phase digital ammeter and digital voltmeter readout via control panel, KW Meter , KWh Meter & Ammeter
e) Voltmeter Elapsed Time Meter

The COP shall not be less than 6.0 and IPLV shall not be more than 7.9 at AHRI conditions and IKW/ TR at actual project conditions shall not be more than 0.65.

1.3. CONDENSER

1.3.1. SCOPE

This chapter covers the requirements of condensers suitable for screw types of refrigeration machines for central air-conditioning.

1.3.2. TYPE

Water cooled condensers

1.3.3. WATER COOLED CONDENSERS

- RATING

i. The condenser capacity shall match the compressor capacity specified in the tender specifications. The condenser shall be selected for 5.5 degree C temperature rise of water through the condenser unless otherwise specified in the tender specifications.
ii. The condenser shall be designed for a fouling factor of 0.0005 FPS
iii. Unless otherwise specified, the condenser shall be designed for entering water temperature of 31.1°C.

- MATERIAL AND CONSTRUCTION

i. The condenser shall be horizontal, shell and tube type, designed, constructed and tested for the refrigerant specified in the tender specifications.
ii. The shell of the condenser shall be made of MS of thickness not less than 8mm, with electric fusion welded seams. The shell capacity shall be such as to hold 1.25 times the refrigerant charge in the machine of which the condenser is a part, under pumped down conditions.
iii. The end plates of condenser shall be made of MS of thickness not less than 25mm.
iv. The condenser shall be designed for a working pressure on the refrigerant side suitable for the refrigerant offered, and on the water side for 10 kg/sqcm gauge.

v. The tubes shall be of seamless hard drawn copper and finned, unless otherwise specified.
vi. The minimum wall thickness shall be 1.0 mm with root thickness of 0.63 mm below the fins.
vii. Intermediate tube supports of steel shall be provided at no more than 1250 mm intervals to prevent sagging and vibration of the tubes. The condensers shall have water boxes designed for multi pass flow.
viii. The tubes may be provided with special tabulating arrangement to improve heat transfer where such an arrangement is a standard design of the manufacturer.
ix. The condensers shall be provided with removable heads on either side made of cast iron or steel with neatly machined surface for effective jointing with the shell for easy accessibility for cleaning/replacement of the tubes. Suitable baffles shall be incorporated to achieve the required number of passes. It should be possible to descale the tubes without disconnecting the water line connections, wherever marine water boxes have been specified in the tender documents.
x. The condenser shall be provided with baffle arrangement for preventing direct impingement of hot gas over the tubes and to enable even distribution of the gas over the tube bundles.
xi. The condenser shall include necessary provision for sub-cooling of the refrigerant where the refrigerating machine is selected with such sub-cooling requirement. The arrangement shall be such that the cold water entering the condenser first cools the liquid refrigerant in the sub-cooler.
xii. The condenser shall be sand blasted from both inside & outside.

- CONNECTIONS AND ACCESSORIES

The condenser shall be provided with the following connections and accessories and conforming to Section "Refrigerant Piping" where applicable:

i. Hot gas inlet and liquid outlet connections. The liquid line connections shall be provided with isolating valves.
ii. Water inlet and outlet connections.
iii. Pressure relief device.
iv. Drain connection with valve for water side.
v. Differential flow switch/ pressure switch/ flow switch/ flow sensor in the water line(s).

- PRESSURE TESTING

i. The condenser shall be tested at the works to 1.5 times the maximum working pressure or 15 kg/sq.cm. (Pneumatic) whichever is higher.
ii. The water side of the condenser shall also be tested to a hydraulic pressure of 10 kg./sq.cm. in the works.
iii. Pressure test certificates shall be produced in respect of each condenser.

1.4. CHILLER

1.4.1. SCOPE

This chapter covers the requirements of chillers suitable for screw types of refrigerating machines for air-conditioning.

1.4.2. TYPES

This section covers the shell and tube type water chillers. The chiller shall be of flooded type.

1.4.3. SHELL AND TUBE TYPE WATER CHILLERS

- RATING

i) In a package water chilling machine, the chiller shall match the compressor capacity specified in the tender specifications. The chiller shall be selected for 5°C temperature drop of water through the chiller

ii) The fouling factor shall be 0.0002 FPS.

- MATERIAL AND CONSTRUCTION

i. The water chiller shall be horizontal, shell end tube type, designed, constructed and tested for the refrigerant specified in the tender specifications.
ii. The chiller shall be designed for a working pressure on the refrigerant side suitable for the refrigerant offered, and on the water side for 10 kg./sq.cm. gauge.
iii. The end plates of chiller shall be made of MS of thickness not less than 25mm.
iv. The shell of the chiller shall be made of MS of thickness not less than 8 mm with electric fusion welded seams.
v. The tubes shall be of seamless, hard drawn copper with a minimum tube wall thickness of 0.71 mm for plain tubes & minimum 0.63mm at the root of fins.
vi. The tubes may be either plain or internally finned as per manufacturer's design.
vii. The tubes shall be rolled into grooves in the tube sheets and flared at ends.
viii. Intermediate tube supports of steel or polypropylene shall be provided at spacing not less than 1250 mm to prevent sagging / vibration of tubes.
ix. The flooded chillers shall have water boxes designed for multipass flow.
x. The chiller shall be smooth finished with one coat of paint as per manufacturing practice before the insulation is applied.
xi. The chiller shall be sand blasted from both inside (before insertion of tubes) & outside.
xii. Sight glass to check the level of refrigerant

- CONNECTIONS AND ACCESSORIES

The chiller shall be provided with the following connections and accessories and conforming to section "Refrigeration Piping" where applicable

i) Refrigeration inlet and outlet connections
ii) Liquid refrigerant float for level control expansion valve/ fixed or variable orifice
iii) Pressure relief device
iv) Charging connection with valve
v) Eliminator plate
vi) Drain and vent connections with valves
vii) Water inlet and outlet connections
viii) Proper oil return system
ix) Flow switch/pressure switch/differential flow switch/ flow sensor in the water line(s)

- PRESSURE TESTING

i) The chiller shall be tested in the works to 1.5 times the maximum working pressure or 21 kg/sqcm (Pneumatic), whichever is higher.
ii) The water side of the chiller shall also be tested to a hydraulic pressure of 10 kg/sqcm at the works.
iii) Pressure test certificates shall be produced in respect of each chiller.

1.5. REFRIGERANT PLUMBING

1.5.1. DESIGN ASPECTS OF REFRIGERANT PLUMBING

- Refrigerant piping shall be designed and installed so as to:

i) Ensure circulation of adequate refrigerant at all loads.
ii) Ensure oil return to crank case of compressor positively and continuously.
iii) Keep pressure losses within limits, especially in suction lines.
iv) Prevent oil/liquid refrigerant from entering the compressor when the compressor is working as well as when it has stopped.
v) Prevent trapping of oil in evaporator or suction lines, which may return to the compressor in the form of slug.

- Hot gas lines: Oil shall be entrained and carried by hot gas under all load conditions likely to be encountered in normal operation.

- Liquid Lines:

i) Liquid lines shall be designed to ensure that flashing of liquid refrigerant does not occur by minimizing the pressure drop suitably, by avoiding long vertical risers, and appropriate sub cooling.
ii) Each liquid line shall be provided with a permanently installed refrigerant drier of throw away or rechargeable type. The drier shall be installed in a valved line.
iii) Flow indicator (moisture indicating type) shall be installed on all liquid lines.

- Suction Lines:
  a) Oil shall be entrained and carried by the suction gas under all conditions of load likely to be encountered in normal operation.
  b) Piping shall be designed for a suitable velocity of refrigerant (similar to hot gas line) to ensure that oil will not separate from the gas and drain to the compressor in slugs.
  c) The refrigeration system shall be equipped with controls for pump down system so that the evaporator and suction line are emptied before the compressor shuts off, thus preventing liquid refrigerant and oil from entering the compressor when restarted.
  d) Refrigerant lines shall be sized to limit pressure drop between evaporator and condensing unit to less than 0.2 kg. per sq.cm. (3 psi).
- Isolating valve shall be provided to enable isolation of each compressor in case of multiple compressor units (as built in valves), strainer, drier and any other components as may be required for proper operation and maintenance.
- Thermostatic expansion valve/float valve shall be provided in refrigerant circuit.

1.5.2. MATERIAL

i) Refrigerant plumbing for chilling machine shall be of mild steel or wrought iron/copper to manufacturer's standards.
ii) Fittings like bends, tees, sockets etc. shall be of wrought copper or forged brass and shall be suitable for the duty involved. Flare type compression fittings of forged brass shall be allowed upto 15 mm piping size. Tubes upto and including 15mm size may be bent to form 90 degree bends with inside radius not less than 3tube dia. For bigger sizes, bend fittings as mentioned above must be used.
iii) Where specified in the tender specification, mild steel may be provided for refrigeration piping, with seamless MS tubes and fittings of heavy class conforming to IS: 1239. All liquid lines and instruments lines shall however be of copper only.

iv) Valves shall be of the packed, back-seating type for both copper and MS refrigerant plumbing work, and these shall be of forged or cast brass construction.

1.5.3. PRESSURE TESTING

After completion of the piping installation, the entire chilling unit shall be pressure tested with dry nitrogen or any other inert gas at the following pressures for the particular refrigerant to be used:

Test pressure (Kg./Sq.cm. (Gauge)	
High pressure side	Low pressure side
20	8

This test shall be carried out as follows:

i) The system shall be charged with nitrogen or inert gas to 1.0 Kg./sq.cm. gauge and all joints shall be checked for leakage with a mixture of four part water, one part liquid soap and a small amount of glycerin. Leaks shall be marked, pressure released and repairs done. Brazed joints, which leak, shall be opened and redone. These shall not be repaired by addition of brazing alloy to the joints.

ii) The system shall now be charged with nitrogen or the inert gas to the pressure specified in the above table and the process of locating leaks and repairs shall be repeated.

iii) Final pressure test: After all the leaks have been repaired, the system shall be retested with the test pressure maintained for a period of not less than 8 hours. No measurable drop in pressure should be detected after the pressure readings are adjusted for temperature changes. Pressure Gauges, controls and compressors may be valved off during pressure testing.

1.6. MICROPROCESSOR CONTROLLER

- Each chilling unit shall be complete with a microprocessor based interactive control console in a locked enclosure factory mounted (directly on the unit), prewired with all operating and safety controls and tested.
- It will provide start, stop, safety, interlock, capacity control and indications for operation of the chiller units through alphanumeric/graphical display.
- Controls shall provide to view and change digital programmable essential set points, cause of shutdown and type of restart required.
  - i) Leaving chilled water temperature
  - ii) Percent current limit
  - iii) Remote reset temperature range
- All safety and cycling shutdowns shall be enunciated through the alphanumeric/ graphical display and consist of day, time, cause of shutdown and type of restart required.
- Cycling shutdown shall include low leaving chilled water temperature, chiller/ condenser water flow interruption, power fault, internal time clock and anti-recycle.
- Safety shutdowns shall include low oil pressure, high compressor discharge temperature, low evaporator pressure, motor controller fault and sensors malfunction.
- The default display screen shall indicate the following minimum information
  - i. Date and time

ii. Return and leaving chilled water temperatures
iii. Return and leaving condenser water temperatures
iv. Differential oil pressure
v. Percent motor rated current
vi. Evaporator &condenser refrigerant saturation temperatures
vii. Chiller operating hours (hour run) and
viii. Number of compressor starts
ix. Oil sump temperature
x. Status message

- Security access shall be provided to prevent unauthorized change of set points, to allow local or remote control of the chiller and to allow manual operation of the perforation vanes and oil pump.
- The chiller shall be provided with ports compatible with any building management system offered, to output all system operating information, shutdown/cycling message and a record of last four cycling or safety shutdowns to a remote printer (option) . The control centre shall be programmable to provide data logs to the printer at a set time interval.
- Control centre shall be able to interface with an automatic control system to provide remote chiller Start/stop; reset of chilled water temperature, reset of current limit, and status messages indicating chiller is ready to start, chiller is operating, chiller is shut down on a safety requiring reset and chiller is shut down on a recycling safety.
- The microprocessor control system shall include the interlocking of compressor motor with chilled and condenser water flows, guide vane position of compressor in case of centrifugal units and lubricating oil pump pressure.
- On initiation of start, the microprocessor control system shall check all pre-start safeties to verify that all prestart safeties are within limits. (If one is not, an indication of the fault will be displayed and the start aborted).

1.7. FACTORY TESTING

- The complete unit shall be factory tested and witnessed by 4 Client's Representatives at conditions as per Client's representative's choice for performance at the rated conditions by simulating the actual design conditions. One unit of each capacity shall be tested.
- All controls and switchgear shall be tested for proper functioning and set of design values.
- The capacity in kcal/hr (tons) shall be calculated from measurements of temperature difference and flow rate of water, in condenser and chiller. The power consumption shall be checked from current measurement of the motor. All calculated and checked results shall match the specified data within tolerances as stipulated by AHRI 550/ 590.
- All instruments and personnel for tests shall be provided by the contractor. Contractor shall inform the client about the chiller testing schedule min.10 to 15 days before the chiller is ready for factory testing.

1.8. INSTALLATION

- The complete chilling unit shall be installed over a RCC foundation and shall be adequately isolated against transmission of vibrations to the building structure. Special attention shall be paid to the alignment of the driving and driven shaft. Final alignment shall be checked at site in presence of the Engineer-in-charge using a dial indicator. Necessary foundation bolts, nuts, leveling screws etc. wherever required for mounting the unit shall be provided by the contractor.

1.9. PAINTING

- The equipment shall be supplied as per manufacturer's standard finish painting.

PART VI PART III OF TECHNICAL SPECIFICATION PACKAGE 3A: CIRCULATING WATER PUMPS

1.1. SCOPE

This chapter covers the general requirements of water circulating pumps for central air-conditioning. This includes Primary pumps, secondary pumps with VFD, condenser pumps, Hot water pump etc.

1.2. TYPE

The pumps shall be centrifugal type direct driven with 3 phase, 415 ± 10% volts, 50 Hz, A.C motor. The Primary, Condenser, Hot water pumps shall be of End suction top discharge type vertical split casing type with operating speed not exceeding 1500 rpm and Secondary pump is vertical inline pump with VFD. **The pump motor shall be energy efficient with efficiency level of IE-3.**

1.3. RATING

The pumps shall be suitable for continuous operation in the system. The head and discharge requirements shall be as specified in the tender documents. The discharge rating shall not be less than the flow rate requirement of the respective equipment's through which the water is pumped. The head shall be suitable for the system and shall take into consideration the pressure drops across the various equipment's and components in the water circuit as well as the frictional losses. The pumps offered shall be of high efficiency. The pump shall meet minimum ECBC compliance.

1.4. MATERIAL AND CONSTRUCTION

- The centrifugal pumps shall be as per manufacturer's standard. The motor starter shall be in accordance with electrical specifications. The motor shall be totally enclosed fan cooled type.
- The pump casing shall be of heavy section close grained cast iron. The casing shall be provided with air release cock, drain plug and shaft seal arrangement as well as flanges for suction and delivery pipe connections as required.
- The impeller shall be of bronze or gunmetal. This shall be shrouded type with machined collars. Wear rings, where fitted to the impeller, shall be of the same material as the impeller. The impeller surface shall be smooth finished for minimum frictional loss. Rile impeller shall be secured to the shaft by a key.
- The shaft shall be of stainless steel and shall be accurately machined. The shaft shall be balanced to avoid vibrations at any speed within the operating range of the pump.
- The shaft sleeve shall be of bronze or gunmetal. This shall extend over the full length of the seal housing. The sleeve shall be machined all over and ground on the outside.
- The bearings shall be ball or roller type suitable for the duty involved. These shall be grease lubricated and shall be provided with grease nipples/cups. The bearings shall be effectively sealed against leakage of lubricant.

- The shaft seal shall be as per manufacturer's standard and to allow minimum leakage compatible with the operation of the seal. The shaft seal shall be of adequate length and shall be packed with graphite asbestos or any other suitable material for the operating temperature. A drip well shall be provided beneath the seal.
- The pump and motor shall be mounted on a common base plate either of cast iron or fabricated from rolled steel section. The base plate shall have rigid, flat and true surfaces to receive the pump and motor mounting feet.

1.5. ACCESSORIES

Each pump shall be provided with the following accessories:-

- Pressure gauges at suction and discharge sides,
- Butterfly valves on suction and discharge, and
- Reducers, as may be required to match the sizes of the connected pipe work.
- Non-return valve at the discharge.
- Strainer at suction side.
- Strainers before the pump.

1.6. NAME PLATES

Each pump shall be provided with a name plate indicating the following details:

i. Pump type designation
ii. Pump Model
iii. Rated flow
iv. Rated head
v. Pressure rating/max temperature
vi. Rated speed

1.7. WORKING PRESSURE

Maximum allowable working pressure (MAWP) for all the pressure containing parts shall in no case be less than the maximum discharge pressure produced by the pump at shut off (including tolerances), at the max suction pressure, for the maximum impeller diameter and the maximum continuous speed.

It shall not be less than 10 kg/cm² for pumps with DN150 flanges & 16 kg/cm² for pumps with DN32 to DN250 flanges.

Pump shall be rated for minimum of 10bar working pressure.

1.8. SOUND LEVEL

Sound pressure level of the pump driver shall be max 75 dbA* measure at 2m distance from pumps for the duty points.
(* Note: Based on the motor kW and speed according to ISO 3743)

1.9. INSULATION

The thermal insulation of the pump casing for hot/chilled water circulating pumps shall be of the same type and thickness as provided for the connected pipe work and is discussed in Part XII.

1.10. INSTALLATION

- The pump and motor assembly shall be mounted and arranged for ease of maintenance and to prevent transmission of vibration and noise to the building structure or excess vibration to the pipe work.
- More than one pump and motor assembly shall not be installed on a single base or cement concrete block. The mass of the inertia block shall not be less than the combined mass of the pump and motor assembly. The inertia block shall be vibration isolated from the plant room floor by 25 mm. neoprene or any other equivalent vibration isolation fittings. Where spring mountings are used for vibration isolation, these shall be complete with leveling screws and lock nuts and shall be placed over a concrete plinth for distribution of the mass of the assembly over the plant room floor. The pump motor sets shall be properly aligned to the satisfaction of the Engineer-in-charge.

1.11. PAINTING

The pumps shall be supplied with the manufacturer's standard finish painting.

1.12. PUMP & MOTOR SELECTION

I. The pump(s) selected shall conform to Preferred Operating Region (POR) unless otherwise approved by the engineer.
II. The pumps shall be factory manufactured, assembled and hydrostatically tested as per Hydraulic Institute standards in an ISO 9001 approved facility.
III. Secondary pump Motor should be of variable frequency drive compatible.
IV. Motor should be selected as non-over-loading type.

1.13. INSPECTION & TESTING

Before effecting delivery of the equipment, following inspections and tests as per relevant IS standards shall be carried out. For Pumps:

I. Hydrostatic Testing
II. Performance Test (Single point / Duty point)
III. Dynamic balancing for pump impeller.

1.14. VARIABLE SPEED SECONDARY PUMPING SYSTEM

It shall consist of following item:

a. Individual system components
b. Pump logic control panel
c. Variable frequency drive(VFD)
d. Differential pressure transmitters(DPT)
e. Method of operation

Submittals shall consist of the following

a. Pump data sheets

b. System summary sheet
c. General arrangement drawing of the control panel indicating dimensions, required clearances and location of the field connection.

Submittals must be project specific. General submittals will not be accepted.

1.15. COMPONENT OF PUMP LOGIC CONTROL PANEL

I. To supply and install Multi Pump Controller as per the design
II. The control system should include the Pump logic controller, Variable frequency drive(s) and Differential pressure transmitters as indicated in the design
III. Pump logic control panel should house dedicated Multi Pump Controller,
IV. Variable frequency drive(s) and associated switchgears
V. Pump logic controller, Variable frequency drive(s), Differential pressure transmitters and related equipment shall be installed by the mechanical contractor as shown in the design
VI. Input power wiring to the pump logic control panel and the output wiring to the motors shall be the scope of electrical contractor and to be done as indicated in the electrical drawings submitted for the specific project
VII. Low voltage wiring for the Building Management System to be done by the BMS contractor from the pump logic control panel to the IBMS system

1.16. SPECIFICATION

Pump Logic Controller

I. Multi Pump Controller shall be listed by and bear the label of Underwriter's Laboratory Inc. (UL). The controller shall be specifically designed for variable speed pumping applications
II. Pump logic controller in built in Variable frequency drives are not accepted.
III. Logic controller should be external to the drives used in the system
IV. Multi Pump Controller shall have programs to safeguard the system against the following conditions
    - Pump
    - flow
    - surges
    - System
    - Hunting

V. Multi Pump Controller shall be capable of receiving multiple analog input signals from zone differential pressure transmitters as indicated in the design. Multi Pump Controller will then select the analogue signal that has deviated most from its set point. The selected signal will then be used as the process input value for the hydraulic stabilization function.

VI. Multi Pump Controller shall be capable of controlling up to six pumps in parallel
VII. Multi Pump Controller shall be capable of accepting an additional analog input signal from a flow sensor. This input shall be used for the end of curve protection. Instantaneous Flow value should be displayed in the front page. Cumulative Flow data's should be logged into Multi pump controller.
VIII. Multi Pump Controller shall be capable of accepting 7 different set points activated through either clock program or individual digital inputs
IX. Multi Pump Controller shall be capable of accepting additional analog input as external set point influential signal to vary the primary analog input signal. This external set point influential signal shall be user selectable from various types of signals like ambient temperature signal or like
X. Multi Pump Controller shall have program function to accept the pump curve data for optimizing the system performance in terms of energy consumption for the pump being

controlled

XI. The hydraulic stabilization program shall utilize a proportional-integral control function. The proportional-integral values shall be user adjustable in the Multi Pump Controller over a finite range

XII. Multi Pump Controller shall be self-prompting and all alarm messages shall be displayed in plain English. The operator panel shall have the following features:

- Multi fault memory and recall of last 24 faults with time stamping
- Red fault light with related alarm message on default screen with graphical representation of the fault
- Soft touch membrane keypad switches

XIII. Multi Pump Controller shall have a display screen size of minimum 320 pixels X 240 pixels VGA display with backlight. Current status of settings and measured values are to be displayed in the default screen

- Multi Pump Controller shall have an installation wizard to enable the user to configure the system with minimum assistance
- Multi Pump Controller shall have minimum 2 level password protection to safe guard the settings against unwanted/unauthorized changes
- Display should have menu driven function for the operation easiness
- Multi Pump Controller shall be capable of performing the following pressure boosting function:
- Low suction pressure cut out to protect the pumps against operating with insufficient suction pressure
- High system pressure cutout to protect the piping system against high-pressure conditions

XIV. The following communication features shall be provided to the BMS

- Remote start/stop of the VSPS through potential free contact from BMS
- Individual pump start/stop/trip status from VSPS through potential free contact to BMS

XV. The following communication features shall be provided to BMS system via RS-485 port utilizing Mod bus protocol

- Individual analog input
- Individual pump/VFD on/off status System percent reference
- System start/stop command System operating mode Individual pump kW consumption Individual pump operating hours
- Individual pump running speed in Hz/percentage reference System flow, when optional flow sensor is provided

XVI. Multi Pump Controller shall have on board Ethernet port for connecting the VSPS to BMS. If given static IP address, Multi Pump Controller should be accessible over Intranet or Internet.

1.17. VARIABLE FREQUENCY DRIVE

I. The variable frequency drive(s) shall be pulse width modulation (PWM) type, microprocessor controlled design

II. VFD, including all factory-installed options, is tested to UL standard 508. VFD shall also meet C-UL and be CE marked and built to ISO 9001:2000 standards
III. VFD shall comply EMC directives as per IEC 61800-3:2004, category C1 with 50 meter motor cable (for power less than or equal to 90 Kw) & category C2 with 50 meter motor cable (for power more than 90 Kw)
IV. VFD shall be housed in IP21 enclosures for indoor applications. Wall mounted/VFDs with plastic enclosures shall not be acceptable. For outdoor applications, VFDs shall be housed in IP 54 enclosure.
V. VFD shall employ an advanced sine wave approximation and voltage vector control to allow operation at rated motor shaft output speed with no derating. This voltage vector control shall minimize harmonics to the motor to increase motor efficiency and life. Power factor shall be near unity regardless of speed or load.
VI. VFD shall have balanced DC link chokes to minimize power line harmonics.
VII. VFDs without a DC link choke shall provide a 3% impedance line reactor
VIII. Automatic motor adaptation (AMA) algorithm shall be available in the VFD. This feature shall allow for automatic adaptation of drive to meet the characteristics of the motor to have increased efficiency leading to additional energy savings. AMA feature should be able to configure without disconnecting the motor from the VFD
IX. Output power switching shall be done without interlocks or damage to VFD
X. VFD shall be capable of displaying the following data in plain English via 40 character alphanumeric display:
    - Frequency
    - Voltage
    - Current
    - Kw per hour consumption
    - Running hours
    - Run mode(remote/local) Active power

a. VFD(s) shall be warranted for a period of 18 months.

1.18. DIFFERENTIAL PRESSURE TRANSMITTERS

Differential pressure transmitters shall be field mounted and shall transmit an isolated 4-20mA DC signal indicative of process variable to the pump logic controller via standard three wire 24DC system.

Unit shall have stainless steel wetted parts with two 7/16" process connections. It shall be protected against radio frequency interference and shall have water tight, IP 55 electrical enclosure. Sensor should be capable of withstanding a burst pressure of 25 bar. Accuracy shall be within 2.5% BFSL

PART XV: AIR COOLED HEAT PUMP

1.19. EQUIPMENT

The Air Cooled scroll heat pump having multi compressors and circuits machine shall be factory assembled & tested. The heat pump comprising of Scroll Compressors, direct driven with Electric Motor, Air-Cooled Condenser, Plate type heat pump, inter connecting refrigerant piping, microprocessor based control panel, all safeties and controls including first charge of refrigerant & compressor oil.

1.20. UNIT CONSTRUCTION:

Unit base frame shall be constructed of 100 to 200mm rolled steel channel sections welded and bolted to form rigid load bearing framework to support all major unit components and safe lifting platform. Frame shall be sand blasted after welding and finished with corrosion resistant primer and air drying epoxy based enamel. Condenser coil frameworks, cabinet and control center cabinet shall be of heavy gauge galvanized sheet steel with oven baked powder coating capable of withstanding 500 hour salt spray test in accordance with A.S.T.M.-117 Standard.

The unit shall be complete with all components i.e. compressor motor, heat pump, inter connecting, control panel, refrigerant piping duly insulated, valves, microprocessor control panel with isolator, associated safeties, sensors duly wired and gas & oil charged, vibration isolators should be provided below compressor.

1.21. QUALITY ASSURANCE:

The Air Cooled Heat Pump shall be designed, manufactured and tested in a facility with a quality assurance system certified ISO 9001 and an environment management system certified ISO 14001.

Thermodynamic performances shall be in accordance and sound levels in accordance with ISO 9614 standards.

All units shall undergo a complete run test in the factory before shipment.

1.22. PERFORMANCE

The heat pump should be tested in factory for its satisfactory performance at full load capacities. Test certificate should be provided along with heat pumps for its performance confirmation at designed parameters. The heat pump shall be paint finished as per manufacturers standard.

1.23. COMPRESSOR

- The compressor shall have Scroll Hermetically sealed compressor. Suitable for using refrigerant R407a/R410 a
- Air Cooled Heat Pump shall be Multiple Compressor and Refrigerant circuits.
- The compressor shall be suitable for safe operation upto a speed of 3000 RPM for 50 Hz operation.
- The compressor housing shall be of high grade cast iron, machined with precision, to provide a very close tolerance between the rotor(s) and the housing.
- The rotor(s) shall be mounted on antifriction bearings designed to reduce friction and power input. There shall be multiple cylindrical bearings to handle the radial and axial loads.
- There shall be oil pump or other means of differential pressure inside the compressor for forced lubrication of all parts during startup, running and during shut down. An oil sump header shall be provided in the casing.

The electrical motor driving the compressor shall be squirrel cage induction motor class `F' insulation, totally enclosed refrigerant cooled with full stream 120 micron efficiency suction gas filter for semi-hermetic unit. The motor shall be suitable for operation on 415 + 10% volts, 3 phase, 50 HZ alternating current supply, Synchronous speed of the motor shall not exceed 3000 RPM. Continuous BHP rating of the motor shall not be less than the maximum power requirement of the

compressor and drive under specified design conditions . The motor shall be totally enclosed with IP-54 protection. Motor protection during over current shall be provided through winding temperature sensor the current sensing each phase through microprocessor. The motor shall be protected against overload according to current drawn, loss of phase, pipe and voltages by

1.24. INTERLOCKING

- Differential pressure switch in the hot water line(s) shall be provided
- Air flow switch in the condenser fan discharge shall be provided in air cooled condenser.
- Anti-freeze thermostat in case of heat pump.
- Condenser fan of Air Cooled Condenser.
- Hot water pump for hot water system
- Automatic defrosting arrangement for condenser coil.

1.25. CONTROL CENTER:

Shall be mounted on one end of the unit (opposite to that of the cooler connections) and shall comprise an enameled steel enclosure to IP-54 with separate power (high voltage) section with door interlocked isolators and a control (low voltage) section, housing microprocessor, LED display and safety controls. All doors to be key lockable. Power Sections shall contain closed transition star delta starters for each compressor and fan contactors all with thermal and current overloads for each phase. For applications in design ambient temperatures above 46ºC(115ºF) the Control Center shall be provided with an independent cooling system to project the operational and safety controls from excessive temperature rise(sun baking).

1.26. CONTROLS, SAFETIES AND DIAGNOSTICS

1.26.1. CONTROLS:

Heat pump controls shall include the following minimum requirements

a. Microprocessor with permanent memory (battery back up system not accepted).
b. Separate terminal block for supply of power and controls.
c. Separate supply to serve all controllers, relays and control components as required by manufacturer.
d. ON/OFF control switch.
e. Replaceable solid state controllers.
f. 4 way reversible valve.
g. Pressure sensors and transducers to measure suction, intermediate economizer, discharge and oil pressures. Thermostats to measure hot entering and leaving fluid temperatures and outside ambient temperatures.

1.26.2. CONTROL FUNCTIONS:

Unit control functions shall be included the following

a. Automatic circuit lead/lag.
b. Capacity control based on leaving hot fluid temperature Limiting the hot fluid temperature pull down rate at start-up to an adjustable range of 0.2ºF to 2ºF (0.01. to 1.1ºC) per minute to prevent excessive demand spikes at start-up.
c. One day time schedule

d. Leaving heat pump fluid temperature reset from fluid and outside air temperature
e. Hot water pump start/ stop control.
f. Heat pump control for parallel heat pump applications without addition of hardware modules and control panels(requires thermostats).
g. Timed maintenance scheduling to signal maintenance activities for strainer maintenance activities.

1.27. AIR COOLED CONDENSERS

- **Material and Construction**

i. The condenser coil shall be fabricated of seamless hard drawn copper tubes with mechanically bonded aluminium fins of 0.18 mm minimum thickness, fins spacing ranging from 3 to 5 fins per cm. The minimum wall thickness of tubes shall be 0.5 mm.
ii. The coil shall normally be 4 rows deep as per manufacturer standards.
iii. The condenser shall be designed so as to hold 1.25 times the refrigerant charge in the system during the idle periods.
iv. The coils shall be arranged in V shape with minimum 500 angle between coils.
v. Suitable number and capacity of propeller type fans with Aerofoil blades shall be provided for moving the air through the entire condenser coils. For more uniform flow over the condenser coil, the condenser shall be designed on the draw through principle. The air velocity over the condenser coil shall be maintained below 200 mpm maximum.

- **Connections and Accessories**

The following connections and accessories shall be provided on the condenser and conforming to Section “Refrigeration

Piping” where applicable: -

a) Hot water inlet and liquid outlet connections. The liquid outlet connections shall be provided with isolating valves,
b) Pressure relief device, Pressure Testing

The Air Cooled Heat Pump shall be Shell and Tube Direct expansion type.

a) The Air Cooled Heat Pump shall match the compressor capacity as specified in the tender specifications for 11 deg C temperature drop of water through heat pump.
b) The fouling factor shall be 0.00018 hr. sq.mtr. degree C temperature difference/K. Cal. unless otherwise specified in the tender specifications.
c) The end plates of Air Cooled Heat Pump shall be made of MS of thickness not less than 25mm.
d) The shell of the Air Cooled Heat Pump shall be made of MS of thickness not less than 8mm with electric fusion welded seams.
e) The tubes shall be of seamless, hard drawn copper with a minimum tube wall thickness of 0.71 mm for plain tubes & minimum 0.63mm at the root of fins.

f) The tubes shall be plain for internally grooved as per manufacturer's design.
g) The tubes shall be rolled into grooves in the tube sheets and flared at ends.
h) The DX type heat pumps shall be provided with adequate number of properly spaced baffles so that the water passes through the tube bundle many times.
i) The Air Cooled Heat Pump shall be smooth finished with one coat of zinc chromate primer before the insulation is applied.
j) The Air Cooled Heat Pump shall be sand blasted from both inside & outside (before insertion of tubes).

The Air Cooled Heat Pump Shell shall be provided following Connections and Accessories:

a. Refrigerant inlet and outlet connections with Isolation valves.
b. Liquid Line solenoid valve, or pilot solenoid valves as required.

1.28. INSULATION :

The Air Cooled Heat Pump shall be provided with minimum 19 mm thick nitrile sheet insulation.

1.29. INSTALLATION

The Air Cooled Heat Pump shall be installed on RCC foundation with adequate isolators against transmission of vibration. Water plumbing and electric cabling should be provided as per tender specifications.

1.30. PAINTING

The Air Cooled Heat Pump shall be supplied as per manufacturer's standard finishing panting.

PART XVI: PLATE TYPE HEAT EXCHANGER

The plate heat exchanger shall consist of a pack of corrugated metal plates with portholes for the passage of the two fluids between which heat transfer will take place. The plate pack shall be assembled between a frame plate and a pressure plate and threaded by tightening bolts. The plates shall be fitted with a gasket which seals the channel and directs fluids into alternate channels. The number and size of the plates shall be determined by the flow rate, physical properties of the fluids, pressure drop and temperature difference. The plate corrugations shall promote fluid turbulence and support the plates against differential pressure.

The plates and the pressure plate shall be suspended from an upper carrying bar and located by a lower guiding bar both of which shall be fixed to the support columns. Connections shall be located in the frame cover, or if either or both fluids make more than a single pass within the unit, the frame and pressure plates.

Heat Exchanger shall be provided with valves on the inlet and outlet of the primary and secondary sides. Pressure gauges and temperature gauges shall be provided on the inlets and outlets on both the primary and secondary sides.

Where 2 heat exchangers are connected in parallel, a balancing valve shall be provided to act as a bypass in the event of one heat exchanger being taken down for maintenance.

Strainers with valves and bypass shall be provided on the inlets of the primary and secondary sides of the heat exchanger.