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## 2 CENTRAL REFRIGERATION & AIR CONDITIONING EQUIPMENT

### 2.1 GENERAL

#### 2.1.1 Scope

1 This Part specifies the requirements of the design manufacture, construction installation testing and commissioning of central refrigeration and air conditioning equipment.

2 Related Sections and Parts are as follows:

This Section

Part 1 ..... General

Section 1 General

Section 10 Instrumentation, Control and Automation

Section 16 Structural Metalwork

Section 21 Electrical Works

#### 2.1.2 References

1 The following standards and organisations are referred to in this Part:

ARI Standard 210

ARI Standard 450

ARI Standard 480

ARI Standard 550

ASHRAE

#### 2.1.3 Products

1 Materials and equipment furnished under these specifications shall be standard catalogue products of manufacturers regularly engaged in production of such materials or equipment and shall be the manufacturer's latest standard design complying with the specification requirements and meets and capacity indicated in the Project Documentation. Where two or more units of the same class of equipment are required, these units shall be produces of a single manufacturer. However, the component parts of the system need not be the products of the same manufacturer.

2 Each major component of equipment shall have the manufacturer's name address, and catalogue number on a nameplate securely affixed in a conspicuous place; the nameplate of a distributing agent only will not be acceptable.

## 2.2 PACKAGE CHILLERS

### 2.2.1 Air Cooled Package Chillers

1 The air-cooled packaged chillers shall be factory assembled complete with piping and wiring and shipped with refrigerant charge and oil change.

2 The only required field connections shall be the system water piping, electrical power supply and external control cables when required.

3 The units shall be provided with lifting lugs for easy site handling.

- 4 All components shall be mounted on a continuous structural steel base resting on vibration isolators. The isolators shall be proportional for the loads at all points under the unit.
- 5 The chiller control and starters shall be housed in a weather proof and dust proof enclosure with lockable door. The minimum rating for the enclosure shall be IP55.
- 6 The system shall be designed and supplied with the refrigerant as specified in the Project Documentation.
- 7 The power supply cables and protective devices shall be rated as recommended by the manufacturer.
- 8 The chiller shall be selected to meet the capacities as detailed in the Project Documentation.
- 9 The compressor type shall be as specified in the Project Documentation.
- 10 The chiller shall be in accordance with the latest QGEWC regulations.
- 11 The manufacturer's details should be followed wherever possible.
- 12 Adequate space shall be provided for operating and maintenance purpose.

#### **2.2.2 Water Cooled Package Chillers**

- 1 The water-cooled packaged chillers shall be factory assembled complete with piping and wiring and shipped with refrigerant charge and oil change.
- 2 The associated condensor capacity shall be matched with the capacity of the chillers.
- 3 The only required field connections shall be the system water piping, electrical power supply and external control cables when required.
- 4 The units shall be provided with lifting lugs for easy handling.
- 5 All components shall be mounted on a continuous structural steel base resting on vibration isolators. The isolators shall be proportional for the loads at all points under the unit.
- 6 The chiller control and starters shall be housed in a weather proof and dust proof enclosure with lockable door. The minimum rating for the enclosure shall be IP55.
- 7 The system shall be designed and supplied with the refrigerant as specified in the Project Documentation.
- 8 The power supply cables and protective devices shall be rated as recommended by the manufacturer.
- 9 The chiller shall be selected to meet the capacities as detailed in the Project Documentation.
- 10 The compressor type shall be as specified in the Project Documentation.
- 11 The chiller shall be in accordance with the latest QGEWC regulations.
- 12 The manufacturer's details should be followed wherever possible.
- 13 Adequate space shall be provided for operating and maintenance purpose.

### **2.3 PACKAGED AIR CONDITIONERS**

#### **2.3.1 Air Cooled Packaged Air Conditioning Units**

- 1 The air-cooled packaged Air Conditioning Units shall be factory assembled complete with piping and wiring and shipped with refrigerant charge and oil change.
- 2 The only required field connections shall be the system ductwork, electrical power supply and external control cables when required.

- 3 The units shall be provided with lifting lugs for easy site handling.
- 4 All components shall be mounted on a continuous structural steel base resting on vibration isolators. The isolators shall be proportional for the loads at all points under the unit.
- 5 The Packaged Air Conditioning Units controls and starters shall be housed in a weather proof and dust proof enclosure with lockable door. The minimum rating for the enclosure shall be IP55.
- 6 The system shall be designed and supplied with the refrigerant as specified in the Project Documentation.
- 7 The power supply cables and protective devices shall be rated as recommended by the manufacturer.
- 8 The Packaged Air Conditioning Units shall be selected to meet the capacities as detailed in the Project Documentation.
- 9 The compressor type shall be as specified in the Project Documentation.
- 10 The Packaged Air Conditioning Units shall be in accordance with the latest QGEWC regulations.
- 11 The manufacturer's details should be followed wherever possible.
- 12 Adequate space shall be provided for operating and maintenance purpose.
- 13 Minimum Equipment Efficiency:
  - (a) Cooling equipment shall meet or exceed the minimum efficiency requirements mentioned in the table below. Equipment not listed here shall comply with ASHRAE 90.1 – 2007, 6.4.1
  - (b) The efficiency shall be verified through certification under an approved certification program or if no certification program exist the equipment efficiency ratings shall be supported by data furnished by the manufacturer

Package Air Conditioners Minimum Efficiency

Equipment Type	Minimum EER(	Rating Outdoor	Test Standard
Single Package Air Conditioners	9.0	35°C ( 95°F)	ARI 210/240
Single Package Air Conditioners	8.9	35°C ( 95°F)	ARI 340/360
Single Package Air Conditioners	8.6	35°C ( 95°F)	ARI 390

### 2.3.2 Water Cooled Packaged Air Conditioning Units

- 1 The water-cooled packaged Air Conditioning Unit shall be factory assembled complete with piping and wiring and shipped with refrigerant charge and oil change.
- 2 The associated condensor capacity shall be matched with the packaged Air Conditioning Units requirements.
- 3 The only required field connections shall be the condensor system water piping ductwork, electrical power supply and external control cables when required.

- 4 The units shall be provided with lifting lugs for easy site handling.
- 5 All components shall be mounted on a continuous structural steel base resting on vibration isolators. The isolator shall be proportional for the loads at all points under the unit.
- 6 The Packaged Air Conditioning Units controls and starters shall be housed in a weather proof and dust proof enclosure with lockable door. The minimum rating for the enclosure shall be IP55.
- 7 The system shall be designed and supplied with the refrigerant as specified in the Project Documentation.
- 8 The power supply cables and protective devices shall be rated as recommended by the manufacturer.
- 9 The Packaged Air Conditioning Units shall be selected to meet the capacities as detailed in the Project Documentation.
- 10 The compressor type shall be as specified in the Project Documentation.
- 11 The chiller shall be in accordance with the latest QGEWC regulations.
- 12 The manufacturer's details should be followed wherever possible.
- 13 Adequate space shall be provided for operating and maintenance purpose.
- 14 Minimum Equipment Efficiency:
  - (a) Cooling equipment shall meet or exceed the minimum efficiency requirements mentioned in the table 22.2.3.2a. Equipment not listed here shall comply with ASHRAE 90.1 – 2007, 6.4.1
  - (b) The efficiency shall be verified through certification under an approved certification program or if no certification program exist the equipment efficiency ratings shall be supported by data furnished by the manufacturer

Water Chillers Minimum Efficiency

Equipment Type	Minimum	Minimum IPLV	Test Standards
Air Cooled Chiller All Capacities	2.8	3.0	ARI 550/590
Centrifugal Water Cooled Chiller < 530 kW ( 150 Tons )	5.0	5.2	ARI 550/590
Centrifugal Water Cooled Chiller ≥ 530 kW and < 1050 kW ( ≥ 150 Tons and < 300 Tons )	5.5	5.9	ARI 550/590
Centrifugal Water Cooled Chiller ≥ 1050 kW ( 300 Tons )	6.1	6.4	ARI 550/590
Reciprocating Compressor Water Cooled Chiller All Capacities	4.2	5.0	ARI 550/590
Rotary Screw and Scroll Compressor Water Cooled Chiller < 530 kW ( 150 Tons )	4.4	5.2	ARI 550/590

Rotary Screw and Scroll Compressor Water Cooled Chiller ≥ 530 kW and < 1050 kW ( ≥ 150 Tons and < 300 Tons )	4.9	5.6	ARI 550/590
Rotary Screw and Scroll Compressor Water Cooled Chiller ≥ 1050 kW ( 300 Tons )	5.5	6.1	ARI 550/590

Note: For centrifugal chiller operates at temperatures different from the ARI 550/590 rating condition, refer ASHRAE 90.1 – 2007.6.4.1.2

## 2.4 COMPRESSORS

### 2.4.1 General

- 1 Compressors shall be tested and rated in accordance with ISO Standard 917 or equivalent and guaranteed to operate at published capacities.

#### 1. Centrifugal Compressors

- 2 Shall be serviceable, hermetically sealed requiring no shaft seals, or required stages and consisting of the following:

#### 3 Impeller

- (a) shall be made of non-ferrous, cast aluminium alloy or approved alloy or approved equivalent material
- (b) shall be dynamically and statically balanced after fabrication and tested minimum 25 % overspeed
- (c) shall be sufficiently rigid to prevent any vibration at operating speed
- (d) the impeller operating speed shall be below first critical speed
- (e) two-stage impellers shall be connected to the motor by a gear train.

#### 4 Casing

- (a) all external parts shall be constructed of steel, high-strength ductile iron casting or approved equivalent material
- (b) O-ring gaskets shall be used between casings

#### 5 Lubrication System

- (a) shall be of the forced-feed type and shall provide oil at the proper temperature to all parts requiring lubrication
- (b) on units providing forced-feed lubrication prior to starting, a differential oil pressure cut-out interlocked with the compressor starting equipment shall allow the compressor to operate only when the required oil pressure is provided to the bearings
- (c) the lubrication system shall be complete with the following:
  - (i) pressure relief valves
  - (ii) oil piping
  - (iii) gauges
  - (iv) thermometers

- (v) oil pressure switches
- (vi) oil cooler designed for use with chilled water, condenser water or directly cooled by refrigerant
- (vii) oil filter
- (viii) oil reservoir
- (ix) oil heater, of a size to prevent oil from absorbing refrigerant during shut-down, thermostatically controlled. It shall not be required if the system is designed to prevent the refrigerant from contact with the oil and guaranteed not to absorb oil during prolonged shutdowns.

6 Capacity Control

- (a) the compressor shall be provided with temperature or pressure-actuated capacity reduction to the pre-rotation vane or suction damper type to provide automatic capacity modulation from 100 to 10 percent capacity
- (b) hot gas by-pass automatically controlled shall be provided if required to maintain stable operation.

7 Gear Transmission

- (a) the gear transmission shall be of the self-aligning type, having sufficient capacity to transmit the maximum compressor load under all operating conditions without objectionable noise or vibration
- (b) the gears shall be double helical type, and the teeth shall be continuously flooded with filtered oil
- (c) the bearings shall be of the pressure lubricated type, and suitable for both gears and pinions.

8 Motors

- (a) the motors shall be of the hermetically sealed, refrigerant-cooled type, the winding specifically insulated for use with refrigerant
- (b) the motors shall be designed for continuous operation at nameplate rating, provided with a load limit mechanism and solid state sensors in motor winding to provide positive thermal and current overload protection
- (c) the motor starter shall be contained in a weatherproof enclosure, completely pre-wired to the motor.

9 Lifting device

- (a) An eyebolt or approved equal device to permit lifting compressor shall be included:

**2.4.2 Reciprocating Compressors**

1 Clarification

- (a) reciprocating compressors may be of the open or semi-hermetic serviceable type, or of the welded hermetic type, with the motor and compressor contained within the same pressure vessel and the motor shall be in contact with the refrigerant
- (b) reciprocating compressors shall be capable of operating at partial load conditions a continuous operating down to the lowest step of unloading
- (c) reciprocating compressors shall be designed for use with a fluorocarbon refrigerant.

2 Drivers and Starters

- (a) open type compressor

- (i) open type compressor may be driven by an external motor, directly through a coupling or indirect through a belt-drive or gearbox. Starting of open type compressors shall be across the line or in accordance with the manufacturer's recommendations.
- (b) hermetic type compressors
  - (i) hermetic type compressors shall be direct driven by either a standard motor and across the line starter or a reduced voltage starter
  - (ii) the motor insulation and rubber materials shall be compatible with refrigerant and oil mixtures.

### 3 Lubrication System

- (a) reciprocating compressors shall be provided with a forced feed lubrication system by means of eccentric gear-pump, vane pump or piston pump. The lubrication pumps shall be equipped with bleed provisions on the discharge side to vent the pump and to prevent excessive pressures, and with a strainer or oil filter in the suction line
- (b) small reciprocating compressors may be lubricated by a splash. The crankcase shall be filled with oil up to the bottom of the main bearings or to the middle of the crankshaft main bearings. At each revolution the crankshaft or the eccentric shall splash the oil around the inside of the compressor.

### 4 Features: Reciprocating compressors shall be provided with the following features:-

- (a) capacity control for unloaded start and noted capacity steps
- (b) suction strainer
- (c) crankcase heater
- (d) hot gas muffler
- (e) replaceable bearings
- (f) suction and discharge stop valves
- (g) oil level sight-glass
- (h) suction and discharge refrigerant gas pressure gauges
- (i) high and low gas pressure adjustable safety control
- (j) vibration isolators
- (k) oil safety switch

## 2.4.3 Rotary Compressors

### 1 Description

- (a) rotary compressors shall be designed and rated in accordance with ASHRAE recommendations or equivalent
- (b) rotary compressors used for household refrigerators using R-12 refrigerant or for window type air conditioners using R-22 refrigerants shall be of the rolling piston or rotating vane type
- (c) rotary compressors shall be designed to have a high volumetric efficiency and an acceptable sound level, particularly where they are intended for use in homes
- (d) rotary compressors shall have a rigidly constructed shaft to meet deflection allowances and cast iron bearing with a hardened, steel journal rotary compressors shall have tow blades, designed for maximum reliability, and constructed to limit the deflection under load to no more than 0.05 mm per/m of blade length. The slots shall be hardened, steel journal

- (e) the journal shall be ground round and honed or polished
- (f) rotary compressor shall be equipped with a check valve at the suction inlet to close automatically when the compressor stops to prevent high pressure gas from migrating into the evaporator.

2        Lubrication System

- (a) rotary compressors shall be provided with a good lubricating system to circulate an ample supply of clean oil to all working surfaces, bearings, blades, slots, and seal faces
- (b) oil grooves shall have outlets to permit free flow of the excess lubricant, and to flush particles into the sump.

3        Drivers and Starters

- (a) rotary compressors shall be equipped with a standard split-phase motor or a permanent split-capacitor motor in accordance with the manufacturer's recommendations.

## 2.5        CONDENSERS

### 2.5.1      Air Cooled Condenser

- 1        Air-cooled condenser shall be rated to ARI Standard 210 or equivalent and guaranteed to operate at published capacities.
- 2        Air-cooled condenser shall be suitable for remote installation in a weather protected casing, or for use with self-contained air conditioners.
- 3        The air-cooled condenser shall be a complete factory-fabricated and factory assembled unit consisting of the following:
- 4        Coils shall be as follows:
  - (a) the tubes shall be Seamless copper
  - (b) the fins: shall be Aluminium
  - (c) condenser coils for installation in salt air or corrosive atmosphere shall be constructed of aluminium alloys tubes and brazed fins.
  - (d) All condenser coils shall be provided with protective coating as specified in the Project Documentation with five years guarantee.
- 5        Fans
  - (a) propeller type or centrifugal type directly connected to the motor shaft or indirectly connected to the motor by means of a V-belt drive
  - (b) belt drives shall be completely enclosed within the unit casing or equipped with a guard
  - (c) fans shall be statically and dynamically balanced
- 6        The Housing shall consist of:
  - (a) the frame and supports shall be constructed of galvanized angle iron
  - (b) the casing shall be constructed of hot dip galvanized steel
  - (c) vibration isolators
- 7        Motors
  - (a) totally enclosed, fan-cooled for all installations where motor is exposed to the weather or in an air stream.

- (b) open drip-proof type within an enclosure to be fully protected from the weather
  - (c) motor starter shall be a magnetic across the line type within a watertight enclosure
  - (d) thermal protection shall be of the manual or automatic reset type
- 8 Condenser Controls. One of the following methods of controlling condensing temperature shall be provided:
- (a) air volume control
    - (i) thermostat or pressure switch type with a control relay shall be provided to modulate fan discharge dampers and maintain adjustable pre-set refrigerant condensing temperatures
    - (ii) a solid state variable speed fan motor controller may be provided in lieu of volume dampers to control the airflow over the coil
    - (iii) a condenser with multiple fans may be provided with a fan cycling control to cycle one of two, or two of three fans act in response to outdoor ambient temperatures.
  - (b) condenser flooding. On a decrease in refrigerant discharge pressure, a head pressure sensitive valve shall start to throttle the liquid flow from the condenser outlet and thereby increase the amount of liquid in the condenser. The liquid leaving the condenser shall be reheated by hot gas to increase the temperature of the sub-cooled liquid sufficiently to maintain a balanced pressure temperature relationship in the receiver.
- 9 Liquid Receiver
- A liquid receiver of a minimum capacity of 125 % of the refrigerant charge shall be supplied and connected to the refrigerant circuit, complete with
- (a) inlet and outlet service valves
  - (b) charging connections
  - (c) relief valve
- An air-cooled condenser may be used for refrigerant storage in lieu of separate receiver, provided that the condenser storage capacity is 20 percent in excess of the fully charged system.
- 2.5.2 Water Cooled Condenser**
- 1 Water cooled condenser shall be rated in accordance with ARI Standard 450 or equivalent and guaranteed to operation at published capacities. Fouling factor shall be a minimum of 0.000088 in accordance with ARI Standard 550.
- 2 Shells and Tubes
- (a) the welded steel shells and copper tubes shall be rolled into grooved holes in tube sheets
  - (b) the tube shall be removable without affecting tube sheet or causing leakage of adjacent tubes
  - (c) the tube sheets shall be made of carbon steel suitable for withstanding working pressure
  - (d) intermediate tube sheet supports shall be installed prevent tube vibration.
- 3 Water Boxes

- (a) the water boxes shall be made of high grade carbon steel or material of equivalent strength and suitable for the specified pressure
- (b) water boxes shall have the following:
  - (i) separable cover with eyebolt
  - (ii) vent and drain connections
  - (iii) connected to shell in a manner to prevent shell exposure to water
  - (iv) flanged water nozzles for main piping connections
  - (v) tappings for thermometers, control bulbs and gauges
  - (vi) piping connections shall be arranged to permit cleaning without removing the piping.

4 Baffles

- (a) to prevent direct impingement of refrigerant gases upon tubes
- (b) to uniformly distributes gas refrigerant over length of condenser
- (c) non-corrodible baffle sheet to segregate and collect non-condensable gases for compression purging. Purge connections non-corrodible materials
- (d) purge and recovery unit connection to remove non-condensable gases and water vapour.

5 Condenser Controls capacity control by means of restricting water flow through condenser using one of the following two methods.

- (a) two-way throttling valve to maintain condensing pressure in once-through applications utilising city or well water
- (b) three-way valve to direct water around the condenser as the condensing temperature is lowered. This system is most often used with a cooling tower.

**2.5.3 Evaporative Condensers**

- (a) draw through or blow-through type sized and installed in accordance with ASHRAE recommendations consisting of the following:
  - (i) galvanized steel casing and basin with overflow and drain connection
  - (ii) frame made of angle iron
  - (iii) removable galvanized steel eliminators
  - (iv) access panels of adequate size for maintenance
  - (v) make-up water float valve
  - (vi) fan with adjustable pitch belt drive with belt guard and weather protection cover for motor. Fan shaft shall be epoxy coated, zinc chromatised or approved equal finish
  - (vii) condensing coil with a liquid sub-cooler made of hot-dip galvanized steel, copper tubing or iron pipe
  - (viii) recirculating pump factory installed and piped to bronze non-clog spray nozzles
  - (ix) galvanized steel piping
  - (x) flanged collars for duct connections for indoor installations
  - (xi) water bleed system

- (xii) capacity control can be obtained as a modulating discharge damper to vary air flow across the coil or a multi-speed fan motor to vary airflow across the coil.

#### 2.5.4 Dual Condensing

- 1 Dual condensing systems shall consist of a heat rejection and an auxiliary heat recovery condenser to extract heat from refrigerant and reject some of that heat to a warm circuit.
- 2 Heat Rejection Condenser. The heat rejection condenser shall be of the water-cooled condenser type, as described in clause 2.9 or of the air-cooled condenser type as described in the Clause 2.8.
- 3 Heat recovery Condenser. The heat rejection condenser shall be of the water-cooled condenser type as described in Clause 2.9.

### 2.6 COOLER

#### 2.6.1 General

- 1 Cooler shall be designed and rated in accordance with ARI Standard 480.
- 2 Shell and tube type and performance is based on a fouling factor to 0.000088 for non-ferrous tubes, and 0.000176 for steel tubes, consisting of the following:-
- 3 Shells and Tubes see Clause 2.9.2.
- 4 Water Boxes
  - (a) water boxes made on high-grade carbon steel or material or equivalent strength suitable for specified pressure, provided at each end for an odd number of passes and one end for an even
  - (b) water boxes shall have the following specifications : See Clause 2.9.3.
- 5 Baffles
  - (a) to prevent direct impingement of liquid on tubes
  - (b) to distribute liquid refrigerant uniformly.
- 6 Eliminators
  - (a) non-ferrous
  - (b) to prevent liquid refrigerant from entering compressor.
- 7 Anti-freeze thermostat
- 8 Insulation with a vapour barrier

### 2.7 COOLING TOWERS

#### 2.7.1 General

- 1 Cooling towers shall be designed, constructed and rated in accordance with ASHRAE Recommendation 21 - Equipment.
- 2 Field-assembled Cooling Towers. Field assembled cooling towers shall consist of the following :
- 3 Framework
  - (a) Steel framework bolted, reinforced and interconnected so that stresses are transmitted directly to the tower foundation
  - (b) Bolts, nuts, washers and corners shall be made of hot-dipped galvanized steel

- (c) Roof framing designed for additional loads of fan, fan motors, gear-reducer if required, fan-casing, and other loads during erection or normal operation.
- 4 Casing. Casing shall be water and-air tight made of stainless steel, galvanized steel with a zinc coating or hot-dip galvanized after fabrication, as specified in the Project Documentation. Casing fastening to frames shall be by means of stainless steel hardware.
- 5 Partitions
- (a) full height of tower
- (b) water and air tight
- 6 Water Distribution
- (a) distribution system for each cell.
- (b) header system with branches, spray arm and nozzles.
- (c) nozzles made of non-clogging cast bronze or polyethylene type.
- 7 Collection Basin
- (a) made of hot-dipped galvanized steel or stainless steel one-piece, factory-welded design
- (b) overflow and cleanout
- (c) drain connector.
- 8 Access. To fan deck, gear and fan, water distribution area and basin.
- 9 Fans
- (a) propeller or centrifugal type with adjustable pulley
- (b) gear speed reducer, if required, with a stainless steel shaft, flexible coupling and extension pipe to permit filling, draining and sampling of the oil level out-side fan housing with an oil sight-glass
- (c) totally enclosed fan cooled type motor
- (d) removable wire screen, hot-dipped galvanized steel.
- 10 Vibration Eliminators. Vibration eliminators with an isolation efficiency of a minimum of 70 percent.
- 11 Corrosion Protection. Interior and exterior corrosion protection coating and lining.
- 12 Eliminators. Removable made of asbestos neoprene honeycomb or approved equal materials, and supported by galvanized steel channel sections.
- 13 Fill Material. Made of polyvinyl chloride film-type or approved equal materials supported at close centres by galvanized steel structural members.
- 14 Bleed-off and Make-up Water. The cooling tower shall be provided with a controlled bleed-off feature to minimise scale formation and to inhibit corrosion and with a make-up water connection controlled by a large-diameter seamless type copper float to maintain automatically the water level in the sump at a predetermined level.

## 2.8 PACKAGE COOLING TOWERS

### 2.8.1 General

- 1 Package cooling towers shall be factory-assembled of the counterflow through design, with centrifugal or propeller fan assemblies built completely into the pan, with all moving parts factory-mounted and aligned. The packaged cooling tower shall consist of the following:

2 Pan Section

- (a) the pan section shall consist of a steel framework and a sloped stainless steel or hot-dipped galvanized steel basin
- (b) the pan section shall be provided with access door, stainless steel strainer with perforated openings smaller than spray nozzle orifices, waste water bleed-off line with valve, and a make-up valve with a large diameter float arranged for easy adjustment.

3 Fan Assembly

- (a) the fan shall be of the propeller or centrifugal type. The housing of the fan shall have compound curve inlet rings for efficient air entry and a discharge cover within the pan to prevent water from entering the fan
- (b) the fan shaft shall be mounted in heavy-duty, grease-packed, self-aligning ball bearings
- (c) V-belt drives shall be designed for not less than 150 percent of motor nameplate horsepower. Drives and all moving parts shall be completely enclosed by removable screens made of stainless steel or hot-dipped galvanized steel.

4 Surface Section

- (a) the heat transfer section shall be removable from the pan made of stainless steel or other approved material supported in galvanized steel frame, and waveformed or honeycomb in shape for optimum heat transfer.

5 Water Distribution

- (a) water distribution shall be evenly spread over the tower's fill area through gravity or sprayhead tree, consisting of stainless steel header and removable branches with replaceable spray nozzles made of plastic or approved equal materials. The nozzles shall be held in place with snap-in rubber grommets to provide quick removal of individual nozzles or branches for cleaning or flushing.

6 Eliminators

- (a) eliminators shall be removable in easily handled sections made of stainless steel or other approved material.

7 Fan Motors

- (a) fan motors shall be of the encapsulated epoxy-insulated drip-proof type.

## 2.9 REFRIGERATION ACCESSORIES

- 1 Combination filter with a dryer in the refrigerant line, so arranged that cartridges can be replaced when the refrigerant circuit is changed.
- 2 Combination sight-glass and moisture indicator.
- 3 Solenoid valve in the refrigerant line and in the oil bleeder lines from flooded evaporators.
- 4 Expansion valve on refrigerant line at coil inlet with the bulb located immediately after the coil outlet.
- 5 Strainer in suction line on steel piping systems to protect pressure-regulating devices.
- 6 Strainer in refrigerant line to protect expansion valve.
- 7 Refrigerant charging connection in the liquid line.
- 8 Liquid suction interchange in the liquid line.

- 9 Muffler in the hot-gas line in the downward flow risers or in the horizontal lines near the compressor.
- 10 Oil trap (separator) in the discharge line.

## 2.10 MISCELLANEOUS

### 2.10.1 Water Chemical Treatment

- 1 After preliminary design, the Contractor shall submit to the Supervising Agency a complete analysis of local water or actual water samples at the site. This information shall be accompanied by a description of each system to be treated with anticipated make-up rates and other available data.
- 2 Make-up rates of chemicals and water quality requirements for each system shall be in accordance with the ASHRAE recommendations and the chemical analysis.
- 3 Water Treatment Firm
  - (a) the Contractor shall engage a water treatment firm which shall :
    - (i) supervise installation and application of water treatment
    - (ii) supply required treatment chemicals and instructions for application and control of initial cleaning of all piping systems
    - (iii) supply testing equipment and reagent
    - (iv) instruct the Contractor on installation of chemical feeding equipment before start-up
    - (v) demonstrate the proper application of treatment materials to be used, operation of feeding equipment as installed and operation of testing equipment required
    - (vi) collect samples of each treated system for analysis at laboratory and submit result, with comments
    - (vii) provide written proposals detailing services to be performed for an extended service period of one year from date of start-up.
- 4 Condenser Water System
  - (a) chemicals. Selection of treatment chemicals for the cooling tower system shall be based upon characteristics and solids content of make-up water as follows :
    - (i) chemical formulation to control corrosion and scale as directed by raw water analysis or sea water analysis where applicable and equipment operating conditions, is to be introduced to system through automatic treatment equipment
    - (ii) this formulation shall be a non-metallic blend of corrosion and scale inhibitors capable of producing desired treatment results without supplementary acid feed
    - (iii) biological fouling liquid formulation as dictated by water analysis and local environmental conditions to be slug-fed to system
    - (iv) cycles of concentration are to be maintained at a level consistent with raw water analysis and operating conditions
    - (v) biocides shall be added if significant amount of algae or slime are detected after system operation. Compounds of mercury, copper or arsenic are not permitted.
  - (b) Equipment

- (i) diaphragm chemical proportioning pump shall be furnished to pump algae inhibitors. The pump shall include suction strainer, check valve and associated piping including corporation stop injection assembly
- (ii) water meter shall be located in the cooling tower make-up line and shall be sized for combined peak flow of evaporation and bleed-off
- (iii) automatic re-set timer unit and counter-unit shall be assembled as a package to modulate chemical feed and bleed in proportion to tower make-up water
- (iv) a solenoid bleed valve and Y-strainer shall be furnished.

5 Chilled Water System

- (a) Chemicals. Treatment shall consist of a buffered nitride-based product, maintained in circulating water systems at 700 - 1000 PPM sodium nitride.
- (b) Equipment. By-pass chemical pot feeders, consisting of cast iron and steel body, easy to fill.

**2.10.2 Water Softeners**

1 Water softeners shall be fully automatic downflow, pressure-type water softeners, having capacities as indicated in the Project Documentation.

2 Piping. Piping shall be copper tubing with brass or wrought copper solder joint fittings, or as required in the Project Documentation.

3 Tank

- (a) softener tank shall be made of riveted or welded stainless steel construction in accordance with the relevant ISO Standards and/or ASME Code
- (b) the shell shall be designed and tested at 50 percent greater pressure than the working pressure
- (c) the tank and both sides of false bottoms shall be lined with plastic, rubber or equivalent corrosion-resistant material
- (d) upper head and lower side of each tank shall be provided with access openings.

4 Collector System

- (a) a suitable device shall be provided within the softener tank for collecting softened water and distributing wash water. The device shall be deflector-plate type, or false-bottom type, or other approved equal type
- (b) the underdrain system shall distribute the backwash water in a manner that will not cause channelling of the gravel and exchange material.

5 Deflector-plate Type

- (a) the deflector-plate type collector shall be made of cast iron, or corrosion-resistant steel, securely fastened to the bottom of the tank and arranged for discharge around the circumference of the plate or through radial slots in the plate. The deflector-plate type require a gravel bed
- (b) pipe connection for softened-water outlet or backwash inlet shall be on the underside between deflector and tank bottom.

6 False-bottom Type

- (a) the false-bottom type collector shall consist of a false bottom with strainers attached thereto and therefore does not require a gravel bed.

- (b) strainers and fasteners shall be made of corrosion-resistant metal.

7 Gravel Bed

- (a) the gravel supporting bed shall be placed immediately above the underdrain system of all types except the false-bottom type collector
- (b) the gravel shall be washed and free from any foreign materials
- (c) the gravel bed shall be properly graded to prevent loss of exchange material during normal operation and back-washing.

8 Exchange Material

- (a) exchange material shall be quartz sand, washed, processed and not less than 0.35 mm in size and with uniformity coefficient not higher than 1.2
- (b) exchange material shall not require dosing or adding of any chemical mixture or solution to the water to be treated or to the water used for back-washing or regeneration other than common salt, NaCl.

9 Brine-storage Tank

- (a) one brine-storage tank shall be provided for each water softening unit, made of steel, reinforced and lined with enamel or other approved brine-resistant material, provided with an automatic, float-controlled water control valve, located in an independent float chamber, inside the tank.

END OF PART