

SECTION 23 64 00
PACKAGED WATER CHILLERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Centrifugal water-cooled chillers, complete with accessories.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- D. Section 23 21 23, HYDRONIC PUMPS.
- E. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- F. Section 23 21 13, HYDRONIC PIPING.
- G. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- H. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- I. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS
- J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 DEFINITION

- A. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.
- B. BACNET: Building Automation Control Network Protocol, ASHRAE Standard 135.
- C. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.
- D. SCBA: Self-Contained Breathing Apparatus.

1.4 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, and comply with the following.
- B. Refer to PART 3 herein after and Section 01 00 00, GENERAL REQUIREMENTS for test performance.
- C. Comply with AHRI requirements for testing and certification of the chillers.
- D. Refer to paragraph, WARRANTY, Section 00 72 00, GENERAL CONDITIONS, except as noted below:

1. Provide a 5-year motor, and compressor warranty to include materials, parts and labor.
- E. Refer to OSHA 29 CFR 1910.95(a) and (b) for Occupational Noise Exposure Standard
- F. Refer to 42 CFR—Public Health, Part 84, "Approval of Respiratory Protective Devices," Subpart H—"Self-Contained Breathing Apparatus," 1998.
- G. Refer to ASHRAE Standard 15, Safety Standard for Refrigeration System, for refrigerant vapor detectors and monitor.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating and Refrigeration Institute (AHRI):
 - 370-01.....Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
 - 495-1999 (R2002).....Refrigerant Liquid Receivers
 - 550/590-03.....Standard for Water Chilling Packages Using the Vapor Compression Cycle
 - 575-94.....Methods for Measuring Machinery Sound within Equipment Space
- C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
 - ANSI/ASHRAE-15-2007....Safety Standard for Mechanical Refrigeration Systems
 - GDL 3-1996.....Guidelines for Reducing Emission of Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems
- D. American Society of Mechanical Engineers (ASME):
 - 2007ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels - Division 1"
- E. American Society of Testing Materials (ASTM):
 - C 534/ C 534M-2008.....Preformed, Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
 - C 612-04.....Mineral-fiber Block and Board Thermal Insulation
- F. National Electrical Manufacturing Association (NEMA):
 - 250-2008.....Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. National Fire Protection Association (NFPA):
 - 70-2008.....National Electrical Code

H. Underwriters Laboratories, Inc. (UL):

1995-2005..... Heating and Cooling Equipment

1.6 SUBMITTALS

- A. Submit in accordance with Specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data.
 - 1. Centrifugal water chillers, including motor starters, control panels, and vibration isolators, and remote condenser data shall include the following:
 - a. Rated capacity.
 - b. Pressure drop.
 - c. Efficiency at full load and part load WITHOUT applying any tolerance indicated in the AHRI 550/590/Standard.
 - d. Refrigerant
 - e. Accessories.
 - f. Installation instructions.
 - g. Start up procedures.
 - h. Wiring diagrams, including factory-installed and field-installed wiring.
 - i. Sound/Noise data report. Manufacturer shall provide sound ratings. Noise warning labels shall be posted on equipment.
 - j. Self-contained breathing apparatus (SCBA).
 - k. Refrigerant vapor detectors and monitors.
- C. Maintenance and operating manuals for each piece of equipment in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- D. Run test report for all chillers.
- E. Product Certificate: Signed by chiller manufacturer certifying that chillers furnished comply with AHRI requirements. The test report shall include calibrated curves, calibration records, and data sheets for the instrumentation used in factory tests.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL WATER-COOLED WATER CHILLERS

- A. General: Chillers shall have two (2) oil-free, magnetic bearing, variable speed, two stage, centrifugal compressors. Chiller shall be factory-assembled and-tested, complete with flooded evaporator, condenser, marine water boxes for condenser and evaporator, magnetic bearing compressors, motors, starters (variable frequency drive type), inlet guide vanes, electronic expansion valves, load balance valve for each compressor, economizer or intercooler, refrigerant piping, instrumentation and control piping, operating and safety controls

mounted on the chiller, and other auxiliaries necessary for safe and proper operation of the unit. Chiller operation shall be fully automatic. Make provision for space and design piping layout to suit the marine water boxes.

- B. Performance: Provide the capacity as shown on the drawings. Part load and full load efficiency ratings of the chiller shall not exceed those shown on the drawings.
- C. Capacity of a single water-cooled chiller shall not exceed 1,250 Tons (Standard AHRI Conditions).
- D. Applicable Standard: Chillers shall be rated and certified in accordance with AHRI Standard 550/590. Chillers shall be AHRI stamped. Chiller efficiency shall comply with FEMP (Federal Energy Management Progress) requirements.
- E. Acoustics: Unit sound performance data shall be measured at the highest level recorded at all load points. Unit sound performance shall not exceed a level of 70 DBA measured at a distance of five (5) feet. The manufacturer shall provide sound treatment if required to comply with the specified maximum levels. Testing shall be in accordance with AHRI 575.
- F. Minimum Operating Conditions: Lowest evaporator saturated suction temperature shall not be below 34°F. Lowest leaving chilled water temperature shall not be below 38°F. Lowest entering condenser water temperature shall not drop below 55°F. A differential of 12°F between the leaving chilled water temperature and entering condenser water temperature is required to ensure chiller can maintain minimum lift requirements.
- G. Hermetic: Chillers shall be hermetically sealed, using the following refrigerant: HFC-134a.
- H. Compressor (Centrifugal Type): Two stage, having statically and dynamically balanced impeller, direct driven. Impeller shaft shall be heat-treated carbon steel of sufficient rigidity to prevent whip or vibration at operating speed. Shaft main bearings shall be oil free magnetic type, liquid refrigerant cooled. Casing shall be cast iron or steel plate with split sections gasketed and bolted together. Capacity and optimization control shall be by means of an integral variable speed drive, variable inlet guide vanes in the compressor suction and a load balancing valve to modulate the compressor capacity from 100 to 10 percent of full unit rated capacity without unstable compressor operation. Hot gas bypass shall not be utilized to obtain the required turndown capacity range. The inlet guide vanes shall be electrically

operated upon the actuation of a temperature or pressure sensor. Each compressor shall incorporate the following features:

1. Each compressor shall have a microprocessor controller networked to the master controller via an Etherbus connection with a refresh rate of 50 microseconds and the microprocessor of each compressor shall control the variable speed drive and inlet guide vanes on each compressor to maximize unit efficiency.
 2. Each compressor shall be capable of coming to a controlled safe stop in the event of a power outage. Unit shall be capable of auto restart in the event of a power outage once power has been restored.
 3. All compressors shall be mechanically and electrically isolated to facilitate proper maintenance, service, and or removal
- I. Prime Mover: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION. Compressor motor furnished with the chiller shall be in accordance with the chiller manufacturer and the electrical specification Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT. The prime mover shall be of sufficient size to effectively meet the compressor horsepower requirements. Prime mover shall be a one or more liquid refrigerant cooled, hermetically sealed, permanent magnet synchronous motor. Motor shall be controlled by a variable speed drive. Motor shall utilize soft start capabilities with an inrush current no greater than two (2) amps. Motor shall have internal thermal overload protection devices embedded in the winding of each phase of the motor
- J. The chillers evaporator, condenser, and electronic expansion valves shall be common to all compressors. The chiller shall operate with one (1) refrigerant circuit.
- K. Evaporator: Shell-and-tube type, constructed and tested and stamped in accordance with Section VIII D1 of ASME Boiler and Pressure Vessel Code where applicable for working pressure produced by refrigerant used and water system installed, but not less than 1035 kPa (150 psig) waterside working pressure. Evaporator shall be flooded type with refrigerant surrounding the tubes and water passing through the tubes. Shell shall be fabricated of carbon steel and shall have carbon steel tube sheets; drilled and reamed to accommodate the tubes. Tubes shall be externally and internally enhanced and rifled, shall be individually replaceable and shall be expanded full diameter into tube sheets, and sealed with Loctite or equivalent sealant providing a leak proof seal. Intermediate tube supports sheets shall be provided as recommended by the manufacturer to minimize tube vibration, stress, and wear. Performance

shall be based on a water velocity not less than 1 m/s (3 fps) nor more than 2.67 m/s (8 fps), and fouling factor of 0.0000176 m² degrees C (0.0001 hr. sq. ft. degrees F/Btu). Evaporator shall include liquid eliminator baffle plate, pressure relief vent, water drains and vents. Pressure relief valve shall be spring loaded self-seating type in accordance to ASHRAE 15 standard. Removable marine water box shall be constructed of steel. Tube sheets and water boxes shall be epoxy coated on the water side. Design working pressure shall be 1035 kPa (150 psig); pressure tested at 130 percent of working pressure. Water nozzle connections shall be flanged.

- L. Condenser: Shell-and-tube type, constructed, tested, and stamped in accordance with applicable portions of Section VIII D1 of the ASME Boiler and Pressure Vessel Code, where applicable for working pressure produced by the refrigerant used and water system installed, but not less than 1035 kPa (150 psig). Condenser shall be water cooled type with refrigerant surrounding the tubes and water passing through the tubes. Shell shall be fabricated of carbon steel and shall have carbon steel tube sheets; drilled and reamed to accommodate the tubes. Tubes shall be nonferrous metal, externally enhanced, and internally enhanced and rifled, individually replaceable, and shall be expanded full diameter into tube sheets, and sealed with Loctite or equivalent sealant providing a leak proof seal. Intermediate tube support sheets shall be provided as recommended by the manufacturer to minimize tube vibration, stress and wear. Tubes shall fit tightly in the supports to prevent chafing due to vibration or pulsation. Performance of condenser shall be based on a water velocity not less than 1 m/s (3 fps) nor more than 2.67 m/s (8 fps), and a fouling factor of 0.000044 m² degrees C (0.00025 hr. sq. ft.) degrees F/Btu. Condenser shall include pressure relief tree with isolation valves, water drain and vents. Pressure relief tree to be equipped with isolation/transfer valve to prevent the loss of refrigerant when relief is removed for testing and or replacement. Rupture disks are not acceptable. Removable marine water box shall be constructed of steel. Tube sheets and water boxes shall be epoxy coated on the water side. Design working pressure shall be 1035 kPa (150 psig); pressure tested at 130 percent of working pressure. Water nozzle connections shall be flanged.
- M. Insulation: Evaporator, suction piping, compressor, and all other parts subject to condensation shall be insulated with 40 mm (1.5 inch) minimum thickness of flexible-elastomeric thermal insulation, complying with ASTM C534.

- N. Water Flow Indication: **Factory mounted differential pressure transmitters shall be provided for flow safety on the evaporator and condenser. Flow switches are not acceptable.** Provide thermal dispersion water flow switches on the evaporator and condenser. Flow switches may be shipped loose for field installation.
- O. Refrigerant Control: Chiller with multiple compressors shall feature dual electronic expansion valves with a step count of 6,386 steps to full open. A single compressor machine shall have one electronic expansion valve with 6,386 steps. Fixed orifices and float controls are not acceptable. The electronic expansion valve shall operate from minimum chiller capacity to the full load of the chiller's capacity. A high side refrigerant level sensor, constructed out of stainless steel, with a stainless steel canister with sight glass shall be used to provide feedback to the expansion valves for proper control to ensure that a proper liquid seal is always present on the compressors power electronics. A refrigerant sight glass shall be provided on the main liquid line feeding the electronic expansion valves. Isolation valves before and after the EXV shall be provided for proper service without removing the entire refrigerant charge. Provide refrigerant charging and transfer connections.
- P. Motor Load Limiter: Provide a sensing and control system, which will limit maximum load current of compressor motor to a manually selectable percentage of 40 percent to 100 percent of full load current. System shall sense compressor motor current and limit it by varying the compressor speed and modulating inlet guide vanes at the compressor, overriding other controls in their ability to increase loading, but not overriding their ability to reduce loading.
- Q. Isolation Pads: Provide neoprene vibration isolation pads of type and size recommended by chiller manufacturer.
- R. Refrigerant:
1. Provide sufficient volume of dehydrated refrigerant to permit maximum unit capacity operation before and during tests. Refrigerant charge lost during the warranty period due to equipment failure shall be replaced without cost to the Government.
 2. The manufacturer shall certify that chiller components, such as seals, o-ring, motor windings, etc, are fully compatible with the specified refrigerants.
- S. Service valves shall be provided to facilitate refrigerant reclaim/removal required during maintenance.

T. Controls: Chiller shall be furnished with unit mounted, stand-alone, microprocessor-based controls in NEMA 1 enclosure, hinged and lockable, factory wired with a single point power connection and separate control circuit. The central processing unit shall be an industrial grade Intel CPU. The control panel shall provide chiller operation, including monitoring of sensors and actuators. All chiller and compressor I/O shall be controlled via Etherbus with an update rate of 50 microseconds. Controller shall have 15 inch touch screen interface that can be disconnected without shutting down the chiller. Controller shall use proprietary control logic to optimize loading, unloading, and control of multiple compressors. User interface to operate the chiller shall include Human Machine Interfaces (HMI) consisting of a touch screen and a remote web connection. All system parameters, compressor status, alarms, and faults, trend graphing, fault logging, BAS communication window, manuals, wiring diagrams, log book, and control set points shall be viewable. Touch screen shall provide full commissioning and adjustment of all components on the chiller, including the compressors without an auxiliary computer or software.

1. The chiller controller shall include the following features:

- a. Hardware.
- b. Two EXV Outputs.
- c. Eight Digital Inputs.
- d. Eight Digital Outputs.
- e. Ten Analog Inputs.
- f. Eight Analog Outputs (0-10 VDC).
- g. Eight Temperature Inputs.
- h. One Compressor hub per compressor including:
 - 1) Addressable Bus Coupler.
 - 2) Addressable Bus Coupler.
 - 3) R5-485 Module.
 - 4) RS-232 Module.
 - 5) Four Digital Inputs.
 - 6) Two Digital Outputs.
- i. Windows-based industrial PC featuring Intel® Processor for maximum reliability and performance:
- j. Dual-Hard drives for maximum reliability and redundancy. Hard drives feature no moving parts to ensure nothing mechanically fails. With dual-hard drives there is no need to partition a single drive. One drive handles the operating system while the other handles all data acquisition to ensure no data is corrupted.

- k. DC Powered to ensure maximum resistance to EMI and RFI noise.
 - l. Built in 2-port Ethernet Switch for easy integration to BAS interface and web control feature.
 - m. Features industrial-style battery back-up in the event of a power outage.
 - n. On board USB drives to support external peripheral devices including, keyboard, mouse, and printer.
 - o. 15"TFT Display featuring 1024 X 768 Resolution.
 - p. All hardware, including I/O is CE and UL Certified.
 - q. I/O features modular design to simplify troubleshooting and or replacement if required.
 - r. I/O has LED Indicators for all inputs and outputs to ease the troubleshooting process.
 - s. I/O can be directly connected to without the use of terminal blocks.
 - t. All wiring utilizes spring capture technology to prevent loose connections or wires from falling out.
 - u. Dedicated Ethernet communication at a communication rate of 50 microseconds to all compressors and I/O.
 - v. Compressor hubs feature dedicated inputs for high pressure switch, low pressure switch, dedicated compressor interlocks, and dedicated compressor communications. This allows each compressor to be handled independently by itself without affecting the rest of the system.
2. Software:
- a. Can control one (1) to eight (8) compressors on single or multiple refrigerant circuits.
 - b. Control System can control up to 24 EXVs with proper hardware and network all EXVs to the control system.
 - c. Control system capable of controlling different size compressors simultaneously.
 - d. HMI interface is only control system on the market with a user definable points list, tag names, and functions without special software. With this feature, end user can scale all inputs and outputs, change what controls it, change the functionality, the name of it etc.
 - e. Control system shall be field reconfigured through HMI to remap I/O to change functionality on the fly. This allows for customized integration into the end users system.

- f. Control system shall be capable of trend graphing up to two (2) years of data without overwriting or decreasing data acquisition time.
 - g. Chiller controller shall utilize the Danfoss Turbocor Compressor Software on board to allow servicing and advanced remote troubleshooting without a laptop computer.
 - h. Control System shall feature an easy to use web interface to allows the user to do anything remotely that could be done on sight
 - i. Controller shall provide trend graphing and recording for more than 200 data points in five (5) second intervals. Data shall be stored on separate 32 GB hard drive for analysis through the zoom feature. Trend graph images shall be exportable to a csv file.
 - j. Advanced Fault Logging featuring calendar capability for ease of use. Data shall be available for recalled up to two (2) years. Data shall be sorted by alarm type, time stamp, or compressor.
 - k. Data shall be color coded with green data meaning good, yellow meaning alarm, and red meaning fault or off.
 - l. Controller shall log when user makes any type of change
 - m. Controller shall be loaded with all manuals, wiring diagrams, and supporting data which can be recalled via touch screen
 - n. Controller shall have onboard maintenance log to store system information
 - o. Controller shall feature e-mail fault notification
 - p. Controller shall provide real time capacity and efficiency data
3. BAS Interfaces shall include:
- a. Chiller control panel shall reside on the "BACnet network", and provide data using open protocol network variable types and configuration properties, BACnet interworking using ARCNET or MS/TP physical data link layer protocol for communication with building automation control system.
 - b. BAS interface dashboard shown on HMI. This allows the user to view what data is being written to the BAS system, if there is an error, lost com, and how many times the data was sent or received.
 - c. Control system shall use proprietary optimization logic to perform accurate energy balance on all systems for maximum system performance.
 - d. Control system shall feature an optimum start function to ensure initial lift is always made. This prevents nuisance check valve flutter and compressor faults.

4. Following functions shall be displayed as a minimum on the HMI:
 - a. Date and Time.
 - b. Outdoor air temperature.
 - c. Operating set point temperature and pressure.
 - d. Operating hours.
 - e. Operating or alarm status.
 - f. Chilled water temperature-entering and leaving.
 - g. Condenser water temperature-entering and leaving.
 - h. Refrigerant pressure-condenser and evaporator.
 - i. Chiller diagnostic codes.
 - j. Current limit set point.
 - k. Number of compressor starts.
5. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Control set points for entering and leaving chilled temperatures.
 - c. Condenser water temperature.
 - d. Current/demand limit.
 - e. Motor load limit.
6. Safety Controls: Following conditions shall shut down the chiller and require manual reset to start:
 - a. High condenser pressure.
 - b. Loss of flow-condenser or chilled water.
 - c. Low chilled water temperature.
 - d. Low evaporator refrigerant temperature.
 - e. Sensor malfunctions.
 - f. Power fault.
 - g. Extended compressor surge.
 - h. Communication loss between the chiller and its control panel. A signal must be transmitted to Energy Control Center, if provided, for this communication loss and for any abnormal condition.
7. Leaving chilled water temperature reset, where specified in the control sequence, shall be based on 4-20 MA or 0-10 VDC signal from a building automation system.
8. Chillers shall be pre-wired to terminal strips for interlocked to other equipment.
9. Provide contacts for remote start/stop, alarm for abnormal operation or shut down, and for Engineering Control Center (ECC) interface.
10. Auxiliary hydronic system and the chiller(s) shall be electronically interlocked to provide time delay and starting sequence as indicated on control drawings.

11. The chiller control panel shall utilize the following components to automatically take action to prevent unit shutdown due to abnormal operating conditions which will perform as follows.
 - a. High pressure transmitter that is set to 20 psig (adjustable setting) lower than factory pressure switch that will automatically unload the compressor to help prevent a high pressure condenser control trip. One transmitter is required for each compressor and its status shall be indicated on the HMI.
 - b. Motor surge pressure that is set at 95% of compressor RLA that will automatically unload the compressor to prevent an over current trip. One protector is required for each compressor and its status shall be indicated on the HMI.
 - c. Low pressure transmitter that is set at 5 PSIG above the factory low pressure switch that will automatically unload the compressor to help prevent a low evaporator temperature trip. One transmitter is required for each compressor and its status shall be indicated on the HMI.
 - d. In all the above cases, the chiller will continue to run, in an unloaded state and will continue to produce some chilled water in an attempt to meet the cooling load. However, if the chiller reaches the trip-out limits, the chiller controls will take the chiller off line for protection, and a manual reset is required. Once the "near trip" condition is corrected, the chiller will return to normal operation and can then produce full load cooling.
12. With variation of +/-10% of design flow per minute, chiller shall be able to maintain +/-0.5 degrees F leaving water temperature control. The chiller must be able to withstand a +/- 30% change in flow rate per minute without unit trip. Variations in the primary flow allow for optimal system efficiency, but the chiller must be able to maintain temperature control to help ensure occupant comfort.
13. The chiller control panel shall provide +/-0.5 degrees F leaving water temperature control during normal operation. The chiller shall provide multiple steps of leaving chilled water temperature control to minimize part load energy use and optimize leaving chilled water temperature control.
14. The chiller control panel shall provide a 2-minute stop-to-start and 5 minute start-to-start solid state timer.
- U. Motor Starter: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Provide a starter for each centrifugal chiller in NEMA I enclosure, designed for unit mounting. Starter shall be a

variable frequency drive type and shall utilize Insulated Gate Bi-Polar Transistors. Provide starter with the following features in addition to the ones specified in Electrical Specification Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

1. Each compressor shall have a variable frequency drive with line reactor and circuit breaker.
2. Starter shall include incoming line provision for the number and size cables shown on the drawings. Incoming line lugs shall be copper mechanical type.
3. Terminals connection pads shall be provided to which customers supply lugs can be attached.
4. Starters shall be coordinated with chiller packages(s) making certain all terminals are properly marked according to the chiller manufacturer's wiring diagram.
5. Contactors shall be sized per NEMA requirements to the chillers for full load currents.
6. Ammeter(s) shall be provided, capable of displaying current to all three phases. Ammeter shall be calibrated so that inrush current can be indicated.
7. Chiller starter shall include an advanced motor protection system incorporating electronic three phase overloads and current transformers. This electronic motor protection system shall monitor and protect against the following conditions:
 - a. Three phase loss with under and over voltage protection.
 - b. Phase imbalance.
 - c. Phase reversal.
 - d. Motor overload.
 - e. Motor overload protection incorrectly set.
 - f. Momentary power loss protection with auto restart consisting of three phase current sensing device that monitor the status of the current.
 - g. Starter contactor fault protection.
 - h. Starter transition failure.
 - i. Distribution fault protection.
8. The starter shall be equipped with pilot relays to initiate the start sequence of compressor. These relays shall be a self-monitoring safety circuit, which shall indicate improper operation (slow operation, welding of contacts, etc) and shall cause the chiller unit to be shut down and a fault trip indicator be displayed. The "starter

circuit fault" indicator shall be located in the door of the enclosure and shall require manual reset.

9. A lockout transition safety circuit shall be provided to prevent damage from prolonged energization due to malfunction of the transistor contactor. Malfunction shall cause the chiller unit to shut down and the "starter circuit fault" indicator be displayed.
 10. A permanent nameplate shall be provided and mounted on the starter panel. It shall identify the manufacturer, serial or model number identifying the date of manufacturing and component replacement parts, and all current and voltage rating, and as built wiring schematic showing all items provided.
- V. Main Power Circuit: Chiller shall feature single-point power connection with main disconnect switch and shall not utilize adjoining power cabinets as pull boxes

2.2 REFRIGERANT MONITORING AND SAFETY EQUIPMENT

- A. General: Provide refrigerant monitoring sensor/alarm system and safety equipment as specified here. Refrigerant sensor and alarm system shall comply with ASHRAE Standard 15. The refrigerant monitoring system will be provided by the chiller manufacturer and shall be interfaced with the DDC control system.
- B. Refrigerant monitor shall continuously display the specific gas (refrigerant used) concentration; shall be capable of indicating, alarming and shutting down equipment; and automatically activating ventilation system. On leak detection by refrigerant sensor(s), the following shall occur:
 1. Activate machinery (chiller) room ventilation.
 2. Activate visual and audio alarm inside and outside of machinery room, with beacon light(s) and horn sounds equipment room and outside equipment room door(s).
 3. Notify Engineering Control Center (ECC) of the alarm condition.
- C. Refrigerant monitor shall be capable of detecting concentration of 1 part per million (ppm) for low-level detection and for insuring the safety of operators. It shall be supplied factory-calibrated for the apparent refrigerant.
- D. Monitor design and construction shall be compatible with temperature, humidity, barometric pressure, and voltage fluctuations of the machinery room operating environment.
- E. Self-Contained Breathing Apparatus (SCBA):
 1. Self-contained breathing apparatus shall comply with 42 CFR 84.

2. Orthopedically designed for shoulder mounting, portable, and compressed-air type, completely assembled with face-piece and harness carrier assembly.
3. Face-piece to be constructed of durable material, complete with adjustable straps to hold face piece to head, close fitting nose piece to ensure no CO2 build-up, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.
4. Air cylinder shall be fitted with quick refill assembly and air transfer.
5. Minimum SCBA gear rating shall be 30 minutes duration.
6. SCBA shall be housed in leak-proof, corrosion-resistant, tough plastic case for wall mounting. Minimum three (3) SCBA shall be provided.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping and electrical to verify actual locations and sizes before chiller installation and other conditions that might affect chiller performance, maintenance, and operation. Equipment locations shown on drawings are approximate. Determine exact locations before proceeding with installation.

3.2 EQUIPMENT INSTALLATION

- A. Install chiller on concrete base with isolation pads or vibration isolators.
 1. Vibration isolator types and installation requirements are specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT
 2. Anchor chiller to concrete base according to manufacturer's written instructions.
 3. Charge the chiller with refrigerant, if not factory charged.
 4. Install accessories and any other equipment furnished loose by the manufacturer, including remote flow switches, according to the manufacturer written instructions and electrical requirements.
 5. Chillers shall be installed in a manner as to provide easy access for tube pull and removal of compressor and motors etc.
- B. Install refrigerant monitoring and safety equipment in accordance with ASHRAE Standard 15.
- C. Install thermometers and gages as recommended by the manufacturer and/or as shown on drawings.
- D. Piping Connections:

1. Make piping connections to the chiller for chilled water, condenser water, and other connections as necessary for proper operation and maintenance of the equipment.
2. Make equipment connections with flanges and couplings for easy removal and replacement of equipment from the equipment room.
3. Extend vent piping from the relief valve to the outside.

3.3 STARTUP AND TESTING

- A. Engage manufacturer's factory-trained representative to perform startup and testing service.
- B. Inspect, equipment installation, including field-assembled components, and piping and electrical connections.
- C. After complete installation startup checks, according to the manufacturers written instructions, do the following to demonstrate to the VA that the equipment operate and perform as intended.
 1. Check refrigerant charge is sufficient and chiller has been tested for refrigerant leak.
 2. Verify proper motor rotation.
 3. Verify pumps associated with chillers are installed and operational.
 4. Verify thermometers and gages are installed.
 5. Operate chiller for run-in-period in accordance with the manufacturer's instruction and observe its performance.
 6. Check and record refrigerant pressure, water flow, water temperature, and power consumption of the chiller.
 7. Test and adjust all controls and safeties. Replace or correct all malfunctioning controls, safeties and equipment as soon as possible to avoid any delay in the use of the equipment.
 8. Prepare a written report outlining the results of tests and inspections, and submit it to the VA.
- D. Engage manufacturer's certified factory trained representative to provide training for 8 hours for the VA maintenance and operational personnel to adjust, operate and maintain equipment, including self-contained breathing apparatus.

- - - E N D - - -