

SECTION 23 81 23

COMPUTER ROOM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, the project specification manual, and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DEFINITIONS

- A. ASCE: American Society of Civil Engineers.
- B. ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers.
- C. BAS: Building Automation System—Building heating, ventilating, air conditioning, and electrical power monitoring system utilizing direct digital control (DDC) hardware and software. The system communicates using one or more digital communication networks.
- D. Contractor: Trade contractors responsible for constructing the project.
- E. Construction Manager: Construction partner responsible for delivery of the project.
- F. COP: Coefficient of performance.
- G. CRAC: Computer Room Air Conditioning – Air cooled, split refrigeration system used for precision conditioning of mission critical equipment.
- H. DB: Dry-bulb temperature.
- I. Design Professional: Refers to kW Mission Critical Engineering (kW MCE) in Milwaukee, WI as the Engineer of Record.
- J. Drawings: Refers to kW MCE documents (drawings and/or specifications) for this project.
- K. Owner: Refers to Aligned Energy.
- L. EER: Energy efficiency ratio.
- M. SEI: Structural Engineering Institute.
- N. WB: Wet-bulb temperature.

1.3 SUBMITTALS

- A. Compliance Review: In addition to the submittal requirements of this section, preorder bidders shall provide a Compliance Review of the Specifications and Addenda. The Compliance Review shall be a paragraph-by-paragraph review of the Specifications with the following information, "C", "D," or "E" marked in the margin of the original Specifications and any subsequent Addenda.
1. "C": Comply with no exceptions.
 2. "D": Comply with deviations. For each and every deviation, provide a numbered footnote with reasons for the proposed deviation and how the intent of the Specification can be satisfied.
 3. "E": Exception, do not comply. For each and every exception, provide a numbered footnote with reasons and possible alternatives.
 4. The notes associated with "D" and "E" responses shall be typewritten and submitted alongside the compliance review for review by the Design Professional.
 5. Unless a deviation or exception is specifically noted in the Compliance Review, it is assumed that the Bidder is in complete compliance with the plans and Specifications. Deviations or exceptions taken in cover letters, subsidiary documents, by omission or by contradiction do not release the Bidder from being in complete compliance, unless the exception or deviation has been specifically noted in the Compliance Review submitted with the Bid. Any deviation from the specification must be reviewed and approved by the Owner and Design Professional to be implemented.
- B. Product Data / Technical Data Sheets: Include rated capacities, electrical load data, physical dimensional data, weights (shipping, installed, and operating), component specifications, sound data, power and control wiring diagrams, shipping splits, furnished specialties, and accessories.
- C. Performance Data Sheet: Provide the manufacturers standard performance data sheet showing the performance data for the scheduled conditions.
1. Provide certified data sheets showing the coil, fan, and electrical performance data.
 2. The performance data provided shall be within tolerance requirements.
 3. Ambient temperature for full economizer mode.
- D. Compliance Document: Provide documentation showing the equipment as a system is listed in the Compliance Certification Database for the United States Department of Energy under the Energy Efficiency and Renewable Energy, Appliance and Equipment Standards Program. Demonstrate the Sensible Coefficient of Performance (SCOP) complies with the applicable energy code without the use of an economizer for this project.
- E. Shop Drawings: Provide project specific dimensional drawings, including required service clearances.

- F. Installation Procedures: Provide step by step descriptions and details for the field installation of the equipment. Include fabrication details for anchorage and attachment to the structure and to support the equipment.
- G. Warranty Information
 - 1. Clearly state in the submittal the duration of the parts and labor warranty being provided directly by the manufacturer or manufacturer's representative, and indicate the warranty is applicable to the location where the equipment shall ultimately operate at.
 - 2. Provide a generic copy of the manufacturer's warranty certificate as part of the initial submittal. Provide the actual warranty certificate as part of the project closeout phase.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Deliver equipment with protective factory-installed crating and covering. The materials shall be shipped by direct and dedicated carrier on an air ride truck. Final delivery location, date, and time shall be coordinated with the Owner-assigned Construction Manager prior to shipment of the equipment. The shipping costs shall be included in the Bid. The sales tax shall be listed as excluded.
- B. The units shall be shrink-wrapped in plastic or tarped at the factory prior to shipment to prevent damage due to weather and road debris and grime during transportation and thereafter while in storage awaiting installation.
- C. Pipe openings shall be temporarily capped.
- D. The loose shipped items shall be packed, protected, and secured with or inside the units. The spare components shall be shipped loose from the factory, either with the unit delivery or at a later date, as dictated by the Construction Manager.
- E. Store units in a clean, dry place, and protected from weather and construction traffic.
- F. Construction Manager and/or Contractor shall handle equipment according to manufacturer's written rigging and installation instructions for unloading and transporting.
- G. Handle units carefully to avoid damage to components, enclosures, and finish. Do not install damaged components. Damaged or rusted parts or equipment shall be rejected by the Construction Manager. Replace damaged parts and units with new.
- H. Comply with the manufacturer's rigging instructions for unloading and moving units to final location.
- I. Final delivery location, date, and timing shall be coordinated with the Owner assigned Construction Manager prior to shipment of equipment.

1.5 COORDINATION

- A. Coordinate layout and installation of computer room air conditioning units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Coordinate installation of computer room air conditioning units with computer room access flooring Installer.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One (1) set of filters for each unit.
 - 2. Fan Jack: One (1) fan jack per unit type per this project.
 - 3. Touch-Up Paint: One (1) case of paint, per cabinet color, for the project.

1.7 WARRANTY

- A. The Equipment Supplier shall warrant that the equipment supplied is of a proven design and can meet the requirements specified. Workmanship shall be of the best quality, free from any defects that might render the equipment unsuitable or inefficient for the purpose for which it is to be used. In the event of problems or malfunctions, the Equipment Supplier shall have qualified technicians capable of affecting all necessary repairs and restoring the system to full operation within eight hours of notification. There shall be no cost to the Owner for corrective repairs or firmware upgrades during the first twelve (12) months following successful integrated site commissioning and the project substantial completion date. Owner and Engineer shall be made aware prior to any firmware flashes after equipment has left the factory.
- B. If at any time during the first twelve (12) months of operation as defined below, the Owner shall accumulate sufficient evidence to reasonably indicate that the equipment or any part thereof, is not in accordance with the Specifications, the Owner shall so notify the Equipment Supplier in writing, and the Equipment Supplier shall repair or replace the defective components. The cost of removal, reinstallation and complete re-testing of the equipment, and any associated freight charges (via air ride truck) or service engineering charges, shall be at the Equipment Supplier's expense. The warranty for the repaired or replaced equipment shall be extended for twelve (12) months from the completion of repairs or replacement.
- C. If the equipment fails to meet the specific performance guarantees, the Equipment Supplier shall recommend to the Owner adjustments or modification. Upon approval by the Owner, the adjustments or modifications shall be made, and tests shall be rerun. The cost of these adjustments or modifications and complete re-testing shall be made at the Equipment Supplier's expense. After such adjustments or modifications, should the equipment fail to achieve the guaranteed performance, an equitable settlement shall be made which may, without limitation, include an adjustment of the contract price.

- D. Complete re-testing, as referred to in this Section, shall mean site acceptance testing as stipulated in testing portions of this Specification. The conditions which apply to original testing requirements, shall also apply to the re-testing of any equipment performed under the conditions of this warranty.
- E. Commercial operation is defined as commencing on the date on which the equipment covered by these Specifications has successfully completed final site integrated acceptance testing and the project substantial completion date.
- F. Identify any manufacturer's standard warranty periods that exceed the time frame listed above.
- G. Special Warranty: Manufacturer agrees to repair or replace components of computer room air conditioning units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion. The first year to include labor coverage.
 - 2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three (3) years from date of Substantial Completion. The first year to include labor coverage.

1.8 COMMISSIONING

- A. Commissioning of equipment or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Construction Manager and the Commissioning Authority. Project Closeout is dependent on successful completion of the commissioning procedures, documentation, and issue closure.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Subject to compliance with the requirements, provide the basis of design product indicated.
 - 1. Vertiv Corporation: DS split system without refrigerant economizer.

2.2 CRAC UNITS

- A. General:
 - 1. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in a down airflow configuration.
 - 2. Each unit shall be brand new, certified as such from the factory, with a date of manufacturer engraved on the unit.

3. The cabinet shall be designed so that the components are easily accessible for service and maintenance through the front of the unit.
- B. Cabinet and Frame: Welded tubular or formed steel frame, braced for rigidity, and supporting mechanical equipment, piping, wiring and other internal components.
1. The frame shall be capable of being separated into three parts in the field to accommodate rigging through small spaces.
 2. Doors and Access Panels: Galvanized or steel with powder coat with polyurethane gaskets, hinges, and concealed fastening devices. The removable panels shall have captive quarter-turn fasteners.
 3. Finish of Exterior Surfaces: Black gray matte color, provide one of the following
 - a. Powder coated.
 - b. Baked-on, textured vinyl enamel;
 - c. 2-ply epoxy finish.
 4. Finish of Interior Surfaces: Surfaces in contact with the air stream shall comply with requirements in ASHRAE 62.1.
 5. Gaskets: Neoprene or similar material, applied around entire perimeters of panel frame.
 6. Cabinet Panel Access Key (Dzus fastener or similar): Provide one key per CRAC unit to lock and unlock the cabinet panel doors.
 7. User Interface Display Panel: Installed on the front cabinet door no higher than 5'-6" from finished floor in area of installation.
 8. Insulation: Thermally and acoustically insulate cabinet interior with one of the following or an approved alternate:
 - a. 1-inch thick 1.5 lbs./cu. ft. density fiberglass insulation.
 - b. 1/2-inch thick 2.0 lbs./cu. ft. density fiberglass insulation.
 9. Grounding Lug: Provide each unit with a factory welded (prior to finish painting) ground lug in an accessible, concealed location.
 10. Bypass Air: Internal openings, such as wireway holes, shall be sealed air-tight to prevent unnecessary air bypass and air recirculation.
 11. Supply Air Grilles: Mechanical Contractor to provide front discharge, adjustable, vertical, 3-inch wide, deflection blade grilles.
- C. Supply-Air Fan:
1. Direct Drive Electronically Commutated (EC) Centrifugal Plug Fan: Direct driven with a single-inlet, two fold backward curved radial fan with an electronically commutated motor and variable speed. Each fan shall be low noise, low vibration manufactured with an anti-corrosive aluminum impeller. Each fan impeller shall be dynamically and statically balanced in two planes to minimize vibration during operation throughout operational speed range.
 2. The motor shall include integrated electronic control board and direct microprocessor control signaling for fan speed control, soft starting capabilities, RS-485 BMS connection, and integrated current limitations. Motors shall include status LED indicating lights to provide easy diagnosis of normal operation and trouble shooting.

3. The fans shall be located to either draw or blow air through the coil to ensure even air distribution and maximum coil performance. The EC fans shall also be capable of operating within the unit cabinet, instead of under the floor.

D. Refrigeration System:

1. Compressor:
 - a. The compressors shall be tandem, scroll-type with a variable capacity operation capability of one compressor of the pair. Compressor solenoid valve shall unload the compressor and allow for variable capacity operation. The compressor shall have resilient vibration suspension system, internal motor thermal overload protection, automatic reset high-pressure switch with lockout after three failures, rotalock service valves, suction line strainer and a maximum operating speed of 3500 rpm. The compressor motor shall be suction gas cooled.
 - b. The compressors shall include crankcase heaters, powered from the indoor unit electric panel.
 - c. Compressors shall be located outside the air stream and shall be removable and serviceable from the front of the unit.
 - d. Each compressor circuit shall be connected to the full-face area of the evaporator coil.
 - e. A pair of N/O contacts shall be factory-installed and wired to each compressor to indicate Compressor Overload.
2. Refrigeration Circuits:
 - a. Two independent circuits with hot-gas mufflers.
 - b. Pumped refrigerant system.
 - c. Liquid line filter driers.
 - d. Refrigerant sight glass with moisture indicator.
 - e. Electronic thermal expansion valves with external equalizers.
 - f. Low-pressure switch.
 - g. Manually reset, high-pressure switch.
 - h. Service shutoff valves.
 - i. Charging valves.
3. Refrigerant R-410A:
 - a. The indoor evaporator unit shall contain a factory holding charge of nitrogen. The hot-gas and liquid line stubs shall be spun shut and each shall include a factory-installed Schrader valve. Field-relief of the Schrader valve shall indicate a leak-free system from the factory. Installing Contractor shall cut the refrigerant piping and shall evacuate and charge the system.
 - b. Refrigerant shall be field supplied and field charged by the Installing Contractor.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless, rifled copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
 - a. The evaporator coil shall be of A-frame design for downflow units and have 4 to 6 rows, with a maximum face velocity of 550 ft. per minute.
 - b. Mount stainless-steel drain pan complying with ASHRAE 62.1. under coil assembly.

- c. Internal P-trap for condensate drain water.
 5. Refrigerant Piping:
 - a. The refrigerant piping and compressors shall be insulated to minimize heat gain and to prevent the formation of condensate.
 - b. Pipe Insulation: Elastomeric, flexible, closed cell neoprene type, minimum 1/2" thick, or as necessary to prevent sweating.
 - c. Piping shall be removable around serviceable components.
 - d. The refrigeration system shall be specifically designed and optimized for the higher evaporator and condensing temperatures required for data centers.
 - e. Piping within the units shall be completed at the factory, pressure tested, and insulated.
- E. Return Air Filters:
 1. The filter plenum housing shall be exterior to the main cooling unit and shall be field assembled and installed. The filters shall be removable from the front of the filter plenum. The filter plenum shall be painted to match the panel colors of the indoor CRAC unit. The return air filter plenum housing shall be 36" high.
 - a. Pre-Filter: 2-inch thick, disposable, deep-pleated, glass-fiber media. Minimum Efficiency Reporting Value of MERV 8 and the corresponding average arrestance according to ASHRAE 52.2.
 - b. Final Filter: 2-inch thick, disposable, deep-pleated, glass-fiber media. Minimum Efficiency Reporting Value of MERV 11 and the corresponding average arrestance according to ASHRAE 52.2.
 2. Final Resistance (Dirty Filter) Allowance: 0.3 inches wg.
 3. Filter holding frames shall be constructed of galvanized steel, installed and individually sealed to prevent leakage around frames. Filter banks shall be reinforced with vertical stiffeners to assure rigidity. Unit manufacturer shall provide flashing between filter banks and unit casings to prevent air leakage or bypass around the frames. Installation techniques, sealing methods, and structural reinforcement eliminate unfiltered air bypass and assure system cleanliness based on filter efficiencies specified.
- F. Integral Electrical Power Components: The electrical system shall conform to the National Electrical Code and local code requirements. Unit-mounted electrical enclosure with hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer. The components shall be fully wired to the utility power terminal identified below.
 1. Single, integral, non-fused, manual, locking, disconnect switch. The disconnect switch shall be mounted in the high-voltage section of the electrical panel. The switch shall be accessible from the outside of the unit with the door closed and shall prevent access to the high-voltage electrical components until switched to the OFF position.
 2. Provide single CRAC unit power connection to power the heat rejection units and economizer refrigerant pumps from the indoor CRAC unit.
 3. The operating mechanism for the disconnect switch shall not be higher than 6'-7" above the floor on which service personnel stand.

4. Short Circuit Current Rating: The high-voltage electrical configuration shall provide at least 65.0 kAIC SCCR and shall be labeled.
 5. Input Power Termination: Terminal(s) shall be able to accommodate copper conductors of scheduled size and quantity as shown on the electrical one-line diagrams.
 6. Electrical Connections: Manufacture shall allocate space within the unit for contractor installed raceway from point of entry to the unit to the electrical enclosure. Pathways allocated for electrical raceway shall not be located within the unit plenum. Entrance into the unit shall be able to accommodate top or bottom entry. At minimum manufacture shall provide enough space for one (1) raceway for each of the following systems: Source 1 electrical service, source 2 electrical service, AC electrical I/O, DC electrical I/O, and communications cabling.
 7. Provide each unit with a factory welded (prior to finish painting) ground lug in an accessible, concealed location.
 8. Factory wiring shall be 600-volt rated, type #12 THHN copper (minimum size). The wiring shall be plenum rated for installation within the units.
 9. Active Control Power: Provide a short term power supply for a minimum ride through time period of one-minute using a battery or capacitor backup. The control power shall allow the controller to manage the power transfer switch from one source to the other source while maintaining communications with an active monitoring system.
 10. Each wire shall end with a service loop and be securely fastened by an approved method. Each wire in the unit shall be numbered for ease of service tracing.
 11. The electrically actuated components shall be easily accessible from the front of the unit without reaching over exposed high voltage components or rotating parts.
 12. Each high voltage circuit shall be individually protected by circuit breakers or fused circuit protection, manual motor starters on the three phases. Line voltage and 24-volt control circuit wiring shall be routed in separate bundles.
- G. Integral Automatic Transfer Switch: Not required.
- H. Power Quality:
1. The CRAC units shall comply with the power quality requirements identified here within. If the standard CRAC units do not comply, then the CRAC unit manufacturer shall provide a third party harmonic filtration system to achieve the power quality requirements identified here within.
 - a. The total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE std 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. These limits shall apply while operating on either utility supply or generator supply and the Point of Common Coupling (PCC) shall be defined as the power input terminals to each unit.
 - b. Total Demand Distortion (TDD) of the current shall not exceed the limits as defined in Table 10.3 of IEEE std 519 or greater than 5%, whichever is lower. The PCC shall be defined as the power input terminals to each unit.

- c. Power Factor: Provide equipment with power factor correction as required to maintain a displacement power factor of 95% (leading or lagging) across all load conditions.
 - d. Where passive harmonic filters are installed, the total capacitive reactive power of the filter(s) shall not exceed 15% of the fundamental KVA, either through inherent design or capacitor switching contactors.
 - I. Remote Air-Cooled Refrigerant Condenser:
 1. General:
 - a. The condenser shall be designed to reject waste heat to outdoor air and to control refrigerant head pressure as indoor equipment loading and outdoor ambient conditions change.
 - b. The air-cooled condenser shall be a factory-assembled unit, complete with integral electrical panel, disconnect switch, and designed for outdoor installation. The condenser shall be a draw-through design.
 2. Condenser Cabinet: The condenser cabinet shall be divided into multiple fan/coil sections by configuring two coils into a V-bank or flat coil arrangement for each variable-speed EC fan. Fan/coil sections shall be created and protected by galvanized panels on each V-bank end. Internal structural support members, including coil support frame, shall be painted or galvanized steel for strength and corrosion resistance. Panel doors are provided on the outside of each coil/fan section to provide for coil cleaning. An electrical panel shall be contained inside a factory mounted NEMA 3R weatherproof electrical enclosure.
 3. Condenser Coils:
 - a. Microchannel coils shall be constructed of aluminum microchannel tubes, fins, and manifolds, configured in V-banks or flat depending on the model.. Tubes shall be flat and contain multiple, parallel flow microchannels and span between aluminum headers. Full-depth louvered aluminum fins shall fill spaces between the tubes. Tubes, fins, and aluminum headers shall be oven brazed to form a complete refrigerant to air heat exchanger coil. Copper stub pipes shall be electric resistance welded to aluminum coils and joints protected with polyolefin to seal joints from corrosive environmental elements. Coil assemblies shall be factory leak-tested at a minimum of 300 psig. Hot gas and liquid lines shall be type ACR copper and shall be brazed using nitrogen gas flow to the stub pipes with spun closed ends for field piping connections.
 - b. The condenser unit shall contain a factory holding charge of nitrogen. The hot-gas and liquid line stubs shall be spun shut and each shall include a factory-installed Schrader valve. Field-relief of the Schrader valve shall indicate a leak-free system from the factory. Installing Contractor shall cut the refrigerant piping and shall evacuate and charge the system.
 4. Condenser Fans: The fan motor/blade assembly shall have an external rotor motor, propeller type fan blades, fan/finger guard, and integral orifice plate. Fan blades shall be constructed of cast aluminum or glass-reinforced polymeric material. Fan guards shall be heavy gauge, close meshed steel wire, coated with a black corrosion resistant finish. Orifice plate shall be coated with a black, corrosion-resistant finish. Fan terminal blocks shall be located in an IP54 enclosure located on the top of the fan motor. Fan assemblies shall be factory-

balanced, tested before shipment and mounted securely to the condenser structure.

5. Condenser Fan Motors: The fan motors shall be electronically commutated for variable speed operation and shall have ball bearings. The EC fans shall provide internal overload protection through built-in electronics. Each EC fan motor shall have a built-in controller and communication module, linked via RS485 communication wire to each fan and the Premium Control Board, allowing each fan to receive and respond to precise fan speed inputs from the Premium Control Board.
6. Refrigerant Receiver: Provide a refrigerant receiver if required by the manufacturer for this application. Receiver shall be painted, un-insulated receiver with integral fusible plug, formed copper pipe for ease of connecting condenser liquid line to receiver and mounting bracket. The receivers shall be factory installed and piped to the condenser unit skid assembly.
7. Electrical Controls: Electrical controls and service connection terminals shall be provided and factory wired inside the attached control panel section. A locking disconnect switch shall be factory-mounted and wired to the electrical panel and controlled via an externally mounted locking and lockable door handle. High-voltage supply wiring and low voltage indoor unit communication/interlock wiring shall be factory-wired to customer connection boxes mounted on the base.
 - a. Premium Efficiency Fan Control:
 - 1) The EC Fan/Premium Control System shall include an electronic control board, EC fan motor(s) with internal overload protection, refrigerant and ambient temperature thermistors, and refrigerant pressure transducers. The Premium Control Board shall communicate directly with the indoor CRAC unit's controller via field supplied CANbus communication wires and via field-supplied low-voltage interlock wires. The control board shall use sensor and communication inputs to maintain refrigerant pressure by controlling each EC fan on the same refrigerant circuit to the same speed. The control system provides refrigerant head pressure and system starting for outdoor ambient temperature as low as -30°F, provided the total temperature range (from minimum design ambient to maximum design ambient) is 125°F or less.
 - 2) The mode of the condenser unit shall be controlled by the CRAC unit controller and shall be in either DX or Idle Mode by each refrigerant circuit. The dual circuit condensers shall operate fans to meet airflow needs and mode of each circuit independent of the other. Fan(s) on common refrigerant circuit shall operate in synchronous speed when that circuit is active.
 - b. High-voltage Supply Connection Box: A high-voltage, customer connection box shall be provided for each condenser unit and matching refrigerant pumping unit to provide a single, high-voltage connection. The connection box shall be factory-mounted to the condenser base and wired to the electrical panels of the condenser unit and the refrigerant pumping units. A locking-type disconnect switch shall be accessible from the outside of the unit with the door closed, and shall prevent access to the high-voltage electrical components until switched to the Off position. The locking

- disconnect shall be lockable in support of lockout/tag-out safety programs. Condenser unit with surge protection device (SPD).
- c. Low-voltage Connection Box: A low-voltage connection box shall be provided for each condenser unit and matching refrigerant pumping unit to provide a single, low-voltage connection from the indoor CRAC unit. The connection box shall be factory-mounted to the condenser base and wired to the electrical panels of the condenser unit and the refrigerant pumping units.
 - d. Short Circuit Current Rating: The high-voltage electrical configuration shall provide at least 65.0 kAIC SCCR and shall be labeled.
8. Condenser Unit Skid Assembly:
- a. The skid assembly is available as a single skid assembly or a double skid assembly. Refer to the equipment schedule and Drawings to determine the skid assembly required.
 - b. The single skid assembly shall consist of a galvanized-steel base with the condenser, and receivers (if required) mounted to provide a single, high-density heat-rejection unit to support one CRAC unit. The components shall be factory-wired to a centralized connection location for high-voltage connection and low-voltage connection boxes. The refrigeration components shall be factory piped, insulated, secured to a common location on the base, and sealed with an inert gas for shipment. Field relief of the Schrader valve shall indicate a leak-free system.
 - c. Condenser Support Legs: The condenser shall be shipped with 36 inch high mounting legs with stabilization bracing. The legs, bracing and hardware shall be galvanized steel and shall be field installed and anchored to the mounting surface.
 - d. IBC/OSHPD Seismic Certification and IBC Wind/Snow Load Compliant condensers shall be provided with any applicable bracing and field-installation instructions. The condensers shall bear a label certifying compliance with IBC/OSHPD requirements.
- J. Refrigerant Pumping Unit (EconoPhase): Not required.
- K. CRAC Unit Microprocessor Control System
- 1. Unit Controller:
 - a. The Liebert iCOM shall be microprocessor-based with a 7-inch, high-definition, capacitive, color touchscreen display and shall be mounted in an ergonomic, aesthetically pleasing housing. The display and housing shall be viewable while the front panel is open or closed. The controls shall be menu driven. The system shall display user menus for active alarms, event log, graphic data, unit view/status overview (including the monitoring of room conditions, operational status in percentage of each function, date and time), total run hours, various sensors, display setup and service contacts. A password shall be required to make system changes. Service menus shall include setpoints, standby settings (lead/lag), timers/sleep mode, alarm setup, sensor calibration, maintenance/wellness settings, options setup, system/network setup, auxiliary boards and diagnostics/service mode. The Liebert iCOM control shall provide Ethernet/RS-485 ports dedicated to BMS connectivity (i.e. Base-Comms).

- 1) Password Protection – The Liebert iCOM shall contain two unique passwords to protect against unauthorized changes. An auto hide/show feature allows the user to see applicable information based on the login used.
- 2) Unit Backup and Restore – The user shall be able to create safe copies of important control parameters. The Liebert iCOM shall have the capacity for the user to automatically backup unit configuration settings to internal memory or USB storage drive. Configuration settings may be transferred to another unit for a more streamlined unit startup.
- 3) Parameter Download – The Liebert iCOM shall enable the user to download a report that lists parameter names, factory default settings and user-programmed settings in .csv format for remote reference.
- 4) Parameter Search – The Liebert iCOM shall have search fields for efficient navigation and parameter lookup.
- 5) Parameter Directory – The Liebert iCOM shall provide a directory that lists all parameters in the control. The list shall provide Line ID numbers, parameter labels, and current parameter values.
- 6) Context-Sensitive Help – The Liebert iCOM shall have an on-board help database. The database shall provide context sensitive help to assist with setup and navigation of the menus.
- 7) Display Setup – The user shall have the ability to configure the Liebert iCOM information based on the specific user's preference. Language, units of measure, screen contrast, home screen layout, back-light timer and the hide/show of certain readouts shall be configurable through the display.
- 8) Additional Readouts – The Liebert iCOM shall permit the user to configure custom widgets on the main screen. Widget options shall include items such as fan speed, call for cooling, call for free-cooling, maintenance status, call for hot water reheat, call for electric reheat, call for dehumidification, call for humidification, airflow, static pressure, fluid flow rate and cooling capacity.
- 9) Status LEDs – The Liebert iCOM shall provide the user with the unit's operating status using an integrated LED. The LED shall indicate if the unit has an active alarm; if the unit has an active alarm that has been acknowledged; or if the unit is On, Off or in standby status.
- 10) Event Log – The Liebert iCOM shall automatically store the last 400 unit-only events (messages, warnings, and alarms).
- 11) Service Contact Information – The Liebert iCOM shall have the ability to store the local service or sales contact information.
- 12) Upgradeable – Liebert iCOM firmware upgrades shall be performed through a USB connection.
- 13) Timers/Sleep Mode – The menu shall allow various customer settings for turning the unit On or Off.
- 14) Menu Layout – The menus shall be divided into two main menus: User and Service. The User screen shall contain the menus to access parameters required for basic unit control and setup. The Service screen shall be designed for service personnel and shall provide access to advanced control setup features and diagnostic information.
- 15) Sensor Calibration – The menus shall allow unit sensors to be calibrated with external sensors.

- 16) Maintenance/Wellness Settings – The menus shall allow reporting of potential component problems before they occur.
 - 17) Options Setup – The menus shall provide operation settings for the installed components.
 - 18) Auxiliary Boards – The menus shall allow setup of optional expansion boards.
 - 19) Various Sensors – The menus shall allow setup and display of optional custom sensors. The control shall include four customer-accessible analog inputs for sensors provided by others. The analog inputs shall accept a 4 to 20mA signal. The user shall be able to change the input to 0 to 5VDC or 0 to 10VDC. The gains for each analog input shall be programmable from the front display. The analog inputs shall be able to be monitored from the front display. When configuring the analog inputs, the selectable items to choose shall include air pressure, fluid pressure, temperature, percentage, general amperage, condenser amps, compressor amps, reheat amps, humidifier amps, unit amps, fan amps factory standard, and not used.
 - 20) Diagnostics/Service Mode – The Liebert iCOM™ control shall be provided with self-diagnostics to aid in troubleshooting. The microcontroller board shall be diagnosed and reported as pass/not pass. Control inputs shall be indicated as On or Off at the front display. Control outputs shall be able to be turned On or Off from the front display without using jumpers or a service terminal. Each control output shall be indicated by an LED on a circuit board.
 - 21) Base-Comms for BMS Connectivity – The Vertiv/Liebert iCOM controller shall provide one Ethernet Port and RS-485 Port dedicated to BMS Connectivity. Provides ground fault isolated RS-485 Modbus, BACnet IP & Modbus IP network connectivity to Building Management Systems for unit monitoring and management. Also, provides ground fault isolated 10/100 baseT Ethernet connectivity for unit monitoring and management. The supported management interfaces include: SNMP for Network Management Systems, HTTP for web page viewing, SMTP for email, and SMS for mobile messaging. The iCOM controller can support dual IP on a single network and one 485 protocol simultaneously.
- b. Display Panel Mounting Height: CRAC units shall have the display panel mounted lower than the standard height to accommodate the 24" high floor stand.
2. Alarms:
 - a. All unit alarms shall be annunciated through both audio and visual cues, clearly displayed on the screen, automatically recorded in the event log and communicated to the customer's Building Management System/Building Automation System. The Liebert iCOM control shall activate an audible and visual alarm in the event of any of the following conditions:
 - 1) High Temperature
 - 2) Low Temperature
 - 3) High Humidity
 - 4) Low Humidity
 - 5) EC Fan Fault

- 6) Change Filters
 - 7) Loss of Air Flow
 - 8) Loss of Power
 - 9) Compressor Overload (Standard on DA050 and Optional DA080 to DA165)
 - 10) Humidifier Problem
 - 11) High Head Pressure
 - 12) Low Suction Pressure
 - 13) Custom Alarms
 - b. Custom alarm inputs shall be provided to indicate facility-specific events. Custom alarms can be identified with programmable labels. Frequently used alarm inputs shall include:
 - 1) Leak Under Floor
 - 2) Smoke Detected
 - 3) Standby Unit On
 - c. Each alarm (unit and custom) shall be separately enabled or disabled, selected to activate the common alarm and programmed for a time delay of 0 to 255 seconds.
3. Control Methods:
- a. The Liebert iCOM shall be flexible in the sense that it shall allow for controlling the capacity and fan from multiple different sensor selections. The sensor selections shall be:
 - 1) Cooling Capacity
 - a) Supply
 - b) Remote
 - c) Return
 - 2) Fan Speed
 - a) Supply
 - b) Remote
 - c) Return
 - d) Manual (for diagnostics or to receive a signal from the BMS through Liebert remote monitoring devices or analog input)
 - e) Static Pressure (requires an external device, by others)
 - b. Temperature Compensation: The Liebert iCOM™ shall be able to adjust the capacity output based on supply and return temperature conditions to meet SLA guidelines while operating at highest efficiency.
 - c. Humidity Control: Dew point and relative humidity control methods shall be available (based on user preference) for humidity control within the conditioned space.
4. Multi-Unit Coordination
- a. Liebert iCOM teamwork shall save energy by preventing multiple units in an area from operating in opposing modes. Teamwork allows the control to optimize a group of connected cooling units with Liebert iCOM using the U2U (Unit-to-Unit) network. There shall be three modes of teamwork operation:
 - b. Teamwork Mode 1 (Parallel) – Is best in small rooms with balanced heat loads. The controlling temperature and humidity sensor readings of all units in operation (fan On) are collected to be used for an average or worst-case sensor reading (user selectable). The master unit shall send the operating

- requirements to all operating units in the group. The control band (temperature, fan and humidity) is derived and shared among the units in the group. Each unit will receive instructions on how to operate from the Master unit based on how far the system deviates from the setpoints. Evaporator fans and cooling capacity are ramped in parallel.
- c. Teamwork Mode 2 (Independent) – The Liebert iCOM calculates the worst-case demand for heating, cooling humidification and dehumidification. Based on the greatest demand within the group, each unit operates independently, meaning that the unit may respond to the thermal load and humidity conditions based on the units controlling sensors. All sensor readings are shared.
 - d. Teamwork Mode 3 (Optimized Aisle) – May be employed in large and small rooms with varying heat loads. Optimized Aisle is the most efficient teamwork mode that allows the unit to match cooling capacity with heat load. In the Optimized Aisle mode, the fans operate in parallel. Fans can be controlled exclusively by remote temperature or using static pressure with a secondary remote temperature sensor(s) as an override to ensure that the inlet rack temperature is being met. Cooling (Compressors, Economizer or EconoPhase) is controlled through unit supply-air conditions. The Liebert iCOM calculates the average or worst-case sensor reading (user-selectable) for heating, cooling humidification and dehumidification. Based on the demand within the group, units will be allowed to operate within that mode until room conditions are satisfied. This is the best form of control for a room with an unbalanced load.
5. Standby/Lead-Lag: The Liebert iCOM shall allow scheduled rotation to keep equal run time on units and provide automated emergency rotation of operating and standby units.
 6. Standby Unit Cascading: The Liebert iCOM cascade option shall allow the units to turn On and Off based on heat load when utilizing Teamwork Mode 3–Optimized Aisle mode with remote temperature sensors. In Teamwork Mode 3, Cascade mode will stage units On based on the temperature and humidity readings and their deviation from setpoint. Cascade mode coordinates the fan speed dynamically to save energy and to meet the cooling demands. For instance, with a Liebert iCOM group of six units and only 50% of the heat load, the Liebert iCOM shall operate only four units at 80% fan speed and leave the other two units in standby. As the heat load increases, the Liebert iCOM shall automatically respond to the additional new load and bring on another unit, increasing the units in operation to five. As the heat load shifts up or down, the control shall meet the needs by cascading units On or putting them back into standby.
 7. Virtual Master: As part of the robust architecture of the Liebert iCOM control, it shall allow for a virtual master that coordinates operation. The Virtual Master function shall provide smooth control operation if the group's communication is compromised. When the lead unit, which is in charge of component staging in teamwork, unit staging and standby rotation, becomes disconnected from the network, the Liebert iCOM shall automatically assign a virtual master. The virtual master shall assume the same responsibilities as the master until communication is restored.

8. Virtual Back-Draft Damper: The Liebert iCOM shall allow the use of a virtual back-draft damper, eliminating the need for a mechanical damper. This shall allow the fans of a stand-by unit to spin slower (15% or less) to act as a damper.
9. Compressor Short Cycle Control: Compressor short cycle control shall be available to prevent compressor short-cycling and needless compressor wear.
10. Condenser Communication: The Liebert iCOM shall communicate directly with the Liebert MC condenser unit via field-supplied CANbus communication wires and via field-supplied, low-voltage interlock wires. This communication shall allow Liebert iCOM to control Liebert MC condenser modes and operation and to monitor their health and alarm status.
11. Wired Supply Sensor: Each Liebert iCOM shall have one factory-supplied and connected supply air sensor that may be used as a controlling sensor or reference. When multiple sensors are applied for control purposes, the user shall be able to control based on a maximum or average temperature reading.
12. System Auto Restart: The auto restart feature shall automatically restart the system after a power failure. Time delay shall be programmable. An optional capacitive buffer may be provided for continuous control operation through a power outage.
13. Sequential Load Activation: On initial startup or restart after power failure, each operational load shall be sequenced with a minimum of one second delay to minimize total inrush current.
14. Low-Pressure Monitoring: Units shall ship standard with low-pressure transducers for monitoring individual compressor suction pressure. If the pressure falls due to loss of charge or other mechanical cause, the corresponding circuit shall shut down to prevent equipment damage. The user shall be notified of the low-pressure condition through the local display and remote monitoring.
15. Winter Start Time Delay: An adjustable software timer shall be provided to assist with compressor starting during cold weather. When the compressor starts, the low-pressure input shall be ignored for the period set in the user-adjustable timer. Once the delay after the compressor start has elapsed, the low-pressure input should remain in the normal state. If the low-pressure input does not remain in the normal state after the delay has elapsed, the circuit shall lock out on low pressure. The low-pressure alarm shall be announced on the local display and communicated to remote monitoring systems.
16. Advanced Freeze Protection: Units shall ship standard with advanced freeze protection enabled. The advanced freeze protection shall monitor the pressure of each circuit using a transducer. The control shall interact with the fan and compressor to prevent the unit coil from freezing if circuit suction pressure drops. Applying fan speed to direct expansion systems requires limitations to avoid freezing condensate on the coil when the unit operates below 100% fan speed. Liebert iCOM's advanced freeze protection provides the ability to predict freeze conditions and correct this condition automatically by adjusting fan speed and compressor capacity. If a freeze condition is detected, the user shall be notified through the local display and remote monitoring systems.
17. Advanced High-Pressure Protection: When the compressor is initially activated, the system shall be monitored for high pressure. When high pressure is detected, the control shall reduce the system discharge pressure by altering the compressor loading and the condenser fan speed, preventing circuit shut down. If the unit is

unsuccessful in correcting the problem through this interaction, an alarm shall occur, and the affected compressor shall be immediately locked off. The control shall automatically re-enable the compressor when pressure returns to a safe level.

18. Refrigerant Pressure Transducer Failure: The control shall monitor the high-side and low-side refrigerant pressure transducers. If the control senses that the transducer has failed, has been disconnected, shorted or the reading has gone out of range, the user shall be notified through the local display and remote monitoring. The corresponding circuit that the failure has occurred on shall be disabled to prevent unit damage.
19. Oil Return Protection: The control shall monitor compressor operation and staging to ensure that liquid and hot gas velocity are maintained for proper oil return to the compressor.
20. Digital Scroll High-Temperature Protection: The control shall monitor digital scroll temperature during unit operation. A compressor temperature limit shall be imposed to help prevent damage to the compressor. If the temperature reaches the maximum temperature limit, the compressor shall be locked out for 30 minutes and an alarm shall be annunciated on the local display and through monitoring. After the initial lockout, the control shall continue to monitor compressor temperature during the off-cycle and re-enable the circuit once a safe operating temperature is reached and the 30 minutes has elapsed. The control shall store the number of high-temperature trips. The number of trips shall be accessible through the local display.
21. Digital Scroll Sensor Failure: The control shall monitor the status of the digital scroll sensor(s). If the control senses the thermistor becomes disconnected, shorted or the reading goes out of range, the user will be notified through an event on the local display and remote monitoring.
22. Compressor Sequencing: A user-selectable compressor sequencing parameter shall be provided and access through the local control. This sequencing parameter presents the user with three choices:
 - a. Always use Compressor 1 as lead compressor.
 - b. Always use Compressor 2 as lead compressor (Models DA080-DA165).
 - c. Auto: The unit shall automatically stage compressors to keep each unit's run time within 8 hours of the other unit's run time.
 - d. NOTE: The Auto setting attempts to maintain equal run times between compressors. However, the control will not turn Off a compressor to equalize run time when it is needed to control the space.
 - 1) First priority – If the safety timings are acceptable for only one compressor, that compressor shall be the next to be started/stopped.
 - 2) Second priority – If both compressors are Off, the one with fewer working hours shall be the next to start.
 - 3) Third priority – If both compressors are in operation, the one that has been operating longer since the last start shall be the next to be stopped.
23. Compressor High- And Low-Temperature Limit Protection: The control shall monitor the return air to ensure that the compressor(s) are operated within the manufacturer's defined window of operation. If the return air temperature deviates

from the manufacturer's window of operation, the Liebert iCOM shall automatically adjust to prevent damage to the cooling unit or reduction in its reliability.

24. Compressor Run Time Monitoring:
 - a. The control shall log these compressor statistics:
 - 1) Number of compressor starts
 - 2) Run hours
 - 3) Average run time
 - 4) Starts per day
 - 5) Starts per day worst
 - 6) Number of high-pressure alarms
 - 7) Operating phase in which the high-pressure alarm occurred
 - 8) Number of low-pressure alarms
 - 9) Operating phase in which the low-pressure alarm occurred
 - 10) Number of compressor overloads
 - 11) Number of high-temperature alarms (scroll compressors)
 - b. The user shall have the ability to monitor compressor operating temperature and pressure from the local display to be used as a diagnostic tool.
25. Manual Compressor Disablement: The user shall have the ability to disable compressor operation using a set of either normally open or normally closed dry contacts tied directly to the control or through remote monitoring. An additional enable/disable feature shall be provided to allow the user to permanently disable an individual compressor circuit for maintenance using the local display.
26. Manual Compressor Operation: The user shall be able to operate each compressor manually from the local display. The user shall be able to energize refrigeration components including liquid-line solenoid valves, compressor contactors, electronic expansion valves and adjust capacity for troubleshooting or repair. The control shall monitor the compressor during manual operation and shall shut the compressor down if needed to prevent electrical or mechanical damage.
27. Provide supply and return air temperature/humidity sensors. The sensors shall be field installed in the supply and return air plenum housings.
28. Quick Start Function: Provide quick restart software and controls powered by integral capacitor.
 - a. When enabled, the quick-start feature shall become available in the event the capacitive buffer is no longer able to maintain power to the unit controller and the unit controller powers down. Upon power restoration to the unit controller, the quick-start feature shall activate and provide fan/cooling output. The quick-start feature shall support the full range of cooling operating modes for the CRAC system: DX Mode, Mixed Mode, and Economizer Mode. Upon a system power restoration, the CRAC unit shall continue operation and start in the last known cooling operating mode that was active prior to the loss of power. The unit restart time for full cooling shall be 40 seconds or less after power to the unit has been restored, with fans starting within 15 seconds. The unit shall be equipped with a UPS or capacitive buffer to provide the unit controller with a minimum of 3 minutes of ride-through power. The capacitive buffer shall provide power for continuous connectivity to the Building Automation System through the unit controller.

29. Wired Remote Sensor: Each Liebert iCOM™ can have up to 10 (ten) 2T sensors (20 sensor readings total) for control or reference. As part of the U2U network, those sensors shall be shared and used to control the cooling units and provide greater flexibility, visibility, and control to respond to changes in the conditioned space. When the sensors are used for control, the user may set the control to be based off a maximum or average of a selected highest temperature reading.

L. Floor Stand:

1. Provide a factory integrated floor stand constructed of a heliarc welded tubular steel frame and adjustable legs.
2. The floor stand height shall be 24 inches high.
3. The floor stand shall be constructed to comply with the seismic criteria and be anchored to the concrete floor slab and to the unit.
4. Provide a grounding lug on the floor stand.

M. Integral CRAC Unit Smoke Detector: Required.

N. Integral Dry Contacts for Fire Alarm System Shut Down: Upon sensing smoke in the room, the building fire alarm system shall utilize the dry contacts to immediately shut down the CRAC unit and activate the alarm system when activated.

O. Water Detection Cable: Provide 30-foot long cable. Contractor to field install leak detection cable within containment area, around unit.

P. Low Voltage Terminal Package: Factory-installed and factory-wired terminals shall be provided.

1. Remote Shutdown Terminals: Two (2) additional pairs of terminals provide the customer with additional locations to remotely shut-down the unit by field-installed devices or controls.
2. Extra Common-Alarm Contacts: Two (2) additional pairs of terminals provide the customer with normally-open contacts for remote indication of unit alarms.
3. Main-Fan Auxiliary Switch: One (1) set of normally-open contacts wired to the EC-fan motor contactor will close when EC-fan operation is required.
4. Leak Detection CRAC Unit Shutdown: One (1) pair of dry contacts for the water sensor signal to shut down CRAC unit.

Q. Accessories Not Required: The following accessories are not required and will not be furnished.

1. Humidifier.
2. Reheat coil.
3. Condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

2.3 CAPACITIES AND CHARACTERISTICS

A. Refer to the equipment schedules in the Drawings for capacities and characteristics.

PART 3 - EXECUTION

3.1 EXAMINATION (INSTALLING CONTRACTOR)

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for refrigerant piping, condensate drain piping, and electrical systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where computer room air conditioning units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION (INSTALLING CONTRACTOR)

- A. Install the computer room air conditioning units in accordance with the Manufacturer's requirements.
- B. The Contractor shall remove shipping bolts, blocks, and tie-down straps.
- C. Layout and install computer room air conditioning units and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- D. Install computer room air conditioning units level and plumb, maintaining manufacturer's recommended clearances.
- E. Install the components shipped loose with the computer room air conditioning units.
- F. Computer Room Air-Conditioning Unit Mounting: Install units on manufacturer furnished floor stands.
- G. Secure the air conditioning unit to the floor stand and anchor the floor stand to the concrete floor slab.
- H. Provide plenum approved, liquid-tight flexible conduits to route high voltage and low voltage conductors inside the units.
- I. Connect the supply air temperature cable to the unit and attach the sensing cable to the front of the unit, to sense the discharge supply air temperature.
- J. Install the static air pressure transducer at the mid-point of a raised access floor pedestal, centered on the front of the computer room air conditioning unit, and a minimum distance of six feet from the front face of the computer room air conditioning unit, as indicated on the Drawings. This is applicable only for raised access floor installations.

- K. Provide temporary equipment tag labels after the units are set in place. The temporary labels may be painter's tape with hand-written tags in black ink or equivalent. Remove the temporary labels after final labels are installed.
- L. Install and secure the return air plenum housings on top of the computer room air conditioning units.
- M. Connect the fire alarm system wiring to the computer room air conditioning units.
- N. Upon completion of the start-up service, the Contractor shall remove dirt and construction debris, final clean inside and outside of units, and repair damaged finishes including chips, scratches and abrasions in the factory furnished materials through full panel removal, complete refinishing and re-installation. Touch-up shall not be permitted.
- O. The Contractor shall provide a synthetic/polyester, MERV 5, bulk media roll material as a construction pre-filter upstream of the return filters for the air conditioning units. Remove construction pre-filters after successful completion of commissioning.
- P. Provide one (1) air conditioning unit panel key to the Design Professional during the final punch list.
- Q. Air-Cooled Refrigerant Condenser Mounting: Install on structural steel frame above the roof level.

3.3 CONNECTIONS (INSTALLING CONTRACTOR)

- A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to computer room air conditioning units, allow space for service and maintenance.
- C. The Contractors are responsible for making final connections to the equipment:
 - 1. Refrigerant Piping Connections.
 - 2. Drainage Connections.
 - 3. Electrical Power Connections.
 - 4. Controls and Monitoring Connections.
 - 5. Fire Alarm Connection.

3.4 START-UP SERVICE

- A. Provide an authorized factory-trained representative to perform start-up service for every unit.
 - 1. Provide start-up checklist forms for each unit to the Contractors prior to performing start-up service.
 - 2. Tests and Inspections:
 - a. Verify shipping bolts, blocks, and tie-down straps have been removed.

- b. Verify power supply sources are available and of the correct characteristics.
 - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - e. Inspect unit and components for damage.
 - f. Verify unit is level.
3. Conduct start-up service and complete start-up test forms.
 4. Submit test forms to the Owner and Construction Manager upon completion.
- B. Computer room air conditioning units shall be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

- A. A factory-authorized service representative shall adjust the units as follows:
1. Adjust initial temperature set points.
 2. Verify the alarms operate properly and sensors properly calibrated.
 3. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 4. The adjustable parameters shall be documented for each unit and provided to the Owner. Parameter settings shall be consistent for the installed units.

3.6 COMMISSIONING ASSISTANCE

- A. A factory-authorized service representative is not required to be on-site during the commissioning process.
- B. A factory-authorized service representative shall correct any deficiencies discovered during the commissioning process. The anticipated schedule is for commissioning to occur during the last six to eight weeks of construction. The construction timeline, duration, and schedule shall be dictated by the Owner and Construction Manager.

3.7 DEMONSTRATION

- A. A factory-authorized service representative shall train Owner's maintenance personnel as specified below.
1. Provide a written training agenda to the Owner, through the Construction Manager, a minimum of 7-days prior to training session.
 2. Schedule training with Owner, through the Construction Manager with at least 7 days of notice.
 3. Provide a minimum of 8-hours of on-site technician-level training. Training to be performed within one year of the substantial completion date.
 4. The Owner will provide a suitable classroom environment on site for the instruction sessions.

5. Train Owner's maintenance personnel on procedures and schedules related to operating, startup and shutdown, adjusting, troubleshooting, servicing, and preventive maintenance.
6. Review data in the maintenance manuals.
7. Provide the software and hardware necessary to access the system logic for service training.
8. If the Owner elects to video record the training session, the Owner will need to sign the manufacturer's waiver.

END OF SECTION