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USACE / NAVFAC / AFCEC / NASA **UFGS-23 81 23 (November 2020)**

Preparing Activity: NAVFAC **Superseding**
UFGS-23 81 23.00 20 (February 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2023
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COMPUTER ROOM AIR CONDITIONING UNITS

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SECTION 23 81 23

COMPUTER ROOM AIR CONDITIONING UNITS
11/20

****
NOTE: This guide specification covers the requirements for heating, ventilating, and cooling (HVAC) equipment for thermal, humidity, and airflow control in data processing environments.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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NOTE: Use the most efficient, competitively available CRAC for which there are at least two products available for the indicated ranges of comparability. Design parameters for each item of equipment shall be indicated on the drawings including capacity, efficiency, sound ratings, motor speeds, electrical characteristics, and special features.

System requirements must conform to UFC 3-410-01, "Heating, Ventilating, and Air Conditioning Systems".
****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 1360	(2017) Performance Rating of Computer and Data Processing Room Air Conditioners
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ANSI/AHRI 520	(2004) Performance Rating of Positive Displacement Condensing Units

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2016) Ventilation for Acceptable Indoor Air Quality

ASHRAE 90.1 - IP	(2019; Errata 1 2019; Errata 2-5 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 6-8 2021; Interpretation 1-4 2020; Interpretation 5-8 2021 Addenda AS-AQ 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2019; Errata 1-4 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 5-7 2021; Interpretation 1-4 2020; Interpretation 5-8 2021; Addenda AU-CM 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 127	(2020) Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.1	(2022) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME BPVC	(2010) Boiler and Pressure Vessels Code

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM C1338	(2014) Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings
ASTM D5864	(2011) Standard Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or Their Components
ASTM D6081	(1998; R 2014) Aquatic Toxicity Testing of Lubricants: Sample Preparation and Results Interpretation
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM G21	(2015; R 2021; E 2021) Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

ETL TESTING LABORATORIES (ETL)

ETL DLP	(updated continuously) ETL Listed Mark Directory

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2023) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1424	(2016) Engineering and Design -- Lubricants and Hydraulic Fluids

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

16 CFR 1201	Safety Standard for Architectural Glazing Materials
40 CFR 82	Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 94	(2013; Reprint Apr 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 181	(2013; Reprint Dec 2021) UL Standard for Safety Factory-Made Air Ducts and Air Connectors
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL Elec Equip Dir	(2011) Electrical Appliance and Utilization Equipment Directory

1.2 DEFINITIONS

Computer Room Air Conditioner (CRAC): A single, self-contained unit or split-system unit designed and manufactured specifically for temperature and humidity control of data processing environments.

Cold Aisle: The aisle between or adjacent to rows of racks from which the computing equipment draws cool air.

Hot Aisle: The aisle between or adjacent to rows of racks to which the computing equipment ejects hot air.

Rack: Telecommunications support frame that can consist of post-and-frame or full cabinet construction. Racks are provided under Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.3 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that

will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Computer Room Air Conditioner; G[, [_____]]

Small Computer Room Air Conditioners; G[, [_____]]

Space Temperature Control System Drawings; G[, [_____]]

Filters

Refrigerants; S

[Cold][and][Hot] Aisle Containment Systems; G[, [_____]]

Rack Mounted Fans; G[, [_____]]

Leak Detection; G[, [_____]]

SD-06 Test Reports

****

NOTE: Factory witness testing is expensive and rarely necessary for commonly manufactured mechanical equipment such as CRAC. Confirm with the facility owner that witness testing is necessary and worth the cost.

****

CRAC Production Schedule and Factory Test Schedule; G[, [_____]]

Manufacturer's Factory Test Plans; G[, [_____]]

Factory Test Reports; G[, [_____]]

Field Test Schedule; G[, [_____]]

Manufacturer's Field Test Plans; G[, [_____]]

Field Test Reports; G[, [_____]]

SD-07 Certificates

Certificate of Specification Compliance; G[, [_____]]

Credentials of the Manufacturer's Field Test Representative; G[, [_____]]

Ozone Depleting Substances Technician Certification

Certified List Of Qualified Permanent Service Organizations

Seismic Certification; G[, [_____]]

SD-08 Manufacturer's Instructions

Installation Manual for Each Type of CRAC

Installation Manual for Each Type of Aisle Containment System

Installation Manual for Each Type of Rack Mounted Fan

SD-10 Operation and Maintenance Data

Computer Room Air Conditioner Operation and Maintenance Data, Data Package 4; G[, [_____]]

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.4 REFRIGERANTS

****
NOTE: EPA, per the Significant New Alternative Policy rule, reviews refrigerant substitutes on the basis of ozone depletion potential, global warming potential, toxicity, flammability, and exposure potential. Lists of acceptable and unacceptable substitutes are updated several times each year. A chronological list of SNAP updates is available at https://www.epa.gov/snap/substitutes-refrigeration-and-air-conditioning or from the stratospheric ozone information hotline at 1 (800) 296-1996. Reducing ozone depletion and global warming potential by reducing or eliminating CFC, and reducing or eliminating HCFC and Halon use in air conditioning equipment is required.
****

Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0. CFC-based refrigerants are prohibited. [HCFCs][and][Halons] are not permitted. Provide SDS sheets for all refrigerants.

1.5 QUALIFICATIONS

1.5.1 Ozone Depleting Substances Technician Certification

****
NOTE: The following paragraph requires a certification for technicians who work on equipment that could release ozone depleting refrigerants, such as R-123, into the atmosphere. This is required as of January 1, 2018 to meet the requirements of 40 CFR 82, Subpart F.
****

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.6 QUALIFICATIONS

1.6.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacturer of such products, which are of a similar material, design, and workmanship. Standard products must have been in satisfactory commercial or industrial use for two years prior to bid opening. The two-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the two-year period.

1.6.2 Alternative Equipment Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.6.3 Service Support

The equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.4 Manufacturer's Nameplate

For each item of equipment, provide a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.6.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.6.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions must be considered mandatory, the word "should" is interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" must be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" must be interpreted to mean the "lessor." References to the "permit holder" must be interpreted to mean the "Contractor."

1.6.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of

Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.7 PROJECT REQUIREMENTS

1.7.1 Verification of Dimensions

Become familiar with the details of the work, verify all dimensions in the field, and provide adequate clearance for all connections and service access. Notify the Contracting Officer of any discrepancy before performing any work.

1.7.2 Energy Efficiency

****
NOTE: Refer to ASHRAE 90.1 - SI ASHRAE 90.1 - IP Table 6.8.1-11 for the minimum efficiency requirements of air conditioners and condensing units serving computer rooms. Efficiencies should be indicated on schedules and should be better than or equal to the minimum efficiencies required by ASHRAE 90.1 - SI ASHRAE 90.1 - IP.
****

Provide equipment with minimum efficiencies [as indicated][as required by ASHRAE 90.1 - SI ASHRAE 90.1 - IP].

1.8 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

PART 2 PRODUCTS

2.1 COMPUTER ROOM AIR CONDITIONER (CRAC)

****
NOTE: The indoor components of the CRAC are inherently noisy. In noise sensitive areas, designers should take steps to attenuate CRAC generated sound. Determine the maximum acceptable sound level limit for the application in NC level or dbA and add the limit to the CRAC equipment schedule. This sound level compliance may be verified by the CRAC factory and field tests.
****

****
NOTE: Designers should locate the floor registers in a raised floor system as far from the CRAC as possible to reduce direct sound transmission from the unit to the conditioned space and to improve air

distribution performance. Floor registers should be coordinated with Section 09 69 13 RIGID GRID ACCESS FLOORING.

****

****

NOTE: Designers should indicate the mandatory routing of piping around the floor stand of a downflow CRAC in their piping plan view and piping details. Ensure, by dimensioning of piping details, that no piping interferes with the air flow performance of the CRAC.

****

****

NOTE: Refer to ASHRAE 90.1 - SI ASHRAE 90.1 - IP Table 6.8.1K for the minimum efficiency requirements of air conditioners and condensing units serving computer rooms.

****

Provide complete working CRACs, designed, [and] factory assembled[, and factory tested]. Equipment must be listed in UL Elec Equip Dir or ETL DLP for computer room application. CRACs must have a minimum sensible coefficient of performance of [_____] in accordance with ASHRAE 127. Computer Room Air Conditioners must have [a minimum [seasonal]energy efficiency ratio ([S]EER) of [_____],] [a minimum Heating Seasonal Performance Factor (HSPF) of [_____],] [a minimum Integrated Part Load Value (IPLV) of [_____],][and][a minimum COP of [_____]]. CRACs must include room cabinet and frame, [floor stand,]fan section, filter section, cooling coil, [reheat coil,][humidifier,][compressor[s],][condenser[s],]controls, and, interconnecting piping internal to the CRAC. Provide units rated in accordance with AHRI 1360.

2.1.1 Unit Airflow Configuration

****

NOTE: Indicate the airflow configuration for each unit on the equipment schedule.

****

2.1.1.1 Downflow Units

The CRAC must draw return air in at the top [or sides]of the cabinet and discharge supply air at the bottom of the cabinet.

2.1.1.2 Upflow Units

The CRAC must draw return air in at the bottom [or sides]of the cabinet and discharge supply air at the top of the cabinet.

2.1.1.3 In-row Units

****

NOTE: Security and procurement constraints may not allow the use in in-row units. In-row units must be coordinated with the support frame provided under Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM, which, in some instances, may be provided

under a separate contract.
****

The CRAC must be designed and manufactured to be installed within the row of server cabinets where it must draw return air in at the back (from the hot aisle) and discharge supply air at the front (into the cold aisle). In-row units must match the height and depth of the adjacent racks and integrate into the row such that no gaps exist that would allow air to bypass from the cold aisle to the hot aisle.

2.1.1.4 Ceiling Mounted Units

The CRAC must be designed to be installed at or above the ceiling where it must draw return air in at a duct connection or integral return grille and discharge supply air at a duct connection or integral supply register.

2.1.2 Cabinet and Frame

2.1.2.1 Unit Frame

Unit frame must be manufactured of welded steel tubes and must be mill-galvanized or coated with an epoxy finish.

2.1.2.2 Unit Cabinet

Exterior panels must be steel sheet, minimum of 1.0 mm 20 gage, mill-galvanized or coated with a corrosion-inhibiting epoxy finish in [manufacturer's standard][the specified][the indicated] color. Mill galvanized sheet metal must be coated with not less than 380 gram of zinc per square meter 1.25 ounces of zinc per square foot of two-sided surface. Mill rolled structural steel must be hot-dip galvanized or primed and painted. Cut edges, burns and scratches in hot-dip galvanized surfaces must be coated with galvanizing repair coating. Manufacturer's standard cabinet materials and finishes will be acceptable if equivalent to the above requirements and approved by the Contracting Officer.

Provide removable panel for access to controls without interrupting airflow. Panels must be gasketed to prevent air leakage under system operating pressure and must be removable for service access without the use of special tools.

[Provide double deflection [supply][and][return] grille[s] integral to unit. Grilles must be factory coated the same as the unit cabinet.

][2.1.2.3 Cabinet Interiors Sound Attenuation

****
NOTE: For CRAC interior cabinets located in spaces which require low sound levels because of interaction requirements of the operating personnel, select desired sound attenuation methods specified in this paragraph. In noise sensitive areas, specifiers should take special steps to attenuate CRAC generated sound, such as using the two inch foam requirement, in lieu of the fiber glass insulation.
****

Provide a factory-installed sound attenuation system in the interior of

the CRAC cabinet.

[CRAC cabinet panels interior must be provided with 25 millimeters of 24 kilogram per cubic meter 1 inch of 1 1/2 pound per cubic foot fiber glass insulation on interior of cabinet panels. Insulation must be applied to the cabinet panels with 100 percent adhesive coverage and both the insulation and the adhesive must conform to NFPA 90A. Insulation must be rated for 6000 fpm per UL 181 and ASTM C1071. Insulation must resist the growth of microorganisms per ASTM C1338 and ASTM G21.

][CRAC cabinet panels interior must be provided with minimum 50 millimeters two inch thick acoustical sound absorbing foam with a minimum Noise Reduction Coefficient (NRC) of 0.85.

][Compressors located in CRAC interior cabinets must be either wrapped in a sound absorbing insulating blanket or enclosed in its' own sound absorbing insulated mini-cabinet inside of the larger CRAC interior cabinet.

][Fans and compressors located in the CRAC interior cabinet must be provided with vibration isolators between their respective support frames and the cabinet framing.

] CRAC manufacturer's standard interior cabinet sound attenuation materials and finishes will be acceptable if equivalent to the above requirements and approved by the Contracting Officer.

]2.1.3 Fan Section

****
NOTE: For CRAC units of sizes 6 tons and more, when specifying a belt drive, specify dual V-belt fan drives.
****

Provide fan(s) and fan motor(s) as integral, factory installed components of the CRAC.[Provide units with capability to lower fans into the floorstand below the raised floor. The procedure to lower the fans must be described in the manufacturer's written installation instructions.]

2.1.3.1 Fan Wheel

The supply air fan must be AMCA certified. Provide [steel][aluminum], [forward curved, double-width, double-inlet][backward curved, plenum/plug type] fan wheel. The fan must be statically and dynamically balanced. The fan must have self-aligning, permanently lubricated ball bearings with a minimum life span of 100,000 hours. Assess potential effects of lubricant on aquatic organisms in accordance with ASTM D6081 and submit aquatic toxicity reports. Assess biodegradation in accordance with ASTM D5864. In accordance with EM 1110-2-1424 Chapter 8, aquatic toxicity shall exceed 1,000 ppm at LL50 and biodegradation shall exceed 60 percent conversion of carbon to carbon dioxide in 28 days.

2.1.3.2 Motor and Drive

[Provide fan wheel directly coupled to motor shaft.] [Provide [V-belt drive][dual V-belt drive] sized for 200 percent of the motor nameplate rating. Fan speed must be adjustable with cast iron variable pitch pulleys. Sheaves must be within the middle one third of the sheave adjustment range.]

[Provide drip-proof, permanent split capacitor type, NEMA rated motor with inherent overload protection and sliding adjustable motor base.] [Provide electronically commutated motor with integrated electronic control board and direct microprocessor control signaling for speed control.]

[Provide variable frequency drive(s) in accordance with Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

]2.1.4 Cooling Coil

****

NOTE: Indicate on the design drawings the minimum required head for the coil condensate pump. Do not locate units with hydronic coils directly above computer racks. A double-sloped pan prevents water from standing and stagnating in the pan.

****

Provide AHRI 410 coil and slope for drainage. Coil must be manufactured of seamless copper tubes with plate [aluminum][copper] fins.[Indoor and outdoor coils must be matched and from same manufacturer.] Each coil, in the production process, must be individually tested at 2200 kPa 320 psi with compressed air under water and verified to be air tight. Factory dehydrate and seal each coil after testing and prior to evaluation and charging.[Provide DX coil complete with a distributor and thermostatic expansion valve with external equalizer.][Provide hydronic coils complete with drain and vent connections.] Provide [double-sloped]condensate drain pan of [minimum 1.0 millimeter 22 gage Type 304 stainless steel][plastic] with nonferrous connections[,[and] internal trap,][, and a condensate pump system complete with integral pump discharge check valve, integral float switch, reservoir, and pump and motor assembly.]

2.1.5 Filters

****

NOTE: MERV 13 filters are typically at least 6 inches deep with 0.8 inch wg pressure drop or higher, making them only feasible in applied, belt-driven central station air handling units. Terminal equipment or smaller packaged rooftop equipment cannot achieve this level of filtration or generate the static pressure needed to deliver proper airflow when using this high efficiency filtration. Typically MERV 6 or 8 is the highest efficiency filter that can be applied for that equipment.

****

Provide UL listed [50] [100] [_____] mm [2] [4] [_____] inches thick deep pleated fiberglass throwaway type filters.[Additionally, provide [50] [_____] mm [2] [_____] inches thick deep pleated fiberglass throwaway type pre-filters.] Provide filtration media with a Minimum Efficiency Reporting Value (MERV) of [6][8][13] as determined by ASHRAE 52.2. Provide one complete spare filter bank set per unit for installation prior to final acceptance testing covered in Part 3 of this section.

2.1.6 Reheat Coil

[Provide AHRI 410 reheat coils and slope for drainage. Provide coil manufactured of seamless copper tubes with plate [aluminum][copper] fins. Each coil, in the production process, must be individually tested at 2200 kPa 320 psi with compressed air under water and verified to be air tight.

][Provide electric reheat coils with low watts density. The electric reheat coils must be enclosed in 304 stainless steel tubes and 304 stainless steel fins. Provide modulating control of the electric reheat coils by [multiple stages][or][Silicon Controlled Rectifier (SCR)]. Provide UL or ETL listed safety switches to protect system from overheating.

][2.1.7 Humidifier

****

NOTE: Investigate the water source conditions of the project site and specify the appropriate type of humidifier. If site water is very poor, a water treatment system may be required. Provide a deionized water system if using adiabatic humidifiers such as ultrasonic type. Specify an evaporator pan for infrared and ultrasonic humidifiers. Specify dispersion tube for steam generating humidifiers. Indicate steam generating capacities on the equipment schedule.

****

Humidifier section must include liquid-level control, emergency overflow and automatic water supply system factory pre-piped for final connection.[Provide stainless steel evaporator pan with water high level and low level alarms].[Provide [copper][stainless steel] atmospheric steam dispersion tube for installation in a [vertical][or][horizontal] air stream. Dispersion tube must have integral condensate return to the steam generator.] Arrange system to be cleanable and serviceable. Provide water chemistry requirements with humidifier submittal data.

[Provide infrared type humidifier, including high intensity quartz lamps mounted above and out of water supply.

][Provide humidifier of the self-contained steam generating electrode type utilizing a [plastic][disposable] canister with full probes connected to electric power via electrode screw connectors. Provide electrodes manufactured from expanded low carbon steel, zinc plated and dynamically formed for precise current control. The humidifier assembly must include integral fill cup, fill and drain valves and associated piping. Design the canister to collect the mineral deposits in the water and provide clean particle free steam to the air stream.

][Provide humidifier of the self-contained ultrasonic type operating on the principle of ultrasonic nebulization of water. Provide 300 series stainless steel casing. The ultrasonic humidifier must not produce any unacceptable noise radiation or frequency interference with communications or other electronic equipment. Provide water chemistry requirements with humidifier submittal data.

]][2.1.8 Compressor

Provide compressor that is direct drive, [semi-hermetic][or][hermetic

reciprocating,][or][scroll] type capable of operating at partial load conditions. Compressor must be capable of continuous operation down to the lowest step of unloading as specified. Provide compressors of 26 kW 7.5 tons and larger with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors operate in sequence, and each compressor has an independent refrigeration circuit through the condenser and evaporator. Start each compressor in the unloaded position. Provide compressor[s] complete with vibration isolation, suction and discharge service valves, high and low pressure safety switches, protection against short cycling, and built-in overload protection. Provide refrigeration circuits including hot gas mufflers, liquid-line filter-drier, refrigerant sight glass,[lubrication pump,] and moisture indicator, externally equalized expansion valve, and liquid-line solenoid valve factory connected with refrigeration copper tubing.[Crankcase heaters are required.][Provide hot gas bypass.]

2.1.8.1 Refrigeration Circuit

****
NOTE: Filter-driers are optional and may be deleted on most pre-charged systems.

Delete the last two sentences in the last paragraph except when needed for a self contained heat pump with an integral water cooled condenser.
****

Provide field-installed refrigerant tubing for split systems in accordance with Section 23 23 00 REFRIGERANT PIPING.

Refrigerant-containing components must comply with ANSI/ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged with [nitrogen][refrigerant and oil] and sealed. Provide refrigerant charging valves and connections, and pumpdown valves for each circuit.[Provide reversible-flow type filter-drier in each liquid line.][Refrigerant flow control devices must be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. Provide a refrigerant suction line [thermostatic][thermostatic and water flow switch] control to prevent freeze-up in event of loss of water flow during heating cycle.]

]2.1.9 Condenser[and][Dry Cooler]

****
NOTE: Insert minimum temperature at which the mechanical cooling equipment will be required to operate.
****

Provide condenser circuit pre-piped with start-up and head pressure controls to maintain system operation at ambient temperatures down to [4.4 degrees C] [minus 6.6 degrees C] [[_____] degrees C] [40 degrees F] [20 degrees F] [[_____] degrees F].

[Provide an integral factory wired and tested control panel for each condenser[and][dry cooler]. The factory control board must control each

condenser fan speed individually to optimize overall system performance.

][2.1.9.1 Air-cooled Condenser

Provide remote air-cooled condenser arranged for [vertical][or][horizontal] air discharge, designed and manufactured specifically for permanent outdoor installation. Condenser performance must be rated in accordance with ANSI/AHRI 460. Condenser must have head pressure control to allow unit operation down to [minus 18 degrees C] [minus 29 degrees C] [minus 34 degrees C] [0 degrees F] [minus 20 degrees F] [minus 30 degrees F].

2.1.9.1.1 Condenser Fans

Provide direct-driven propeller fans with factory balanced [aluminum][or][glass-reinforced polymer] blades and equipped with fan guards. Provide [permanent split capacitor][or][electronically commutated] fan motors with [drip proof][totally enclosed][explosion proof] enclosures.

2.1.9.1.2 Condenser Coils

Air-cooled condenser coils must be [seamless copper tubes with plate type [aluminum][cooper] fins][or][all aluminum microchannel type][with coating as described in [paragraph CORROSION PROTECTION FOR COASTAL INSTALLATIONS][Section 09 96 00 HIGH PERFORMANCE COATINGS]]. The coils, in the production process, must be pressure tested with compressed air at 2068 kPa 300 psig under water and verified to be leak-free. Factory dehydrate and seal each coil after testing and prior to evaluation and charging.

2.1.9.1.3 Unit Casing

Provide air-cooled condenser casings and mounting legs manufactured from [aluminum][or][galvanized steel] with[manufacturer's standard corrosion-resistant finish][coating as described in [paragraph CORROSION PROTECTION FOR COASTAL INSTALLATIONS][Section 09 96 00 HIGH PERFORMANCE COATINGS]].

][2.1.9.2 Liquid-cooled Condenser

****

NOTE: In cold climates it is often cost effective to install an economizer coil that is used instead of the evaporator during cold weather. During periods of cold weather "free cooling" can be provided. When the glycol in the condenser can be cooled to about 10 degrees C 50 degrees F or less, the refrigeration unit is bypassed and the air that is normally passed through the evaporator goes through the economizer coil which contains cold glycol flowing from the condenser.

Specify a fouling factor of 0.001 for projects with unknown water quality and/or questionable water treatment practices. Otherwise, specify 0.0005 fouling factor.

****

Provide cleanable, cast iron or steel shell and [copper][copper-nickel]

tubes, [counterflow type,][water-cooled][or][glycol-cooled]condenser with removable cast iron or steel heads. The condenser must be constructed in accordance with ASME BPVC.[As an option, a coaxial [copper][copper-nickel] tube-in-copper tube type water-cooled condenser may be provided.] Select liquid cooled condensers with a fouling factor of [0.001][0.0005]. Condensers must be rated for not less than 2758 kPa 400 psi refrigerant pressure and 862 kPa 125 psi water pressure at operating temperatures.

Water supply and return connections and piping internal to unit must be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement must include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Provide a separate condenser for each compressor circuit.

][2.1.9.3 Dry Coolers

Provide dry cooler arranged for vertical air discharge, designed and manufactured specifically for permanent outdoor installation.

2.1.9.3.1 Dry Cooler Fans

Provide direct-driven propeller fans with factory balanced [aluminum][or][glass-reinforced polymer] blades and equipped with fan guards. Provide [permanent split capacitor][or][electronically commutated] fan motors with [drip proof][totally enclosed][explosion proof] enclosures.

2.1.9.3.2 Dry Cooler Coils

Dry cooler coils must be seamless copper tubes with plate type [aluminum][copper] fins[with coating as described in [paragraph CORROSION PROTECTION FOR COASTAL INSTALLATIONS][Section 09 96 00 HIGH PERFORMANCE COATINGS]]. The coils, in the production process, must be pressure tested with compressed air 2068 kPa 300 psig under water and verified to be leak-free. Factory dehydrate and seal each coil after testing and prior to evaluation and charging.

2.1.9.3.3 Dry Cooler Casing

The dry cooler casings and mounting legs must be manufactured from [aluminum][or][galvanized steel] with[manufacturer's standard corrosion-resistant finish][coating as described in [paragraph CORROSION PROTECTION FOR COASTAL INSTALLATIONS][Section 09 96 00 HIGH PERFORMANCE COATINGS]].

[2.1.9.3.4 Integral Pump Package

Provide dry cooler with a [single][double] pump package complete with an open expansion tank. The pump package must be mounted in a weatherproof enclosure.

]][2.1.10 Economizers

****

NOTE: In most cases, the conditions for economizer operation should be determined by the CRAC controller. In some cases, a facility manager may want to control this with the Building Automation

System. Coordinate this specification with the specific site requirements.

****

The factory mounted CRAC controls must control the economizer operation process to ensure coordination of all components. The conditions for economizer operation must be determined[by the factory mounted CRAC controls based on indoor and outdoor conditions][by the HVAC control system].

[2.1.10.1 Air Economizers

****

NOTE: The use of air economizers in computer rooms requires careful evaluation for each individual application. In warm, moist climates, the number of available economizer hours often does not warrant the construction expense. In cold dry climates, the cooling savings may be partially offset by humidification loads.

****

Provide factory mounted dampers and duct connection flanges to allow up to 100 percent outdoor air through the unit for free cooling. Dampers must meet the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

][2.1.10.2 Water Economizers

****

NOTE: For use with water cooled direct expansion systems. Economizer operation in chilled water systems is accomplished at the chiller plant and is beyond the scope of this specification.

****

Provide factory mounted coil and condenser water changeover valve. When commanded, the changeover valve must divert condenser water flow from the condenser coil to the economizer coil.

Coil must meet AHRI 410 and be sloped for drainage. Provide coil manufactured of seamless copper tubes with plate aluminum fins. Each coil, in the production process, must be individually tested at 320 psi 2200 kPa with compressed air under water and verified to be air tight.

][2.1.10.3 Refrigerant Economizer

****

NOTE: For use with air cooled direct expansion systems. Verify the capability of site personnel to operate and maintain this system.

****

Provide fully integrated, pumped refrigerant economizer operation. In addition to the specified CRAC and air cooled condenser, provide a refrigerant pump package from the same manufacturer. The entire system must be controlled and optimized by the CRAC controls. During cold outdoor temperatures, the compressors must reduce capacity as much as possible. As compressor capacity decreases, a variable speed pump on each

refrigeration circuit must then pump the liquid refrigerant through the air cooled condenser and evaporator for free cooling.

]][2.1.11 Floorstand

Provide a[n] [adjustable] [225] [300] [450] [600] [_____] mm [9] [12] [18] [24] [_____] inches high [seismic rated]floorstand for each CRAC for freestanding installation on the main building structural floor. Floorstand must elevate the unit to the height of the raised computer floor and must allow for leveling and locking at the desired height. Floorstand must be retractable, or removable, for installing the unit directly on the raised floor. Unit must be fully gasketed (rubber or neoprene) to prevent air leakage at the raised floor penetration.[Provide radiused turning vane integral to floorstand.]

[For units requiring seismic certification, the floorstand must be included in the unit certification.

]]2.2 SMALL COMPUTER ROOM AIR CONDITIONERS

****
NOTE: Use this section for console type and ceiling mounted type computer room air conditioners under 5 tons. These units are typically used in telecom closets or small, low density computer rooms where airflow management is less of a concern.
****

Provide complete working CRACs, designed and factory assembled. Equipment must be listed in UL Elec Equip Dir or ETL DLP for computer room application. CRACs must have a minimum sensible coefficient of performance of [_____] in accordance with ASHRAE 127. CRACs must include room cabinet and frame, fan, filter, cooling coil, [reheat coil,][humidifier ,][compressor[s],][condenser[s],]controls, and, interconnecting piping internal to the CRAC. Provide units rated in accordance with AHRI 1360. Provide all refrigerant piping in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.2.1 System Configuration

****
NOTE: Specify each configuration type needed. If multiple types are required, indicate type for each equipment mark on the schedule. Retain the applicable subparagraphs "[EVAPORATOR][OR][COOLING COIL] CABINET CONSTRUCTION" through "INDOOR [WATER][GLYCOL] COOLED CONDENSING UNIT" to specify the various components necessary for each configuration included in the design.
****

[Self Contained Air Cooled: Provide an indoor unit for [ducted concealed][exposed] application. Unit must have connections for supply and return ducts from the central air handling system for heat rejection. Unit must consist of a direct expansion system evaporator and an indoor, air cooled condensing unit.

][Split System Air Cooled: Provide an indoor unit for [ducted concealed][exposed] application, an outdoor condensing unit, and

interconnecting refrigerant piping. Unit must consist of a direct expansion system evaporator and an outdoor, air cooled condensing unit.

][[Water][Glycol] Cooled: Provide an indoor unit for [ducted concealed][exposed] application.[Provide dry cooler as specified elsewhere in this section.][Provide [cooling tower][remote evaporatively cooled condenser] as specified in 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.] Unit must consist of a direct expansion system evaporator and an indoor, [water][glycol] cooled condensing unit.

][Chilled Water: Provide an indoor unit for [ducted concealed][exposed] application with a chilled water coil.

]2.2.2 [Evaporator][or][Cooling Coil] Cabinet Construction

Provide cabinet and chassis constructed of heavy gauge galvanized steel with all service access from a single side of the unit. Mounting brackets must be integral to the cabinet. Internal cabinet insulation must meet ASHRAE 62.1 requirements for Mold Growth, Humidity & Erosion, tested per UL 181 and ASTM C1338 standards.

2.2.3 Air Distribution Components

Provide direct-drive fan assembly equipped with double-inlet blower, self-aligning ball bearings and lifetime lubrication. Fan motor must be permanent-split capacitor, high-efficiency type, equipped with two speeds for airflow modulation. The microprocessor controller must use the lower fan speed for precise dehumidification control. Fan speed must also be user selectable from the wall controller. System must be suitable for supply and return air plenum or ducted supply and return air distribution. Provide filter rack designed to accept 100 mm 4 inch thick filters. Provide pleated filters with a MERV 8 rating in accordance with ASHRAE 52.2.

[2.2.4 Direct Expansion System Evaporator Components

The evaporator section must include evaporator coil, thermostatic expansion valve and filter drier. The evaporator coil must be constructed of copper tubes and aluminum fins. Provide an externally equalized thermostatic expansion valve to control refrigerant flow. The refrigerant piping must be spun-closed and filled with a nitrogen holding charge. Evaporator and condensing unit must be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. The evaporator unit can be coupled directly with the condensing unit or mounted remote to the condensing unit. The coil assembly must be mounted in a condensate drain pan with an internally trapped drain line. The evaporator drain pan must include a factory-installed float switch to shut down the evaporator upon high water condition.

][2.2.5 Chilled Water System Components

Provide a motorized, slow-close, two-position, chilled water control valve. Valve design pressure rating must be not less than 2068 kPa 300 psig static pressure, with a maximum close-off pressure rating of not less than 414 kPa 60 psig.

Provide a cooling coil constructed of copper tubes and aluminum fins with integral drain and vent. The coil assembly must be mounted in a condensate drain pan with an internally trapped drain line. The

evaporator drain pan must include a factory-installed float switch to shut down the evaporator upon high water condition.

][2.2.6 Indoor, Air-Cooled Condensing Unit

Condensing unit components must include condenser coil, direct drive centrifugal blower, scroll compressor, high-pressure switch, refrigerant receiver, head pressure control valve, hot gas bypass system, and liquid line solenoid valve. Provide a factory mounted disconnect switch in the high voltage section of the electrical panel. The switch handle must be accessible from the unit front. The cabinet and chassis must be constructed of heavy gauge galvanized steel, and must be serviceable from one side of the unit. Mounting brackets must be integral to the cabinet design and be designed for ceiling mounting.

Provide hot gas bypass to reduce compressor cycling and improve operation under low-load conditions. The hot gas bypass must be completely contained in the condensing unit. Field installed third refrigerant line is not acceptable. Hot gas bypass must be automatically deactivated upon a call for dehumidification. Provide a high pressure switch to protect the unit from abnormal refrigerant pressure conditions and deactivate the compressor and annunciate an alarm at the wall controller. The blower must continue to circulate air. The wall controller must be used to manually restart the compressor function after the automatic pressure switch resets. Three high head pressure alarms in a rolling 12-hour period must lock out the manual restart feature until power is cycled to the evaporator unit. A pressure balancing valve must be factory installed to reduce the chance of high pressure cut-out due to excessive refrigerant migration to the receiver due to changing outdoor temperatures during off-cycles. The refrigerant piping must be spun-closed and filled with a nitrogen holding charge. Evaporator and condensing unit must be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. Condensing unit must be designed for 35 degrees C 95 degrees F ambient and be capable of operation to minus 34 degrees C minus 30 degrees F. The condensing unit can be mounted directly to the evaporator or can be mounted remote to the evaporator. The condensing coil must be constructed of copper tubes and aluminum fins. The condenser fan must be centrifugal type, double inlet, direct drive.

][2.2.7 Outdoor, Air-Cooled Condensing Unit

Provide condensing unit rated in accordance with ANSI/AHRI 520 and designed for permanent outdoor installation. Provide removable panels for access to all components. Condensing unit components must include condenser coil, direct drive propeller fan, scroll compressor, high-pressure switch, refrigerant receiver, head pressure control valve, hot gas bypass system, and liquid line solenoid valve. Unit casing and chassis must be constructed of heavy gauge galvanized steel.

Provide hot gas bypass to reduce compressor cycling and improve operation under low-load conditions. The hot gas bypass must be completely contained in the condensing unit. Field installed third refrigerant line is not acceptable. Hot gas bypass must be automatically deactivated upon a call for dehumidification. Provide a high pressure switch to protect the unit from abnormal refrigerant pressure conditions and deactivate the compressor and annunciate an alarm at the wall controller. The blower must continue to circulate air. The wall controller must be used to manually restart the compressor function after the automatic pressure switch resets. Three high head pressure alarms in a rolling 12-hour

period must lock out the manual restart feature until power is cycled to the evaporator unit. A pressure balancing valve must be factory installed to reduce the chance of high pressure cut-out due to excessive refrigerant migration to the receiver due to changing outdoor temperatures during off-cycles. The refrigerant piping must be spun-closed and filled with a nitrogen holding charge. Evaporator and condensing unit must be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. Condensing unit must be designed for [35 degrees C] [40.6 degrees C] [95 degrees F] [105 degrees F] ambient and be capable of operation to [minus 18 degrees C] [minus 34 degrees C] [0 degrees F] [minus 30 degrees F].[Condensing unit must operate at a sound level less than 58 dbA.] The condensing coil must be constructed of copper tubes and aluminum fins.

][2.2.8 Indoor [Water][Glycol] Cooled Condensing Unit

Condensing unit components must include coaxial condenser coil, scroll compressor, high-pressure switch, water regulating valve, hot gas bypass system, and liquid line solenoid valve. Provide a factory mounted disconnect switch in the high voltage section of the electrical panel. The switch handle must be accessible from the unit front. The cabinet and chassis must be constructed of heavy gauge galvanized steel, and must be serviceable from one side of the unit. Mounting brackets must be integral to the cabinet design and be designed for ceiling mounting.

Provide hot gas bypass to reduce compressor cycling and improve operation under low-load conditions. The hot gas bypass must be completely contained in the condensing unit. Field installed third refrigerant line is not acceptable. Hot gas bypass must be automatically deactivated upon a call for dehumidification. Provide a high pressure switch to protect the unit from abnormal refrigerant pressure conditions and deactivate the compressor and annunciate an alarm at the wall controller. The blower must continue to circulate air. The wall controller must be used to manually restart the compressor function after the automatic pressure switch resets. Three high head pressure alarms in a rolling 12-hour period must lock out the manual restart feature until power is cycled to the evaporator unit. The refrigerant piping must be spun-closed and filled with a nitrogen holding charge. Evaporator and condensing unit must be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. The condenser circuit must be pre-piped with a [2-way][3-way] regulating valve which is head-pressure actuated. The condenser water/glycol circuit must be designed for a static operating pressure of [1034 kPa] [2413 kPa] [150 PSI] [350 PSI].

][2.2.9 Steam Generating Humidifier

Provide a factory mounted steam generating humidifier that is controlled by the integral unit controls. Humidifier must include disposable canister, all supply and drain valves, 25.4 mm 1 inch air gap on fill line, inlet strainer, steam distributor and electronic controls. The need to change canister must be annunciated on the wall-mounted controller. An LED light on the humidifier assembly must indicate cylinder full, overcurrent detection, fill system fault and end of cylinder life conditions. The canister flush water must not drain into the coil drain pan. The humidifier wand must be mounted over the coil drain pan.

][2.2.10 Electric Reheat

Provide factory mounted, 304/304 stainless steel, finned-tubular electric

resistance heater. Reheat must be controlled by the integral unit controls to maintain room dry bulb temperature when dehumidification is required. Provide UL listed safety switch to protect the system from overheating. Provide a factory mounted ground current detector to shut-down the entire unit if a ground fault in the reheat system is detected.[Provide Silicon Controlled Rectifier (SCR) controller to proportionally control the reheat elements to maintain the selected room temperature.]

][2.2.11 Hot Water Reheat

Provide hot water reheat coil constructed of copper tubes and aluminum fins with integral drain and vent.

]2.2.12 Controls

Provide remote mounted color touchscreen display for each unit. Provide remote mounted temperature[and humidity] sensor[s] for each unit. Controls must be organized by menus with minimum menu selection of: Alarms, Event Log, Graphics, and Status Overview. The Graphics menu must display a minimum of the following: zone temperature[and humidity], zone setpoints, fan status[, and valve position]. Controls must include a control system interface. The control system interface must meet DDC Hardware requirements of Section [23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

[Integrate CRAC control into the HVAC control system defined in Section [23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.02 BACNET DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][and][UMCS defined in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION].[HVAC control system interface point is located in [indicate room number].][UMCS interface is located in [indicate building and room number].][Refer to controls drawings for minimum points required to interface with the [HVAC control system][and][UMCS].]

][2.3 [COLD] [AND] [HOT] AISLE CONTAINMENT SYSTEMS

****

NOTE: Aisle containment systems must be closely coordinated with the communications, lighting, and fire protection systems. The ceiling of an aisle containment system is an obstruction to light and sprinkler spray and can make routing of data cable in overhead cable tray more difficult. Containment systems are typically only required in very high density data centers or in retro-fit applications where fundamental best practice in airflow design cannot be applied due to physical constraints. If containment is required, it should be provided under the same contract as the server racks themselves. Containment systems connect directly to the racks, so this must be a fully coordinated system. Coordinate with fire protection to extend the suppression system into the contained aisles.

****

Provide an engineered and manufactured system of solid panels to fully

enclose each [hot][cold] aisle. The system must connect to uniform rows of same-height racks. The containment system must be provided in its entirety from a single manufacturer. All components must be selected for compatibility with the equipment support frame provided under Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. All materials in the containment system must have a flame spread index not greater than 75 and a smoke developed index not greater than 450 when tested in accordance with ASTM E84 or UL 723.

Wall Panels: [Translucent][or][Transparent] 6.0 mm 0.236 inch minimum thickness polycarbonate panels framed within 25.4 mm x 25.4 mm 1 inch x 1 inch T-slot aluminum extrusion or extruded aluminum tube. Panels must be UL 94 listed with a minimum rating of V-1.

Roof Panels: Construction same as wall panels.

Doors: [Sliding][or][Hinged] doors of similar construction to wall panels. Doors must comply with the requirements of CPSC 16 CFR 1201.

Grommets: At each penetration through the aisle enclosure system, provide brush-type grommets to minimize air leakage. Grommets must be of ABS or polypropylene construction with nylon brush filaments and EPDM gasket.

Blanking Panels: Provide panels to blank off openings in the aisle. Panel construction must be similar to wall panel construction or rack enclosure construction.

][2.4 RACK MOUNTED FANS

****

NOTE: Provide a fan schedule on the drawings that, at minimum, indicates: airflow, configuration (top, side, bottom, front, or back of rack), number of fans, and electrical requirements.

Similar to containment systems, the need for rack mounted fans should be closely evaluated by the designer, and only specified when absolutely needed.

****

Provide an engineered and manufactured fan system, designed to attach directly to the equipment support frame provided under Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. Fan system must circulate air evenly through the entire rack that it serves.

2.4.1 Cabinet

Exterior panels must be steel sheet, minimum of 1.0 mm 20 gage, mill-galvanized or coated with a corrosion-inhibiting epoxy finish in [manufacturer's standard][the specified][the indicated] color. Mill galvanized sheet metal must be coated with not less than 380 gram of zinc per square meter 1.25 ounces of zinc per square foot of two-sided surface. Mill rolled structural steel must be hot-dip galvanized or primed and painted. Cut edges, burns and scratches in hot-dip galvanized surfaces must be coated with galvanizing repair coating. Manufacturer's standard cabinet materials and finishes will be acceptable if equivalent to the above requirements and approved by the Contracting Officer.

2.4.2 Fan

Provide array of propeller type fans powered via single point cord-and-plug connection.[Provide dual power feeds for redundancy.]

]2.5 INSTRUMENTATION AND CONTROLS

****

NOTE: Evaluate the project in accordance with UFC 4-010-06 Cybersecurity of Facility Related Control Systems. Coordinate with, reference, and provide content in Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS to ensure that control systems provided under this section meet the project cybersecurity requirements.

Indicate on the controls drawings the required control points that the CRAC unit manufacturer must provide to the HVAC control system. Coordinate with the system owner to determine the minimum points.

The recommended method of CRAC unit control is a rack mounted temperature and humidity sensor. Selection of the appropriate rack for mounting the sensors may be coordinated during the design if the racks are part of the construction contract, or the contractor should be required to coordinate with the Contracting Officer if the racks are part of another contract.

For buildings with an HVAC control system, provide a room temperature sensor independent of the CRAC unit controls. monitor the room temperature and send an alarm when out of range. Critical applications or the use of aisle containment systems may necessitate the use of multiple room temperature sensors.

****

All controls provided under this section must comply with the requirements of Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

[2.5.1 Unit Level Controls

Provide factory installed components and wiring to control a unit's basic functions and space ambient conditions[including [humidification][and][dehumidification]] at one factory installed and tested station. Controller modules must provide automatic centralized control of computer room critical equipment, simplifying emergency switching and unit testing. When the module recognizes an alarm condition, it must automatically switch to a stand-by device. User must be able to program a switching delay to allow time to correct emergency conditions. Provide modules with capability to balance the runtime of all connected air units. Provide clear, simplified instructions for programming and configuration of controllers, minimizing the chances of operator error. Provide an electronic temperature and humidity recorder, integral or external to the unit, readable to specified control accuracy, complete with supplies required for one year of operation. Controls must include a control system interface to an HVAC control system. The control system interface must meet DDC Hardware requirements of Section [23 09 23.02

BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]. Unit controls must comply with the requirements of Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.5.1.1 Display Panel

Provide[color LED touchscreen display with graphical menu navigation][LCD digital display with push button navigation]. Display panel must include the following minimum data: power on, power off, unit in alarm, description of alarm, filter status,[rack inlet temperature,][room temperature,][room relative humidity ,][event log,][service contact information,] and unit run hours.[Display must have capability to set up password protection].

Provide the following minimum externally accessible controls at the unit: start and stop total system functions, silence audible alarm, main power disconnect.

2.5.1.2 Alarms

Display alarms on unit display panel. Alarm for the following: high and low space temperature, high and low space humidity, dirty filters, loss of airflow,[loss of [water][or][glycol] flow,] compressor high head pressure,[custom alarms as indicated on the controls drawings,] humidifier problems, and leak detection. Provide field accessible local audible alarm with silence pushbutton. Provide push-to-test lamps or all-lamp test pushbutton.[CRACs must have local devices which provide signals for remote audible and visual alarming capability for the above specified alarm conditions.]

2.5.1.3 Leak Detection

****

NOTE: Describe here or indicate on drawings the layout of rope type detection systems. For mission critical applications with tier 3 or tier 4 infrastructure, the rope detection system should monitor the entire underfloor area in the data center. For mission critical applications with tier 1 or tier 2 infrastructure, the rope detection system should monitor the areas around the CRACs. Ultimately, the extent of the leak detection system should be coordinated with the owner of the computer room.

****

Provide [spot][or][rope] moisture detection system for each computer room. Leak detection must be designed for installation on the subfloor below the raised floor of the computer room. Leak detection system must interface with the associated CRAC control panel to alarm upon detection of moisture on the subfloor.

2.5.1.4 Factory Wired Components

[Provide factory installed and wired[chilled][,][and][condenser][,][and][hot] water valve[s]. Valve[s] must meet the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

][Provide CRAC manufacturer's remote [room temperature sensor][,][and][rack mounted temperature sensor array][,][and][room humidity sensor]. Sensors must meet the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

][Provide factory wired discharge air temperature sensor. Sensors must meet the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC.

]][2.5.2 Supervisory CRAC Controls

In addition to stand alone controls, provide [a]device[s] to network together all CRACs [in each computer room][in this contract][as indicated]. The network device must integrate all data for each CRAC, as required under stand alone controls, and display it on any connected CRAC's display panel.[The network device must optimize the operation of all connected CRACs to minimize energy use.] The network device must balance runtime across all connected units. The network device must automatically switch to a standby unit upon detection of failure of a duty unit. Provide all control wiring among CRACs and network device[s] as required to meet this specification.

][2.5.3 Integration to [HVAC control system] [and] [Basewide Utility Monitoring and Control System (UMCS)]

****

NOTE: Coordinate with the owner/operator of the data center for which points must be interfaced into the HVAC control system and/or UMCS. Indicate those points on the controls drawings. At a minimum, call for entering and leaving air temperatures, valve positions, fan speed, and alarms.

****

Integrate CRAC control into the HVAC control system defined in Section [23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][23 09 23.02 BACNET DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][and][UMCS defined in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION].[HVAC control system interface point is located in [indicate room number].][UMCS interface is located in [indicate building and room number].]

[Refer to controls drawings for minimum points required to interface with the [HVAC control system][and][UMCS].

]][2.6 CORROSION PROTECTION FOR COASTAL INSTALLATIONS

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NOTE: For all outdoor applications and in Environmental Severity Classification (ESC) locations C3 thru C5 and all humid locations, as well as all indoor applications in a harsh environmental, add sentence below to paint in accordance with Section 09 96 00 HIGH PERFORMANCE COATINGS. See UFC 1-200-01 for determination of ESC for a project location; humid locations are those in ASHRAE climate zones 0A, 1A, 2A, 3A, 3C, 4C and 5C (as identified in ASHRAE 90.1 - SI ASHRAE 90.1 - IP).

High Performance coatings are specified for all outdoor applications because ultraviolet radiation breaks down most standard coatings, causing a phenomena know as chalking, which is the first stage of the corrosion process. For additional information, contact The Coating Industry Alliance, specific suppliers such as Keeler and Long PPG and NACE International (NACE).

****

[Coat exterior coils, exterior casings, interior coils exposed to outdoor air, and interior casings exposed to outdoor air, in accordance with Section 09 96 00 HIGH PERFORMANCE COATINGS.

][Provide the [polyelastomer][or][phenolic] finish coating system on exterior coils, exterior casings, interior coils exposed to outdoor air, and interior casings exposed to outdoor air. The coating system must not reduce the HVAC equipment's performance rating.

] Finish coating must be applied at the premises of the HVAC equipment manufacturer or at the premises of the coating manufacturer or his authorized applicator. Provide finish coating in colors gray, or aluminum, or ivory. All components of the special finish coating systems, including primers and intermediate coats, must be applied by immersion dip-coating or spray-coating in accordance with coating manufacturer's written procedures.

If special finish coatings are applied at the finish coating manufacturer's (or his authorized applicator's) premises, the equipment to be finish coated must be transported to and from the finish coating manufacturer's premises by the Contractor. The finish-coating manufacturer must be responsible for necessary disassembly of the HVAC equipment and re-assembly of final finish coated equipment.

Submit for approval a Certificate of Specification Compliance provided by the finish coating system manufacturer. Requirements for certificate include:

a. Name of firm that provided the finish coating system.

b. Project title and Navy construction contract number.

c. Listing of the pieces of equipment that were finish coated by this firm.

d. Certificate must certify that the finish coating materials and application procedures employed conform to the contract specifications.

e. Date of final inspection by this firm and printed name and signature of the inspector.

f. Printed name and signature of the officer of the firm that is responsible for firm's certification program.

[2.6.1 Polyelastomer Finish Coating System

2.6.1.1 Heat Exchanger Coil (Including Evaporator Coil) Surfaces

a. Acrylic polymer resin primer: 0.025 mm 1 mil minimum dry film

thickness.

b. Polyelastomer resin top coating: 3 coats, 0.038 mm 1.5 mils minimum total dry film thickness.

c. In lieu of coating, provide copper tubes and copper fins

2.6.1.2 Uninsulated Interior Surfaces and Exterior Surfaces

Polyelastomer resin: 3 coats, 0.100 to 0.150 mm 4 to 6 mils minimum total dry film thickness.

2.6.1.3 Insulated Interior Surfaces

Vinyl: 0.050 to 0.250 mm 2 to 10 mils minimum dry film thickness.

][2.6.2 Phenolic Finish Coating System

Provide a resin base thermosetting phenolic finish.

2.6.2.1 Heat Exchanger Coil (Including Evaporator Coil) Surfaces

a. Apply phenolic finish to the entire coil. Provide a minimum of two coats. Total minimum dry film thickness must be 0.075 mm 3 mils.

b. In lieu of coating, provide coil of copper tubes and copper fins

2.6.2.2 Uninsulated Interior Surfaces and Exterior Surfaces

Amine cured epoxy phenolic finish: 0.150 to 0.175 mm 6 to 7 mils minimum total dry film thickness.

2.6.2.3 Insulated Interior Surfaces

Polyester or Vinyl Ester finish: 0.050 to 0.250 mm 2 to 10 mils minimum dry film thickness.

]]2.7 FACTORY PAINTING SYSTEMS

Provide manufacturer's standard factory painting. Certify that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 3 mm 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. The factory painting system must be designed for the anticipated temperature service.

2.8 ELECTRICAL

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NOTE: Coordinate the Short Circuit Current Rating

(SCCR) with the electrical engineer. This value varies for every application and is not easily fixed in the field if the equipment is not specified correctly. For multiple CRACs with different SCCR requirements, indicate this information on the equipment schedule or reference its location on the electrical drawings.

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Provide an integral electrical panel of similar construction to the unit cabinet. Within the electrical panel, provide a single point power connection terminal block and [fused disconnect switch,][fuse block and disconnect switch]. The electrical panel must provide at least [65,000][_____] amp Short Circuit Current Rating (SCCR).[Refer to electrical drawing [_____] for Short Circuit Current Rating (SCCR).]

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NOTE: Use this paragraph for other than NAVFAC SE projects.

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[2.8.1 Electrical Motors, Controllers, Contactors, and Disconnects

Provide motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors must conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors must have a maximum of 120 volt control circuits, and must have auxiliary contacts for use with the controls provided. When motors and equipment provided are larger than sizes indicated, the cost of additional electrical service and related work must be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment must be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

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NOTE: Use this paragraph and its subparagraphs regarding electrical components and energy efficient motors for NAVFAC SE projects.

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[2.8.2 Electrical Installations

Conform to IEEE C2, NFPA 70, and requirements specified herein.

2.8.2.1 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters[(except starters/controllers which are indicated as part of a motor control center)], control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors are not to be permitted. The

interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit,[the motor control equipment forming a part of motor control centers,] and the electrical power circuits must be provided under Division 26, except internal wiring for components of package equipment must be provided as an integral part of the equipment. When motors and equipment provided are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

2.8.2.2 Modifications to Existing Systems

Where existing mechanical systems and motor-operated equipment require modifications, provide electrical components under Division 26.

2.8.2.3 High Efficiency Motors

2.8.2.3.1 High Efficiency Single-Phase Motors

Unless otherwise specified, single-phase fractional-horsepower alternating-current motors must be high efficiency types corresponding to the applications listed in NEMA MG 11.

2.8.2.3.2 High Efficiency Polyphase Motors

Unless otherwise specified, polyphase motors must be selected based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings must meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

2.8.2.4 Three-Phase Motor Protection

Provide controllers for motors rated 1.34 kilowatts 1 horsepower and larger with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

]2.8.3 Electrical Control Wiring

[Provide control wiring under Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.][Provide control wiring under Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.][Provide control wiring under this section in accordance with NFPA 70 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.] Provide Space temperature control system drawings which include point-to-point electrical wiring diagrams.

2.9 [HVAC WATER PIPING][AND][METAL DUCTWORK]

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NOTE: Do not locate units with hydronic coils directly above computer racks. Design piping systems to limit the amount of overhead hydronic piping installed in the computer room. Do not locate hydronic piping directly above computer racks. Ideally, hydronic piping should be installed below the raised access floor. Locate hydronic piping under raised access floors such that it does not block airflow from downflow CRAC units.

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Requirements for HVAC water piping and metal ductwork are specified in [Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS][and][Section 23 30 00 HVAC AIR DISTRIBUTION].

[2.10 FIRE PROTECTION DEVICES

The requirements for duct smoke detectors are specified in Section [23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS].

]2.11 SOURCE QUALITY CONTROL

Provide factory test plan[s], factory test schedule[s], factory test[s] and factory test report[s] on [each of the CRAC[s];][CRAC-1 through CRAC-[_____]].

2.11.1 Manufacturer's Factory Test Plans

For [each CRAC][insert specific unit marks], submit a factory test plan which when followed during factory testing shall verify that the performance scheduled on the drawings is met by the produced CRAC models.

The manufacturer shall perform factory tests on the actual CRAC[s] produced for this project. The test reports shall document the performance tests conducted on the factory assembled computer room air conditioning units. Performance testing on the individual computer room air conditioning unit components, not factory assembled, is not acceptable.

Submit the required test plans for review and approval to the Contracting Officer at least [90][_____] calendar days before scheduled factory test date.

2.11.1.1 Test Procedure

Indicate in each test plan the factory acceptance test procedures. Procedures shall be structured to test all modes of operation to confirm that the controls are performing in accordance with the intended sequence of control.

Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

2.11.1.2 Performance Variables

Each test plan shall list performance variables that are required to be measured or tested as part of the field test. Include in the performance variables list the performance indicated on the equipment schedules on the contract design drawings.

Manufacturer must provide with each test procedure a description of acceptable performance results that shall be verified. Manufacturer shall identify the acceptable limits or tolerances within which each tested performance variable shall acceptably operate.

2.11.1.3 Test Configuration

Plans shall indicate that tests are to be performed for a minimum of four continuous hours[in a wet coil condition]. If test period is interrupted, the four hour test period shall be started over. Each test plan shall be job specific and shall address the particular CRAC[s] and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.[Tests shall include [a pressurized raised floor discharge configuration at the specified or indicated height above the floor,][with or without the air discharge elbows;][or a top air discharge configuration][and phenolic coated coils].]

2.11.1.4 Tested Variables

Plans shall provide for air side testing which includes verification of the airflow, total static pressure; fan drive motor KW, amperage and RPM; and fan RPM. Provide entering air temperatures equal to those indicated on the CRAC schedules.

2.11.1.5 Thermal Testing

Plans shall provide thermal testing utilizing [chilled water][40 percent ethylene glycol and 60 percent water solution][and][hot water] with temperatures equal to those indicated on the CRAC schedules. Thermal testing shall verify CRAC heating, sensible cooling, total cooling, and humidifying performance scheduled on the contract drawings.

2.11.1.6 Specialized Components

Include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

[2.11.1.7 Factory Test For Sound Pressure Level

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NOTE: Do not include the following sound rating tests in the specification without written permission from the Engineering Field Division's Mechanical Design Branch for a particular project. Prior to including the following sound testing paragraph, coordinate the following aspects of the requirements:

1. Determining the sound ratings of CRACs requires specific factory testing. This testing may need to be witnessed by a representative of the Contracting Officer to verify compliance since no manufacturer to date has performed these sound rating tests.

2. Sound rating testing will add significant cost to each CRAC and therefore must be covered by the project cost estimate.

3. Ensure that acceptable sound ratings for each CRAC is indicated.

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Determine the A-weighted sound pressure level for the indoor portion of

each of the CRACs; [CRAC-1 through CRAC-[_____]].

Each unit shall be mounted on a [raised]floor duplicating of the installation configuration indicated on the contract drawings. Unit shall be located at least 1.5 meters 150 mm 5 feet 6 inches from test room walls. No other equipment shall be operating in the test room during sound level testing of subject unit. Background sound levels shall be at least 10 dB below lowest sound pressure level measured on subject unit. Testing shall be conducted by using an ANSI Type 1 or 2 sound level meter located 1.0 meter 3.3 feet from the unit under test and 1.0 meter 3.3 feet above raised floor. Measure and record A-weighted sound pressure level on all four sides of unit.

]2.11.1.8 Factory Tests Reporting Forms

Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Submit factory test reports, referencing each tested CRAC serial number, and receive approval before delivery of CRAC to the project site.

[2.11.2 CRAC Production Schedule and Factory Test Schedule

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NOTE: Factory witness testing is expensive and rarely necessary for commonly manufactured mechanical equipment such as CRAC. Confirm with the facility owner that witness testing is necessary and worth the cost. If desired, remove the brackets from the "CRAC Production Schedule and Factory Test Schedule" paragraph.
****

The Government [will][reserves the right to] witness factory tests for [CRAC-1][and CRAC-[_____] through CRAC-[_____]].

Provide the CRAC production schedule and factory test schedule for tests to be performed at the manufacturer's test facility. Submit planned production schedule, and factory test schedule and test location, to the Contracting Officer as soon as it is scheduled but not less than 60 calendar days prior to the scheduled factory test date. Track this schedule through the production phases and if a scheduled factory test date changes, give advanced notice to Contracting Officer as soon as possible but at least 15 calendar days in advance of the scheduled test dates.

]2.11.3 Factory Tests

Conduct the factory testing in compliance with the Contracting Officer approved manufacturer's field test plan, and in accordance with additional field testing requirements specified herein. Record the required data using the test reporting forms approved of the approved field test plan. Conduct the test for each CRAC for the continuous test period in the approved test plan. A CRAC shutdown before the continuous test period is completed shall result in the test period being started again and run for the required duration.

2.11.4 Deficiency Resolution

The test requirements shall be acceptably met; deficiencies identified

during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections tested as specified in the paragraph FACTORY TEST PLANS.

2.11.5 Factory Test Reports

Use the test reporting forms approved in the factory test plan. Final test report forms shall be typed including data entries and remarks. Completed test report forms for each CRAC shall be reviewed, approved, and signed by the Manufacturer's test director.

[2.12 SEISMIC REQUIREMENTS

CRAC units must be seismically certified in accordance with the requirements in Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC. Provide seismic bracing in accordance with Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC.

]PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 CRAC System

Installation of each CRAC system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing, must be in accordance with ASME B31.1, ASME B31.5, NFPA 70, as modified and supplemented by the requirements of this section and the CRAC manufacturer's written installation instructions.

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

3.1.2 Installation Instructions

Provide a manufacturer's installation manual for each type of CRAC.[Provide a manufacturer's installation manual for each type of aisle containment system.][Provide a manufacturer's installation manual for each type of rack mounted fan.]

3.1.3 Operation and Maintenance Data

Submit Computer Room Air Conditioner Operation and Maintenance Data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

3.1.4 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Provide materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Provide labor and tools for making actual connections to existing systems.

3.2 FIELD QUALITY CONTROL

Upon completion and before final acceptance of work, test each CRAC

subsystem in service to demonstrate compliance with the contract requirements, including field testing specified below. Adjust controls and balance systems prior to final acceptance of completed systems. Test controls through every cycle of operation. Test safety controls to demonstrate performance of required function. Correct defects in work provided and repeat tests. Provide steam, fuel, water, electricity, instruments, connecting devices, and personnel for tests. Flush and clean piping before placing in operation. Clean equipment, piping, strainers, and ducts. Prior to commencement of field testing, remove all filters and provide new filters. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided.

3.3 FIELD TESTING

Provide field test plan[s], field test schedule[s], field test[s] and field test report[s] on each of the CRAC[s]. Field test each CRAC for Contracting Officer acceptance in accordance with the CRAC manufacturer's approved field test plan.

3.3.1 Manufacturer's Field Test Plans

Submit field test plans developed by the manufacturer for each CRAC; [submit the field test plans along with the factory test plans specified herein before][submit the field test plans at least 90 calendar days prior to planned date of the field test]. Field test plans developed by the installing Contractor, or the equipment sales agency furnishing the CRAC, will not be acceptable.

The Contracting Officer will review and approve the field test plan for each of the listed CRACs prior to commencement of field testing of the equipment. The approved field test plans must be followed for the field tests of the CRAC and test reporting.

3.3.1.1 Coordinated Testing

Indicate in each field test plan when work required by this section requires coordination with test work required by other specification sections. Provide test procedures for the simultaneous or integrated testing of: CRAC controls which interlock and interface with controls factory prewired[; and external controls for the CRAC provided under [Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS][Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC]].

3.3.1.2 Prerequisite Testing

Each CRAC for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field test plan when such prerequisite work is required.

3.3.1.3 Test Procedure

Indicate in each field test plan the CRAC manufacturer's published start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

3.3.1.4 Performance Variables

Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include, in the listed performance variables, requirements indicated on the CRAC schedules on the design drawings. Manufacturer must provide, with each test procedure, a description of acceptable results that have been verified.

Manufacturer must identify the acceptable limits or tolerances within which each tested performance variable must acceptably operate.

3.3.1.5 Test Configuration

Plans must indicate that tests are to be performed for a minimum of four continuous hours[in a wet coil condition]. If test period is interrupted, the four hour test period must be started over. Each test plan must be job specific and must address the particular CRAC[s] and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.[Tests must include [a pressurized raised floor discharge configuration at the specified or indicated height above the floor,][with or without the air discharge elbows;][or a top air discharge configuration][and corrosion protection.]]

3.3.1.6 Tested Variables

Plans must provide for air side testing which includes verification of the airflow, total static pressure; fan drive motor KW, amperage and RPM; and fan RPM. Provide entering air temperatures equal to those indicated on the CRAC schedules.

3.3.1.7 Thermal Testing

Plans must provide thermal testing utilizing [chilled water][40 percent ethylene glycol and 60 percent water solution][and][hot water] with temperatures equal to those indicated on the CRAC schedules. Thermal testing must verify CRAC heating, sensible cooling, total cooling, and humidifying performance scheduled on the contract drawings.

3.3.1.8 Specialized Components

Include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.3.1.9 Field Test Reporting Forms

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives.

3.3.2 Field Test Schedule

Notify the Contracting Officer in writing at least 30 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for the review and approval of the Contracting Officer.

3.3.3 Manufacturer's Test Representative

Provide a factory trained field test representative authorized by the CRAC manufacturer to oversee the complete execution of the field testing. This test representative must also review, approve, and sign the completed field test report. Signatures must be accompanied by the person's name typed.

Submit credentials of the manufacturer's field test representative proposed, including current telephone number, to the Contracting Officer for review and approval. Submit these credentials with the written advance notice of the field tests.

3.3.4 Field Tests

Conduct the field testing in compliance with the Contracting Officer approved manufacturer's field test plan, and in accordance with additional field testing requirements specified herein. Record the required data using the test reporting forms approved of the approved field test plan. Conduct the test for each CRAC for a continuous 24-hour test period. A CRAC shutdown before the continuous 24-hour test period is completed must result in the 24-hour test period being started again and run for the required duration.

3.3.5 Deficiency Resolution

The test requirements must be acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations. Corrections must be tested again in compliance with the requirements specified in the paragraph FIELD TEST PLANS.

3.3.6 Field Test Reports

Use the test reporting forms approved in the field test plan. Final test report forms must be typed, including data entries and remarks. Completed test report forms for each CRAC must be reviewed, approved, and signed by the Contractor's test director and the QC manager.

3.4 INSTRUCTION TO GOVERNMENT PERSONNEL

Provide the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work.

Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. Provide [4][_____] hours of training for each type of CRAC specified.[Provide [2][_____] hours of training for each [aisle containment system][and][rack mounted fan] specified.]

-- End of Section --