

PART 1 – GENERAL PROVISIONS

1.01 SUMMARY

Furnish and install controlled environment rooms complete with all equipment, controls and accessories required for specified operation and performance, coordinating with other trades as required to complete the specified work.

1.02 SCOPE OF WORK

Work included in this section includes the following:

- A. Complete controlled environment room(s) including all components required to achieve and maintain specified temperature and/or humidity levels;
- B. Transportation and delivery of components to their final location, including all lighting fixtures and accessories specified herein.
- C. All refrigeration piping, electrical power wiring, and control wiring integral to the room.
- D. Installation and materials for all electrical and data outlets inside the room. Electrical receptacles to be circuited through control console. [OPTION: If multiple circuits are required to service receptacles within the room, these may be circuited directly from building electrical panels and not through CER control console.]
- E. Closure trim between insulated room panels and adjacent walls, floor and/or ceiling furnished and installed as appropriate.
- F. Startup and field testing of rooms.

1.03 RELATED SECTIONS

Work included in this section is to be coordinated with related work specified elsewhere, including but not limited to:

- A. Applicable provisions of Division 1 shall govern the work of this section.
- B. Division 11: Laboratory casework and equipment.
- C. Division 13: Furnish and install all fire suppression systems, coordinating penetrations with CER manufacturer.
- D. Division 15: Furnishing and installation of plumbing fixtures and utilities, including final connections to service fixtures.
- E. Division 15: Furnishing and installation of ventilation supply/exhaust ductwork. Division 15 will be responsible for all ventilation air ductwork to and from CER or desiccant dehumidification unit servicing the CER, as required. Division 15 scope includes all required transition pieces, registers, grills, dampers and diffusers. Ceiling penetration(s) shall not exceed 4" in diameter.
- F. Division 15: Final condensate drain connections at sink tailpiece or floor sink as indicated on plans.

- G. Division 16: Electrical service required for controlled environment room, including final electrical connection to each CER control panel and final connection with disconnect to each CER condensing unit.
- H. Division 16: Connection of CER control panel alarm contacts to building monitoring system.

1.04 REFERENCE STANDARDS

Comply with all applicable codes, specifications and standards below, except where more stringent local codes may apply:

- A. ASHRAE/ANSI: American Society of Heating, Refrigeration and Air Conditioning Engineers, Standard 15-1994 – Refrigeration Components, Safety and Use of Refrigerants.
- B. FM: Factory Mutual Standard #4880 – Insulated Panel Construction
- C. NEC: National Electrical Code
- D. NSF: National Sanitary Foundation Seal of Approval – Room Panels.
- E. UL: Underwriters Laboratories, 508A – Industrial Control Panels
- F. UL: Underwriters Laboratories, 723 – Room Panel Flame Spread Ratings

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications.

Controlled environment room(s) shall be produced by a manufacturer with a minimum of 10 years' experience in manufacturing equipment of the same type and scope of project specified herein. A minimum of 200 rooms shall have been fabricated and installed within the past 5 years. Manufacturer shall submit a statement of qualification with the submittal materials.

- B. Installer Qualifications.

Installer shall be factory trained and shall have a minimum of 10 years experience in the installation of laboratory controlled environment rooms.

- C. Single Source Responsibility.

Controlled environment rooms shall be designed, manufactured and installed by one supplier for single source responsibility.

1.06 SUBMITTALS

Submittals required under this section shall be submitted electronically in PDF format, and shall include the following items:

- A. **Product Data:** Submit technical product data sheets for all materials, equipment and components to be supplied under this Section, including at minimum insulated urethane panels and panel accessories, lighting, fans, evaporator coils, condensing units, humidifiers, dehumidifiers, controllers, and recorders.
- B. **Shop Drawings:** Submit shop drawings, including fully dimensioned plan view, elevation and sections at not less than ¼ inch scale. Drawings shall include overall panel layout, panel finishes, doors, accessories, hardware, control panels, refrigeration equipment, refrigerant, refrigeration piping, condensate lines, utility requirements, connection points, and all other information required for proper coordination with related work.
- C. **Schematics and Calculations:** Submit all calculations necessary to demonstrate compliance with load requirements contained herein, including cooling, heating, humidification and/or dehumidification load calculations as applicable. Provide electrical schematic showing all power and control system components, including voltages and amperage loads. Provide refrigeration piping schematic showing all system components clearly identified.
- D. **Equipment schedule** indicating operating temperature/humidity conditions, utility requirements, and model/quantity for all evaporator coils, condensing units, dehumidifiers, humidifiers, and controls.
- E. **Finish Samples:** Submit 6"x 6" samples of all metal finishes to be used in the construction of the ceiling, wall, and floor panels.
- F. **Closeout submittals** shall be submitted prior to substantial completion, and shall include:
 - (1) Operation and Maintenance Manuals, including startup, operation, and maintenance instructions, replacement parts list, and factory contact information.
 - (2) Test reports: Submit reports of all specified factory and field performance tests.
 - (3) Certificate of Warranty, with warranty period commencing on date of substantial completion.

1.07 PROJECT HANDLING

All equipment and components shall be protected to avoid damage during transportation, storage, and installation, including protection of final product from damage by other trades prior to final completion.

Prior to installation, materials shall be stored off the ground and shall be protected from the elements. No equipment shall be delivered to the site until installation areas are secure and weathertight.

1.08 COORDINATION

CER manufacturer shall coordinate scheduling with Owner's Representative or General Contractor, and shall schedule installation in sequence to ensure that rooms are protected from damage by other trades and to prevent delays in overall project completion.

1.09 WARRANTY

Manufacturer shall provide a written warranty that all CER equipment and components shall be free of defects in materials and workmanship under normal use and service. Manufacturer's warranty shall cover all parts and labor for a period of one year and shall commence upon acceptance date. Additional warranties shall be provided for the following items as indicated:

- (1) Ten years: Insulated panels, including doors.
- (2) Five years: Refrigeration compressors.

PART 2 – PRODUCTS

2.01 GENERAL

Controlled Environment Room shall be furnished as a complete functional unit with essential piping, ductwork, control systems and conditioning systems to satisfy the environmental conditions listed in this specification and on the drawings. Room shall be shipped in sections that shall be designed to pass through standard doorways. Construction shall allow for future disassembly and relocation. All metal surfaces will be finished smooth with punching and shearing neatly done.

2.02 PERFORMANCE REQUIREMENTS

Controlled Environment Room shall be designed to maintain the temperature and humidity ranges indicated on the CER room schedule, including the combination of highest temperature/highest humidity and of lowest temperature/lowest humidity within the ranges specified. Performance shall be achieved with the cumulative loads specified, including loads from lighting, fans, ventilation air, and other equipment within the room as specified.

2.02.1 Control

Temperature control, defined as the control of temperature at a single point within the chamber over a period of time, shall be maintained at setpoint $\pm 0.3^{\circ}\text{C}$. For rooms operating in degrees Fahrenheit, control shall be maintained at setpoint $\pm 0.6^{\circ}\text{F}$.

Humidity control (if applicable), defined as the control of relative humidity at a single point within the chamber over a period of time, shall be maintained at setpoint $\pm 5\%$ RH.

Temperature and humidity control shall be documented as indicated under the Sustained Operation Testing requirement.

2.02.2 Uniformity

Temperature uniformity, defined as the uniformity of temperature at a minimum of twelve points evenly distributed on a horizontal plan at 44" AFF and no more than 12" from each wall, shall be maintained at setpoint $\pm 1.0^{\circ}\text{C}$.

Humidity uniformity, measured at a minimum of three points within the chamber, shall be maintained at setpoint $\pm 5\%$ RH.

Temperature and humidity uniformity shall be documented as indicated under the Chamber Uniformity Testing requirement.

2.02.3 Chamber Design Loads

- A. Ambient conditions: Rooms shall be designed to operate in ambient conditions ranging from 60°F to 85°F, and at humidity levels ranging from 15% to 75%RH.
- B. Door openings: Temperature and humidity calculations shall assume two (2) door openings per hour for an average duration of 30 seconds each.
- C. [OPTIONAL] Temperature calculations shall assume electrical equipment load of 5 watts per square foot in each controlled environment room.
- D. [OPTIONAL] Temperature and humidity calculations shall assume one (1) person working the controlled environment room continuously for 8 hours per day.
- E. [OPTIONAL] Water Temperature Range: Water-cooled condensing units shall be designed for water temperatures from 50°F to 85°F at water inlet.

2.03 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with this specification, acceptable manufacturers include:
 - (1) BioCold Environmental, Inc., Fenton, Missouri, (636) 349-0300.
 - (2) Bahnon Environmental Specialties, LLC, Raleigh, NC, (919) 829-9300
 - (3) Harris Environmental Systems, Inc., Andover, MA, (978) 470-8600
- B. Proposed substitutions must be approved in an addendum prior to bid date as specified in bid documents. Manufacturers who have not received prior approval will be unacceptable.

2.04 ROOM CONSTRUCTION

2.04.1 Modular Panel Construction

- A. Provide insulated panel construction manufactured by one of the following:
 - 1) Bally Refrigerated Boxes, Morehead City, NC, (800) 242-2559

2) Kolpak, a division of the Manitowoc Company, Parsons, TN, (800) 826-7036

- B. Panel construction: Panels shall consist of urethane insulation foamed in place between interior and exterior metal skins precisely foamed with steel and dies and roll-form equipment and thoroughly checked with gauges for accuracy. To assure perfect alignment and maximum strength, corner panels shall employ a right-angle configuration with exterior horizontal dimensions of 12" on each side. Sections shall be made of 11½", 23", 34½", and 46" widths and shall be interchangeable, unless otherwise required to attain specified chamber dimensions. No section shall be less than 11½" or more than 46" in width, except door sections where required to accommodate door width.
- C. Panel insulation: Panels shall contain 100% urethane insulation and have no internal wood or structural members between the skins. The metal skins shall be placed into heated molds and liquid urethane injected between them. Urethane insulation shall have a minimum compressive strength of 28 pounds per square inch and shall be minimum 97% closed cell structure. Insulated panels shall comply with current EPA Regulations.
- D. Gaskets: To insure tight joints, panel edges must have foamed-in-place tongues and grooves with a flexible vinyl gasket on the interior and exterior of all tongue edges. Gaskets shall be NSF Certified and resistant to damage from oil, fats, water and detergents. Gaskets must be foamed in place and not attached by staples or other fasteners.
- E. Assembly: Panels shall be joined by non-corrosive cam action speed locks, consisting of a hooked locking arm placed in one panel, and a steel rod positioned in the adjoining panel, so that when the arm is rotated, the hook engages the rod and draws the panels tightly together with cam action. Arms and rods shall be housed in individual steel pockets. Pockets on one side of the panel shall be connected to pockets on the other side in width, by the use of 2" wide metal straps set into and completely surrounded by the insulation. Each vertical joint shall contain a minimum of three locking devices, and the distance between locks shall not exceed 46". Seal wrench holes with flush-mounted plastic, aluminum or stainless steel caps.
- F. Certifications:
 - 1) Panels shall comply with the Energy Independence and Security Act of 2007 (EISA) and shall further carry a minimum insulating value of R-29 for coolers and R-32 for freezers.
 - 2) Panels shall be certified by Underwriters Laboratories as having a flame spread of 25 or lower and a smoke generation of 450 or lower when tested in accordance with ASTM E84.
 - 3) Panels shall be NSF certified.

2.04.2 Wall & Ceiling Panels:

- A. Interior finish [ARCHITECT SELECTION REQUIRED]
 - 1) Interior surface shall consist of 0.032 inch embossed aluminum with a white polyester enamel finish.
 - 2) Interior surface shall consist of 26 gauge embossed galvanized steel with a white polyester enamel finish.

- 3) Interior surface shall consist of 26 gauge smooth galvanized steel with a white polyester enamel finish.
 - 4) Interior surface shall consist of 20 gauge Type 304 stainless steel, #3 finish.
- B. Exposed exterior finish [ARCHITECT SELECTION REQUIRED]
- 1) Exposed exterior surface shall consist of 0.032 inch embossed aluminum with a white polyester enamel finish.
 - 2) Exposed exterior surface shall consist of 26 gauge embossed galvanized steel with a white polyester enamel finish.
 - 3) Exposed exterior surface shall consist of 26 gauge smooth galvanized steel with a white polyester enamel finish.
 - 4) Exposed exterior surface shall consist of 20 gauge Type 304 stainless steel, #3 finish.
- C. Unexposed exterior finish shall consist of 26 gauge embossed Galvalume steel, mill finish.
- D. Wall panels shall be reinforced to support wall-mounted shelving as shown on Drawings.
- E. Wall and ceiling panels shall contain all required junction boxes and electrical conduit foamed in place and not surface mounted. Surface-mounted conduit exposed within the room shall be avoided.
- F. Ceiling panels shall be reinforced as required to support CER equipment loads and maintenance traffic on top of room. Ceiling panels shall not be designed for regular foot traffic or

2.04.3 Floor Panels

- A. Floor panels, where required, shall cam-lock to wall panels and shall be of similar construction to other insulated panels. Panels shall be made to withstand a uniformly distributed floor load of not less than 600 pounds per square foot. All panel surfaces shall be foamed in place. Separate treadplate overlay shall not be permitted.
- B. [ARCHITECT SELECTION REQUIRED]
- 1) Floor panels shall be 2" thick and shall be equipped with ADA-compliant interior ramp
 - 2) Floor panels shall be 4" thick and shall be equipped with ADA-compliant interior ramp
 - 3) Floor panels shall be 2" thick and shall be installed in 2.25" deep recessed slab, leveled and flush with surrounding finished floor surfaces.
 - 4) Floor panels shall be 4" thick and shall be installed in 4.25" deep recessed slab, leveled and flush with surrounding finished floor surfaces.
 - 5) Floor panels shall be 4" thick and shall be installed in 8" deep recessed slab, with 4" concrete topping slab with thermal break leveled and flush with surrounding finished floor surfaces. All concrete work by others and not by CER manufacturer.
 - 6) Room shall be floorless over existing building floor. Concrete slab to be insulated by others with sawcut perimeter to prevent condensation outside of controlled environment room.

- 7) [NOTE: Two-inch thick floors are commonly used to reduce the length of an ADA ramp (1:12) on cold rooms. For insulating purposes, a 4" floor is required on all freezers. Cold rooms may be floorless when installed slab on grade; if the underside of the slab is exposed, it must be insulated from below to prevent condensation.]

C. [ARCHITECT SELECTION REQUIRED]

- 1) Interior floor panel finish shall be 12 gauge rigidized aluminum.
- 2) Interior floor panel finish shall be 10 gauge smooth aluminum
- 3) Interior floor panel finish shall be 16 gauge smooth galvanized steel.
- 4) Interior floor panel finish shall be 16 gauge smooth stainless steel.
- 5) Interior floor panel finish shall be 16 gauge rigidized stainless steel.

- D. [OPTION: To be selected with 16 gauge smooth galvanized steel floors.] Interior wearing surface shall be covered with slip-resistant continuous vinyl sheet flooring with welded seams and a 4" covered base. Flooring shall be equal to Altro Walkway 20 or Altro Stronghold 30 vinyl flooring, and shall have temperature stability, dimensional stability and flexibility over the full operating range of the controlled environment room. Color shall be approved by architect from manufacturer's standard color options. Vinyl flooring shall be installed per manufacturer's recommendations.

- E. Exterior floor surface shall consist of 26 gauge embossed Galvalume steel, capped to match exterior wall finish where floor panels are exposed.

2.04.4 Standard Hinged Entrance Doors

- A. Doors shall be in-fitting, flush mounted type with a minimum clear opening of 36" x 78" unless otherwise shown on drawings, with the same metal finish and insulation as adjacent walls. A thermoplastic gasket with a magnetic core shall be mounted on the top edge and along both sides of the door. The magnetic force of the gasket and a hydraulic door closure shall keep the door closed and the gasket shall form a tight seal. The bottom edge of the door shall contain a flexible, dual blade wiper gasket. All gaskets shall be NSF approved.

Construction of the door panel shall include a heavy "U" channel type reinforced steel frame around the entire perimeter of the door opening to prevent rocking or twisting. [OPTION: Provide 30" high stainless steel kickplate at interior and exterior of door and door jambs.]

- B. On any room operating at +15°C or lower, anti-condensate heaters shall be connected to a temperature switch to provide sufficient heat to eliminate condensation and frost under various humidity conditions. Anti-condensate heater wires shall be concealed behind the metal edge of the door jambs on all sides including the threshold plate.
- C. Doors shall have a minimum of three hinges of the self-closing type with plated steel pins and Delrin cam-type bearings. Doors of 36" or lesser width shall be fully self-closing.
- D. The door latch shall be designed to open the door easily by breaking the magnetic force of the door gasket. The latch shall have a cylinder key lock. The door shall also include an interior safety release

handle to allow for emergency exit in case of accidental confinement. Hardware shall be satin-finish aluminum.

- E. Observation Window. For visual observation into a walk-in cooler or freezer a 14" x 24" view window shall be installed in the walk-in entrance door. Window shall be three-pane heated tempered safety glass to prevent frost formation and fog.

2.04.5 Sliding Doors

- A. Where shown on plans, provide 4" thick manually operated single slide door designed for operation at the CER operating conditions. Dimensions as shown on plans.
- B. Door leaf to have steel structure and shall be constructed of CFC-free and HCFC-free foam insulation with metal skin finish matching room exterior.
- C. Door shall be fully gasketed on four sides. The bottom edge of the door shall contain a flexible, sweep type gasket. All gaskets shall be NSF approved, and shall be easily replaceable.
- D. Where CER operating range extends below 0°C, provide anti-condensate, anti-frost heaters at perimeter of door on four sides.
- E. Track shall be made of non-corrosive extruded anodized aluminum or polished stainless steel. Trolley rollers shall conform to contour of track and be equipped with heavy-duty bearings, permanently lubricated with low temperature grease. Track to have "down and in" design to assure positive seal and minimum gasket wear during operation.

2.05 INSTRUMENTATION AND CONTROLS

2.05.1 General

- A. All operating controls, instrumentation, functional switches and major electrical components shall be located in a single, surface-mounted control console mounted at operator eye level at the latch side of the entrance door to each room unless otherwise shown on the drawings. Control console shall be ADA compliant and exterior depth shall not exceed 4 inches. The control panel shall be hinged for easy opening by authorized service personnel.
- B. All room equipment except condensing unit, unless otherwise indicated on drawings, shall be circuited through the control console and wired by CER installer, with a single-point connection to the control console supplied by Division 16.
- C. Control panel assembly shall contain only commercially available components available from third-party suppliers. CER manufacturer's proprietary printed circuit boards are not acceptable.
- D. Overcurrent protection shall be provided within the control console. All branch circuits shall be equipped with circuit breakers. Fuses are not permitted.
- E. Control panel assembly shall be tested by a UL listed shop in accordance with NFPA 70 and UL 508A, and shall bear a UL 508A label.

2.05.2 Color Touchscreen Interface

- A. User interface shall consist of a LCD color touchscreen display at least 7 inches in diagonal with minimum resolution of 640 x 480 pixels.
- B. Color touchscreen shall provide intuitive operation and sufficient on-screen instructions such that reference manuals are not required for day-to-day operation.
- C. Color touchscreen shall provide multi-level password-protected access to monitor and adjust all chamber operating parameters, including but not limited to the following functions:
 - 1) Temperature setpoint
 - 2) Real-time temperature display in 0.1°C or 0.1°F increments
 - 3) Humidity setpoint (if applicable)
 - 4) Real-time humidity display in 0.1% RH increments
 - 5) User-selectable temperature display in °C or °F.
 - 6) High & low temperature and humidity alarm setpoints
 - 7) Alarm time delay period
 - 8) Alarm silence with adjustable callback timer
 - 9) Automatic, programmable defrost system with automatic bypass when operating above 3°C, adjustable.
 - 10) Manual defrost and manual defrost termination capabilities for testing and maintenance.
 - 11) Real-time system clock.
 - 12) Real-time graphical trend data with minimum of 31 day viewable history
 - 13) Print and/or download trend data for minimum of 360 days in PDF or CSV format
 - 14) Parameter change log.
 - 15) Alarm history log
 - 16) Remote access capability via Ethernet, RS-485 Modbus or similar, non-proprietary communications protocol.

2.05.3 Temperature & Humidity Controller

- A. Temperature and humidity control (if applicable) shall be user-selectable PID or hysteresis control using programmable logic controller with fixed programmable logic. Control logic shall be stored on non-volatile memory card within the controller.
- B. Manufacturers: Subject to compliance with project requirements, provide programmable control device by one of the following:
 - 1) Allen-Bradley

- 2) Emerson Controls
- 3) Seimens
- C. Controller shall include a minimum of six (6) open loop control circuits for lights or other on/off switchable operations.
- D. Sensors.
 - 1) Temperature sensor shall be 100 ohm platinum RTD or Type T Thermocouple. Temperature sensor shall be located for fast responsiveness and shall display and control air temperature. Sensor shall not display “product temperature” or be placed in glycol or other cold mass to improve display performance.
 - 2) Humidity sensor shall be thin-film capacitance sensor with accuracy of $\pm 2\%$ RH or better. Wet bulb/dry bulb, lithium chloride, gold grid, bulk resistance, or similar sensors are not acceptable.
- E. Temperature safety limit controls shall be provided:
 - 1) High temperature safety limit control shall activate an alarm and shall de-energize all electric heaters, hot gas valves, dehumidifiers and other heat-producing equipment within the room. When temperature returns to normal range, limit controls shall automatically reset.
 - 2) Low temperature safety limit control shall activate an alarm and shall shut down the refrigeration compressor. When temperature returns to normal range, limit controls shall automatically reset.

2.05.4 Alarm Systems

- A. Temperature Alarm
 - 1) Control system to include both audible and visible alarm indicators upon high or low alarm conditions. High/low safety alarms set digitally in 0.1°C increments.
 - 2) Upon an alarm event, a popup text message shall appear on-screen indicating the alarm type, alarm setpoint, and current chamber conditions. The popup text message shall remain on-screen until the alarm condition clears or the alarm is acknowledged by an operator.
 - 3) Control system shall include an field adjustable alarm delay timer and alarm silence button which will temporarily silence audible alarm buzzer. The alarm delay timer shall be adjustable from 0 to 30 minutes before the alarm buzzer is activated.
 - 4) Provide remote alarm dry contacts for connection to building automation or monitoring systems. Alarm dry contacts shall be of active design, such that contacts will close upon power failure, controller failure, or temperature alarm event.
- B. [OPTION – Recommended for rooms operating below 0°C] Personnel Emergency Alarm
 - 1) Rooms shall be equipped with a reset type, electrically powered emergency alarm system. Alarm shall be circuited from the control console on a low voltage circuit. The system shall consist of an actuator within the room, and an audible/visual alarm mounted on the front of the chamber. Alarm shall be silenced only by deactivating the switch inside the chamber. All

conduit and junction boxes for personnel emergency alarm system shall be foamed in place. Exposed conduit shall not be permitted.

- i. The alarm system actuator shall be a heavy duty, oil-tight switch, equipped with a red button marked "EMERGENCY ALARM – PULL TO RESET." The actuator button shall be mounted on the interior wall of the room adjacent to the doorjamb and 12 inches (305 mm) above finished floor. Coordinate alarm actuator location with casework locations. Emergency alarm actuator shall be lighted.
- ii. The external alarm indicator shall include both high decibel horn and strobe and shall white with blue strobe to avoid confusion with fire alarm systems. Alarm indicator shall be mounted over CER door, and shall be prominently labeled: "PERSONNEL EMERGENCY."
- iii. Provide an independent set of alarm dry contacts for connection to remote annunciator panel or to building automation system.

2.05.5 [OPTION] Redundant Systems

- A. Rooms equipped with redundant refrigeration systems shall provide controls that perform the following functions, adjustable by user through the touchscreen user interface.
 - 1) Automatic switchover from primary to backup system on high or low temperature alarm event. When such switchover occurs, touchscreen shall indicate the failed system and shall inhibit periodic switchovers until the failed system has been manually acknowledged and reset.
 - 2) Weekly switchover from primary to backup system to ensure equal system wear and current readiness of both systems. Weekly switchover shall include user selectable switchover day/time and shall only occur when no system failures are indicated.

2.06 MECHANICAL SYSTEMS

2.06.1 General

- A. The mechanical systems shall include the following major components: condensing unit, evaporator fan coil, thermostatic expansion valve with external equalizer, hot gas and liquid line solenoid valves, and all required refrigeration piping.
- B. The refrigeration system design shall be continuous proportional hot gas bypass in which the compressor does not cycle to control temperature. At manufacturer's option, hot gas modulation may be accomplished by 2-way modulating valve or pulse-width modulation using rapid cycle solenoid valves with extended stem. Standard refrigeration solenoid valves are not permitted.
- C. Refrigeration system shall be sized to accommodate all chamber loads with sufficient excess capacity to satisfy system recovery tests. For sizing purposes, each system shall be capable of removing not less than 5 watts of live load per square foot of floor area, in addition to chamber equipment and lighting.
- D. Refrigerant shall be R404a or R134a. All rooms on a single project shall use the same refrigerant.

- E. Compressor and evaporator shall be sized with matching capacities such that regular defrost cycles are not required for rooms operating at +4°C or above.
- F. [OPTION] Redundant systems. Provide each room with two (2) independent refrigeration systems for 100% redundancy. Each system shall be capable of operating independently to control chamber temperature under maximum load conditions. Dual-circuit evaporator fan coils may be used, based on room size and system capacities.

2.06.2 Condensing Units

- A. Compressor-Condensing Unit shall be UL labeled and of hermetic, semi-hermetic or Scroll type, and shall include high/low pressure safety control with automatic reset, suction accumulator, receiver with fusible plug, liquid line drier, sight glass, suction line drier, vibration absorbers, and thermal protection.
- B. [ARCHITECT SELECTION REQUIRED – SELECT ONE]
 - 1) Condensing unit shall be air-cooled and located on top of each controlled environment room.
 - 2) Condensing unit shall be water-cooled and located on top of each controlled environment room. Water-cooled condensing units shall be equipped with two-way water regulating valve to maintain pressures. Valve body shall be cast brass with aluminum bronze seats, brass extension sleeve and disc holder, and be suitable for a water pressure of 150 psi at 170 degrees F. Total pressure drop through the condenser shall not exceed 5 psi.
 - 3) Condensing unit shall be water-cooled and located remotely as shown on plans. Water-cooled condensing units shall be equipped with two-way water regulating valve to maintain pressures. Valve body shall be cast brass with aluminum bronze seats, brass extension sleeve and disc holder, and be suitable for a water pressure of 150 psi at 170 degrees F. Total pressure drop through the condenser shall not exceed 5 psi.
 - 4) Condensing unit shall be air-cooled and located remotely as shown on plans. Units located outdoors shall be equipped with weatherproof housing, low ambient protection, and crankcase heaters.
- C. Compressor shall be manufactured by Copeland Corporation, Sidney, Ohio.
- D. All components shall be designed for 250 psig working pressure or 150 percent of maximum operating pressure, whichever is greater.

2.06.3 Evaporators

- A. Room air shall be continuously conditioned in a low velocity, low profile ceiling evaporator plenum. Evaporator plenum shall hang down inside room a maximum 16" from ceiling. Evaporator plenum shall include evaporator coil, fan motors, heating elements (if applicable), expansion valve, and condensate drain pan.
- B. Evaporator coil shall be copper tube, aluminum fin design with heavy gauge aluminum housing. Maximum 8 fins per inch, minimum 4 rows deep. Air velocity shall be less than 500 fpm.

- C. Evaporator fan motors shall be lifetime sealed high efficiency permanent split capacitor (PSC) or electronically commutated (ECM) motors. Shaded pole motors are not permitted.

2.06.4 Defrost System

- A. All systems operating at temperatures of 10°C or below shall be equipped with a programmable automatic defrost system to control length of defrost and the time of day of defrost cycle.
- B. Systems operating at temperature of +4°C and above shall be designed to not require regular defrost cycles in normal operation.
- C. Rooms operating above 0°C shall be equipped with hot gas defrost system.
- D. Rooms operating below 0°C shall have electric defrost system that includes automatically controlled drain pan heaters, mechanical fan delay and defrost termination switches, and condensate drain line heaters.
- E. On rooms with redundant refrigeration systems, the standby system shall be brought online during the defrost cycle of the primary system to minimize temperature upset during defrost.

2.06.5 Piping and Insulation

- A. Install all refrigerant components in accordance with applicable codes and good practice for proper system operation. Piping shall be routed so as to minimize exposed piping.
- B. All refrigerant piping shall be seamless copper tubing, Type L ACR.
- C. Brazing material shall be minimum 15% silver solder alloy, Harris Stay Silv 15 or equal.
- D. Suction lines shall be sized for 500-700 fpm on horizontal runs pitched ¼ inch per 10 feet toward condensing unit to ensure oil return. Suitable P-traps shall be located at the base of each suction riser of four (4) feet or greater with additional P-traps not more than 15' apart on extended risers.
- E. Liquid lines shall be sized for maximum 2 psig pressure drop.
- F. For rooms operating at +2°C or above, condensate drain lines shall be run in 3/4 inch Schedule 40 PVC or in 7/8 inch Type L copper. In rooms operating below +2°C, drain lines shall be run in 7/8 inch Type L copper and shall be heated and insulated to prevent ice buildup. Condensate drains shall be gravity fed and pitched 1/4 inch per foot. All condensate drain lines shall contain a union allowing the condensate drain pan to be easily lowered for maintenance or service. In rooms with sinks, the drain lines shall be run below sink with connection to sink tailpiece by Division 15. In rooms without sinks, drain lines shall be extended to exterior of controlled environment room and terminated at condensate drain.
- G. Suction lines, hot gas lines and freezer condensate lines shall be insulated with Armaflex closed cell foam plastic insulation or equal, minimum ½" wall thickness. Insulation shall meet NFPA-90A flame spread and smoke developed requirements and shall comply with state and local fire codes. Joints shall be bonded using manufacturer's recommended sealant to provide a complete vapor barrier.

2.06.6 Heating Systems

- A. Heaters shall be incoloy sheathed Nichrome wire with a maximum watt density of 23 watts per square inch. Heaters shall be mounted on downstream side of evaporator coil and shall be positioned so as to prevent accidental contact with the heated surfaces.
- B. Provide mechanical limit control to monitor air temperature in the conditioning plenum, disabling heaters in the event air temperature exceeds preset limits. High limit cutout shall be factory preset and non-adjustable, with high limit cutout not to exceed 65°C. Tripped limit control shall be equipped with manual reset button.

2.06.7 Dehumidification Systems

- A. Rooms designed for operation at or below a 10°C dewpoint shall be equipped with a desiccant dehumidification system sized to maintain specified chamber conditions.
- B. Dehumidifier shall be of the non-cycling sorption type with a single desiccant rotary structure. The casing will be fabricated as a unitized body with welded aluminum construction for maximum strength and durability. Suitable access panel shall allow access for inspection or servicing without disconnecting ducting or electrical wiring. Airflow balancing dampers to be furnished.
- C. Dehumidifier shall be factory assembled, fully automatic, complete with silica gel HoneyCombe desiccant wheel, reactivation heaters, reactivation energy control system, roughing filters, motors, fans, non-racheting desiccant drive unit, automatic controller and all components' auxiliaries. Reactivation energy modulation shall be stepless solid state proportioning type. Dehumidifier shall be functionally tested at the manufacturer's factory and shipped complete with all components necessary to maintain normal operation.
- D. Desiccant shall not channel, cake or fracture due to repeated temperature and moisture cycling. The materials of construction shall be non-toxic and NFPA 225-ASTM E84 compliant. Full face contact pressure seals shall be provided to separate the process and reactivation air streams and eliminate detrimental leakage of air or moisture with static pressure differentials of up to 3" of water gauge.
- E. Desiccant dehumidifier shall be circuited and controlled from chamber control console.

2.06.8 Humidification Systems

- A. Where elevated humidity control is required to achieve scheduled room conditions, manufacturer shall provide ultrasonic humidification system, equipped with the following features:
 - 1) Non-corrosive polycarbonate water reservoir;
 - 2) Automatic water fill solenoid valve;
 - 3) Safety overflow;
 - 4) Instantaneous on/off control;
 - 5) Operation on reverse osmosis, deionized or distilled water

- B. Humidifier shall be circuited from control console on PID control loop, with humidity levels continuously displayed on touchscreen interface. Steam generators operating at 500W or greater shall not be permitted.
- C. Water vapor shall be introduced into chamber conditioning plenum downstream of evaporator coil for uniform distribution.

2.07 LIGHTING

- A. Lighting output shall be a minimum of 75 foot-candles as measured 40 inches above finished floor at 22°C.
- B. Low temperature electronic ballasts shall be provided for cold rooms operating below 10°C.
- C. Lighting systems shall utilize cool white fluorescent T8 lamps. Lamps and ballasts shall be enclosed in UL listed vapor-proof fixtures surface mounted with no exposed conduit.
- D. Incandescent, vapor-proof lights shall be provided for rooms operating below 0°C.
- E. Provide exterior light switch with pilot light at latch side of entrance door.

2.08 ACCESSORIES

- 2.08.1 Electrical receptacles. Electrical receptacles shall be 115V, 20 amps, NEMA 5-20R, located as shown on electrical plans.

[CHOOSE ONE: Electrical receptacles shall be foamed in place in wall panel with conduit concealed and stubbed through the top of the ceiling panel. CER manufacturer shall provide electrical receptacles and circuit them through the control console. OR

[CHOOSE ONE: Division 16 shall provide surface-mounted wiremold as specified. Controlled environment room manufacturer shall provide junction boxes foamed into wall panel for circuiting of receptacles by others. Junction box to be located as shown on plans, and coordinated with Division 16 contractor.]

- 2.08.2 Casework and Shelving. Casework and shelving shall be supplied by the laboratory equipment supplier. Controlled environment room manufacturer to provide reinforced wall panels for wall-mounted counters or shelving as shown on plans.

2.09 UTILITY REQUIREMENTS

- 2.09.1 Electrical Services. Division 16 shall make final electrical connections at two points for each room:
- A. Service to be provided at control console shall be 115/208 VAC, 60 hz, 3 phase, 4 wire service.
 - B. Service to be provided at condensing unit shall be 208-230 VAC, 3 phase, 60 hz, 3 wire service with disconnect.

- 2.09.2 Ventilation System. Division 15 shall provide conditioned air supply and exhaust to the room at a rate of 0.5 cfm per square foot for all occupied spaces. CER manufacturer shall provide inlet and exhaust dampers for final connection by Division 15.
- 2.09.3 Condenser Water (if applicable). Division 15 to make final condenser water connections to CER water-cooled condensing unit. Water supply lines to be coordinated with condensing unit requirements.
- 2.09.4 Drains. Division 15 to provide floor drain within 10' of controlled environment room as shown on plans, unless sink is provided within CER for condensate drain connections.
- 2.09.5 Fire Suppression. Fire suppression systems to be provide by fire sprinkler contractor. Penetrations and sprinkler layout to be coordinated with controlled environment room manufacturer.

PART 3 – EXECUTION

3.01 EXAMINATION

Examine existing conditions and confirm field measurements prior to beginning work and notify Architect in writing of unsatisfactory conditions.

3.02 INSTALLATION

- 3.02.1 Install work in accordance with approved submittals and written specification.
- 3.02.2 Install components straight, plumb level, and true. Install service lines at right angles to walls and floors except where required to pitch to drains.
- 3.02.3 Install all components in accordance with manufacturer's written instructions and good refrigeration practices. All electrical installation shall be performed in accordance with National Electrical Code.

3.03 CLOSURE TRIM & SEALANTS

- 3.03.1 Seal all service penetrations with silicone to maintain vapor barriers and insulation. Seal off all electrical conduits to prevent condensation in electrical devices.
- 3.03.2 Install all closure trim to cover gaps between controlled environment room panels and adjacent wall/ceiling surfaces.

3.04 STARTUP & TESTING

3.04.1 General Requirements

- A. Provide written startup report indicating, at minimum, date/time of startup, pressure test duration and start/end pressures, vacuum test results, refrigerant type and volume, and operating pressures once system has stabilized at setpoint.

- B. Controlled environment rooms shall be tested by the manufacturer for proper operation. Manufacturer shall notify owner a minimum of 7 days in advance to provide owner opportunity to witness the room tests. Manufacturer shall provide written documentation of all test results. Written test reports for sustained operation and uniformity testing shall include: control setpoint, date/time test was initiated, date/time test was completed, manufacturer model and serial number of test instrument(s), calibration certification for each test instrument.
- C. For any tests not satisfactorily completed, manufacturer shall make appropriate chamber modifications and repeat the failed test.

3.04.2 Refrigerant Piping Test

Pressure test: Refrigerant piping shall be pressurized with dry nitrogen gas and shall hold a pressure of 250 psi for a minimum of 2 hours prior to startup.

Vacuum test: Refrigeration systems shall be evacuated to below 500 microns and then monitored for pressure rise above 500 microns for a period of 20 minutes prior to charging and startup.

3.04.3 Sustained Operation Testing (24 hours, single point)

- A. Sustained operation test shall demonstrate consistent control at a single point over a period of 24 hours. For rooms designed to operate over a range of temperature conditions, the test shall consist of 24-hour operation at each of the maximum, minimum and one intermediate point for a total of 72 hours of sustained operation testing.
- B. Rooms with humidity control shall record chamber humidity levels to demonstrate consistent control at a single point over a period of 24 hours. For rooms designed to operate over a range of humidity conditions, the test shall consist of 24-hour operation at each of the maximum, minimum and one intermediate point for a total of 72 hours of sustained operation testing. Minimum humidity test shall coincide with minimum temperature test, and maximum humidity test shall coincide with maximum temperature test to ensure limits of humidity system operation.
- C. Integrated data logging feature of touchscreen control interface shall be sufficient to document sustained operation, with data to be printed or downloaded for submittal of test results.

3.04.4 Chamber Uniformity Testing (8 hours, 12 point)

- A. Each room shall be temperature mapped with a minimum of ten (10) temperature sensors evenly distributed on a plane 44" above finished floor, with sensors located a minimum of 12" from walls, counters and shelving obstructions.
- B. Test instrument(s) shall have been certified for accuracy by a recognized testing laboratory within one (1) year prior to testing.
- C. Uniformity test shall be conducted for a minimum of eight (8) hours per room.

3.04.5 Chamber Recovery Testing (30 second door opening, 3 minute recovery)

- A. To demonstrate adequate system capacity for chamber recovery, perform a chamber recovery test on each chamber at minimum operating temperature.
- B. With chamber conditions stabilized, open door to a minimum angle of 120 degrees for a period of 30 seconds. When 30 second period is complete, close the door and wait for chamber to recover. Document start time, door open time, door close time, maximum chamber temperature reached, and system recovery time.

3.05 PROTECTION

Protect controlled environment room panels and equipment as required to prevent damage.

3.06 FIELD ADJUSTMENTS AND CLEANING

Maintain clean work area, removing all packing materials and other construction waste to approved dumpster location.

Clean control console exterior and exposed room panels (interior/exterior), leaving room in move-in condition.

PART 4 – ROOM SCHEDULE

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4.01 ROOM SCHEDULE (IF NOT ON LABORATORY PLANS – SAMPLE)

Room #	Ext. Dimensions	Room Height (Exterior)	Temp Range (°C)	Humidity Range (%RH)	Refrigerant	Control Panel Electrical
1A	8'-8 1/2" x 11'-7"	9'-6"	+4°C	Noncondensing	R-404a	115/208/3-ph/20A