ADDENDUM NO 2

ISSUE DATE: February 11, 2021

RE: Biochemistry Cryo-Electron Microscopy Renovation
University of Wisconsin – Madison
Madison, Wisconsin
MSN Project No. 0084 2014 / UWSA Project No. A-20-012

BID OPENING:
MEP – 2:00 pm, February 18, 2021
GPC – 2:00 pm, March 4, 2021

FROM: Aro Eberle Architects
116 King Street, Suite 202
Madison, WI 53703

TO: Prospective Bidders

This addendum forms a part of the Contract Documents and modifies the original Contract Documents dated January 8, 2021 as noted below. Acknowledge receipt of this Addendum by inserting the number and issue date of this addendum in the blank space provided on the Bid Form. Failure to do so may subject the Bidder to disqualification.

This Addendum consists of 2 pages and the attached documents; Specifications 23 09 93 and 23 73 13; Drawings None.

CHANGES TO DRAWINGS:
1. Sheet E001 – Electrical Notes, Legends & Abbreviations; Revise sheet as noted in this Addendum.
   a. REVISE surface raceway schedule to include only (SR-2) dual channel raceway, and relabel (SR/2) to (SR/1).
2. Sheet E111 – Basement Floor Power Plan; Revise sheet as noted in this Addendum.
   a. ADD room number B1108 to room located at gridlines D.10/YE.
   b. ADD existing panel “L1NDH1” location to existing electrical room B1108.
3. Sheet E133 – Penthouse Electrical Plans; Revise sheet as noted in this Addendum
   a. CLARIFY that existing panel “L3NPL26” is located in the Penthouse west of column line S5 about 98ft.

CHANGES TO SPECIFICATIONS (DIVISIONS 2 THRU 33):

4. Specification section 21 10 00 Water Based Fire Suppression Systems; Page 6, Line 45:
   a. Add “This fire protection contractor shall be responsible to provide new or extend existing pre-action detection system to the new coverage area as shown on FP101.”
5. Specification section 22 60 00 Gas and Vacuum Systems for Laboratory and Healthcare Facilities; Page 4, Line 14:
   a. Replace original language with the following:
      Provide extension from existing Vacuubrand Vacuu Lan system using components supplied from the Vacuu Lan vendor. Coordinate design and installation of all components with Vacuu Lan vendor. Components Include:
      • PTFE tubing
      • PVDF compression fittings
      • Shutoff Valves
6. Specification Section 23 09 93 Sequence of Operation for HVAC Controls; Page 1, Line 25:
   a. ADD “Desiccant Dehumidification Unit Control”
7. Specification Section 23 09 93 Sequence of Operation for HVAC Controls; Pages 13-14:
   a. REVISE Desiccant Dehumidification Unit Control Sequence.
8. Specification Section 23 73 23 Factory Fabricated Custom Air-Handling Units:
   a. REPLACE Section with 23 73 13 Modular Indoor Air-Handling Units.
9. Specification Section 26 05 00; Page 1, Line 18 –
   a. ADD “Electrical contractor shall be responsible for all work pertaining to DIV 26, 27, 28 specifications”.

END OF ADDENDUM

Aro Eberle Architects
116 King Street, Suite 202
Madison, WI 53703

The Board of Regents of the University of Wisconsin
1220 Linden Drive
Madison, WI 53703
SECTION 23 09 93
SEQUENCE OF OPERATION FOR HVAC CONTROLS
BASED ON DFD MASTER SPECIFICATION DATED 4/08/2020

PART 1 - GENERAL

SCOPE
This section includes control sequences for HVAC equipment as well as equipment furnished by others that
may need monitoring or control. Included are the following topics:

PART 1 - GENERAL
Scope
Related Work
Description of Work
Submittals
Operation and Maintenance Data
Design Criteria

PART 2 - PRODUCTS
Not Applicable

PART 3 - EXECUTION
General Control
Terminal Unit Control – DDC and Electric
Laboratory Terminal Unit Control
Variable Volume Mixed Air Handling Unit Control
Desiccant Dehumidification Unit Control
Lab Exhaust Fan Control
Functional Performance Testing

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 09 24 - Direct Digital Controls (DDC) System for HVAC (For Information Only)
Section 23 09 14 - Pneumatic and Electric Instrumentation and Control Devices for HVAC
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC – Coordination
Division 23 - HVAC - Equipment provided to be controlled or monitored
Division 26 - Electrical - Equipment provided to be controlled or monitored
Division 28 - Electronic Safety and Security

REFERENCE
Section 23 09 14 work includes furnishing and installing all field devices, including electronic sensors for
the DDC of this section, equipment, and all related field wiring, interlocking control wiring between
equipment, pneumatic tubing, sensor mounting, etc., that is covered in that section.

Motorized control dampers and actuators, thermowells (temperature sensing wells), automatic control
valves and their actuators are also covered in Section 23 09 14.

DESCRIPTION OF WORK
Control sequences are hereby defined as the manner and method by which automatic controls function.
Requirements for each type of operation are specified in this section.

Operation equipment, devices and system components required for automatic control systems are specified
in other Division 23 control sections of these specifications.

All temperature, humidity, and pressure sensing, and all other control signal transportation for the control
sequences shall be furnished under Section 23 09 14. All pneumatic, electronic, and electric input/output
signals shall be extended under Section 23 09 14, with adequate lead length for termination within the
appropriate control panel being provided under Section 23 09 24.

Sequences for equipment controlled by Direct Digital Controls (DDC) as specified are accomplished by
hardware and software provided under Section 23 09 24. Sequences for equipment controlled by
pneumatic or electric self-contained controls are accomplished by hardware provided under Section
23 09 14.
SUBMITTALS
Refer to Division 1, General Conditions, Submittals, Section 23 05 00 and Sections 23 09 24, and 23 09 14 for descriptions of what should be included in the submittals.

Shop drawings shall be provided by contractor(s) providing equipment under Sections 23 09 24 and 23 09 14. The contractor providing the DDC equipment shall provide a complete narrative of the sequence of operations for equipment that is controlled through the DDC system. The contractor providing the 23 09 14 equipment shall provide a complete narrative of the sequence of operation for equipment that is controlled directly from that equipment (without control logic through the DDC system). The narrative of the sequence of operation shall not be a verbatim copy of the sequences contained herein, but shall reflect the actual operation as applied by the contractor.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA
Reference Section 23 09 14.

PART 2 - PRODUCTS
Not applicable to this Section – reference Sections 23 09 24 and 23 09 14 for product descriptions.

PART 3 - EXECUTION

GENERAL

BACNET OBJECTS:
All hardwired points listed in 23 09 15 and any setpoints, timers, or other control elements that are specified to be adjustable (adj.) in the following control sequences shall be mapped as BACnet objects and be available on the user interface to be adjusted. Consult with the user agency HVAC and/or DDC personnel prior to programming to determine if there are any items that they do not want to have mapped as BACnet objects. This is especially important for DDC controlled items that are duplicative, i.e. air terminal units.

BACNET ADDRESSING:
BACnet instance ID’s shall be coordinated with the agencies established BACnet instance ID addressing scheme. If there is not such a scheme in place, the contractor(s) providing BACnet DDC controllers shall work with the agency to establish such a scheme and document this in the asbuilt control drawings. BACnet/IP addressing shall be coordinated with the agency prior to installation. BACnet MSTP addressing shall be addressed to provide for consecutive addressing to provide for the best speed of response. Max Master address shall be set appropriately for speed of response.

USER INTERFACE/FEATURE SOFTWARE:
Consult with the user agency HVAC and/or DDC personnel prior to programming to determine BACnet object naming conventions, user views, graphic layout, security matrix, alarming, trending, and scheduling preferences desired by the agency. Failure to consult and come to agreement prior to programming shall require the DDC contractor to make changes in the above listed items as desired by the user agency to the system at no cost. Section 23 09 15 feature software checkmarks are guides only and are not specific to what is required by the user agency.

SETPOINTS:
All setpoints indicated in the control specification are to be adjustable. The setpoints shall be readily available to be modified in the mechanical system software system summary (either textual or graphic based) and under the same software level as hardware points. Some less used setpoints may be provided on a lower software level, if requested by the user Agency for clarity. The setpoints indicated herein are only specified as a calculated starting point (or initial system operation). It is expected that setpoint adjustments and control loop tuning shall be required to provide optimum system operation based on requirements of the building. The control contractor shall work with the balancing contractor and the user Agency to provide the final system setpoint adjustments and control loop tuning after the system is in operation and building is in use. Document all final setpoints on the as-built control drawings. Any questions regarding
the intended operation of the HVAC equipment and control systems shall be referred to the HVAC design engineer through the appropriate construction communication process. The following setpoints should be used as initial setpoints unless otherwise specified in the individual control sequences or instructed by the user Agency. If the contractor fails to check with the user Agency for final setpoints, they shall adjust setpoints at no additional cost.

Occupied Space Terminal Unit Heating: 68º F
Occupied Space Terminal Unit Cooling: 76º F
Unoccupied Space Terminal Unit Heating: 62º F
Unoccupied Space Terminal Unit Cooling: 82º F
Microscope Space Terminal Unit Heating: 72º F
Microscope Space Terminal Unit Cooling: 72º F
Microscope Space Terminal Unit Relative Humidity: 20% RH

ANTI-CYCLING:

When HVAC equipment or a sequence is specified to be started and stopped by a temperature, humidity, pressure setpoint or any other controlled variable, there shall be an adjustable differential setpoint that shall be set to prevent short cycling of the systems and equipment due to minor changes in the controlled variable. Temperature differential setpoints shall be set at 2º F and non-temperature setpoints shall be set at 10% of the controlled range unless otherwise specified. Setpoints shall indicate at when the process should be turned on. Heating and cooling differentials shall be set for above setpoint and shall be used to turn the process off. For example, an economizer sequence called to switch at 68º F, would turn on at 68º F and off at 70º F since it is a cooling function. A heating lockout setpoint of 50º F would turn on heating control at 50º F and off at 52º F. Non-temperature differentials shall be set above setpoint if the setpoint is indicating a minimum value or below setpoint if the setpoint is indicating a maximum value. Provide minimum runtime timers for loads that are cycled to prevent over-cycling. Timers shall be set as specified or as needed to prevent damage or excessive wear to the equipment. Unless otherwise specified in the individual control sequences, fans and pumps shall have a minimum runtime on timers of 15 minutes (adj.) and off timers of 5 minutes (adj.) and staged condensing units shall have on timers of 10 minutes (adj.) and off timers of 5 minutes (adj.) or the recommended timers by the manufacturer. Safeties shall override runtime timers.

DEADBANDS:

Provide deadbands for all DDC control loops to prevent constant hunting of output signals to controlled devices. Deadbands shall be set to provide adequate control around setpoint as follows unless otherwise specified in the individual control sequences:

Temperature Control: ±0.5º F
Humidity Control: ±1% RH
Airflow Control: ±2% of total flow
AHU Static Pressure Control: ±0.01 in. w.c.

ALARMS:

Provide all alarmed points with adjustable time delays to prevent nuisance tripping under normal operation and on equipment start-up. For all commanded outputs that have status feedback, provide an alarm that shall indicate the commanded output is not in its commanded state. Provide alarms on all points as indicated on point charts. For existing campus automation systems, add/delete what is called on the point charts for after consultation with user Agency to provide consistent alarming throughout the automation system.

For devices that have form “C” contacts available for alarm monitoring, use closed contacts for the Normal condition and open contacts on Alarm condition. This shall provide a level of supervision by detecting a break in the wiring.

EQUIPMENT START/STOP FAILURE STATES:

All start/stop points for equipment shall utilize normally open contacts unless called out specifically in the individual control sequences.

RESTART DELAYS:

Provide restart delays for all large loads (15 HP or greater) to be invoked on emergency power and after normal power is restored. Manifolded air and water system loads shall be started simultaneously, if required. Timers shall be embedded in individual controllers and staggered by five seconds (adj.). Systems shall be restarted in a logical manner so systems serving other systems are started first, i.e. hot water
systems started before AHU’s served. Adjust timers as needed to have systems fully operational if serving other systems. If specific start-up sequences are specified below, these shall take precedence over this sequence.

LEAD/LAG/STANDBY SEQUENCING:
For sequences that call for lead/lag/standby control of equipment connected to building automation systems, the lead device shall be able to be chosen through a selectable day of the week and time of day through the building automation system. Coordinate with the user Agency for scheduling switchover and frequency. Unless otherwise directed, switchover shall occur at 10AM Tuesday and shall rotate the lead device on a weekly cycle rotating through all devices sequentially. For standalone lead/lag/standby sequence controllers (non-DDC), the lead device shall be selected by a switch on the panel face.

VARIABLE FREQUENCY DRIVE (VFD) MOTOR RUN STATUS:
Use the VFD programmable relay dry contact output specified to be provided with the VFD under Section 23 05 14 to prove motor run status and detect belt loss or coupling break. If a bypass contactor is provided with the VFD, provide an adjustable current switch and wire it in parallel with the VFD output for proving motor status.

VFD BYPASS & SAFETY INTERLOCKS:
VFD’s equipped with bypass starters shall be interlocked so that the start/stop and safety circuits that are called out for VFD operation shall be functional when the VFD is indexed to the bypass starter mode. Unless otherwise specified in the sequence below, the switch from inverter to bypass starter modes shall be through a manual switch provided on the VFD/bypass starter package.

VFD MINIMUM SPEED & RAMP TIMERS:
The VFD start-up technician shall work with the DDC Temperature Control Contractor to set the minimum speed required for the motor controlled by the VFD to provide cooling of the motor as installed to prevent heat related problems. This minimum speed shall be set in the VFD controller. Unless otherwise noted in the following control sequences or needed for lower turndown for volume matching, minimum speeds for fans shall be set at 15 Hz. If a lower minimum speed is required for volume matching of fans, the minimum speed shall never be set below 6 Hz to prevent overheating of the motor. Pump minimum speeds shall be 20 Hz for 1750 RPM motors and 25 Hz for 1150 RPM motors to ensure seals stay lubricated. For splash-lubricated cooling tower fans and submersible pumps, minimum speed shall be 30 Hz. The controlled motor shall ramp linearly in speed between the minimum Hz and the maximum Hz required for the application (may not be 60 Hz) as the control speed signal increases from 0% to 100% speed. The VFD start-up technician shall work with the DDC Temperature Control Contractor to set the acceleration and deceleration timers in the VFD controller at 30 seconds for motors less than 40 HP and 60 seconds for motors 40 HP and greater.

CURRENT SWITCH SETUP:
When current switches are used for proving fan or pump status, they shall be set up so that they will detect belt or coupling loss by the reduction in current draw on loss of coupled load. The current switch set up shall be redone by the 23 09 14 contractor after the balancer is complete.

DAMPER INTERLOCKS FOR FANS WITH STARTERS:
For fan systems with magnetic starters and shutoff dampers specified with end switches, the damper interlock shall be hardwired in such a way that the damper shall open if the fan starter hand / off / auto switch is in the hand or in the auto position and being called to start. After the damper end switch has proven the damper open, a hardwire interlock from the end switch to the starter holding coil for the fan shall cause the fan to start. For fan systems that are ducted in parallel, see specific sequence for fan system on interlock requirements.

DAMPER INTERLOCKS FOR FANS WITH VFD’S:
For fan systems with VFD’s and shutoff dampers specified with end switches, hardwire interlock the shutoff damper with the fan VFD. When the fan is remotely or locally commanded to start, VFD contacts shall energize outside air damper actuator to open damper. The damper position end switch shall be wired to run permissive input on the VFD and enable the VFD to start when the damper position end switch provides the damper is open. This operation shall be provided for VFD and bypass operation if the VFD is provided with a bypass. The damper end switch shall also be monitored by the DDC system. For fan systems that are ducted in parallel, see specific sequence for fan system on additional interlock requirements.
SMOKE DAMPER CONTROL:
Smoke dampers provided in ducts are required to close by building code in the event their associated smoke detectors are in alarm or if the associated duct smoke detector requires a minimum velocity to operate and the associated fan(s) that supply, return, or exhaust air through them are shutdown.

For software interlocks of smoke dampers to the fan systems, the smoke dampers shall be commanded open and closed on fan status through the DDC smoke damper control output.

For fans systems with safety circuit hardware interlocks and fan fails to start after an appropriate time delay (not longer than five minutes), smoke dampers shall close through the DDC smoke damper control output. The fan shall be latched off, and an alarm sent through the DDC system. A software reset point and a momentary pushbutton located at the temperature control panel for the associated fan system shall be provided to reset the fan system. On fan system start-up, a time delay shall allow the dampers to open before the fan is started. All necessary software and hardware interlocks shall be provided to perform these functions. See individual fan system control sequences for the type of smoke damper interlock to use and more details on how this should be accomplished. The smoke dampers shall be hardware interlocked to the associated fire alarm control module to close whenever the fire alarm control module indicates an alarm to shut down the associated AHU.

Alarms shall be provided for each smoke damper by the 23 09 23 or 23 09 24 contractor. The alarm shall be generated when the smoke damper is not in its commanded position after the appropriate time delay to allow for the smoke damper to actuate fully. Alarms shall be provided regardless if the smoke damper command is from the DDC system or fire alarm system. Binary inputs to the DDC system from the fire alarm system devices commanding the AHU systems and associated dampers shall be provided for to allow for all required alarming. For smoke dampers that are controlled by individual duct smoke detectors in shaft penetrations and the AHU system is not programmed to shutdown, these smoke dampers shall go into alarm when they close.

FAN INTERLOCKING:
Provide interlocks between supply and return or exhaust fan systems as scheduled on the plans or called out in individual control sequences. If DDC controlled, interlocks shall be done through DDC start/stop points unless otherwise specified in individual control sequences. If not DDC controlled, interlocks shall be accomplished via hardware interlocks between fan starters or VFD’s.

THERMOSTATS AND SENSORS:
All devices and equipment including terminal units, specified to be controlled in a control sequence by a thermostat or sensor, shall be provided with a thermostat or sensor, whether or not the device is indicated on the plans. Consult the HVAC design engineer for the thermostat or sensor location.

PNEUMATIC INDEXING:
When sequences call for two-position (i.e. open/closed or max flow/min flow) indexing of pneumatic devices such as terminal units, this shall be accomplished in such a way that there is not a constant bleed of air. Non-bleed pneumatic relays shall be used in these switching applications. Pneumatic high selectors are not acceptable to use as switching devices.

ORIGINAL EQUIPMENT MANUFACTURER (OEM) CONTROLLER DDC INTEGRATION:
Provide DDC programming to define all equipment integral input/output points, setpoints, data points, calculations, etc. that are available through the manufacturers communication interface. Consult with the Agency DDC operations personnel to determine if some of the points should be omitted (for clarity or lack of value). The following equipment shall be integrated into the DDC system:

- Variable Frequency Drives
- Dehumidification Unit Control
- Lighting Control (furnished by Div. 26)
- Power Quality Meters (furnished by Div. 26)

WATCH DOG TIMER
Where the integrated system consists of programmable DDC controllers with BACnet objects mapped to an enterprise level Building Automation System (BAS) and it is shown that the BACnet objects do not indicate when they are offline on the enterprise level BAS when communication is lost between the two systems, software algorithms shall be provided to alarm when communication is lost. The integrated system shall program a binary data object that is toggled on and off at an adjustable rate (initially one minute) that shall be monitored by the enterprise level BAS which shall alarm if the toggling ceases.
WEEKLY SCHEDULING
Provide scheduling of DDC terminal units in groups based on occupancy. Work with the user Agency to determine how many groups are required and which zones should be included. Individual terminal units shall be able to receive temporary schedules that shall override the group schedules. Temporary override buttons at the zone sensor (where specified on point charts) shall override the scheduling to occupied. When groups that consist of more than 20% of terminal units are indexed to occupied, the associated air handling unit shall start if not already running.

PARALLEL FAN BUMPLESS TRANSFER
For fan systems that have multiple fans ducted in parallel, sequencing of the fans shall be programmed so that when a planned start or stop of a fan is initiated either manually or automatically, the isolation dampers and fan speeds shall be sequenced to limit the static pressure variance in the system to + or − 10% of the static setpoint.

DDC CONTROLLER COMMUNICATION BUS CONFIGURATION
The actively controlled primary mechanical equipment (AHU’s, hot water, chilled water, boilers, etc.) shall be configured to be located on the same supervisory controller BACnet MSTP communication trunk unless the supervisory controller capacity prevents it. If this is the case, the primary mechanical equipment DDC controllers shall be separated onto supervisory controllers in such a way that the systems that need to share information for operation and interlocking shall reside on the same supervisor controllers. When AHU systems have associated exhaust fan systems that are interlocked and designed to operate together as a combined air system within a building, these must be on the same BACnet MSTP trunk. Peer to peer communication shall be used for interlocks and data sharing between the AHU and exhaust fans systems when possible to limit air system disruptions in the event of a supervisory controller failure. Other critical building systems that require communication between DDC controllers to operate shall be on the same BACnet MSTP communication trunk. Terminal unit controllers shall be located on a separate BACnet MSTP trunks if necessary to allow for primary equipment to reside on the same BACnet MSTP trunk. If the DDC controllers used for control of primary mechanical equipment and interlocks or point information is required for proper operation as described above do not use BACnet MSTP communication but use Ethernet communication, the DDC controllers shall be connected to the same Ethernet switch. If the controllers cannot be connected to the same switch, hardwired points between controllers shall be used to share information.

CONTROLLED VARIABLE REQUIREMENTS
All controlled variables, i.e. static pressure, differential pressure, temperature, humidity, etc., shall be wired directly to the DDC controller in which the software PID loop or other similar software loop resides unless the control sequence specifically allows the controlled variable to be routed over the network. Where a controlled variable is used for reset of a PID loop, the controlled variable shall be allowed to be shared over the network unless specified to be directly wired to the DDC controller.

CALCULATED DATA POINTS
Provide calculated data points for actual dirty pressure drop for all variable volume air handling units with supply flow measurement based on the following equation:
Actual Dirty Filter ΔP = (Measured Supply CFM/Design CFM)² x Design Dirty Filter ΔP

Where Supply CFM is measured either on variable volume fans or as balanced on constant volume units, MAT is Mixed Air Temperature, RAT is Return Air Temperature, and OAT is Outside Air Temperature. This point is designed as a check for outside air flow stations accuracy and outside air ventilation minimum damper positions. It should be noted that the accuracy of the calculated outside airflow will diminish as outside air temperature approaches return air temperature. It should be used as a check only when the RAT and OAT are greater than 20 DegF and the accuracy of the RAT and OAT temperature sensors are assured.

TERMINAL UNIT CONTROL – DDC and ELECTRIC

GENERAL:
See the valve chart in Section 23 09 14 for requirements for type of valve, signal required, spring return requirements, and fail positions. The valve requirements specified in the Section 23 09 14 valve chart shall supersede what is called out in the terminal unit sequences.

DDC CONTROLLED TERMINAL UNIT MASTER COMMAND POINTS:
Provide individual master software points for each of the following functions that can be executed from a single command through the DDC system:
Command all terminal unit heating valves open by floor (i.e. reheat, radiation, fan coil, etc.).
Command all terminal unit heating valves closed by floor.
Command all terminal unit cooling valves open by floor.
Command all terminal unit cooling valves closed by floor.
Command all VAV terminals to scheduled minimum flow by scheduled groups as described below. If groups are not specified, provide a master software point for all VAV terminals by associated AHU.
Command all VAV terminals to scheduled maximum flow by scheduled groups as described below. If groups are not specified, provide a master software point for all VAV terminals by associated AHU.

REHEAT COIL CONTROL:
Provide a DDC space temperature sensor to control a modulating electronic control heating coil valve to maintain space temperature. When space temperature is below setpoint modulate the heating coil valve open. The reverse shall occur when space temperature is above setpoint. Provide a discharge air temperature sensor for monitoring purposes. The heating coil valve shall be commanded closed whenever the associated AHU is off.

VAV TERMINAL UNIT WITH REHEAT DDC CONTROL:
Refer to the Air Terminal Schedules on the plans for occupancy sensor interlock requirements, minimum and maximum flow rates, grouping of terminals for scheduling, and CO2 control.
Provide a DDC space temperature sensor to control, in sequence, a modulating electronic control valve for the hot water reheat coil and actuator for terminal air flow. When space temperature is below setpoint, the air terminal damper shall modulate toward the cooling minimum flow position. After the air terminal damper is at its minimum flow, the hot water valve shall modulate open to maintain space temperature. The reverse shall occur when space temperature is below setpoint. The heating coil valve shall be commanded closed whenever the associated AHU is off. When the space temperature is between the heating and cooling setpoints, the heating valve shall be closed and the supply airflow at heating and cooling minimum flow. The reheat coil valve shall be limited in opening to prevent the discharge air temperature leaving the air terminal from exceeding 95º F (adj.).

Time of Day Scheduling:
Weekly schedule the occupied mode for each zone and/or group by function to reduce the number of schedules required per user agency needs or as specified in the air terminal unit schedules.

Occupancy Modes:
For zones that have space occupancy sensors specified, occupancy sensors shall be used for determining the mode of the terminals. The occupancy sensor auxiliary contact, provided by Division 26, shall be wired to a DDC controller for indexing the zone to occupied, standby, or unoccupied. The occupancy sensor has an internal adjustable time delay before switching to unoccupied, specified in Division 26 to be set at 10 minutes (but is typically adjustable from 15 seconds to 30 minutes). When the room is time of day scheduled through the DDC system to be occupied or unoccupied and the occupancy sensor indicates the zone is occupied, the zone shall be indexed to the occupied mode. When the zone is scheduled to be occupied and the occupancy sensor indicates the zone has been unoccupied (auxiliary occupancy sensor contact opens) the DDC system shall delay for 20 minutes (adj.) before indexing the zone to the standby mode. When the zone is scheduled to be unoccupied and the occupancy sensor indicates the zone is unoccupied the DDC system shall delay for 20 minutes (adj.) before indexing the zone to the unoccupied mode.

For zones that do not have occupancy sensors specified, there shall only be occupied and unoccupied modes that are time of day scheduled.

Airflow Mode Control:
In the occupied mode, the zone air terminals shall modulate between the minimum and maximum occupied flow rates as specified in the Air Terminal Schedules. In the standby and unoccupied mode, the zone air terminals shall modulate between the minimum unoccupied flow rate and the maximum occupied flow rate as specified in the Air Terminal Schedules except as required for unoccupied/standby heating control. All airflow setpoints shall be adjustable.

Unoccupied/Standby Heating Control without Radiation:
If the space temperature falls below the unoccupied zone heating setpoint and the VAV terminal unoccupied airflow setpoint is zero CFM, the VAV terminal shall be indexed to the occupied minimum airflow and the heating valve controlled to maintain the VAV terminal discharge at the discharge air temperature limit control setpoint. When the space temperature rises 2º F (adj.) above the unoccupied space temperature setpoint, the VAV terminal damper and heating valve shall close.
Temperature Mode Control:
In the occupied mode, the occupied zone temperature heating and cooling setpoints shall be maintained.
In the standby mode, the standby zone temperature heating and cooling setpoints shall be maintained.
In the unoccupied mode, the unoccupied zone temperature heating and cooling setpoints shall be maintained.

Temperature Setpoints:
Temperature setpoints listed below shall be the default setpoints, but all setpoints shall be verified and documented with the agency prior to programming the air terminal DDC controllers. For the standby mode, the heating and cooling setpoints shall be 2°F greater and less than the cooling and heating setpoints respectively. For the unoccupied mode, the heating and cooling setpoints shall be 6°F greater and less than the cooling and heating setpoints respectively. All heating and cooling setpoints for each mode shall be adjustable.

<table>
<thead>
<tr>
<th>Space</th>
<th>Mode</th>
<th>Temp. Setpoint (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging Support, Storage</td>
<td>Cooling</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Heating</td>
<td>68</td>
</tr>
</tbody>
</table>

LABORATORY TERMINAL UNIT CONTROL

GENERAL:
Space temperature and ventilation control shall be accomplished by DDC Variable Air Volume (VAV) controllers with electric actuation and fixed flow venturi air valves as defined in the General control sequences and numbered control sequences below.

Refer to the Air Terminal Schedules on the plans for control sequence numbers, occupancy sensor interlock requirements, grouping of terminals for scheduling (if scheduled), grouping of terminals for flow control to maintain volume matching within a zone, minimum and maximum airflow rates, supply and exhaust CFM offset, fume hood control method, terminal unit type (butterfly or venturi), terminal unit construction material types, and terminals that are switched (fixed flow/no flow from a manual switch).

Occupy Modes:
For zones that have space occupancy sensors specified, occupancy sensors shall be used for determining the mode of the terminals that are scheduled to be controlled together for room volume matching. The occupancy sensor auxiliary contact, provided by Division 26, shall be wired to a DDC controller for indexing the zone to occupied, standby, or unoccupied. The occupancy sensor has an internal adjustable time delay before switching to unoccupied, specified in Division 26 to be set at 10 minutes (but is typically adjustable form 15 seconds to 30 minutes). When the room is time of day scheduled through the DDC system to be occupied or unoccupied and the occupancy sensor indicates the zone is occupied, the zone shall be indexed to the occupied mode. When the zone is scheduled to be occupied and the occupancy sensor indicates the zone has been unoccupied (auxiliary occupancy sensor contact opens) the DDC system shall delay for 20 minutes (adj.) before switching to occupied.

For zones that do not have occupancy sensors specified, there shall only be occupied and unoccupied modes that are time of day scheduled.

Airflow Mode Control:
In the occupied mode, the zone air terminals shall modulate between the minimum and maximum occupied airflow rates as specified in the Air Terminal Schedules. In the standby and unoccupied mode, the zone air terminals shall modulate between the minimum unoccupied flow rate and the maximum occupied flow rates as specified in the Air Terminal Schedules. All airflow setpoints shall be adjustable.

Unoccupied/Standby Heating Control without Radiation:
If the space temperature falls below the unoccupied zone heating setpoint and the VAV terminal unoccupied airflow setpoint is zero CFM, the VAV terminal shall be indexed to the occupied minimum airflow and the heating valve controlled to maintain the VAV terminal discharge at the discharge air temperature limit control setpoint. When the space temperature rises 2°F (adj.) above the unoccupied space temperature setpoint, the VAV terminal damper and heating valve shall close.

Temperature Mode Control:
In the occupied mode, the occupied zone temperature heating and cooling setpoints shall be maintained.
In the standby mode, the standby zone temperature heating and cooling setpoints shall be maintained.
In the unoccupied mode, the unoccupied zone temperature heating and cooling setpoints shall be maintained.

Temperature Setpoints:

Temperature setpoints listed below shall be the default setpoints, but all setpoints shall be verified and documented with the agency prior to programming the air terminal DDC controllers. For the standby mode, the heating and cooling setpoints shall be 2º F greater and less than the cooling and heating setpoints respectively. For the unoccupied mode, the heating and cooling setpoints shall be 6º F greater and less than the cooling and heating setpoints respectively. All heating and cooling setpoints for each mode shall be adjustable.

Where there are multiple sensors in large labs controlling individual pairs of supply/exhaust air terminals, the local setpoint adjustment of the most centrally located sensor shall reset the setpoints of all terminals within the lab. The other sensors in the same lab shall not have local setpoint adjustments. Additionally, the heating and cooling software setpoints of all controllers within a single lab shall be set from the controller with the sensor with the local setpoint adjustment.

<table>
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Volume Matching:

Where volume offsets are specified in the Air Terminal Schedules, the total zone supply and exhaust airflows shall be summed and controlled to maintain the scheduled offset at all times. The general and/or the zone. The supply air flow shall track the exhaust airflow to maintain the offset if the supply air terminal is controlling to maintain temperature and exceeds the exhaust airflow plus the positive or negative offset in the zone. The supply air flow shall track the exhaust airflow to maintain the offset if the exhaust airflow exceeds the supply airflow plus the positive or negative offset. See detailed volume matching sequences in the numbered lab terminal unit sequences below.

Fixed Flow Terminals:

If the fume hood or other exhaust does not have a measured flow value (fixed venturi valve), the final balanced flow value determined by the balancer shall be entered into the DDC controller (adj.) by the contractor.

CONSTANT VOLUME LAB EXHAUST CONTROL (Fixed Venturi Air Valve Control):

Fume hoods, snorkels, and miscellaneous exhaust air terminals that are scheduled on the Air Terminal Unit Schedule as venturi air valves and for constant volume shall be venturi valves without controls and shall be manually set to maintain a constant flow at all times. For fume hood applications, the air balancer shall manually set the venturi air valve to maintain the airflow required for the face velocity of the fume hood at 100 FPM at 18” sash height.

CONSTANT VOLUME LAB EXHAUST CONTROL (Butterfly Air Terminal DDC Control):

Fume hoods, snorkels, and miscellaneous exhaust air terminals that are scheduled on the Air Terminal Unit Schedule as butterfly air terminals and for constant volume shall be butterfly air terminals with DDC controls and shall be set to maintain a constant flow during normal operation and other airflows as defined by the Failure and Safe Egress modes. For fume hoods, the air balancer shall work with the DDC contractor to have the air terminal to maintain the airflow required for the face velocity of the fume hood at 100 FPM at 18” sash height.

LAB TERMINAL CONTROL SEQUENCE 1 – VARIABLE VOLUME SUPPLY AND GENERAL EXHAUST

Provide a DDC space temperature sensor to control, in sequence, a modulating electronic control valve for the hot water reheat coil and actuator for supply terminal air flow. When space temperature is below setpoint, the air terminal damper shall modulate toward the cooling minimum flow position. After the air terminal damper is at its minimum flow, the hot water valve shall modulate open to maintain space temperature. The reverse shall occur when space temperature is below setpoint. The heating coil valve shall be commanded closed whenever the associated AHU is off. The reheat coil valve shall be limited in opening to prevent the discharge air temperature leaving the air terminal from exceeding 95º F (adj.).

Where radiation is provided within the lab zone, modulate the electronic control hot water valve in sequence (simultaneously) with the reheat coil valve to maintain space temperature when associated AHU is running. When space temperature is below setpoint modulate the hot water valve open. The reverse shall
occur when space temperature is above setpoint. When the associated supply air system is off, the radiation
valve shall be modulated to maintain heating setpoint and the associated reheat valve shall be closed. Lock
hot water valve closed whenever outside air is above 50º F (adj.).

Minimum and maximum terminal unit airflows and temperature setpoints shall be set by mode as described
in the General, Terminal Unit Failure, and Safe Egress sequences.

The general exhaust air terminal airflow setpoint shall be calculated by adding the measured supply airflow
to the scheduled airflow offset CFM (adj.) and minus other lab exhaust (i.e. snorkels, chemical cabinet,
etc.) flow values (measured or fixed value for non-measured terminals). The general exhaust air terminal
shall be controlled to maintain this calculated general exhaust airflow setpoint down to the scheduled
minimum airflow.

LAB TERMINAL CONTROL SEQUENCE 6 – CONSTANT VOLUME SUPPLY AND GENERAL
EXHAUST
Provide a DDC space temperature sensor to control, in sequence, a modulating electronic control valve for
the hot water reheat coil and actuator for supply terminal air flow. When space temperature is below
setpoint, the hot water valve shall modulate open to maintain space temperature. The reverse shall occur
when space temperature is below setpoint. The heating coil valve shall be commanded closed whenever
the associated AHU is off. The reheat coil valve shall be limited in opening to prevent the discharge air
temperature leaving the air terminal from exceeding 95º F (adj.).

The terminal unit airflows and temperature setpoints shall be set by mode as described in the General,
Terminal Unit Failure, and Safe Egress sequences.

Under the normal mode, the general exhaust air terminals shall be controlled to a fixed airflow setpoint as
specified in the Air Terminal Schedule.

The supply air terminal airflow setpoint shall be calculated by adding the measured general airflow to the
scheduled airflow offset CFM (adj.) and minus other lab exhaust (i.e. snorkels, chemical cabinet, etc.) flow
values (measured or fixed value for non-measured terminals). The general exhaust air terminal shall be
controlled to maintain this calculated general exhaust airflow setpoint. This sequence is designed to
maintain a negative pressure in the lab on exhaust air flow loss.

LAB TERMINAL CONTROL SEQUENCE 7 – VARIABLE VOLUME SUPPLY AND RETURN AIR
TERMINALS
Provide a DDC space temperature sensor to control, in sequence, a modulating electronic control valve for
the hot water reheat coil and actuator for supply terminal air flow. When space temperature is below
setpoint, the air terminal damper shall modulate toward the cooling minimum flow position. After the air
terminal damper is at its minimum flow, the hot water valve shall modulate open to maintain space
temperature. The reverse shall occur when space temperature is below setpoint. The heating coil valve
shall be commanded closed whenever the associated AHU is off. The reheat coil valve shall be limited in
opening to prevent the discharge air temperature leaving the air terminal from exceeding 95º F (adj.).

Where radiant cooling panel (RCP) is provided within the lab zone (B1118B Krios and B1118 Aquilos,
modulate the electronic control chilled water valve based on position of chilled water control valve for
AHU-19. Provide interlock to prevent simultaneous heating valve and cooling valve operation. When space
is calling for cooling, heating valve shall be closed. When the chilled water control valve for AHU-19 is
greater than 30% (FA) open, the radiant panel control valve shall be slowly modulated open to 30% (FA)
over a period of 2 minutes (FA). If the chilled water control valve for AHU-19 is open greater than 50% (FA),
the radiant panel control valve shall slowly modulate open to 75% (FA) over a period of 2 minutes
(FA). If the chilled water control valve for AHU-19 is open greater than 75% (FA), the radiant panel
control valve shall be slowly opened to 100% (FA) over a period of 2 minutes (FA). The reverse shall
occur as the cooling coil control valve for AHU-19 is closed. The radiant panel control valve shall remain
in set position for a period of 5 minutes (FA) before being allowed to change setpoint.

Minimum and maximum terminal unit airflows and temperature setpoints shall be set by mode as described
in the General, Terminal Unit Failure, and Safe Egress sequences.

The return air terminal airflow setpoint shall match the measured supply airflow. The return air terminal
shall be controlled to maintain this calculated return airflow setpoint down to the scheduled minimum
airflow.
VARIABLE VOLUME MIXED AIR HANDLING UNIT CONTROL (AHU-19)

GENERAL:
The Air Handling unit is variable air volume, indoor air unit.
The Air Handling unit is controlled by direct digital controller (DDC).
The Air Handling unit is equipped with the following:
- Supply fans with VFDs.
- Return air damper furnished by TCC. (Refer to specification 23 09 14)
- Chilled water coil for cooling.
- MERV 8 and and HEPA filter banks.
- Actuators furnished by TCC. (Refer to specification 23 09 14)

The heating, cooling, and dehumidification systems serving B1118B (Krios), B1118C (Prep Lab), and B1118D (Aquilos) are intended to maintain space conditions of 68ºF +/- 1.8ºF at <20% RH. DD-4, AHU-19, room level VAV w/RHC and radiant cooling panels are all operating to maintain space conditions.

FAN CONTROL:
Start/Stop:
The DDC system shall start the supply and return fan via the VFD.

Interlock DD-4 to operate any time AHU-19 is operating.

For fan systems with two supply fans, sequence fans on based on supply fan speed. When fan speed is at 95% or more for 15 minutes (adj.), start the next supply fan. All supply fans shall be controlled at the same speed. When commanded fan speeds fall to 40% for 15 minutes (adj.), shut off the lag supply fan. When starting a fan, command the fan to start and run at minimum speed. When fan status is proven on, command the isolation damper open and release the fan to control. If a fan status does not prove on or the isolation damper end switch does not prove open within 2 minutes (adj.) of the fan start or damper open commands, command the supply fan off and the isolation damper closed, latch out this supply fan, and send a supply fan failure alarm through the DDC system. When stopping a lag fan, command the damper to close and ramp the fan down to minimum speed at the same rate as the damper actuator stroke time (typically 90 seconds). After the fan is at minimum speed and the damper end switch indicates the damper is closed, command the fan off. When switching lead fans and stopping a lag fan, prove operation of the new lead fan and allow 2 minutes (adj.) for the fan to come up to speed before initiating the stop fan sequence. Provide a software point and hardware switch located inside the control panel for each fan to be taken out of service that shall initiate the shutdown sequence for the fan. If there is a lag fan that is available, it’s start sequence shall be initiated and come into control before the shutdown sequence for the fan being taken out of service is stopped. When alarms are cleared, unit shall restart automatically.

The above sequence may need to be modified to prevent static pressure variances as specified General, Parallel Fan Bumpless Transfer sequence. This may entail adjusting minimum speeds and/or ramping dampers or fans at different rates than specified above.

Current Status Switch:
Provide as described under GENERAL, VFD Motor Run Status, in this Section for both the supply and return fans.

Manual VFD Bypass Operation:
In the event of a VFD failure and bypass operation is desired, the VAV terminals associated with the AHU shall be indexed to their maximum flow rate through the VAV terminal master command point (see DDC Controlled Terminal Unit Master Command Points). After sufficient time to allow the VAV terminals to open (approximately two minutes), the supply and return fan VFD’s shall be manually indexed to bypass.

Supply Fan Speed Control:
The purpose of the supply fan control is to maintain a minimum static pressure in the supply ductwork to insure proper terminal air box operation. Install a static pressure sensing probe in the main supply duct located at approximately ¾ of the way down the main supply duct as shown on the plans and pipe to the differential pressure transmitter that shall be located in the unit temperature control panel. The inputs to the differential pressure transmitter shall be the static pressure inside of the duct and the reference input shall sense the actual space served by the air system located in the ceiling below the duct probe. The DDC system shall modulate the supply fan VFD to maintain the static pressure setpoint as sensed by the static pressure sensor. If multiple supply fans are used, the same speed signal shall be sent to all operating fans unless the fan is in start or stop mode as described above. If multiple sensing locations are shown, the DDC system shall maintain the static pressure setpoint at the lowest reading sensor. If the static sensors
deviate by more than 0.5 in. w.c. (adj.), an alarm shall be sent through the DDC system. Static pressure setpoint shall be as described in the Static Pressure Reset Control below.

Fan Static Pressure Setpoint Reset Control:
Static pressure setpoint shall be reset using true Trim & Respond logic within the range 0.3 in. w.c. (adj.) to 1.2 in. w.c. (adj.). When the fan is off, the setpoint shall be reset to 1 in. w.c. (adj.) and this setpoint shall be used on system start up. While the fan is on, every three minutes, (adj.) trim the setpoint by 0.04 in. w.c. downward if there are zero zone pressure requests. If there are more than one zone pressure requests, respond by increasing the setpoint upward by 0.06 in. w.c. If there is exactly one zone pressure request, the static pressure setpoint shall not be adjusted.

Each zone VAV shall produce a zone pressure request analog value of 0, 1 or 2. When the VAV damper is less than 90% (adj.) open the pressure request analog value shall be zero. If the VAV damper is greater than 90% (adj.) and less than the pressure request two setpoint, then the pressure request analog value shall be one. If the VAV Damper is greater than 99% open for 60 seconds (adj.) then the zone pressure request analog value shall be two. Zone pressure requests for each VAV zone associated with the AHU shall be summed in the supervisory controller.

Provide a binary data enable point for each zone to enable/disable the VAV damper in the trim and respond algorithm. All setpoints, timers, and zone pressure request threshold for the static pressure reset shall be adjustable. Tune the reset to prevent cyclic instability after the space is occupied. Provide a trend graph to show the relative stability of the static pressure setpoint. Final maximum setpoint shall be determined by the Balancing Contractor to satisfy the worst case zone at maximum design condition.

When indexing more than 10% of the air terminals to occupied to occupied and the static pressure setpoint is below the fan start static setpoint, reset the static pressure to the fan start setpoint and release to trim and respond control. This is to prevent slow system recovery on scheduled start-up.

Supply System High Static Pressure Control:
Install a static pressure probe located in the supply fan discharge or on a manifolded supply system, in the common supply plenum or ductwork and pipe to a differential pressure sensor located in the temperature control panel. This sensor shall override the speed signal to supply fan VFD to limit the static pressure to 3.5" w.c. (adj.) (this setpoint should be set to 0.5" w.c. less than the pressure class of the ductwork). Reference input for the differential pressure sensor shall be the temperature control panel. If this control is invoked, send a supply high pressure alarm to the DDC system.

VENTILATION AIR CONTROL:
Fixed Ventilation Air Flow Setpoint:
The AHU ventilation rate shall be maintained at 2030 CFM via DD-4. Ventilation and makeup air is supplied through the Dehumidification Unit (DD-4) for conditioning and then to AHU-19 inlet.

DD-4 bypass control shall be based on either manual override via DDC controller to bypass DD-4 while AHU-19 continues to operate. When Bypass Mode is initiated, bypass damper shall open, DD-4 shall turn off desiccant wheel and reactivation heat.

FILTERS:
Install a differential static pressure sensor across each filter bank. Ensure that the static probes do not impede filter removal.

For pre-filter bank, provide an alarm to the operator interface when the differential static pressure exceeds 0.6" W.C. (adj.).

For HEPA filter bank, provide an alarm to the operator interface when the differential static pressure exceeds 2.0" W.C. (adj.).

DISCHARGE AIR TEMPERATURE CONTROL:
Provide high accuracy space temperature sensors and modulate chilled water control valve to maintain discharge temperature necessary to maintain 68°F +/- 1.8°F (adj.) room temperature. As reheat coils associated with VAVs serving these spaces open, discharge temperature shall reset up to 68°F (adj.). As VAV reheat coil valves close and air flow increase, discharge temp shall reset down to 55°F (adj.).

Discharge Air Temperature Setpoint:
Discharge air temperature setpoint shall be 55°F (adj.).
SAFETIES:

General: All safeties shall be hard wired to the supply and return fan starters or VFD safety circuits. Starters shall not function in the “Hand” or “Auto” and VFD’s shall be disabled if they are indexed to the “Auto” or “Hand” position in either the VFD or bypass modes.

Freezestat:
Install an electric freezestat (refer to specification Section 23 09 14 for location) to shut down the unit (see Unit Shutdown for additional information) if the temperature downstream of the heating coil drops below 35°F (adj.). The electric freezestat shall act independently of the DDC system via hardwire interlock and shall override the DDC system control signal to open the heating coil control valve(s). A freezestat trip shall notify the DDC system that shall send an alarm to the operator interface.

Supply Fan High Pressure Limit:
Install a static pressure probe located in the air handling unit main discharge duct at least six feet or as far as physically possible downstream of the fan and upstream of any dampers and pipe to a differential pressure switch located in the temperature control panel. Wire in series with the safety circuit of the supply and return fan. Differential pressure switch shall be a manual reset type and the DDC system shall monitor the status of the differential pressure switch. Initial setpoint shall be +4.0” w.c. (adj.)

Return Low Pressure Limit:
Install a static pressure probe located in the return ductwork six feet or as far upstream as physically possible of the AHU and before any dampers and pipe to a differential pressure switch located in the temperature control panel. Wire in series with the safety circuit of the supply fans. Differential pressure switch shall be a manual reset type and the DDC system shall monitor the status of the differential pressure switch. Initial setpoint shall be -2.0” w.c. (adj.).

Fire Alarm Shutdown:
Upon a Fire Alarm System alarm, the fire alarm control module provided by the electrical contractor at the temperature control panel shall change state of its contacts. This shall cause the unit to be shut down (see Unit Shutdown for additional information) and all fire/smoke and smoke dampers within this system shall close immediately through a hardwire interlock. An auxiliary contact shall be provided to notify the DDC system of a fire alarm shutdown. Upon reset of the fire alarm system, the unit shall restart automatically without user intervention subject to any restart delays. See Section 28 31 00 for fire alarm system programming requirements for AHU’s.

SMOKE DAMPER INTERLOCK (HARDWARE TYPE):
Wire smoke damper end switches into the supply fan safety circuits so that the following selected smoke dampers are proven open before the supply fans are allowed to start. All smoke dampers on the AHU-19 system shall be hardwired to the fan safety circuits. All smoke damper end switches including smoke dampers that are hardwired and are not hardwired to the fan safety circuits shall be monitored individually by the DDC system.

Smoke dampers shall be commanded open on system startup and after a 2 minute delay to allow dampers to open the AHU shall be commanded to start. If the AHU supply fan fails to prove on after a delay of 5 minutes (adj.), the dampers shall be commanded closed again to prevent smoke migration and the AHU fans shall be latched off in software. Provide manual push-button switch located in this control panel and a software point to reset latch out of the unit. Smoke damper power shall be by the 23 09 14 temperature control contractor and shall have the smoke damper binary output relay contact wired in series a relay contact slaved from the fire alarm control module so that either signal shall cause the smoke dampers to close.

UNIT SHUTDOWN:
Whenever the air handling unit is indexed off, the supply fans shall stop. On a failure of the supply fan, an alarm shall be sent through the DDC system. Whenever supply fans are off for any reason the following shall occur:
- The associated Dehumidification Unit (DD-4) shall be off.
- The chilled water control valve(s) shall close.
- All fire/smoke dampers associated with the air handling system shall close.

DESICCANT DEHUMIDIFICATION UNIT CONTROL (DD-4)

The heating, cooling, and dehumidification systems serving B1118B (Krios), B1118C (Inner Prep Lab), and B1118D (Aquilos) are intended to maintain space conditions of 68°F +/- 1.8°F at <20% RH. DD-4,
AHU-19, room level VAV w/RHC and radiant cooling panels are all operating to maintain space conditions. DD-4 supplies constant makeup air to AHU-19 and units shall operate in unison.

Start/Stop/Interlock: The DDC system shall start/stop the dehumidifier any time AHU-19 is operating.

HUMIDITY CONTROL:
Humidity and Temperature sensors located in inlet to AHU-19, return duct and supply discharge shall monitor relative humidity and calculate return air supply air dewpoint temperature. DD-4 shall operate via integral packaged unit controller to maintain 260.7°F (adj.) supply air dewpoint temperature. When the return air humidity exceeds setpoint by 1°F (adj.), the controller shall enable call for dehumidification, open reactivation air outlet damper, and activate the reactivation fan, reactivation heater, desiccant rotor, and rotor face and bypass dampers.

Reactivation air heat, desiccant rotor revolution, and rotor face and bypass damper shall modulate heat input, rotor speed, and rotor bypass to maintain dewpoint setpoint. Face and bypass dampers shall serve as first stage of humidity control, when outdoor air/makeup air conditions meet dehumidification load. On increase in dewpoint above setpoint, the face and bypass damper shall modulate to 20% (adj.) open (through rotor), start reactivation fan, and modulate heater to minimum input. On continued increase in dewpoint beyond setpoint, face and bypass damper shall modulate open followed by modulation of rotor speed and speed to maintain setpoint. On drop in dewpoint below setpoint, the reverse shall occur.

Unit controls shall include modulating and staged heater controls to limit heater cycling and maintain dewpoint setpoint +/-1°F.

In the event of reactivation air sensor failure and continued call for dehumidification, controller shall initiate alarm condition, open face damper, and set heater output signal to 50%. In the event of reactivation air overheat condition, a high limit temperature switch shall turn reactivation heat off and signal alarm condition.

Reactivation air outlet damper shall prove open prior to start of reactivation fan. Damper shall fail open to allow dehumidification unit operation.

Integral Face and Bypass Heating Coil Control:
Install a heating coil discharge temperature sensor as far downstream of the heating coil as possible while still being upstream of the chilled water coil. The heating coil shall be controlled to maintain a heating coil discharge air temperature setpoint of 53°F (adj.). Heating control shall be locked out whenever outside air temperature is above 53°F (adj.). When outdoor air temperature is below 53°F (adj.), the heating coil control valve shall be modulated to maintain the discharge air temperature setpoint.

Pre-Cooling Coil Control:
Install a cooling coil discharge temperature sensor downstream of the cooling coil and upstream of desiccant wheel. The cooling coil shall be controlled to maintain a cooling coil discharge air temperature setpoint of 53°F (adj.). Cooling control shall be locked out whenever outside air temperature is below 53°F (adj.). When outdoor air temperature is above 53°F (adj.), the cooling coil control valve shall be modulated to maintain the discharge air temperature setpoint.

LAB EXHAUST FAN CONTROL (xEF-16, EF-17, EF-18)

GENERAL:
The exhaust system is a variable volume exhaust fan system.
The exhaust system is controlled by direct digital controller (DDC).
The ventilation system is equipped with the following:
Three exhaust fans with VFD’s
Isolation air dampers furnished by ATC. (Refer to specification 23 09 14)
Outside air bleed damper(s) furnished by ATC. (Refer to specification 23 09 14)
Damper actuators furnished by ATC. (Refer to specification 23 09 14)

FAN CONTROL:
Current Status Switch:
Provide for all exhaust fans and set up as described under GENERAL, Current Switch Setup, in this Section.

Start/Stop:
The DDC system shall start the exhaust fans via their VFD’s. A minimum of two exhaust fans shall operate and a third fan shall be a standby fan that shall only runs if required by a failure of one or more fans.

Lead Fan Selection:
There shall be two fans designated lead and one standby fan. Lead fan selection shall be based on rotational sequencing. Provide a single software point that shall designate the lead fans.

Shutdown Service Switch:
Provide a software point and hardware switch located inside the control panel for each fan to be taken out of service that shall initiate the shutdown sequence for the fan. If there is a standby fan that is available, it’s start sequence shall be initiated and come into control before the shutdown sequence for the fan being taken out of service is stopped.

Exhaust Fan Start/Stop Sequencing:
Sequence fans on based on exhaust fan flow and outside air bleed damper position in the order designated by the Lead Fan Selection sequence. If a fan has failed or has been designated “out of service” per the sequence below, the next fan in sequence shall initiate its start sequence without delay.

Minimum exhaust fan speed shall maintain minimum exhaust ejection velocity by maintaining a minimum flow of 5000 CFM (adj.). The DDC controller shall prevent the exhaust fan from falling below this minimum speed to prevent the ejection velocity from falling below design.

Minimum exhaust fan flow shall maintain minimum exhaust ejection velocity by maintaining a minimum flow of 5000 CFM as measured by the exhaust fan inlet air flow station.

When fan speed is at 95% or more for 15 minutes (adj.), start the next exhaust fan. All exhaust fans shall be controlled at the same speed. When the commanded fans speeds fall to minimum design exhaust flow for 15 minutes (adj.) and the outside air bleed damper is fully open, shut off a lag exhaust fan.

When starting a fan, command the fan to start and run at minimum speed set in the VFD. When fan status is proven on, command the isolation damper open and release the fan to control. If a fan status does not prove on or the isolation damper end switch does not prove open within 2 minutes (adj.) of the fan start or damper open commands, command the exhaust fan off and the isolation damper closed, latch out this exhaust fan, and send an exhaust fan failure alarm through the DDC system. Provide a manual push-button switch located in the control panel and a software point to reset the shutdown latch out of the fan.

When stopping a lag fan, command the damper to close and ramp the fan down to minimum speed at the same rate as the damper actuator stroke time (typically 90 seconds). After the fan is at minimum speed and the damper end switch indicates the damper is closed, command the fan off.

When switching lead fans and stopping a lag fan, prove operation of the new lead fan and allow 2 minutes (adj.) for the fan to come up to speed before initiating the stop fan sequence. Provide a software point for each fan to be taken out of service that shall initiate the shutdown sequence for the fan. If there is a lag fan that is available, the fan start sequence shall be initiated and come into control before the shutdown sequence for the fan being taken out of service is stopped.

The above sequences may need to be modified to prevent static pressure variances as specified General, Parallel Fan Bumpless Transfer sequence. This may entail adjusting minimum speeds and/or ramping dampers or fans at different rates than specified above.

STATIC PRESSURE CONTROL:
Exhaust Fan Speed Control:
The purpose of the exhaust fan control is to maintain a minimum static pressure in the exhaust ductwork to insure proper terminal air box operation. Install a static pressure sensing probe(s) in the main exhaust duct located at approximately ¾ of the way down the main exhaust duct or as shown on the plans and the reference input shall sense the actual space served by the air system located in the ceiling below the duct probe. Pipe to the differential pressure transmitter that shall be located in the unit temperature control panel. The DDC system shall modulate the exhaust fan VFD’s and outside air bleed dampers in sequence to maintain the static pressure setpoint as sensed by the static pressure probe(s). As exhaust airflow requirements decrease and the static pressure becomes more negative than setpoint, decrease the exhaust fans VFD speed signals simultaneously and in parallel to maintain the static pressure setpoint until the minimum fan flow setpoint is reached. If the static pressure continues to fall, modulate open the outside air bleed dampers (in parallel, if more than one) to maintain the static pressure setpoint. If static pressure
continues to fall below setpoint, stage off a lag exhaust fan as described in the Exhaust Fan Start/Stop
Sequencing.

As exhaust airflow requirements increase and duct static pressure becomes less negative than setpoint, the
fans shall continue to operate at their minimum fan flow setpoints, and the outside air bleed dampers shall
be modulated closed to maintain duct static setpoint. When the outside air bleed dampers are fully closed,
the exhaust fans shall then be modulated up in speed to maintain static.

If multiple sensing locations are shown, the DDC system shall maintain the static pressure setpoint at the
lowest reading sensor. If the static sensors deviate by more than 0.5 in. w.c. (adj.), an alarm shall be sent
through the DDC system. Static pressure setpoint shall be as described in the Static Pressure Setpoint
Control below.

Fan Static Pressure Setpoint Reset Control:
Static pressure setpoint shall be reset using true Trim & Respond logic within the range of negative 0.6 in
w.c. (adj.) to 1.3 in w.c. (adj.). When the fan is off, the setpoint shall be reset to 1.0 in. w.c. (adj.) and this
setpoint shall be used on system start up. While the fan is proven on, every three minutes, (adj.) trim the
setpoint by 0.04 in. w.c. downward if there are zero zone pressure requests. If there are more than one zone
pressure requests, respond by increasing the setpoint upward by 0.06 in. w.c. If there is exactly one zone
pressure request, the static pressure setpoint shall not be adjusted.

Each zone VAV shall produce a zone pressure request analog value of 0, 1 or 2. When the VAV damper is
less than 90% (adj.) open the pressure request analog value shall be zero. If the VAV damper is greater
than 90% (adj.) and less than the pressure request two setpoint, then the pressure request analog value shall
be one. If the VAV Damper is greater than 99% open for 60 seconds (adj.) then the zone pressure request
analog value shall be two. Zone pressure requests for each VAV zone associated with the AHU shall be
summed in the supervisory controller.

Provide a binary data enable point for each zone to enable/disable the VAV damper in the trim and respond
algorithm. All setpoints, timers, and zone pressure request threshold for the static pressure reset shall be
adjustable. Tune the reset to prevent cyclic instability after the space is occupied. Provide a trend graph to
show the relative stability of the static pressure setpoint. Final maximum setpoint shall be determined by
the Balancing Contractor to satisfy the worst case zone at maximum design condition.

Exhaust System Low Pressure Limit:
Install a static pressure probe located in the exhaust fan plenum or common exhaust ductwork and pipe to a
differential pressure switch located in the temperature control panel. Wire in series with the safety circuit
of the exhaust fans VFD’s. Differential pressure switch shall be a manual reset type and the DDC system
shall monitor the status of the differential pressure switch. Initial setpoint shall be -negative 4.0” w.c. (adj.)
(this setpoint should be set to two inches more negative than the pressure class of the ductwork).

FUNCTIONAL PERFORMANCE TESTING
Contractor is responsible for utilizing the functional performance test forms supplied under specification
Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section
01 91 01.

END OF SECTION
SECTION 23 73 13
INDOOR CENTRAL-STATION AIR-HANDLING UNITS
BASED ON DFD MASTER SPECIFICATION DATED 06/02/2015

PART 1 - GENERAL

SCOPE
This section includes specifications for indoor central station package air handling units. Included are the following topics:

PART 1 - GENERAL
Scope
Related Work
Reference
Reference Standards
Quality Assurance
Submittals
Operation and Maintenance Data
Design Criteria

PART 2 - PRODUCTS
Manufacturers
Casing
Access Doors
Electrical and Lights
Fan Sections
Fan Inlet Air Flow Stations
Coil Sections
Filter Sections
Access Sections
Filter/Mixing Box Sections

PART 3 - EXECUTION
Installation
Leakage Test
Construction Verification
Functional Performance Testing
Agency Training
Leakage Test Report

RELATED WORK
Section 01 91 01 – Commissioning Process
Section 23 05 13 - Common Motor Requirements for HVAC Equipment
Section 23 05 14 - Variable Frequency Drives
Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
Section 23 08 00 – Commissioning of HVAC
Section 23 31 00 – HVAC Ducts and Casings
Section 23 41 00 - Particulate Air Filtration
Section 23 33 00 - Air Duct Accessories
Section 23 34 00 – HVAC Fans
Section 23 73 12 - Air Handling Unit Coils

REFERENCE
Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS
ARI 430 (latest edition) Standard for Central Station Air Handling Units
NFPA 90A Standard for Installation of Air Conditioning and Ventilation Systems

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

SUBMITTALS
Refer to division 1, General Conditions, Submittals
Submit shop drawings including the following information: specific manufacturer and model numbers, submittal equipment identification corresponding to project drawings and schedules, unit dimensional and weight data, materials of construction, capacities and ratings, fan curves, fan type, drive and motor information, vibration isolation, coil performance data, sound power levels, filter information, information for all accessories.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA
Furnish factory fabricated indoor air handling units meeting the configuration shown on drawings and/or as scheduled. Unit dimensions for factory splits or breakdown sections shall allow unit to be installed through existing Penthouse access doors (36”w x 84” h).

Units to be tested, rated and certified in accordance with ARI Standard 430 and bear ARI certification label. All material shall meet NFPA 90A flame spread and smoke develop rating requirements. Any revisions made by the Contractor to the inlet and outlet ductwork conditions from that shown on the drawings shall not increase system effect and/or static pressure and shall not decrease mixing efficiencies.

DELIVERY, STORAGE, AND HANDLING
Provide protective coverings for all openings during shipping. Loose shipped items must be contained within factory provided protective coverings, with factory installed shipping skids and lifting lugs. Store the unit in a clean dry place and protect from weather and construction traffic.

WARRANTY
Provide a manufacturer’s parts and labor warranty against factory defects in material and workmanship for the entire unit for a period of 1 year after startup.

PART 2 - PRODUCTS

MANUFACTURERS
Carrier, Daikin, Trane, York, Ventrol

CASING

WALL/ROOF CONSTRUCTION
Construct walls and roof from 2” thick double wall panel assemblies. Panels shall be injected with polyurethane foam insulation and shall have a minimum thermal conductivity (R) of at least 12.5. The outer shell shall be constructed of solid G90 galvanized steel with baked enamel or mill galvanized finish or G40 galvanized steel with gardobond finish. The inner liner shall be constructed of solid G90 galvanized steel or G40 galvanized steel with gardobond finish. Panels shall be gasketed with permanently applied bulb-type gaskets and able to be removed without affecting the integrity of casing structure.

Casing joints and seams shall be thermally broken. Under 55°F supply air temperature and design conditions on the exterior of the unit of 91°F dry bulb and 74°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying or replacing units should external condensate form on them.

Wall/Roof panel deflection shall not exceed L/240 ratio at a maximum +/- 8 inches of static pressure. Deflection shall be measured at the midpoint of the panel.

FLOOR CONSTRUCTION
Construct floors from 2” thick double wall panel assemblies. Panels shall be injected with polyurethane foam insulation and shall have a minimum thermal conductivity (R) of at least 12.5. The outer shell shall be
constructed of solid G90 galvanized steel with baked enamel or mill galvanized finish or G40 galvanized steel with gardobond finish. The inner liner shall be constructed of solid G90 galvanized steel or G40 galvanized steel with gardobond finish. Panels shall be gasketed with permanently applied bulb-type gaskets.

Under 55°F supply air temperature and design conditions on the exterior of the unit of 91°F dry bulb and 74°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying or replacing units should external condensate form on them.

Floor panel deflection shall not exceed L/240 ratio based upon a 300 lb concentrated load at the mid-span of the panel.

A full perimeter base rail shall be installed at each air handling unit. The base rail shall be constructed from a minimum of 16 gauge G90 galvanized steel and shall at a minimum, accommodate necessary cooling coil drain trap height requirements (Refer to Equipment Schedules and drawings for rail height requirements and trap details). Panels shall be able to be removed without affecting the integrity of casing structure.

**LEAKAGE RATE**
Leakage rate shall not exceed 0.5 CFM/ft² of casing surface area when subjected to +/- 5” static pressure.

**CASING PENETRATIONS**
Install sealing collars to the interior and exterior of each penetration to prevent air leakage where coil piping, humidifier piping, air vents, drain piping, and electrical conduits penetrate air handling unit casing. Silicone sealants and duct sealants are not acceptable to seal pipe penetrations of the air handling unit casing.

Duct sealant and/or gaskets as indicated in specification section 23 31 00 may be utilized to seal duct connections to the air handling unit casing. Silicone sealants are not acceptable.

**ACCESS DOORS**
Access doors shall be double wall, of same construction and thickness as casing, hinged, continuously gasketed with bulb type gaskets, reinforced nylon handles with cam type latches, and inspection windows. Door swing shall open in direction against pressure of the section. If not possible, safety chains or secondary latches shall be provided along with labels indicating that the access door opens with the pressure of the unit/section. Provide access doors on both sides of casing for fan sections, access sections, air to air energy recovery sections, filter sections, damper sections, air blender sections and upstream and downstream of every coil and humidifier.

**ELECTRICAL AND LIGHTS**
Provide a marine grade light and GFI receptacle in all fan sections and marine grade light in all access sections on units above 10,000 CFM as well as a switch located on the exterior of the fan section to control the lights.

Provide a GFI receptacle on either side of the exterior of the air handling unit where the air handling unit is less than 10'-0" in length. Provide two GFI receptacles spaced at least 5'-0" apart on either side of the exterior of the air handling unit where the air handling unit exceeds 10'-0" in length.

All lights and receptacles shall be wired from the factory to a separate junction box located on the exterior of the air handling unit. The lights and receptacles must remain on if the air handling unit fan’s disconnects are switched off.

**FAN SECTIONS**
Double width, double inlet, housed centrifugal type or single width single inlet plenum type, statically and dynamically balanced fans. For variable speed applications, fan shall be dynamically balanced through entire range of operation. Fan wheels shall be backward inclined, forward curved or airfoil type as specified or required by performance characteristics.

Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. The motor furnished with the fan shall not operate into the motor service factor when operating under these conditions.

Fans to be fastened to hollow or solid steel shafts and designed for continuous operation at maximum rated static pressure.
Fan bearings shall be self-aligning, pillow block, regreasable ball type selected for a minimum average $L_{50}$ life of 200,000 hours.

Furnish extended grease lines from bearings to allow servicing without entering the unit. Grease lines can be terminated within the unit as long as they are able to be easily serviced by opening the access door.

Furnish variable pitch sheaves for drives 3 hp and smaller, fixed pitch sheaves for drives 5 hp and larger. Drives shall be designed for 150% of motor rating. Furnish OSHA approved belt guards for all fans.

Consider drive efficiency in motor selection according to manufacturer's published recommendation or according to AMCA Publication 203, Appendix L.

Furnish a metal access guard at the access door of all plenum fan sections. A wheel guard may be substituted if a metal access guard is not available from the manufacturer.

Fan, drive and motor assembly shall be mounted inside fan casing section and integrally isolated within unit. Vibration isolation shall be in compliance with section 23 05 48. Provide flexible connection and thrust restraints at fan discharge connection to casing.

Furnish galvanized mesh inlet screens for fans without inlet ductwork connections.

Furnish a label inside the fan section that identifies the specifications of the v-belt drive kit. Include motor sheave, drive sheave and belt data.

Fan motors shall be provided in accordance with section 23 05 13.

**FAN INLET AIR FLOW STATIONS**

Provide a piezometer ring air flow station mounted on the fan inlet bell housing. Pressure tubes from the piezometer ring shall be extended to a termination plate labeled with the high- and low-pressure connections. Provide an initial flow rate coefficient that will be adjusted by the balancing contractor for measured flow reading. Piezometer ring air flow station shall measure static pressure drop through the fan inlet cone to provide an overall air flow measurement to within +/- 5% accuracy. In lieu of a piezometer ring air flow station, a fan inlet probe air flow stations as specified under Section 23 09 14 may be furnished and factory mounted in the fan inlet. Differential pressure transducers for measuring the velocity pressure for air flow measurement shall be supplied under Section 23 09 14 and be mounted in the temperature control panel.

**COIL SECTIONS**

Coils shall be provided in accordance with section 23 73 12.

Air handling unit coils mounted in casing shall be accessible for removal from either side of unit casing without disturbing adjacent sections.

Entire coil frame, headers and U-bends shall be enclosed within air handling unit casing. Interior piping and equipment installation shall be complete. Piping shall be installed and tested per appropriate specification sections. Extend coil piping connections, air vent and drain connections to exterior of casing. Refer to drawing details for coil piping requirements and including air vent and drain requirements. Unit manufacturer shall be responsible for any leaks which occur in unit during system testing which occurs before system startup.

Support coils along entire length within casing and pitch coil for proper drainage.

Blank off space between coil frames and air handling unit casing.

Fabricate cooling coil drain pans from type 304 stainless steel. Install a drain pan under each cooling coil. Extend drain pans the entire width of each coil, including the header, and from the upstream face of each coil to a distance ½ of the vertical coil height of the bottom coil or 6", whichever is greater, downstream from the downstream face. Pitch drain pans in two directions towards the outlet. Pipe drain pans individually down to the drain pan below using a minimum 1” type 304 stainless steel piping. The bottom drain pan shall be piped to the exterior of the unit base using a minimum of 1.25” type 304 stainless steel piping.

**FILTER SECTIONS**

Provided and installed by the air handling unit manufacturer in accordance with specification section 23 41 00.
Construct frames of type 304 or 316 stainless steel with provisions for assembly in a bank.

Filters shall be accessible from the front of the filter rack. Frames for HEPA filters to have provisions for installation of MERV 8 prefilters upstream of high efficiency media. Secure prefilters by means of spring clips or a spring loaded mechanism. Spring clips or latches shall be on the upstream side of the prefilter. Provide leak-proof gaskets between prefilter media and holding frame. Prefilters shall be removable without removal of final filters.

Provide static pressure tips that are arranged to prevent damage to the filter elements during replacement. Provide minimum 2” gap between final and prefilters for static pressure probes.

ACCESS SECTIONS
Provide access sections where shown on drawings.

PART 3 - EXECUTION

INSTALLATION
Install all air handling units and accessories as indicated on drawings and/or as scheduled and according to manufacturer’s installation instructions.

Contractor shall verify unit split dimensions allow installation through existing access doors to the Penthouse.

Mount units at appropriate height above floor to insure proper condensate trap depth and condensate drainage. Install air-handling unit to provide for adequate service access. Coordinate with other trades to assure air handling unit does not infringe upon access or service clearances of other equipment.

Lubricate fan bearings. Verify fan isolators have proper deflection.

Upon completion of installation of air handling units, start-up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning components, then retest to demonstrate compliance.

Furnish one spare set of fan drive belts and three reinforced nylon access door handles.

LEAKAGE TEST
Field test all modular air handling units.

Seal all openings and dampers at the air handling unit to the pressure class listed below before performing the test. A minimal amount of ductwork may be connected to the air handling unit in order to seal off large openings. The ductwork must meet or exceed the larger of the ductwork pressure class or the air handling unit pressure requirement.

Test draw through air handling units at -5” static pressure. The contractor and/or the unit manufacturer may brace the access doors in positive sections of the air handling unit to meet the testing requirements.

If excessive air leakage is found locate leaks, repair in the area of the leak, seal, and retest.

Leakage rate shall not exceed more that 1% of the total system air quantity when subjected to +/- 5” static pressure.

Submit a signed report to the Division’s Construction Representative, indicating test apparatus used, results of the leakage test, and any remedial work required to bring modular air handling units into compliance with specified leakage rates.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING
Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.
AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 019101.

END OF SECTION
# MODULAR INDOOR CENTRAL-STATION AIR HANDLING UNIT LEAKAGE TEST REPORT

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