INVITATION FOR BIDS: CCK-2392-19
RESEARCH BUILDING #2 – PHASE 2:
Bid Package 01 – Design Release 1 – Fit-Out
Project #2499.0
ADDENDUM # 08 REBID 23B
March 28, 2019

ATTENTION: This is not an order. Read all instructions, terms and conditions carefully.

IMPORTANT:
BID AND ADDENDUM MUST BE RECEIVED BY:
WC 23B Bid Date is 04/04/2019 @ 3:00 P.M. LEXINGTON, KY TIME.

Bidder must acknowledge receipt of this and any addendum as stated in the Invitation for Bids.

Bidders shall conform to the following clarifications, corrections and changes, as same shall become binding on the Contract to be issued in response to this Invitation for Bids. Bidders must acknowledge receipt of this Addendum in the space provided on the Form of Proposal. Failure to do so may subject Bidder to disqualification.

1. Clarification to Subcontract Work Categories 23B:
2. Questions/Answers submitted for WC23B will be answered via future addenda.

OFFICIAL APPROVAL
UNIVERSITY OF KENTUCKY

Mike Mudd / (859) 257-5409

Typed or Printed Name

Attachments:
1. Addenda #08 Drawings

End of Addendum #08

University of Kentucky
Purchasing Division
322 Peterson Service Building
Lexington, KY 40506-0005

Page 1 of 1

An Equal Opportunity University
<table>
<thead>
<tr>
<th>NO.</th>
<th>Question</th>
<th>Responder</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Addendum #5 provides a responsibility matrix. Regarding the Aircuity matrix and controllers, is there one Aircuity controller per supply air valve?</td>
<td>AEI</td>
<td>Refer to Plans for Quantities on MF-550.</td>
</tr>
<tr>
<td>2</td>
<td>How are the terminal units shown on the mechanical schedules that do not reference a sequence to be operated? No detail provided for those.</td>
<td>AEI</td>
<td>Sequences will be assigned to the remainder of VSV/VEV’s on the Addendum 8 schedules.</td>
</tr>
<tr>
<td>3</td>
<td>Mechanical schedule sheet MF-951 references a Sequence M for (5) VSV units and (7) VEV Units. Unable to locate a detail drawing referencing this sequence. Please provide drawing. Please provide responsible party for this sequence. Not listed in the matrix on MC-950 or IC-950.</td>
<td>AEI</td>
<td>M will be replaced with appropriate sequences on Addendum 8</td>
</tr>
<tr>
<td>4</td>
<td>Control sequence details for Sequences C, F, G, N and Q are provided but there are no terminal units shown on the mechanical schedules for these sequences. Are we to assume there are no terminal units in this phase for these sequences? If there are units with these sequences required, please provide updated schedule.</td>
<td>AEI</td>
<td>If no terminal unit is assigned the sequence it is not required.</td>
</tr>
<tr>
<td>5</td>
<td>The controls contractor is to provide control panels for housing Air Valve Controllers for sequences H, I, J, K &amp; l; please provide submittals for the air valve controllers that are being supplied by the owner.</td>
<td>UK</td>
<td>These will be issued once the Design team has reviewed and approved.</td>
</tr>
<tr>
<td>6</td>
<td>The controls contractor is to provide wiring to Building Level Controllers for sequences H, I, J, K &amp; l; please provide submittals for those controllers that are being supplied by the owner.</td>
<td>UK</td>
<td>These will be issued once the Design team has reviewed and approved.</td>
</tr>
<tr>
<td>7</td>
<td>For the Phoenix Control System, will one controller be provided by Phoenix for integration to BAS via BACnet MS/TP?</td>
<td>AEI</td>
<td>Per IC-550, the Phoenix Building Level Controller Provided will connect to Tridium Via IP connection (Ethernet Cable).</td>
</tr>
<tr>
<td>8</td>
<td>Please provide submittals for all Aircuity equipment (controllers, sensors, etc.) being provided by the owner.</td>
<td>UK</td>
<td>These will be issued once the Design team has reviewed and approved.</td>
</tr>
<tr>
<td>9</td>
<td>Please provide submittals for all Aircuity Building Level Controllers being provided by the owner.</td>
<td>UK</td>
<td>These will be issued once the Design team has reviewed and approved.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>10</td>
<td>Please verify the controls electrical subcontractor is to obtain 120VAC power at a breaker panel for power to transformers.</td>
<td>WT</td>
<td>WC 26A will run the power from the existing panelboard to a new box adjacent to the controller’s transformer. WC 23B shall make the terminations from this power source to the transformers and or controllers being supplied by WC 23B.</td>
</tr>
<tr>
<td>11</td>
<td>Monitoring meters – please confirm if there are any meters in this phase which require monitoring. Unable to locate points etc. in supplied documentation.</td>
<td>AEI</td>
<td>Per the drawings, no water flow meters monitoring is required.</td>
</tr>
<tr>
<td>12</td>
<td>Clarification on Freezestats: Specification section 23 0903-3 C.1 references Electric 2 position type with temperature sensing element and manual reset. Specification section 23 0903-3 D.1 references Electric 2 position type with temperature sensing element and automatic reset. Which type is to be used on Air Handling Units?</td>
<td>AEI</td>
<td>Freezestat types should have a manual reset.</td>
</tr>
<tr>
<td></td>
<td>RFI 1. System Air Volume Control (for variable volume AHUs with static pressure transmitters) References: 230993 3.1.J.4 230993 3.1.H.1</td>
<td>AEI</td>
<td>The AHUs in this sequence serve a common duct. Tridium will average the pressure signals for the fan control of the AHUs. 230993-3.1-H-1 Intent is that signal sharing is not allowed over the MSTP network. Per the sequence in 230993-3.1-J-4 addendum #1 “Upon loss of Tridium static pressure average, each AHU shall control to static pressure sensor wired to individual AHU controller.” It is the intent to hardwire the pressure sensors to each AHU controller as specified in 230993.</td>
</tr>
<tr>
<td>13</td>
<td>RFI 2. Konvekta Communication References: 230993 3.3.B</td>
<td>AEI</td>
<td>1. This scope has been clarified in PCO 363 of Phase 1. Any communication to Konvekta in phase 2 will hardwired. No communication through</td>
</tr>
</tbody>
</table>
Description
During sequence testing and evaluation the importance of the Konvekta communication with the AHUs was essential (if signal is lost from Konvekta, the AHUs shutdown, or risk sending the spaces into a negative pressure state). While conducting a post CX troubleshooting meeting of RB2 Phase 1, in a meeting with UK, AEI, JCI, and Konvekta, it was decided by UK that the communication of Konvekta to AHUs and EAHUs served should not go across the UK Campus IT network. This decision led to the change the communication protocol from BACnet IP to BACnet MSTP under addendum 4.

Clarification Request:
1) The intent of having a MSTP communication protocol for Konvecta is unclear. Please clarify if the Konvekta MSTP communication does need to be on the same trunk as AHU-1, 2, 3, 4, 5, 6, 7, 8, and the EAHUs, or if the Konvekta system can be on any MSTP trunk and the data shared across the network as is currently being done.

1. The phase 2 contractor will be responsible for reprogramming the impacted Phase 1 AHU & EAHU controls.

Controls contractor for phase 1 is responsible for the phase 1 warranty. Controls contractor for phase 2 is responsible for the phase 2 warranty.
Clarification Request:
1) Will the controls contractor, that is awarded this contract, be responsible all work related to reprogramming the impacted Phase 1 AHUs and EAHUs?

2) Will the controls contractor, that is awarded this contract, be required to assume the remainder of the UK RB2 Phase 1 controls warranty or provide an additional warranty in accordance with this contracts warranty requirements on any of the equipment or controls of modified Phase 1 work?

<table>
<thead>
<tr>
<th>RFI 4. Konvekta Interlocking</th>
<th>Konvekta, AHU 1-8 and the EAHU shall be on a common MSTP trunk.</th>
</tr>
</thead>
<tbody>
<tr>
<td>References: 230993 3.3.C</td>
<td></td>
</tr>
<tr>
<td>C. Interlocking:</td>
<td></td>
</tr>
<tr>
<td>1. Energy Recovery System shall be interlocked with the following:</td>
<td></td>
</tr>
<tr>
<td>a. Interlock with each AHU and EAHU associated with the e shutdown.</td>
<td></td>
</tr>
<tr>
<td>b. Each AHU (AHU-1 thru 8) via BAS BACnet MSTP control following:</td>
<td></td>
</tr>
<tr>
<td>1). Supply air flow</td>
<td></td>
</tr>
<tr>
<td>2). Outside air temperature</td>
<td></td>
</tr>
<tr>
<td>3). Supply air temperature setpoint</td>
<td></td>
</tr>
<tr>
<td>4). Supply air temperature</td>
<td></td>
</tr>
<tr>
<td>5). Glycol water supply temperature</td>
<td></td>
</tr>
</tbody>
</table>

Description
SOO section 3.3.C indicates that Konvekta, AHU-1 thru 8, and the EAHUs are required to be installed on a common MSTP trunk to ensure that imperative data is not lost or delayed by being passed across the UK IT infrastructure.

Clarification Request:
1) Please confirm that the intent is to have the Konvekta system, AHU-1 thru 8, and the EAHU on a common MSTP trunk.

<table>
<thead>
<tr>
<th>RFI 5. Vivarium AHU System</th>
<th>1. Refer to addendum #5. Each unit shall have its own controller.</th>
</tr>
</thead>
<tbody>
<tr>
<td>References: 230923 3.2.B</td>
<td>2. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium.</td>
</tr>
<tr>
<td>B. Control software algorithm and inputs and outputs for each AHU reside on a single controller and shall not be distributed pieces of equipment to be interlocked, a single 'M' interlocked pieces of equipment, i.e. an AHU and interlock.</td>
<td>3. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium. Refer to addendum #8 for new hardwired interlocks for AHU fan speed control.</td>
</tr>
<tr>
<td>230993 3.5</td>
<td></td>
</tr>
<tr>
<td>3.5  VIVARIUM AHU-7 &amp; 8 (5&amp;6 EXISTING) - CONTROL SYSTEM</td>
<td></td>
</tr>
<tr>
<td>A. System Description:</td>
<td></td>
</tr>
<tr>
<td>1. Refer to drawings IC-750.</td>
<td></td>
</tr>
<tr>
<td>2. System</td>
<td></td>
</tr>
<tr>
<td>a. Air handling units operate in parallel between vivarium space, AHU-7 and AHU-8.</td>
<td></td>
</tr>
<tr>
<td>b. Each unit is 100% outside air unit with room humidification, single duct, variable volume.</td>
<td></td>
</tr>
<tr>
<td>c. Units are sized so that one of the three vivarium spaces at 100% design air flow to a unit at a time.</td>
<td></td>
</tr>
</tbody>
</table>

Description
The UK BAS specification 3.2.B sets the standard that
“all inputs and outputs for a single **SYSTEM** shall reside on a single controller”. SOO section 3.5 clearly identifies AHU-5, 6, 7, & 8 as a **SYSTEM** that operate together to serve a common duct and the associated spaces.

Clarification Request:
1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent of this spec that all the AHUs will be on a single field controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?

2) AHUs 5 and 6 are not currently programmed to “Lead-lag-lag-Standby”. Will the reprogramming of AHU5 and 6 be required to accommodate the new sequence be executed by this controls contractor under this contract?

3) Is there a process for staging up and down AHUs in the system to accommodate the “Lead-Lag-Lag-Standby” Controls? For example If two AHU VFDs are at greater than 90% for 10 minutes, a third AHU should be brought online, or if One AHU us unable to meet the AVG Static pressure setpoint for 15 minutes then the 1st Lag AHU should ramp up to control with the lead AHU.

RFI 6. Vivarium Interlocking References: 230923 3.2.B

B. Control software algorithm and inputs and outputs for pieces of equipment are to be **interlocked**, a single “M” interlocked pieces of equipment, i.e. an AHU and interlocked.

<table>
<thead>
<tr>
<th>AEI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Refer to addendum #5. Each unit shall have its own controller.</td>
</tr>
<tr>
<td>2. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium.</td>
</tr>
<tr>
<td>3. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium. Refer to addendum #8 for new hardwired interlocks for AHU fan speed control.</td>
</tr>
</tbody>
</table>
Bidders Questions

Addendum #2

Description

The UK BAS specification 3.2.B sets the standard that “if multiple pieces of equipment are to be INTERLOCKED, a single master controller shall provide control for all pieces of equipment”. SOO section 3.5 clearly identifies AHU-5, 6, 7, 8, EAHUs, dampers, etc. are to be INTERLOCKED.

Clarification Request:

1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent of this spec that all the AHUs and EAHUs will be on a single field controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?

RFI 7. Vivarium Volume Control

References: 230993 3.5.F

AEI

Refer to specification 230993-3.5-F, sensors have been provided in phase 1 thus are existing. Per the specification sensors are to be wired in Phase 2.
Description
SOO Section 3.5.F indicates that there are existing pressure transmitters that have already been installed for hardwire static pressure on AHU 7 and 8.

Clarification Request:
1) Please confirm that these static pressure sensors exist, and do not have to be provided or installed by this contractor.

RFI 8. Lab AHU System
References: 230923 3.2.B

A. Control software algorithm and inputs and outputs for reside on a single controller and shall not be distributed. All pieces of equipment are to be interlocked, a single “Master Controller” of all interlocked pieces of equipment, i.e. an AHU and interlock.

230993 3.6

3.6 LAB AIR HANDLING UNIT AHU-2 & 4 (1 & 3 EXISTING)

A. System Description:
1. Refer to drawing IC-751.
2. Each unit is 100% outside air unit with run-around cooling.
3. Units are sized so that 4 air handling units can serve air flow.
4. Air handling unit consists of:
   a. Supply fan array with backdraft damper on each
   b. Two VFDs for supply fan array. One VFD is for a.
   c. Chilled water cooling coil
   d. Energy Recovery water heating/cooling coil
   e. Pre-filter
   f. Final-filter
   g. Bipolar Ionization
   h. Outside air damper
   i. Supply smoke/isolation air damper

Description
The UK BAS specification 3.2.B sets the standard that “all inputs and outputs for a single SYSTEM shall reside on a single controller”. SOO section 3.6 identifies AHU-1, 2, 3, 4 as a SYSTEM that are sized so that 4 AHU work together to serve the associated spaces.

Clarification Request:
1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent of this spec that all the AHUs will be on a single field
controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?

**RFI 9. Lab Interlocking**

References: 230923 3.2.B

B. Control software algorithm and inputs and outputs for reside on a single controller and shall not be distributed pieces of equipment are to be **interlocked**, a single “MASTER” interlocked pieces of equipment, i.e. an AHU and Interlock: 230993 3.5

1. Whenever an AHU stops, all AHU supply fans on isolation damper shall close and be proven closed.
2. Energy Recovery system shall prove operationally indicated by BAS signal from Energy Recovery System. There shall be an optional override at the Energy Recovery System enabled.
3. Exhaust air handling unit (AHU-1, 2 and 3) fans shut on exhaust fans prior to enabling supply air system. There shall be an optional override at the BAS EAHU enabled.
4. Refer to Energy Recovery System Control Sequence hardwired sensors.

Description

The UK BAS specification 3.2.B sets the standard that “if multiple pieces of equipment are to be **INTERLOCKED**, a single master controller shall provide control for all pieces of equipment”. SOO section 3.5 clearly identifies AHU-1, 2, 3, 4, EAHUs, dampers, etc. are to be **INTERLOCKED**.

Clarification Request:

1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent of this spec that all the AHUs and EAHUs will be on a single field controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?

2) SOO 3.6 indicated that this is a system of 4 AHUs (See RFI 8) SOO 3.5.B.1 indicates that, whenever an AHU stops, the other AHUs shall stop. Please confirm, for example; AHU-1 fails due to low temp cutout, and are then to command AHU-2, 3 & 4 to stop.

3) Is the contractor, which is awarded this contract, responsible for reprogramming the 2 existing (Phase 1) AHUs to react to the addition of this equipment as defined SOO 3.5 and elsewhere?

---

**RFI 10. Lab AHU Unit Operation**

References: MF-552 230990 3.6.A.3

AEI

1. Refer to addendum #5. Each unit shall have its own controller.
2. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium.
3. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium. Refer to addendum #8 for new hardwired interlocks for AHU fan speed control which will be the reasonability of the phase 2 contractor.

---

22

21
### Description

MF-552 shows that AHU1&2 and AHU3&4 share common ducts respectively. SOO 3.6.4.3 indicates that the 4 units operate as a system. SOO 3.6.C says that “all units shall start and ramp together. All units shall receive a static pressure setpoint from Tridium for fan control”. Tridium sending a setpoint for fan control is not unusual and may have actually intended to indicate that Tridium should send the AHUs a avg static pressure.

Clarification Request:

1. Please confirm the intent of specifically indicating that the static pressure setpoint will be received from tridium.

2. Currently AHU1 & three control from a Tridium setpoint to their lowest static pressure sensor respectively. Should all the AHUs in the system control the VFDs based on the low select of any static pressure sensor in the common duct?

### RFI 11. Lab AHU Unit Operation

**References:** 230993 3.6.F

**F. System Air Volume Control**

1. Each AHU shall have its own hardwired discharge static pressure sensor located where the ducts first converge into a single duct. Wire to existing:
   a. (5) sensors for AHU-3/4

**Description**

SOO 3.6.F.1.a.1 indicates that there are 5 existing duct static pressure sensors that are currently installed and wired to the controller for AHU-3.

Clarification Request:

1. Please confirm that you want these to remain wired to AHU-3, but also wired to AHU-4.

2. Please provide a wiring diagram that indicates how you would like us to wire 2 controllers to one sensor.

### AEI

1. 5 sensors are existing and wired to AHU-3, one of these existing sensors shall disconnected from AHU-3 and wired to AHU-4. The signal from the sensor shall not be split.
RFI 12. Exhaust energy recovery unit interlocking
References: 230923 3.2.B
B. Control software algorithm and inputs and outputs for
   reside on a single controller and shall not be distributed
   pieces of equipment are to be interlocked, a single “M
   interlocked pieces of equipment, i.e. an AHU and inte
230993 3.7.B
B. Interlocking:
1. EAHU-1 is interlocked with the following units:
   a. AHU-1
   b. AHU-2
   c. EF-1A thru 1D
   d. North side of the building exhaust and fume hood
   e. HBP-2
2. EAHU-2 is interlocked with the following units:
   a. AHU-3
   b. AHU-4
   c. EF-2A thru 2D
   d. South exhaust ducts and fume hoods for all floor
   e. HBP-2
3. EAHU-3 is interlocked with the following units:
   a. AHU-1
   b. AHU-2
   c. EF-3A thru 3D
   d. HBP-3
4. EAHU-4 is interlocked with the following units:
   a. AHU-5 (Existing)
   b. AHU-6 (Existing)
   c. AHU-7
   d. AHU-8

Description
The UK BAS specification 3.2.B sets the standard that “if
   INTERLOCKED, a single master controller shall
   provide control for all pieces of equipment”. SOO
   section 3.7.B clearly identifies AHU-1 thru 8, EAHU,
   dampers, etc. are to be INTERLOCKED.

Clarification Request:
1) Please clarify what is required by BAS spec 3.2.B in
   regards to a “Master Controller”. Is the intent of this
   spec that all the AHUs and EAHU will be on a
   single field controller, or does it simply prevent the
   reliance on the UK IT infrastructure by requiring all
   of the field controllers in a “SYSTEM” be installed
   on the same MSTP trunk (utilizing a Master
   Supervisory controller)?

2) Please confirm the contractor, that is awarded this
   contract, is responsible for all programming and
   modifications to the existing EAHU controls to
   accomplish the interlocking as shown in SOO 3.7.B
   and elsewhere.

1. Refer to addendum #5. Each
   unit shall have its own
   controller. All EAHU
   continually operate and shall
   be controlled by Phase 1
   contractor.

2. Phase 2 contractor shall be
   responsible for new interlocks
   for EAHU.

AEI

RFI 13. Payment and Performance Bonds
References: WC 23B will be responsible for the
P&P Bond on the Labor Only amount
since it is the labor to install the owner
provided equipment. The equipment

WT
<table>
<thead>
<tr>
<th>BIDDERS QUESTIONS Page 11 of 13</th>
<th>ADDENDUM #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>It appears that the controls contractor is required to provide a performance bond for the amount of their subcontract with Whiting Turner. The controls contractor has also been asked to carry, as part of their contract, the owner’s allowance for Phoenix and Aircuity. Clarification Request: 1) Is it the intent that the controls contractor will need to include a bond for their entire contract amount or only on their labor?</td>
<td>itself is being purchased under separate contract with the university and will not need to have the P&amp;P bond on it.</td>
</tr>
</tbody>
</table>
| **RFI 14. Electrical Manhole Bore**  
**References:** IC800 Add#1 Keynote 1  
**Description**  
IC 800 indicates that a controls conduit needs to be bored between 2 manholes. We need clarification as to what trade will bore the conduit.  
**Clarification Request:** 1) Please confirm if the intent is to have the controls contractor bore a conduit across this finished area, or will the bore and conduit be furnished by another trade?  
2) Who is responsible for repair of the site, concrete or asphalt?  
3) Who is responsible for any damage to existing underground utilities in the area bored? | This scope of work is shown in the WC 23B Subcontract, so the WC 23B scope for the electrical would be responsible for the excavation and boring required to complete the conduit run to be able to complete the wiring. WC 23B will be responsible to all work and repairs if any damage occurs.  
**WT** |
| **RFI 15. Static Pressure Sensors being shared across the UK campus IT Network**  
**Description**  
There are several Systems of AHUs that will work together to feed common ducts. Throughout the SOO there are a few references that indicate static pressure readings should be sent across the campus network to the Tridium Server to be averaged, before being sent back across the campus network to the associated AHUs for control over the Supply Fans.  
Supply fan PID loops are a typically one of the faster PIDs. Given the potential communication delay, there could create control issues or hunting, especially on startup or AHU switchover from lead-lag or lead-standby. There are also several instances throughout the project SOO and UK standards that show that all of the AHUs and Konvekta will be on the same MSTP trunk.  
Given the requirements for 1 MSTP trunk for all the AHU systems and Konvekta, It could be a better solution to have the Static Pressures be passed to each associated AHU, for averaging, via the MSTP trunk. This would remove any delay or failures created by passing | **AEI** |

---

BIDDERS QUESTIONS  
ADDENDUM #2  
Page 11 of 13
information across the Campus IT Network.

The average static pressure setpoint could still be sent to all controllers through Tridium, but the control process variables would remain within BACnet MSTP level and not reliant on the Campus infrastructure.

Clarification Request:
1) Please confirm the intent of controlling the AHU supply fans to a common Average Static Pressure, and how information should be shared to obtain the “average static pressure” to be used as a control point.

<table>
<thead>
<tr>
<th>RFI 16. Composite Cleanup</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>References:</strong></td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>There appears to be composite clean-up on the project, where each contractor will have to supply a person all day, every day that they are on-site. That person will be dedicated to cleanup of general cleanup and not for the cleanup of own work.</td>
</tr>
</tbody>
</table>

Clarification Request:
1) Does the controls contractor have to provide labor for composite cleanup for every day that they or their subcontractors are on site?

<table>
<thead>
<tr>
<th>Due to some corporate approvals and signature requirements that are required, and may take us some time to get, can we officially request a 1 week extension to the bid date? I know time is important on this, but I have been requested to ask. Looking for 4/4 as the new bid date?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Owner has pushed the bid date for WC23B to 3:00 pm on 4/4/2019 at the same location.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Conditions indicate we will need to provide for 100% onsite PM/supervision. Is this actually required for the temperature control contractor?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Subcontract states each Subcontractor must have a supervisor that can answer for the company and is a competent person. If WC 23B has one programmer onsite running data point that employee can be the supervisor and competent person as required by the contract.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Conditions indicate to carry costs for on-site dumpster and street cleaning. Will the temperature control contractor need to provide dumpsters?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Conditions indicate to carry costs for a trailer and utility costs. Will the temperature control contractor need to carry these costs?</th>
</tr>
</thead>
<tbody>
<tr>
<td>WT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Can you confirm that the Automatic Transfer Switch and Power Monitoring points are already points that are being picked up by the existing control system. If so, do we still need to provide these points separate from the existing?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes these points are already picked up.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>35</td>
</tr>
<tr>
<td>36</td>
</tr>
<tr>
<td>37</td>
</tr>
<tr>
<td>38</td>
</tr>
</tbody>
</table>
Addendum #08

Client | University of Kentucky | Date | 3/27/2019
Project | RB2 Phase 2 | Champlin Project # | 514-5350

This addendum provides information to clarify or adjust construction items which may affect any or all trade contractors. The original documents for the referenced project are amended as noted in this addendum and made part of said documents and shall govern the work covered by the Form of Proposal. All work to be in strict accordance with the terms, stipulations and conditions of contract documents.

SUMMARY OF ATTACHMENTS

PART A - DRAWINGS:

MF-250III
1. Renamed VSV serving room 036 to eliminate redundant identifiers

MF-350B
1. Added controls & sensors
2. Added RC-045 (previously captured on schedules only)

MF-350D
1. Added controls & sensors

MF-354A
1. Added controls & sensors

MF-354B
1. Added controls & sensors

MF-354C
1. Added controls & sensors

MF-355A
1. Added controls & sensors

MF-355B
1. Added controls & sensors

MF-951
1. Assigned sequences to some of the air valves.
2. Renamed VSV serving room 036 to eliminate redundant identifiers

MF-953
1. Assigned sequences to some of the air valves.
IC-757
1. Added Sequence U and Sequence V

IC-758
1. Added Laundry Exhaust Diagram

IC-950
1. Added Sequences U & V to responsibility matrix

PART B - SPECIFICATIONS:

Section 230903 Control Instrumentation
1. Removed Automatic Reset Freeze stat 230993

Section 230993 Control Sequences
1. Added Terminal Unit Sequence U
2. Added Terminal Unit Sequence V
3. Added Laundry Exhaust Sequence
4. Clarified Lab AHUs 1-4 Sequencing
5. Clarified Existing MeeFog Sequence
6. Clarified Existing Konvekta Sequence
7. Clarified System Air Volume Control sequences (For AHUs)

PART C – WRITTEN QUESTIONS AND ANSWERS:

See attached log

End of Addendum
GENERAL NOTES

1. PROVIDE BALANCING DAMPER AT EACH DIFFUSER, GRILL E, AND BRANCH TAKEOFF IN ALL SUPPLY, RETURN, AND EXHAUST DUCTWORK. LOCATE BALANCING DAMPER AS CLOSE TO BRANCH TAKEOFF AS POSSIBLE.

2. DUCT SIZE TO DIFFUSERS, REGISTERS, AND GRILLES SHALL BE SAME AS NECK SIZE UNLESS OTHERWISE NOTED.

3. DUCT SIZE TO AIR TERMINAL DEVICES SHALL BE SAME AS AIR TERMINAL INLET UNLESS OTHERWISE NOTED.

4. LOCATION OF CEILING MOUNTED DIFFUSERS, REGISTERS AND GRILLES SHALL BE AS SHOWN ON ARCHITECTURAL REFLECTED CEILING PLANS (RCP). MAKE ADJUSTMENTS TO DUCT LAYOUT AS NECESSARY TO COORDINATE WITH RCP.

5. MAINTAIN WORKING CLEARANCE ON CONTROLLER SIDE OF EACH AIR TERMINAL UNLESS OTHERWISE SHOWN. COORDINATE PIPING AND OTHER TRADES TO MAINTAIN ACCESS TO CONTROLLER.

6. FLEXIBLE DUCT MAY NOT BE SHOWN. FLEXIBLE DUCT MAY BE USED FOR CONNECTIONS TO DIFFUSERS, GRILLES, AND REGISTERS ABOVE ACCESSIBLE CEILINGS PER SECTION 23-3114. FLEXIBLE DUCT SHALL NOT EXCEED SIX FEET. REFER TO SECTION 23-3114 FOR ADDITIONAL REQUIREMENTS.

7. CRITICAL DAMPER LOCATIONS ARE SHOWN TO ENSURE PROPER LOCATION AND ACCESS. PROVIDE DAMPERS PER GENERAL NOTE 1 WHETHER SHOWN OR NOT.

8. PROVIDE 12" MINIMUM STRAIGHT LENGTH OF DUCT BETWEEN SUPPLY AIR TERMINAL AND REHEAT COIL FOR ACCESS PANEL.

9. ALL NON-FIRE/SMOKE DAMPERED EXHAUST DUCTS SHALL BE COATED WITH CONQUEST-FIRESPRAY FROM THE POINT THEY ENTER THE RATED SHAFT TO THE UNDERSIDE OF THE ROOF SLAB.

10. REFER TO AIR TERMINAL DEVICES SCHEDULES FOR SOUND ATTENUATING DEVICE REQUIREMENTS.

11. PROVIDE COMBINATION FIRE SMOKE DAMPER AT ALL DUCT PENETRATIONS TO SHAFTS.
GENERAL NOTES - PIPING

2. BRANCH PIPING TO RCP AND FTR SHALL BE 3/4" UNLESS OTHERWISE NOTED.

3. ALL PIPE PENETRATIONS THROUGH 1-HOUR RATED PARTITIONS SHALL BE FIRESTOPPED PER UL DETAILS TO ACHIEVE A 1-HOUR RATING.

4. DRAIN PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1/8" PER 1'-0".

5. HIGH PRESSURE STEAM PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1" PER 40'-0".

6. HIGH PRESSURE CONDENSATE PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1" PER 20'-0".

7. COORDINATE EXACT LOCATION OF WALL MOUNTED THERMO STATS, HUMIDISTATS AND CARBON DIOXIDE SENSORS WITH ARCHITECTURAL PLANS AND ELEVATIONS. MINIMUM MOUNTING HEIGHT TO BE 48" AF.
1. BRANCH PIPING TO TERMINAL UNITS SHALL BE 3/4" UNLESS OTHERWISE NOTED.
2. BRANCH PIPING TO RCP AND FTR SHALL BE 3/4" UNLESS OTHERWISE NOTED.
3. ALL PIPE PENETRATIONS THROUGH 1-HOUR RATED PARTITIONS SHALL BE FIRESTOPPED PER UL DETAILS TO ACHIEVE A 1-HOUR RATING.
4. DRAIN PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1/8" PER 1'-0".
5. HIGH PRESSURE STEAM PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1" PER 40'-0".
6. HIGH PRESSURE CONDENSATE PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1" PER 20'-0".
7. COORDINATE EXACT LOCATION OF WALL MOUNTED THERMO STATS, HUMIDISTATS AND CARBON DIOXIDE SENSORS WITH ARCHITECTURAL PLANS AND ELEVATIONS. MINIMUM MOUNTING HEIGHT TO BE 48" ABOVE.
3. ALL PIPE PENETRATIONS THROUGH 1-HOUR RATED PARTITIONS SHALL BE RCP 2 1/2" RHWR 400S - 3/4" MTCHS

5. HIGH PRESSURE STEAM PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1" PER 20'-0".
GENERAL NOTES - PIPING

1. BRANCH PIPING TO TERMINAL UNITS SHALL BE 3/4" UNLESS OTHERWISE NOTED.

3. ALL PIPE PENETRATIONS THROUGH 1-HOUR RATED PARTITIONS SHALL BE PER 1'-0".

5. HIGH PRESSURE STEAM PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1" PER 20'-0".

7. COORDINATE EXACT LOCATION OF WALL MOUNTED THERMO STATS, HUMIDISTATS AND CARBON DIOXIDE SENSORS WITH ARCHITECTURAL PLANS.
GENERAL NOTES - PIPING

1. BRANCH PIPING TO TERMINAL UNITS SHALL BE 3/4" UNLESS OTHERWISE NOTED.

2. BRANCH PIPING TO RCP AND FTR SHALL BE 3/4" UNLESS OTHERWISE NOTED.

3. ALL PIPE PENETRATIONS THROUGH 1-HOUR RATED PARTITIONS SHALL BE FIRESTOPPED PER UL DETAILS TO ACHIEVE A 1-HOUR RATING.

4. DRAIN PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1/8" PER 1'-0".

5. HIGH PRESSURE STEAM PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1" PER 40'-0".

6. HIGH PRESSURE CONDENSATE PIPING SHALL BE SLOPED DOWN IN THE DIRECTION OF FLOW AT 1" PER 20'-0".

7. HUMIDISTATS AND CARBON DIOXIDE SENSORS WITH ARCHITECTURAL PLANS AND ELEVATIONS. MINIMUM MOUNTING HEIGHT TO BE 48" AFF.
GENERAL NOTES - PIPING

1. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

2. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

3. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

4. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

5. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

6. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

7. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

8. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

9. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

10. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

11. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

12. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

13. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

14. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

15. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

16. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

17. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

18. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

19. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

20. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

21. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

22. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

23. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".

24. All drain piping shall be sloped down in the direction of flow at 1/8" of flow at 1" per 40'-0".
1. Branch piping to terminal units shall be 3/4" unless otherwise noted.

2. Branch piping to RCP and FTR shall be 3/4" unless otherwise noted.

6. High pressure condensate piping shall be sloped down in the direction of flow at 1" per 20'-0" and elevations. Minimum mounting height to be 48" from floor.
<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment Description</th>
<th>Location</th>
<th>Type</th>
<th>Device</th>
<th>Size (MBH)</th>
<th>Size (CFM)</th>
<th>Max Flow</th>
<th>Min Flow</th>
<th>Actuator Speed</th>
<th>Max Pressure</th>
<th>Min Pressure</th>
<th>Max Temp</th>
<th>Min Temp</th>
<th>Max Vane Size</th>
<th>Min Vane Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VSV 087N</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>310</td>
<td>310</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>2</td>
<td>VEV 087M</td>
<td>LOWER LEVEL EXHAUST EAHU/EF 4</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>200</td>
<td>200</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>3</td>
<td>VSV 079D</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>300</td>
<td>300</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>300</td>
<td>6804</td>
<td>0.7</td>
</tr>
<tr>
<td>4</td>
<td>VEV 079D-1</td>
<td>LOWER LEVEL EXHAUST EAHU/EF 4</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>200</td>
<td>200</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>5</td>
<td>VSV 087J</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>-10</td>
<td>210</td>
<td>210</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>210</td>
<td>4762.8</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>VEV 079H</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>300</td>
<td>300</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>300</td>
<td>6804</td>
<td>0.7</td>
</tr>
<tr>
<td>7</td>
<td>VSV 079L</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>300</td>
<td>300</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>300</td>
<td>6804</td>
<td>0.7</td>
</tr>
<tr>
<td>8</td>
<td>VSV 079M</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>300</td>
<td>300</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>300</td>
<td>6804</td>
<td>0.7</td>
</tr>
<tr>
<td>9</td>
<td>VEV 079L-1</td>
<td>LOWER LEVEL EXHAUST EAHU/EF 4</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>200</td>
<td>200</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>10</td>
<td>VSV 079N-1</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>310</td>
<td>310</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>11</td>
<td>VSV 079N-2</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>310</td>
<td>310</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>12</td>
<td>VEV 079N-1</td>
<td>LOWER LEVEL EXHAUST EAHU/EF 4</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>200</td>
<td>200</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>13</td>
<td>VSV 087F</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>210</td>
<td>210</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>210</td>
<td>4762.8</td>
<td>0.5</td>
</tr>
<tr>
<td>14</td>
<td>VSV 087K-1</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>310</td>
<td>310</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>15</td>
<td>VSV 087K-2</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>210</td>
<td>210</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>210</td>
<td>4762.8</td>
<td>0.5</td>
</tr>
<tr>
<td>16</td>
<td>VSV 087B-1</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>310</td>
<td>310</td>
<td>0.80</td>
<td>0</td>
<td>30</td>
<td>0.7</td>
<td>51</td>
<td>72</td>
</tr>
<tr>
<td>17</td>
<td>VSV 085</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>610</td>
<td>610</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>610</td>
<td>13834.8</td>
<td>1.4</td>
</tr>
<tr>
<td>18</td>
<td>VSV 072</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>LOW</td>
<td>10</td>
<td>100</td>
<td>480</td>
<td>480</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>500</td>
<td>11340</td>
<td>1.1</td>
</tr>
<tr>
<td>19</td>
<td>VSV 087F</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>610</td>
<td>610</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>610</td>
<td>13834.8</td>
<td>1.4</td>
</tr>
<tr>
<td>20</td>
<td>VSV 045</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>10</td>
<td>0</td>
<td>55</td>
<td>55</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.80</td>
<td>0</td>
</tr>
<tr>
<td>21</td>
<td>VSV 036</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>W</td>
<td>LOW</td>
<td>10</td>
<td>100</td>
<td>480</td>
<td>480</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td>500</td>
<td>11340</td>
<td>1.1</td>
</tr>
<tr>
<td>22</td>
<td>VSV 045</td>
<td>LOWER LEVEL SUPPLY AHU 5/6/7/8</td>
<td>VENTURI</td>
<td>D</td>
<td>HIGH</td>
<td>10</td>
<td>0</td>
<td>55</td>
<td>55</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.80</td>
<td>0</td>
</tr>
<tr>
<td>No.</td>
<td>Type</td>
<td>Level</td>
<td>Terminal</td>
<td>Actuator</td>
<td>Offset</td>
<td>Flow</td>
<td>Lat</td>
<td>LWT</td>
<td>Speed (CFM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>-------</td>
<td>----------</td>
<td>----------</td>
<td>--------</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>VSV 410A</td>
<td>04</td>
<td>Supply AHU 1/2</td>
<td>VENTURI A</td>
<td>LOW</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>VSV 420</td>
<td>04</td>
<td>Supply AHU 1/2</td>
<td>VENTURI F</td>
<td>LOW</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>VSV 435</td>
<td>04</td>
<td>Supply AHU 1/2</td>
<td>VENTURI A</td>
<td>LOW</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>VSV 449</td>
<td>04</td>
<td>Supply AHU 3/4</td>
<td>VENTURI A</td>
<td>LOW</td>
<td>8</td>
<td>0</td>
<td>405</td>
<td>1.0</td>
<td>51</td>
<td>72</td>
<td>180</td>
<td>160</td>
<td>0.25</td>
<td>WATER</td>
</tr>
<tr>
<td>1.5</td>
<td>VSV 450</td>
<td>05</td>
<td>Supply AHU 1/2</td>
<td>VENTURI A</td>
<td>HIGH</td>
<td>8</td>
<td>0</td>
<td>110</td>
<td>0.5</td>
<td>51</td>
<td>72</td>
<td>180</td>
<td>160</td>
<td>0.25</td>
<td>WATER</td>
</tr>
<tr>
<td>1.6</td>
<td>VSV 473</td>
<td>04</td>
<td>Supply AHU 3/4</td>
<td>VENTURI A</td>
<td>LOW</td>
<td>8</td>
<td>0</td>
<td>100</td>
<td>0.5</td>
<td>51</td>
<td>72</td>
<td>180</td>
<td>160</td>
<td>0.25</td>
<td>WATER</td>
</tr>
<tr>
<td>1.7</td>
<td>VSV 474</td>
<td>04</td>
<td>Supply AHU 3/4</td>
<td>VENTURI A</td>
<td>LOW</td>
<td>8</td>
<td>0</td>
<td>225</td>
<td>0.5</td>
<td>51</td>
<td>72</td>
<td>180</td>
<td>160</td>
<td>0.25</td>
<td>WATER</td>
</tr>
<tr>
<td>1.8</td>
<td>VSV 460-1</td>
<td>04</td>
<td>Supply AHU 3/4</td>
<td>VENTURI F</td>
<td>LOW</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0.80</td>
<td>1.1</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td>VSV 476</td>
<td>04</td>
<td>Supply AHU 3/4</td>
<td>VENTURI A</td>
<td>LOW</td>
<td>8</td>
<td>0</td>
<td>240</td>
<td>0.5</td>
<td>51</td>
<td>72</td>
<td>180</td>
<td>160</td>
<td>0.25</td>
<td>WATER</td>
</tr>
</tbody>
</table>

**Notes:**
- Speed (CFM) values are given in cubic feet per minute (CFM).
- Lat and LWT refer to the limits of travel and load weight, respectively.
- Terminal types include various systems such as VENTURI A, B, and F.
THE CONTROL/FLOW DIAGRAM IS ONLY INTENDED TO PROVIDE CONTROL AND INSTRUMENTATION RELATED INFORMATION. REFER TO MECHANICAL DETAILS FOR VALVING, DAMPERING AND ASSOCIATED SPECIALTIES' INSTALLATION REQUIREMENTS.

CONTROL/FLOW DIAGRAM INCLUDES GENERAL ARRANGEMENT OF SYSTEM COMPONENTS. REFER TO FLOOR PLANS AND EQUIPMENT SCHEDULES FOR COMPONENT QUANTITIES.
Note: The control/flow diagram is only intended to provide control and instrumentation related information. Refer to mechanical details for valving, dampering and associated specialties' installation requirements. Control/flow diagram includes general arrangement of system components. Refer to floor plans and equipment schedules for component quantities.

1. The control/flow diagram is only intended to provide control and instrumentation related information. Refer to mechanical details for valving, dampering and associated specialties' installation requirements.

2. Control/flow diagram includes general arrangement of system components. Refer to floor plans and equipment schedules for component quantities.

GENERAL NOTES:
## V-Ball May Be Substituted for Globe Valve

1. V-ball may be substituted for globe valve terminal units.

### Airflow Meters

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Type</th>
<th>Pressure Drop</th>
<th>Minimum Capacity</th>
<th>Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU Smoke Damper &amp; Actuators</td>
<td>Provided with AHU.</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

### Control Valves

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Type</th>
<th>Pressure Drop</th>
<th>Minimum Capacity</th>
<th>Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU Smoke Damper &amp; Actuators</td>
<td>Provided with AHU.</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

### Airflow

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Type</th>
<th>Pressure Drop</th>
<th>Minimum Capacity</th>
<th>Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU Smoke Damper &amp; Actuators</td>
<td>Provided with AHU.</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

### Accessories

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Type</th>
<th>Pressure Drop</th>
<th>Minimum Capacity</th>
<th>Maximum Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU Smoke Damper &amp; Actuators</td>
<td>Provided with AHU.</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

### Remarks

- Airflow meters provided with AHU.
- Control dampers provided with AHU.
- Valves shall be line size furnished by Konvekta.

### Other

- Fullport ball characterized.
- Globe characterized.
- 2-way modulating unit.
- See plans for valve locations.
- Head size (ft).
- Duct size (in).
SECTION 23 0903 CONTROL INSTRUMENTATION

PART 1 - GENERAL

1.1 RELATED WORK
A. Section 23 0901 - Control Systems Integration
B. Section 23 0905 - Instrument Point List
C. Section 23 0993 - Control Sequences
D. Section 23 2120 - Piping Specialties

1.2 REFERENCE
A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 GENERAL
A. Devices containing mercury are not allowed.

1.4 SUBMITTALS
A. Devices shall be indexed by bill of material for each system as detailed in Section 23 0901 - Control Systems Integration.
B. Thermostat/Room Temperature Sensor Schedules:
   1. Submit thermostat/room temperature sensor schedule with shop drawings. Thermostat/room temperature sensor schedule shall have detailed listing of which type is used for each room, including data concerning service and model numbers, sizes, cover types, and engineering data sheets for each control device.
C. Warranty
   1. Provide 1 year warranty on all materials and labor.
   2. Warranty requirements shall include furnishing and installing software upgrades issued by the manufacturer during the 1 year warranty period.

1.5 FCC COMPLIANCE
A. Digital equipment furnished under this Contract shall be tested and made to comply with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environments. Literature shall so note and equipment shall be so labeled.

PART 2 - PRODUCTS

2.1 GENERAL
A. Pressure and temperature ratings of devices indicated in Part 2 - of this Section are minimum required. Devices shall be designed to withstand maximum pressures and temperatures encountered in respective systems.
B. No devices containing mercury will be allowed under this Specification.

2.2 GENERAL INSTRUMENTATION

A. Pressure Gauges:
   1. Refer to Section 23 2120 - Piping Specialties

B. Thermometers (Dial-Type):
   1. Refer to Section 23 2120 - Piping Specialties

C. Analog Electronic Instrument Indicators:
   1. Electronic indicators, used for displaying sensor and/or output values as measured by current or voltage, shall be panel mount type and at least 2" square. Output may be either analog needle type or digital with 1/2" high LED or backlit LCD displays.
   2. Electronic indicators shall be marked in appropriate units (degrees, psi, % rh, gpm, cfm, etc.) and with appropriate range of values. Panel mounted indicators shall have minimum accuracy of 1% of scale range. Digital units shall be scaled to show 3 digits plus 1 decimal point.

D. Building Utility Meters:
   1. All building utility meters shall be equipped with pulse initiators which shall be connected to a totalizer input on the FMS. This includes but is not limited to electric meters, water meters, condensate meters, and BTU meters.

E. Control Panels
   1. Panelboard shall contain all instruments and accessories. Provide each item of equipment with an engraved nameplate. Panelboard shall be wall mounted or stand mounted and shall be completely enclosed.
   2. As far as is practical, the control components for each system shall be grouped. Provide each group of components with identification.
   3. The entire panelboard shall be pre wired and brought to a main terminal strip. All relays, switches, etc., shall be installed, furnished and wired on panelboard. Clearly mark each terminal strip as to which wire from which component is to be connected.
   4. Fabricate panels of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color.
   7. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

2.3 DISCRETE ELECTRIC INSTRUMENTATION

A. General:
   1. Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of project. Terminal connections shall be made at terminal blocks inside of NEMA 1 enclosures unless otherwise specified. Outdoor units shall be NEMA 4 with concealed adjustment.
2. Ratings of normally open and normally closed contacts shall be adequate for applied load (minimum 5 amps at 240 Volts).
3. Accuracy of devices shall be ± 1% of scale with adjustable offset unless otherwise specified.

B. Temperature Switches (Electric Thermostats):
1. Line voltage or low voltage type suitable for application with adjustable setpoint and setpoint indication.
2. Low voltage type to have heat anticipation.
3. Thermostats with remote sensing bulb shall have liquid filled sensing element and exposed setpoint adjustment.
4. Wall mounted space thermostat enclosure shall have concealed sensing element and exposed setpoint adjustment.
5. Unless otherwise stated, space thermostat covers shall be custom color “bright white”.

C. Temperature Low Limit Switches (Freezestats):
1. Electric 2 position type with temperature sensing element and manual reset. Controls shall be capable of opening circuit if any 1 foot length of sensing element is subject to temperature below setting.
2. Sensing element shall not be less than one lineal foot per square foot of coil surface areas. Unless otherwise indicated, calibrate temperature switch setpoint to 38°F.
3. Provide adjustable time delay relay for 0.5 to 5 minutes. Time delay relay shall be wired between freezestats and controller to allow air handling unit mixed air to stabilize upon startup or transition from unoccupied to occupied mode to prevent spurious trips from occurring when outside air damper(s) opens and cold outside air enters air handling unit.
4. Where any freezestat is mounted higher than 6ft above the floor, manual reset to be provided by remote manual reset panel consisting of remote trip relays, master trip relay and master reset relay.
   a. Each freezestat operates its remote trip relay which is locked out upon freezestat trip. Indicator lamps at remote trip relay shall indicate which relay has tripped and therefore indicates which freezestat has caused trip.
   b. Remote trip relays will trip master trip relay that interfaces with BAS to cause air handling unit shutdown.
   c. Master reset relay is activated by reset pushbutton at remote manual reset panel to reset locked out trip relays and master trip relay.

D. Temperature Low Limit Switches (Freezestats):
1. Electric 2-position type with temperature sensing element and automatic reset. Controls shall be capable of opening circuit if any one foot length of sensing element is subject to temperature below setting.
2. Sensing element shall not be less than one lineal foot per square foot of coil surface areas. Unless otherwise indicated, calibrate temperature switch setpoint to 38°F.
3. Provide adjustable time delay relay for 0.5 to 5 minutes. Time delay relay shall be wired between freezestats and controller to allow air handling unit mixed air to stabilize upon startup or transition from unoccupied to occupied mode to prevent spurious trips from occurring when outside air damper(s) opens and cold outside air enters air handling unit.

E.D. Temperature Switches (Aquastats):
1. Electric 2-position type with strap-on or immersion temperature sensing element. Switch contacts close on increasing temperature to provide start signal for unit heaters, cabinet unit heaters and open on high limit control for heating hot water heat exchangers.

2. Sensing element shall be set for 100°F (FA) for unit heater control. For setpoints to aquastats for hot water heat exchangers, refer to control sequences for each hot water system. Provide screw-type terminals in NEMA 12 switch enclosure for field mounting at unit heaters.

F.E. Space Humidity Switches (Humidistats):
1. SPDT line voltage or low voltage type suitable for application. Provide NEMA 1 metal enclosure suitable for intended use. Wall mounted space humidistat enclosure shall be designed with concealed sensing element and exposed setpoint adjustment.
   a. Humidity Range: 10 to 95% rh between 40 and 125°F
   b. Accuracy: ± 5% rh
   c. Offset Differential: 5% rh

G.F. Duct High Limit Humidity Switches (Humidistats):
1. Manufacturers: Rotronic or approved equal
   a. SPDT line voltage or low voltage type suitable for application. Provide NEMA 12 metal enclosure suitable for intended use. Duct mounted humidistat enclosure shall be designed with concealed setpoint adjustment.
   b. Control signal to humidifier control valve shall be passed through normally closed (NC) contacts that open when humidity level exceeds high limit setpoint to interrupt the control signal to the humidifier control valve and fails it closed. Reset of the high limit humidistat will enable the humidifier control valve to operate again.
      1). Humidity Range: 10 to 95% rh between 40 and 125°F
      2). Accuracy: ± 5% rh
      3). Offset Differential: 5% rh

H.G. Relays:
1. Manufacturers: IDEC, Potter Brumfield, Square D, or Allen Bradley
2. Equal to IDEC Type RH2B-U, miniature 8 blade pilot relay with DPDT silver cadmium oxide contacts rated at 10A, 30 VDC, or 120 VAC. Coil shall match control circuit characteristics. DDC outputs shall be 24 VDC with maximum current burden of 50 milliamps. Rectangular base socket mount with blade type plug-in terminals and polycarbonate dust cover.
3. Provide DIN rail mountable (Snap type) mounting sockets equal to IDEC SH2B-05.

I.H. Enclosed Relay (Relay-in-a-Box):
1. Manufacturers: Veris Industries, Kele & Associates, Functional devices, Inc. or approved equal
2. 1 or 2 SPDT relays in NEMA 1 or better enclosure. Coil shall be selected for control circuit characteristics.
3. Contacts rated at 10A, 28 VDC or 120 VAC. Conduit nipple is 1/2" NPT. Maximum coil current burden 50 milliamps.

J.J. Pressure Differential Switches (Air Systems):
1. Manufacturers: Cleveland Controls, Dwyer, Honeywell, Johnson Controls/Penn, Siemens Building Technologies, or TAC
2. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
3. Pressure differential switches for air systems shall have pressure rating of at least 10” WC.
4. Pressure indicating differential switches for air systems shall be equal to Dwyer Series 3000 photohelic gauge.
   a. Maximum Temperature Rating: 180°F
   b. Repeatability: ± 1%

**K.J. Pressure Differential Switches (Water Systems):**
1. Manufacturers: Allen Bradley, Ashcroft, Dwyer, Honeywell, Johnson Controls/Penn, Siemens Building Technologies, TAC, SOR, or United Electric
2. Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
3. Pressure differential switches for water systems shall be rated for 150 psig unless otherwise noted. Chilled water pressure differential switches shall be provided with totally sealed vapor tight switch enclosure on 300 psig body. Differential pressure switches to have 3-valve manifold for servicing.
   a. Maximum Temperature Rating: 300°F
   b. Repeatability: ± 1%

**L.K. Target Type (Paddle) Flow Switches:**
1. Manufacturers: Honeywell, Johnson Controls, Kobold, McDonnell & Miller, Dwyer or SOR
2. Adjustable set point, paddle type. Select switches for accuracy and ranges to match process conditions, electrical requirements, to implement intended functions.
3. Air sensing switches shall be for duct mounting, top, side, or bottom. Mounting in vertical duct with downward flow is not allowed.
4. Furnish water sensing switches with NPT fittings suitable for piping mounting. Switches shall be rated for 150 psig except chilled water switches shall be rated for 300 psi.

**M.L. Thermal Dispersion Flow Switches:**
1. Manufacturers: Fluid Components, Inc., Delta M, Dwyer or Magnetrol
2. Units shall use thermal dispersion sensors to detect flow from heated reference elements whenever flow is above threshold setpoint. Setpoint shall be adjustable between 20 and 80% flow. Select units for proper installation orientation.
   a. Maximum Response Time: 1 minute
   b. Maximum Temperature: 200°F
   c. Repeatability: ± 1%
   d. Pressure Rating:
      - 300 psi for chilled water
      - 150 psi for other applications

**N.M. Level Switches:**
1. Manufacturers: Drexelbrook, Magnetrol, Endress and Hauser or Dwyer
2. Radio Frequency (RF) type continuous level probe with multiple adjustable setpoints and SPDT snap action contacts to meet intended use. Probe shall have probe shielding to reject build up of conductive, sticky or viscous material. Probe length shall match vessel dimensions to measure within 6” of bottom.
3. Provide probe brace every 4 ft if probe length exceeds 6 ft, and not installed in stilling well.
   a. Supply Voltage: 120 VAC/60 Hz
   b. Fail Safe: Low Level output on instrument failure
c. Ambient Temperature Limits: -40 to 160°F

d. Minimum Enclosure Rating: NEMA 4

e. Transmitter Mounting: Remote

f. Performance:
   1). Accuracy: ± 2% nominal
   2). Linearity: ± 1% nominal
   3). Repeatability: ± 1% nominal
   4). Response Time: 20 milliseconds
   5). Ambient Temperature Effect: 2% per 100°F max.
   6). Voltage Variation Effect: ± 0.2% maximum per 10 V change

Q.N. Time Switches (Time Clocks):
   2. Programmable electronic clock type consisting of electronic clock, LED or LCD display, user interface keypad, and multiple normally open/fail close contacts. Time clocks shall be programmable for up to 8 start/stops per day for each 7 day period.
   3. Provide each time clock with battery that will maintain programming schedule for up to 8 hours upon electric power failure and shall return to its programmed position after re-start.

P.O. Duct Mounted Smoke Detectors:
   1. UL Listed for use in air handling systems. Detectors shall be designed to provide detection of combustion gases, fire and smoke in air conditioning and ventilating duct systems in compliance with NFPA and UL 167. Further they shall contain ionization type detector and air sampling chamber with sampling tubes extending through width of air duct. Alarm status indicating lights shall be visible on front of detector. Key controller test and reset switches plus easily accessible test jack shall be provided. It shall include alarm relay contact (DPDT) capable of handling loads of up to 5 amperes at 120 VAC or 28 VDC resistive. Unit shall have self-contained power supply requiring XXX power.

Q.P. Position Switches (End Switches):
   1. Manufacturers: Allen Bradley, Johnson Controls/Penn, Honeywell, Ruskin, Greystone Energy Systems, Reed National Air Products, NAMCO, Omron or Westlock
   2. Provide damper position switches, as required to meet specified sequence. Rotary switches shall be cam action, lever, or proximity type. Provide damper brackets and connecting rods for connecting position switch actuation levers to damper blades or jackshafts.
   3. “Tip Switches” or other position switches that contain mercury shall not be used for damper end switch applications.

R.Q. E-P Switches (Solenoid Valves):
   1. Manufacturers: Asco, Johnson Controls, Siemens Building Technologies, TAC, Kele & Associates or MAC Valves
   2. E-P switches shall provide control air for operation of fan isolation dampers, smoke or smoke/fire dampers, or other On/Off dampers. Line voltage actuators shall be Class “H” (high temperature) and listed by UL or CSA.
      a. Valve Body: Brass or bronze
      b. Valve Type: 2-way or 3-way
      c. Operating Voltage: 24 VDC, 24 VAC, 120 VAC or as specified
d. Operating Temperature: 32 to 104°F

e. Operating Pressure: Greater than maximum supply pressure

f. Pipe Size: 1/4" NPT

g. Enclosure Rating: NEMA 4 (locally mounted), NEMA 1 (Panel Mounted)

h. Conduit Connection: 1/2"

S.R. Current Switches - Constant Load, Constant Speed:


2. These shall be Induction type sensors clamped over single phase conductor of AC electrical power and shall be solid-state sensors with adjustable threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.

   a. Output: Solid state relay or relay contacts

   b. Trip Setpoint: Adjustable by multi-turn potentiometer

   c. Operating Temperature: 32 to 131°F

   d. Response Time: < 0.5 seconds

T.S. Current Switches - Variable Load, Variable Speed

1. Manufacturers: Veris Industries, N-K Technologies or approved equal

2. These shall be induction type sensors clamped over single-phase conductor of AC electrical power and shall consist of solid-state sensors with self-calibrating threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.

   a. Output: Solid state relay or relay contacts

   b. Trip Setpoint: Self-calibrating through microprocessor

   c. Operating Temperature: 32 to 131°F

   d. Response Time: < 0.5 seconds

U.T. Mechanical Room and Local Control Panel Alarm Horns:

1. Manufacturers: Honeywell, Johnson Controls, Siemens, Panalarm, TAC, or Ronan

2. 24 V alarm horn suitable for panel mounting.

V.U. Plant Alarm Horns:

1. Manufacturers: Panalarm, Johnson Controls/Penn, Honeywell, Siemens Building Technologies, or Sonalert

2. Equal to Honeywell model SC806A rated at 64-100 dBA at 10 ft, 24 VAC operation. UL Listed and FM approved.

W.V. Indicator Lights:

1. Manufacturers: Allen Bradley, GE, Square-D, or Idec

2. 1/4" minimum size or 1-1/4" maximum size, push-to-test type. Use green for normal, yellow for warning (low/high values), and red for alarm or fail (low-low or high-high conditions). AC or DC type with voltage matched to control circuit without transformers.

X.W. Moisture Detector:

1. Manufacturers: Raychem Corp. or approved alternate.

   a. Moisture detector shall alarm in the event of water or other conductive liquid present on floors or areas damage may occur to. Moisture detectors shall be used in but not limited
to mechanical equipment rooms, computer rooms or other spaces where liquid leakage may cause damage to equipment in the space.

2. Alarm Module: Raychem Model TTA-1 or equal.
   a. Supply Voltage: 120/240 VAC, 60 Hz
   b. Power Consumption: 14 VA
   c. Temperature Rating: 32°F to 105°F (0°C to 40°C)
   d. Sensing Cable: Raychem Trace Tek® Series
   e. Max. Sensing Cable Length: 50 ft. (15 m)
   f. Relays Contacts:
      1). Type: 4PDT
      2). Rating: 3A at 120 VAC/28 VDC
      3). Audible Alarm: 95 decibels
      4). Enclosure Rating: NEMA 12 (Optional NEMA 4X)

3. Sensing Cable: Raychem Model TT1000 or equal.
   a. Sensing Fluid: Water
   b. Cable Characteristics:
      1). Cable Diameter: 0.24 in. (6.0 mm) nominal
      2). Continuity/signal wires: 2 x 26 AWG with fluoropolymer insulation
      3). Sensing Wires: 2 x 30 AWG with conductive fluoropolymer jacket
      5). Max. Cable weight: 2.3 lbs.
      6). Max. Operating Temp.: 174°F (75°C)
   c. Sensitivity length: 2 inches maximum at any point along sensing cable.
   d. Drying time: Cable dries and resets within 15 seconds of removal from standing water.

4. Accessories:
   a. Modular Leader Cable: Non-conductive cable for connecting Sensing Cable to the Alarm Module.
   b. Modular End Termination: Required for Sensing Cable operation.
   c. Hold Down Clips: For anchoring the Sensing Cable to floor, bottom of trough or wall.

5. Mount Alarm Module near area to be monitored at approximately 5 feet above finished floor. Run Modular Leader Cable through conduit to location where it connects to the Sensing Cable. In mechanical equipment rooms or electrical equipment rooms, specify NEMA 4X enclosures for the Alarm Module. In computer rooms or other environmentally controlled area a NEMA 12 enclosure may be used for the Alarm Module.

\(Y.X.\) Drain Pipe Moisture Detector:

1. Manufacturers: Honeywell 470-12 or approved alternate.
   a. Moisture detector shall alarm in the event of water flowing through drain pipe. Moisture detectors shall be provided with two sensitivity settings.
   b. Supply Voltage: 12 VDC
   c. Power Consumption: 1 mA
   d. Relay Rating: 5 A
   e. Alarm Output: SPDT Form C Contact
2.4 ANALOG ELECTRONIC INSTRUMENTATION

A. Space Temperature Sensors:
   1. Sensors shall be platinum RTD type, with the following minimum performance:
      a. Temperature Coefficient of Resistivity (TCR): 0.00385 ohm/ohm/°C
      b. Accuracy: ± .54°F + (0.005 X T) (Class B)
      c. Accuracy: ± .27°F + (0.005 X T) (Class A)
         T = Temperature of interest
      d. Conformance: DIN-IEC 751
      e. Operating Range: 32 to 122°F, 0 to 99% rh
   2. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that device will maintain its accuracy within tolerance of ± 0.36°F between 32°F and 65.150°F, and 0.5°F between -20°F and 212°F.
      1. Unless otherwise stated, space sensor cover shall be brushed aluminum or brushed nickel.
      2. Provide visible setpoint, set point adjustment, and space temperature indication.
      3. Unless otherwise stated, space thermostat covers shall be custom color “bright white”.

B. Duct Mounted or Insertion Temperature Sensors:
   1. Platinum RTD type, with the following minimum performance:
      a. Temperature Coefficient: 0.00385 ohm/ohm/°C
      b. Accuracy: ± .54°F + (0.005 X T) (Class B)
      c. Accuracy: ± .27°F + (0.005 X T) (Class A)
         T = Temperature of interest
      d. Conformance: DIN-IEC 751
      e. Operating Range: -50 to 170°F, 0 to 99% RH
   2. Install insertions sensors in stainless steel probes or wells.
   3. Standard lengths to be 5.5”, 11.5” and 17.5”. Other lengths will be at owner’s written approval.
   4. Outside air sensors shall be weatherproof of noncorrosive construction and protected with solar shield. Mount outside air sensors on north side of building or in area intake wells for air handling systems to avoid thermal effects from direct sunlight. Glass encapsulated element unless otherwise approved.
   5. Sensors mounted in air streams, such as air handling units, supply ducts, exhaust ducts or return ducts, shall be averaging type. Averaging type sensor to be installed in ducts larger than 24” x 24” or greater than 576in². Mount averaging sensor across duct area in a “Z” pattern using mounting clips specific for averaging temperature sensor probes.
   6. Thermistors will be acceptable in lieu of RTD provided thermistor carries 5 year guarantee that the device will maintain its accuracy within a tolerance of ± 0.36°F between 32°F and 150°F, and 0.5°F between -20°F and 212°F.

C. Direct Insertion Temperature Sensors:
   1. Sensor assembly shall be direct insertion, suitable for use with water systems, 150 lb class, minimum rating.
   2. Sensor shall be platinum wound RTD, minimum accuracy of ± 0.06% at 32°F.
   3. Sheath diameter shall not exceed 5/16”. Length shall be such that sheath, containing sensor, projects into process fluid from 2” to 2.5” beyond pipe wall when installed. Material to be 304 or 316 stainless steel. Process coupling to be 3/8” or 1/2” NPT.
4. Connection head to be NEMA 4, cast iron, with screw on cap. Provide internal termination for RTD and wire connection. Conduit connection shall be 1/2" NPT.

5. Provide hot tap assembly and extension. Material to be 304 or 316 stainless steel. Support hot tap at minimum of 2 points to eliminate vibration. Extension shall exceed insulation thickness by 1".

6. Refer to Section 25 3003 - Process Instrumentation Device Specifications.

D. RTD Temperature Sensor/Transmitters:

1. Manufacturers: Rosemount, Burns, Minco Products, Weed or Pyromation

2. Transmitters shall provide 2 wire, 4-20 mA current output signal proportional to specified temperature span of transmitter and compatible with DDC equipment.
   a. These shall be 100Ω platinum RTD type temperature instruments for process immersion or air duct mounting
   b. Operating Temperature: -20 to +180°F
   c. Power Supply Voltage: 13 to 35 VDC unregulated
   d. Accuracy or Output Error: 0.1% of span of sensor and transmitter combination
   e. Temperature Coefficient: 0.00385 ohm/ohm/°C
   f. Thermowells: By same manufacturer as Sensor/Transmitter or approved alternate.

3. Provide local temperature indicator with 3 LCD digital readout.

E. Space Humidity Sensors/Transmitters:

1. Manufacturers: General Eastern, Automation Components Inc., Veris Industries, Hy-Cal (Honeywell), Rotronic or Vaisala

2. Space humidity sensors shall be wall mount type covers shall be custom color “bright white” to match room thermostats and/or temperature sensors.

3. Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance:
   a. Accuracy: ± 2% rh at 25°C over range of 20-95% rh including hysteresis, linearity and repeatability
   b. Temperature Effect: Less than 0.06% per °F at baseline of 68°F
   c. Sensitivity: 0.1% rh
   d. Repeatability: 0.5% rh
   e. Hysteresis: Less than 1%
   f. Long Term Stability: Less than 1% rh drift per year
   g. Adjustment: ± 20% rh zero, non-interactive
      ± 10% rh span, non-interactive
   h. Operating Range: 0-99% rh, non-condensing, sensor
      0-95% rh, non-condensing, electronics
   i. Output: 4-20 mA, 0-100% linear, proportional
   j. Power: 12-36 VDC

F. Duct Mounted Humidity Sensors/Transmitters:

1. Manufacturers: General Eastern, Automation Components Inc., Versis Industries, Minco, Rotronic or Vaisala

2. Probe type, temperature compensated, resistive bulk polymer or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.
a. Accuracy: ± 2% rh at 25°C over 20-95% rh including hysteresis, linearity and repeatability
b. Temperature Effect: Less than 0.06% per °F at baseline of 68°F.
c. Sensitivity: 0.1% rh
d. Repeatability: 0.5% rh
e. Hysteresis: Less than 1%
f. Long Term Stability: Less than 1% drift per year
g. Adjustment: ± 20% rh zero, non-interactive
   ± 10% rh span, non-interactive
h. Operating Range: 0-99% rh, non-condensing, sensor
   0-95% rh, non-condensing, electronics
i. Output: 4-20 mA, 0-100% linear, proportional
j. Power: 12-36 VDC

G. Combination Temperature/Humidity Transmitter:
1. Manufacturers: Automation Components Inc., Veris Industries, Vaisala, Minco or General Eastern
2. Combination Temperature and Humidity sensor/transmitter shall meet the following minimum requirements:
3. Temperature:
   a. Temperature Sensor: 100 or 1000 Ohm Pt RTD
   b. Temperature Coefficient: .00385 ohm/ohm/°C
   c. Accuracy: ± .5°F + (0.005 X T) (Class B)
   d. Accuracy: ± .27°F + (0.005 X T) (Class A)
   T = Temperature of interest
e. Operating Range: -10 to 160°F
f. Supply Voltage: 18 to 36 VDC / VAC
g. Output Ranges: 2-wire, 4 to 20 mA or 3-wire, 0 to 5, 0 to 10 VDC or 4 to 20 mA (24 VAC)
4. Humidity:
   a. Temperature Compensated: Full range of rh signal
   b. Response Time: 30 seconds for 63% step
   c. Accuracy Range: ±2% rh between 20 to 95% rh Span (including hysteresis, linearity repeatability).
   d. Sensing Element: Resistance or Capacitance humidity sensor
   e. Operating rh Range: 0 to 100% rh(non-condensing)
   f. Supply Voltage: 24 VDC (current or voltage output) 24 VAC (contact factory)
g. Output Ranges: 4 to 20mA, 0 to 5V, 0 to 10V
h. Long Term Stability: Less than 2% rh drift per year
5. Enclosure shall be made of ABS Plastic or equivalent and include an optional LCD display on face of enclosure.
6. Optional LCD readout shall be capable of °C or °F operation with an adjustable display toggle switch to change from temperature to humidity display. Unit shall include capability of temperature and humidity setpoint value display during adjustment.
H. Dew Point Temperature Transmitter:
   1. Manufacturers: General Eastern, Kele & Associates or Vaisala
   2. Microprocessor type primary dew point temperature measurement using platinum RTD, 4 wire, 100 ohm temperature sensing element with 4-20 mA transmitter.
      a. Accuracy: ± 1°F
      b. Repeatability: ± 0.1°F
      c. Hysteresis: None
      d. Sensor Range: -10°F to +140°F dew point
                     32°F to 140°F ambient
   3. Unit shall be selected for proper application (wall or duct mounted).

I. Ducted Air System Static Pressure and Differential Pressure (Velocity) Transmitters:
   1. Manufacturers: GE Modus, Setra, Ashcroft XLDp or approved equal
   2. Provide transducers/transmitters to convert velocity pressure differential or static duct pressure relative to sensor location into electronic signal.
   3. Unit shall be capable of transmitting linear 4 - 20 mA DC output signal proportional to differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:
      a. Span: Not greater than twice duct static or velocity pressure at maximum flow rate, or more than 16 times velocity pressure at minimum flow rate.
      b. Accuracy: ± 1.0% of span or ± 1.0% of full scale
      c. Dead Band: Less than 0.5% of output
      d. Hysteresis: Within 0.5% of span or within 0.5% of full scale
      e. Linearity: Within 1.0% of span or within 0.5% of full scale
      f. Repeatability: Within 0.5% of output
      g. Response: Less than 1 second for full span input
   4. Return and exhaust air system static pressure transducers/transmitters shall be furnished with protective integral air filters on pressure sensing lines from static pressure sensing stations and with static air probes to prevent migration of moisture and particulate matter into transducers. If inputs to pressure transducers/transmitters are dead-ended, integral air filters are not required. Supply air system sensors do not require integral air filters.

J. Space Pressure Monitoring System:
   1. Manufacturers: Tek-Air Systems, TSI, Siemens Building Technologies, or approved equal
   2. Provide directional pressure monitoring system for clean rooms, isolation rooms. Biosafety research labs and hospital rooms. System shall include ultra-low differential pressure transmitter including thermal mass airflow sensor, two space pressure probes, room display for visual monitoring of space pressurization and LCD readout of space differential pressure.
   3. Space pressure monitoring system shall have the following characteristics:
      a. Accuracy: ± 2% of set range.
      b. Pressure Range: 0.100 to -0.100" WC, full scale range, adjustable to ± 0.001, ± 0.005, to 0.010 or 0.10" WC.
      c. Analog Resolution: 0.0001" WC.
      d. Digital Resolution: ± 0.00005" WC.
      e. Output: 4-20 mA DC, self-powered, 5000 ohm load max.
      f. Power Supply: 24 VAC =/- 4 VAC, <10 VA.
g. Communications: RS-485, RS-232, BACnet, Ethernet or LonWorks.

K. Building and Space Pressure Differential Transmitter:
   1. Provide directional mass flow transmitter installed in 2" Schedule 40 black steel pipe between spaces to measure relative velocity created by pressure difference. Provide algorithm in software to convert air velocity to pressure differential (\( \Delta P = C \left( \frac{V}{4005} \right)^2 \)). Field determine coefficient \( C \) by calibrated measurement.
   2. Air velocity transmitter shall be equal to Omega FMA-900 Series with the following characteristics:
      a. Accuracy: ± 1.5% full scale, ± 0.5% reading
      b. Repeatability: ± 0.2% of full scale
      c. Probe Temperature Range: -40°F to 250°F
      d. Pressure Range: 150 psig, max
      e. Response Time: 400 msec. to within 63% of final value
      f. Output Signal: 4-20 mA
      g. Accessories: Compression Fittings - Omega 55 LK with Teflon Ferrules.

L. Vortex Shedding Air Flow Sensors/Transmitters:
   1. Manufacturers: Tek-Air
   2. Velocity measured by each sensor shall be linearized, summed, averaged, and converted to 4-20 mA output signal proportional to air flow rate (cfm) by transmitter electronics. Measured value converted to airflow (cfm) shall have accuracy within 2% rate ± 0.1% full scale throughout velocity range and temperature and humidity change of 40 to 130°F, and 10-95% rh (non-condensing). Transmitter shall be provided as part of air flow sensor, and shall include integral diagnostics with on-line zeroing and sensor operation verification.
   3. Manufacturer shall provide cabling required to connect probe assemblies and transmitter electronics. Transmitter and/or systems, which require periodic calibration to maintain accuracy specified shall not be acceptable.

M. Current Transformers:
   1. Manufacturers: General Electric, Square D, Kele & Associates, N-K Technologies or Veris Industries
   2. Alternating current transformers shall conform to latest applicable Standards including AEIC, EEI-NEMA, Standards for Instrument Transformers (MSJ-11) and ANSI Standard C57.13 for instrument transformers.
      a. Rated Voltage: 480 V
      b. Insulation Class: 600 V
      c. Basic Impulse Level: 60 Hz
      d. Short Time Current Rating: 100% (1 second)
      e. Accuracy Class: 0.3
      f. Continuous Current Rating: 150%

N. Rotary (Damper) Position Sensors:
   1. Manufacturers: Kele & Associates, Fisher Controls or Westlock
   2. Provide position 4-20 mA transmitter with potentiometer type (variable resistance) sensor for damper position measurement. Measurement to be linear to damper stroke.
      a. Performance:
         1). Power Supply: 24 VDC unregulated
2). Accuracy: ± 1% of output span
3). Repeatability: ± 0.5% of full span
4). Maximum Temperature: 125°F

O. P-E Transducers (Pressure Transmitters):
   1. Manufacturers: Ashcroft, Mamac, Setra, Kele & Associates or GE Modus
   2. Units shall have the following characteristics:
      a. Input: Pressure 0-15 psig, minimum
      b. Output Signal: 4-20 mA, 0-5 VDC, 1-5 VDC, 1-10 VDC
      c. Accuracy: 1% of span
      d. Operating Temperature: 32 to 125°F
      e. Power Requirements: 24 VDC (10-30 VDC)

P. Air Quality Monitor:
   1. MSA, Toxalert, Vulcain, Honeywell, Texas Instruments, Vaisala, Kele & Associates, Automation Components Inc. or approved equal
   2. Provide Air Quality Monitor as listed below for monitoring and control of minimum outside area for Building Areas. System shall be complete package with integral sensor, duct probe assembly, monitor, relay output, with local indication of current measured values for sensor and status of monitor. Device shall be housed in plastic enclosure. Indicator shall be mounted on enclosure faceplate.
   3. Unit shall have adjustable setpoints and self-test diagnostics.
      a. Gas to be Detected: Carbon Dioxide (CO₂)
      b. Power Requirements: 18 - 30 VAC, 50/60 Hz or 18-42 VDC
      c. Accuracy: ± 100 ppm
      d. Signal Input: Non-dispersive Infrared, Integral Sensor
      e. Signal Output: Linearized 0-10 VDC, or 4-20 mA DC
      f. Output Relay Rating: 2 Amp @ 24 VAC or 30 VDC
      g. Alarm Setpoint: User defined, software adjustable in 100 ppm increments via LCD or Interface Keypad
      h. Ranges: 0-2000 ppm
      i. Locations: Duct mounted in return duct or outside air plenum.
   4. Provide 120 VAC to 24 VAC transformer adjacent to Air Quality Monitor or provide 24 VAC from Temperature Control Panel nearest Air Quality Monitor.

Q. Space CO2 Sensors
   1. Manufacturers: Vaisala, Automation Components Inc., Toxalert, or approved alternate.
   2. Provide Carbon Dioxide Monitor as listed below. The system shall be a complete package with integral sensor, monitor, alarm contacts, local indication of current measured value for sensor.
      a. Gas to be Detected: Carbon Dioxide (CO₂)
      b. Power Requirements: 24 VAC, 50/60 Hz, 50 VA
      c. Signal Input: Integral Sensor
      d. Signal Output: 4-20 mA DC or 0-10 VDC
      e. Alarm Relays: 1 Amps, 120 VAC, Form C
      f. Range: 0-2000 ppm
      g. Alarm Setpoint: Field Adjustable, Factory set at 1000 ppm
h. Sensor  Infrared CO2 Sensor
i. Mounting:  Wall-mounted

3. Provide local display for continuous reading of CO₂ levels. Data shall be recorded on system with DDC to the zone level.

4. Unit shall have adjustable set points and self-test diagnostics.

5. Certified by manufacturer to require calibration no more frequently than once every 5 years. Provide 120 VAC to 24 VAC transformer adjacent to Air Quality Monitor or provide 24 VAC from Temperature Control Panel nearest Air Quality Monitor.

6. Sensors shall be wall mount type covers shall be custom color “bright white” to match room thermostats and/or temperature sensors.

R. Carbon Monoxide/Nitrogen Oxide Monitor:


2. Provide gas detection systems as listed below. Each system shall be complete package with remote or local space sensors, detection instruments, alarm contacts, local indication of current measured value for each sensor and status indicator lights for power and status of each sensor. Devices not requiring remote mounting shall be housed in metal control panel. All status indicators shall be mounted on panel faceplate.

3. Units shall have adjustable setpoints and self-test diagnostics.
   a. Carbon Monoxide
   b. Panel Location: Loading Dock
   c. Gas to be Detected: Carbon Monoxide, CO
   d. Alarm Setpoint: 35 ppm (FA)
   e. Range: 0-2.5 times Alarm Setpoint
   f. Nitrogen Dioxide
   g. Panel Location: Loading Dock
   h. Gas to be Detected: Nitrogen Oxide, NOX
   i. Alarm Setpoint: 1 ppm (FA)
   j. Range: 0-2.5 times Alarm Setpoint

4. Provide panel mounted alarm horn with silence switch.

5. Provide remote alarm/strobe panel as required when local alarm is not visible to occupants.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment, wiring and air piping in neat and workmanlike manner and in accordance with manufacturer's recommendations. Maintain clearances, straight length distances, etc., required for proper operation of each device. Mark and detail on coordination drawings, exact locations of inline devices, wells, and taps to be installed by Mechanical Contractor.

B. Coordinate timely delivery of materials and supervise activities of other trade Contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished by Control Contractor which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.
D. Mount motor control devices within 5 ft of disconnect switch, or starting device furnished by Electrical Contractor unless noted otherwise. Maintain required NEC clearances.

E. Control Contractor and Mechanical Contractor shall review proposed static pressure sensor and flow meter locations with Owner and Engineer for approval prior to installation.

### 3.2 GENERAL INSTRUMENTATION

A. Pressure Gauges (Pressure Indicators):
   1. Install pressure gauge for indication of supply and control pressure in pneumatic systems at output of controllers, I/P transducers, electric air solenoid valves, pressure switches and other points where visible indication of air pressure is required for operating and maintenance purposes.
   2. Provide test port for quick connection of test gauges at valve, damper motor and other actuator branch lines.
   3. Pressure gauge tappings in piping will be provided by Mechanical Contractor.

B. Thermometers (Temperature Indicators):
   1. Install thermometers at each point of temperature transmission and control, except for those that are indicated at local control panels. Install thermometers to permit easy reading from floor or operating platform (within 3 ft of line of sight). Provide remote bulb thermometers with readout indicators mounted within 3 ft of line of sight whenever sensing point is more than 3 ft from line of sight.
   2. Thermometer wells in piping will be installed by Mechanical Contractor.

C. Local Control Panels:
   1. Install remote mounted devices, controllers, I/O terminal blocks, power supplies, etc., inside of local control panels.
   2. Locate panels as shown on drawings.
   3. Locate panels adjacent to equipment served with minimum of 3 ft clearance in front of door. Provide sufficient clearances to allow full door swing and full access to internal components. Submit proposed panel locations with shop drawing submittals.
   4. Mount top of panels between 5 and 6 ft above floor so that gauges and indicators are at eye level.

D. General Instrumentation at Local Control Panels:
   1. Provide record control drawings of systems served by each local panel, in location adjacent to or inside of panel cover. Provide protective cover for drawing.

### 3.3 DISCRETE AND ANALOG INSTRUMENTATION

A. Wall Mounted Space Thermostats/Temperature Sensors:
   1. Install space thermostats/sensors where indicated, as required to perform specified control sequences, and as directed to meet job site conditions.
   2. Mount space thermostats/sensors at 5 ft above floor unless otherwise indicated.
   3. Mount space thermostats/sensors with accessible setpoint adjustment or temperature reading (thermometer or digital temperature readout) at 4 ft above floor.
   4. Space thermostats/sensors located on exterior walls shall be mounted on thermally insulated sub-base.
   5. Relocate space thermostats/sensors if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.
6. Mount space thermostats/sensors in corridors, stairways and public toilets 7 ft above floor.
7. Space thermostats/sensors in corridor, stairways, vestibules and toilets shall be aspirating type.

B. RTD Temperature Transmitters:
1. Provide RTD temperature transmitters whenever DDCPs cannot receive RTD type inputs.

C. Low Limit Temperature Switches (Freeze Stats):
1. Install low limit controls where indicated on drawings or as specified. Unless otherwise indicated, install sensing element on upstream face of cooling coil where cooling coil is provided, or at downstream side of heating coils where no cooling coil is provided.
2. Distribute sensing element across entire area of medium being sensed. Install controls at accessible location with suitable mounting brackets and element duct collars where required.

D. Static Pressure and Air Flow Stations:
1. Furnish static pressure and air flow measuring stations to Mechanical Contractor for installation.
2. Stations shall be installed in strict accordance with manufacturer's published requirements. These stations serve as primary signals for airflow control systems; therefore it shall be responsibility of Control Contractor to verify location and installation to assure that accurate primary signals are obtained.
3. Pressure differential switches shall be piped across device creating differential between fan discharge and fan suction.

E. Outdoor Static Pressure Sensor:
1. Furnish outdoor static pressure sensor as specified in control sequence. Mechanical Contractor will install sensor and associated pipe to below roof as shown on detail.

F. Direct Insertion Temperature Sensors:
1. Install sensor so that sensor is pointed down stream.

G. Temperature Switches (Aquastats):
1. Install aquastats across discharge face of coil or as close to outlet of coil on return water piping as possible.

H. Aquastats:
1. Aquastats for unit heaters and cabinet unit heats shall be mounted with sensing element in contact with leaving side of coil or the bottom of coil. If sensing element cannot be mounted in contact with coil, mount sensing element on pipe as close to discharge of coil as possible.

I. Outside Air Temperature Sensors:
1. Mount on north side of building or in intake area wells for air handling systems. Provide solar shields for installations where sensors may be exposed to sunlight conditions.

J. Building or Space Static Pressure Control System:
1. Extend 2” pipe between spaces for room pressure control or between space and outside for building static pressure control. Mount velocity sensor in tee fitting with one foot of straight pipe on either side of sensor. Terminal space and points inside of sheet metal plenum attached to return/exhaust grille. Terminate outside sensors on prevailing windward side of building with flapper type damper and full weather cover shroud constructed of aluminum painted to match building exterior.

K. Water Flow Meters and Flow Switches:
1. Install flow measuring devices with recommended straight pipe diameters upstream and downstream of elbows, tees, valves, or other fittings that cause uneven turbulent flow conditions.

2. If no recommendations are given, provide straight pipe equal to 10 pipe diameters upstream and 5 pipe diameters downstream.

L. Sensor Wells:
   1. Wells mounted in pipe 3" and larger may be installed in horizontal or vertical lines provided that element is always in flow, (for condensate and other gravity return lines, install in bottom of pipe). Wells mounted in pipe 2-1/2" and smaller shall be installed at elbow tee fittings with well pointed upstream. Minimum of 2" pipe size for elbow tee installation.

M. Transmitters, Indicators, and Transducers:
   1. Locate transmitters at sensing devices or within 100 ft of remote mounted transmitters. For hot systems (150°F and higher) mount electronics on side of pipe or remotely mount. For indicating type instruments, locate indicating element within 6 ft of floor with readout easily visible from floor level. Provide remote readouts if necessary.
   2. Provide pressure transducers integral to DDC panels or separate components to convert digital analog signals to variable pneumatic air pressure signals.
   3. Provide P-E transducers to convert analog pressure signals to analog electronic signals for input to DDC panels.

N. Air Quality Monitors:
   1. Provide duct mounting hardware for mounting in return air duct and outside air duct. Where mounting in walk-in plenum, use wall mounted installation.
   2. Locate in duct with 3 diameters straight run of duct before monitor for good air flow pattern. Locate wall mounted units in area with good air flow representation.
   3. Provide 120 VAC to 24 VAC transformer where monitor requires 24 VAC power.

END OF SECTION
SECTION 23 0993 CONTROL SEQUENCES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 0901 - Control System Integration, applies to the work of this Section.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Refer to sections stated under related work.

PART 3 - EXECUTION

3.1 CONTROL SEQUENCE

A. Systems shall perform in accordance with the following.

B. Refer to Control/Flow Diagrams and Control Points List for additional information.

C. Alarms

1. All Control and alarm setpoints shall be adjustable from the operator’s workstation for the Tridium Enterprise System or at local controllers via laptop software unless otherwise noted.

2. BAS shall annunciate alarm conditions when analog input values exceed their programmed ranges.

   a. Unless otherwise noted, alarm ranges shall be:

      1). Air Temperature: +/- 5°F from setpoint
      2). Water Temperature: +/- 10°F from setpoint
      3). Humidity: +/- 10% RH from setpoint
      4). Air Pressure: +/- 0.5" W.C. from setpoint
      5). Water Pressure: +/- 5 psig from setpoint
      6). Flow: +/- 25% of maximum flow range
      7). Level or Value: +/- 5% of maximum level or value from setpoint

3. All references to alarms, alarm setup, and alarm enunciation are to be programmed in the UK Tridium system and shall not be programmed in the BAS to annunciate at a non-Tridium workstation. Controls contractor shall coordinate all alarming with UK staff for required alarms.

   a. The contractor is set up the alarm parameters specified by the system sequences of operations without enabling the alarms. Contractor is to provide a list of points containing alarm extensions to PPDMC. PPDMC will be responsible for doing the alarm names, alarm texts and enabling the alarm points provided on the list.

4. Program alarm levels as indicated in sequences, based on the following levels.

   a. Urgent
   b. High Priority
   c. General Maintenance
5. All Input/Output points and BAS data objects shall have alarm parameters available for defining alarms.
6. Alarm monitoring and programming functions shall be restricted by password protection.
7. Coordinate alarm action requirements (printing, automatic dialing, etc.) with Owner.
8. Alarms shall remain active until alarm condition has cleared and alarm is reset manually.

D. Setpoints
1. All controlling setpoints shall be field-adjustable. The Control Contractor shall work in conjunction with the owner, commissioning agent, and Testing and Balancing Contractor to field adjust all final set points.
2. Control Contractor shall verify setpoints, time intervals, and limits based on actual field conditions. All setpoints, time intervals, and limits shall be optimized to achieve stable system operation, prevent damage to equipment, minimize maintenance requirements, and eliminate nuisance alarms (such as premature filter loading, false tripping of freezestats, and other similar conditions).
3. The terms ‘Adjustable Temperature Sensor’ and ‘Non-adjustable Temperature Sensor’ are used to describe space temperature sensors.
   a. Adjustable/User-Adjustable Temperature Sensor – space temperature sensor is provided with a slide or buttons that allow the space occupant to locally adjust the setpoint. All Adjustable Sensors shall be programmed with a locked/limited range. The range shall be displayed on the BAS graphic for each space and shall be adjustable from the graphic.
   b. Non-Adjustable Temperature Sensor – Flat plate type or plastic with no local adjustment. Setpoints are programmed at the BAS and shall be adjustable from the graphic for each room.

E. Switch Point Actuation
1. Provide each switch/Alarm trip point with an adjustable time delay to prevent nuisance tripping. These time delays apply to all switch points whether hardware or software and for normal operation. Additional or longer delays may be necessary during start-up or shut down as noted herein.
2. Unless otherwise specified, the time delay shall be as follows:

<table>
<thead>
<tr>
<th>Process or operation</th>
<th>Time Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>2 minutes</td>
</tr>
<tr>
<td>Motor starter</td>
<td>1 minute</td>
</tr>
<tr>
<td>Liquid pressure</td>
<td>1 minute</td>
</tr>
<tr>
<td>Gas pressure</td>
<td>1 minute</td>
</tr>
<tr>
<td>Pressure differential</td>
<td>1 minute</td>
</tr>
<tr>
<td>Level</td>
<td>30 seconds</td>
</tr>
<tr>
<td>Valve limit switch</td>
<td>2 minutes</td>
</tr>
<tr>
<td>Temperature indoor</td>
<td>5 minutes</td>
</tr>
<tr>
<td>High/Low Pressure Switch</td>
<td>5 second</td>
</tr>
<tr>
<td>High/Low Temperature Switch</td>
<td>5 second</td>
</tr>
</tbody>
</table>

3. If the time delays are less than the controller scan rate, the minimum controller scan rate shall be the time delay.

F. Variable Frequency Drives
1. VFDs shall be switched between HAND, OFF, and AUTO modes via manual local control adjustment at each VFD.
2. Control loops other than volume/pressure control loops using VFD speed outputs, shall continue to function in the HAND mode.
3. Motors shall operate at constant speed in the HAND mode. Remote start/stop control shall be via local control at each VFD.

4. All safety devices shall be wired as to be still active in the HAND mode.

5. Coordinate communication requirements with VFD manufacturer. All monitoring and control point data from VFD interface card shall be mapped to the BAS. VFD start/stop control and speed control points shall be hard wired from the BAS controller to the drive.

6. The control contractor shall coordinate with the Testing and Balancing Contractor to establish all final minimum and maximum VFD speeds. All minimum and maximum speeds listed in this specification are initial setpoints only.

G. Safety Devices
   1. All safety devices (low limits, high limits, etc.) shall have local manual reset.
   2. All safety devices shall be wired as to be still active when a VFD is in the HAND mode.

H. Pressure Transmitter/Sensors
   1. Pressure transmitter/sensors shall be hardwired directly back to the BAS controller that provides the control signal to the VFD(s). Sharing the static pressure or pressure differential signal via the BAS network is not allowed for control. **AHU static pressure signals will be shared through Tridium. Each AHU shall have at least 1 pressure transmitter hardwired directly back to each AHU controller.**
   2. All locations of pressure transmitters/sensors shall be supplied to the owner for inclusion on the building graphics.

I. Pump or Fan Operation Feedback
   1. When a device is required to run, the control system shall command the device to start by energizing the discrete output to the motor starting device. The device shall run until the control system commands the device to stop by de-energizing the discrete output to the motor starting device or an equipment failure occurs.
   2. Equipment failure is detected by opening of a low current switch, pressure differential switch, current input in Low-Low alarm condition (VFD), or VFD fault input when the device is commanded on, or is operating, or anytime the device status does not match the commanded state. If a failure occurs, the device shall be stopped and an alarm shall be generated at the BAS, designating that device has failed (see each sequence for alarm type details). This interlock shall be disabled for 30 seconds (FA) after the device is initially commanded to start. Failed pump or fan shall be locked out until manually reset through the BAS.
   3. Current switches affixed to one of the motor feed cables or pressure differential switch piped across inlet and outlet of fan or pump shall be used for equipment status indication.

J. System Air Volume Control (for variable volume AHUs with static pressure transmitters)
   1. Supply fans are variable speed and are controlled through variable frequency drives (VFD). Fan speed shall be controlled through BAS, to maintain system static pressure setpoint. **Phase 2 control contractor shall wire from Phase 2 AHU controller to the associated Phase 1 AHU controller a speed signal so fans ramp up and down together. Provide All existing static pressure transmitter(s) in supply ducts (as shown on drawings) that will be referenced to modulate fan VFD thru BAS.**
      b. See Section 3.1.H – Pressure Transmitter/Sensors
      c. Controls Contractor is to provide exact location of static pressure transmitters for inclusion on the building graphics.
2. Supply system static pressure control:
   a. If the static pressure at any transmitter drops below its respective setpoint, AHU supply fan VFD increase to maintain the static pressure transmitter at respective setpoint.
   b. If multiple static pressure transmitters rise above their respective setpoints, AHU supply fan VFD decrease until the pressure at one static pressure transmitter drops to its respective setpoint.
   c. All static pressure transmitter(s) shall be installed two-thirds down longest main duct section in each system and shall meet sensor manufacturer’s recommendations for locating devices of this type. Controls Contractor shall verify location of automatically operating dampers (including control dampers, fire/smoke, and smoke dampers) in the duct upstream of the static pressure transmitters. Any dampers located upstream of static pressure transmitters that can close automatically without operator intervention (manually operated dampers are the only exclusion) shall have damper position monitored by the BAS. When one of these automatically operating dampers is proven closed, the operating fans shall automatically be commanded to 30% (FA) of their maximum speed. After a 3 minute (FA) delay, the fans shall be released to control, however, static pressure transmitter(s) that are downstream of closed automatically operating dampers shall be flagged as inoperable and shall be disregarded by the AHU supply duct static pressure control sequence. When automatically operating dampers are proven open, static pressure transmitter(s) downstream of the previously closed automatically operating dampers shall be used in the low select process to modulate supply fan speed to maintain system static pressure. The Controls Contractor is responsible for determining the quantity and location of all automatically operating dampers.

3. If any static pressure transmitter is 80% above or below its setpoint, the static pressure transmitter shall be alarmed at the BAS, disregarded for the supply air static pressure control and remaining static pressure transmitters shall be used for control.

4. Upon loss of Tridium static pressure average signals, each AHU shall control to static pressure sensor wired to individual AHU controller.

5. Control Contractor shall work in association with Test and Balance Contractor to determine actual required static pressure setpoint ranges of each transmitter. Setpoints indicated above are to be used for initial system startup. Actual static pressure setpoints shall be the minimum static pressure required to achieve system design flow at minimum and maximum design conditions.

3.2 POWER FAILURE MODE SEQUENCE

A. General:

1. Power failure shall be determined by position of automatic transfer switch in conjunction with test mode indication from power management system. Control Contractor is responsible for obtaining status signal and all necessary wiring for status signal from automatic transfer switches to BAS.

2. Pump and fan VFDs shall be programmed for automatic restart after a complete stop upon power resumption when normal power is lost and automatic transfer switches are in the essential power system position.
   a. Test mode indication from power management system shall be monitored by the BAS. During the monthly routine tests of the power system when test mode status is indicated, pumps and fans served by essential power shall not be shut down and restarted when automatic transfer switches are in essential power position.

3. All control valves serving reheat coils shall maintain their last control position upon loss of power or loss of control signal.
B. Managed Restart:
   1. BAS shall monitor normal power indication and on loss of normal power for duration of 2
      seconds (FA) or longer, all equipment shall be commanded stopped by the BAS. When
      Essential Power is established as indicated by automatic transfer switches, BAS shall restart
      system components served by Essential Power based on the following Priority Sequence. Start
      sequence under each automatic transfer switch shall not begin until associated automatic
      transfer switch has been proven switched to the generators. Equipment designated to operate
      on essential power, but not included in the following priority list (referred to hereinafter as
      “subsequent” equipment) shall not start until priority equipment start-up sequence is complete.
      Start-up of subsequent equipment shall not be delayed for proof of actual operation of priority
      equipment. Once all priority equipment has been commanded to start, proceed immediately to
      start-up of subsequent equipment. Provide software adjustable time delay between starting of
      components serving a common system (set initial delay at 5 seconds (FA)).
   2. Equipment operating under essential power shall not exceed the respective system capacity
      requirements. Capacity control sequencing (lead-lag control for capacity control) shall remain
      in effect during essential power operation. The following priority sequence indicates the
      equipment designated (given permission) to operate on essential power if needed by system
      capacity control sequence and the relative operation priority of that equipment.

C. Priority Sequence:
   1. Automatic Transfer Switches shall be monitored by the BAS via MODBUS connection. Monitor
      the following status:
      a. Switch in Normal Position
      b. Normal Source Not Available
      c. Switch in Essential Position
   2. Upon power failure, HVAC equipment shall begin restarting in sequence as indicated below
      upon indication the equipment’s respective Automatic Transfer Switch (ATS) has switched to
      Essential Power. No delay shall be programmed on a switch back to Normal Power from
      Essential power. Refer to electrical schedules, control sequences, and DDC points schedule
      for equipment connected to Essential Power and ATS the equipment resides on.
   3. When Equipment ATS is proven in the Essential Power position by contacts, the following
      HVAC devices shall be started in order listed by respective ATS as indicated in device
      sequences following with 5 second (FA) intervals between restart of devices:
      a. HW, RHW, CHW, MTCHW, Energy Recovery System (Konvekta)
         1). Converters
         2). Pumps
      b. All EAHUs
      c. All AHUs
      d. Humidification RO water system
      e. Terminal Units

3.3 ENERGY RECOVERY SYSTEM (KONVEKTA) - CONTROL SEQUENCE

A. Scope:
   1. Existing energy recovery system consists of:
      a. Hydronic skid which is provided with variable volume pumps, heating hot water heat
         exchangers, medium temperature chilled water pumps, medium temperature heat
         exchangers and all necessary control valves.
b. Energy recovery coils in supply and exhaust air handling units.

c. System is existing provided with a packaged controller which controls safety, operating and capacity control of the system.

2. Energy recovery pumps will circulate glycol water to energy recovery coils located in the supply and exhaust air handling units to recovery energy.

B. Unit Operation:

1. Unit operation shall be automatic and activated through building automation system.

2. Konvekta shall provide a BACnet MSTP connection port on their controller for communication to the controller Phase 1 contractors system.
   a. BACnet MSTP connection to Phase 1 BAS.

C. Interlocking:

1. Energy Recovery System shall be interlocked with the following:
   a. Interlock with each AHU and EAHU associated with the energy recovery system startup shutdown.
   b. Each AHU (AHU-1 thru 8) via BAS BACnet MSTP communication will provide the following:
      1). Supply air flow
      2). Outside air temperature
      3). Supply air temperature setpoint
      4). Supply air temperature
      5). Glycol water supply temperature
   c. Each AHU (AHU-1 thru 8) shall have the following sensors/valves hardwired back to the Konvekta controller:
      1). Glycol water supply control valve (provided by Konvekta)
      2). Glycol water supply temperature sensor
      3). Coil discharge temperature sensor (provided by Konvekta)
   d. MeeFog Humidification
      1). Shall have a direct cable connection between the MeeFog controller and the Konvekta controller.
      2). Phase 2 control contractor to wire 0-10V signal from Konvekta panel to solenoid valve control panel to modulate valves.

3.4 EXISTING HUMIDIFICATION RO WATER SYSTEM (MEEFOG) - CONTROL SEQUENCE

A. Scope

1. Existing humidification system consists of:
   a. Two humidifier booster pumps will deliver RO water to AHU-5 thru 8, atomizing humidifier control valves.
   2. Humidification RO water system shall provide humidification to AHUs meet the humidification setpoint.

B. Operation

1. On call for either evaporative cooling or humidification, MeeFog skid shall be enabled and interlocked pumps shall start.
a. On call for evaporative cooling, via Konvekta control, Konvekta will send signals to MeeFog valve control panel.
   1) Konvekta will enable MeeFog valve control panel based on airflow in EAHU from airflow measuring station.
   2) Konvekta will send a humidification setpoint, 4-20V signal, to the MeeFog valve control panel to modulate the evaporative cooling valves.

b.a. On call for humidification from AHUs, BAS shall send signals to MeeFog valve control panel.
   1) BAS will enable MeeFog valve control panel based on airflow in AHU via supply airflow measuring station.
   2) BAS will send a humidification setpoint, 4-20-10V signal, to the MeeFog valve control panel to modulate the evaporative cooling valves.
      a). When the exhaust relative humidity less than 30% (FA), the MeeFog valves shall modulate to maintain the exhaust humidity setpoint. The reverse shall occur as the exhaust air humidity increases past the setpoint.

C. Interlocking:
   1. Humidification RO water system shall be interlocked with the following:
      a. Interlock with each AHU and EAHU that is provided with humidification or adiabatic cooling startup shutdown.
      b. Each AHU via BAS communication (thru Tridium) will provide the following:
         1). BAS shall calculate exhaust air dew point to send signal to modulate humidification valves
            a). Exhaust air Humidity existing sensor
            b). Exhaust air temperature existing sensor
         2). Airflow via supply airflow measuring station.
         3). High limit supply humidity sensor shall shut off humidification valves when high humidity setpoint is met.

3.5 VIVARIUM AHU-7 & 8 (5&6 EXSITING) - CONTROL SEQUENCE

A. System Description:
   1. Refer to drawings IC-750.
   2. System
      a. Air handling units operate in parallel Lead-lag-lag-Standby to serve each respective vivarium space. AHU-7 and 8 serve Level SB vivarium spaces.
      b. Each unit is 100% outside air unit with run-around heat recovery/preheating, cooling and humidification, single duct, variable volume system.
      c. Units are sized so that one of the three air handling units can serve the respective vivarium space at 100% design air flow to allow downtime for routine maintenance of one unit at a time.
   3. Each air handling unit consists of:
      a. Supply fan array with backdraft damper on each fan
      b. Two VFDs for each fan array. One VFD in each array is fully redundant.
      c. Energy Recovery coil
      d. Cooling coil
      e. Humidifier
      f. Pre-filter and final filter
g. UV Light
h. Outside air damper
i. Supply/discharge air smoke/isolation damper

4. Air handling unit supply fan array. Each fan is controlled via a packaged VFD with backup VFD.

B. Interlocking:

1. Whenever an AHU stops, all supply fans stop, AHU outside air and supply isolation dampers shall close and be proven closed by end switches.

2. Energy Recovery system shall be proven operational prior to enabling supply air system as indicated by BAS signal from Energy Recovery System controller.
   a. There shall be an optional override at the BAS to start the unit without the Energy Recovery system enabled.

3. Exhaust air handling unit (EAHU-X) fans shall be proven operational via exhaust fan status prior to enabling supply air system.
   a. There shall be an optional override at the BAS to start the unit without the associated EAHU enabled.

4. Refer to Energy Recovery System Control Sequence for additional interlocked points and hardwired sensors.

5. Software interlock associated humidifier so that humidifier will be inoperative and humidifier control valves will be fully closed when the following conditions occur:
   a. Respective air handling unit supply fans are not operating.

6. When an air handling unit is not operating except during low temperature switch shutdown, control devices shall be in the following positions:
   a. Supply smoke/isolation air damper Closed
   b. Outside air damper Closed
   c. Chilled water cooling coil control valve Closed
   d. Hot glycol water heating coil control valve Closed
   e. Energy Recovery coil control valves Under Control
   f. Humidifier solenoid control valves Under Control
   g. Supply fans Off

C. Unit Operation:

1. Unit operation shall be automatic and activated through Tridium.
   a. If one of three units in parallel is shut down for maintenance or due to safety interlock, the other unit shall continue to operate and the standby AHU shall be started.
   b. If one unit is on (lead unit) and the other is off (standby unit) in parallel, when the standby unit is commanded to start, following start up sequence below, unit shall restart with the lead unit still on. When the standby unit is proven operational and fan arrays for primary unit and standby unit are operating in parallel, lead unit shall stop. When lead AHU is stopped, lead-lag-standby AHU designation shall be switched.
   c. On failure of lead/lag AHU, lock out primary AHU, start standby AHU, and generate an alarm through the BAS.
      1). When an automatically locked out AHU is released from lockout, it shall become the standby AHU, and the operating AHU shall become the primary.
2. System does not require occupied-unoccupied operation. System shall operate continuously when enabled.

D. System and Fan Operation:
   1. System shall manually start/stop and run continuously by command from operator via BAS command point.
   2. When an AHU is commanded to start via BAS command point, the following sequence shall occur:
      a. Associated EAHU system shall be proven on.
      b. Energy recovery system shall be proven on.
      c. AHU supply fans shall start and hold at minimum speed while AHU discharge smoke/isolation damper and outside air damper open. When discharge smoke/isolation damper and outside air dampers are proven open via open position end switches, AHU supply fans shall be released to control allowing fans to ramp up.
         1). On initial startup and any time system has been restarted after a shutdown, supply and associated exhaust systems shall be held at minimum speed and released to control simultaneously.
         2). Whenever the respective supply isolation damper or outside air damper do not prove open via open position end switches within 60 seconds (FA) of open command, the dampers shall close, the AHU fans shall fail, and an alarm shall be annunciated at the BAS. The failed AHU shall be locked out and remain locked out until manually reset though the BAS.
      d. When system is commanded to stop; supply fans shall stop, the outside air dampers shall close. AHU supply smoke/isolation damper shall close when supply fans reach minimum speed.
      e. When any fan is commanded to start via H-O-A switch on VFD, the following sequence shall occur:

E. Fan Failure Detection:
   1. If an AHU supply fan failure occurs, as detected by VFD status or fault indication, the failed supply fan shall be stopped, remaining operating supply fans shall ramp up to maintain system airflow, and an alarm shall be annunciated at the BAS. This alarm interlock shall be disabled for 60 seconds (FA) after the fan is initially commanded to start.
      a. When failed AHU supply fan is reset through BAS, failed supply fan shall restart on minimum speed. When failed AHU supply fan is operating normally, AHU supply fan speeds shall be controlled in parallel.
   2. If two or more supply fans fail, as detected by VFD status or fault indication, or system duct static pressure falls and remains below setpoint for 5 consecutive minutes (FA), the AHU shall be stopped, the outside air and outlet isolation dampers shall be closed, and an alarm shall be annunciated at the BAS. This alarm interlock shall be disabled for 60 seconds (FA) after the AHU is initially commanded to start.
      a. When failed AHU is reset through BAS, failed AHU supply fans shall restart as indicated previously in this section. When failed AHU supply fan is operating normally, AHU supply fan speeds shall be controlled in parallel.
   3. If both AHU fan arrays fail, as detected by system duct static pressure fails and remains below setpoint for 10 consecutive minutes (FA), the interlocked EAHU exhaust fans shall go to
minimum speed. Interlocked EAHU exhaust fans shall remain at minimum speed until system duct static pressure setpoint is met.

4. If an AHU failure occurs, as detected by all VFD fault indications, or failed outlet isolation damper, the failed AHU shall be stopped, standby AHUs shall start and ramp up to maintain system airflow, and an alarm shall be announced at the BAS. This alarm interlock shall be disabled for 60 seconds (FA) after the AHU is initially commanded to start.
   a. When failed AHU is reset through BAS, failed AHU supply fan wall array fans shall restart on minimum speed. When failed AHU supply fans are proven operational by status indication, outside air damper of failed AHU shall open. When outside air damper is proven open with open position end switch, AHU supply fans shall ramp up to 20% speed while operating AHU’s serving the system ramp down to 55%. When AHU fan speeds are at the speeds indicated, the restarted AHU’s supply smoke/isolation damper shall open and restarted AHU fan speeds shall ramp up to match the operating AHU’s fan speeds. When all fans are operating at same speed, speed control of all AHU’s shall be released to control, to maintain system at static pressure setpoint.
   b. When failed AHU is reset through BAS, failed AHU supply fan wall array fans shall restart on minimum speed. When failed AHU supply fans are proven operational by status indication, outside air damper of failed AHU shall open. When outside air damper is proven open with open position end switch, AHU supply fans shall ramp up to 20% speed while operating AHU’s serving the system ramp down to 55%. When AHU fan speeds are at the speeds indicated, the restarted AHU’s supply smoke/isolation damper shall open and restarted AHU fan speeds shall ramp up to match the operating AHU’s fan speeds. When all fans are operating at same speed, speed control of all AHU’s shall be released to control, to maintain system at static pressure setpoint.

5. If both AHU’s fail, as detected by system duct static pressure falls and remains below setpoint for 10 consecutive minutes (FA), the interlocked EAHU exhaust fans shall go to minimum speed. Interlocked EAHU exhaust fans shall remain at minimum speed until system duct static pressure setpoint is met.

6. Provide a manual reset switch at the AHU temperature control panel to reset all locked out fans locally as well as through the BAS.

7. Provide a manual reset switch at the AHU temperature control panel to reset all locked out fans locally as well as through the BAS.

F. System Air Volume Control:
   1. Each AHU shall have its own hardwired discharge static pressure sensor. Both sensors will be located where the ducts first converge into a single duct.
      a. Wire the following to the individual AHU controller:
         1). (1) one existing sensor for AHU-7
         2). (1) one existing sensor for AHU-8
   2. Static pressure control shall low select the lowest reading static of existing pressure transmitters. Low selected remote static pressure sensor shall reset setpoint of both AHU discharge static pressure transmitters.
      a. See 3.1.J System Air Volume Control (for variable volume AHUs with static pressure transmitters)
      b. Controls Contractor is to provide exact location of static pressure transmitters for inclusion on the building graphics.

G. Unit Discharge Air Temperature Control:
   1. General:
      a. Discharge air temperature shall be controlled through the BAS with temperature sensors located as specified herein.
      b. Discharge air temperature shall be controlled to 55°F (FA).
   2. Energy Recovery/Preheating Coil – All Modes
      a. Energy recovery AHU control valves shall be enabled when air flow is detected via supply airflow measuring station.
      b. Energy recovery system controller shall modulate flow to each respective coil to maximize heat transfer and to maintain discharge air temperature setpoint immediately downstream of energy recovery coil.
1). When cooling coil is off and unit supply temperature is above setpoint, cooling coil discharge temperature shall be reset -1°F (FA) until unit supply temperature is at setpoint.

3. Reheating Coil Discharge Air Temperature Control – Normal Operation:
   a. Reheating coil control valve shall modulate to maintain coil discharge air temperature at setpoint via averaging type sensor downstream of the humidifier.
      1). As coil discharge air temperature decreases, reheating coil control valve shall modulate open to maintain coil discharge air temperature at setpoint. The reverse shall occur as coil discharge air temperature increases.
   b. Reheating coil discharge air temperature setpoint shall be reset to maintain AHU discharge air temperature at 55°F (FA), as measured by probe type sensor downstream of the discharge air smoke/isolation damper.

4. Reheating Coil Discharge Air Temperature Control – AHU Not Running Operation:
   a. Reheating coil control valve shall modulate to maintain 48°F (FA) reheating coil discharge air temperature anytime AHU is not running and safety low temperature limit control (freeze-stat) is not in alarm.

5. Cooling Coil Discharge Air Temperature Control:
   a. On a call for cooling, the heating valves shall be closed before the cooling coil control valve shall be allowed to modulate open.
   b. Cooling coil control valve shall modulate to maintain unit discharge air temperature of 55°F (FA) via probe type sensor located in the supply duct downstream of the AHU discharge smoke/isolation dampers.
      1). In cooling mode when outside air temperature is above 49°F (FA) as unit discharge air temperature increases, cooling coil control valve shall modulate open to maintain unit discharge air temperature at setpoint. The reverse shall occur as unit discharge air temperature decreases.
   c. Cooling coil control valve shall be locked in closed position whenever outside air temperature is below 49°F (FA) for 10 consecutive minutes (FA) or whenever associated supply fan is not operating, when safety low temperature limit control (freeze-stat) is not in alarm.
   d. The BAS shall monitor space humidity via return air humidity sensor. When the space dew point rises above 53°F (FA), the cooling coil control shall be overridden and the discharge air temperature setpoint shall be lowered to maintain space dew point at 52°F (FA) or below.

6. The cooling coil control valve and preheating coil control valve shall not be allowed to operate simultaneously.

H. Humidity Control:
   1. Humidifiers - Space Humidity Control
      a. If all supply fans are off, its respective humidifier valves shall close.
      b. Humidifier valves shall be enabled when air flow is detected via supply airflow measuring station.
      c. Humidifier control package, after being enabled by AHU control, shall be staged open/closed solenoid control valves to maintain exhaust humidity setpoint 30% RH within ±5% RH of setpoint (FA).
   2. Exhaust air humidity sensors are located in exhaust air ducts upstream of Exhaust Air Handling Unit.
3. Exhaust Air Handling Units Control is part of the Phase 1 provided Controller. AHU shall receive humidity signal through Tridium for humidity control.

I. Duct Mounted Ion Detector (IDETECT)
   1. IDETECT sensor is owner furnished contractor installed. Install sensor in supply ductwork at discharge of AHU.

J. Smoke Control:
   1. Duct Smoke Detectors
      a. Duct mounted smoke detectors are specified to be furnished, installed, and wired to the building fire alarm system under Fire Alarm.
      b. Each detector shall provide an available contact closure for use by BAS, or an external addressable relay module shall be provided for this function. The contact shall be hardwired by the BAS contractor to shut down the supply fan and return fan arrays, and generate a binary input alarm at the BAS. The BAS contactor shall provide a pilot relay if necessary.
      c. Through software, this shall disable the supply fan arrays, close the outdoor air damper, and close the chilled water valve.

K. Safeties:
   1. Provide safety low temperature limit control (freeze-stat), with 3 minute (FA) time delay from fan start signal at entering side of cooling coil. Low limit shall de-energize unit supply fans; close outside air damper, close supply isolation damper, open cooling coil control valve; and modulate reheating coil control valves to maintain reheat coil discharge air temperature (measured downstream of reheat coil) at 60°F (FA) when air temperature falls below 38°F (FA) over any one-foot section of the freezestat. Low limit shall be functional in VFD H-O-A mode of operation.
   2. Provide high static pressure limit control, with sensor located in unit discharge air duct downstream of supply smoke/isolation damper, to limit fan volume control at 4.5" WC (FA) when pressure reaches this value.
   3. Provide high static pressure safety switch between discharge of supply fan wall array fans and outlet smoke/isolation damper and wire in series with VFD safety circuits to stop respective supply fans. The pressure switch shall be adjusted to 5.0" WC (FA). The status of the pressure switch shall be wired to the BAS system for alarming. The pressure switch must be manually reset locally before the air handling unit can be restarted. High static pressure safety switch shall be functional in VFD hand mode of operation. If high static pressure safety switch is tripped, AHU shall be shutdown.
   4. Provide low static suction pressure safety switch downstream of cooling coil and upstream of supply fan wall array fans and wire in series with VFD safety circuit to stop respective supply fans. The pressure switch shall be adjusted to -5.0° WC (FA). The status of the pressure switch shall be wired to the BAS system for alarming. The pressure switch must be manually reset locally before the air handling unit can be restarted. Low static pressure safety switch shall be functional in VFD hand mode of operation. If low static suction safety switch is tripped, AHU shall be shutdown.

L. Power Failure Mode:
   1. AHU is served by emergency power and shall be allowed to operate during emergency power operation.
   2. When normal power fails as indicated by automatic transfer switch, all operating AHU in the system shall be commanded stopped.
3. When emergency power is established as indicated by automatic transfer switch, normal control sequence shall be initiated. Refer to POWER FAILURE MODE SEQUENCE, Paragraph 3.2 for restart sequence.

4. Upon resumption of normal power as indicated by automatic transfer switch, normal AHU system operation shall resume with no interruption of power to operating AHU. Refer to POWER FAILURE MODE, previously documented in this specification section for restart sequence of stopped AHUs.

M. Monitor and Alarm
1. Each alarm shall be recorded in the alarm event log. Each alarm shall require an operator acknowledgment at the BAS.
2. Each alarm shall automatically return to normal when status and command conditions match. The return to normal status shall be recorded in the alarm event log. No operator acknowledgment shall be required on the return to normal.
3. Monitor, through BAS, the following points associated with air handling system and generate the alarms indicated:
   a. Discharge air temperature – each AHU (AI)
      1. Generate Urgent Alarm if temperature exceeds setpoint by ±3°F (FA).
   b. Discharge air humidity – each AHU (AI) (See humidit13y control sequence)
      1. Generate Urgent if supply humidity rises above 70% RH (FA).
   c. Reheating coil discharge air temperature – each AHU (AI)
      1. Generate High Priority alarm if temperature deviates from setpoint by ±3°F (FA) for 10 consecutive minutes (FA).
   d. Low limit thermostat (freezeastat) – each AHU (DI)
      1. Generate Urgent alarm and stop AHU.
   e. Discharge air humidity – each AHU (AI)
      1. Generate Urgent alarm if discharge % RH exceeds setpoint by ±5% RH.
   f. Supply fan VFD status - each fan (DI)
   g. Supply fan VFD Fault – (DI)
      1. Generate Urgent alarm.
   h. VFD H-O-A switch –VFD (DI)
      1. Generate High Priority alarm if switch is in any position other than auto.
   i. Outside air damper position – open and closed (DI)
      1. Generate Urgent alarm if damper is not proven open within 60 seconds (FA) of AHU start signal or closed within 60 seconds (FA) of AHU stop signal.
   j. AHU smoke/isolation damper position – open and closed – (DI)
      1. Generate Urgent alarm if damper is not proven open within 60 seconds (FA) of fan start signal or proven closed within 60 seconds (FA) of fan stop signal.
   k. Prefilter pressure drop – each filter (AI)
      1. Generate General Maintenance alarm when filter pressure drop exceeds setpoint of 0.5" WC (FA).
   l. Final filter pressure drop – each filter (AI)
      1. Generate General Maintenance alarm when filter pressure drop exceeds setpoint of 1.5" WC (FA).
   m. Supply duct static pressure transmitter – each transmitter (AI)
1. Generate High Priority alarm if pressure deviates from setpoint by ±1” WC (FA) for 5 consecutive minutes (FA).

n. Fan discharge low static pressure safety switch – (DI)
   1. Stop fan and generate Urgent alarm if pressure exceeds -5” WC (FA).

o. Fan discharge high static pressure safety switch – (DI)
   1. Stop fan and generate Urgent alarm if pressure exceeds 5” WC (FA).

p. Duct static pressure transmitter – (AI)
   1. Generate High Priority alarm if pressure exceeds setpoint by ±1.0” WC (FA).

q. Supply fan discharge smoke detector – (DI)
r. IDETECT - Duct Mounted Ion Detector
   1. Generate High Priority alarm.

3.6 LAB AIR HANDLING UNIT AHU-2 & 4 (1 & 3 EXISTING)

A. System Description:
   1. Refer to drawing IC-751.
   2. Each unit is 100% outside air unit with run-around heat recovery.
   3. Units are sized so that 24 air handling units can serve the respective lab space at 100% design air flow.
      a. AHU-1 & AHU-2 serve the Wet Labs
      b. AHU-3 & AHU-4 serve the Dry Labs

3.4 Each pair of AHUs shall run lead-lag.

4.5 Air handling unit consists of:
   a. Supply fan array with backdraft damper on each fan
   b. Two VFDs for supply fan array. One VFD is fully redundant.
   c. Chilled water cooling coil
   d. Energy Recovery water heating/cooling coil
   e. Pre-filter
   f. Final-filter
   g. Bipolar Ionization
   h. Outside air damper
   i. Supply smoke/isolation air damper

5.6 Supply fan motor status is indicated by a current switch on each fan.

B. Interlocking:
   1. Whenever an AHU stops, all AHU supply fans stop, AHU outside air damper and supply isolation damper shall close and be proven closed by end switches.
   2. Energy Recovery system shall prove operational prior to enabling supply air system as indicated by BAS signal from Energy Recovery System controller.
      a. There shall be an optional override at the BAS to start the unit without the Energy Recovery system enabled.
   3. Exhaust air handling unit (EAHU-1, 2 and 3) fans shall be proven operational via current sensor on exhaust fans prior to enabling supply air system.
      a. There shall be an optional override at the BAS to start the unit without the associated EAHU enabled.
4. Refer to Energy Recovery System Control Sequence for additional interlocked points and hardwired sensors.

5. When an air handling unit is not operating except during low temperature switch shutdown, control devices shall be in the following positions:
   a. Supply smoke/isolation air damper         Closed
   b. Outside air damper                        Closed
   c. Chilled water cooling coil control valve  Closed
   d. Hot glycol water heating coil control valve Closed
   e. Energy Recovery coil control valves      Under Control
   f. Supply fans                               Off

6. C. Unit Operation:
   1. Unit operation shall be automatic and activated through Tridium.
   2. All units shall start and ramp fans together. All units shall receive static pressure setpoint from Tridium for fan control.
   3. System does not require occupied-unoccupied operation. System shall operate continuously when enabled.

D. System and Fan Operation:
   1. System shall operate continuously.
   2. System shall manually start/stop and run continuously by command from operator via BAS command point.
   3. When an AHU is commanded to start via TridiumBAS command point, the following sequence shall occur:
      a. AHU supply fans shall start and hold at minimum speed while AHU discharge smoke/isolation damper and outside air damper open. When supply smoke/isolation damper and outside air dampers are proven open via open position end switches, AHU supply fans shall be released to control allowing fans to ramp up.
      b. When system is commanded to stop; supply fans shall stop, the outside air dampers shall close. AHU supply smoke/isolation damper shall close when supply fans reach minimum speed.
      c. When any fan is commanded to start via H-O-A switch on VFD, the following sequence shall occur:

E. Fan Failure Detection:
   1. If an AHU supply fan failure occurs, as sensed by current switch, an alarm shall be annunciated at the BAS. This alarm interlock shall be disabled for 120 seconds (FA) after the fans are initially commanded to start. Upon failure, affected supply fan shall shut down while remaining supply fans continue to operate to maintain static pressure setpoint.
   2. If supply fan VFD failure occurs, as detected VFD fault indication from VFD output, the fans shall be stopped and an alarm shall be annunciated at a Tridium workstation. This alarm interlock shall be disabled for 60 seconds (FA) after the fans are initially commanded to start. Upon failure, the AHU shall be shut down.
   3. If AHU fails, the interlocked EAHU exhaust fans shall go to minimum speed. Interlocked EAHU exhaust fans shall remain at minimum speed until system duct static pressure setpoint is met.
4. Provide manual reset switch at the AHU temperature control panel to reset unit locally as well as through the BAS.
   a. Each alarm shall automatically return to normal when status and command conditions match. The return to normal status shall be recorded in the alarm event log. No operator acknowledgment shall be required on the return to normal.

F. System Air Volume Control

1. Each AHU shall have its own hardwired discharge static pressure sensors. Both sensors will be located where the ducts first converge into a single duct.
   a. Wire to existing:
      1). (4) existing sensors for AHU-1/2
      2). (5) existing sensors for AHU-3/4

2. Existing static pressure transmitters in supply ducts shall reset setpoint of both AHU discharge static pressure transmitters. Discharge static pressure transmitter shall be used to modulate fan VFD thru BAS. AHU 1&2 shall modulate to maintain lowest pressure transmitter of 4 existing sensors. AHU 3 &4 shall modulate to maintain lowest pressure transmitter of 5 existing sensors.
   a. See 3.1.O System Air Volume Control (for variable volume AHUs with static pressure transmitters)
   b. AHU controllers shall receive an averaged static pressure control setpoint from Tridium.
   c. Controls Contractor is to provide exact location of static pressure transmitters for inclusion on the building graphics.

G. Unit Discharge Air Temperature Control:

1. General:
   a. Discharge air temperature shall be controlled through the BAS with temperature sensors located as specified herein.
   b. Discharge air temperature shall be controlled to 55°F (FA).

2. Energy Recovery/Preheating Coil– All Modes
   a. Energy recovery AHU control valves shall be enabled when air flow is detected via supply airflow measuring station.
   b. Konvekta control package shall modulate flow to each respective coil based on proprietary software to maximum heat transfer and to maintain discharge air temperature setpoint immediately downstream of energy recovery coil.
      1). When cooling coil is off and unit supply temperature is above setpoint, cooling cool discharge temperature shall be reset -1°F (FA) until unit supply temperature is at setpoint.
   c. Phase 2 Control contractor shall send the energy recovery coil discharge air temperature setpoint to Konvekta via hardwired connection to Konvekta controller.
      1). Control contractor shall program a coil discharge temperature setpoint reset to maintain the AHU discharge air temperature setpoint.
      1). e.d. Energy recovery coil control valve shall modulate to maintain 48°F (FA) heating coil discharge air temperature anytime AHU is not running and safety low temperature limit control (freeze-stat) is not in alarm.

3. Cooling Coil Discharge Air Temperature Control:
   a. On a call for cooling, the heating valves shall be closed before the cooling coil control valve shall be allowed to modulate open.
b. Cooling coil control valve shall modulate to maintain unit discharge air temperature of 55°F (FA) via probe type sensor located in the supply duct downstream of the AHU discharge smoke/isolation dampers.

1). In cooling mode when outside air temperature is above 49°F (FA) as unit discharge air temperature increases, cooling coil control valve shall modulate open to maintain unit discharge air temperature at setpoint. The reverse shall occur as unit discharge air temperature decreases.

c. Cooling coil control valve shall be locked in closed position whenever outside air temperature is below 49°F (FA) for 10 consecutive minutes (FA) or whenever associated supply fan is not operating, when safety low temperature limit control (freeze-stat) is not in alarm.

d. The BAS shall monitor space humidity via return air humidity sensor. When the space dew point rises above 53°F (FA), the cooling coil control shall be overridden and the discharge air temperature set point shall be lowered to maintain space dew point at 52°F (FA) or below.

4. The cooling coil control valve and preheating coil control valve shall not be allowed to operate simultaneously.

H. Smoke Control:

1. Duct Smoke Detectors
   a. Duct mounted smoke detectors are specified to be furnished, installed, and wired to the building fire alarm system under Fire Alarm.
   b. Each detector shall provide an available contact closure for use by BAS, or an external addressable relay module shall be provided for this function. The contact shall be hardwired by the BAS contractor to shut down the supply fan and return fan arrays, and generate a binary input alarm at the BAS. The BAS contractor shall provide a pilot relay if necessary.
   c. Through software, this shall disable the supply fan arrays, close the outdoor air damper, and close the chilled water valve.

I. Duct Mounted Ion Detector (IDETECT)
   1. IDETECT sensor is owner furnished contractor installed. Install sensor in supply ductwork at discharge of AHU.

J. Safeties:

1. Provide safety low temperature limit control (freeze-stat), with 3 minute (FA) time delay from fan start signal at entering side of cooling coil. Low limit shall de-energize unit supply fans; close outside air damper, close supply isolation damper, open cooling coil control valve; and modulate re-heating coil control valves to maintain reheat coil discharge air temperature (measured downstream of reheat coil) at 60°F (FA) when air temperature falls below 38°F (FA) over any one-foot section of the freeze-stat. Low limit shall be functional in VFD H-O-A mode of operation.

2. Provide high static pressure limit control, with sensor located in unit discharge air duct downstream of supply smoke/isolation damper, to limit fan volume control at 4.5″ WC (FA) when pressure reaches this value.

3. Provide high static pressure safety switch between discharge of supply fan wall array fans and outlet smoke/isolation damper and wire in series with VFD safety circuits to stop respective supply fans. The pressure switch shall be adjusted to 5.0″ WC (FA). The status of the pressure switch shall be wired to the BAS system for alarming. The pressure switch must be manually reset locally before the air handling unit can be restarted. High static pressure safety
switch shall be functional in VFD hand mode of operation. If high static pressure safety switch is tripped, AHU shall be shutdown.

4. Provide low static suction pressure safety switch downstream of cooling coil and upstream of supply fan wall array fans and wire in series with VFD safety circuit to stop respective supply fans. The pressure switch shall be adjusted to -5.0” WC (FA). The status of the pressure switch shall be wired to the BAS system for alarming. The pressure switch must be manually reset locally before the air handling unit can be restarted. Low static pressure safety switch shall be functional in VFD hand mode of operation. If low static suction safety switch is tripped, AHU shall be shutdown.

K. Power Failure Mode:

1. AHU is served by emergency power and shall be allowed to operate during emergency power operation.
2. When normal power fails as indicated by automatic transfer switch, all operating AHU in the system shall be commanded stopped.
3. When emergency power is established as indicated by automatic transfer switch, normal control sequence shall be initiated. Refer to POWER FAILURE MODE SEQUENCE, Paragraph 3.2 for restart sequence.
4. Upon resumption of normal power as indicated by automatic transfer switch, normal lab AHU system operation shall resume with no interruption of power to operating AHU. Refer to POWER FAILURE MODE, previously documented in this specification section for restart sequence of stopped AHUs.

L. Monitor and Alarm

1. Each alarm shall be recorded in the alarm event log. Each alarm shall require an operator acknowledgment at the BAS.
2. Each alarm shall automatically return to normal when status and command conditions match. The return to normal status shall be recorded in the alarm event log. No operator acknowledgment shall be required on the return to normal.
3. Monitor, through BAS, the following points associated with air handling system and generate the alarms indicated:
   a. Unit discharge air temperature – each AHU (AI)
      1). Generate High Priority Alarm if temperature deviates from setpoint by ±2°F (FA) for 10 consecutive minutes (FA).
   b. Discharge air humidity – each AHU (AI) (See humidity control sequence)
      1). Generate High Priority Alarm if supply humidity rises above 65% RH (FA).
   c. Low limit thermostat (freeze stat) – each AHU (DI)
      1). Generate Urgent alarm and stop AHU.
   d. Supply fan VFD Fault – each fan (DI)
      1). Generate Urgent alarm.
   e. Supply fan VFD motor status – each fan (DI)
      1). Generate High Priority alarm if fan is not in commanded state after a 120 (FA) second delay.
   f. VFD H-O-A switch – each VFD (DI)
      1). Generate High Priority alarm if switch is in any position other than auto.
   g. Discharge static pressure high limit – each AHU (AI)
      1). Generate High Priority alarm if pressure deviates from setpoint by +0.5” WC (FA) for 5 consecutive minutes (FA).
h. Supply duct static pressure transmitter – each transmitter (AI)
   1). Generate High Priority alarm if pressure deviates from setpoint by ±1” WC (FA) for 5
      consecutive minutes (FA).

i. Discharge static pressure safety switch – each AHU (DI)
   1). Generate Urgent alarm and stop AHU if pressure exceeds 4.0” WC (FA).

j. AHU supply static suction safety switch – each AHU (DI)
   1). Generate Urgent alarm and stop AHU if pressure falls below -3.0” WC (FA).

k. Supply discharge smoke detector – each AHU (DI)
   1). Generate Urgent alarm and stop AHU.

l. Pre-filter pressure drop – (AI)
   1). Generate General Maintenance alarm when filter pressure drop exceeds setpoint of
      0.5” WC (FA).

m. Final filter pressure drop – each AHU (AI)

n. Generate General Maintenance alarm when pressure drop exceeds 1.2” WC

o. IDETECT - Duct Mounted Ion Detector
   1). Generate High Priority alarm.

3.7 EXISTING EXHAUST ENERGY RECOVERY WITH EVAPORATIVE COOLING (UNITS 1-4)

A. Scope

1. System Function
   a. Each exhaust energy recovery unit has one fan will always be on standby.
   b. Fan use will be rotated on a lead/standby status.
   c. Outlet cones are selected to provide minimum stack velocities at minimum flow with the
      use of OA bypass. Outlet cones for will require replacement as the system capacity is
      increased when additional spaces are fitted out.

2. Components/control devices provided by others.
   a. Exhaust fans with no bypass starters.
   b. Isolation dampers per exhaust fan.
   c. Exhaust fan VFDs.
   d. DIV 28 smoke detectors
   e. Glycol water valve will be furnished by Konvekta.
   f. Dampers shall be provided with the unit.
   g. All other devices are assumed to be by this controls contractor.

3. Operating Modes:
   a. Normal Occupied Mode: Fans shall run continuously.
   b. Normal Unoccupied Mode: Not applicable.
   c. Emergency Standby Power Mode: Fans are connected to emergency standby power.
      Fans shall automatically restart on resumption of power per cold start sequence.
   d. Fire/Smoke Mode: Fans shall continue to operate when a general fire alarm is
      annunciated and shall stop when smoke is detected in the supply air at any associated air
      handling unit.

B. Interlocking:

1. EAHU-1 is interlocked with the following units:
   a. AHU-1
   b. AHU-2
   c. EF-1A thru 1D
d. North side of the building exhaust and fume hoods for all floors

2. EAHU-2 is interlocked with the following units:
   a. AHU-3
   b. AHU-4
   c. EF-2A thru 2D
   d. South exhaust ducts and fume hoods for all floors
   e. HBP-2

3. EAHU-3 is interlocked with the following units:
   a. AHU-1
   b. AHU-2
   c. EF-3A thru 3D
   d. HBP-3

4. EAHU-4 is interlocked with the following units:
   a. AHU-5 (Existing)
   b. AHU-6 (Existing)
   c. AHU-7
   d. AHU-8
   e. HBP-3 (Existing)

5. Whenever an EAHU stops, exhaust inlet air and exhaust outlet isolation dampers shall close and be proven closed by end switches.

6. Associated AHU will stop when associated EAHU stops.

3.8 TERMINAL UNITS - CONTROL SEQUENCES

A. General:

1. Where CO2 sensors are shown in a space with air terminal units, the BAS shall monitor the CO2 level, and a General Maintenance alarm shall be annunciated at the BAS when the space CO2 level exceeds 1000 ppm.
   a. Where multiple CO2 sensors are shown in a space, the BAS shall average the reading among the sensors and use the average reading for control.
   b. On failure of one or more CO2 sensors as, indicated by loss of control signal the control loop(s) associated with the failed transmitter(s) shall be removed from the average reading algorithm, an alarm generated at the BAS and the remaining operating CO2 sensor(s) shall be used for CO2 control.

2. When a space is provided with multiple temperature sensors, unless otherwise indicated, the BAS shall select the temperature sensor which is farthest from set point for terminal unit control.
   a. On failure of one or more temperature sensors as, indicated by loss of control signal, the control loop(s) associated with the failed transmitter(s) shall be removed from the average reading algorithm, an alarm generated at the BAS and the remaining operating temperature sensor(s) shall be used for temperature control.

3. When a space is served by multiple supply air terminals, unless otherwise indicated, controls shall modulate the reheat valves to maintain common supply air temperature from each supply air terminal which is reset to maintain space temperature.
   a. When a space is served by multiple supply air terminals, controls shall modulate the damper actuators in parallel unless otherwise noted in the sequences below.
4. Where humidity sensors are shown, the BAS shall calculate room dew point using space humidity and temperature sensors.

5. The electrical contractor shall provide an occupancy sensor with a dedicated dry contact or relay for each occupancy sensor. Occupancy sensors shall be hard wired from the dry contact/relay to the controller by the Controls Contractor. Where multiple occupancy sensors are shown within a space, wire the sensors in series or parallel to provide one occupied/unoccupied signal to the controller. Occupancy sensors shall be used for control of ‘Vacant Mode’ as described below in each sequence.

6. Dew point monitoring and safety control (where applicable) shall be active in occupied and unoccupied modes.
   a. When the space dew point rises above 56°F (FA), the chilled water control valve serving the space shall be commanded closed.
   b. When the space dew point drops below 56°F (FA), the chilled water control valve serving the space shall be released back to control per Air Flow Control and Temperature Control.

7. The office areas served by chilled beam shall use a common area (hallway) humidity sensor for dew point safety.
   a. When the dew point rises above 56°F (FA), the associated chilled water control valves serving the spaces shall be commanded closed.
   b. When the space dew point drops below 56°F (FA), the chilled water control valve serving the space shall be released back to control per Air Flow Control and Temperature Control.

8. Room Pressure Monitor:
   a. The room pressure shall be monitored at the BAS.

B. Occupied Modes
   1. Office Area Occupancy Modes:
      a. Each zone shall operate on an occupied/unoccupied schedule. Initial occupied schedule shall be from 7 am to 7 pm and shall be fully adjustable at the BAS. Occupancy schedule shall be globally adjustable for all zones.
         1). Occupied Mode
            a). Terminal units and space temperature shall be controlled as described below.
            b). Spaces with adjustable thermostats shall have the maximum and minimum setpoint range programmed at the BAS. Initial range shall be 68°F - 74°F (FA). Local LCD display shall not be capable of adjustment beyond the range set at the BAS.
            c). Initial Occupied setpoint for spaces with non-adjustable thermostats shall be:
            d). Interior Zones: 73°F (FA) with a field adjustable deadband between heating and cooling adjustable at the BAS.
            e). Exterior Zones: 75°F Cooling (FA) and 70°F heating (FA).
         2). Unoccupied Mode
            a). Terminal units shall close or modulate to minimum, refer to mechanical schedules.
            b). Space temperature shall be allowed to drift ±4°F (FA) from space setpoint.
            c). When the space temperature drifts outside the allowable range, the air terminal and cooling terminal devices shall be released to control to bring the space back into the allowed range.
            d). Relative humidity shall be allowed to drift ±5%RH (FA) from space setpoint.
e). When the space relative humidity drifts outside the allowable range, the air terminal and cooling terminal devices shall be released to control to bring the space back into the allowed range.

f). Occupant-adjustable temperature sensors shall have an occupancy override button. The occupancy override button, when pressed shall override the zone into occupied mode for 2 hours (FA). For each zone graphic, provide a button/icon to allow the BAS operator to lock out the occupancy override button.

3). Vacancy Mode
a). During Occupied Mode, when the space occupancy sensor indicates that the room is unoccupied, the room shall enter Vacant Mode.

b). During vacant mode, the space temperature shall be allowed to drift ±3°F (FA) from space setpoint. The air terminal serving the space shall remain under Occupied Mode control.

c). When the occupancy sensor indicates that the room is occupied, the space shall return to Occupied Mode.

2. Lab Occupancy Modes:
a. Lab zones shall not have occupied/unoccupied modes. Zones shall operate continuously.
b. Occupancy schedule shall be globally adjustable for all zones.
   1). Occupied Mode
      a). Terminal units and space temperature shall be controlled as described below.
      b). Spaces with adjustable thermostats shall have the maximum and minimum setpoint range programmed at the BAS. Initial range shall be 65°F - 75°F (FA). Local LCD display shall not be capable of adjustment beyond the range set at the BAS.
      c). Initial Occupied setpoint for spaces with non-adjustable thermostats shall be 73°F (FA) with a 4 degree deadband between heating and cooling adjustable at the BAS.

3. Lab Occupancy Modes for zones with Aircuity
a. Lab zones shall not have occupied/unoccupied modes. Zones shall operate continuously.
b. Occupancy schedule shall be globally adjustable for all zones. Purge Mode (each Zone)
   1). Indicated at the BAS or Purge Push Button within the zone.
      a). For each zone graphic, provide a button/icon to allow the BAS operator to start/stop the Purge Mode.
   2). When Purge Mode is activated, Terminal units shall maintain Maximum Occupied airflow as indicated on terminal unit schedules.

c. Occupied Mode
   1). For each zone graphic, provide a button/icon to allow the BAS operator to

2). Occupied Mode
   a). Terminal units and space temperature shall be controlled as described below.
   b). Spaces with adjustable thermostats shall have the maximum and minimum setpoint range programmed at the BAS. Initial range shall be 70°F - 74°F (FA). Local LCD display shall not be capable of adjustment beyond the range set at the BAS.
   c). Initial Occupied setpoint for spaces with non-adjustable thermostats shall be 73°F (FA) with a 4 degree deadband between heating and cooling.
4. Occupancy Modes for Vivarium
   a. Vivarium spaces shall not have occupied/unoccupied modes. Zones shall operate continuously.

C. Zones will typically consist of the following units:
   1. Terminal Chilled Beams, reheat coils, and/or radiant panels:
      a. Refer to drawings IC07-30 through IC07-33 for determination of control sequence applications.
      b. Provide one control valve per zone for each type of unit, i.e. for multiple chilled beams in a zone, provide one control valve.
   2. Air terminal Valves:
      a. Laboratory Temperature and Airflow Control System contractor shall provide controls and actuators. Refer to Section 23 3614 Laboratory Temperature and Airflow Control.
      b. Air Terminal Valves are pressure independent type.
      c. Refer to Air Terminal Device Schedules and drawings IC07-30 through IC07-33 for determination of control sequence applications.
      d. Unit dampers, damper actuators, pressure sensors, are furnished and installed by unit manufacturer.
   3. Fume Hoods:
      a. Fume hood air flow set point determination (vertical sash hoods).
         1). The current sash height shall be determined by a sash position sensor installed into the hood. The sash shall be considered fully closed when it reaches any mechanical stops that limit closure.
         2). Fixed parameters for each hood shall be configured for sash width, and for hood surface area in square feet.
         3). Open face area shall equal the sash height multiplied by the sash width, in feet.
         4). Current hood air flow setpoint shall be computed based on sash position.
      b. Fume hood monitor
         1). The face-mounted fume hood monitor shall display current face velocity.
         2). The face-mounted fume hood monitor shall indicate alarm via dedicated indicator light.
   4. Aircontuity air quality sensors.

D. Air Flow for Terminal Units
   1. Office
      a. Constant Volume Control
         1). Damper actuator on supply air terminal shall maintain airflow quantity scheduled. DDC Constant Air Volume (CAV) controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.
         2). DDC controller shall utilize airflow sensors in exhaust air terminal to continuously measure room exhaust airflow. CAV controller shall continuously calculate required exhaust airflow rate necessary to maintain predetermined offset, between total exhaust and supply airflows, by subtracting or adding offset from/to total supply airflow rate to determine exhaust airflow rate. Damper actuator serving exhaust air terminal shall be modulated to maintain predetermined offset.
            a). Refer to terminal unit schedules for tracking pairs, including exhaust terminals tracking multiple supply terminals.
3. Refer to terminal schedules for CFM setpoints.

b. Variable Volume Control

1). Damper actuator on supply air terminal shall modulate between maximum and minimum airflow setpoints to maintain space setpoint or CO2 level, as described below. DDC Variable Air Volume (VAV) controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.

2). DDC controller shall utilize airflow sensors in exhaust air terminal to continuously measure room exhaust airflow. CAV controller shall continuously calculate required exhaust airflow rate necessary to maintain predetermined offset, between total exhaust and supply airflows, by subtracting or adding offset from/to room’s total supply airflow rate to determine exhaust airflow rate. Damper actuator serving exhaust air terminal shall be modulated to maintain predetermined offset.

3). Refer to terminal schedules for supply CFM minimum and maximum setpoints.

2. Laboratory

a. Constant Volume Control (Negatively Pressurized Space)

1). Damper actuator on exhaust air terminal shall maintain airflow quantity scheduled. DDC Constant Air Volume (CAV) controller shall utilize airflow sensor in exhaust air terminal to continuously measure exhaust flow rate.

2). DDC controller shall utilize airflow sensors in supply air terminal to continuously measure room supply airflow. CAV controller shall continuously calculate required supply airflow rate necessary to maintain predetermined offset, between total exhaust and supply airflows, by subtracting or adding offset from/to room’s total exhaust airflow rate to determine supply airflow rate. Damper actuator serving supply air terminal shall be modulated to maintain predetermined offset.

3). Refer to terminal schedules for supply CFM minimum and maximum setpoints.

b. Constant Volume Control (Positively Pressurized Space)

1). Damper actuator on supply air terminal shall maintain airflow quantity scheduled. DDC Constant Air Volume (CAV) controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.

2). DDC controller shall utilize airflow sensors in exhaust air terminal to continuously measure room exhaust airflow. CAV controller shall continuously calculate required exhaust airflow rate necessary to maintain predetermined offset, between total exhaust and supply airflows, by subtracting or adding offset from/to room’s total exhaust airflow rate to determine exhaust airflow rate. Damper actuator serving exhaust air terminal shall be modulated to maintain predetermined offset.

3). Refer to terminal schedules for supply CFM minimum and maximum setpoints.

c. Variable Volume Control (Negatively Pressurized Space)

1). Damper actuator on exhaust air terminal shall modulate between maximum and minimum airflow setpoints to maintain space setpoint or CO2 level, as described below. DDC Variable Air Volume (VAV) controller shall utilize airflow sensor in exhaust air terminal to continuously measure exhaust flow rate.

2). DDC controller shall utilize airflow sensors in supply air terminal to continuously measure room supply airflow. VAV controller shall continuously calculate required supply airflow rate necessary to maintain predetermined offset, between total exhaust and supply airflows, by subtracting or adding offset from/to room’s total exhaust airflow rate to determine supply airflow rate. Damper actuator serving supply air terminal shall be modulated to maintain predetermined offset.

3). Refer to terminal schedules for supply CFM minimum and maximum setpoints.

d. Variable Volume Control (Positively Pressurized Space)
1. Damper actuator on supply air terminal shall modulate between maximum and minimum airflow setpoints to maintain space setpoint or CO2 level, as described below. DDC Variable Air Volume (VAV) controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.

2. DDC controller shall utilize airflow sensors in exhaust air terminal to continuously measure room exhaust airflow. CAV controller shall continuously calculate required exhaust airflow rate necessary to maintain predetermined offset, between total exhaust and supply airflows, by subtracting or adding offset from/to room’s total supply airflow rate to determine exhaust airflow rate. Damper actuator serving exhaust air terminal shall be modulated to maintain predetermined offset.

3. Refer to terminal schedules for supply CFM minimum and maximum setpoints.

E. Temperature Control

1. Heating and cooling devices in each space shall operate described below. Refer to individual sequences for order in which devices are activated to control room setpoints.

2. Heating Devices
a. On a decrease in space temperature the following can occur in any sequence or in parallel:
   1. The space temperature sensor shall reset the terminal unit discharge air setpoint. Reheat coil valve shall modulate to maintain terminal unit discharge air setpoint.
   2. The radiant ceiling panel valve shall modulate to maintain the space setpoint.
   3. The chilled beam hot water valve shall modulate to maintain the space setpoint.
   4. The supply terminal unit shall modulate airflow to maintain the space setpoint, refer to the mechanical schedules for the maximum heating airflows.

3. Cooling Devices
   a. On an increase in space temperature the following can occur in any sequence:
      1. The chilled beam chilled water valve shall modulate to maintain the space setpoint.
      2. The supply terminal unit shall modulate the airflow to maintain the space setpoint, refer to the mechanical schedules for the maximum airflows.

4. Program a 4°F (FA) deadband between heating and cooling devices. Heating and Cooling valves shall not operate at the same time.

F. Monitor and Alarm
   1. Refer to Points list for BAS monitoring points for possible points for each sequence and generate the alarms. Additionally, the BAS shall monitor all humidity, CO2, occupancy sensors, room pressure sensors, and points associated with Aircuity.
   a. Space temperature (AI)
      1. Generate High Priority alarm if space temperature exceeds setpoint by ±5°F (FA) for 15 consecutive minutes.
   b. Space temperature fault (DI)
      1. Generate High Priority alarm if space temperature sensor indicates a loss of signal.
   c. Space relative humidity (AI)
      1. Generate High Priority alarm if space temperature exceeds setpoint by ±5%RH (FA) for 15 consecutive minutes.
   d. Space CO2 Level (AI) – where shown
      a). Generate High Priority alarm when space CO2 level exceeds 1000 ppm (FA).
   e. Space CO2 fault (DI)
      1. Generate High Priority if CO2 sensor indicates a loss of signal.
   f. Supply/Return or Exhaust Offset (AD) – each room
      a). Generate High Priority alarm if offset exceeds setpoint by ±25% (FA) for 15 consecutive minutes (FA).

G. Sequence #A: Office with Exterior Exposure
   1. General
      a. Refer to Detail 1 on IC-753.
   2. Zone Consists of:
      a. Terminal Supply Valve
      b. Reheat coil
      c. Radiant Ceiling Panel (each office)
      d. Chilled Beam (each office)
      e. Space temperature sensor in each office
   3. Occupancy Mode:
a. Office Area Occupancy Mode
4. Air Flow Control
   a. Office Variable Volume Control
5. Temperature Control:
   a. The terminal supply valve discharge air temperature sensor setpoint shall reset to maintain the lowest space temperature setpoint. The reheat coil shall modulate to maintain the supply valve discharge air temperature setpoint.
   b. On a decrease in space temperature the following devices will modulate to maintain the office room temperature setpoint:
      1) Radiant panel valve
   c. On an increase in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
      1) Chilled beam chilled water valve
      2) Then the terminal unit valve modulates airflow

H. Sequence #B: Hallways Associated with Offices
1. General
   a. Refer to Detail 2 on Drawing IC-753.
2. Zone Consists of:
   a. Terminal exhaust valve
3. Occupancy Mode:
   a. Office Area Occupancy Mode
4. Air Flow Control
   a. Office Variable Volume Control

I. Sequence #C: Lobby Areas
a. Refer to Detail 3 on Drawing IC-730.
2. Zone Consists of:
   a. Terminal supply unit with a reheat coil.
   b. Combo AFMS and damper
   c.
3. Occupancy Mode
   a. Office Area Occupancy Mode
4. Air Flow Control
   a. Office Variable Volume Mode
      1) Damper actuator on supply air terminal shall modulate between maximum and minimum airflow setpoints to maintain space setpoint or CO2 level, as described below. DDC Variable Air Volume (VAV) controller shall utilize airflow sensor in supply air terminal to continuously measure supply flow rate.
      2) DDC controller shall utilize airflow station in exhaust duct to continuously measure room exhaust airflow. CAV controller shall continuously calculate required exhaust airflow rate necessary to maintain predetermined offset, between total exhaust and supply airflows, by subtracting or adding offset from/to room’s total supply airflow rate to determine exhaust airflow rate. Damper actuator serving exhaust duct shall be modulated to maintain predetermined offset.
      3) Refer to terminal schedules for supply CFM minimum and maximum setpoints.
5. Temperature Control:
   a. On a decrease in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
      1). Terminal supply valve shall modulate from max to min airflow per occupancy mode.
      2). Reheat coil valve
      3). Terminal supply valve shall modulate from min to max (max heating airflow per mechanical schedules) airflow per occupancy mode.
   b. On an increase in space temperature the devices will modulate in reverse of the above to maintain the room temperature setpoint:

J. Sequence #D: Main Hallways
   1. General
      a. Refer to Detail 4 on Drawing IC-753.
   2. Zone Consists of:
      a. Terminal supply valve
      b. Reheat coil
      c. Radiant Ceiling Panel
   3. Occupancy Mode
      a. Office Area Occupancy Modes
   4. Air Flow Control
      a. Office Variable Volume Mode
   5. Temperature Control:
      a. On a decrease in space temperature the following devices will modulate in sequence to maintain the office room temperature setpoint:
         1). Radiant panel valve
         2). Reheat coil
      b. On an increase in space temperature the devices will modulate in reverse of the above to maintain the room temperature setpoint:

K. Sequence #E: Open Two Story Area
   1. General
      a. Refer to Detail 1 on IC-754.
   2. Zone Consists of:
      a. Constant volume air terminal valve with a reheat coil.
      b. Heating and Cooling Chilled Beam(s)
      c. Fin tube radiation
   3. Occupancy Mode:
      a. Office Area Occupancy Mode
   4. Air Flow Control
      a. Office Variable Volume Control
   5. Temperature Control:
      a. The terminal supply valve discharge air temperature sensor setpoint shall reset to the maintain space temperature setpoint. The reheat coil shall modulate to maintain the supply valve discharge air temperature setpoint.
b. On a continued decrease in space temperature the following devices will modulate in parallel to maintain the room temperature setpoint:
   1). Chilled beam hot water valve
   2). Fin tube radiation hot water valve

c. On an increase in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
   1). Chilled beam chilled water valve
   2). Then the terminal unit valve modulates airflow

L. Sequence #F: Open Office Areas
   1. General
      a. Refer to Detail 2 on Drawing IC-754.
   2. Zone Consists of:
      a. Terminal supply valve with a reheat coil.
      b. Terminal exhaust valve
      c. Chilled Beam(s)
   3. Occupancy Mode:
      a. Office Area Occupancy Mode
   4. Air Flow Control
      a. Office Variable Volume Control
   5. Temperature Control:
      a. On a decrease in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
         1). Terminal supply valve shall modulate from max to min airflow per occupancy mode.
         2). Reheat coil valve
         3). Terminal supply valve shall modulate from min to max (max heating airflow per mechanical schedules) airflow per occupancy mode.
      b. On an increase in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
         1). Chilled beam chilled water valve
         2). Terminal supply valve shall modulate from min to max airflow per occupancy mode.

M. Sequence #G: Restrooms
   1. General
      a. Refer to Detail 4 on Drawing IC-754.
   2. Zone Consists of:
      a. Terminal Exhaust Valve
      b. Radiant Ceiling Panel (where shown on plans)
   3. Occupancy Mode
      a. Office Area Occupancy Mode
   4. Air flow Control
      a. Office Constant Volume Control
   5. Temperature Control:
      a. On a decrease in space temperature the following devices will modulate to maintain the room temperature setpoint:
1. Radiant heating panel valve (where shown on plans)
   b. On an increase in space temperature the devices will modulate in reverse of the above to maintain the room temperature setpoint:

N. Sequence #H: Main Laboratory Area & Fume Hood Room
1. General
   a. Refer to Detail 1 on IC-755.
2. Zone Consists of:
   a. Terminal supply valve(s) with a reheat coil.
   b. Terminal exhaust valve(s)
   c. Aircuity
   d. Chilled Beam(s)
   e. Fume Hood(s)
3. Occupancy
   a. Lab Occupancy Mode with Aircuity
4. Air Flow
   a. Variable Volume Control with Fume Hood
5. Temperature Control
   a. On a decrease in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
      1). Terminal supply valve shall modulate from max to min airflow per occupancy mode.
      2). The terminal supply valve discharge air temperature sensor setpoint shall reset to the maintain space temperature setpoint. The reheat coil shall modulate to maintain the supply valve discharge air temperature setpoint.
      3). Terminal supply valve shall modulate from min to max (max heating airflow per mechanical schedules) airflow per occupancy mode.
   b. On an increase in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
      1). Chilled beam chilled water valve
      2). Terminal supply valve shall modulate from min to max airflow per occupancy mode.

O. Sequence #I: Vivarium Animal Procedure/Holding Room
1. General
   a. Refer to Detail 1 on IC-756.
2. Zone Consists of:
   a. Terminal Supply Valve
   b. Terminal Exhaust Valve
   c. Terminal Exhaust Valve serving cages (where shown on plans)
   d. Reheat coil
   e. Aircuity
3. Occupancy Mode:
   a. Occupancy Mode for Vivarium
4. Air Flow:
   a. Laboratory Constant Volume Control
5. Temperature Control:
a. On a decrease in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
   1). Reheat coil valve
b. On an increase in space temperature the devices will modulate in reverse of the above to maintain the room temperature setpoint:

P. Sequence #J: Linear Equipment Room
1. General
   a. Refer to Detail 2 on Drawing IC-756.
2. Zone Consists of:
   a. Terminal supply valve with reheat
   b. Terminal exhaust valve
   c. Chilled Beam
3. Occupancy Mode:
   a. Lab Occupancy Mode
4. Air Flow Control:
   a. Laboratory Constant Volume Control
5. Temperature Control:
   a. On a decrease in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
      1). Reheat coil valve
   b. On an increase in space temperature the following devices will modulate to maintain the room temperature setpoint:
      1). Chilled beam chilled water valve

Q. Sequence #K: Wet Lab Procedure Room
1. General
   a. Refer to Detail 3 on Drawing IC-756.
2. Zone Consists of:
   a. Terminal supply valve with a reheat coil.
   b. Terminal exhaust valve
   c. Chilled Beam(s)
3. Occupancy Mode:
   a. Lab Occupancy Mode
4. Air Flow Control
   a. Laboratory Variable Volume Control
5. Temperature Control:
   a. On a decrease in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
      1). Terminal supply valve shall operate airflow per occupancy mode.
      2). The terminal supply valve discharge air temperature sensor setpoint shall reset to the maintain space temperature setpoint. The reheat coil shall modulate to maintain the supply valve discharge air temperature setpoint.
   b. On an increase in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
1. Chilled beam chilled water valve
2. Then the terminal unit valve modulates airflow

R. Sequence #L: Sterilizer/Clean/Soil Room
   1. General
      a. Refer to Detail 4 on IC-756.
   2. Zone Consists of:
      a. Terminal Supply Valve
      b. Terminal Exhaust Valve serving sterilizer
      c. Reheat coil
   3. Occupancy Mode:
      a. Lab Occupancy Mode
   4. Air Flow:
      a. Laboratory Constant Volume Control
   5. Temperature Control:
      a. On a decrease in space temperature the following devices will modulate in sequence to maintain the room temperature setpoint:
         1). Reheat coil valve
      b. On an increase in space temperature the devices will modulate in reverse of the above to maintain the room temperature setpoint.

S. Sequence #N: Hallways
   1. General
      a. Refer to Detail 1 on Drawing IC-757.
   2. Zone Consists of:
      a. Terminal supply valve
      b. Reheat coil
   3. Occupancy Mode
      a. Lab Occupancy Mode
   4. Air flow Control
      a. Lab Constant Volume Control
   5. Temperature Control:
      a. On a decrease in space temperature the following devices will modulate to maintain the room temperature 70°F (FA) heating setpoint:
         1). Reheat coil
      b. On an increase in space temperature the devices will modulate in reverse of the above to maintain the room temperature setpoint.

T. Sequence #Q: Vivarium Mechanical Room
   1. General
      a. Refer to Detail 2 on IC-757.
   2. Zone Consists of:
      a. Terminal Supply Valve
      b. Terminal Exhaust Valve
      c. Reheat Valve
3. Occupancy Mode:
   a. Laboratory Occupancy Mode
4. Air Flow Control
   a. Laboratory Variable Volume Control
5. Temperature Control:
   a. On a decrease in space temperature the following devices will modulate to maintain the room temperature setpoint:
      1). Then the reheat coil valve modulates to maintain room temperature setpoint of 70°F (FA).

U. Sequence #U: Additional Office Spaces
1. General
   a. Refer to Detail 3 on Drawing IC-757.
2. Zone Consists of:
   a. Terminal supply valve
   b. Terminal exhaust valve
   c. Reheat coil
3. Occupancy Mode
   a. Office Occupancy Mode
4. Air flow Control
   a. Office Variable Volume Control
5. Temperature Control:
   a. On a decrease in space temperature the following devices will modulate to maintain the room temperature 70°F (FA) heating setpoint:
      1). Reheat coil
      2). Terminal supply valve shall operate airflow per occupancy mode.
   b. On an increase in space temperature the devices will modulate in reverse of the above to maintain the room temperature setpoint.

V. Sequence #V: Lab with Exhaust Switch
1. General
   a. Refer to Detail 1 on Drawing IC-757.
2. Zone Consists of:
   a. Terminal supply valve
   b. Terminal exhaust valve
   c. Reheat coil
3. Occupancy Mode
   a. Lab Occupancy Mode
4. Air flow Control
   a. Lab Constant Volume Control
      1). When the exhaust switch is enabled, the exhaust valve shall modulate to maximum flow, and the supply valve shall modulate to maintain CFM offset.
5. Temperature Control:
a. On a decrease in space temperature the following devices will modulate to maintain the room temperature 70°F (FA) heating setpoint:
   1. Reheat coil
b. On an increase in space temperature the devices will modulate in reverse of the above to maintain the room temperature setpoint.

3.9 FIN TUBE AND RADIANT PANEL - CONTROL SEQUENCE

A. General
   1. Refer to Detail 1 & 5 on drawing IC-758.

B. System Operation
   1. A space temperature sensor shall modulate control valve to each unit to maintain space set point temperature.

C. Monitor through the BAS the following points and generate the alarms indicated (refer to Points List for additional monitoring points):
   1. Space temperature (AI)
      a. Generate General Maintenance alarm if space temperature exceeds setpoint by ±5°F (FA) for 15 consecutive minutes (FA).

3.10 UNIT HEATERS/CABINET UNIT HEATERS - CONTROL SEQUENCE

A. General
   1. Refer to Detail 2 on drawing IC-758.

B. Space temperature sensor shall open/close control valve in return line from each unit to maintain space set point temperature. Line voltage aquastat shall start unit fan on rise in return line temperature above preset temperature of 175°F (FA) and stop fan on drop below set temperature.

C. Cabinet unit heater serving ComEd space shall have line voltage temperature sensor.

3.11 BLOWER COIL UNIT/COOLING ONLY FAN COIL UNIT (COOLING ONLY)

A. General
   1. Refer to Detail 3 on drawing IC-758.

B. System Operation
   1. Fan shall start on a call for cooling and shall stop when space temperature setpoint is satisfied.
   2. Setpoint for IT closets/spaces shall be 72°F (FA).
   3. Setpoint for all other spaces shall be 80°F (FA).
   4. DDC controller shall modulate control valve on chilled water coil to maintain space temperature setpoint.
   5. On a call for cooling, when space temperature rises above setpoint by 2°F (FA), fan coil unit fan shall start and cooling coil control valve shall modulate open to maintain space temperature at setpoint. When space temperature falls below setpoint by 2°F (FA), cooling coil control valve shall modulate closed. When cooling coil control valve is closed for 5 consecutive minutes (FA) fan coil unit fan shall stop. Cooling coil control valve shall close if a fan failure is detected, as sensed by current switch.
6. Wire the high level limit switch (float), located on the unit drain pan to shut the fan down and close the cooling coil upon activation.

C. Monitor and Alarm:
   1. Monitor through the BAS the following points and generate the alarms indicated (refer to Points List for additional monitoring points):
      a. Space temperature (AI)
         1). Generate General Maintenance alarm if space temperature exceeds setpoint by ±5°F (FA) for 15 consecutive minutes (FA).
      b. Fan coil unit fan current switch (DI)
         1). Generate a General Maintenance alarm if fan status does not match commanded state.
      c. High level water switch (DI)
         1). When water high level switch is activated, a High Priority alarm shall be generated, the fan shall be stopped, and fan coil unit cooling coil control valve shall be commanded closed.

3.12 HEATING AND COOLING FAN COIL UNIT

A. General
   1. Refer to Detail 4 on drawing IC-758.

B. System Operation
   1. Fan shall start on a call for cooling or heating and shall stop when space temperature setpoint is satisfied.
   2. Space cooling setpoint shall be 75°F (FA).
   3. Space heating setpoint shall be 68°F (FA).
   4. DDC controller shall modulate control valves on chilled or hot water coils to maintain space temperature setpoint.
   5. On a call for cooling, when space temperature rises above cooling setpoint, fan coil unit fan shall start and cooling coil control valve shall modulate open to maintain space temperature at setpoint. When space temperature falls below setpoint, cooling coil control valve shall modulate closed. When cooling coil control valve is closed for 5 consecutive minutes (FA) fan coil unit fan shall stop.
   6. On a call for heating, when space temperature drops below heating setpoint, fan coil unit fan shall start and heating coil control valve shall modulate open to maintain space temperature at setpoint. When space temperature rises above setpoint, heating coil control valve shall modulate closed. When heating coil control valve is closed for 5 consecutive minutes (FA) fan coil unit fan shall stop.
   7. Valves shall be sequenced so that heating and cooling cannot occur simultaneously.
   8. Cooling coil and heating coil control valves shall close when a fan failure is detected.
   9. Wire the high level limit switch (float), located on the unit drain pan to shut the fan down and close the cooling coil upon activation.

C. Monitor and Alarm:
   1. Monitor through the BAS the following points and generate the alarms indicated (refer to Points List for additional monitoring points):
      a. Space temperature (AI)
1. Generate General Maintenance alarm if space temperature exceeds setpoint by ±5°F (FA) for 15 consecutive minutes (FA).

b. Fan coil unit fan current switch (DI)
   1. Generate General Maintenance alarm if fan status does not match commanded state.

c. High level water switch (DI)
   1. When water high level switch is activated, a High Priority alarm shall be generated, the fan shall be stopped, and fan coil unit cooling coil control valve shall be commanded closed.

3.13 LAUNDRY EXHAUST FAN

A. General
   1. Refer to Detail 6 on drawing IC-757.
   2. Exhaust fan is sized for 100% capacity.
   3. Exhaust fan is constant volume.

B. Interlocking
   1. Exhaust fan starter shall be hard wire interlocked with dryer dry contact so that the exhaust fan is enabled when the dryer is enabled.

C. System Operation
   1. Exhaust fan shall be started and stopped automatically by the dry contact.
   2. Provide manual software command to allow the operator to enable or disable fan.

D. Power Failure Mode
   1. Fans are not served by emergency power. Fan shall automatically restart if indexed to run upon resumption of normal power.

E. Monitor and Alarm
   1. Monitor, through the BAS, the following points and generate the alarms indicated (refer Points List for additional monitoring points):
      a. Exhaust fan motor status – (DI)
         1). Generate Non-Critical alarm if fan is not in commanded state.

3.13.14 SMOKE/FIRE ALARM MODE - CONTROL SEQUENCE

A. Smoke Detectors in Ductwork:
   1. Smoke detectors will be furnished, installed, and wired to Fire Alarm Control Panel by Electrical Contractor.
   2. Wire contact on Fire Alarm System provided by EC to air handling unit supply fan starter to shut down unit fan when Fire Alarm System is in alarm condition.
   3. Wire auxiliary contact on smoke detector to air handling unit supply fan starter. Each air handling unit’s smoke detector(s) upon detection of smoke shall stop its respective air handling unit.
   4. Smoke detectors will be provided as shown in plans.

B. Smoke Dampers:
1. Smoke dampers in ducts shall be furnished by TCC and installed by MC. Smoke dampers required in ducts passing through smoke partitions are shown on Mechanical Plans (smoke partitions are shown on Architectural Plans).

2. Smoke dampers shall be provided at air handling units for isolation for all AHUs:
   a. Supply air discharge
   b. Smoke dampers isolating air handling system shall be closed automatically when air system is not in operation.

3. Wire contracts provided by Fire Alarm System to close smoke dampers and shut down air handling units when fire alarm system is in alarm condition. Smoke dampers shall automatically reset on Fire Alarm System reset. Air handling units shall have manual restart on Fire Alarm System reset.

4. Wire auxiliary contacts on smoke detectors to close smoke dampers and shut down air handling units when smoke detectors are in alarm condition. Smoke dampers shall automatically reset on smoke detector reset. Air handling units shall have manual restart on smoke detector reset.

1. All locations of smoke detectors and dampers shall be supplied to the owner for inclusion on the building graphics.

3.143.15 RETURN FANS – CONTROL SEQUENCE

   A. Return fans shall be electrically interlocked with associated air handling unit as described in AHU control sequence.

3.153.16 ELECTRICAL AND COMMUNICATION MANHOLES

   A. Electrical Manhole 907 (sump pump) conduit run is required to be wired & installed as indicated on IC-800.

   B. All other conduit runs have been laid in a previous project phase. Control contractor to wire and monitor the points below.

   C. Monitor, through BAS, the following points associated with plumbing system and generate the alarms indicated:
      1. Communication Manhole Sump pump – provide moisture sensor (typical of 5)
         a. General High Priority Alarm
      2. Electrical Manhole Sump pump – provide moisture sensor (typical of 10)
         a. General High Priority Alarm

3.163.17 SUMP PUMP

   A. General
      1. DM-1 & DM-2

   B. Control contractor to provide four floats and wire floats back to sump pump controller.

   C. Monitor, through BAS, the following points associated with plumbing system and generate the alarms indicated:
      1. Sump pump Controller – dry contact (DI)
         a. General High Priority Alarm
END OF SECTION
## Written Questions and Answers

**Research Building 2, Phase 2**  
**Trade Categories 08B Glass Rebid**  
**09C Carpet & Resilient Flooring Rebid**  
**23B Controls (New bid)**  
**Project #2499.0**  
**CCK-2392-19**

<table>
<thead>
<tr>
<th>NO.</th>
<th>Question</th>
<th>Responder</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Addendum #5 provides a responsibility matrix. Regarding the Airuity matrix and controllers, is there one Airuity controller per supply air valve?</td>
<td>AEI</td>
<td>Refer to Plans for Quantities on MF-550.</td>
</tr>
<tr>
<td>2</td>
<td>How are the terminal units shown on the mechanical schedules that do not reference a sequence to be operated? No detail provided for those.</td>
<td>AEI</td>
<td>Sequences will be assigned to the remainder of VSV/VEV’s on the Addendum 8 schedules.</td>
</tr>
<tr>
<td>3</td>
<td>Mechanical schedule sheet MF-951 references a Sequence M for (5) VSV units and (7) VEV Units. Unable to locate a detail drawing referencing this sequence. Please provide drawing. Please provide responsible party for this sequence. Not listed in the matrix on MC-950 or IC-950.</td>
<td>AEI</td>
<td>M will be replaced with appropriate sequences on Addendum 8</td>
</tr>
<tr>
<td>4</td>
<td>Control sequence details for Sequences C, F, G, N and Q are provided but there are no terminal units shown on the mechanical schedules for these sequences. Are we to assume there are no terminal units in this phase for these sequences? If there are units with these sequences required, please provide updated schedule.</td>
<td>AEI</td>
<td>If no terminal unit is assigned the sequence it is not required.</td>
</tr>
<tr>
<td>5</td>
<td>The controls contractor is to provide control panels for housing Air Valve Controllers for sequences H, I, J, K &amp; L; please provide submittals for the air valve controllers that are being supplied by the owner.</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>The controls contractor is to provide wiring to Building Level Controllers for sequences H, I, J, K &amp; L; please provide submittals for those controllers</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>7</strong></td>
<td>For the Phoenix Control System, will one controller be provided by Phoenix for integration to BAS via BACnet MS/TP?</td>
<td>AEI</td>
<td>Per IC-550, the Phoenix Building Level Controller Provided will connect to Tridium Via IP connection (Ethernet Cable).</td>
</tr>
<tr>
<td><strong>8</strong></td>
<td>Please provide submittals for all Aircuity equipment (controllers, sensors, etc.) being provided by the owner.</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td><strong>9</strong></td>
<td>Please provide submittals for all Aircuity Building Level Controllers being provided by the owner.</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Please verify the controls electrical subcontractor is to obtain 120VAC power at a breaker panel for power to transformers.</td>
<td>WT</td>
<td></td>
</tr>
<tr>
<td><strong>11</strong></td>
<td>Monitoring meters – please confirm if there are any meters in this phase which require monitoring. Unable to locate points etc. in supplied documentation.</td>
<td>AEI</td>
<td>Per the drawings, no water flow meters monitoring is required.</td>
</tr>
<tr>
<td><strong>12</strong></td>
<td>Clarification on Freezestats: Specification section 230903-3 C.1 references Electric 2 position type with temperature sensing element and manual reset. Specification section 230903-3 D.1 references Electric 2 position type with temperature sensing element and automatic reset. Which type is to be used on Air Handling Units?</td>
<td>AEI</td>
<td>Freezestat types should have a manual reset.</td>
</tr>
<tr>
<td><strong>13</strong></td>
<td>RFI 1. System Air Volume Control (for variable volume AHUs with static pressure transmitters) References: 230993 3.1.J.4 3.4 Upon loss of Tridium static pressure average, each AHU shall wired to individual AHU controller. 230993 3.1.H.1 H. Pressure Transmitter/Sensors 1. Pressure transmitter/sensors shall be hardwired directly provides the control signal to the VFD’s. Sharing the static signal via the network is not allowed for control. Description 3.1.J.4 appears to refer to duct static pressure sensors that will be used to control multiple AHUs serving a common duct. For Example; AHU 1&amp;2 work together to serve a common ductwork that provides airflow to several floors. AHU-1, installed during Phase 1, currently has 4 duct static transmitters 2/3 down the ductwork. 3.1.J.4 could be interpreted as requiring AHU-1 pressure sensor readings being averaged and sent across the campus IT network to be used as a control point for AHU-2’s VFD speed. Clarification Request: 1) Is the intent to not hardwire all pressure sensor</td>
<td>AEI</td>
<td>The AHUs in this sequence serve a common duct. Tridium will average the pressure signals for the fan control of the AHUs. 230993-3.1.H-1 Intent is that signal sharing is not allowed over the MSTP network. Per the sequence in 230993-3.1-J-4 addendum #1 “Upon loss of Tridium static pressure average, each AHU shall control to static pressure sensor wired to individual AHU controller.” It is the intent to hardwire the pressure sensors to each AHU controller as specified in 230993.</td>
</tr>
</tbody>
</table>
“directly back to the BAS controller that provides the control signal to the VFDs”, as shown in UK BAS standards described in 3.1.H.1, and share the values across the campus network for control of the VFDs?

RFI 2. Konvekta Communication

References: 230993 3.3.B

B. Unit Operation:
1. Unit operation shall be automatic and activated through building
2. Konvekta shall provide a BACnet MSTP connection port on their control contractors system.
   a. BACnet MSTP connection BAS.

UK RB2 Phase 1 Asbuilds

Description
During sequence testing and evaluation the importance of the Konvekta communication with the AHUs was essential (if signal is lost from Konvekta, the AHUs shutdown, or risk sending the spaces into a negative pressure state). While conducting a post CX troubleshooting meeting of RB2 Phase 1, in a meeting with UK, AEI, JCI, and Konvekta, it was decided by UK that the communication of Konvekta to AHUs and EAHUs served should not go across the UK Campus IT network. This decision led to the change the communication protocol from BACnet IP to BACnet MSTP under addendum 4.

Clarification Request:
1) The intent of having a MSTP communication protocol for Konvekta is unclear. Please clarify if the Konvekta MSTP communication does need to be on the same trunk as AHU-1, 2, 3, 4, 5, 6, 7, 8, and the EAHUs, or if the Konvekta system can be on any MSTP trunk and the data shared across the network as is currently being done.

1. This scope has been clarified in PCO 363 of Phase 1. Any communication to Konvekta in phase 2 will hardwired. No communication through MSTP or IP.

Clarification 1 Again:
1. The contract for phase 1 is separate from phase 2. Work in phase 1 will be completed before phase 2.
2. Warranties are separate for each phase.

AEI
| RFI 3. Konvekta Communication | 1. The phase 2 contractor will be responsible for reprogramming the impacted Phase 1 AHU & EAHU controls.  
2. Controls contractor for phase 1 is responsible for the Phase 1 warranty. Controls contractor for phase 2 is responsible for the phase 2 warranty. |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>References: 230993 3.3.B</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Extensive programming exists in the UK RB2 Phase 1 Supervisory Controller that serves the AHU-1, 3, 5, 6, All EAHUs and the EFs.</td>
</tr>
</tbody>
</table>
| Clarification Request:      | 1) Will the controls contractor, that is awarded this contract, be responsible all work related to reprogramming the impacted Phase 1 AHUs and EAHUs?  
2) Will the controls contractor, that is awarded this contract, be required to assume the remainder of the UK RB2 Phase 1 controls warranty or provide an additional warranty in accordance with this contracts warranty requirements on any of the equipment or controls of modified Phase 1 work? |

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>References: 230993 3.3.C</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>SOO section 3.3.C indicates that Konvekta, AHU-1 thru 8, and the EAHUs are required to be installed on a common MSTP trunk to ensure that imperative data is not lost or delayed by being passed across the UK IT infrastructure.</td>
</tr>
<tr>
<td>Clarification Request:</td>
<td>1) Please confirm that the intent is to have the Konvekta system, AHU-1 thru 8, and the EAHU on a common MSTP trunk.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RFI 5. Vivarium AHU System</th>
<th>1. Refer to addendum #5. Each unit shall have its own controller.</th>
</tr>
</thead>
<tbody>
<tr>
<td>References: 230923 3.2.B</td>
<td></td>
</tr>
</tbody>
</table>
Description
The UK BAS specification 3.2.B sets the standard that “all inputs and outputs for a single SYSTEM shall reside on a single controller”. SOO section 3.5 clearly identifies AHU-5, 6, 7, & 8 as a SYSTEM that operate together to serve a common duct and the associated spaces.

Clarification Request:
1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent of this spec that all the AHUs will be on a single field controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?

2) AHUs 5 and 6 are not currently programmed to “Lead-lag-lag-Standby”. Will the reprogramming of AHU5 and 6 be required to accommodate the new sequence be executed by this controls contractor under this contract?

3) Is there a process for staging up and down AHUs in the system to accommodate the “Lead-Lag-Standby” Controls? For example If two AHU VFDs are at greater than 90% for 10 minutes, a third AHU should be brought online, or if One AHU us unable to meet the AVG Static pressure setpoint for 15 minutes then the 1st Lag AHU should ramp up to control with the lead AHU.
BIDDERS QUESTIONS  Page 6 of 13

ADDENDUM #2

Description

The UK BAS specification 3.2.B sets the standard that “if multiple pieces of equipment are to be INTERLOCKED, a single master controller shall provide control for all pieces of equipment”. SOO section 3.5 clearly identifies AHU-5, 6, 7, 8, EAHUs, dampers, etc. are to be INTERLOCKED.

Clarification Request:

1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent of this spec that all the AHUs and EAHUs will be on a single field controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?

RFI 7. Vivarium Volume Control
References: 230993 3.5.F

3. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium. Refer to addendum #8 for new hardwired interlocks for AHU fan speed control.

AEI

Refer to specification 230993-3.5-F, sensors have been provided in phase 1 thus are existing. Per the specification sensors are to be wired in Phase 2.
BIDDERS QUESTIONS  Page 7 of 13

ADDENDUM #2

Description
SOO Section 3.5.F indicates that there are existing pressure transmitters that have already been installed for hardwire static pressure on AHU 7 and 8.

Clarification Request:
1) Please confirm that these static pressure sensors exist, and do not have to be provided or installed by this contractor.

RFI 8. Lab AHU System
References: 230923 3.2.B
B. Control software algorithm and inputs and outputs for reside on a single controller and shall not be distributed pieces of equipment are to be interlocked, a single "M" interlocked pieces of equipment, i.e. an AHU and inter
230993 3.6
3.6 LAB AIR HANDLING UNIT AHU-2 & 4 (1 & 3 EXISTING)

A. System Description:
1. Refer to drawing IC-751
2. Each unit is 100% outside air unit with run-around
3. Units are sized so that 4 AHU air handling units can servair flow
4. Air handling unit consists of:
   a. Supply fan array with backdraft damper on each
   b. Two VFDs for supply fan array. One VFD is for
   c. Chilled water cooling coil
   d. Energy Recovery water heating/cooling coil
   e. Pre-filter
   f. Final-filter
   g. Bipolar Ionization
   h. Outside air damper
   i. Supply smoke/isolation air damper

Description
The UK BAS specification 3.2.B sets the standard that “all inputs and outputs for a single SYSTEM shall reside on a single controller”. SOO section 3.6 identifies AHU-1, 2, 3, 4 as a SYSTEM that are sized so that 4 AHU work together to serve the associated spaces.

Clarification Request:
1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent
of this spec that all the AHUs will be on a single field controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?

<table>
<thead>
<tr>
<th>RFI 9. Lab Interlocking</th>
</tr>
</thead>
<tbody>
<tr>
<td>References: 230923 3.2.B</td>
</tr>
<tr>
<td>B. Control software algorithm and inputs and outputs for pieces of equipment are to be interlocked, a single &quot;SYSTEM&quot; of interlocked pieces of equipment, i.e. an AHU and interlocked dampers etc.</td>
</tr>
<tr>
<td>230993 3.5</td>
</tr>
<tr>
<td>B. Interlocking:</td>
</tr>
<tr>
<td>1. Whenever an AHU stops, all AHU supply fans, isolation dampers shall close and be proven closed.</td>
</tr>
<tr>
<td>2. Energy Recovery system shall prove operational indicated by BAS signal from Energy Recovery System. There shall be an optional override at the Energy Recovery system enabled.</td>
</tr>
<tr>
<td>3. Exhaust air handling unit (EAHU-1, 2 and 3) fans shall be shut down exhaust fans prior to enabling supply air system. There shall be an optional override at the BAS EAHU enabled.</td>
</tr>
<tr>
<td>4. Refer to Energy Recovery System Control Sequence and hard wired sensors.</td>
</tr>
</tbody>
</table>

**Description**

The UK BAS specification 3.2.B sets the standard that “if multiple pieces of equipment are to be **INTERLOCKED**, a single master controller shall provide control for all pieces of equipment”. SOO section 3.5 clearly identifies AHU-1, 2, 3, 4, EAHUs, dampers, etc. are to be **INTERLOCKED**.

**Clarification Request:**

1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent of this spec that all the AHUs and EAHUs will be on a single field controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?

2) SOO 3.6 indicated that this is a system of 4 AHUs (See RFI 8) SOO 3.5.B.1 indicates that, whenever an AHU stops, the other AHUs shall stop. Please confirm, for example; AHU-1 fails due to low temp cutout, and are then to command AHU-2, 3 & 4 to stop.

3) Is the contractor, which is awarded this contract, responsible for reprogramming the 2 existing (Phase 1) AHUs to react to the addition of this equipment as defined SOO 3.5 and

1. Refer to addendum #5. Each unit shall have its own controller.
2. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium.
3. Refer to addendum #5. AHU Lead-Lag-Standby sequencing will be accomplished through Tridium. Refer to addendum #8 for new hardwired interlocks for AHU fan speed control which will be the reasonability of the phase 2 contractor.
### RFI 10. Lab AHU Unit Operation

**References:** MF-552
- 230990 3.6.A.3
- 230993 3.6.C

**C. Unit Operation:**

1. Unit operation shall be automatic and activated through

**TROL SEQUENCES**

<table>
<thead>
<tr>
<th>ALL</th>
<th>UNIT</th>
<th>START</th>
<th>FANS</th>
<th>Together</th>
<th>Units</th>
<th>Shall</th>
<th>ramp</th>
<th>Tridium</th>
<th>for fan control</th>
</tr>
</thead>
</table>

**Description**

MF-552 shows that AHU1&2 and AHU3&4 share common ducts respectively. SOO 3.6.4.3 indicates that the 4 units operate as a system. SOO 3.6.C says that “all units shall start and ramp together. All units shall receive a static pressure setpoint from Tridium for fan control”. Tridium sending a setpoint for fan control is not unusual and may have actually intended to indicate that Tridium should send the AHUs a avg static pressure.

**Clarification Request:**

1) Please confirm the intent of specifically indicating that the static pressure setpoint will be received from tridium.

2) Currently AHU1 & three control from a Tridium setpoint to their lowest static pressure sensor respectively. Should all the AHUs in the system control the VFDs based on the low select of any static pressure sensor in the common duct?

---

### RFI 11. Lab AHU Unit Operation

**References:** 230993 3.6.F

**F. System Air Volume Control**

1. Each AHU shall have its own hardwired discharge static pressure transmitter located where the ducts first converge into a single common duct.
   - Wire to existing:
     1. (5) sensors for AHU-3/4

**Description**

SOO 3.6.F.1.a.1 indicates that there are 5 existing duct static pressure sensors that are currently installed and wired to the controller for AHU-3.

---

1. Refer to Addendum 3
2. Updated per Addendum #8
   - AHU 1 & 2 shall have existing sensors. AHU 1 & 2 shall control to their lowest static pressure transmitter, and AHU 3 & 4 shall control to their lowest static pressure transmitter. Per Addendum #5 “the AHU controller shall receive an averaged static pressure control setpoint from Tridium”.

1. 5 sensors are existing and wired to AHU-3, one of these existing sensors shall disconnected from AHU-3 and wired to AHU-4.
2. The signal from the sensor shall not be split.
<table>
<thead>
<tr>
<th>Clarification Request:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Please confirm that you want these to remain wired to AHU-3, but also wired to AHU-4.</td>
</tr>
<tr>
<td>2) Please provide a wiring diagram that indicates how you would like us to wire 2 controllers to one sensor.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RFI 12. Exhaust energy recovery unit interlocking</th>
</tr>
</thead>
<tbody>
<tr>
<td>References: 230923 3.2.B</td>
</tr>
<tr>
<td>B. Control software algorithm and inputs and outputs for pieces of equipment that reside on a single controller and shall not be distributed shall be interlocked, a single master controller shall provide control for all pieces of equipment, i.e. an AHU and interlocks.</td>
</tr>
<tr>
<td>230993 3.7.B</td>
</tr>
<tr>
<td>B. Interlocking:</td>
</tr>
<tr>
<td>1. EAHU-1 is interlocked with the following units:</td>
</tr>
<tr>
<td>a. AHU-1</td>
</tr>
<tr>
<td>b. AHU-2</td>
</tr>
<tr>
<td>c. EF-1A thru 1D</td>
</tr>
<tr>
<td>d. North side of the building exhaust and fume hood</td>
</tr>
<tr>
<td>e. HBP-2</td>
</tr>
<tr>
<td>2. EAHU-2 is interlocked with the following units:</td>
</tr>
<tr>
<td>a. AHU-3</td>
</tr>
<tr>
<td>b. AHU-4</td>
</tr>
<tr>
<td>c. EF-2A thru 2D</td>
</tr>
<tr>
<td>d. South exhaust ducts and fume hoods for all floors</td>
</tr>
<tr>
<td>e. HBP-2</td>
</tr>
<tr>
<td>3. EAHU-3 is interlocked with the following units:</td>
</tr>
<tr>
<td>a. AHU-1</td>
</tr>
<tr>
<td>b. AHU-2</td>
</tr>
<tr>
<td>c. EF-3A thru 3D</td>
</tr>
<tr>
<td>d. HBP-3</td>
</tr>
<tr>
<td>4. EAHU-4 is interlocked with the following units:</td>
</tr>
<tr>
<td>a. AHU-6 (Existing)</td>
</tr>
<tr>
<td>b. AHU-6 (Existing)</td>
</tr>
<tr>
<td>c. AHU-7</td>
</tr>
<tr>
<td>d. AHU-8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The UK BAS specification 3.2.B sets the standard that “if multiple pieces of equipment are to be INTERLOCKED, a single master controller shall provide control for all pieces of equipment”. SOO section 3.7.B clearly identifies AHU-1 thru 8, EAHUs, dampers, etc. are to be INTERLOCKED.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clarification Request:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Please clarify what is required by BAS spec 3.2.B in regards to a “Master Controller”. Is the intent of this spec that all the AHUs and EAHUs will be on a single field controller, or does it simply prevent the reliance on the UK IT infrastructure by requiring all of the field controllers in a “SYSTEM” be installed on the same MSTP trunk (utilizing a Master Supervisory controller)?</td>
</tr>
</tbody>
</table>
2) Please confirm the contractor, that is awarded this contract, is responsible for all programming and modifications to the existing EAHU controls to accomplish the interlocking as shown in SOO 3.7.B and elsewhere.

<table>
<thead>
<tr>
<th>RFI 13. Payment and Performance Bonds</th>
</tr>
</thead>
<tbody>
<tr>
<td>References:</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>It appears that the controls contractor is required to provide a performance bond for the amount of their subcontract with Whiting Turner. The controls contractor has also been asked to carry, as part of their contract, the owner’s allowance for Phoenix and Aircuity.</td>
</tr>
<tr>
<td>Clarification Request:</td>
</tr>
<tr>
<td>1) Is it the intent that the controls contractor will need to include a bond for their entire contract amount or only on their labor?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RFI 14. Electrical Manhole Bore</th>
</tr>
</thead>
<tbody>
<tr>
<td>References: IC800 Add#1 Keynote 1</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>IC 800 indicates that a controls conduit needs to be bored between 2 manholes. We need clarification as to what trade will bore the conduit.</td>
</tr>
<tr>
<td>Clarification Request:</td>
</tr>
<tr>
<td>1) Please confirm if the intent is to have the controls contractor bore a conduit across this finished area, or will the bore and conduit be furnished by another trade?</td>
</tr>
<tr>
<td>2) Who is responsible for repair of the site, concrete or asphalt?</td>
</tr>
<tr>
<td>3) Who is responsible for any damage to existing underground utilities in the area bored?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RFI 15. Static Pressure Sensors being shared across the UK campus IT Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>There are several Systems of AHUs that will work together to feed common ducts. Throughout the SOO there are a few references that indicate static pressure readings should be sent across the campus network to the Tridium Server to be averaged, before being sent back across the campus network to the associated AHUs for control over the Supply Fans.</td>
</tr>
<tr>
<td>Clarification Request:</td>
</tr>
<tr>
<td>1) Refer to Addendum #5.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WT</th>
</tr>
</thead>
<tbody>
<tr>
<td>WT</td>
</tr>
<tr>
<td>WT</td>
</tr>
<tr>
<td>WT</td>
</tr>
<tr>
<td>WT</td>
</tr>
<tr>
<td>AEI</td>
</tr>
<tr>
<td>1. Refer to Addendum #5.</td>
</tr>
</tbody>
</table>
Supply fan PID loops are a typically one of the faster PIDs. Given the potential communication delay, there could create control issues or hunting, especially on startup or AHU switchover from lead-lag or lead-standby. There are also several instances throughout the project SOO and UK standards that show that all of the AHUs and Konvekta will be on the same MSTP trunk.

Given the requirements for 1 MSTP trunk for all the AHU systems and Konvekta, it could be a better solution to have the Static Pressures be passed to each associated AHU, for averaging, via the MSTP trunk. This would remove any delay or failures created by passing information across the Campus IT Network.

The average static pressure setpoint could still be sent to all controllers through Tridium, but the control process variables would remain within BACnet MSTP level and not reliant on the Campus infrastructure.

Clarification Request:
1) Please confirm the intent of controlling the AHU supply fans to a common Average Static Pressure, and how information should be shared to obtain the “average static pressure” to be used as a control point.

<table>
<thead>
<tr>
<th>RFI 16. Composite Cleanup</th>
<th></th>
<th>WT</th>
</tr>
</thead>
<tbody>
<tr>
<td>References:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>There appears to be composite clean-up on the project, where each contractor will have to supply a person all day, every day that they are on-site. That person will be dedicated to cleanup of general cleanup and not for the cleanup of own work.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarification Request:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Does the controls contractor have to provide labor for composite cleanup for every day that they or their subcontractors are on site?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Due to some corporate approvals and signature requirements that are required, and may take us some time to get, can we officially request a 1 week extension to the bid date? I know time is important on this, but I have been requested to ask. Looking for 4/4 as the new bid date?

<table>
<thead>
<tr>
<th></th>
<th>WT</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

General Conditions indicate we will need to provide for 100% onsite PM/supervision. Is this actually required for the temperature control contractor?

<table>
<thead>
<tr>
<th></th>
<th>WT</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

General Conditions indicate to carry costs for on-site dumpster and street cleaning. Will the

<table>
<thead>
<tr>
<th></th>
<th>WT</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>32</td>
<td>General Conditions indicate to carry costs for a trailer and utility costs. Will the temperature control contractor need to carry these costs?</td>
</tr>
<tr>
<td>33</td>
<td>Can you confirm that the Automatic Transfer Switch and Power Monitoring points are already points that are being picked up by the existing control system. If so, do we still need to provide these points separate from the existing?</td>
</tr>
<tr>
<td>34</td>
<td>Can you clarify if the temperature control contractor is to provide occupancy sensors for the entire project or just for the lab areas shown as Sequence H?</td>
</tr>
<tr>
<td>35</td>
<td>Sequences A, B, C, D, E, F, N, and Q shows the phoenix air valves to be controlled by the BAS for temperature control in the space. What points are to be sent/received to each Phoenix Air Valve? Are these individual hard-wired points or transferred via BACnet?</td>
</tr>
<tr>
<td>36</td>
<td>In our Bid Form Scope of Work, it is stated that Pressure Independent Valves are to be provided where shown in the drawings. We do not see any not to provide these type of valves. Can you confirm that per the valve schedule on drawing IC950 are the only required type of valves on this project and there are no pressure independent valves required?</td>
</tr>
<tr>
<td>37</td>
<td>There are multiple VSV’s that do not have a controls sequence identified int the Air Devices schedule (sheet MF-953).</td>
</tr>
<tr>
<td>38</td>
<td>There are no space temperature sensors indicated on the mechanical floor plans for the majority of the spaces. A few select spaces show temperature and humidity sensors, but no where are the temperature only sensors shown. Please clarify where temperature only sensors are required.</td>
</tr>
</tbody>
</table>