ADDENDUM NO. 5 **(Rev 1/2023)**
ISSUE DATE: **September 9, 2026**

RE: **WIMR EAST WEDGE CYCLOTRON AND EXPANSION**
UNIVERSITY OF WISCONSIN - MADISON
MADISON, WISCONSIN
UW-Madison Project No. **1485-2511** / UWSA Project No. **A-23-011**

Division Project No.

BID OPENING: **MEP Bid - 2:00 P.M., September 16, 2026**
GPC Bid - 2:00 P.M., September 30, 2026.

FROM: **Potter Lawson, Inc.**
749 University Row, Suite 300
Madison, WI 53705

TO: Prospective Bidders

This addendum forms a part of the Contract Documents and modifies the original Contract Documents dated **June 30, 2026** as noted below. Acknowledge receipt of this Addendum by inserting the number and issue date of this addendum in the blank space provided on the Bid Form. Failure to do so may subject the Bidder to disqualification.

This Addendum consists of 3 pages and the attached documents:
Specification Sections: Volume 1 GPC Table of Contents, GPC Bid Form, Volume 1 MEP Table of Contents, MEP Bid Form, Volume 2 Table of Contents, 23 09 14, 23 09 15, 23 09 23, 23 09 93, 23 22 13, 23 33 00, 23 37 13.

Drawings: T0.11, S0.14, S2.02B, T0.21, L7.21, L7.50, T0.31, M2.00B, M7.01, M7.10, M9.02, M9.03, M9.04, E3.00B, E7.03, E9.06.

CHANGES TO BIDDING REQUIREMENTS:

1. Volume 1 GPC Table of Contents
    a. Update Specification Sections and Drawings Tables of Contents as indicated.
2. GPC Bid Form:
    a. Add a fifth Addendum line under Addendum Receipt.
3. Volume 1 MEP Table of Contents
    a. Update Specification Sections and Drawings Tables of Contents as indicated.
4. MEP Bid Form:
    a. Add a fifth Addendum line under Addendum Receipt.

CHANGES TO CONDITIONS OF THE CONTRACT:

NA

CHANGES TO SPECIFICATIONS (DIVISIONS 2 THRU 34):

1. Volume 2 Table of Contents
    a. Update Specification Sections and Drawings Tables of Contents as indicated.
2. 23 09 14 – Pneumatic and Electric Instrumentation and Control Devices for HVAC
    a. Page 16, lines 42-48 were added. This clarifies that not all DDCs will be BACnet/IP.
3. 23 09 15 – Direct Digital Control Input-Output Point Summary Tables
    a. Room Control Sequence B was modified to eliminate HEPA Filter Unit points from this point list.
    b. Room Control Sequence C was modified to eliminate HEPA Filter Unit points from this point list.

c. HEPA Filter Unit typical point list was added. Clarifies the points that should be integrated for all HFUs provided on this Project.

4. 23 09 23 – Direct Digital Control System for HVAC
    a. Specification was updated to clarify that not all DDCs will utilize BACnet IP integration.
5. 23 09 93 – Sequence of Operation for HVAC Control
    a. Page 37, lines 13-15 were added. Clarifies how HEPA filter units are to be integrated into the BAS.
    b. Page 38, lines 7-9 were added. Clarifies how HEPA filter units are to be integrated into the BAS.
6. 23 22 13 – Steam and Condensate Heating Piping
    a. Page 3, lines 18-21, Added section for 2" and Smaller Finned Pipe.
7. 23 33 00 – Air Duct Accessories
    a. Page 4, lines 45-52, Revised construction material for sound attenuators from galvanized steel to stainless steel.
8. 23 37 13 – Diffusers, Registers & Grilles
    a. Page 1, SCOPE paragraph was updated.
    b. Page 4, lines 19-50, were added. This addition details the requirements of BAS integration of the HEPA ceiling diffusers with integral fans.

CHANGES TO DRAWINGS:

5. SHEET T0.11 – SHEET INDEX VOLUME 1
    a. Added Sheet L7.50 – Vault Penetrations
6. SHEET S0.14 – DESIGN LOAD PLANS
    a. Revise Area 11 Description to say future.
7. SHEET S2.02B - L2 - SECOND LEVEL ENLARGED FLOOR PLAN - AREA B
    a. Revise note about future topping slab.
8. SHEET T0.21 – SHEET INDEX VOLUME 2
    a. Added Sheet L7.50 – Vault Penetrations
9. SHEET L7.21 - INTERIOR ELEVATIONS
    a. Added callout to detail 5.
10. SHEET L7.50 - VAULT UTILITY PENETRATIONS
    a. Added Sheet.
11. SHEET T0.31 – SHEET INDEX VOLUME 3
    a. Added Sheet L7.50 – Vault Penetrations
12. SHEET M2.00B – B1 – BASEMENT LEVEL MECHANICAL PLAN – AREA B
    a. Revised HFU tags in the clean rooms to be unique and match new tags on schedule.
    b. Added TCP-HFU, control panel for the Hepa filter units
    c. Added sheet keynote #13 to provide information on HFU control panel.
    d. Revised "DDC" tags to "TCP" tags for control panels.
13. SHEET M7.01 – BUILDING AUTOMATION SYSTEM ARCHITECTURE
    a. Sheet keynote #6 was updated.
    b. Sheet keynotes #10-12 was updated.
    c. TCP-HFU was added. The integration of the HEPA filter units (HFUs) was modified to align with the basis of design units.
14. SHEET M7.10 – ROOM HVAC CONTROL DIAGRAMS
    a. Sheet keynote #11 was updated. The integration of the HEPA filter units (HFUs) was modified to align with the basis of design units.
15. SHEET M9.02 – MECHANICAL SCHEDULES
    a. Revised enclousure type for VFD-EF-66A – C from NEMA 4 to NEMA 1.
    b. Revised HFU tags to be unique on the "Hepa Fan Filter Unit" schedule.
    c. Revised location of "Hepa Fan Filter Unit" and "Expansion Tank" schedules on sheet.
16. SHEET M9.03 – MECHANICAL SCHEDULES
    a. Revised SAT-37-B-17 and GET-66-B-10 from Venturi type to Butterfly type.
17. SHEET M9.04 – MECHANICAL SCHEDULES
    a. Revised material for GEV-66-B-4.
    b. Added note #4 to GEV-66-B-4.
18. SHEET E3.00B - B1 – BASEMENT LEVEL ELECTRICAL POWER PLAN – AREA B

a. Revised HFU equipment names to have individual designators.
b. Revised keynote 7 to provide cord reel information.

19. SHEET E7.03 – ELECTRICAL GROUNDING RISER DIAGRAM
    a. Added keynote 1 to clarify lightning protection system scope.
20. SHEET E9.06 – ELECTRIAL PANEL SCHEDULES
    a. Revised load descriptions in panel EB1NPL19-1 and -2 to match new HUF equipment names.

END OF ADDENDUM

Potter Lawson, Inc.
749 University Row, Suite 300
Madison, WI 53705

Division of Facilities Development
Department of Administration
Madison, Wisconsin 53707-7866

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51	E3.03S	L3 - THIRD LEVEL ELECTRICAL POWER PLAN - SOUTH
52	E3.04	L8 - EIGHTH LEVEL ELECTRICAL POWER PLAN
53	E4.00	B1 - BASEMENT LEVEL ELECTRICAL SYSTEMS PLAN
54	E4.00M	B1M - BASEMENT MEZZANINE LEVEL ELECTRICAL SYSTEMS PLAN
55	E4.01	L1 - FIRST LEVEL ELECTRICAL SYSTEMS PLAN
56	E4.02	L2 - SECOND LEVEL ELECTRICAL SYSTEMS PLAN

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BID FORM – GENERAL PRIME CONTRACTOR (GPC) (Rev 04/2024)
THE BOARD OF REGENTS OF THE UNIVERSITY OF WISCONSIN SYSTEM
s.16.855 Wis. Stats.

WIMR EAST WEDGE CYCLOTRON AND EXPANSION
UNIVERSITY OF WISCONSIN - MADISON
MADISON, WISCONSIN

UW- Madison Project No. **1485-2511 /** UWSA Project No**. A-23-011**

General Prime Contractor (GPC) Bid Opening: 2:00 P.M., September 30, 2026.

To: University of Wisconsin System Administration (UWSA)

(a joint venture)
(a corporation)
(a partnership)
We_____ (an individual)
(Cross out inapplicable)

Of_____
Street City State Zip

hereby agree to execute a contract with the Board of Regents of the University of Wisconsin System (the Owner) and a subcontract with all successful MEP Bidders identified by the Owner and listed in this bid, and to furnish satisfactory separate 100% Performance Bond and 100% Payment Bond in the amount specified no later than ten (10) days of the contract offer, and to provide all labor and material required for the construction of the project designated above, for the prices hereinafter set forth, in strict accordance with the Contract Documents prepared by Potter Lawson, Inc, 749 University Row, Suite 300, Madison, WI 53705 for the Owner and dated **June 30, 2026.**

Contact Instructions:
(For use by Owner to offer contract to the successful bidders)

Contact name:_____

Title:_____

Telephone Number:_____

Email address:_____

IMPORTANT: BEFORE SUBMITTING YOUR BID, PLEASE VERIFY THAT:

1. You have been **certified by DOA as a qualified and responsible bidder** for the amount of your bid within the division(s) of work being bid.
2. You have **entered all Bid amounts in numeric characters** (Example: $9,999);
3. You have **acknowledged receipt of all addenda;**
4. You have **signed the Bid Form**
5. You have **included a valid Bid Guarantee** for not less than 10% of the value of the bid as either:
   a) a Bid Bond signed by the contractor and surety, with a Power of Attorney attached, **or**
   b) a Cashier's Check or Bank Check pursuant to Wis. Stat. s. 779.14(1m)(c)2.b. and 779.14(1s). A Company or Personal Check will not be accepted.

SINGLE BASE BID - GENERAL PRIME CONTRACTOR

ALL WORK

BASE BID NO 1. ALL WORK required to fully complete the project in accordance with the Contract Documents,

for the sum of ($_____)
Enter bid amount in numeric characters only *(Example: $9,999). See Instructions to Bidders 'Article 16 Submission of Base Bids' for detailed instructions.*

Base Bid No. 1 includes the bids from the following successful MEP Subcontractors identified by UWSA for the mechanical, electrical, plumbing, and fire protection divisions of work in this project. The General Prime Contractor shall enter into subcontracts with these MEP Subcontractors:

Fire Suppression Base Bid No. 2:
Identified Subcontractor: _____

Amount:_____

Plumbing Base Bid No. 3:
Identified Subcontractor: _____

Amount: _____

Heating Ventilating and Air Conditioning Base Bid No. 4:
Identified Subcontractor: _____

Amount:_____

Electrical Base Bid No. 5:
Identified Subcontractor: _____

Amount:_____

Combined Base Bids Option

Base Bid No. _____ for _____(Division of Work),
Base Bid No. _____ for _____(Division of Work) and
Base Bid No. _____ for _____(Division of Work) and
Base Bid No. _____ for _____(Division of Work) Work fully complete as per specifications and related drawings, for the sum of

($_____)
Enter bid amount in numeric characters only (Example: $9,999).

COMMENCEMENT AND COMPLETION OF CONTRACT WORK

The undersigned agrees, if awarded the contract, to enter into a subcontract with the MEP Bidders identified by the Owner.

ADDENDUM RECEIPT

We acknowledge receipt of the following Addenda:

Addendum No._____ Date_____

Addendum No._____ Date_____

Addendum No._____ Date_____

Addendum No._____ Date_____

Addendum No._____ Date_____

PRIOR TO SIGNING, BIDDERS' ATTENTION IS DIRECTED TO INSTRUCTIONS TO BIDDERS TO AVOID THE POSSIBILITY OF INVALIDATING THIS BID.

BY SIGNING THIS BID FORM, THE BIDDER ATTESTS TO PERSONAL KNOWLEDGE OF THE FOLLOWING:

1.	Bidder is certified by DOA as a qualified and responsible bidder for the amount of the bid submitted, within the division(s) of work being bid.
2.	In accordance with Wis. Stats. 16.855 (13) and (14) and ARTICLE 21 of these Bidding Documents, Bidder agrees to enter into a subcontract with the successful MEP Subcontractors identified by the Owner.
3.	Bidder has examined the drawings and specifications, carefully prepared the bid form, and has reviewed all forms in detail before submitting bid; and bidder, or the agents, officers, or employees thereof, have not, either directly or indirectly, entered into any agreement, bid rigging, bid rotation, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in connection with this bid.
4.	That all work will be performed at the Bidder's own proper cost and expense, that the Bidder will furnish all necessary materials, labor, tools, machinery, apparatus, and other means of construction in the manner provided in the applicable specifications, and at the time stated in the contract.

_____
(Firm Name)

_____
(Bidder's Printed Name)

_____
(Bidder's Title)

(Seal, if bid is by a corporation)

Date: _____ By _____
(Signature of Bidder)

[ ] Place an "X" in the box if Bidder is certified as a minority business enterprise or disabled veteran-owned business by the Wisconsin Supplier Diversity Program and wishes to be considered for the 5% bidder preference.

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E3.00MB	B1M - BASEMENT MEZZANINE LEVEL ELECTRICAL POWER PLAN - AREA B
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BID FORM – MECHANICAL, ELECTRICAL, PLUMBING, AND FIRE PROTECTION (MEP) (Rev 04/2024)
THE BOARD OF REGENTS OF THE UNIVERSITY OF WISCONSIN SYSTEM
s.16.855 Wis. Stats.

WIMR EAST WEDGE CYCLOTRON AND EXPANSION
UNIVERSITY OF WISCONSIN - MADISON
MADISON, WISCONSIN

UW- Madison Project No. **1485-2511 /** UWSA Project No**. A-23-011**

Mechanical, Electrical, Plumbing, and Fire Protection (MEP) Bid Opening: 2:00 P.M., September 16, 2026

To: University of Wisconsin System Administration (UWSA)

(a joint venture)
(a corporation)
(a partnership)
We_____ (an individual)
(Cross out inapplicable)

Of_____
Street City State Zip

hereby agree to execute a subcontract with the General Prime Contractor awarded the contract for the project designated above and to furnish satisfactory separate 100% Performance Bond and 100% Payment Bond in the amount specified no later than ten (10) days after execution of the subcontract with the General Prime Contractor, and to provide all labor and material required for the construction of the project designated above, for the prices hereinafter set forth, in strict accordance with the Bidding Documents prepared by Potter Lawson, Inc, 749 University Row, Suite 300, Madison, WI 53705 for the Owner and dated **June 30, 2026.**

(For use by General Prime Contractor to offer subcontract to the successful MEP bidders identified through UWSA)

Contact name: _____

Telephone Number: _____

Email address: _____

FAX Number: _____

IMPORTANT: BEFORE SUBMITTING YOUR BID, PLEASE VERIFY THAT:

1. You have been **certified by DOA as a qualified and responsible bidder** for the amount of your bid within the division(s) of work being bid.
2. You have **entered all Bid amounts in numeric characters** (Example: $9,999);
3. You have **acknowledged receipt of all addenda;**
4. You have **signed the Bid Form**
5. You have **included a valid Bid Guarantee** for not less than 10% of the value of the bid as either:
   a) a Bid Bond signed by the contractor and surety, with a Power of Attorney attached, **or**
   b) a Cashier's Check or Bank Check pursuant to Wis. Stat. s. 779.14(1m)(c)2.b. and 779.14(1s). A Company or Personal Check will not be accepted.

FIRE SUPPRESSION

BASE BID NO. 2 Fire Suppression Work fully complete as per Bidding Documents, for the sum of

($_____)

Enter bid amount in numeric characters only *(Example: $9,999). See MEP Instructions to Bidders 'Article 16 Submission of Base Bids' for detailed instructions.*

PLUMBING

BASE BID NO. 3 Plumbing Work fully complete as per Bidding Documents, for the sum of

($_____)

Enter bid amount in numeric characters only *(Example: $9,999). See MEP Instructions to Bidders 'Article 16 Submission of Base Bids' for detailed instructions.*

HEATING, VENTILATING AND AIR CONDITIONING

BASE BID NO. 4 Heating, Ventilating, Air Conditioning Work fully complete as per Bidding Documents, for the sum of

($_____)

Enter bid amount in numeric characters only *(Example: $9,999). See MEP Instructions to Bidders 'Article 16 Submission of Base Bids' for detailed instructions.*

ELECTRICAL

BASE BID NO. 5 Electrical Work fully complete as per Bidding Documents for the sum of

($_____)

Enter bid amount in numeric characters only *(Example: $9,999). See MEP Instructions to Bidders 'Article 16 Submission of Base Bids' for detailed instructions.*

COMBINED BASE BIDS OPTION

BASE BID NO. _____ for _____(Division of Work),
BASE BID NO. _____ for _____(Division of Work) and
BASE BID NO. _____ for _____(Division of Work) and
BASE BID NO. _____ for _____(Division of Work) Work fully complete as per specifications and related drawings, for the sum of

($_____)

Enter bid amount in numeric characters only *(Example: $9,999). See MEP Instructions to Bidders 'Article 16 Submission of Base Bids' for detailed instructions.*

COMMENCEMENT AND COMPLETION OF WORK

The undersigned agrees, if identified as the lowest qualified responsible certified bidder for the divisions(s) of work bid on, to enter into a subcontract with the General Prime Contractor.

ADDENDUM RECEIPT

We acknowledge receipt of the following Addenda:

Addendum No._____ Date_____

Addendum No._____ Date_____

Addendum No._____ Date_____

Addendum No._____ Date_____

Addendum No._____ Date_____

PRIOR TO SIGNING, BIDDERS' ATTENTION IS DIRECTED TO MEP INSTRUCTIONS TO BIDDERS TO AVOID THE POSSIBILITY OF INVALIDATING THIS BID.

BY SIGNING THIS BID FORM, THE BIDDER ATTESTS TO PERSONAL KNOWLEDGE OF THE FOLLOWING:

1. Bidder is certified by DOA as a qualified and responsible bidder for the amount of the bid submitted, within the division(s) of work being bid.

2. Bidder agrees to enter into a subcontract with the General Prime Contractor in accordance with Wis. Stats. s. 16.855(14) and ARTICLE 9 of these Bidding Documents.

3. Bidder has examined the drawings and specifications, carefully prepared the bid form, and has reviewed all forms in detail before submitting bid; and bidder, or the agents, officers, or employees thereof, have not, either directly or indirectly, entered into any agreement, bid rigging, bid rotation, participated in any collusion, or otherwise taken any action in restraint of free competitive bidding in connection with this bid.

4. That all work will be performed at the Bidder's own proper cost and expense, that the Bidder will furnish all necessary materials, labor, tools, machinery, apparatus, and other means of construction in the manner provided in the applicable specifications, and at the time stated in the General Prime Contractor's Notice to Proceed.

_____
(Firm Name)

_____
(Bidder's Printed Name)

(Seal, if bid is by a corporation)

Date: _____ By _____
(Signature of Bidder)

[ ] Place an "X" in the box if Bidder is certified as a minority business enterprise or disabled veteran-owned business by the Wisconsin Supplier Diversity Program.

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SECTION 23 09 14
PNEUMATIC AND ELECTRIC INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
BASED ON DFD MASTER SPECIFICATION DATED 9/6/2023

P A R T 1 - G E N E R A L

SCOPE

This section includes control system specifications for all HVAC work as well as related control for systems found in other specification sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Point List
- Related Work
- Reference
- Quality Assurance
- Reference Standards
- System Description
- Submittals
- Demolition
- Design Criteria
- Operation and Maintenance Data
- Material Delivery and Storage

PART 2 - PRODUCTS
- Air Piping
- Control Dampers
- Control Valves
- Control System Instrumentation
- Thermostat Guards
- Electric/Electronic Thermostats
- Duct Smoke Detector and Fire Alarm Interface Modules
- Water Flow Measurement (HVAC Water)
- Water Flow Measurement (Domestic Water)
- Steam Flow Measurement
- Steam Condensate Ultrasonic Flow Meters
- Temperature Control Panels
- Temperature Sensors
- Humidity Sensors
- Pressure Transducers (Air)
- Pressure Transducers (Liquid/Steam)
- Current Status Switches
- Fume Hood Presence Sensors
- Flammable Gas Detection Sensors
- Oxygen Depletion Sensors
- Horns/Strobes – Flammable Gas Detection Sensors & Oxygen Depletion Sensors
- Water Leak Detectors
- Power Supplies

PART 3 - EXECUTION
- Installation
- Air Piping
- Wire and Air Piping Conduit and Tubing Installation Schedule
- Control Dampers
- Control Valves
- Control System Instrumentation
- Room Thermostats and Temperature Sensors
- Low Limit Thermostats (Freezestats)
- Liquid and Steam Flow Sensors
- Steam Condensate Water Meters
- Pressure Transducers
- Temperature Control Panels
- Air Pressure Safety Switches
- Current Status Switches
- Fume Hood Presence Sensors

Preconstruction Review Meeting
Construction Verification
Functional Performance Testing
Agency Training

POINT LIST (Section 23 09 15)

RELATED WORK
Section 01 91 01– Commissioning Process
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC - Coordination
Section 23 08 00 – Commissioning of HVAC
Section 23 09 15 - Direct Digital Control Input/Output Point Summary Tables
Section 23 09 23 - Direct Digital Control System for HVAC
Section 23 09 93 - Sequence of Operation
Section 23 33 00 - Ductwork Accessories - for control damper installation
Division 23 - HVAC - Equipment provided to be controlled or monitored
Division 26 - Electrical - Installation requirements & Equipment provided to be controlled or monitored
Division 28 - Electronic Safety and Security

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

QUALITY ASSURANCE
Installing contractor must be a manufacturer's branch office or an authorized representative of a Direct Digital Control (DDC) equipment manufacturer that provides engineering and commissioning of the DDC equipment. Submit written confirmation of such authorization from the manufacturer. Indicate in letter of authorization that installing contractor has successfully completed all necessary training required for engineering, installation, and commissioning of equipment and systems and that such authorization has been in effect for a period of not less than three years. DDC equipment may or may not be required to be installed by this contractor as part of the project, but the intent of this quality assurance specification is to ensure that the installing contractor has the capabilities to engineer, install, and commission the field devices supplied under this section for temperature control.

REFERENCE STANDARDS

ANSI B16.22	Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings
ANSI/ASTM B32	Specification for Solder Metal
ASTM B75	Seamless Copper Tube
ASTM D1693	Environmental Stress-Cracking of Ethylene Plastics
ASTM D 635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
AMCA 500-D	Laboratory Method of Testing Dampers for Rating

SYSTEM DESCRIPTION
System is to use direct digital control with electric actuation for air handling units; direct digital control with electric actuation for room temperature, room humidity, and terminal airflow control; and electric control for other terminal units.

All pneumatic tubing and electrical wiring are to be permanently tagged or labeled (within one inch of terminal strip) with a numbering system to correspond with the "Record Drawings". Tags or labels shall be printed not hand written.

SUBMITTALS
Include the following information:

Manufacturer’s data sheets indicating model number, pressure/temperature ratings, capacity, methods and materials of construction, installation instructions, and recommended maintenance. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked.

Schematic flow diagrams of systems showing fans, pumps, coils, dampers, valves, and other control devices. Each control device provided under this Section shall be uniquely labeled. Duplicate labeling may be used within similar mechanical systems. Label each device with setting or adjustable range of control. Indicate all wiring, clearly, differentiating between factory and field installed wiring. Wiring should be shown in

schematics that detail contact states, relay references, etc. Diagrammatic representations of devices alone are not acceptable.

Details of construction, layout, and location of each temperature control panel within the building, including instruments location in panel and labeling. Also include on drawings location of mechanical equipment controlled (room number), horsepower and flow of motorized equipment (when this data is available on plans), locations of all remote sensors and control devices (either by room number or column lines).

Schedule of control dampers indicating size, leakage rating, arrangement, pressure drop at design airflow, and number and size of operators required.

Schedule of control valves indicating system in which the device is to be used, rated capacity, flow coefficient, flow required by device served, actual pressure drop at design flow, size of operator required, close-off pressure, and locations where valves are to be installed.

A complete description of each control sequence for equipment that is not controlled by direct digital controls. Direct digital controlled equipment control sequences will be provided by the DDC control contractor.

Calculations completed to determine size of control air compressor(s) and dryer (s).

Prior to request for final payment, submit record documents which accurately record actual location of control components including panels, thermostats, wiring, and sensors. Incorporate changes required during installation and start-up.

All submittals are to comply with submission and content requirements specified in specification Section01 91 02.

DEMOLITION

Where existing control devices, piping, or wiring are discontinued from use, remove, and turn over to owner. If owner does not want them remove from premises. Remove any previously abandoned control devices in a similar manner.

DESIGN CRITERIA

Size all control apparatus to properly supply and/or operate and control the apparatus served.

Provide control devices subject to corrosive environments with corrosion protection or construct them so they are suitable for use in such an environment.

Provide devices exposed to outside ambient conditions with weather protection or construct them so they are suitable for outdoor installation. DDC panels installed outdoors shall be NEMA 4X.

Use only UL labeled products that comply with NEMA Standards. Electrical components and installation to meet all requirements of the electrical sections (Division 26) of project specifications.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.
In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Lubrication instructions, including list/frequency of lubrication
2. List indicating types and grades of oil and/or grease, packing materials, normal and abnormal tolerances for devices, and method of equipment adjustment.
3. Table noting full load power factor, service factor, NEMA design designation, insulation class and frame type for each motor provided
4. A complete set of record control drawings.

MATERIAL DELIVERY AND STORAGE

Provide factory shipping cartons for each piece of equipment and control device. This contractor is responsible for storage of equipment and materials inside and protected from the weather.

P A R T 2 - P R O D U C T S

AIR PIPING

ASTM B75 seamless, hard drawn, or annealed copper tubing with ANSI B16.22 wrought copper fittings, except final connections to apparatus may be made with brass compression-type fittings. Use ANSI/ASTM B32, 95/5 tin antimony solder.

Virgin polyethylene plastic tubing classified as flame retardant under UL 94 and conforming to ASTM D1693 stress-crack test.

CONTROL DAMPERS

Provide control dampers shown on the plans and as required to perform the specified functions. Dampers shall be rated for velocities that will be encountered at maximum system design and rated for pressure equal or greater than the ductwork pressure class as specified in Section 23 31 00 of the ductwork where the damper is installed.

Use only factory fabricated dampers with mechanically captured replaceable resilient blade seals, stainless steel jamb seals and with entire assembly suitable for the maximum temperature and air velocities encountered in the system.

All dampers in stainless steel, PCD coated steel, PVC, PTFE, or fiberglass ductwork shall be constructed of stainless steel.

All dampers in aluminum ductwork shall be constructed of stainless steel or aluminum.

Dampers in galvanized ductwork shall be constructed of galvanized steel and/or aluminum.

All dampers, unless otherwise specified, to be rated at a minimum of 180º F working temperature. Leakage testing shall be certified to be based on latest edition of AMCA Standard 500-D and all dampers, unless otherwise specified, shall have leakage ratings as follows:

Damper Class	Differential Pressure	Leakage
Class IA	1" w.g.	≤3 CFM/ft^2
Class I	4" w.g.	≤8 CFM/ft^2
Class I	8" w.g.	≤11 CFM/ft^2
Class I	12" w.g.	≤14 CFM/ft^2

Leakage rate dampers for differential pressures that they will encounter at maximum system design pressures.

Steel framed dampers: Nailor models 2010 & 2020; Greenheck models VCD-33 & VCD-42; Johnson Controls model VD-1630; Ruskin Models CD60 & CD40; other approved equal.

Aluminum frame and blade dampers: Nailor models 2010EAF & 202EAF; Greenheck model VCD-43; Ruskin model CD50; Arrow model AFD-20; other approved equal.

Dampers used for directed mixing of airstreams, i.e., outside air and return air, to be parallel blade type and sized for an air velocity of 1800 to 2000 fpm with the damper blades shall be arranged so that the air streams are directed at one another to facilitate mixing. Dampers used for throttling or modulating applications other than air stream mixing to be opposed blade type. Two position dampers may be parallel or opposed blade type.

Dampers used for isolation on the discharge of centrifugal fans shall have damper blades perpendicular to the fan shaft to minimize system effect. Dampers mounted with blades vertically shall be designed for vertical blade orientation.

Dampers for applications other than lab exhaust to have frames of not less than 16 gauge galvanized steel or 12 gauge extruded aluminum. Blades to be two-ply steel airfoil of not less than 2 x 20 gauge galvanized steel (14 gauge equivalent) or extruded aluminum airfoil, with stainless steel, acetal, Celcon, bronze, or nylon bearings. Maximum allowable blade width is 8 inches. Use plated steel linkage hardware.

Dampers used for laboratory fume or general exhaust systems shall have not less than 8" wide x 14 gauge frames and not less than 16 gauge two-ply airfoil blades. Laboratory fume exhaust damper frames, blades, and axles to be constructed of 304 stainless steel. Laboratory general exhaust damper frames, blades, and axles to be constructed of galvanized steel. Dampers shall be selected for a minimum rating of 10" water gauge at a velocity of 4000 FPM and rated at a minimum of 250º F. Blade bearings to be constructed of stainless steel or Teflon. Blade seals to be silicone. Leakage testing shall be certified to be based on latest edition of AMCA Standard 500-D and laboratory fume exhaust dampers, shall have leakage ratings as follows:

Damper Class	Differential Pressure	Leakage
Class I	1” w.g.	≤4 CFM/ft^2
Class I	4” w.g.	≤8 CFM/ft^2
Class I	8” w.g.	≤11 CFM/ft^2
Class I	12” w.g.	≤14 CFM/ft^2

Laboratory fume and general exhaust dampers: Ruskin model CD80AF; Greenheck model HCD-230; or approved equal.

Maximum damper width is 48 inches; where required width exceeds 48 inches, use multiple damper sections. Inside frame free area shall be a minimum of 90% of total inside duct area.

Multiple width damper sections shall utilize jack shaft linkages unless noted below. Sections over 144 inches wide shall be actuated from two locations on the jack shaft. Double width damper sections for two-position operation may be actuated without jack shafts if each damper section is actuated separately. Dampers that have multiple width and multiple vertical sections shall have a jackshaft for each vertically stacked set of dampers and be provided with crossover linkages between jack shafts to transfer uneven loading.

Jack shafts shall be extended outside of the ductwork for external actuator mounting. Provide bearings on the point of exit for support of damper shafts to prevent wear on the shaft and the ductwork. If locating actuators out of the air stream is impossible, obtain mounting location approval from the designer unless the contract documents indicate in air stream mounting is acceptable. In no cases shall damper actuators for fume exhaust systems be located in the air stream or require entering the air stream to service an actuator.

Provide weatherproof NEMA 4 enclosures (Belimo N4 option or equal, Belimo ZS-100 or ZS-150 are not acceptable) that have removable covers that have clasps or machine screws (no sheet metal screws) and that do not require removing fasteners from the ductwork to prevent actuator failure or freeze-up when mounting in locations exposed to harsh environments or outdoor locations.

Size operators for smooth and positive operation of devices served, and with sufficient torque capacity to provide tight shutoff against system temperatures and pressure encountered. For electric modulating actuation, use fully proportional actuators with zero and span adjustments. For two-position electric actuation use 24 VAC for DDC controlled actuators, 120 VAC actuators may be used for hardwire interlocking. See 23 09 15 for specific type of input signal required. Actuator stroke times shall match the requirements of the DDC controllers provided under 23 09 23, and/or the specific system requirements for proper operation. All electric actuators will be provided with overload protection to prevent motor from damage when stall condition is encountered. Equip operators with spring return for applications involving fire, freeze protection, moisture protection or specified normally open/closed operation. If spring return actuators are not available for applications because of torque requirements or other application requirements, stored energy fail safe may be used if approved by the AE. Face and bypass dampers for heating applications shall fail to the face position. For all two position isolation dampers that are controlled by the DDC system, provide actuators that are powered open and closed and do not utilize the actuator fail position spring for DDC commanded operation unless specified. This is to prevent fast closure by the spring return. Dampers wired to fan power can utilize the actuator fail position spring to actuate the damper.

Where control sequences require damper position indication or interlock, provide damper end switches integral to the damper actuators with form “C” contacts. Damper end switches shall have adjustable positions that can be set for proving the damper open, closed, or both depending on the specified application. End switch contact ratings shall be suitable for application. Where multiple banks of dampers are provided and not physically interlocked, end switches shall be provided for each bank of dampers and wired together to prove all dampers are in the position to be indicated. End switches shall not contain mercury.

All power required for electric actuation shall be provided by this contractor if it is not able to be directly provided from the DDC controller.

Provide operators with linkages and brackets for mounting on device served.

CONTROL VALVES

Provide all control valves as shown on the plans/details and as required to perform functions specified. Spring ranges must be selected to prevent overlap of operation and simultaneous heating and cooling.

Size operators to allow smooth and positive operation of devices served and to provide sufficient torque capacity for tight shutoff against system temperatures and pressure encountered. For electric modulating actuation, use fully proportional actuators with 0-10VDC inputs and zero and span adjustments unless

specified otherwise in the chart below. If TriState with feedback is specified, valve position shall be fed back to the controller and controller shall position valve based on this feedback. For two-position electric actuation use 24 VAC for DDC controlled actuators, 120 VAC actuators may be used for hardwire interlocking. Electric actuators, for applications other than terminal units, shall be provided with a manual override capability. All electric actuators shall be provided with a visible position indicator.

All power required for electric actuation shall be provided by this contractor if it is not able to be directly provided from the DDC controller.

Provide operators that are full proportioning or two-position, as required for specified sequence of operation. Provide spring-return for applications involving fire, freeze protection, moisture protection or specified normally open/closed operation. Valves shall move to their fail positions on loss of electrical power.

Provide end switches integral to the valve actuator to prove the valve open, closed, or both to meet the application where specified in the plans or specifications. End switch contact ratings shall be suitable for application.

Two-position shut-off valves used for isolation of mechanical devices shall be sized for a maximum pressure drop of 2 PSI at design flow and shall be a minimum of line size.

Provide operators with linkages and brackets for mounting on device served.

All valves unless specifically noted on the plans or indicated below shall be globe style valves.

VALVE SERVING	**TYPE** Globe Butterfly (BF) Ball	**SIGNAL** 0-10 VDC TriState (24VAC) 2-Position Elect Pneumatic (Pneu)	**SPRING RETURN** REQUIRED Yes No	**FAIL POSITION** Open (thru Coil) Closed (bypass Coil) Last Position
Reheat Coil	Ball	0-10 VDC	No	Last Position
CUH and UH	Ball	TriState or 2-Pos Elect	Yes	Open
Fan Coil Heating	Ball	0-10 VDC	No	Last Position
Fan Coil Cooling	Ball	0-10 VDC	No	Last Position
AHU Reclaim Water Coil	Globe	0-10 VDC	Yes	See Flow Diagram
AHU Steam Coil	Globe	0-10 VDC	Yes	Open
AHU Cooling Coil	Ball	0-10 VDC	Yes	Closed
Humidifiers[1]	Globe[1]	0-10 VDC[1]	Yes[1]	Closed[1]
HW Heat Exchanger	Globe	0-10 VDC	Yes	Open
Process CHW HX	Ball	0-10 VDC	No	Last Position
Process CHW Isolation	Butterfly	2-Pos Elect	Yes	See Flow Diagram
Tempered Water	Ball	2-Pos Elect	Yes	Closed

See plan details, notes, and schedules for where two-way and three-way valves should be used.
1. Humidifier control valves shall be furnished by humidifier manufacturer.

WATER SYSTEMS:
Use equal percentage valves for two-way control valves; size for a pressure drop not less than 4 psi or more than 6 psi. Where valve sizes are less than line size, Corrected Cv should be used to correct for piping reducers/increasers. Modulating valve size should never be less than half of line size. Consult with AE for acceptable pressure drop if available valve selections do not fall within the desired pressure range. Note: For low flows, the required minimum Cv size will result in lower pressure drop than 4 psi.

Use three-way valves sized for a maximum pressure drop of 5 psi and that have linear characteristics so that the valve pressure drop remains constant regardless of the valve position.

Globe valves 2" and smaller: Cast bronze or forged brass body, brass plug and brass or stainless steel seat, stainless steel stem, screwed ends, suitable for use on water systems at 150 psig and 240° F. Seat leakage with actuator supplied will meet ANSI class IV leakage (0.01%). For globe valves that are specified to fail in place, valves shall be open when the stem is up. Only the following globe valve body styles will be acceptable for terminal unit control: Siemens Powermite 599 VF Series (599 VE Series Zone Valves are not

acceptable), Invensys VB7200 Series, Johnson Controls VG7000 Series, Belimo G200 and G300 Series, and Honeywell V5011/V5013 Series. Minimum size for globe valves shall be 0.7 Cv.

Globe valves 2-1/2" and larger: Iron body, brass plug and seat, stainless steel stem, spring loaded Teflon, or EPDM (EPT) packing, flanged ends, suitable for use on water systems at 150 psig and 240° F.

Butterfly valves: Iron body, stainless steel shaft, bronze bearings, and resilient seat. Disc to be aluminum-bronze, nickel-plated ductile iron, cast iron with welded nickel edge, Nylon 11 coated, or stainless steel. Valve assembly to be bubble tight, suitable for use on water systems at 150 psig and 240° F. For pneumatically actuated valves, provide pilot positioners on all operators for butterfly valves used in modulating applications. When butterfly valves are used in modulating applications, entering, and leaving pipe sizes and required transition distances shall be detailed on the control valve submittals. The control contractor shall be responsible for coordinating the proper pipe sizes and transitions with the mechanical contractor to provide the correct Cv at 70° open position.

Characterized Ball Valves 2” and smaller: The following manufacturers are acceptable: Honeywell, Belimo, Johnson Controls, KMC Controls, Yamatake, Bray, Siemens, Siral. Forged brass or bronze body, stainless steel shaft and ball, reinforced Teflon or PTFE ball seals, double O-ring stem seals, characterized disk, maximum of ANSI Class IV (0.01%) leakage, suitable for use on water systems at 150 psig and 212° F. Minimum size for ball valves shall be 0.4 Cv.

Characterized Ball Valves 2-1/2” and larger: Brass or cast iron body, stainless steel shaft and ball, reinforced PTFE Ball seats, EPDM double O-ring stem seals or reinforced PTFE stem packing, characterized disk, iron flanged ends, maximum of ANSI Class IV (0.01%) leakage, suitable for use on water systems at 218 psig and 280° F.

STEAM SYSTEMS (15 psig and less):
Use equal percentage or modified equal percentage valves that have a minimum rangeability of 30 to 1. Size for a pressure drop equal to 80% of the inlet steam gauge pressure. For integral face and bypass coils, size steam valves for a pressure drop that will provide an inlet pressure recommended by coil manufacturer for freeze protection. Typically, this is 5 PSI for single tube and 2 PSI for inner distributing tube types. Seat leakage with actuator supplied will meet ANSI class III leakage (0.1%) or better.

Globe valves 2" and smaller: Bronze body, cage trim, brass or stainless steel plug and seat, stainless steel stem, screwed ends, suitable for 35 psig saturated steam (281°F). Only the following globe valve body styles shall be acceptable for terminal unit control: Siemens Powermite 599 VF Series (599 VE Series Zone Valves are not acceptable), Invensys VB7200 Series, Johnson Controls VG7000 Series, Belimo G200 and G300 Series, Honeywell V5011/V5013 Series.

Characterized ball valves 2” and smaller: Forged brass or bronze body, stainless steel shaft and ball, Reinforced PTFE Ball seats, double O-ring stem seals, characterized disk, maximum of ANSI Class IV (0.01%) leakage, suitable for use on steam systems at 15 psig and 250° F. Minimum size for ball valves shall be 0.7 Cv.

Globe valves 2-1/2" and larger: Iron body, brass or stainless steel plug and seat, stainless steel stem, flanged ends, suitable for suitable for 35 psig saturated steam (281°F).

Characterized ball valves 2-1/2" and larger: Brass or cast iron body, stainless steel shaft and ball, reinforced PTFE Ball seats, EPDM double O-ring stem seals or reinforced PTFE stem packing, characterized disk, iron flanged ends, maximum of ANSI Class IV (0.01%) leakage, suitable for use on steam systems at 25 psig and 280° F.

CONTROL SYSTEM INSTRUMENTATION
Manufacturers: Bulb Type - Johnson Controls, Ashcroft, Marshall, Weksler
Solar Digital Type – Trerice, Palmer, or equal.

SOLAR POWERED DIGITAL DUCT THERMOMETERS:
Solar powered thermometer that is self-powered with no batteries required. LCD display digits ½” minimum with adjustable swivel mount and minimum 6” probe that is vibration resistant.

THERMOSTAT GUARDS
Provide clear plastic locking covers keyed the same. For locations that are subject to physical abuse, provide metal guard, Johnson Controls GRD10A-601, Shaw Perkins Series 16 or equal.

ELECTRIC/ELECTRONIC THERMOSTATS

ELECTRIC THERMOSTATS:

For single setpoint applications, provide line or low voltage electric type suitable for heating or heating and cooling as required. Provide the required number of heating and/or cooling stages required for the application. For line voltage ventilation applications utilizing fans and where specified in the sequence of operations, provide an integral manual On/Off/Auto selector switch. Minimum contact rating shall be equal or greater to electrical load of device being controlled. For all thermostats not located in mechanical rooms, provide concealed adjustment. For thermostats located in mechanical rooms, provide exposed adjustment.

LOW VOLTAGE ELECTRONIC THERMOSTATS:

Manufacturers: Honeywell, Johnson Controls, Viconics, or equal.

Where unoccupied setpoints are specified, provide electronic programmable type with seven day setup/setback scheduling with a minimum of two occupied and unoccupied schedules per day through keypad entry on front of unit. For heating and cooling applications, provide automatic heating/cooling switchover. For applications that control fans, provide fan override switch. For ventilation or packaged economizer applications provide a dry contact for ventilation damper or economizer initiation. For thermostat control of economizer, provide a 0-10VDC modulated output for economizer damper control.

For applications that require integration to the building automation system, provide a BACnet communication interface. If a communication interface is specified, occupancy scheduling in the thermostat is not required.

LOW LIMIT THERMOSTATS (freezestats):

Electric two-position type with temperature sensing element and manual reset for all applications. Unit to be capable of opening control circuit if any one-foot length of sensing element is subject to a temperature below the setpoint. Length of sensing element to be not less than one lineal foot per square foot of coil surface areas. Unless otherwise indicated, set low limit controls at 36°F.

AQUASTATS:

Line voltage type with single pole, double throw switch of adequate rating for the applied load.

REMOTE BULB THERMOSTATS:

Line voltage type with single pole, double throw switch of adequate rating for the applied load. Thermostat to have adjustable setpoint suitable for controlled load.

IMMERSION TYPE THERMOSTAT SENSORS:

Rod and tube type with linear output. Provide separable wells with heat conductive fluid for installation in pipeline. Units shall be factory calibrated.

DUCT SMOKE DETECTOR AND FIRE ALARM INTERFACE MODULES

Duct smoke detectors and fire alarm control modules shall be provided by others. Provide wiring, conduit, and necessary interface with fire alarm system to perform specified sequence of operation.

WATER FLOW MEASUREMENT (HVAC WATER)

Manufacturers: Onicon Inc., Emerson Rosemount, Yokogawa., or approved equal.

Provide an Electromagnetic Flow Meter complete with integral electronics module. The flow meter shall be full bore flanged meter installed in either the supply or return pipe of the system to be measured following the manufacturer's installation instructions. Full bore style flow meters shall be installed via flanges matching the ANSI class (150, 300) required for the application. The installing contractor is responsible for providing suitable mating flanges.

The manufacturer shall provide a certificate of NIST traceable wet-calibration for each flow meter. Accuracy shall be as follows:

± 1% of reading over a 10:1 turndown (from 2 to 20 ft/s)

Overall rangeability shall be from 0.25 ft/s to 20 ft/s (80:1 turndown ratio).

The flow meter shall have a maximum operating pressure of 400 PSI, maximum operating temperature of 200^0 F (optional 300^0 F peak) and a pressure drop of less than 1 PSI at 17 feet per second flow velocity.

The flow meter shall have a minimum of one analog output, 0-10 VDC or 4-20 mA for connection to the BAS for liquid flow rate and a scalable dry contact output for totalization unless the flow meter is connected to a BTU measurement system that will provide this output or be directly integrated to the BAS. The flow meter shall also include integral frequency output for diagnostic purposes and for connection to local display. All outputs shall be linear with flow rate.

Local display of flow rate to be provided in a steel NEMA 4 remote wall mounted enclosure with internal terminal strip connections and shall be powered by 24 VAC or VDC and provide necessary power to flow meter.

Provide a BTU Measurement System that shall consist of a flow sensor, two temperature sensors, a BTU meter, thermowells and all required mechanical installation hardware. The BTU meter shall include a front panel mounted display for BTU total, liquid flow rate, supply temperature and return temperature. The meter shall be supplied by 24VAC or 24VDC to provide power to the BTU meter electronics, flow meter, and temperature sensors.

- IMPORTANT – BTU meters shall include sufficient hardwire I/O contacts to allow BAS to monitor/trend points listed in 23 09 15. If BTU meters do not have sufficient I/O contacts, the 23 09 23 Contractor shall provide independent instrumentation which will allow BAS to monitor/trend the points listed in 23 09 15.

The BTU measurement system shall provide a MODBUS RS485 communication interface that will provide information corresponding to total thermal energy transfer, supply temperature, return temperature, and liquid flow rate. For meters that do not have integral MODBUS RS485 communications, provide a separate gateway device that will provide MODBUS RS485 communication interface. All programming of the gateway device shall be provided by this Contractor. Temperature sensors shall be calibrated and matched for the specific temperature range for each application. The calculated differential temperature used in the energy calculation shall be accurate to within $\pm$ 0.15^0F (including the error from individual temperature sensors, sensor matching, input offsets, signal conditioning, and calculations). When DDC PI control loops are specified in 23 09 93 that use flow or temperatures from the flow meter and BTU measurement system, provide a compatible discrete hardwired output to the DDC controller that is doing the control loop in addition to the information provide through the communication interface.

WATER FLOW MEASUREMENT (DOMESTIC WATER)

TURBINE STYLE METERS:

Manufacturers: Badger Meter, Carlon Meter Co, Neptune, or Hersey.

Meter shall in-line turbine type. Meter shall have integral analog totalizer. Meter shall be factory sized and programmed for its specific application and flow range. Meter body shall be lead-free bronze construction with stainless steel trim. Meter shall have thermoplastic rotor with stainless steel rotor pivots.

Meter materials and finish shall meet AWWA Standard C701.

Meter shall be provided with ANSI Class 150 flanges.

Meter shall be selected for 10:1 turndown. Meter shall be wet-calibrated an accurate to within ±2% of reading. Meters shall be shipped with certificate of calibration. Meter shall include transmitter with programmable pulse output signal.

Basis of design is Badger Recordall Series.

DISC STYLE METERS:

Bronze body, NPT ends, positive displacement disc type meter with built-in strainer, magnetic drive and thermoplastic disc/register gearing. Meters shall meet ANSI/AWWA Standard C700. Sealed register shall be odometer type totalization display having 10,000,000 gallon capacity. Register shall also have 360 degree sweep hand with 10 gallon range and 0.1 per gallon increments. Meters shall be suitable for 150 psig pressure at 80 degrees F. Badger Recordall Disc Meter, Carlon Meter Co., Neptune, Hersey, Venture Measurement Niagara

Meters shall be shipped with certificate of calibration. Meter shall include transmitter with programmable pulse output signal.

Basis of design is Badger Recordall Series.

STEAM FLOW MEASUREMENT

The selection of the steam meter shall be based on the following parameters and recommendations to guarantee that the accuracy of the steam meter station reading stays within the ± 1% of the actual flow from 5% to 100% of the maximum rated flow, and ± 1% of FSD from 1% to 5% of the maximum rated flow and the repeatability within ± 0.5% over the entire specified turndown.

- The location of the steam meter shall comply with the straight-run pipe lengths upstream and downstream recommended by the manufacturer.

- The pressure drop through the primary element and sensor, shall not be greater than 400 inches w.c. / 14.4 PSI for the maximum mass flow rate.
- The mass flow rate shall be computed in lbs./hour, temperature and pressure compensated. The steam meter turndown shall be no less than 30 to 1 for high pressure applications and 15 to 1 for low pressure applications based on actual flow conditions or the turndown required in the meter schedule, whichever is greater.

Primary Element, Flow Sensor:
Manufacturers: Spirax/Sarco ILVA, Veris Accelebar, V-Cone, or approved equal.

- A Variable Area, either non-spring loaded, or spring loaded, shall be used as the primary element of the steam meter. The material of the components of the flow sensor must be 316-stainless-steel. The primary element shall comply with standard codes, ISO, ASME.
- The flow sensor shall be installed between pipe flanges, with body constructed of carbon steel, rated for 200 psig and 660°F for high pressure applications and rated for 150 psig and 370°F for low pressure applications. If the primary flow element is a wafer or lug type arrangement and is longer than its flange-to-flange dimension, then a spool piece shall be included of sufficient length to permit the removal of the primary flow element with spool piece and eliminate disassembly of any downstream or upstream piping when servicing the element. Provide a separate flanged spool piece (specified under Section 23 05 15) that can directly replace the meter assembly when it is removed. Coordinate with mechanical contractor for providing required spool pieces and proper installation of the meter.

Secondary Elements, Differential Pressure and Gauge Pressure Transmitter(s):
Manufacturers: Rosemount, Honeywell, ABB, Siemens, Foxboro, or approved equal.

- The output shall be 4-20mA with digital signal with HART protocol. The accuracy shall be at least ±0.1% of span, 4 to 20mA, and ±0.07% of span, digital. Drift less than ±0.1% of URL over at least 8,000 hours.
- Maximum range for the differential pressure measurement shall be 0 to 400 inches w.c. with a transmitter pressure rating of 300 psi. Range limits for absolute pressure shall be 0 to 300 psia. The transmitter shall be energized with a 24-VDC source. The Differential Pressure transmitter shall be mounted below the flow element using process tubing as specified below.
- Provide stacked (two) differential pressure transmitters for Veris Accelebar, V-Cone, or other fixed orifice primary element flow sensors. Size transmitters as required to meet or exceed accuracy and turndown requirements for the specified application.

RTD Temperature Sensor:
Manufacturers: Rosemount, Honeywell, ABB, Moore, JMS or approved equal.

- Furnish a spring loaded Dual Element RTD assembly.
- The temperature process input range shall be a minimum of 20 to 600°F.
- The 10hermos-well shall be 316-stainless steel, suitable for the size of the process pipe, and provided with a ¾-inch NPT process connection.

Flow Computer:
Manufacturers: Kessler-Ellis Products model 749, Spirax/Sarco FP93B, Foxboro, or equal.

- The flow computer shall provide loop powered, 4-20 mA inputs for the temperature and pressure compensated mass flow rate in lbs./hr. The flow computer shall totalize the mass flow rate and shall be equipped with Modbus RTU (RS485) communication.
- Standard LCD indicator with backlight shall be included with the flow computer.
- The flow computer shall provide precise and reliable measurement of absolute/gauge and differential pressure, sensor and electronics temperatures, and process temperature from an external transmitter/RTD combination. It shall calculate densities, according to Steam Tables ASME 1997, and mass flow rates for the actual pressure and temperature in line for both saturated and superheated steam.
- Meter data in the form of total consumption, flow rate and a meter diagnostic must be communicated to the Building Automation System (BAS). Consumption shall be in billable units,

klbs. Of steam. Flow rate will be in klbs. /hr of steam. Meter diagnostic will be in the form of Normal or Failure.

- Power for flow computer to be 24 VAC/VDC. Provide transformer or power supply externally mounted to flow computer.
- IMPORTANT – BTU meters shall include sufficient hardwire I/O contacts to allow BAS to monitor/trend points listed in 23 09 15. If BTU meters do not have sufficient I/O contacts the 23 09 23 Contractor shall provide independent instrumentation which will allow BAS to monitor/trend the points listed in 23 09 15.

The process connectors, normally NPT 3/8-inch, shall be 316 stainless steel. A 316 stainless steel 3-valve manifold to mount the pressure differential transmitter shall be supplied. Drain/vent material and isolation valves shall be also 316 stainless steel and furnished. A minimum of 18" horizontal piping off of primary device before vertical piping to secondary element shall be provided. Interconnections and drawings for installation of the primary, secondary, and tertiary elements of the corresponding devices shall be submitted prior to their installation for review by the project AE. Installation and piping to be provided by the Division 23 mechanical contractor in accordance with manufacturer supplied installation drawings.

STEAM CONDENSATE ULTRASONIC FLOW METERS FOR UTILITY DISTRIBUTION

PUMPED CONDENSATE RETURN:

Manufactuers: Cadillac Meter (CMAG) or approved equal.

Electro-Mag Meter:

Provide an electromagnetic flow meter complete with integral electronics module. The flow meter shall be full bor flanged meter capable of measuring fluids with a conductivity greater than or equal to 3 micro siemens per centimeter.

Also include NIST traceable we flow certificate of accuracy.

Meter shall include the following:

- Communications: Include MODBUS RS-485 communications port – provide MODBUS RS485 to MODUBS TCP/IP router device if required.
- Analog Outputs: Qty. (1) 4-20 mA output provided.
- Binary Outputs: Qty. (1) solid-state relay outputs provided.
- Supply Power: 24 VDC
- Accuracy: +/- 0.25% of reading
- Turndown: 300:1
-

TEMPERATURE CONTROL PANELS

Constructed of steel or extruded aluminum, with hinged door, keyed lock, and baked enamel finish. Install controls, relays, transducers, and automatic switches inside panels. Label devices with permanent printed labels and provide asbuilt wiring/piping diagram within enclosure. Provide raceways for wiring and poly within panel for neat appearance. Provide termination blocks for all wiring terminations. Label outside of panel with panel number corresponding to plan tags and asbuilt control drawings as well as building system(s) served.

Any panel that houses a 23 09 23 DDC, or instrumentation provided under 23 09 14, shall not have any control voltage 50V or high within it. Provide a separate panel for only the 50V and higher devices such as 120/24 VAC power transformers. Extend 24VAC power into the control panel.

For panels that have 120VAC power feeds provide a resettable circuit breaker. Provide label within the panel indicating circuit number of 120VAC serving panel.

Provide a service shutdown toggle switch for each air handling unit system located inside the temperature control panel that will initiate a logical shutdown of the air handling unit system. Label the switch so it is clear which position is shut down and which is auto.

TEMPERATURE SENSORS

Thermistor temperature sensor manufacturers: PreCon, BAPI, and ACI

Use thermistor or RTD type temperature sensing elements constructed so accuracy and life expectancy is not affected by moisture, physical vibration, or other conditions that exist in each application.
RTD's shall be of nickel or platinum construction and have a base resistance of 1000Ω at 70°F and 32°F, respectively. 100Ω platinum RTD's are acceptable if used with temperature transmitters.

The temperature sensing device used must be compatible with the DDC controllers used on the project.

RTD	
Accuracy (Room Sensor Only)	minimum ± 1.0°F
Accuracy (Averaging)	minimum ± 1.2°F
Accuracy (Other than Room Sensor or Averaging)	minimum ± 0.65°F
Range (Bulb)	minimum -40 – 220°F
Range (Averaging)	minimum -40 – 200°F
Thermistor	
Accuracy (All)	minimum ± 0.36°F
Range (Bulb)	minimum -30 – 230°F
Range (Averaging)	minimum -30 – 200°F
Heat Dissipation Constant	minimum 2.7 mW/°C
Temperature Transmitter	
Accuracy	minimum ± 0.1°F or ±0.2% of span
Output	4-20 mA

Provide limited range or extended range sensors if required to sense the range expected for a respective point. Use RTD type sensors for extended ranges beyond -30 to 230°F. If RTD's are incompatible with DDC controller direct temperature input, use temperature transmitters in conjunction with RTD's.

Use wire size appropriate to limit temperature offset due to wire resistance to 1.0°F. If offset is greater than 1.0°F due to wire resistance, use temperature transmitter. If feature is available in DDC controller, compensate for wire resistance in software input definition.

Unless otherwise noted, all zone (space) temperature sensors shall be provided with digital displays that indicate room temperature and setpoint and have manual adjustment. The following types of zones shall be provided with blank covers and no adjustments:

- Corridors / Circulation
- Entrance Vestibules
- Stairwells
- Lobbies
- Electrical Rooms
- Telecom Rooms
- Mechanical Rooms

Use averaging elements on duct sensors when the ductwork is ten square feet or larger. All mixed air and heating coil discharge sensors shall have averaging elements regardless of duct size. For mixed air, heat wheel leaving outside air, and heating coil discharge sensors, provide multiple sensors for coverage of the coil to be one foot of coverage for 2 ft^2 of air plenum or coil size with a +25% variance allowable for the coverage, i.e. a single 24' averaging element shall cover an area of up to 60 ft^2 and two 24' sensors would cover areas of 60 ft^2 to 120 ft^2, three 24' for 180 ft^2 and larger. A maximum of three 24' averaging sensors shall be used for any of the above applications regardless of plenum or coil size. Averaging temperature sensors with a maximum length of 24' shall be used for large coil or plenum applications where more than one averaging temperature sensor is required unless a smaller element can provide the coverage as specified above. Each averaging temperature element shall be wired to a separate analog input on the DDC controller.

For all averaging temperature sensor applications other than the three specified above, provide a single averaging sensor of a length that will provide the coverage as specified above. For plenum or coils larger than 60 ft^2, one averaging sensor with a minimum length of 24' shall be provided.

In piping systems use temperature sensors with separable wells designed to be used with temperature element.

HUMIDITY SENSORS

Use capacitive thin-film polymer sensor types with a range of 0-100% RH. Accuracy to be no less than **±2%** in the range of 20% RH to 80% RH with a response time of 120 seconds or less. Provide covers for room humidity sensors as specified for temperature sensors.

For outside air applications, use sensor designed for outside air use along with weather enclosure. Provide sensor equal to Vaisala Model HMD60UO w/ DTR503B enclosure and weather resistant mounting hardware.

For space humidity sensors, provide a humidity sensor that has both humidity and temperature sensors and display. Space humidity sensor accuracy to be a minimum of 1.7 %RH accuracy from 0-90 %RH and 2.5 %RH accuracy from 90 – 100 %RH humidity at temperatures from 50 to 104 DegF, with NIST traceable calibration certificate. Temperature sensor accuracy to be a minimum of + or - 0.54 DegF at temperatures from 50 to 86 DegF, Vaisala model HMW92D or equal. Duct humidity sensor accuracy to be a minimum of 1.5 %RH accuracy from 0-90 %RH and 2.5 %RH accuracy from 90 – 100 %RH at temperatures from 50 to 104 DegF, with NIST traceable calibration certificate. Vaisala model HMD65 or equal.

Provide a handheld humidity and temperature meter and all cables and accessories for connection to space and duct humidity sensors for calibration, a duct humidity probe, and carrying case for the indicator and probe. Handheld humidity sensor accuracy to be a minimum of 1 %RH accuracy from 0-90 %RH and 1.7 %RH accuracy from 90 – 100 %RH humidity with NIST traceable calibration certificate, Vaisala model HM70 or equal.

PRESSURE TRANSDUCERS (AIR)

Provide pressure transducers specified below for the following applications:

- Duct static pressure applications where setpoints are specified to control at greater than 0.1” w.c.
- Pitot type fan inlet air flow stations.
- Air filtration in fan powered equipment.

Manufacturers: Mamac Systems, Setra, and Veris Industries.

Provide a transmitter that operates on the capacitance principle and is capable of sensing low positive, negative or differential pressures. Transmitter shall have a minimum of three pressure ranges adjustable by an onboard switch or jumper. Size the transmitter where the middle or high range is suitable for the application. Use a bi-directional transmitter for applications that may have both positive and negative pressure excursions. Transmitter shall be provided with an integral four-digit display of the pressure sensed.

Accuracy (including non-linearity and hysteresis)	± 1% FS
Compensated Temperature Range	32°-140° F
Temperature Effect	0-1”wc Range .09% FS/°F
	>1”wc Range .02% FS/°F
Output	4-20 MA
Load Impedance (smallest maximum acceptable)	800 Ω max.
Operating Temperature	32°-140° F

For air filtration monitoring, size differential pressure transducers to provide for the following ranges:

Filter Type	Scale Range (inch W.G.)
MERV 7	0.0 to 1.0
MERV 11	0.0 to 2.0
MERV 14	0.0 to 2.0

For space pressure monitors, provide pressure transducers specified below:

Manufacturers: Setra FLEX-RM Room Pressure Monitor is basis of design.

Provide a wall-mounted differential pressure transmitter for clean rooms. Transmitter shall utilize a 7-inch capacitive color touchscreen that works with medical gloves.

- Accuracy: ±0.25% FS
- Pressure Range: ±0.25” WC
- Output: 4-20 mA

Configure display to only show current measured pressure with green background. Do not setup any visual and audible alarms.

PRESSURE TRANSDUCERS (LIQUID/STEAM)

Provide a transmitter that utilizes capacitive or thin film strain gauge sensing. Provide for an analog gauge piped in parallel with the transducer. Gauge shall meet specifications as specified in Section 23 05 15. Coordinate with mechanical contractor to provide and install this gauge. For differential pressure applications provide with bypass valve manifold assembly with valved venting capability.

Accuracy (including non-linearity and hysteresis)	± 0.5% FS
Compensated Temperature Range	32°-150° F
Temperature Effect (over compensated range)	0.03%/°F
Output	4-20 MA
Load Impedance (smallest maximum acceptable)	600 Ω Minimum
Operating Temperature	0°-175° F
Hysteresis	0.75% of span

AIR PRESSURE SAFETY SWITCHES

Air pressure safety switches shall be a differential pressure switch that will sense differential, negative, or positive pressure as required by the sequence of operation specification. Device shall be rated for a minimum of 150% of maximum system pressures that may be encountered. Provide with pressure range that will be required to meet specified operation in the system served. Provide with a normally closed contact that will open above setpoint and will not close until the manual reset button is depressed. Setpoint shall be manually adjustable. For static pressure sensing, use gasketed metal static pressure sensors for insertion into fan housing and ductwork. Mamac A-520 or equal.

CURRENT STATUS SWITCHES

Provide a current sensor with adjustable threshold and digital output with LED display, equal to a Veris model H-708/H-904. Threshold adjustment must be by a multi-turn potentiometer or set by multiprocessor that will automatically compensate for frequency and amperage changes associated with variable frequency drives. When used on variable speed motor applications, use a current sensor that will not change state due to varying speeds. Current switches with integral relays shall not be used for start/stop and status motor applications.

FUME HOOD PRESENCE SENSORS:

Manufacturers: Pepperl & Fuchs Proscan/38a or approved alternate.

Infrared sensor shall be mounted to top/front of fume hood to indicate presence of individual in front of fume hood. Provide swivel mounting bracket and all mounting hardware.

Minimum Detection Field: 72” x 3”
Switch Open Time: 3 min/10 s, programmable
Light type: Infrared, modulated light
Function display: LED red: on for object detection
Operating elements: Programmable switch for switching type, open time, detection field
Operating voltage: 12-38 V DC / 12-28 V AC
Signal output: Relay

FLAMMABLE GAS DETECTION SENSORS

Approved Sensor: Honeywell Midas®S2 Gas Detectors. MSA, Draeger, RC Systems, and Tox-Alert will be considered provided they are aspirating (remote air sampling) type and meet these specifications.

Sensor shall be remote air sampling type of sensor. Sensor shall be combo sensing device and air extractive vacuum pump. Sensor shall be factory provided with hydrogen (H2) sensing cartridges and calibrated at the factory.

Sensor/Transmitter Display:

- There shall be a local display indicating the gas type being monitored and concentration of gas present. Display will be integral part of the sensor/transmitter and shall be visible from a minimum of 5 feet. Display will be two and one half inch (2-1/2”) digit LCD.
- Sensor/Transmitter display shall indicate all diagnostic check/fault conditions with a scrolling message detailing the condition.
- Sensor/Transmitter display will display 3 levels of alarm.

Sensors shall be catalytic bead (pellistor) type and shall have the following specifications:

- Power: 24 VAC or VDC
- Scale: 0-100% LEL (lower explosive limit).
- Accuracy: < ±5% of measured value.

- Resolution: 1% LEL.
- Response Time: < 5 seconds.
- Operating Temperature: 32°F to 104°F
- Operating Humidity: 10 to 90% RH

Sensor/Transmitter Outputs:
- Three (3) relay outputs: alarm level 1, alarm level 2, and fault.
- One (1) 4-20 mA analog output: output scales with level of LEL gases detected.

Air sampling will be remote from the sensor. Air sampling tubing will be required between the sensor and the point of sampling. Tubing shall be 1/8" ID Teflon FEP.
- Polyethylene tubing is also acceptable for sampling. Polyethylene tubing shall meet stress-crack test ASTM D1693 and shall be rated as self-extinguishing when testing in accordance with ASTM D 635.

Provide sensor with manufacturer's air filters. Air filters shall attach to bottom of sensor where air sampling tubing connects to the sensor.

Equivalent sensors will be considered provided they are air sampling type.

OXYGEN DEPLETION SENSORS
Approved Sensor: Honeywell E3SM Point. Equivalent submittals from RC Systems, Toxalert, Draeger, or MSA will be considered.

Sensors are non-aspirating type and air sampling tubing or vacuum pump is not required.

Sensors shall be wall mount type with sensor integral to assembly. Install sensors where shown on mechanical floor plans.

Sensors shall include oxygen (O2) detection cartridge. Sensor shall have ±3% accuracy over full scale range. Sensor shall have full scale range of 0-25% Volume.

Sensor shall utilize 24 VAC power. Controls Contractor responsible for all power wiring.

Sensor shall include LCD display that continuously displays measured oxygen level.

Sensor shall have the following outputs:
- Two (2) relay outputs.
- One (1) 4-20 mA analog output: output scales with level oxygen detected.

HORNS/STROBES – FLAMMABLE GAS DETECTION SENSORS & OXYGEN DEPLETION SENSORS
Horn/strobes shall be equal to Allen Bradley class #855W. Lights shall be mounted vertically.

Provide red and greens strobes. Horns shall have a minimum db level of 90 and shall be adjustable down to 70 db. Horns shall sound distinctly different than the existing building fire alarm horns in either pattern, sound, and/or announcement.

WATER LEAK DETECTORS
Manufacturers: Kele WD-1B or Veris SD-R01

Detectors shall utilize conductivity probes. Do not provide rope leak detectors.
- Gold plated sensing probes
- Encapsulated in epoxy or polymer – no exposed metals
- Automatically resets when conductive fluid is no longer present.
- Relay contact outputs rated at 1 amp at 24 VDC.
- Powered with 12-24 FAC from BAS power source. Battery power is not acceptable.
- Level detection shall be adjustable

POWER SUPPLIES
Provide all required power supplies for transducers, sensors, transmitters, and relays. All low voltage transformers shall have a resettable secondary circuit breaker and be listed as class 2 power supplies. All

transformer assemblies in enclosures shall have isolated high and low voltage compartments with separate removeable covers for connections.

PART 3 - EXECUTION

INSTALLATION

Install system with trained mechanics and electricians employed by the control equipment manufacturer or an authorized representative of the manufacturer. Where installing contractor is an authorized representative of the control manufacturer, such authorization shall have been in effect for a period of no less than three years.

Install all control equipment, accessories, wiring, and piping in a neat and workmanlike manner. All control devices must be installed in accessible locations. This contractor shall verify that all control devices furnished under this Section are functional and operating the mechanical equipment as specified in Section 23 09 93.

Label all control devices except for terminal unit devices with permanent printed labels that correspond to control drawings. Labeling for each device shall be unique within each mechanical system. Temperature control junction and pull boxes shall be identified utilizing spray painted green covers. Other electrical system identification shall follow the 26 05 53 specification. For control devices mounted above accessible ceilings, label the ceiling tile grid at the ceiling tile that is to be removed for access to the control device. The label shall be pre-printed using clear polyester tape with black bold 28 size font for ceilings under 12 feet. For ceilings over 12 feet high, use bold 40 size font. For accessible ceilings, use an arrow to point at ceiling tile to be removed for access.

All control devices and electrical boxes mounted on insulated ductwork shall be mounted over the insulation. Provide mounting stand-offs where necessary for adequate support. Cutting and removal of insulation to mount devices directly on ductwork is not acceptable. This contractor shall coordinate with the insulation contractor to provide for continuous insulation of ductwork.

Mounting of electrical or electronic devices shall be protected from weather if the building is not completely enclosed. This Contractor shall be solely responsible for replacing any equipment that is damaged by water that infiltrates the building if equipment is installed prior to the building being enclosed.

All 23 09 23 controllers shall communicate via BACnet/IP.

- Ethernet cabling for all 23 09 23 DDCs shall be provided by 23 09 23 Contractor. Refer to Sheet M7.01 for details.
- Refer to HORIZONTAL PERMANENT LINK cabling requirements, under Section 27 10 00, for Ethernet cabling requirements. Ethernet cabling provided by 23 09 23 Contractor shall meet the specifications listed under “Instrumentation and Controls Wiring”.
- Ethernet cabling, provided by 23 09 23 Contractor, shall utilize **GREEN** jacket coloring for easy identification.
- Some DDCs, provided by 23 09 23 Contractor, shall utilize BACnet MS/TP for communication. Some DDCs shall utilize peer-to-peer communication, via MS/TP, for interlocking. This shall ensure interlocking is maintained in the even the 23 09 23 Contractor provided network switch fails. Refer to Sheet M7.01 for additional details. The following DDCs shall utilize BACnet MS/TP:
    - TCP-EF-66(A-C)
    - TCP-AHU-37A
    - TCP-AHU-37B

Provide all electrical relays and wiring, line, and low voltage, for control systems, devices, and components. Install all high voltage and low voltage wiring (includes low voltage cable) in metal conduit, Electrical Non-metallic Tubing (ENT), or Electrical Metallic Tubing (EMT), as scheduled below and hereafter referred to generically as conduit except above accessible ceilings as noted below. See Wire and Air Piping Conduit Installation Schedule below for specific conduit or tubing to be used. All raceways, enclosures, fittings, and associated supports shall be provided and installed according to the requirements set forth in Division 26, NFPA 90 (NEC) and Chapter SPS 316 of the Wisconsin Administrative Code. All conduits shall be routed parallel and/or perpendicular to walls and adjacent piping. Raceways shall be located to maintain headroom and working clearance around equipment and devices that require inspection and service.

In general, support all raceways from the building structure. No component of a raceway system shall be secured to corrugated metal roof deck. Do not impose on the installations of other trades. Securing conduit, rods, straps, hangers, etc. to suspended ceiling components, electrical raceways, plumbing piping, fire protection sprinkler piping, HVAC piping or ductwork, or their associated support systems, will not be accepted.

Conduit shall be a minimum of 1/2 " for low voltage control provided the pipe fill does not exceed 40%.

Minimum low voltage wiring gauge to be 18 AWG for outputs and 20 AWG for inputs. All low voltage wiring to be stranded.

Low voltage wiring can be run without conduit above accessible lay-in tile ceilings. All wiring in mechanical rooms, above inaccessible hard ceilings, exterior locations, and in any exposed areas, and in all other locations shall be installed in conduit. Wire for wall sensors shall be installed in conduit concealed in the wall. Wiring for radiation valves shall be installed in conduit concealed in the wall. For retrofit installations, all wiring for sensors and valves shall be installed in conduit concealed in new walls. Sensor wiring for existing walls shall be installed without conduit and concealed in the wall (fished) where possible. If running wire concealed in the existing wall is not possible, install in surface raceway as specified or if not specified, consult with the AE for raceway type and color to be provided.

Where low voltage wiring is installed free-air, installation shall comply with the following:

- Wiring shall utilize the cable tray wherever possible.
- Wiring shall run at right angles and be kept clear of other trades work.
- Wiring shall be supported utilizing "J" or "Bridal-type" steel mounting rings anchored to ceiling concrete, piping supports, walls above ceiling or structural steel beams. Mounting rings shall be of open design (not a closed loop) to allow additional wire to be strung without being threaded through the ring. For mounting rings that do not completely surround the wire, attach the wire to the mounting ring with a strap.
- At HVAC terminal units only, where the wiring serves a specific device; e.g., controller, actuator, transmitter, etc. associated with the unit, the j-hooks or Bridal rings required to support the wiring, may be secured to the rods or straps that support the ductwork or piping that serves the unit. Wall penetrations shall be sleeved.
- Supports shall be spaced at a maximum 4-foot interval unless limited by building construction. If wiring "sag" at mid-span exceeds 6-inches; another support shall be used.
- Wall penetrations shall be sleeved, and fire stopped as specified.
- Wiring shall not be supported from existing cabling, existing tubing, plumbing or steam piping, ductwork, any component of a suspended ceiling, or electrical or communications conduit.

Control panels serving equipment fed by emergency power shall also be served by emergency power. This contractor shall be responsible for all 120VAC power, not provided in the Division 26 specifications, required for equipment provided under this section. Power shown for temperature control panels on plans may be utilized by the 23 09 23 and 23 09 14 contractors.

Provide communication trunk wiring to integrated devices (i.e., VFD’s, etc.) and terminal unit controllers that are specified to be connected to the building automation system. Communication trunk wiring shall be as required by the equipment specified under the 23 09 23 Sections and shall be routed to the DDC panel designated for that equipment as shown on the plans or the closest DDC panel if not designated. If communication trunks require daisy chained style wiring, provide two communication cables to the DDC panel so that the communication trunk is not dead ended.

Install all terminal unit DDC controls and associated sensors furnished under Section 23 09 14 and 23 09 23 that are field mounted at the terminals units (not terminal unit controls that are mounted in centralized temperature control panels). For terminal units, i.e., fin tube radiation, convectors, cabinet unit heaters, fan coils, where the DDC controller is to be installed in the terminal unit enclosure, the DDC controller shall be installed in a location within the terminal unit enclosure designed to house controls. In no cases shall DDC controllers be installed in the convective or forced air flow stream of the terminal unit.

Above accessible lay-in tile ceilings where VAV box DDC controllers are designed to be directly mounted on air terminals, the DDC controller shall be installed without an enclosure. Above accessible lay-in tile ceilings where additional controllers are required, they shall not be mounted directly to the ductwork but be mounted on din rail or back panel in an accessible location as close as possible to the terminal unit(s) being controlled. In exposed ceilings or in mechanical rooms, provide an equipment enclosure that completely encloses the DDC controller and allows for conduit terminations shall be provided as described below..

In mechanical rooms or other locations where the VAV terminal is not above an accessible lay-in ceiling, the enclosure will be provided under Section 23 36 00. If other terminals are associated and controlled from the same VAV terminal DDC controller and additional controllers are required for control, the Section 23 09 23 contractor shall provide the enclosure for mounting under this Section.

Any devices other than DDC controllers, i.e., relays, pressure switches or sensors, etc. associated with VAV terminal unit control shall be installed in an enclosure furnished under this Section.

Where occupancy sensors are to be interlocked with terminal units that serve more than one room, all occupancy sensors for the rooms served shall be wired in parallel and wired to the terminal unit DDC controller.

This contractor shall provide all 24VAC power transformers and wiring for DDC terminal unit controls. This contractor shall provide all communication wiring to the DDC supervisory controller for the terminal units provided under 23 09 23. Provide all power and communication wiring type and installation as required by the DDC controller manufacturer for the terminal units. Tag all terminal units with printed labels to match the terminal unit room schedules. This contractor shall terminate wiring for all terminal unit controllers and perform end to end point checkout of all inputs and outputs to the terminal unit controllers. This contractor shall verify the communication trunk and controller addressing.

Start/stop and safety relays for motor loads shall be mounted remotely at the VFD or starter being controlled. Label these relays per above tagging requirements and locate in position on the VFD or starter where the label and power indication light for the relay is visible.

Install "hand/off/auto" selector switches on systems where automatic interlock controls are specified and "hand/off/auto" selector switches are not supplied with the equipment controlled. Control panel power will not be required for “hand” switch to operate. When switch is in "hand" position, allow manual operation of the selected device without operating the interlocked motors but allowing all unit safety devices to stay in the circuit.

Install all shutdown switches furnished under this Section where specified or shown on the plans. Boiler kill switches shall be wired to each boiler safety circuit and an auxiliary contact shall be wired to a DDC binary input. Emergency HVAC shutdown switches shall be wired to DDC binary inputs for shutdown of all HVAC equipment serving the building.

For service shutdown switches provided in temperature control panels for service shutdown of HVAC systems, label the associated VFD’s or motor starters that there is a service shutdown switch and the temperature control panel designation where the switch is located.

All wiring in control panels shall be terminated on a terminal strip. Wire nuts are not acceptable. A maximum of two wires shall be terminated under any one terminal.

Utilizing a control panel as a raceway for wiring to another control panel is prohibited.

All pneumatic tubing, cabling and electrical wiring terminated at controllers, devices and terminal strips are to be permanently tagged or labeled with permanent adhesive labels within one inch of terminal strip with a numbering system to correspond exactly with the "Record Drawings". Jumpers where both ends of the wire are visible and terminations are within 6” of each other do not need to be labeled. Spare wires are to be labeled as “Spare” with unique number designations.

After completion of installation, test and adjust control equipment. Submit data showing set points and final adjustments of controls.

AIR PIPING

Conceal piping whenever possible. Exposed piping may be run only in mechanical rooms, storage rooms, or other areas where mechanical systems piping is exposed.

Mechanically attach tubing to supporting surfaces. Sleeve through concrete surfaces in minimum one-inch sleeves, extended 6 inches above floors and one inch below bottom surface of slabs. Fire stop any open space in the sleeve after the air piping is installed if the sleeve is in a fire rated surface.

Purge tubing with dry, oil free compressed air before connecting control instruments.

Install all polyethylene tubing in conduit as scheduled below unless specified otherwise hereafter. Exposed polyethylene tubing not exceeding 18 inches may be used for connection to an instrument or operator without being installed in conduit. All Conduit to be independently supported, all boxes must be supported, all conduit ends to have bushings for protection of tubing.

Conduit shall be a minimum of 1/2 " for poly tubing provided the pipe fill does not exceed 40%.

Minimum poly tubing size allowed is ¼" OD. If an instrument has a barbed fitting that will only accept 5/32" tubing, connection to the device can be made with 5/32" tubing that is as short as is practical. Couplings are acceptable in this instance.

Install all exposed piping and conduit parallel to or at right angles to the building structure and support adequately at uniform intervals. Use only tool made bends in copper air pipe.

Tubing must be installed and supported in a manner as specified for exposed locations and acceptable to Owner.

Where polyethylene tubing is installed free-air, installation shall consider the following:

- Tubing shall run at right angles and be kept clear of other trades work.
- Tubing shall be supported utilizing "J-" or "Bridal-type" mounting rings anchored to ceiling concrete, piping supports or structural steel beams. Rings shall be designed to maintain tubing bend to larger than the minimum bend radius (typically 4 x tubing diameter).
- Supports shall be spaced at a maximum 4-foot interval unless limited by building construction. If tubing "sag" at mid-span exceeds 6-inches, another support shall be used.
- Tubing shall never be laid directly on the ceiling grid or attached in any manner to the ceiling grid wires.
- Air piping may be routed with Class 2 control wiring in J-hooks.

Tubing shall not be attached to existing cabling, existing tubing, plumbing or steam piping, ductwork, ceiling supports or electrical or communications conduit.

Tubing connected to air terminal unit devices shall be attached to the terminal unit device to prevent tubing from becoming kinked or becoming disconnected. Tubing serving air terminals may be routed on top of ductwork serving that terminal unit for a maximum distance of eight feet.

Where tubing is connected to ductwork at an exterior location for sensing purposes, the tubing shall be sloped to a heated interior location without sags or traps in the tubing to prevent condensation to be trapped in the tubing and prevent accurate sensing. Install drip leg at low point at interior location and note location on control record drawings.

Number code all polyethylene tubing and install neatly with no concealed splices.

Piping material used shall be as follows:

All exposed copper to be hard drawn.

Use only polyethylene tubing inside panels.

In concealed locations (other than noted below) hard copper, soft copper, or polyethylene tubing in conduit shall be used.

Polyethylene tubing in block, stud. or concrete walls must be in conduit and associated boxes to be of steel.

For exposed outdoor locations, use hard copper or polyethylene tubing in conduit. Provide shielding for polyethylene tubing that is used for final device connection that will be exposed to direct sunlight.

For static sensing lines connected to ductwork located in exposed outdoor locations, slope piping from connection into building to a location that will be above freezing so any condensation will run into the building and not freeze in piping. Piping tap shall not be on the bottom of the ductwork. Provide a drip leg of 3/8" tubing a minimum of one foot in length in an accessible location inside the building that will collect condensation from the sensing line.

Polyethylene tubing may be used in exposed areas if run in a fully enclosed rigid metal raceway or metal conduit and ambient temperature is less than 150°F.

Use copper tubing, where subject to temperatures in excess of 150°F or where adjacent to heating pipes passing through a common sleeve.

When polyethylene tubing is used above accessible lay-in acoustical panel ceilings it must be fire resistance "FR" rated pass the UL 94 vertical flame test with a rating of V2, be rated as self-extinguishing under ASTM D 635, and may be run without conduit.

WIRE AND AIR PIPING CONDUIT AND TUBING INSTALLATION SCHEDULE

The following conduit schedule shall apply to both polyethylene tubing and wire in conduit where conduit is specified for air tubing or wiring. Conduit and tubing referenced below shall meet specifications in Section 26 05 33 and as defined below.

Air piping shall be run in independent conduit without wiring. In no cases shall wiring and air piping share a conduit, raceway, or cable tray.

Where air piping and wiring share a trough or wire management system above a control panel, code required separation shall be provided.

Conduit other than that specified below for specific applications shall not be used.

Exposed Outdoor Locations: Rigid steel conduit.

Concealed in Concrete and Block Walls: Rigid steel conduit. Schedule 40 PVC conduit. Electrical Nonmetallic Tubing (ENT).

Concealed Dry Interior Locations: Rigid steel conduit. Intermediate metal conduit. Electrical Metallic Tubing (EMT).

Exposed Dry Interior Locations: Rigid steel conduit. Intermediate metal conduit. Electrical metallic tubing.

Exposed Dry Interior Locations for Control Devices with Conduit Connections: EMT or Flexible Metal Conduit (FMC). Minimum length shall be one foot (300 mm); maximum length shall be three feet (900 mm). Minimum size FMC of 3/8".

Exposed Dry Interior Locations for Control Devices without Conduit Connections: Where HVAC equipment control panels or devices do not provide for the direct connection of conduits, exposed wiring may be extended to complete the final connections in dry locations, providing it does not exceed 18 inches in length.

CONTROL DAMPERS

All control dampers furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Control Contractor in locations shown on plans or where required to provide specified sequence of control.

Damper end switches, where required, shall be integral to the actuator that is mounted to the damper drive shaft or auxiliary shaft attached to a damper drive blade. End switches shall be adjusted to prove the damper the position opposite the fail position of the damper actuator unless the control sequence requires a different position to be proven to accomplish the specified control sequence.

Coordinate installation with the sheetmetal installer to obtain smooth duct transitions where damper size is different than duct size. Blank off plates will not be accepted.

Each operator shall serve a maximum damper area of 36 square feet. Where larger dampers are used, provide multiple operators.

CONTROL VALVES

All temperature control valves furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Control Contractor in locations shown on plans or where required to provide specified sequence of control.

Steam valve actuators shall be mounted between 45 and 90 degrees from upright vertical to prevent over heating of the actuator unless this orientation is specifically prohibited by the manufacturer. All other valves shall be mounted in the upright vertical position. If upright vertical mounting is not possible due to lack of space, obtain approval from the mechanical engineer of record on the project for alternate mounting that meet the manufacturers recommended installation. Radiation control valves shall not be located in the convective air flow above the heating element.

CONTROL SYSTEM INSTRUMENTATION

Install thermometer on the discharge of the AHU after the supply fan, all coils, and humidifiers but before any booster coils. Install thermometer to permit easy reading from the floor or operating platform. Adjust swiveled mounting for easy reading from floor.

ROOM THERMOSTATS AND TEMPERATURE SENSORS

Check and verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate room thermostats and sensors 48 inches above floor. Align with light switches and humidistats. For drywall installations, thermostat mounting shall use a back-box attached to a wall stud, drywall anchors are not acceptable.

Any room thermostats or sensors mounted on an exterior wall shall be mounted on a thermally insulated sub-base. Subbase to provide a minimum of one half inch of insulation.

For thermostats or sensors seal the conduit and any other opening to prevent air movement that could affect the measurement.

Provide guards where noted on mechanical floor plans or mechanical flow diagrams.

For reheat coil discharge temperature sensors, mount in the duct a minimum of three feet downstream of the reheat coil.

For applications that require more than one averaging element for mixed air, and heating coil discharge temperatures, the elements shall be distributed horizontally across the coil in a serpentine fashion to sense the average temperature across the plenum or coil across the horizontal expanse of the coil, i.e., across the top, middle, and bottom the coil where three averaging sensors are required.

LOW LIMIT THERMOSTATS (Freezestats)

Install low limit controls where indicated on the drawings or as specified.

Distribute (serpentine) sensing element horizontally across the coil to cover every square foot of coil; on larger coils this may require more than one instrument.

Mount the unit head in an accessible location as to allow for resetting after low limit trips while still meeting manufacturer's installation requirements for proper function. Mount units using flanges and element holders. Provide duct collars or bushings where sensing capillary passes through sheetmetal housings or ductwork; seal this penetration to eliminate air leakage. Elements shall be supported across coils or openings adequately to prevent movement from air current. Support methods shall be those suitable for use in air plenums with temperatures of up to 180 deg F. Metal fastening clips are the preferred method. Securing elements by use of plastic or nylon cable ties will not be accepted. Special attention should be paid to ensure elements will not rub on fasteners or other edges that will eventually cause damage.

Freezestats Installed on Entering Face of Cooling Coils:
Distribute (serpentine) sensing element horizontally across the entering face of the cooling coil to cover every square foot of coil; on larger coils this may require more than one instrument.

The 23 09 23 Contractor shall provide a manual switch, within the DDC enclosure, that is hardwired to the DDC. When this switch is in one position, the DDC shall shunt the cooling col freezestat. Owner will manually shunt (bypass) the cooling coil freezestat after the Owner has drained the cooling coil for winter. Refer to control sequences for additional information.

Freezestats Installed at AHU Supply Air Discharge:
Distribute (serpentine) sensing element horizontally across the supply duct opening. Only provide one freezestat for the supply duct opening. If AHU has multiple supply duct openings, install the singular freezestat across the opening with the largest square footage.

Provide enough active element to cover every square feet of supply duct opening. If supply duct opening requires more than one freezestat in order to adequately cover the supply duct opening, then just provide a single freezestat with the longest element possible. The supply air will be sufficiently mixed/blended at the AHU supply discharge.

If a control/isolation damper is present at the AHU supply discharge, freezestat shall be installed upstream of the control/isolation damper.

Ensure the freezestat control enclosure is accessible from outside the AHU fan box or supply duct. Do not install freezestat control enclosure inside the AHU fan box nor inside the supply duct.

Ensure there is access to the freezestat capillary from inside the AHU fan box or from the supply duct. Provide an access door in supply ductwork where necessary to provide access.

LIQUID AND STEAM FLOW SENSORS

Install where indicated on the drawings and details for flow sensing in hydronic and/or steam piping systems. Do not install close to elbows, valves, or other piping specialties, which might affect the reading of the sensor; follow manufacturer's installation instructions. Where flow meters are located more than five feet above the floor or where they cannot be read due to equipment location, provide remote mounting of the flow meter display and programming controls. Location of remote mounted display shall be so that the flow measurement display shall be mounted four to five feet above finished floor. BTU Measurement System displays shall be located so that the display and programming controls are four to five feet above finished floor. All piping to and from sensors shall be by Section 23 21 13 and 23 22 13 contractor and shall comply with requirements of Sections 23 21 13 and 23 22 13.

STEAM CONDENSATE WATER METERS

Mechanical contractor shall install steam condensate meters and associated piping. Install so that they shall always stay flooded and provide a trap to provide for this, if necessary.

Basic parameters to be set on a Flow Meter:

Parameters		**Measuring**
For channel A		Channels A B Y Z
Pipe outer diameter =	(pipe O.D. in inches)	Measure **x** (mark on channel A)
Pipe wall thickness =	(wall thickness - inches)	A: Sound Path = 2 (two sound paths)
Pipe material =	(PVC, C.S., SS, etc.)	Suggested trans. spacing = (read only)
Lining in pipe =	[**No]** or yes	Signal strength = 4 bars or more (read only)
Roughness =	0.000 (default value)	Actual trans. spacing = (enter actual spacing)

Medium =	Water
Temperature =	160 °F (average fluid temp)
Transducer type =	standard
Units =	PPH
Scale =	1,000

PRESSURE TRANSDUCERS AND HIGH LIMIT PRESSURE SWITCHES

Install capped tees in air piping at air pressure transducers for connection of calibration equipment. Capped tee shall consist of two inch poly tubing capped with a brass plug. Rubber caps are not acceptable. Install Petes Plugs fittings at each take-off from main piping for liquid pressure transducers for connection of calibration equipment. Install differential pressure transducers for filter monitoring at the filter section of the air handling unless otherwise specified. All other differential or static pressure transducers and differential or static pressure high limit switches for air applications should be mounted in the temperature control panel serving the equipment being controlled or monitored. All devices mounted on equipment shall be mounted in a location that is at a maximum of five feet above the floor. For all air static and differential pressure applications, use metal static pressure tips for insertion into the fan housing or ductwork. For steam and liquid applications, provide shutoff valves at piping takeoff points.

High and low static safety switches shall be labeled with the static pressure trip setpoint and shall match the record control drawing sequence of operation.

TEMPERATURE CONTROL PANELS

Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. All control panel openings shall be plugged. Conduits and other penetrations on the top of the cabinets shall be sealed on the exterior of the cabinet with silicone caulk to resist water penetration. One cabinet may accommodate more than one system in same equipment room. Provide permanent printed labeling for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

CURRENT STATUS SWITCHES

Provide for each fan or pump specified or shown on point list. Set threshold adjustment to indicate belt or coupling loss. Readjust threshold for proper operation after final balancing is completed. Use the variable frequency drive (VFD) integrated relay output for motor status, if provided on the VFD, in lieu of a discrete current switch. A separate current switch provided under this Section shall be wired in parallel with the VFD motor status relay when a bypass starter is provided on the VFD to prove motor status in the bypass mode. When a VFD serves more than one fan, provide a separate current switch for each fan served.

FUME HOOD PRESENCE SENSORS

Provide fume hood presence sensors for all "Two-Position Exhaust" fume hoods.

The 23 09 23 Contractor shall contact the GPC's selected fume hood vendor prior to fume hood production to coordinate any installation requirements or modifications to the fume hoods to accommodate the installation of the fume hood presence sensors.

23 09 23 Contractor shall submit installation drawings showing how fume hood presence sensors will be installed. Submitted installation drawings shall reflect the actual fume hoods being provided for this Project. Stock installation drawings will be rejected.

PRECONSTRUCTION REVIEW MEETING

This contractor shall attend a meeting or meetings as required prior to construction to review the control system on the project. The meeting attendees shall consist of the AE of Record, Owner, CxP, User Agency, Section 23 09 14 Contractor, Section 23 09 23 or 23 09 24 Contractor, and the Division 23 Contractor. All sequences covered within specification section 23 09 93 and related system configurations and devices shall be reviewed in detail and any corrections to the sequences and mechanical systems shall be made through the Owner construction change process.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 02.

FUNCTIONAL PERFORMANCE TESTING

For commissioning of control systems, the following items shall be complete by the contractor prior to functional performance testing:

- Completed functional performance tests written by the commissioning agent shall have been reviewed at the controls Preconstruction Review Meeting.
- All point to point checkout for each input/output shall be complete and documented.
- All changes to the design need to be incorporated prior to testing.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 02.

END OF SECTION

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DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2343

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:
WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:
MADISON, WI

SYSTEM: STEAM & HEATING HOT WATER DDC

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit	ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
HPS Flow[1]																					X														X												
HPS Pressure[1]																					X														X												
HPS Temperature[1]						X	X																		X	X								X												
PRV-10/11 Outlet Pressure																	X								X	X									X												
Condensate Pump (CP-19) Alarm																						X													X												
Steam Cont. Valve Cmd. (1/3)								X																											X												
Steam Cont. Valve Cmd. (2/3)								X																											X												
HWS Temperature															X										X	X									X												
HWR Temperature															X																				X												
VFD-HWP-7 S/S	X																																														
VFD-HWP-7 Status											X											X														X	X											
VFD-HWP-7 Speed								X																											X												
VFD-HWP-8 S/S	X																																														
VFD-HWP-8 Status											X											X														X	X											
VFD-HWP-8 Speed								X																											X												
Expansion Tank Pressure																	X								X	X									X												
HWS/HWR Differential Pressure (Basement)																	X								X	X									X												
HHW Makeup Water Flow (WFM-8)													X																						X	X											Pulse Input

NOTES:
1. Point shall be hardwired from BTU meter. The 23 09 23 Contractor shall provide BTU meter with sufficient hardwire I/O to monitor this.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: CHILLED WATER & PROCESS COOLING WATER DDC - (Sheet 1 of 2)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
Campus CHW Flow[1]																					X															X										
Campus CHWS Temperature[1]															X										X	X									X										
Campus CHWR Temperature[1]															X																				X										
Campus CHS/CHR Differential Pressure																	X									X									X										(Level 2 - Mechanical Room)
VFD-PCWP-9 S/S	X																																												
VFD-PCWP-9 Status										X												X														X	X									
VFD-PCWP-9 Speed								X																													X									
VFD-PCWP-10 S/S	X																																												
VFD-PCWP-10 Status										X												X														X	X									
VFD-PCWP-10 Speed								X																													X									
VFD-PCWP-11 S/S	X																																												
VFD-PCWP-11 Status										X												X														X	X									
VFD-PCWP-11 Speed								X																													X									
Expansion Tank Pressure																	X								X	X										X									
PCWS/PCWR Differential Pressure (Basement)																	X								X	X										X									
PHX-5 PCW Valve Command				X																																									
PHX-5 PCW Valve Open Switch											X											X															X									
PHX-5 PCW Valve Closed Switch											X											X															X									
PHX-5 PCWS Temperature															X																					X									
PHX-5 CHR Valve Command								X																												X									
PHX-5 CHR Temperature															X																					X									
PCW Makeup Water Flow (WFM-7)													X																							X	X									Pulse Input

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: CHILLED WATER & PROCESS COOLING WATER DDC - (Sheet 2 of 2)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
PHX-6 PCW Valve Command				X																																										
PHX-6 PCW Valve Open Switch											X											X													X										
PHX-6 PCW Valve Closed Switch											X											X													X										
PHX-6 PCWS Temperature															X																			X										
PHX-6 CHR Valve Command								X																										X										
PHX-6 CHR Temperature															X																			X										
FCV-CHS Valve Command				X																																									
FCV-CHS Valve Closed Position Switch											X											X													X										
FCV-CHR Valve Command				X																																									
FCV-CHR Valve Closed Position Switch											X											X													X										
FCV-NPCW Valve Command				X																																									
FCV-NPCW Valve Closed Position Switch											X											X													X										
FCV-IW Valve Command				X																																									
FCV-IW Valve Closed Position Switch											X											X													X										
Water Leak Detection											X											X													X										

NOTES:

1. Point shall be hardwired from BTU meter. The 23 09 23 Contractor shall provide BTU meter with sufficient hardwire I/O to monitor this.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: HEAT RECOVERY WATER DDC	HARDWARE																					SOFTWARE																									Comments
	OUTPUT								INPUT													ALARMS																									
	DIGITAL				ANALOG				DIGITAL						ANALOG							DIGITAL			ANALOG			ENERGY MANAGEMENT SYSTEM FUNCTIONS																			
POINT DESCRIPTION	Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	Equipment Status	Maintenance	Pressure	High Limit	Low Limit		Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	
Hardwire Points :																																															
VFD-HWP-7 S/S	X																																														
VFD-HWP-7 Status												X										X												X	X												
VFD-HWP-7 Speed								X																											X												
Expansion Tank Pressure																	X								X	X									X												
HRS Temperature															X										X	X									X												
HRR Temperature															X																				X												

NOTES:

1. Point shall be hardwired from BTU meter. The 23 09 23 Contractor shall provide BTU meter with sufficient hardwire I/O to monitor this.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: AHU-37A / AHU-37B
POINTS BELOW ARE FOR ONE AHU ONLY.
UNLESS OTHERWISE NOTED, PROVIDE THESE POINTS FOR BOTH AHU-37A AND AHU-37B.
(Sheet 1 of 2)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	HARDWARE: OUTPUT: ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	HARDWARE: INPUT: ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ALARMS: ANALOG: High Limit	Low Limit		SOFTWARE: ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																																
AHU Shutdown Toggle Switch											X											X														X												
AHU Watchdog Signal Output	X																																															Heartbeat from AHU-37A.
AHU Watchdog Signal Input										X												X														X												Heartbeat into AHU-37B.
AHU Supply Fans Proven On	X																					X														X												To Fire Alarm Monitoring Module
Supply Fan Speed Command - Output							X																													X												Output Signal from AHU-37A.
Supply Fan Speed Command - Input																					X															X												Input Signal to AHU-37B DDC.
Supply Fan #1 VFD Start/Stop	X																																															
Supply Fan #1 VFD Speed								X																													X												
Supply Fan #1 VFD Status										X												X														X												
Supply Fan #2 VFD Start/Stop	X																																															
Supply Fan #2 VFD Speed								X																													X												
Supply Fan #2 VFD Status										X												X														X												
Supply Fan #3 VFD Start/Stop	X																																															
Supply Fan #3 VFD Speed								X																													X												
Supply Fan #3 VFD Status										X												X														X												
Supply Fan #4 VFD Start/Stop	X																																															
Supply Fan #4 VFD Speed								X																													X												
Supply Fan #4 VFD Status										X												X														X												
Supply Duct Static Supply Fan Speed Control																	X						X	X	X												X												
AHU Plenum Static (Supply Fan Speed Limiting)																	X						X	X													X												
Outside Air Intake Damper - Command				X																																												
Outside Air Intake Damper - Open Position Switch											X											X														X												
Outside Air Intake Damper - Closed Position											X											X														X												
Supply Air (Smoke) Damper - Command								X																													X												
Supply Air (Smoke) Damper - Open Position											X											X														X												
Supply Air (Smoke) Damper - Closed Position											X											X														X												

NOTES:

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: AHU-37A / AHU-37B
POINTS BELOW ARE FOR ONE AHU ONLY. PROVIDE THESE POINTS FOR BOTH AHU-37A AND AHU-37B.

(Sheet 2 of 2)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	OUTPUT: ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	INPUT: ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ALARMS: ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																																
Heat Recovery Coil Leaving Air Temperature															X																						X												
Heating Coil Leaving Air Temperature															X										X											X												
Supply Air Temperature (Discharge)															X																					X												
Supply Air Humidity #1 (Discharge)																X									X	X										X												
Supply Air Humidity #2 (Discharge)																X									X	X										X												
Heat Recovery Control Valve Command								X																												X												
Heat Recovery Return Water Temperature															X											X										X												
Preheat Coil Control Valve Command								X																												X												
Heat Recovery Return Water Temperature															X											X										X												
Preheat Coil Control Valve Command								X																												X												
Preheat Coil Face/Bypass Damper Command								X																												X												
Cooling Coil Control Valve Command								X																												X												
Cooling Coil Leaving Water Temperature															X																					X												
Humidifier Output Control Valve								X																												X												
Supply Air Prefilter Transmitter (Summer Position)																	X								X											X												
Supply Air Prefilter Transmitter (Winter Position)																	X								X											X												
Supply Air Final Filter Transmitter																	X								X											X												
SA Low Static Pressure Switch													X								X															X											SAFETY!
SA High Static Pressure Switch													X								X															X											SAFETY!
Freezestat at Cooling Coil												X									X															X											SAFETY!
Freezestat at Cooling Coil - Bypass Switch											X										X															X											Hand Switch
Freezestat at Cooling Coil - Bypass Output	X																				X															X											
Freezestat at AHU Discharge												X									X															X											SAFETY!
Supply Air Fire Alarm Shutdown												X									X															X											SAFETY!
Exhaust Air Temperature[1]															X																					X												
Exhaust Air Relative Humidity[1]																X																					X												

NOTES:
1. Points shall be hardwired to AHU-37A DDC only. Points are used for AHU humidifier control. Refer to 23 09 93 for details.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: EF-66A / EF-66B / EF-66C

(Sheet 1 of 2)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
EF-66A Shutdown Toggle Switch											X											X														X										
EF-66B Shutdown Toggle Switch											X											X														X										
EF-66C Shutdown Toggle Switch											X											X														X										
VFD-EF-66A Start/Stop	X																																													
VFD-EF-66A Speed								X																													X										
VFD-EF-66A Status										X												X														X										
ED-EF-66A Isolation Damper Command								X																												X										
ED-EF-66A Iso. Damper - Open Switch											X											X														X										
VFD-EF-66B Start/Stop	X																																													
VFD-EF-66B Speed								X																													X										
VFD-EF-66B Status										X												X														X										
ED-EF-66B Isolation Damper Command								X																												X										
ED-EF-66B Iso. Damper - Open Switch											X											X														X										
VFD-EF-66C Start/Stop	X																																													
VFD-EF-66C Speed								X																													X										
VFD-EF-66C Status										X												X														X										
ED-EF-66C Isolation Damper Command								X																												X										
ED-EF-66C Iso. Damper - Open Switch											X											X														X										
Exhaust Duct Static #1 (Fan Speed Control)																	X								X	X										X										
Exhaust Duct Static #2 (Fan Speed Limiting)																	X								X											X										
OA Bleed Damper Command								X																												X										
OA Bleed Damper Position Feedback																			X																	X										
Low Static Pressure Switch													X											X												X										SAFETY!

NOTES:

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: EF-66A / EF-66B / EF-66C

(Sheet 2 of 2)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
HRU-66 Manual Service Switch											X											X														X										
HRU-66 Safe to Enter Pilot Light	X																																													
HRU-66 Inlet Damper Command				X																																										
HRU-66 Inlet Damper - Open Switch											X											X														X										
HRU-66 Inlet Damper - Closed Switch											X											X														X										
HRU-66 Discharge Damper Command				X																																										
HRU-66 Discharge Damper - Open Switch											X											X														X										
HRU-66 Discharge Damper - Closed Switch											X											X														X										
HRU-66 Filter Pressure Drop																	X								X										X										
HRU-66 Leaving Air Temperature															X																				X										
HRU-66 Bypass Damper Command				X																																										
HRU-66 Bypass Damper - Open Switch											X											X														X										
HRU-66 Bypass Damper - Closed Switch											X											X														X										

NOTES:

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: MECHANICAL ROOM (RM 2376) HVAC CONTROL

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
SF-2 Shutdown Toggle Switch											X											X														X										
SF-2 - Start/Stop			X																																											
SF-2 - Status									X													X														X										
SD-2-2-1 Damper Command								X																												X										
SD-2-2-1 Damper Position Feedback																			X																X										
RD-2-2-1 Damper Command								X																												X										
RD-2-2-1 Damper Position Feedback																			X																X										
ED-2-2-1 Damper Command				X																																X										
ED-2-2-1 Damper Open Position Switch											X											X														X										
Supply Air Temperature															X										X	X										X										
Room (Rm 2376) Temperature															X										X	X										X										
UH-70 Hot Water Control Valve Command				X																																										
UH-70 Fan Status									X													X														X										
EF-21 Shutdown Toggle Switch											X											X														X										
EF-21 - Start/Stop			X																																											
EF-21 - Status									X													X														X										
ED-21-2-1 Damper Command				X																																X										
ED-21-2-1 Damper Open Position Switch											X											X														X										
Oxygen Depletion Alarm - Horn[1&2]	X																																													
Oxygen Depletion Alarm - Red Strobe[1&2]	X																																												
Oxygen Depletion Alarm - Green Strobe[1&2]	X																																												

NOTES:

1. Oxygen depletion sensors required for mechanical room. Refer to 5/M7.08 for additional details.
2. Refer to mechanical pressurization plans for quantity of horns/strobes. Space will require multiple horn/strobes.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ELECTRICAL ROOM (RM 2382) HVAC CONTROL

	HARDWARE																				
	OUTPUT								INPUT												
	DIGITAL				ANALOG				DIGITAL						ANALOG						
POINT DESCRIPTION	Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow
Hardwire Points :																					
SF-3 Shutdown Toggle Switch											X										
SF-3 - Start/Stop			X																		
SF-3 - Status									X												
SD-3-2-1 Damper Command								X													
SD-3-2-1 Damper Position Feedback																			X		
RD-3-2-1 Damper Command								X													
RD-3-2-1 Damper Position Feedback																			X		
ED-3-2-1 Damper Command				X																	
ED-3-2-1 Damper Open Position Switch											X										
Supply Air Temperature															X						
Room (Rm 2382) Temperature															X						

	SOFTWARE																									
	ALARMS																									
	DIGITAL			ANALOG			ENERGY MANAGEMENT SYSTEM FUNCTIONS																			
POINT DESCRIPTION	Equipment Status	Maintenance	Pressure	High Limit	Low Limit		Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																										
SF-3 Shutdown Toggle Switch	X													X												
SF-3 - Start/Stop																										
SF-3 - Status	X													X												
SD-3-2-1 Damper Command														X												
SD-3-2-1 Damper Position Feedback														X												
RD-3-2-1 Damper Command														X												
RD-3-2-1 Damper Position Feedback														X												
ED-3-2-1 Damper Command														X												
ED-3-2-1 Damper Open Position Switch	X													X												
Supply Air Temperature				X	X									X												
Room (Rm 2382) Temperature				X	X									X												

NOTES:

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: FAN COIL UNIT (TYPICAL)[1]

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit	ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
Space Temperature															X										X	X								X												
Supply Air Duct Temperature															X																			X												
Fan Start/Stop Command			X																																											
Fan Status									X													X													X												
Cooling Coil Control Valve Command								X																											X												
Heating Coil Control Valve Command								X																											X												

NOTES:

1. Points listed in this chart are typical for one fan coil. The 23 09 23 Contractor shall provide these points for each fan coil.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: PLUMBING EQUIPMENT MONITORING	HARDWARE																					SOFTWARE																									
	OUTPUT								INPUT													ALARMS																									
	DIGITAL				ANALOG				DIGITAL						ANALOG							DIGITAL			ANALOG			ENERGY MANAGEMENT SYSTEM FUNCTIONS																			
POINT DESCRIPTION	Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	Equipment Status	Maintenance	Pressure	High Limit	Low Limit		Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																															
Sump Pump (SP-16) - Alarm										X												X													X												
Sump Pump (SP-17) - Alarm										X												X													X												
Sump Pump (SP-18) - Alarm										X												X													X												
Sump Pump (SP-19) - Alarm										X												X													X												
Sump Pump (SP-20) - Alarm										X												X													X												
High Purity Water Skid - Alarm										X												X													X												
Lab Vacuum Pump Skid - Alarm										X												X													X												
Nitrogen Generator (N2GEN-1) - Alarm										X												X													X												
Air Compressor (AC-3) - Alarm										X												X													X												
Air Compressor (AC-4) - Alarm										X												X													X												
Tempered Water Ball Valve - Command				X																																											Refer to P7.01. (Level 2)
Tempered Water Ball Valve - Open Position											X											X													X												Refer to P7.01. (Level 2)
Tempered Water Temperature															X										X	X									X												Refer to P7.01. (Level 2)
Tempered Water Pressure																	X									X									X												Refer to P7.01. (Level 2)

NOTES:

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: Fire/Smoke Damper Monitoring

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																																
SFSD-37-1-1 - Open Position Switch											X											X														X												
SFSD-37-1-2 - Open Position Switch											X											X														X												(NOTE 1)
SFSD-37-2-1 - Open Position Switch											X											X														X												(NOTE 1)
EFSD-66-1-1 - Open Position Switch											X											X														X												
EFSD-66-2-1 - Open Position Switch											X											X														X												

NOTES:

1. Hardwire point to the DDC controlling AHU-37A. Points are critical for ensuring supply fans don't operate above minimum speed when either of these fire/smoke dampers are not proven open.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE A (SEE PLANS FOR QUANTITY)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
Space Temperature															X										X	X									X										(Install in Exhaust Duct)
Supply Air Flow[1]																					X														X									
Supply Air Damper Command[1]						X	X																												X									
General Exhaust Air Flow[1]																					X														X									
General Exhaust Air Damper Command[1]						X	X																												X									
Discharge Air Temperature[1]															X																				X									
Reheat Valve Command[1]						X		X																											X									
Flammable Gas Detector Alarm #1										X												X													X									From Gas Cabinet Controller
Flammable Gas Detector Alarm #2										X												X													X									From Wall Mount Detector
Red LED - On/Off Command	X																																											Local Horn/Strobe
Green LED - On/Off Command	X																																											Local Horn/Strobe
Horn - On/Off Command	X																																											Local Horn/Strobe
Software Points[2] :																																													
Occupied Heating Setpoint																																													
Occupied Cooling Setpoint																																													
Failure Mode Heating Setpoint																																													
Failure Mode Cooling Setpoint																																													
Supply Air Occupied Max. Airflow Setpoint																																													
Supply Air Occupied Min. Airflow Setpoint																																													
Supply Air Failure Mode Airflow Setpoint																																													
Gen. Exhaust Differential Air Setpoint																																													
Actual Supply Flow Setpoint																																													
Actual Exhaust Flow Setpoint																																													
Actual Heating Setpoint																																													
Actual Cooling Setpoint																																													
Temperature Setpoint Adjust Range[3]																																													

NOTES:

1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.
3. Separate heating and cooling setpoints are preferred. If temperature setpoint is a single input that will offset the heating and cooling supervisory setpoints up or down together by an adjustable range.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:
WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:
MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE B
(SEE PLANS FOR QUANTITY)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
Space Temperature															X										X	X									X											
Supply Air Flow[1]																					X														X										
Supply Air Damper Command[1]						X	X																												X										
General Exhaust Air Flow[1]																					X														X										
General Exhaust Air Damper Command[1]						X	X																												X										
Point Exhaust Air Flow[2]																					X														X										
Point Exhaust Air Damper Command[2]						X	X																												X										
Discharge Air Temperature[1]															X																				X										
Reheat Valve Command[1]						X		X																											X										
Room Pressure																	X																		X										
Hot Cell Booster Exhaust Fan Speed Signal							X																												X										
~~HEPA Filter Unit - Fan Speed Command~~																																			X					X					BACnet IP (Software Point)
~~HEPA Filter Unit - Speed (RPM)~~																																			X					X					BACnet IP (Software Point)
~~HEPA Filter Unit - Run Time (Hours)~~																																			X					X					BACnet IP (Software Point)
~~HEPA Filter Unit - Enabled (Start/Stop)~~																																			X					X					BACnet IP (Software Point)
~~HEPA Filter Unit - Fan Status~~																						X													X					X					BACnet IP (Software Point)
~~HEPA Filter Unit - Alarm~~																						X													X					X					BACnet IP (Software Point)
Software Points[2] :																																													
Occupied Heating Setpoint																																													
Occupied Cooling Setpoint																																													
Failure Mode Heating Setpoint																																													
Failure Mode Cooling Setpoint																																													
Supply Air Occupied Max. Airflow Setpoint																																													
Supply Air Occupied Min. Airflow Setpoint																																													
Supply Air Failure Mode Airflow Setpoint																																													
Gen. Exhaust Differential Air Setpoint																																													
Point Exhaust Airflow Setpoint																																													
Point Exhaust Failure Mode Airflow Setpoint																																													
Actual Supply Flow Setpoint																																													
Actual General Exhaust Flow Setpoint																																													
Actual Point Exhaust Flow Setpoint																																													
Actual Heating Setpoint																																													
Actual Cooling Setpoint																																													
Temperature Setpoint Adjust Range[3]																																													

NOTES:
1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.
3. Separate heating and cooling setpoints are preferred. If temperature setpoint is a single input that will offset the heating and cooling supervisory setpoints up or down together by an adjustable range.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE C (SEE PLANS FOR QUANTITY)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																																
Space Temperature															X										X	X									X													
Supply Air Flow[1]																					X														X												
Supply Air Damper Command[1]						X	X																												X												
General Exhaust Air Flow[1]																					X														X												
General Exhaust Air Damper Command[1]						X	X																												X												
Point Exhaust Air Flow[2]																					X														X												
Point Exhaust Air Damper Command[2]						X	X																												X												
Discharge Air Temperature[1]															X																				X												
Reheat Valve Command[1]						X		X																											X												
Room Pressure																	X																		X												
~~HEPA Filter Unit - Fan Speed Command~~																																			X		X										BACnet IP (Software Point)
~~HEPA Filter Unit - Speed (RPM)~~																																			X		X										BACnet IP (Software Point)
~~HEPA Filter Unit - Run Time (Hours)~~																																			X		X										BACnet IP (Software Point)
~~HEPA Filter Unit - Enabled (Start/Stop)~~																																			X		X										BACnet IP (Software Point)
~~HEPA Filter Unit - Fan Status~~																						X													X		X										BACnet IP (Software Point)
~~HEPA Filter Unit - Alarm~~																						X													X		X										BACnet IP (Software Point)
Software Points[2] :																																															
Occupied Heating Setpoint																																															
Occupied Cooling Setpoint																																															
Failure Mode Heating Setpoint																																															
Failure Mode Cooling Setpoint																																															
Supply Air Occupied Max. Airflow Setpoint																																															
Supply Air Occupied Min. Airflow Setpoint																																															
Supply Air Failure Mode Airflow Setpoint																																															
Gen. Exhaust Airflow Differential Setpoint																																															
Point Exhaust Occupied Airflow Setpoint																																															
Point Exhaust Failure Mode Airflow Setpoint																																															
Actual Supply Flow Setpoint																																															
Actual General Exhaust Flow Setpoint																																															
Actual Point Exhaust Flow Setpoint																																															
Actual Heating Setpoint																																															
Actual Cooling Setpoint																																															
Temperature Setpoint Adjust Range[3]																																															

NOTES:

1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.
3. Separate heating and cooling setpoints are preferred. If temperature setpoint is a single input that will offset the heating and cooling supervisory setpoints up or down together by an adjustable range.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE D (SEE PLANS FOR QUANTITY)

(Sheet 1 of 2)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
Space Temperature															X										X	X									X											
Occupancy Sensor[4]																																			X										
Supply Air Flow[1]																					X														X										
Supply Air Damper Command[1]						X	X																												X										
General Exhaust Air Flow[1]																					X														X										
General Exhaust Air Damper Command[1]						X	X																												X										
Point Exhaust Air Flow[1]																					X														X										
Point Exhaust Air Damper Command[1]						X	X																												X										
Discharge Air Temperature[1]															X																				X										
Point Exhaust Air Damper Command[1]						X	X																												X										
Discharge Air Temperature[1]															X																				X										
Reheat Valve Command[1]						X		X																											X										
Oxygen Depletion Alarm										X													X												X										
Oxygen Depletion Alarm - Horn[5&6]	X																																													
Oxygen Depletion Alarm - Red Strobe[5&6]	X																																												
Oxygen Depletion Alarm - Green Strobe[5&6]	X																																												

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE D (SEE PLANS FOR QUANTITY)

(Sheet 2 of 2)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Software Points[2]:																																															
Occupied Heating Setpoint																																															
Occupied Cooling Setpoint																																														
Standby Heating Setpoint																																															
Standby Cooling Setpoint																																															
Unoccupied Heating Setpoint																																															
Unoccupied Cooling Setpoint																																															
Failure Mode Heating Setpoint																																															
Failure Mode Cooling Setpoint																																															
Supply Air Occupied Max. Airflow Setpoint																																															
Supply Air Occupied Min. Airflow Setpoint																																															
Supply Air Unoccupied Min. Airflow Setpoint																																															
Supply Air Failure Mode Airflow Setpoint																																															
Gen. Exhaust Airflow Differential Setpoint																																															
Point Exhaust Airflow Setpoint																																															
Point Exhaust Failure Mode Airflow Setpoint																																															
Actual Supply Flow Setpoint																																															
Actual General Exhaust Flow Setpoint																																															
Actual Point Exhaust Flow Setpoint																																															
Actual Heating Setpoint																																															
Actual Cooling Setpoint																																															
Temperature Setpoint Adjust Range[3]																																															

NOTES:

1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.
3. Separate heating and cooling setpoints are preferred. If temperature setpoint is a single input that will offset the heating and cooling supervisory setpoints up or down together by an adjustable range.
4. If space has multiple occupancy sensors, wire to all sensors. Activation of any sensor shall index space into occupied mode. Refer to lighting floor plans for occupancy sensor quantities.
5. Oxygen depletion sensors required for rooms B1343 and B1349M only. Refer to 5/M7.08 for additional details.
6. Refer to mechanical pressurization plans for quantity of horns/strobes. Spaces will require multiple horn/strobes.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE E (SEE PLANS FOR QUANTITY)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																															
Space Temperature															X										X	X									X												
Occupancy Sensor[4]																																			X											
Supply Air Flow[1]																					X														X											
Supply Air Damper Command[1]						X	X																												X											
Discharge Air Temperature[1]															X																				X											
Reheat Valve Command[1]						X		X																											X											
Software Points[2] :																																														
Occupied Heating Setpoint																																														
Occupied Cooling Setpoint																																														
Standby Heating Setpoint																																														
Standby Cooling Setpoint																																														
Unoccupied Heating Setpoint																																														
Unoccupied Cooling Setpoint																																														
Failure Mode Heating Setpoint																																														
Failure Mode Cooling Setpoint																																														
Supply Air Occupied Max. Airflow Setpoint																																														
Supply Air Occupied Min. Airflow Setpoint																																														
Supply Air Unoccupied Min. Airflow Setpoint																																														
Supply Air Failure Mode Airflow Setpoint																																														
Actual Supply Flow Setpoint																																														
Actual Heating Setpoint																																														
Actual Cooling Setpoint																																														
Temperature Setpoint Adjust Range[3]																																														

NOTES:

1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.
3. Separate heating and cooling setpoints are preferred. If temperature setpoint is a single input that will offset the heating and cooling supervisory setpoints up or down together by an adjustable range.
4. If space has multiple occupancy sensors, wire to all sensors. Activation of any sensor shall index space into occupied mode. Refer to lighting floor plans for occupancy sensor quantities.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:
WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:
MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE F
(SEE PLANS FOR QUANTITY)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actu	HARDWARE: OUTPUT: ANALOG: Elect/PneuTransdu	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Sv	Control Relay Cont	Switch Closure	Auxiliary Contact	Diff Pressure Switc	Flow Switch	HARDWARE: INPUT: ANALOG: Temperature	Relative Humidity	Differential Pressur	Carbon Dioxide (PP	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ALARMS: ANALOG: High Limit	Low Limit		SOFTWARE: ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/St	Totalization	Trend		Equipment Integrat	Fire Alarm Integrati	Security/Access Int	Elect PQM Integrat	Chiller Integration	Manual Changeove	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																																
Space Temperature															X										X	X									X												
Occupancy Sensor[4]																																			X												
Fume Hood Presence Sensor[1]										X																									X												
Fume Hood External Relay Signal	X																																														
Fume Hood Air Flow[1]																					X														X												
Fume Hood Damper Command[1]						X	X																												X												
Point Exhaust Air Flow[1]																					X														X												
Point Exhaust Damper Command[1]						X	X																												X												
Supply Air Flow[1]																					X														X												
Supply Air Damper Command[1]						X	X																												X												
Discharge Air Temperature[1]															X																				X												
Reheat Valve Command[1]						X		X																											X												
Software Points[2] :																																															
Occupied Heating Setpoint																																																
Occupied Cooling Setpoint																																																
Standby Heating Setpoint																																																
Standby Cooling Setpoint																																																
Unoccupied Heating Setpoint																																																
Unoccupied Cooling Setpoint																																																
Failure Mode Heating Setpoint																																																
Failure Mode Cooling Setpoint																																																
Fume Hood Exhaust Occupied Airflow Setpoint																																																
Fume Hood Exhaust Unoccupied Airflow Setpoint																																																
Fume Hood Exh. Failure Mode Airflow Setpoint																																																
Point Exhaust Airflow Setpoint																																																
Point Exhaust Failure Mode Airflow Setpoint																																																
Supply Airflow Differential Setpoint																																																
Actual Fume Hood Exhaust Airflow Setpoint																																																
Actual Point Exhaust Airflow Setpoint																																																
Actual Supply Airflow Setpoint																																																
Actual Heating Setpoint																																																
Actual Cooling Setpoint																																																
Temperature Setpoint Adjust Range[3]																																																

NOTES:
1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.
3. Separate heating and cooling setpoints are preferred. If temperature setpoint is a single input that will offset the heating and cooling supervisory setpoints up or down together by an adjustable range.
4. If space has multiple occupancy sensors, wire to all sensors. Activation of any sensor shall index space into occupied mode. Refer to lighting floor plans for occupancy sensor quantities.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE G (SEE PLANS FOR QUANTITY)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																																
Space Temperature															X										X	X									X													
Occupancy Sensor[4]																																			X												
Supply Air Flow[1]																					X														X												
Supply Air Damper Command[1]						X	X																												X												
General Exhaust Air Flow[1]																					X														X												
General Exhaust Air Damper Command[1]						X	X																												X												
Software Points[2] :																																															
Occupied Heating Setpoint																																															
Occupied Cooling Setpoint																																														
Standby Heating Setpoint																																															
Standby Cooling Setpoint																																															
Unoccupied Heating Setpoint																																															
Unoccupied Cooling Setpoint																																															
Failure Mode Heating Setpoint																																															
Failure Mode Cooling Setpoint																																															
Supply Air Occupied Max. Airflow Setpoint																																															
Supply Air Occupied Min. Airflow Setpoint																																															
Supply Air Unoccupied Min. Airflow Setpoint																																															
Supply Air Failure Mode Airflow Setpoint																																															
Gen. Exhaust Airflow Differential Setpoint																																															
Actual Supply Flow Setpoint																																															
Actual General Exhaust Flow Setpoint																																															
Actual Heating Setpoint																																															
Actual Cooling Setpoint																																															
Temperature Setpoint Adjust Range[3]																																															

NOTES:

1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.
3. Separate heating and cooling setpoints are preferred. If temperature setpoint is a single input that will offset the heating and cooling supervisory setpoints up or down together by an adjustable range.
4. If space has multiple occupancy sensors, wire to all sensors. Activation of any sensor shall index space into occupied mode. Refer to lighting floor plans for occupancy sensor quantities.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE H (SEE PLANS FOR QUANTITY)

POINT DESCRIPTION	HARDWARE																						SOFTWARE																							Comments
	OUTPUT								INPUT														ALARMS						ENERGY MANAGEMENT SYSTEM FUNCTIONS																					
	DIGITAL				ANALOG				DIGITAL						ANALOG								DIGITAL			ANALOG																							
	Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	Equipment Status	Maintenance	Pressure	High Limit	Low Limit		Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	
Hardwire Points :																																														
Exhaust Air Flow[1]																					X												X												
Exhaust Air Damper Command[1]						X	X																										X												
Software Points[2] :																																														
Exhaust Air Occupied Airflow Setpoint																																														
Exhaust Air Failure Airflow Setpoint																																														

NOTES:

1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: ROOM CONTROL SEQUENCE I (SEE PLANS FOR QUANTITY)

POINT DESCRIPTION	HARDWARE: OUTPUT: DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	HARDWARE: INPUT: DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow	SOFTWARE: ALARMS: DIGITAL: Equipment Status	Maintenance	Pressure	ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Hardwire Points :																																														
Space Temperature[1]															X										X	X									X											
Supply Air Flow[1]																					X														X										
Supply Air Damper Command[1]						X	X																												X										
Supply Air Discharge Air Temperature[1]															X																				X										
Reheat Valve Command[1]						X		X																											X										
General Exhaust Air Flow[1]																					X														X										
General Exhaust Air Damper Command[1]						X	X																												X										
Unit Heater Hot Water Control Valve Command[1]				X																																									
Unit Heater Fan Current Switch[1]											X																																		
Software Points[2] :																																														
Occupied Heating Setpoint																																														
Occupied Cooling Setpoint																																														
Failure Mode Heating Setpoint																																														
Failure Mode Cooling Setpoint																																														
Supply Air Occupied Max. Airflow Setpoint																																														
Supply Air Occupied Min. Airflow Setpoint																																														
Supply Air Unoccupied Min. Airflow Setpoint																																														
Supply Air Failure Mode Airflow Setpoint																																														
Gen. Exhaust Airflow Differential Setpoint																																														
Point Exhaust Airflow Setpoint																																														
Point Exhaust Failure Mode Airflow Setpoint																																														
Actual Supply Flow Setpoint																																														
Actual General Exhaust Flow Setpoint																																														
Actual Point Exhaust Flow Setpoint																																														
Actual Heating Setpoint																																														
Actual Cooling Setpoint																																														
Temperature Setpoint Adjust Range[3]																																														

NOTES:

1. Refer to floor plans for quantity of these devices.
2. The minimum software points listed, if necessary to the application, shall be mapped. Any additional software points that are requested by the user Agency shall be mapped by the DDC contractor.
3. Separate heating and cooling setpoints are preferred. If temperature setpoint is a single input that will offset the heating and cooling supervisory setpoints up or down together by an adjustable range.

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511 | **DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23**

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: VFD POINTS Thru Integrated Communication Inferface (MS/TP) for all VFDs Provided on Project

HARDWARE

POINT DESCRIPTION	OUTPUT – DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	OUTPUT – ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	INPUT – DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	INPUT – ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow
Software Points :																					
VFD Total Run Time																					
KWH																					
KW																					
VFD Temperature																					
Voltage Output																					
Amperage Output																					
Output Frequency																					
Remote Fault Reset																					
Hand Auto Status																					
VFD Fault Status																					

SOFTWARE

POINT DESCRIPTION	ALARMS – DIGITAL: Equipment Status	Maintenance	Pressure	ALARMS – ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Software Points :																										
VFD Total Run Time														X		X										
KWH														X		X										
KW														X		X										
VFD Temperature														X		X										
Voltage Output														X		X										
Amperage Output														X		X										
Output Frequency														X		X										
Remote Fault Reset														X		X										
Hand Auto Status														X		X										
VFD Fault Status														X		X										

NOTES:

DDC INPUT / OUTPUT SUMMARY TABLE

UW PROJECT NO: A-23-011, 1485-2511

DDC CONTROLLERS PROVIDED UNDER SPECIFICATION SECTION 23 09 23

PROJECT:

WIMR EAST WEDGE CYCLOTRON AND EXPANSION

LOCATION:

MADISON, WI

SYSTEM: HEPA FILTER UNIT POINTS Thru Integrated Communication Inferface (BACnet IP) for all HFUs Provided on Project

HARDWARE

POINT DESCRIPTION	OUTPUT – DIGITAL: Control Relay	Solenoid	Contactor	2-Pos Electric Actuator	OUTPUT – ANALOG: Elect/PneuTransducr	Electric Actuator	4-20 mA	0-10 VDC	INPUT – DIGITAL: Current Sensing Switch	Control Relay Contact	Switch Closure	Auxiliary Contact	Diff Pressure Switch	Flow Switch	INPUT – ANALOG: Temperature	Relative Humidity	Differential Pressure	Carbon Dioxide (PPM)	Potentiometer	Static Pressure	Flow
Software Points :																					
Operation Hours Counter[1]																					
Actual Fan Speed (RPM)[1]																					
Motor Status[1]																					
Warning / General Alarm[1]																					
Current Power[1]																					
Current Set Value[1]																					
Sensor Actual Value[1]																					

SOFTWARE

POINT DESCRIPTION	ALARMS – DIGITAL: Equipment Status	Maintenance	Pressure	ALARMS – ANALOG: High Limit	Low Limit		ENERGY MANAGEMENT SYSTEM FUNCTIONS: Day/Night Setback	Demand Limiting	Dial-up I/O	Duty Cycling	Optimum Start/Stop	Scheduled Start/Stop	Totalization	Trend		Equipment Integration	Fire Alarm Integration	Security/Access Integration	Elect PQM Integration	Chiller Integration	Manual Changeover	HW/OA Reset	CHW Reset	Smoke Control	Fire Alarm Override	Comments
Software Points :																										
Operation Hours Counter[1]														X		X										
Actual Fan Speed (RPM)[1]														X		X										
Motor Status[1]	X													X		X										
Warning / General Alarm[1]	X													X		X										
Current Power[1]														X		X										
Current Set Value[1]														X		X										
Sensor Actual Value[1]														X		X										

NOTES:

1. Refer to M7.01 and specification 23 37 13 for details on BAS integration.

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SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEM FOR HVAC
BASED ON DFD MASTER SPECIFICATION DATED 3/28/2023

P A R T 1 - G E N E R A L

SCOPE

Work in this section includes Direct Digital Control (DDC) panels, main communication trunk, software programming, and other equipment and accessories necessary to constitute a complete Direct Digital Control (DDC) system. This system interfaced with pneumatic/electric controls (Section 23 09 14) utilizing Direct Digital Control signals to operate actuated control devices will meet, in every respect, all operational and quality standards specified herein.

CLASS 1 NOTICE:

Notice is hereby given in accordance with Section 16.855(1), Wisconsin Statues, that the Division believes it is in the best interests of the State to contract the following work from only one source, without the usual statutory procedures:

- DDC provider to be Johnson Controls, Inc.

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 02– Commissioning Process
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC – Coordination
Section 23 08 00 – Commissioning of HVAC
Section 23 09 14 - Pneumatic and Electric Instrumentation and Control Devices for HVAC
Section 23 09 15 - Direct Digital Control Input/Output Point Summary Tables
Section 23 09 93 - Control Sequences

Division 23 - HVAC - Equipment provided to be controlled or monitored
Division 26 - Electrical - Equipment provided to be controlled or monitored

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

REFERENCE STANDARDS
FCC Part 15, Subpart J, Class A - Digital Electronic Equipment to Radio Communication Interference

WORK NOT INCLUDED
Section 23 09 14 work includes furnishing and installing all field devices, including electronic sensors for the DDC of this section, equipment, and all related field wiring, interlocking control wiring between equipment, pneumatic tubing, sensor mounting, etc., that is covered in that section.

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

QUALITY ASSURANCE
MANUFACTURER:
Johnson Controls.

INSTALLER:
A firm specializing and experienced in DDC control system installation for no less than 3 years. All engineering and commissioning work shall be done by qualified employees of this manufacturer, or qualified employees of an Authorized Representative of that manufacturer that provides engineering and commissioning of the manufacturer's control equipment. Where installing contractor is an authorized representative of the control equipment manufacturer, submit written confirmation of such authorization. Indicate in letter of authorization that the installing contractor has successfully completed all necessary training required for the engineering, installation, and commissioning of equipment and systems to be provided for the project and that such authorization has been in effect for a period of not less than three years. The letter of authorization should also indicate that the installing contractor is authorized to install the manufacturer's DDC equipment at the project location at the time the project is bid. Installation of the equipment shall be done by qualified mechanics and/or electricians in the direct employ or be directly subcontracted and under the supervision of the manufacturer or Authorized Representative. The contractor providing and installing the equipment under this specification section shall be the same contractor providing and installing equipment under the 23 09 14 specification section.

RESPONSE TIME:
During warrantee period, four (4) hours or less, 24-hours/day, 7 days/week.

ELECTRICAL STANDARDS:
Provide electrical products, which have been tested, listed and labelled by Underwriters' Laboratories (UL) and comply with NEMA standards.

DDC Standards: DDC manufacturer shall provide written proof with shop drawings that the equipment being provided is in compliance with F.C.C. rules governing the control of interference caused by Digital Electronic Equipment to Radio Communications (Part 15, Subpart J, Class A).

SUBMITTALS
Include the following information:

Details of construction, layout, and location of each temperature control panel within the building, including instrument's location in panel and labelling. Indicate which piece of mechanical equipment is associated with each controller and what area within the building is being served by that equipment. For terminal unit control, provide a room schedule that would list mechanical equipment tag, room number of space served, address of DDC controller, and any other pertinent information required for service.

PRODUCT DATA
Submit manufacturer's specifications for each control device furnished, including installation instructions and start-up instructions. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked. Annotated software program documentation shall be submitted for system sequences, along with descriptive narratives of the sequence of operation of the entire system involved. Submit wiring diagram for each electrical control device along with other details required to demonstrate that the system has been coordinated and will function as a system.

MAINTENANCE DATA
Submit maintenance data and spare parts lists for each control device. Include this data in maintenance manual.

RECORD DRAWINGS
Prior to request for final payment provide complete composite record drawings to incorporate the DDC and Pneumatic/Electric field work. All software addressing for device communication shall be noted for all devices provided under this section and the communication addressing required for devices provided by others that are integrated into the direct digital control system provided under this section. Point to point routing of communication trunks and power wiring between DDC controllers, DDC communication devices, control panels, and Ethernet switches shall be documented. For systems that have additions to existing communication networks, provide complete DDC network diagrams for the entire building with new work clearly delineated. Coordinate with the supplier of the equipment specified to be interfaced through digital communications for communication addressing. Provide circuit number of 120VAC panel power circuit(s) feeding each control panel on record drawings. Label circuit number(s) inside the panel served.

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

MATERIAL DELIVERY AND STORAGE
Provide factory shipping cartons for each piece of equipment and control device. This contractor is responsible for storage of equipment and materials inside and protected from the weather.

P A R T 2 - P R O D U C T S

GENERAL
Provide DDC control products in sizes and of capacities as required, conforming to manufacturer's standard materials and components as published in their product information, designed, and constructed as recommended by the manufacturer and as required for application indicate.

System shall be capable of operating with 120 VAC power supply, fully protected with a shutdown-restart circuit, and associated hardware and software.

All DDC controllers shall use screw terminals for termination of individual wires. Spade lugs are not acceptable.

LOCAL CONTROL PANELS
Use control panels with suitable mounting brackets for each supply fan system. Locate panel adjacent to system served.

Fabricate panels of 14-gauge furniture grade steel or 6063-T5 extruded aluminum alloy, totally enclosed on six sides, hinged door, and keyed lock, with manufacturer's standard shop painted finish and color.

Provide UL listed cabinets for use with line voltage devices.

Any panel that houses a 23 09 23 DDC, or instrumentation provided under 23 09 14, shall not have any control voltage 50V or high within it. Provide a separate panel for only the 50V and higher devices such as 120/24 VAC power transformers. Extend 24VAC power into the control panel. Control panels that have devices or terminations that are fed or switch 50V or higher shall enclose the devices, terminations, and wiring so that Personal Protective Equipment (PPE) is not required to service the under 50V devices and terminations within the control panel.

Plastic control enclosures will be approved provided all conduits are bonded and grounded.

Provide control panels for all DDC Controllers, ASC's, and associated function modules. All controls to be in control panels provided under this Section except for the following:

- Terminal unit controllers mounted within the terminal unit equipment enclosure as specified under Section 23 09 14.
- Above accessible lay-in tile ceilings where VAV box controllers designed to be directly mounted on air terminals.
- Above accessible lay-in tile ceilings where additional controllers are required for air terminal unit control. Where additional controllers are required, they shall not be mounted directly to the

ductwork but be mounted on din rail or back panel in an accessible location as close as possible to the terminal unit(s) being controlled.

- Any devices other than DDC controllers, i.e., relays, pressure switches, etc. shall be installed in an enclosure.
- Enclosures provided under Section 23 36 00 for VAV terminals not mounted above accessible lay-in ceilings. Coordinate with the Division 23 contractor to ensure the controllers provided under Section 23 36 00 are of sufficient size to house the controller required for control of the terminal unit. If additional controllers are required to control other associated terminal units and the enclosure provided under Section 23 36 00 is not of sufficient size, this contractor shall provide an additional enclosure to be mounted adjacent to the terminal unit provided enclosure.

All wiring for controllers shall be managed in a neat and workmanlike manner.

Permanently label all controls; tag all control wiring and document both on control drawings.

DIRECT DIGITAL CONTROLS

System to be capable of integrating multiple building functions, including equipment supervision and control, alarm management, energy management, and trend data collection.

DDC to consist of Supervisory Controllers, Programmable Controllers, stand-alone Application Specific Controllers (ASC's), Operators Terminals, Operator Workstations, DDC system servers, and other operator interface devices.

The vendor of the system provided under this Section shall provide all software and communication interface hardware necessary to program and upload/download programmable and application specific controllers from a laptop computer and make additional copies and future software revisions available for sale directly to the user Agency.

The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASC's, and operator devices.

The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

NETWORKING/COMMUNICATIONS

The design of the DDC shall be networked. Unless otherwise noted, ~~A~~all controllers shall communicate via BACnet/IP. ~~BACnet MS/TP communications shall only be used for third party DDC devices.~~ Inherent in the system's design shall be the ability to expand or modify the network either via a local area network (LAN), wide area network (WAN), or a combination of the two schemes.

Some DDCs, provided by 23 09 23 Contractor, shall utilize BACnet MS/TP for communication. Some DDCs shall utilize peer-to-peer communication, via MS/TP, for interlocking. This shall ensure interlocking is maintained in the even the 23 09 23 Contractor provided network switch fails. Refer to Sheet M7.01 for additional details. The following DDCs shall utilize BACnet MS/TP:

- TCP-EF-66(A-C)
- TCP-AHU-37A
- TCP-AHU-37B

All existing operator workstations shall have the ability to access all points and application reports on the network.

Provide Ethernet communication ports on all ASC's for operator's terminal communications with the DDC Controller.

Access to system data shall not be restricted by the hardware configuration of the DDC system.

Global data sharing or global point broadcasting shall allow point data to be shared between programmable controllers and ASC's when it would be impractical to locate multiple sensors.

The 23 09 23 Contractor shall provide their own ethernet switch for all BACnet/IP communications. Refer to Building Automation System Architecture drawing for details. This ethernet switch shall meet the following requirements:

- Acceptable Manufacturers: Cisco, Red Lion, Moxa, or approved equal. Netgear switches shall not be accepted.

- All new DDCs provided by 23 09 23 shall communicate back to this ethernet switch.
- Division 27 shall furnish and install Ethernet cabling required to connect the Division 23 09 23 BAS Ethernet switch to the Owner's campus network. Division 23 09 23 shall provide the Ethernet switch and coordinate connection requirements with Division 27.
- Ethernet switch shall support Media Redundancy Protocol (MRP) in accordance with IEC 62439-2. BACnet/IP controllers and network devices shall be connected in a ring topology utilizing MRP to provide redundant communication paths. Failure of any single network cable or device-to-device connection shall not result in loss of communications to downstream devices.

BACNET REQUIREMENTS

Unless otherwise noted, ~~A~~all communications for devices provided under this Section shall be BACnet/IP. BACnet MS/TP communication shall be provided for the third-party devices that will use BACnet MS/TP to communicate with the system provided under this Section.

All controllers shall provide a Protocol Implementation Conformance Statement (PICS) and BACnet Interoperability Building Blocks (BIBB"S) as required by the American National Standards Institute/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ANSI/ASHRAE) Standard 135-2001, BACnet protocol.

In general, all devices shall support the following:

Segmentation Capability
Segmentation requests supported
Segmentation responses supported

Standard Object Types Supported

- Analog input
- Analog output
- Analog value
- Binary input
- Binary output
- Binary value
- Calendar
- Device
- Event enrollment
- Group
- Multistate input
- Multistate output
- Multistate value
- Notification class
- Schedule

Character Sets supported

- ANSI X3.4
- ISO 10646 Universal Character Set-2

All highest level networked supervisory devices shall support the following:

Data Link Layer Option

- BACnet Internet Protocol (IP) (Annex J)

Networking Options

BACnet/IP Broadcast Management Device (BBDM)

BACnet object name and description shall match the existing naming conventions used by the state Agency for their existing Building Automation System. Coordinate with Agency control personnel to establish the naming conventions prior to programming of any controllers provided under this specification section. All controllers shall have object names, descriptions, and engineering units that are writable at the controller level and shall be programmed so that the object names, descriptions, and engineering units match the desired

naming standards as specified above. Ensure that the BACnet object attributes for object name, object description, engineering units and other required attributes will be transferred through to the Supervisory Controller when the auto-discovery function is executed.

Coordinate BACnet device instance numbering with the agency facility personnel for controllers provided under this Section that are being connected to an existing building automation system. This contractor shall be responsible for correcting any conflicts with existing devices that may occur or changing the device instance numbers to comply to follow the agency BACnet device instance numbering scheme.

The following table indicates the minimum VAV terminal unit objects, the associated naming, and the object values that are required to be writable that shall be provided for all VAV terminals. If the agency does not have a convention for VAV terminal object names and descriptions that it prefers, use the naming standards as listed below. Provide similar naming and descriptions that are approved by the agency for other types of terminal units and mechanical systems.

Object Type	Object Name Writeable	Object Description	Units
BV	DEVICE-S	DEVICE STATUS - SERVED BY AHU#	ONLINE/OFFLINE
MV	OCC-MODE	OCCUPIED MODE	OCC/UNOCC/STNDBY
BV	OCC-SCHED	OCCUPIED SCHEDULE Xam-Xpm	OCC/UNOCC
DI	OCC-S	OCCUPANCY SENSOR STATUS	OCC/UNOCC
AV	ZN-SP	ZONE TEMPERATURE SETPOINT	DEG F
AI	RM#-T	ROOM #### TEMPERATURE	DEG F
AI	DA-T	DISCHARGE AIR TEMPERATURE	DEG F
AO	HTG-VLV	HEATING VALVE	% OPEN
AO	RAD-VLV	RADIATION VALVE	% OPEN
AO	SA-DPR	SUPPLY AIR DAMPER	% OPEN
AV	CFM-SP	ACTUAL FLOW SETPOINT	CFM
AI	CFM-FLOW	SUPPLY AIR FLOW	CFM
AV	HTG-SP	HEATING TEMPERATURE SETPOINT	DEG F
AV	CLG-SP	COOLING TEMPERATURE SETPOINT	DEG F
AV	OCC-C-CFM-MIN	OCCUPIED CLG CFM MIN SETPOINT	CFM
AV	OCC-C-CFM-MAX	OCCUPIED CLG CFM MAX SETPOINT	CFM

SUPERVISORY CONTROLLERS

Supervisory controllers shall be microprocessor-based, multi-tasking, multi-user, and digital control processors.

Provide a BACnet/IP supervisory controller capable of serving as the primary integration and management device for the new DDCs provided under this Project. The supervisory controller shall communicate with field controllers via BACnet/IP and shall provide alarm management, scheduling, trending, historical data storage, system navigation, and web-based user access. Supervisory controller shall remain fully operational upon loss of connection to cloud-based services.

The contractor shall provide all labor to build the supervisory controller database in conjunction with and under the supervision of the Agency control personnel. Naming conventions, database structure, and global application strategies shall be reviewed and approved by the Agency control personnel before implementation.

Each supervisory controller shall have sufficient memory to support its own operating system and databases including:

- Control processes
- Energy management application
- Alarm management
- Trend data
- Maintenance support applications
- Operator I/O
- Dial-up communications
- Manual override monitoring

The system shall be modular in nature and shall permit easy expansion through the addition of field controllers, sensors, and actuators.

Supervisory controllers shall provide at least two RS-232C or USB serial communication ports or Ethernet ports for simultaneous operation of multiple operator I/O devices, such as laptop computers, personal computers, and video display terminals.

Supervisory controller shall provide at least two RS-485 serial communication ports for MS/TP communication.

- ~~One MS/TP port shall be for integration of the new exhaust fan DDC (EF-66A, EF-66B, & EF-66C).~~
- One MS/TP port shall be for integration of the following DDCs:
  - TCP-EF-66(A-C)
  - TCP-AHU-37A
  - TCP-AHU-37B
- The second MS/TP port shall be for the integration of all third-party DDCs that are not provided by 23 09 23. Devices such as VFDs shall be integrated via this MS/TP port.
- Refer to Building Automation System Architecture for details.

Supervisory controllers shall monitor the status of all overrides and include this information in the logs and summaries to inform the operator that automatic control has been inhibited.

Each supervisory controller shall continuously perform self-diagnostics, communications diagnostics, and diagnostics of all subsidiary equipment. Supervisory controllers shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each supervisory controller.

Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high to allow all signal wiring to be run in the same conduit as high voltage wiring acceptable by electrical code.

In the event of the loss of normal power, there shall be an orderly shutdown of the supervisory controller to prevent the loss of data base or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

Upon restoration of normal power, the supervisory controller shall automatically resume full operation without manual intervention.

Should supervisory controller memory be lost for any reason, the supervisory controller shall have the capability of reloading it's programming via high-speed local area network from the control system archive workstation or server, the local RS-232C port, or telephone line dial-in.

If a supervisory controllers require a software license, this contractor shall provide all labor and software upgrades required so that the manufacturer's current software revision is provided for one year after the project completion date of the project as stated in the project contract documents.

SYSTEM SOFTWARE FEATURES

All necessary software to form a complete operating system, as described in this specification, shall be provided as an integral part of the supervisory controller, and shall not be dependent upon higher level computer for execution.

Control software shall include a provision for limiting the number of times that each piece of equipment may be cycled within any one-hour period.

The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

Supervisory controllers shall have the ability to perform any or all of the following energy management routines:

- Time of day scheduling
- Calendar based scheduling
- Holiday scheduling
- Optimal start
- Optimal stop
- Demand limiting
- Load rolling
- Heating/cooling interlock

All programs to be executed automatically without the need for operator intervention, and be flexible enough to allow user customization. Programs shall be applied to building equipment described in Section 23 09 93 of this specification.

Supervisory controllers shall be able to execute configured processes defined by the user to automatically perform calculations and control routines.

It shall be possible to use any of the following in a configured process:

- Any system-measured point data or status
- Any calculated data
- Any results from other processes
- Boolean logic operators (and, or)

Configured processes may be triggered based on any combination of the following:

- Time of day
- Calendar date
- Other processes
- Events (e.g., point alarms)

A single process shall be able to incorporate measured or calculated data from any and all other ASC's.

A single process shall be able to issue commands to points in any and all other programmable controllers and ASC's on the local network.

Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each supervisory controller shall perform distributed; independent alarm analysis and filtering to minimize network traffic and prevent alarms from being lost. At no time shall the ability of supervisory controllers to report alarms be affected by either operator activity at the local I/O device or communications with other ASC's on the network.

All alarm or point change reports shall include the English language description of each point and the time and date of the occurrence.

The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Users shall have the ability to manually inhibit alarm reporting for each point.

The user shall also be able to define conditions under which point changes need to be acknowledged by an operator and/or logged for analysis at a later date.

Alarms reports and messages shall be directed to an operator device.

In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 60-character alarm message to more fully describe the alarm condition or direct operator response.

Each supervisory controller shall be capable of storing a library of at least 100 messages. Each message may be assignable to any number of points in the panel.

A data collection utility shall be provided to automatically sample, store, and display system data.

Measured and calculated analog and binary data shall be assignable to user definable trends for the purpose of collecting operator specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one minute or one hour intervals, shall be provided. Each supervisory controller shall have a dedicated buffer for trend data and shall be capable of storing 16 trend logs. Each trend log shall have up to four points trended at 48 data samples each. Data shall be stored at the supervisory controller and up-loaded to the DDC system server when archiving is desired.

Supervisory controllers shall automatically accumulate and store runtime hours for binary input and output points specified in Section 23 09 14 of this specification.

Supervisory controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis, user defined, for user-selected analog and binary pulse input type points.

Totalization shall provide calculation and storage accumulations of up to 9,999,999 units (e.g., KWH, gallons KBTU, tons, etc.).

The totalization routine shall have a sampling resolution of one minute.

The user shall have the ability to define a warning limit. Unique, user specified messages shall be generated when the limit is reached.

The information available from pulse totalization shall include, but not be limited to, the following:

- Peak demand, with date and time stamp
- 24-hour demand log
- Accumulated KWH for day
- Sunday through Saturday KWH usage
- Demand KW annual history for past 12 periods
- KWH annual history for past periods

Supervisory controllers shall have the ability to count events, such as the number of times a pump or fan system is cycled on and off.

The event totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

PROGRAMMABLE CONTROLLERS

Programmable controllers shall be provided with a software program that shall allow the user to design flexible software algorithms for the control sequences as described in Sections 23 09 14 and 23 09 93 portions of this specification.

Programmable controllers shall support all necessary point inputs and outputs to perform the specified control sequence in a totally stand-alone fashion.

Each programmable controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

Each programmable controller shall support the use of a locally mounted status and adjust panel interface to allow for the local adjustment of all setpoints, temporary override of any input or output points and status of all points directly at the controller. The capabilities of the locally mounted status and adjust panel shall include, but not be limited to, the following information for the programmable controllers to which:

- Display temperatures
- Display status
- Display setpoints
- Display control parameters
- Override binary output control
- Override analog output control

- Override analog setpoints
- Modification of gain and offset constants

All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the programmable controller.

Programmable controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in Sections 23 09 14 and 23 09 93 portions of this specification, and for future expansion of air handling units:

- Mixed air handling units
- 100 percent outside air handling units
- Boiler or chiller plants with pump logic
- Hot water heat exchangers
- Cooling towers
- Zone pressurization of labs
- Smoke control systems
- Generic system interlocking through hardware

APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

Each supervisory controller shall be able to extend its monitoring and control through the use of stand-alone application specific controllers (ASC's).

Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor based, multi-tasking, real-time digital control processor.

Each ASC shall have sufficient memory to support its own operating system and databases including:

- Control Processes
- Energy Management Applications
- Operator I/O (Portable Service Terminal)

The operator interface to any ASC point or program shall be through the supervisory controller connection to any ASC on the network.

ASC's shall directly support the temporary use of a portable service terminal that can be connected to the ASC via zone temperature or directly at the controller. The capabilities of the portable service terminal shall include, but not be limited to, the following information for the:

- Display temperatures
- Display status
- Display setpoints
- Display control parameters
- Override binary output control
- Override analog output control
- Override analog setpoints
- Modification of gain and offset constants

All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the ASC.

ASC’s shall support, but not be limited to, the following configurations of systems to address current requirements as described in Sections 23 09 14 and 23 09 93 portions of this specification, and for future expansion of air handling units:

- Variable Air Volume Terminals
- Reheat Terminals
- Fan Coils

For butterfly type Variable Air Volume (VAV) Terminals, provide differential pressure transducers and damper actuators for flow measurement and actuation of the VAV terminal damper. Pressure transducers for VAV box flow applications do not need to have adjustable pressure ranges or integral display. Provide filter

on high side of flow pickups if flow measurement device requires airflow through the device. All differential pressure transducer inputs for airflow measurement shall have a method to compensate for sensor drift to calibrate the zero point of the input. The differential pressure transducers and damper actuators can be integrated into the terminal unit controller or be discrete devices.

Unless otherwise indicated, terminal unit space sensors shall be provided with digital displays with setpoint adjustments and manual occupancy override and indication of occupancy status. Provide information to the AE on sensor colors offered by the manufacturer and obtain approval on what color should be provided on the project. Provide setpoint adjustment as specified in the DDC Input/Output Summary Table and sequence of operation.

The following types of spaces shall NOT have digital displays and adjustments. For the space types listed below, provide manufacturer's blank space temperature sensor without adjustments:

- Corridors
- Lobbies
- Public Waiting Areas.
- Mechanical/Electrical Rooms

Provide a method to view and print a summary of current K-factors for flow correction for each VAV terminal through the DDC system. The summary shall have a minimum of 50 K-factors per group of VAV terminals.

All system setpoints, proportional bands, control algorithms, calibration constants, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the ASC.

All application specific controllers shall be fully programmable. Question and answer or template programming is not acceptable unless this is used to generate the initial application program and the result is able to be freely modified without restriction. Control sequences for terminal unit control that utilize devices wired directly to the terminal unit application controller shall be programmed in the application specific controller and shall be stand-alone in function, i.e. occupancy sensing, temperature setpoint setback, etc. Supervisory controllers shall not be involved in the control sequence logic unless it involves sharing data between or from individual terminal unit controllers to be utilized in a global sequence, i.e. trim and respond strategies, terminal unit grouping, etc.

OPERATOR INTERFACE REQUIREMENTS

COMMAND ENTRY/MENU SELECTION PROCESS:

Operator interface software shall minimize operator training through the use of English language prompting and English language point identification.

TEXT-BASED DISPLAYS:

The operator interface shall provide consistent text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.

GRAPHIC-BASED DISPLAYS:

The operator interface shall provide graphic based displays of each system. The point data associated with each system shall dynamically update at a minimum of every 30 seconds. Graphic displays shall be linked to each other to provide a "drill down" capability from main graphic displays to more specific system based displays. Provide a building level graphic display that links to system graphics. For systems that have ASC controlled terminal unit controls, provide a building floor plan with dynamic temperatures shown on the graphic that can be drilled into for more specific terminal information. Points provided in the graphic shall have the override and adjust capability specified under operator commands. The contractor providing the DDC system under this Section shall provide all graphic displays for the project. Submit all graphic displays to the Agency control personnel for review and approval. Graphics shall be completed to provide enough time for approval and time for binding to be in place before control system commissioning is scheduled to occur.

PASSWORD PROTECTION:

Multiple-level password access protection shall be provided to allow the user/manager to limit control, display, and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

Passwords shall be exactly the same for all operator devices.

A minimum of three levels of access shall be supported:

- Level 1: Data access and display
- Level 2 = Level 1 + operator overrides and commands
- Level 3 = Level 2 + database generation and modification

A minimum of 4 passwords shall be supported at each supervisory controller.

Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device shall be limited to only those items defined for the access level of the password used to log-on.

Provide user definable, automatic log-off timers of from 1 to 60 minutes to prevent operators from inadvertently leaving devices on-line.

OPERATOR COMMANDS:
The operator interface shall allow the operator to perform commands including, but not limited to, the following:

- Start-up or shutdown selected equipment
- Adjust setpoints
- Override analog and binary outputs
- Add/modify/delete time programming
- Enable/disable process execution
- Lock/unlock alarm reporting for each point
- Enable/disable totalization for each point
- Enable/disable trending
- Enter temporary override schedules
- Define holiday schedules
- Change time/date
- Enter/modify analog alarm limits
- Enable/disable analog alarm limits
- Enable/disable demand limiting
- Enable/disable duty cycle

LOGS AND SUMMARIES:
Reports shall be generated manually, and directed to the displays. As a minimum, the system shall allow the user to easily obtain the following general listing of all points in the system that shall include, but not be limited to:

- Points currently in alarm
- Off-line points
- Points currently in override status
- Points in weekly schedules
- Holiday programming

Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration on the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

SYSTEM CONFIGURATION AND DEFINITION:
All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

The system shall be provided complete with all equipment, software, and documentation necessary to allow an operator to independently perform the following functions:

- Add/delete/modify application specific controllers
- Add/delete/modify points of any type, and all associated point parameters, and tuning constants
- Add/delete/modify alarm reporting definition for each point
- Add/delete/modify energy management applications
- Add/delete/modify time and calendar-based programming
- Add/delete/modify totalization for every point

- Add/delete/modify historical data trending for every point
- Add/delete/modify configured control processes
- Add/delete/modify dial-up telecommunication definition
- Add/delete/modify all operator passwords
- Add/delete/modify alarm messages

PROGRAMMING DESCRIPTION:
Definition of operator device characteristics, ASC's, individual points, and shall be performed through fill-in-the-blank templates.

NETWORK-WIDE STRATEGY DEVELOPMENT:
Inputs and outputs for any process shall not be restricted to a single ASC, but shall be able to include data from any and all other ASC's to allow the development of network-wide control strategies.

SYSTEM DEFINITION/CONTROL SEQUENCE DOCUMENTATION:
All portions of system definition shall be self-documenting and be capable of providing hardcopy printouts of all configuration and application data.

DATA BASE SAVE/RESTORE/BACK-UP:
Backup copies of all programmable controller, ASC and supervisory controller databases shall be stored in at least one personal computer or laptop. Users shall have the ability to manually execute upload and downloading of a programmable controller, ASC and supervisory controller database.

OPERATOR WORKSTATION & DDC SYSTEM SERVER
All new instrumentation and control work, provided as part of this Project, shall be integrated into the existing BAS server and existing Operator Workstations. Integration shall occur over campus LAN.

P A R T 3 - E X E C U T I O N

GENERAL
All electronic work required as an integral part of the Direct Digital Control system work is the responsibility of this section unless specifically indicated otherwise in this section, Section 23 09 14, or in Division 26.

This contractor shall provide all labor, materials, engineering, software, permits, tools, checkout and certificates required to install a complete Direct Digital Control system as herein specified.

Any and all points added with this project shall be grouped for display purposes into the system such that all points associated with a new or existing DDC system can appear together on the flat panel display or printed log. Assignment of points to a group shall not be restricted by hardware configuration of the points of direct digital control. It shall be possible to assign a point to appear in more than one system. An English descriptor and an alpha/numeric identifier shall identify each system.

This Direct Digital Control system as herein specified shall be fully integrated and completely installed by this section. It shall include all required computer CPU software and hardware. Include the engineering, installation, supervision, calibration, software programming, and checkout necessary for a fully operational system.

INSTALLATION
All work and materials are to conform in every detail to the rules and requirements of the National Electrical Code and present manufacturing standards. All wiring and cable installation shall conform with the wiring installation as specified in the installation section of Section 23 09 14. All material shall be UL approved.

Install system and materials in accordance with manufacturer's instructions, rough-in drawings and details on drawings.

Line voltage wiring to power the DDC Controllers, not provided by the Division 26 contractor, to be by this contractor.

Control panels serving equipment fed by emergency power shall also be served by emergency power.

Provide uninterruptable power supplies where necessary to provide proper start-up of equipment or to accomplish power restart control sequences specified.

Mount control panels adjacent to associated equipment on vibration-free walls or free-standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and on cabinet face.

Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

Cable tray routing of the communication trunks (Ethernet or MS/TP) is acceptable.

Where a new system is required to be extended to an existing agency Building Automation Network (BAN) (typically connected via the agency Local Area Network (LAN) or Wide Area Network (WAN)), extension of the data-net between DDC Controllers and to the BAN to be by this contractor unless specified to be provided by the division 27 contractor. All wiring and cable installation shall conform to the wiring installation as specified in the installation section of Section 23 09 14 and division 27. If division 27 is not specified in this project specifications, the state master specification 27 00 00 located on the Owner Master Specification website should be used as reference.
https://doa.wi.gov/Pages/DoingBusiness/MasterSpecsDesignGuide.aspx

Provide all necessary routers and or repeaters to accomplish connection to the BAN via the panel-mounted port provided.

Provide an input for a service shutdown toggle switch for each air handling unit system provided inside the temperature control panel that will initiate a logical shutdown of the air handling unit system.

All tubing, cable and individual wiring is to be permanently tagged, with numbers corresponding with "Record Drawings", spares are to be labelled as "Spare".

Provide technician to work with air balancing contractor and/or provide balancing contractor with necessary hardware to over-ride DDC controllers for air balancing.

Provide documentation to demonstrate that all points, input and output, have been checked out and verified operational, note any points not operating properly with notation of reason.

PRECONSTRUCTION REVIEW MEETING

This contractor shall attend a meeting or meetings as required prior to construction to review the control system on the project. The meeting attendees shall consist of the AE of Record, Owner, CxP, User Agency, Section 23 09 14 Contractor, Section 23 09 23 Contractor and the Division 23 Contractor. All sequences covered within specification section 23 09 93 and related system configurations and devices shall be reviewed in detail and any corrections to the sequences and mechanical systems shall be made through the Owner construction change process.

ETHERNET CABLE TESTING AND ACCEPTANCE

This Contractor is responsible for testing all ethernet cabling they field cut and crimp.

Refer to TESTING AND ACCEPTANCE within 27 10 00 for required testing criteria.

Test each Ethernet cable between each terminal DDC. Test performance per ANSI/TIA-568-C.2 Permanent Link test configuration and procedures. Testing limits should be set to “Category 6A Permanent Link”.

This Contractor required to submit a testing plan in accordance with 27 10 00. Agency and Owner’s representatives may be in attendance to witness the test procedures. Provie a minimum of one (1) week advance notice to allow for such participation.

If this Contractor provides pre-made ethernet cables, that are factory tested, then those cables do not need to be tested in the field.

- Where pre-made ethernet cables are used, the excess cable shall be neatly coiled and anchored to the controller/air terminal. The ethernet coil shall utilize a minimum of two zip ties to keep cable neatly together. Zip ties shall be installed 180° from each other. Also, when coiling the cable the radius of the coil must be larger than the cable manufacturers guidelines.
- Do not use pre-made ethernet cables where air terminals are exposed. Exposed coiled ethernet cables are not acceptable. Do not coil ethernet cables within DDC control enclosure either, which will block access to the DDC.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 02.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 02.

For commissioning of control systems, the following items shall be complete by the contractor prior to functional performance testing:

- Completed functional performance tests written by the commissioning agent shall have been reviewed at the controls Preconstruction Review Meeting.
- All point to point checkout for each input/output shall be complete and documented.
- All changes to the design need to be incorporated prior to testing.
- Final user interface shall be complete. This includes all graphics, trending, and agency defined user names and grouping.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 02.

Contractor to provide factory authorized representative and/or field personnel knowledgeable with the operations, maintenance and troubleshooting of the system and/or components defined within this section for a minimum period of 8 hours.

Provide two follow-up visits for troubleshooting and instruction, one six months after substantial completion and the other at the end of the warranty period. Length of each visit to be not less than 4 hours or the time necessary to provide required information and complete troubleshooting and inspection activity for all controls installed under 23 09 23, 23 09 14, and 23 09 93. Coordinate the visit with the owner/Agency and provide an inspection report to the owner of any deficiencies found.

END OF SECTION

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SECTION 23 09 93
SEQUENCE OF OPERATION FOR HVAC CONTROLS
BASED ON DFD MASTER SPECIFICATION DATED 3/28/2022

P A R T 1 - G E N E R A L

SCOPE

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

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

PART 2 - PRODUCTS
- Not Applicable

PART 3 - EXECUTION
- General Control
- Steam Monitoring
- Steam Condensate Pump Control
- Campus Chilled Water Consumption Measurement
- Campus Chilled Water Flow Control
- Process Cooling Water Heat Exchanger Control
- Process Cooling Water Pump Control
- Heating Hot Water Converter Control
- Heating Hot Water Pump Control
- Heat Reclaim Pump Control
- WIMR East Wedge Cyclotron AHU Control
- WIMR East Wedge Cyclotron Exhaust Control
- Mechanical Room (Rm 2376) HVAC Control
- Steam Tunnel Exhaust Control
- Electrical Room (Rm 2382) HVAC Control
- Fan Coil Unit Control (Typical)
- Cabinet Unit Heater Control (Non-DDC Control)
- Plumbing Equipment Monitoring
- Plumbing Tempered Water Control
- Fire/Smoke Damper Monitoring
- Room HVAC Control
- Functional Performance Testing

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 – Commissioning Process
Section 23 05 00 – Common Work Results for HVAC
Section 23 05 93 – Testing, Adjusting, and Balancing for HVAC – Coordination
Section 23 08 00 – Commissioning of HVAC
Section 23 09 14 – Pneumatic and Electric Controls
Section 23 09 15 – Direct Digital Control Input/Output Point Summary Tables
Section 23 09 23 - Direct Digital Controls (DDC)

Division 23 - HVAC - Equipment provided to be controlled or monitored.
Division 26 - Electrical - Equipment provided to be controlled or monitored.
Division 28 - Electronic Safety and Security

REFERENCE

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

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

DESCRIPTION OF WORK

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

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

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

Sequences for equipment controlled by Direct Digital Controls (DDC) as specified are accomplished by hardware and software provided under Section 23 09 23. Sequences for equipment controlled by pneumatic or electric self-contained controls are accomplished by hardware provided under Section 23 09 14.

SUBMITTALS

Refer to Division 1, General Conditions, Submittals, Section 23 05 00 and Sections 23 09 23, and 23 09 14 for descriptions of what should be included in the submittals.

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

OPERATION AND MAINTENANCE DATA

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

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. All final setpoints and terminal unit air flow correction factors (“K” factors) shall be documented on the as-built control drawings as determined by working in conjunction with the balancing contractor.

DESIGN CRITERIA

Reference Section 23 09 14.

P A R T 2 - P R O D U C T S

Not applicable to this Section – reference Sections 23 09 23 and 23 09 14 for product descriptions.

P A R T 3 - E X E C U T I O N

GENERAL:

BACNET OBJECTS:

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

BACNET ADDRESSING:

BACnet instance ID’s shall be coordinated with the agencies established BACnet instance ID addressing scheme. If there is not such a scheme in place, the contractor(s) providing BACnet DDC controllers shall work with the agency to establish such a scheme and document this in the asbuilt control drawings. BACnet/IP addressing shall be coordinated with the agency prior to installation. BACnet MSTP addressing

shall be addressed to provide for consecutive addressing to provide for the best speed of response. Max Master address shall be set appropriately for speed of response.

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

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

Office, Conference, and Administrative Support Areas:
Occupied Space Terminal Unit Heating: 68º F
Occupied Space Terminal Unit Cooling: 76º F
Unoccupied Space Terminal Unit Heating: 68º F
Unoccupied Space Terminal Unit Cooling: 76º F

Laboratory and Laboratory Support:
Occupied Space Terminal Unit Heating: 70º F
Occupied Space Terminal Unit Cooling: 72º F
Unoccupied Space Terminal Unit Heating: 70º F
Unoccupied Space Terminal Unit Cooling: 72º F

Miscellaneous Spaces:
Vestibule & Stairwell Heating: 60° F
Mechanical/Electrical or Shell Space Cooling: 85º F
Mechanical/Electrical or Shell Space Heating: 60º F
IDF / MDF Cooling: 72º F

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

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

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

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

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

TREND DATA:
Trends shall be provided for all hardware I/O points and integrated points listed as having trending in Section 23 09 15 point charts and for analog and binary data points mapped to the user interface as specified below. Interval trending with sample intervals of 10 minutes shall be provided on analog process variables (this includes both analog inputs and calculated process variables) and process outputs. In addition, provide Change of Value (CoV) trending for all binary input and output points, binary data points mapped to the user interface, and for all analog inputs and process variables. Analog inputs and process variables and setpoints shall be set at 5% CoV of setpoint. Analog process outputs shall have CoV set at 5% of the output range. Other analog data points mapped to the user interface shall have CoV trends of 5% of their range. Consult with the user agency specific standard values for interval and CoV trends for different points and control types. Data shall be stored at the supervisory controller or in the field controller and up-loaded to the DDC system server when archiving is desired. Consult with the user agency to determine which trends should be archived. Trending shall be in place for a minimum of 24 hours prior to functional testing by the commissioning provider.

EQUIPMENT START/STOP FAILURE STATES:
All start/stop points for equipment shall utilize normally open contacts unless called out specifically in the individual control sequences.

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

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

When equalizing run times, the lead device shall become the standby device, the lag device shall become the lead device, and the standby device shall become the lag device.

The paragraph above shall also apply to sequences that call for primary/standby of equipment. The primary device shall be capable of being selected manually through the BAS, and the BAS shall automatically equalize the run times of those devices as described above.

VARIABLE FREQUENCY DRIVE (VFD) MOTOR RUN STATUS:
Use the VFD programmable relay dry contact output specified to be provided with the VFD under Section 23 05 14 to prove motor run status and detect belt loss or coupling break. If a bypass contactor is provided with the VFD, provide an adjustable current switch and wire it in parallel with the VFD output for proving motor status. For multiple fan units that have multiple fans powered by a single VFD, provide current sensors that shall provide status to the DDC system for each motor as well as the VFD run status.

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

VFD MINIMUM SPEED & RAMP TIMERS:
The VFD start-up technician shall work with the DDC Temperature Control Contractor determine the minimum speed required for the motor controlled by the VFD to provide cooling of the motor as installed to prevent heat related problems. This minimum speed shall be set in the VFD controller. Pump minimum speeds shall be 20 Hz for 1750 RPM motors and 25 Hz for 1150 RPM motors to ensure seals stay lubricated. For splash-lubricated cooling tower fans and submersible pumps, minimum speed shall be 30 Hz. The controlled motor shall ramp linearly in speed between the minimum Hz and the maximum Hz required for the application (may not be 60 Hz) as the control speed signal increases from 0% to 100% speed. The VFD start-up technician shall work with the DDC Temperature Control Contractor to set the acceleration and deceleration timers in the VFD controller at 30 seconds for motors less than 40 HP and 60 seconds for motors 40 HP and greater.

CURRENT STATUS SWITCHES:
Current switches may only be used for constant speed motors or electrically commutated motors (ECM). If motor is powered by a VFD refer to VARIABLE FREQUENCY DRIVE (VFD) MOTOR RUN STATUS section above.

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

SMOKE DAMPER CONTROL:
Smoke dampers provided in ducts are required to close by building code in the event their associated smoke detectors are in alarm or if the associated duct smoke detector requires a minimum velocity to operate and the associated fan(s) that supply, return, or exhaust air through them are shutdown.

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

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

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

FAN SYSTEM ISOLATION DAMPER CONTROL

For fans that have isolation dampers that are controlled by the DDC system, the dampers shall be powered open and closed and not utilize the actuator fail position spring (if specified) to operate. Dampers that are wired to fan power shall use the fail position spring in the actuator to actuate the damper.

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

SERVICE SHUTDOWN SWITCHES
Provide a switch for servicing each AHU and each lab exhaust fan and a software switch in the DDC system that will provide the same function. If either the hardware or software switch is in the off position, the associated AHU or exhaust fan shall be shut down in an orderly fashion following the specific sequences below. When the both the hardware and software switches are on, the AHU or exhaust fan shall be restarted in an orderly fashion following the specific sequences below. For systems that have more than one AHU or exhaust fan manifolded together and if multiple switches are turned off, only the first service switch shall be active to turn off the associated AHU or exhaust fan and the other switches shall be ignored. Multiple AHU's or exhaust fans shall be allowed to be turned off from the DDC workstation through software overrides on the DDC system. If a switch is turned off, an alarm will be annunciated through the DDC system for all switches in the off position. The switches shall be located inside the associated control panel.

AUTO-TUNING CONTROL LOOPS
For systems that have auto-tuning for PID control loops, contact the User for preferences on how the auto-tuning shall be implemented prior to programming. If the agency is not contacted on preferences, the control contractor responsible for programming shall adjust the loops as desired by the user agency at no additional cost. Typically, autotuning for control loops on major mechanical equipment that have services that can be lost, i.e., chilled water, steam, hot water, should be turned off so if there is a loss in service, the control loops do not adjust gain and integral to values that will cause the control loops to not function properly.

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

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

- Chilled Water BTU Meters
- Steam BTU Meters
- Steam Condensate Meters
- Variable Frequency Drives
- Electrical Meters (furnished by Div. 26)

WATCH DOG TIMER
Where the integrated system consists of programmable DDC controllers with BACnet objects mapped to an enterprise level Building Automation System (BAS) and it is shown that the BACnet objects do not indicate when they are offline on the enterprise level BAS when communication is lost between the two systems, software algorithms shall be provided to alarm when communication is lost. The integrated system shall program a binary data object that is toggled on and off at an adjustable rate (initially one minute) that shall be monitored by the enterprise level BAS which shall alarm if the toggling ceases.

WEEKLY SCHEDULING
Provide scheduling of DDC terminal units in groups based on occupancy. Work with the user Agency to determine how many groups are required and which zones should be included. Individual terminal units shall be able to receive temporary schedules that shall override the group schedules. Temporary override buttons at the zone sensor (where specified on point charts) shall override the scheduling to occupied. When groups that consist of more than 20% of terminal units are indexed to occupied, the associated air handling unit shall start if not already running.

PARALLEL FAN BUMPLESS TRANSFER

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

DDC CONTROLLER COMMUNICATION BUS CONFIGURATION

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

CONTROLLED VARIABLE REQUIREMENTS

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

STEAM MONITORING

Steam BTU meter shall communicate via BACnet IP integration. Meter ethernet connection shall be provided by Division 27. The 23 09 23 Contractor shall coordinate with Owner for IP address. Owner shall integrate data to third party webserver that is not associated with the BAS.

BAS shall hardwire several outputs from steam BTU meter. Refer to 23 09 15 for points to be monitored/pressured.

BAS shall monitor steam pressure, downstream of PRV-10/11, within the Level 2 mechanical room.

- If pressure falls below 5 psig (adj.) for a consecutive period of 5 minutes (adj.) the BAS shall annunciate alarm.
- If pressure rises above 15 psig (adj.) for a consecutive period of 5 minutes (adj.) the BAS shall annunciate alarm.

STEAM CONDENSATE PUMP CONTROL

Electric condensate receiver/pump sets have factory installed control panel with motor starters, hand-off-auto switches, float switch level controls, alarm bells, etc. and shall operate through those controls.

Electric condensate receiver/pump sets are furnished with auxiliary dry contact through high level float switch, for monitoring and alarming through BAS.

During power outage operation, the condensate pumps shall operate in accordance with the control sequence noted above.

CAMPUS CHILLED WATER CONSUMPTION MEASUREMENT

Chilled water BTU meter shall communicate via BACnet IP integration. Meter ethernet connection shall be provided by Division 27. The 23 09 23 Contractor shall coordinate with Owner for IP address. Owner shall integrate data to third party webserver that is not associated with the BAS.

BAS shall hardwire several outputs from chilled water BTU meter. Refer to 23 09 15 for points to be monitored/pressured.

CAMPUS CHILLED WATER FLOW CONTROL

GENERAL:
The campus central utility plant will provide sufficient hydraulic pressure to circulate chilled water throughout this building without the need of any building tertiary pumps.

Provide a differential pressure transmitter, across the chilled water mains, located in the Level 2 mechanical room. BAS shall continuously monitor/trend the differential pressure across the supply and return mains in the penthouse. In the event the differential pressure falls below 10 psi (adj.), for longer than 10 minutes (adj.), the BAS shall annunciate an alarm.

PROCESS COOLING WATER HEAT EXCHANGER CONTROL

GENERAL (PHX-5 & PHX-6):
There are two water-to-water heat exchangers in this expansion. Each heat exchanger will be sized to provide 100% of the process cooling water load for the expansion. The heat exchangers are piped in parallel and shall operate in primary/standby control, and the primary heat exchanger shall operate continuously.

The heat exchangers shall utilize campus chilled water to cool the process water loop. The process water loop will directly cool laboratory equipment.

PRIMARY / STANDBY CONTROL:
The primary heat exchanger shall operate continuously. The BAS shall command open the primary heat exchanger's isolation control valve. The isolation valves shall be the two position control valves on the process cooling water side of the heat exchangers. Each isolation control valve has a closed position switch. Set the switch to indicate the valve is closed when its stroke is less than 10%. When the primary heat exchanger's position switch indicates that it is 'not closed', the heat exchanger shall operate as noted under PROCESS COOLING WATER TEMPERATURE CONTROL.

If the primary heat exchanger's position switch does not indicate it is 'not closed' within 2 minutes (adj.) of being commanded to open, the BAS shall annunciate an alarm. The BAS shall then automatically command open the standby heat exchanger's isolation control valve. BAS shall continue to command open the primary heat exchanger's isolation control valve. In the event the primary heat exchanger later proves 'not closed', the BAS shall automatically clear the failed heat exchanger alarm. BAS shall automatically resume modulating the primary heat exchanger's chilled water control as noted in PROCESS COOLING WATER TEMPERATURE CONTROL. When the primary heat exchanger is maintaining process cooling water supply temperature, the standby heat exchanger shall be taken out of service. BAS shall command the standby heat exchangers control valves closed.

The BAS shall equalize the run time of the heat exchangers as noted under PRIMARY/STANDBY CONTROL under the **GENERAL CONTROL** sequences. BAS shall automatically rotate the primary/standby units at 10AM (adj.), on the second Tuesday (adj.), of every month. When equalizing the operation of the heat exchangers, first command open the standby heat exchanger's process cooling water isolation control valve. When the standby heat exchanger's process cooling water control valve is proven 'open' begin modulating its chilled water control valve as noted in PROCESS COOLING WATER TEMPERATURE CONTROL. While the standby heat exchanger is being indexed on, continue modulating the primary heat exchanger's chilled water control as noted in PROCESS COOLING WATER TEMPERATURE CONTROL. Once the standby heat exchanger is maintaining process cooling water supply temperature, the primary heat exchanger shall be taken out of service. DDC shall command primary heat exchanger control valves closed.

BAS Operator shall have the ability to designate which heat exchanger is primary and standby. BAS Operator shall also have the ability to disable/enable heat exchangers individually via software as desired.

PROCESS COOLING WATER TEMPERATURE CONTROL:
Provide a temperature sensor in the process water supply pipe downstream of each heat exchanger. DDC shall modulate the heat exchanger's chilled water control valve to maintain the process cooling water supply at setpoint. When the process cooling supply water is above setpoint, DDC shall modulate the chilled water control valve from closed to open. The reverse sequence shall occur when the process cooling water supply temperature falls below setpoint.

If the process cooling water supply temperature deviates from setpoint by ±2°F (adj.) for a consecutive period of 5 minutes (adj.), the BAS shall annunciate an alarm. The BAS shall immediately enable the standby heat exchanger. When the standby heat exchanger isolation valve is proven 'open' the primary heat exchanger shall be disabled and its control valves commanded closed.

CITY WATER BACKUP CONTROL:

In the event of a failure/shut-down of the campus chilled water system, city water shall be used as a backup source for cooling the process cooling water system.

The campus chilled water system will be isolated from the process cooling water heat exchangers, and city water will be circulated through the operating process cooling water heat exchanger. City water that is circulated through the heat exchanger shall be sent to drain.

Activation:
City water backup shall be enabled by a software selector switch which will be manually selected via BAS Operator. If city water backup is enabled, the BAS shall annunciate an alarm.

Control Valve Operation:
When city water backup control has not been activated, command valves to the following positions:

- FCV-CHS: Open
- FCV-CHR: Open
- FCV-NPCW: Closed
- FCV-IW: Closed
- Primary heat exchanger modulating chilled water control valve: allowed to modulate per PROCESS COOLING WATER TEMPERATURE CONTROL sequence above.

When city water backup has been activated, command valves to the following positions:

- FCV-CHS: Closed
- FCV-CHR: Closed
- FCV-NPCW: Open
- FCV-IW: Control valve shall be modulated to maintain process chilled water supply temperature.
- Primary heat exchanger modulating chilled water control valve shall be commanded fully open. Process cooling supply water temperature shall be controlled via modulating TCV-IW.

Control Valve Interlocking:
FCV-CHS, FCV-CHR, FCV-NPCW, and FCV-IW shall all fail closed.

Hardwire interlock FCV-CHS & FCV-CHR with the closed position switches on FCV-NPCW & TCV-IW. FCV-CHS & FCV-CHR shall lose power unless FCV-NPCW & FCV-IW are both proven closed.

Hardwire interlock FCV-NPCW & FCV-IW with the closed position switches on FCV-CHS & FCV-CHR. FCV-NPCW & FCV-IW shall lose power unless FCV-CHS & FCV-CHR are both proven closed.

Control Valve Sizing:
FCV-CHS, FCV-CHR, FCV-IW, and FCV-NPCW shall be sized equal to the pipe size they serve.

Water Leak Detection:
Provide a leak detector near the basin that is collecting/draining the city water. If the leak detector is activated the BAS shall immediately annunciate an alarm. BAS shall immediately close FCV-IW and FCV-NPCW.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the system shall automatically resume operation when standby power is available.

PROCESS COOLING WATER PUMP CONTROL
GENERAL (PCWP-9, PCWP-10, & PCWP-11):
There are three process cooling water pumps that circulate process cooling water throughout the building. Each pump is sized to provide 50% of the total process cooling water load and the pumps are piped in parallel. Pumps shall operate in lead/lag/standby control. The lead pump shall operate continuously.

LEAD / LAG / STANDBY CONTROL:
The lead pump shall operate continuously. Lead pump is defined as the pump which starts before any other system pump and stops after all other pumps have stopped. Lag pump shall start after the lead pump starts and stop before the lead pump stops. Standby pump shall only operate in event of failure of lead or lag pump.

If only the lead pump is operating, and the speed of the lead pump rises above 90% (adj.), for a consecutive 3 minutes (adj.), the lag pump shall be started. Lag pump shall ramp up slowly in order to avoid system pressure oscillation. As the lag pump increases in speed, the lead pump shall ramp down as required to maintain system differential pressure. When both pumps reach the same speed, pumps shall be released to operate as noted under SPEED CONTROL.

If both the lead and lag pump are operating below 50% (adj.) for a consecutive period of 10 minutes (adj.), the lag pump shall be reduced to minimum speed. As the lag pump is reduced in speed, the lead pump shall ramp up as required to maintain system differential pressure. When the lag pump reaches minimum speed it shall be disabled and coast to a stop.

Current switch integral to the VFD, shall prove pump operation. If the lead pump is called to run and the VFD programmable relay dry contact output status switch indicates that the pump is not operating for 30 seconds (FA), the BAS shall annunciate an alarm. The BAS shall then automatically start the standby pump. Upon a failure of lag pump, standby pump shall start and BAS shall annunciate an alarm.

The BAS shall equalize the run time of the pumps as noted under LEAD/LAG/STANDBY SEQUENCING under the **GENERAL** control sequences. If only lead pump is operating at the time of lead/lag/standby switching, lag pump shall start and prove operational via status indication prior to stopping lead pump. If lead and lag pump are operating at the time of lead/lag/standby switching, standby pump shall start and prove operational via status indication prior to stopping lead pump. Designation of lead, lag and standby pumps shall also be manually definable through the BAS.

Each pump shall also be started and cycled every Tuesday (adj.) at 10:00 a.m. (adj.). At this time, any process cooling water pump that is not operating shall be commanded on at minimum speed and prove operation via VFD current switch. The pumps that were just started shall be operated at minimum speed for a consecutive time period of 10 minutes (adj.). After this time period the just started pump(s) shall be disabled and it shall coast to a stop. If any pump is already operating on Tuesday at 10:00 a.m., it shall continue to operate as described under SPEED CONTROL in this control sequence, and only the idle water pumps shall be cycled on and off.

SPEED CONTROL:
Pump speed shall be controlled from a pressure differential signal. Install differential pressure transmitter across the supply and return main on basement level. Refer to mechanical floor plans for location. The operating pumps shall modulate its speed to maintain an initial setpoint of 10 psi (FA) at the differential pressure transmitter. If both the lead and lag pumps are operating they shall run at the same speed. Pressure differential control setpoint shall be minimum pressure required to achieve system design flow. Final setpoint shall be optimized by the Balancing Contractor.

Differential pressure transmitter hardwired directly back to the BAS controller that provides control signal to the VFD(s). Sharing these signals via the network shall not be allowed for control.

If the pressure differential signal drops below 7 psi (FA) for a period of 3 minutes (FA) the BAS shall annunciate an alarm.

SYSTEM FILL PRESSURE:
Provide a pressure transmitter that monitors the pressure at expansion tank ET-PCW-1. Pressure transmitter shall report to the BAS. Refer to the expansion tank schedule for scheduled air charge pressure setpoint. If the pressure transmitter deviates ±7 psi (adj.) from the scheduled air charge pressure setpoint, for a consecutive 5 minutes (adj.), the BAS shall annunciate an alarm.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the lead process cooling water pump shall be automatically started and operate via standby power from the building standby power system. The lead pump shall operate as described in the above control sequence.

BAS shall also restart the lag process cooling water pump, per this sequence, when operating on standby power. The lag pump shall be indexed on/off, on standby power, as detailed above in LEAD/LAG/STANDBY control.

In the event either the lead or lag pump fails, the BAS shall automatically start the standby process cooling water pump under standby power.

HEATING HOT WATER CONVERTER CONTROL
GENERAL (CV-7 & CV-8):
There are two steam-to-water heat converters in the Building. Each heat exchanger will be sized to provide 100% of the heating/reheat load for the building. The heat exchangers are piped in parallel and shall operate in parallel.

TEMPERATURE CONTROL:
Install a temperature sensor in the heating water supply piping near the combined discharge of both steam-to-water heat exchangers.

Provide 1/3 and 2/3 capacity normally open steam control valves. These control valves shall serve both heat exchangers. Size the control valves so that when both valves are open, they can provide the scheduled steam flow to one heat exchanger.

Whenever any heating hot water pump (HWP-7 or HWP-8) is running, as determined by the DDC system, the temperature of the heating water supply shall be controlled to maintain a setpoint. The setpoint shall be 160°F (adj.).

The 1/3 and 2/3 capacity steam control valves shall be modulated in sequence to maintain the heating water supply temperature. When the hot water supply temperature is below setpoint, the 1/3 control valve shall modulate open first. Once the 1/3 control valve is commanded fully open, and the supply temperature continues to fall below setpoint, the 2/3 control valve shall be modulated open. The reverse shall occur when the hot water supply temperature rises above setpoint.

Whenever both heating hot water pumps are proven off, the steam control valves shall be fully closed.

- Note, if the BAS Operator ever manually disables (turns off) both pumps the steam control valves shall be immediately closed. The operating heating hot water pump shall continue to operate, for five minutes, to dissipate heat from the heat exchangers.

MISCELLANEOUS:
Install a temperature sensor upstream of both heat exchangers that reports to the BAS.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the heat exchangers shall be automatically started and operate via standby power from the building standby power system. During power outage operation, the heat exchangers shall operate in accordance with the control sequences above.

HEATING HOT WATER PUMP CONTROL
GENERAL (HWP-7 & HWP-8):
There are two heating hot water pumps that circulate heating hot water throughout the building. Each pump is sized to provide 100% of the total hot water load and the pumps are piped in parallel. Pumps shall operate in primary/standby control. The primary pump shall operate whenever any of the associated heating hot water control valves are commanded not closed.

PRIMARY/STANDBY CONTROL:
Status point integral to the VFD, shall prove pump operation. If the primary pump is called to run and the VFD programmable relay dry contact output status point indicates that the pump is not operating for 30 seconds (adj.), the BAS shall annunciate an alarm, the standby pump shall start.

If any pumps fails, DDC shall continue to enable the failed pump and command it at minimum speed. If the failed pump finally proves status, DDC shall automatically release the pump to operate per its speed control sequence. DDC shall then automatically stop the standby pump.

The BAS shall equalize the run time of the pumps as noted under PRIMARY/STANDBY sequencing under the GENERAL CONTROL SEQUENCES.

When switching operation between the primary and standby pump, start the standby pump at minimum speed prior to shutting off the primary pump. When the standby pump operation has been proven by VFD status point the standby pump shall be released to operate as noted under PUMP SPEED CONTROL. When the standby pump is operating at the same speed as the primary pump, the primary pump shall then be slowed to minimum speed. When the primary pump reaches minimum speed it shall be disabled and coast to a stop. The primary pump shall then be designated the standby pump, and the standby pump shall then be designated the primary pump.

SPEED CONTROL:
Pump speed shall be controlled based on the feedback signal from one (1) differential pressure transmitter. Install one differential pressure transmitter across the supply and return mains on basement level. Refer to mechanical piping floor plans for locations. Differential pressure transmitter shall be hardwired directly back to the DDC that provides the speed control signal to the pump VFDs. Sharing this signal via the network shall not be allowed for control.

The primary pump shall modulate its speed to maintain an initial setpoint of 10 psi (adj.) at the differential pressure transmitter. Pressure differential control setpoint shall be minimum pressure required to achieve system design flow. Final differential pressure setpoint shall be optimized by the Balancing Contractor.

If the differential pressure signal deviates from setpoint by ±3 psi (adj.), for a consecutive period of 5 minutes (adj.), the BAS shall annunciate an alarm.

If the differential pressure transmitter fails, and its pressure signal goes to zero, DDC shall lock the speed of the primary pump and annunciate an alarm.

SYSTEM FILL PRESSURE:
Provide a pressure transmitter to monitor the water pressure at the heating hot water expansion tank. Pressure transmitter shall report to BAS. If the pressure deviates ±7 psi (adj.) from setpoint the BAS shall annunciate alarm. Setpoint shall be equal to the scheduled fill pressure downstream of the water pressure regulating valve at the expansion tank.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the primary heating hot water pump shall be automatically started and operate via standby power from the building standby power system. The primary pump shall operate as described in the above control sequence.

In the event the primary pump fails, DDC shall annunciate an alarm and automatically start the standby pump.

When normal power is restored, DDC shall continue operating the heating hot water pump. DDC shall not stop and restart any heating hot water pumps.

RECLAIM WATER PUMP CONTROL
GENERAL (RWP-4):
There is one reclaim water pumps (RWP-4) that circulate reclaim glycol/water solution between the exhaust heat recovery unit (HRU-66) and AHU heat recovery coils AHU-37A & AHU-37B. The pump is sized for 100% of the system flow capacity of the system.

START/STOP CONTROL:
When system is operating, pump shall operate continuously.

Pump shall be started when either of the following conditions are proven:
- When the outside air dry-bulb temperature is below 49°F (adj.) for five consecutive minutes (adj.).
- When the outside air dry-bulb temperature is above 80°F (adj.) for five consecutive minutes (adj.).

The primary pump shall be stopped when the above two conditions are not met for 5 consecutive minutes (adj.).

Status point, integral to the VFD, shall prove pump operation. If a pump is called to run and the VFD programmable relay dry contact output status point indicates that the pump is not operating for 30 seconds (adj.), the BAS shall annunciate an alarm.

If the pumps fails, DDC shall continue to enable the pump and command it at minimum speed. If the primary pump finally proves status, DDC shall automatically release the pump to operate per its speed control sequence.

SPEED CONTROL:
BAS shall ramp up the pump to a predetermined speed setpoint, and shall maintain pump at this speed. Speed setpoint shall provide design glycol water flow rate through the AHU heat recovery coils when their 3-way control valves are fully open to AHU coils. 23 09 23 Contractor and TAB Contractor shall coordinate to determine this speed setting.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the pump shall shut-down. This pump is not connected to standby power. When normal power is restored BAS shall automatically restart the pump, if required, per the above control sequence.

SYSTEM FILL PRESSURE:

Provide a pressure transmitter that monitors the pressure at expansion tank ET-HR-1. Pressure transmitter shall report to the BAS. Refer to the expansion tank schedule for scheduled air charge pressure setpoint. If the pressure transmitter deviates ±7 psi (adj.) from the scheduled air charge pressure setpoint, for a consecutive 5 minutes (adj.), the BAS shall annunciate an alarm.

A packaged glycol/water feed pump shall maintain system pressure. The feed pump shall be manually activated to run. When the fill pressure is within ±2 psi (adj.) of the scheduled expansion air charge pressure, the BAS shall clear the low pressure alarm.

MISCELLANEOUS:
Provide a temperature sensor immediately downstream of the heat recovery pump. Provide another temperature sensor in the heat recovery supply pipe downstream of the exhaust heat recovery coils but upstream of the AHU heat recovery coils. These sensors shall report to the BAS as convenience points.

WIMR EAST WEDGE CYCLOTRON AHU CONTROL
GENERAL (AHU-37A & AHU-37B):
These air handling units provide supply air to the occupied spaces of this Building. The air handling units are factory-fabricated custom air handling units, located in the Level 2 mechanical room, and operate as a single system. When operating on normal power, both air handling units shall operate continuously.

The system is designed as heating-cooling-humidification, single duct, variable volume reheat system with heat recovery. The system provides 100% outside airflow and does not have any return airflow.

When this Project is completed, each AHU shall be capable of providing 100% of the system supply airflow. However, when Level 1 and Level 2 are fit-out, each AHU shall only be capable of providing 75% of the system supply airflow.

Each AHU shall be controlled by its own dedicated direct digital controller (DDC). Each controller shall be housed in a separate control panel.

The air handling units are equipped with the following:
- Supply air smoke isolation dampers, with actuator. (Refer to specification 23 33 00)
- Supply fan array with a VFD per supply fan.
- Outside air intake dampers provided by AHU manufacturer. (Actuator shall be provided by 23 09 23.)
- Glycol reclaim water pump.
- VIFB steam coil for heating.
- Steam humidifier.
- Chilled water coil for cooling.
- Various filter banks. (MERV 8 & MERV 14)
- Damper actuators (non-smoke) furnished by TCC. (Refer to specification 23 09 14)

UNIT OPERATING MODE:
For this Project, these AHUs shall operate in primary/standby arrangement. One AHU shall be capable of providing the system airflow required. When Level 1 and Level 2 shell spaces are fit-out, both AHUs will need to operate continuously.

The primary AHU shall operate continuously. The standby AHU shall remain off. The standby AHU shall only run if required for a failure or manual shutdown of the primary AHU.

The BAS shall equalize the run time of the AHUs as noted under PRIMARY/STANDBY sequencing under the **GENERAL** control sequences.

INTERLOCKING:
Software interlock these AHUs with exhaust fans EF-66A, EF-66B and EF-66C.
- If all three exhaust fans are shut-down (manually or on failure) the BAS shall decrease the primary AHU's supply fan speeds to 0% (adj.), close primary unit's supply air smoke isolation dampers, and close its supply air intake damper. This shall be considered "SAFE EGRESS MODE".
    - When this occurs, all terminals connected to this supply/exhaust system shall be locked in their current positions. Do not index air terminals into their failure CFMs. There is no airflow. If air terminals are indexed into their failure CFMs, the air terminals will go full open. Keeping the air terminals locked in their current positions will help the supply/exhaust systems recover when exhaust fans are restarted.

    - BAS shall continue to command the primary AHU supply fan speeds at 0% speed and keep their isolation dampers closed.
    - In the event one exhaust fan is restarted, and proves status via VFD status contact, DDC shall automatically resume startup on the primary AHU. Primary AHU DDC shall immediately open its isolation dampers and increase supply fan speed. Primary AHU shall operate per this sequence. All air terminals connected to this supply/exhaust system shall be released to operate per their control sequence.

Interlock these AHUs with supply air fire/smoke dampers SFSD-37-2-1 and SFSD-37-1-2. These supply air fire/smoke dampers must BOTH be proven open in order to provide supply air to Basement Level. While the primary AHU is in operation, if either fire/smoke damper is NOT proven open the BAS shall react as follows:

- BAS shall annunciate an alarm.
- BAS shall decrease the primary AHU's supply fan speeds to 0% (adj.), close primary unit's supply air smoke isolation dampers, and close its supply air intake damper. (Note, this shall be considered "SAFE EGRESS MODE". The exhaust fans will also react with their own interlocks.)
- When this occurs, all terminals connected to this supply/exhaust system shall be locked in their current positions. Do not index air terminals into their failure CFMs. There is no airflow. If air terminals are indexed into their failure CFMs, the air terminals will go full open. Keeping the air terminals locked in their current positions will help the supply/exhaust systems recover when exhaust fans are restarted.
- BAS shall continue to command the primary AHU supply fan speeds at 0% speed and keep their isolation dampers closed.
- In the event supply air fire/smoke dampers SFSD-37-2-1 and SFSD-37-1-2 are both proven open, DDC shall automatically resume operation of the primary AHU. Primary AHU DDC shall immediately open its isolation dampers and increase supply fan speed. Primary AHU shall operate per this sequence. All air terminals connected to this supply/exhaust system shall be released to operate per their control sequence.

The interlocks listed above are important to prevent over/under pressurizing the Building and the associated ductwork.

FAN CONTROL:
Manual Start/Stop: At each AHU control panel, provide a manual toggle shut-down switch. Manually activating this switch into the off position shall stop the unit as detailed below. Manually putting this switch in the on position, shall allow the BAS to restart the unit. Normally all of these toggle switches shall remain in the 'on' position. When a toggle switch is placed into the off position, the BAS shall annunciate a critical alarm. Note, 23 09 23 Contractor needs to provide software logic that prevents multiple AHUs from being disabled via these toggle switches. If one AHU is already off (manually or on failure), the toggle switch on remaining operating AHU shall NOT be allowed to turn off the unit. If that toggle switch is manually placed in the off position, the BAS shall annunciate an alarm but shall also continue to operate that unit. BAS Operator shall still have the ability to shut-off both units via the BAS Operator interface.

All toggle switches shall be located within control panels. Panel covers will need to be open to access them. Do not install on the face of the panels.

If the primary AHU is manually stopped, and the standby AHU is available, the BAS shall automatically start the standby AHU. Start the standby unit as detailed within this control sequence. The standby AHU supply fans shall be operating at the same speed as the primary AHU prior to beginning shutdown of the primary AHU.

Initial Startup: The DDC system shall start the supply fan arrays via the VFDs. When starting the system with all AHUs off, the BAS shall start the primary AHU. Follow the steps below for initial startup:

1. When the system is started, with no AHUs running, command the primary AHU supply fan array to start and run at the minimum speed (0%).
2. While the primary AHU supply fan array is being started, start the primary exhaust fan (EF-66A, EF-66B, or EF-66C) on and run at minimum speed.
3. At this point, the primary AHU supply fans and the primary exhaust fan shall be running at their minimum speeds but with their isolation dampers fully closed. See the remainder of the sequence for next steps.
4. Each AHU controller shall provide a hardwire digital output to the fire alarm system. This AHU digital output will be activated when at least one of its supply fans is proven operating via VFD status switch. The fire alarm system shall monitor each digital output through its own monitoring modules. When at least one of these digital outputs are activated the fire alarm control system shall be programmed to command open all fire/smoke dampers in this supply air system. When none of

the AHUs are proven operational these digital outputs are de-activated, and the fire alarm control system shall be programmed to close all fire/smoke dampers in this supply air system.

5. The BAS shall monitor the open positions of all the fire/smoke dampers. Refer to **FIRE/SMOKE DAMPER MONITORING** in this specification for details. The following fire/smoke dampers are upstream of the supply duct static pressure transmitter: SFSD-37-2-1 and SFSD-37-1-2. Both of these supply fire/smoke dampers shall be proven open before allowing the initial startup sequence to continue. These fire/smoke dampers are in series, and if either are closed, the basement rooms will not be able to receive supply air.
6. After SFSD-37-2-1 and SFSD-37-1-2 are both open, the BAS shall command open primary AHU outside air damper and primary AHU supply air smoke damper. After the supply air smoke damper proves it is not closed, the BAS shall release the supply fans to operate per their speed control sequences. If either AHU isolation damper end switches do not prove open, within 2 minutes (adj.) of being commanded open, command the associated AHU supply fans to minimum speed and annunciate a critical alarm at the BAS.
    a. BAS shall immediately begin startup of the standby AHU, if available to operate.
    b. When an AHU's isolation damper does not prove open, DDC shall continue to command open both isolation dampers. DDC shall also continue to enable the failed unit's supply fan VFDs and command all VFDs at minimum speed.
    c. If the DDC is waiting for all AHU isolation dampers to recover (prove open), DDC shall continue to operate its glycol heat reclaim coil, steam preheat coil, and cooling coil per DISCHARGE AIR TEMPERATURE CONTROL. There will be some supply airflow movement, and it will be imperative to keep maintaining discharge air temperature and prevent freezestat trips.
    d. In the event both isolation dampers, on the failed AHU, later do prove open, DDC shall automatically resume startup of the failed AHU. BAS shall automatically clear the failed AHU alarm.

Unit Restart: If an AHU is manually restarted while the other AHU is operating, it shall be restarted similar to Initial Startup. The shut-down unit supply fan array shall be started at low speed and prove operation. After the fan array has proven operation, command open both AHU isolation dampers. When the restarted unit's supply air smoke damper is proven not closed, release the supply fans to operate per their speed control sequences. Adjust fan ramp up rate to prevent static pressure variances as specified in PARALELL FAN BUMPLESS TRANSFER under the **GENERAL** control sequences. Note, the supply air smoke isolation dampers shall be provided with analog type actuators. The 23 09 23 Contractor shall also control the opening/closing rate of these dampers to prevent duct pressure fluctuations.

After the restarted AHU supply fans are operating at the same speed as the other operating AHU, the BAS may begin shutdown procedures of the other AHU.

Unit Stop: If an AHU is manually stopped, BAS shall automatically restart the standby AHU as noted above. After the restarted AHU supply fans are operating at the same speed as the other operating AHU, the BAS may begin shutdown procedures of the other AHU.

If an AHU is manually stopped, the AHU supply fans shall be slowed to minimum speed while its supply air smoke isolation damper is being closed. Adjust supply fan deceleration, with smoke damper stroke, to prevent static pressure variances as specified in PARALELL FAN BUMPLESS TRANSFER under the **GENERAL** control sequences. The supply fans should be at minimum speed when the smoke damper is fully closed. Once the smoke damper is closed, disable the supply fans and they shall coast to a stop.

Supply Fan Speed Control: The purpose of the supply fan control is to maintain a minimum static pressure in the supply ductwork to ensure proper terminal air box operation. (Note, the supply fan speed control below shall normally use AHU-37A DDC for supply fan speed control. This shall be done, even though the AHUs run in primary/standby. This is done so the system is ready to operate with both AHUs simultaneously in the future.)

Provide two (2) static pressure sensing probes in the main supply duct. Install the sensing probes on Basement Level. Refer to the ductwork plans for locations. Pipe from this sensor ports to the differential pressure transducers in the AHU DDC panels. The inputs to the differential pressure transmitter shall be the static pressure inside of the duct and the reference input shall sense the actual space served by the air system located in the ceiling below the duct probe. One pressure transducer shall be installed in the AHU-37A panel and hardwired to the AHU-37A DDC. The other pressure transducer shall be installed the AHU-37B panel and be hardwired to the AHU-37B DDC. The DDC system shall modulate the operating supply fan VFDs to maintain the static pressure setpoint as sensed by these static pressure sensors.

AHU-37A DDC panel shall control the supply fan speeds, in both AHUs, to maintain the supply duct static pressure. The AHU-37A DDC calculated fan speed command signal shall be hardwired to an input on the AHU-37B DDC. If the AHU-37A DDC is functional, the AHU-37B DDC shall pass through the AHU-37A DDC fan speed signal to it supply fan VFDs. Provide a watchdog reliability output from the AHU-37A DDC to the AHU-37B DDC. When this watchdog reliability output is energized it shall prove the AHU-37A DDC is functional. When the AHU-37A DDC watchdog reliability output is deenergized, the AHU-37B DDC shall control its fans speed based the supply duct pressure transducer that is hardwired to it.

Initial supply duct static setpoint shall be 1.2 in. w.c. (adj.). Final setpoint to be determined through test and balancing. If a static sensor deviates, from setpoint, by more than ±0.5 in. w.c. (adj.), an alarm shall be sent through the BAS system.

High Static Pressure Override: Provide a third supply duct pressure transmitter for high static pressure override. This transmitter shall sense the duct static in the mechanical room supply air plenum. Hardwire this transmitter to each dedicated AHU DDC. The dedicated AHU DDCs shall limit its supply fan speed if this pressure rises above +4.5" WC (adj.). If the BAS ever has to limit supply air plenum static, the BAS shall annunciate an alarm.

Fan Failure Detection: Fan failures shall be proven via their status contacts integral to the VFDs. When starting a fan, time limit for determining fan failure shall be 60 seconds (adj.) after the fan is initially commanded to start. When there is a fan failure the BAS shall annunciate an alarm. DDC shall continue to command the supply fan at its minimum speed while it is failed. In the event the VFD status contact is finally proven, DDC shall automatically increase the supply fan speed per fan speed control sequence.

- When the primary AHU has one supply fan fail, BAS shall annunciate an alarm. The BAS shall immediately begin startup procedures for the standby AHU. Do not proceed with this subsequence until the standby AHU supply fans are operating at the same speed as the primary AHU.
- After the standby AHU supply fans are operating at the same speed, BAS shall slow the primary AHUs supply fans to minimum speed and close its isolation dampers.
- BAS shall continue to command the primary AHUs supply fans at minimum speed. If later all four supply fans prove operation, BAS shall automatically recover the primary AHU. When the primary AHU supply fans are operating at the same speed as the standby AHU, BAS shall clear the failed primary AHU alarm and begin shutdown of the standby AHU.
- If the standby AHU is in operation, and it has one, two, or three supply fan failures the BAS shall annunciate an alarm. However, the BAS shall continue to operate the standby AHU with its remaining supply fans.
- If the standby AHU is in operation, and all four supply fans fail the BAS shall annunciate an alarm. BAS shall close the standby AHU's isolation dampers, but continue to enable all of the standby AHU's supply fan VFDs and command them at minimum speed. BAS shall consider this "SAFE EGRESS MODE". (Refer to **WIMR EAST WEDGE CYCLOTRON EXHAUST FAN CONTROL** for details on SAFE EGRESS MODE.)
    - If the standby AHU later has one, or more, supply fans prove operation, BAS shall automatically restart the standby AHU.

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

For pre-filter banks, provide an alarm to the operator interface when the differential static pressure exceeds 1.0 in. w.c. (adj.).

For final filter banks, provide an alarm to the operator interface when the differential static pressure exceeds 1.2 in. w.c. (adj.).

DISCHARGE AIR TEMPERATURE CONTROL:
Install a temperature sensor in the supply air downstream of the supply fan array for each AHU. Discharge air temperature shall be controlled through the BAS with temperature sensors specified herein.

Discharge Air Temperature Setpoint:
Discharge air temperature setpoint shall be 55ºF (adj.). If discharge air temperature exceeds 58°F (adj.) or drops below 52°F (adj.), for 10 consecutive minutes (adj.), the BAS shall annunciate an alarm.

Heat Recovery Coil Control:
Heat recovery coil control valves shall modulate via software interlock anytime its associated supply fan is proven operational, via supply fan VFD feedback, and when the reclaim water pump (RWP-4) is proven on via its VFD status input. When valves are not being modulated they shall be placed in bypass to the AHU coil.

The heat recovery coils shall be used as the first stage of heating and cooling, and shall be sequenced with the preheat coil and cooling coil to maintain the discharge air temperature setpoint subject to the frost control override. In heating mode, as the discharge air temperature falls below setpoint the heat recovery control valve shall modulate open to coil and the reverse shall occur as discharge air temperature rises above setpoint. Preheat coil control valve shall not be allowed to modulate unless heat recovery coil is fully open to coil or operating under frost control. In cooling mode, DDC shall continuously command heat recovery control valve to be modulated fully open to coil and the cooling coil control valve shall be allowed to modulate.

Heat Recovery Frost Control: The DDC system shall monitor the leaving reclaim glycol temperature at each AHU heat recovery coil. Install a temperature sensor in the heat reclaim return water pipe which is downstream of the three-way mixing valve. DDC shall override the air handling unit heat recovery coil discharge temperature control to maintain a minimum reset frost control temperature of 31°F (adj.).

Integral Face and Bypass Heating (Preheat) Coil Control: The preheat coil shall be controlled to maintain the AHU discharge air temperature setpoint. The preheat coil control valve shall be locked closed whenever the air entering the preheat coil is above 50ºF (adj.). When the air entering the preheat coil falls below this setpoint, the preheat coil shall be allowed to operate. Note the following operating requirements:

- The preheat coil control valve shall be sequenced so that it is 25% open (adj. BAS Setpoint) before the face and bypass dampers begin to modulate from full bypass to full face operation.
- Whenever the heating coil entering air temperature is below 38˚F (adj.), the heating coil control valve shall be fully open and the face and bypass dampers shall modulate to maintain the discharge air temperature setpoint.

Cooling Coil Control:
Modulate cooling coil control valve to maintain an AHU discharge air temperature of 55°F (adj.). Cooling coil control valve shall be locked closed whenever the outside air temperature is below 52°F (adj.).

Cold Weather Start-up:
On AHU start up when the outside air temperature is below 40ºF (adj.), the preheat coil control valve shall be commanded to 100% open to coil and its face and bypass dampers shall be commanded into full face position, before opening the AHU outside air damper and supply air smoke damper. This shall be done to reduce the possibility of the freezestats tripping on unit startup. When the AHU's outside air damper and supply air smoke damper have both been proven open, for 1 consecutive minute (adj.), the preheat coil valve and its face and bypass damper shall be released to operate per DISCHARGE AIR TEMPERATURE CONTROL.

Also, open the heat reclaim control valve to provide full flow through the heat reclaim coil allowing time for the valve to provide full flow through the reclaim coil before opening the AHU outside air damper and supply air smoke damper. When the AHU's outside air damper and supply air smoke damper have both been proven open, for 1 consecutive minute (adj.), the heat reclaim control valve shall be released to operate per DISCHARGE AIR TEMPERATURE CONTROL.

BAS shall suppress all discharge air temperature alarms until the preheat coil control valve has been released to operate, per DISCHARGE AIR TEMPERATURE CONTROL, for a consecutive 5 minutes (adj.).

AHU HUMIDIFIER CONTROL:
AHU humidifier shall only be allowed to operate if its supply air smoke isolation damper is proven open and its supply fans are operating above minimum speed. If this condition is not proven, the AHU humidifier control valve shall be commanded closed.

Each AHU shall have a steam injection humidifier. Humidifier manufacturer shall furnish a modulating steam control valve for each humidifier. Each AHU DDC shall directly modulate its humidifier control valve to control steam output.

Note, humidifier output control will be based on calculated dewpoint measurements and not directly based on relative humidity measurements.

Install an exhaust air duct temperature sensor and exhaust air duct relative humidity sensor. Refer to mechanical ductwork plans for locations on where to install these sensors. Hardwire these sensors back to AHU-37A DDC. AHU-37A DDC will utilize these sensors to calculate the Building dewpoint. The Building dewpoint will be the feedback control setpoint.

- The Building dewpoint control setpoint shall be reset linearly between 33°F dewpoint (adj.) at an outside air dry bulb temperature of 50°F (adj.) and 27°F dewpoint (adj.) at an outside air dry bulb temperature of 0°F (adj.). (Note, a 33°F dewpoint equates to approximately 25% RH and a 27°F dewpoint equates to approximately 20% RH.).

In order to maintain the Building dewpoint, the AHU supply air dewpoint shall be reset between 15°F dewpoint (adj.) and 50°F dewpoint (adj.) to maintain the PI loop calculated reset Building dewpoint setpoint. AHU-37A DDC shall reset the supply air dewpoint setpoint. AHU-37A DDC shall share this dewpoint setpoint to AHU-37B DDC via peer-to-peer communication. In the event AHU-36A DDC fails, AHU-36B shall continue to humidify. AHU-37B shall maintain the last sent supply air discharge dewpoint setpoint for control until AHU-37A DDC has recovered.

As AHU supply air dewpoint falls below setpoint, its DDC shall modulate its humidifier steam control valve from closed to open. The reverse sequence shall occur as AHU supply air dewpoint rises above setpoint. Provide two electronic discharge air humidity sensors at each AHU. DDC shall utilize the discharge air temperature sensor and discharge humidity sensors to calculate supply air dewpoint. The highest humidity reading, of the two discharge humidity sensors, shall be utilized for calculating supply air dewpoint. If the humidity readings of the two sensors vary by more than 8% RH (adj.), an alarm shall be sent through the DDC system. Mount the humidity sensors at the same location a minimum of 6 feet downstream of the humidifier, or greater if required by humidifier manufacturer, and a maximum distance of 15 feet. The humidifier control loop shall not be active until the supply fan speed signal exceeds 20% (adj.) command.

SAFETIES:
General: All safeties shall be hard wired to the VFD safety circuits. Starters shall not function in the “Hand” or “Auto” and VFD’s shall be disabled if they are indexed to the “Auto” or “Hand” position. If a unit is shut-down due to these safeties, the BAS shall at a minimum shut-off the entire AHU. The BAS shall disable all supply VFDs and close the affected unit’s outside air damper and supply air smoke damper. BAS shall annunciate alarm.

Freezestat: A freezestat trip shall notify the DDC system that shall send an alarm to the operator interface.

Provide freezestat(s) on the entering face of the cooling coil to shut down the unit (see Unit Shutdown for additional information) if the cooling coil entering temperature drops below 36ºF (adj.). This freezestat trip shall notify the DDC system and shall send an alarm to the operator interface.

- In addition, AHU DDC shall include a binary output that bypasses the cooling coil entering air freezestat. The User will manually activate this binary output, via manual toggle switch at the DDC, to disable the hardwire safety contact when the cooling coil has been drained.
- When this manual toggle switch is placed into bypass, it shall also shunt the cooling coil freezestat contact to the DDC. This will prevent the BAS from alarming when the cooling coil freezestat is activated but the coil has been drained.
- When the manual toggle switch is placed in the bypass position, the BAS shall annunciate a low-level maintenance alarm.

Provide an additional freezestat at the AHU discharge (supply) duct connection to shutdown unit if the discharge air temperature drops below 36°F (adj.). DDC system shall send an alarm to the operator interface.

When any freezestat is activated, the freezestat trip shall hardwire override the DDC system control signal to the preheat coil control valve(s). The preheat coil control valve(s) shall fail-open. DDC shall continue to modulate the preheat coil face and bypass dampers to maintain 90°F (adj.) at the inlet of the cooling coil. If the cooling coil air temperature is below setpoint, DDC shall modulate the preheat coil bypass dampers from bypass to open to coil. If the cooling coil air temperature is above setpoint, DDC shall modulate the preheat coil bypass dampers from open to bypass to the coil.

- When the cooling coil freezestat has been manually bypassed (shunted), the control valve signal to the preheat coil shall still be maintained when the cooling coil freezestat is activated. The 23 09 23 Contractor shall bypass the cooling coil freezestat hardwire override. Refer to the previous paragraph regarding the cooling coil freezestat bypass/shunt for details.

- If the cooling coil freezestat has been bypassed (shunted), and cooling coil freezestat is activated, DDC shall continue to modulate preheat coil face and bypass dampers to maintain discharge air temperature setpoint. Do not modulate preheat coil face and bypass dampers to maintain 90°F (adj.) at the inlet of the cooling coil.

Supply Fan High Pressure Limit: Install a static pressure probe located in the air handling unit main discharge duct at least six feet or as far as physically possible downstream of the fan array and upstream of any dampers and pipe to a differential pressure switch located in the DDC panel. Wire in series with the safety circuit of the unit's VFDs. Differential pressure switch shall be a manual reset type and the DDC system shall monitor the status of the differential pressure switch. Initial setpoint shall be +5.0" w.c. (adj.). This pressure differential switch shall utilize the space (room) pressure as the reference pressure. Use the space pressure port that this DDC is using for supply fan speed control as the reference pressure.

Supply Fan Low Pressure Limit: Install a static pressure probe located in the air handling unit immediately downstream of outside air intake damper and pipe to a differential pressure switch located in the DDC panel. Wire in series with the safety circuit of the unit's VFDs. Differential pressure switch shall be a manual reset type and the DDC system shall monitor the status of the differential pressure switch. Initial setpoint shall be -5.0" w.c. (adj.). This pressure differential switch shall utilize the space (room) pressure as the reference pressure. Use the space pressure port that this DDC is using for supply fan speed control as the reference pressure.

Fire Alarm Shutdown: Division 26 Contractor shall provide a shut-down relay at each dedicated AHU DDC panel. Upon a Fire Alarm System alarm, this fire alarm control relay shall change state of its contacts. This shall cause the AHU to be shut down (see Unit Shutdown for additional information) and the supply air smoke damper shall close. An auxiliary contact shall be provided to notify the DDC system of a fire alarm shutdown. When the fire alarm resets this control relay, unit DDC shall be allowed to restart the unit if required per this sequence.

Note, Division 26 Contractor shall also provide a smoke detector in the supply air duct from each AHU. Upon detection of smoke, the Fire Alarm system shall activate its shut-down relay at the AHU DDC panel. This shall also cause the AHU to be shut down.

UNIT SHUT DOWN:
Whenever an air handling unit is shut down, all unit VFDs shall be disabled. Whenever the unit is off for any reason the following shall occur:

The affected unit's dampers shall close. This includes the outside air intake damper and supply air smoke damper.

The affected unit's chilled water control valve shall close.

If the outside air temperature is below 50°F (adj.), the affected unit's heating coil control valve(s) shall remain under control from the sensor immediately upstream of the cooling coil to maintain 60ºF (adj.). The heating coil bypass dampers shall be commanded into full face (non-bypass) position.

The affected unit's humidifier control valve shall close.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the primary AHU shall be automatically restarted when standby power is available. If the primary AHU is shut-down (manually or on failure) the BAS shall automatically start-up and operate the standby AHU.

If the standby AHU is started, because of a failed primary supply fan or damper, continue to enable the primary AHU as described in the sequence above. If the failed supply fan or damper automatically recovers, BAS shall automatically resume using the primary AHU on standby power and shut-down the standby AHU.

When normal power is restored, the BAS shall continue operating the primary AHU without stopping and restarting the unit.

WIMR EAST WEDGE CYCLOTRON EXHAUST FAN CONTROL
GENERAL (EF-66A, EF-66B, & EF-66C):
The exhaust system serves the occupied spaces of this Building. Three exhaust fans are provided.

- When this Project is completed a single exhaust fan will have sufficient capacity to serve all spaces.

- When Level 1 and Level 2 shell spaces are fitted out, each exhaust fan will provide 50% of the exhaust capacity.

The exhaust system is a variable volume exhaust fan system.

The exhaust system is controlled by its own dedicated direct digital controller (DDC). This DDC shall be installed on the 8th floor roof of the East WIMR Tower. Provide NEMA 4X control panel enclosure.

The exhaust system is equipped with the following:

- Three centrifugal exhaust fans with VFD's.
- Exhaust fan isolation air dampers furnished by TCC. (Refer to specification 23 09 14.)
- One outside air bleed damper furnished by TCC. (Refer to specification 23 09 14.)
-
- One heat recovery unit. (HRU-66)
- Heat recovery inlet dampers and discharge dampers. Dampers furnished by HRU manufacturer. (Refer to specification 23 09 14.)
- Heat recovery bypass damper. Damper furnished by HRU manufacturer. (Refer to specification 23 09 14)
- Damper actuators provided by TCC. (Refer to specification 23 09 14)

UNIT OPERATING MODE:
The system shall operate in primary/standby1/standby2 arrangement. The primary exhaust fan shall operate continuously. The standby1 exhaust fans shall operate in the event the primary exhaust fan fails or is manually shutdown. The standby2 exhaust fan shall operate in the event the primary and standby1 exhaust fan are both failed and/or manually shutdown.

INTERLOCKING:
Software interlock these exhaust fans with AHU-37A and AHU-37B. In the event both AHUs are shut-down, the BAS shall slow the lead and lag exhaust fan to 0% (adj.) speed and hold. This shall be considered "SAFE EGRESS MODE". Refer to EXHAUST FAN SPEED CONTROL (SAFE EGRESS MODE) below for details. This interlocking is important to prevent over/under pressurizing the Building and associated ductwork.

- Note, this interlocking shall be required when both AHU-37A and AHU-37B have their supply air smoke isolation dampers proven closed. Do not wait for a complete shut-down of AHUs before activating this interlocking. AHUs may continue to operate supply fans, at minimum speed, in attempt to restart failed AHUs.
- In "SAFE EGRESS MODE" all air terminals connected to this supply/exhaust system shall be locked in their current positions. Do not index air terminals into their failure CFMs. There will be very little airflow. If air terminals are indexed into their failure CFMs, the air terminals will just end up commanded full open. Keeping the air terminals locked in their current positions will help the supply/exhaust systems recover when AHUs are restarted.
- In "SAFE EGRESS MODE" if the primary exhaust fan is shut-down (manually or on failure) the BAS shall automatically startup the standby exhaust fan. Standby exhaust fan's isolation damper shall be commanded open and standby exhaust fan shall be commanded to 0% speed.
- When one AHU is restarted, DDC shall automatically increase the primary exhaust fan speed after the restarted AHU(s) is operating above minimum fan speed.

PRIMARY/STANDBY1/STANDBY2 CONTROL:
The primary exhaust fan shall operate continuously. Standby fan shall only operate in event of failure of the lead or lag fan. The BAS shall equalize runtime of these exhaust fans as noted under PRIMARY/STANDBY SEQUENCING under the **GENERAL** control sequences. Refer to "Run-Time Equalization Sequence", within this sequence, for details on starting the standby exhaust fan and stopping the lead or lag fan.

Primary/Standby1/Standby2 Fan Selection: There will be one exhaust fan designated primary, one exhaust fan designated standby1, and one exhaust fan designated the standby2 fan. Primary fan selection shall be based on rotational sequencing. Provide a single software point that shall allow the User to designate the primary fan. The BAS shall then designate the next sequential fan as the standby1 fan and the remaining fan shall be the standby2 fan. For example, if EF-66B is designated the primary fan then EF-66C is the standby1 fan and EF-66A is the standby2 fan.

FAN CONTROL:
Start/Stop: The DDC system shall start the exhaust fans via their VFDs.

Manual Start/Stop: At the exhaust fan BAS panel, provide a manual toggle shut-down switch for each exhaust fan. Manually activating this switch into the "off" position shall stop an exhaust fan as detailed below. Manually putting this switch in the "on" position, shall allow the BAS to restart the unit. Normally, all toggle switches shall be in the "on" position. When a toggle switch is placed into the "off" position, the BAS shall annunciate a critical alarm. Also, provide a software point for each exhaust fan, which shall allow units to be turned on/off manually for maintenance. If an operating fan is manually or automatically stopped, and the next standby fan is available, the BAS shall first automatically start the next standby fan. The standby fan shall come into control before the shutdown sequence for the fan being taken out of service is stopped. Refer to "Run-Time Equalization Sequence" below for details. Note, 23 09 23 Contractor needs to provide software logic that prevents more than two exhaust fans from being disabled via these toggle switches. If two exhaust fans are already off (manually or on failure), the toggle switches on remaining operating exhaust fan shall NOT be allowed to turn off those units. BAS Operator shall still have the ability to shut-off multiple fans via the BAS Operator interface.

All toggle switches shall be located within control panels. Panel covers will need to be open to access them. Do not install on the face of the panels.

Exhaust Fan Start/Stop Sequencing: When initially starting up the system, with all exhaust fans off, the primary exhaust fan shall be sequenced on in unison with the primary AHU. Start primary exhaust fan with its isolation damper closed and run it at minimum speed.

When the exhaust fan has proven operation, and is spinning at minimum speed, the BAS shall command open their exhaust fan isolation dampers. (BAS shall simultaneously open the primary AHU supply air smoke isolation damper.) As the dampers are being opened, the BAS shall release the primary exhaust fan to operate as noted under EXHAUST FAN SPEED CONTROL (NORMAL MODE) in this sequence.

If an exhaust fan isolation damper is not proven open within 2 minutes (adj.) of the damper open command, command the associated exhaust fan to minimum speed, continue commanding open the failed exhaust fan isolation damper, and send an exhaust fan failure alarm through the DDC system. The BAS shall automatically begin start-up procedures of the standby1 exhaust fan.

- In the event the failed exhaust fans isolation damper later does prove open, DDC shall immediately increase the failed exhaust fan speed per the exhaust fan speed control sequence. After the failed exhaust fan is operating at the same speed as the standby1 exhaust fan, BAS shall begin shutdown of the standby1 exhaust fan. BAS shall automatically clear the failed exhaust fan alarm.

In the event the standby1 exhaust fan's isolation damper does not prove open, DDC shall continue to command standby1 exhaust fan at minimum speed. BAS shall annunciate an alarm for the failed standby1 exhaust fan control damper. The BAS shall automatically begin start-up procedures of the standby2 exhaust fan.

When stopping an exhaust fan, either manually or automated, slow the fan to minimum speed. When minimum speed has been proven, via VFD feedback, the fan shall be commanded off. Command the exhaust fan isolation damper closed at the same rate as the exhaust fan is being slowed. The isolation damper should be closed when the exhaust fan is at minimum speed.

- Note, when an exhaust fan is being controlled to a stop its isolation damper will not be proven open. While slowing/stopping the exhaust fan, BAS shall suppress the alarm that is generated because the exhaust fan isolation damper is not proven open. Do not immediately disable/lockout an exhaust fan, when going through a controlled shutdown, because its isolation damper is not proven open.
- If standby1 exhaust fan is available, DDC shall automatically start the standby1 exhaust fan before beginning the shut-down procedure of the stopped exhaust fan. Refer to "Run-Time Equalization Sequence" below for details.

Run-Time Equalization Sequence: The BAS shall equalize runtime of these exhaust fans as noted under PRIMARY/STANDBY SEQUENCING under the **GENERAL** control sequences. When sequencing on the standby1 fan and stopping the primary fan, first start the standby1 fan at minimum speed. After the standby1 fan is proven on, command open its isolation damper and at the same time increase the speed of the standby1 fan. The primary exhaust fan shall continue to operate per EXHAUST FAN SPEED CONTROL (NORMAL MODE). When the standby1 fan is operating at the same speed as the primary exhaust fan, the primary exhaust fan shall begin shutdown procedure.

When starting/stopping exhaust fans, prevent static pressure variances as specified in PARALELL FAN BUMPLESS TRANSFER under the **GENERAL CONTROL** sequences. This may entail adjusting minimum speeds and/or ramping dampers or fans at different rates than specified above. Provide analog actuators for the exhaust fan isolation dampers.

Fan Failure Detection: If the primary exhaust fan fails, as detected by status contact integral to the VFD, the BAS shall annunciate a critical alarm. The BAS shall then automatically start the standby1 exhaust fan. Time limit for determining fan failure shall be 60 seconds (adj.) after fan is initially commanded to start. DDC shall command the failed fan's isolation damper closed and continue to command the failed exhaust fan at its minimum speed. In the event the failed fan's VFD status contact is finally proven, DDC shall automatically open the failed fan's isolation damper and recover. The standby1 exhaust fan shall then be shut-down. BAS shall automatically clear the failed exhaust fan alarm.

In the event the standby1 exhaust fan fails, DDC shall continue to command standby1 exhaust fan at minimum speed. BAS shall automatically start the standby2 exhaust fan.

EXHAUST STACK VELOCITY CONTROL & STATIC PRESSURE CONTROL (NORMAL MODE):
The following sequence applies if one exhaust fan is operating above minimum speed and one AHU (AHU-37A & AHU-37B) is operating above minimum speed. This is normally how the system operates and shall be considered "NORMAL MODE".

Exhaust Stack Velocity Control: Minimum exhaust fan speed shall maintain minimum exhaust ejection velocity at 3,000 fpm (adj.). The DDC controller shall prevent the exhaust fan from falling below this minimum speed to prevent the ejection velocity from falling below design. Two minimum fan speed setpoints shall be determined - heat recovery mode and non-heat recovery mode.

- The heat recovery mode minimum fan speed setpoint, for exhaust through the heat recovery coil, shall be determined by minimum exhaust flow rate required to maintain a minimum exhaust ejection velocity when the heat recovery filters are at design dirty suction pressure drop.
- The non-heat recovery mode minimum fan speed setpoint for exhaust through the heat recovery coil bypass shall be determined by the minimum exhaust ejection velocity with the heat recovery coil bypass dampers open and the heat recovery coil isolation dampers open.
- These minimum flow setpoints shall be determined by balancer by measuring flow in both modes when the outside air bleed damper is closed and noting the VFD speed. Dirty filter pressure drop shall be simulated by blocking portions of the filter banks to produce a pressure equivalent to the listed pressure drop for the filter type specified.

Exhaust Fan Speed Control: The purpose of the exhaust fan control is to maintain a minimum static pressure in the exhaust ductwork to ensure proper terminal air box operation. Install one (1) static pressure sensing probe in the exhaust air main located on the Basement Level. Refer to ductwork plans for locations. Pipe to the differential pressure transmitter that shall be located in the DDC enclosure panel. The DDC shall modulate the operating exhaust fan VFD and outside air bleed damper in sequence to maintain the static pressure setpoint as sensed by the static pressure probe. As exhaust airflow requirements decrease and the static pressure becomes more negative than setpoint, decrease the exhaust fan VFD speed signal to maintain the static pressure setpoint until the minimum fan flow setpoint is reached. (Refer to Exhaust Stack Velocity Control.) If the static pressure continues to fall (becomes more negative), modulate open the outside air bleed damper to maintain the static pressure setpoint. The reverse sequence shall occur as exhaust duct static rises (becomes more positive) above setpoint. Do not increase the operating exhaust fan above minimum speed until the outside air bleed damper is commanded fully closed.

The exhaust fan speed control shall maintain a static pressure setpoint of -1.0" WC (adj.). Final setpoint shall be determined by system air balance. If this static pressure deviates from setpoint by ±0.5" WC (adj.), for longer than 10 minutes (adj.), BAS shall annunciate an alarm.

If the static pressure signal is lost, and not reporting, DDC shall lock the speed of the operating exhaust fan, lock the position of the outside air bleed damper, and annunciate an alarm.

Provide a second exhaust duct pressure transmitter for Low Static Pressure override. This transmitter shall sense the duct static in the exhaust air mains on Level Eight, upstream of HRU-66. The transmitter shall reside in this exhaust system's DDC panel. Pipe pneumatic tubing from this transmitter to the exhaust duct static sensor. Exhaust DDC shall limit exhaust fan speeds if this pressure becomes more negative than -4.5" WC (adj.). If the DDC ever has to limit exhaust air duct static, the BAS shall annunciate an alarm.

EXHAUST FAN SPEED CONTROL (SAFE EGRESS MODE):
This sequence shall be used when both AHUs (AHU-37A and AHU-37B) are shut-down. BAS shall consider both AHUs are shutdown when AHU's supply air smoke dampers are not proven open. If both AHU supply air smoke damper are not proven open, there is no way for supply air to be provided to the Building.

When this occurs, the exhaust fan DDC shall react as follows:

- The primary exhaust fan shall be spun at its minimum speed (0%) and its exhaust isolation damper shall be commanded open. Maintaining stack minimum velocity shall not be required in SAFE EGRESS MODE.
- The outside air bleed damper shall be commanded fully closed.

SAFE EGRESS MODE will provide minimal exhaust from this Building. This will ensure the Building space remains slightly negative to the adjacent spaces and the exterior. This exhaust fan speed will also ensure safe egress is maintained for building occupants.

HEAT RECOVERY UNIT DAMPER CONTROL:
Heat Recovery Operation: Upon start of the reclaim water pump (RWP-4) both HRU face dampers shall be commanded open and the HRU bypass damper shall be commanded closed.

Non-Heat Recovery Operation: When the reclaim water pump is off, the HRU bypass damper shall be commanded open and the HRU face dampers shall also be commanded open.

Maintenance Mode Operation: Within the exhaust DDC panel enclosure, provide a switch labeled “HRU-66 Service Access”. The switch shall be a 2-position toggle switch. One position shall be labeled “Normal” and the other “Service”. When the HRU’s switch is put into “Service” the BAS shall open the HRU bypass damper and close the HRU face dampers. When the face dampers have both proven closed a green status light shall energize indicating the unit is safe to enter. When the unit’s switch is put into “Normal” the heat recovery unit dampers shall be indexed into the position dictated by the operation of the reclaim water pump and the green status light shall be extinguished. The HRU switch is normally to be positioned in the “Normal” position. When the switch is positioned into “Service” the BAS shall annunciate an alarm.

Damper Interlocks: All dampers (face & bypass) shall fail open.

Hardwire HRU bypass damper actuator so that the bypass damper cannot be closed unless both of its associated face dampers are proven open through their respective damper open position switches.

Hardwire both HRU face damper actuators so that a face damper cannot be closed unless the HRU bypass damper is proven open through its respective damper open position switch.

SAFETIES:
General: All safeties shall be hard wired to the VFD safety circuits. If any safety relay is activated, the VFD safety circuit will be open. VFD’s shall not be capable of operating if they indexed into “Auto” or “Hand” position.

Exhaust Fan Low Pressure Limit: Install a static pressure probe in the Level 8 exhaust duct. Pipe this static pressure probe to a differential pressure switch located in the DDC panel. Set switch to open if pressure in the plenum drops below -5.0” WC (adj.). If switch is opened the BAS shall annunciate a critical alarm.

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

Provide an alarm to the operator interface when the HRU filter differential static pressure exceeds 1.0” WC (adj.).

POWER OUTAGE OPERATION:
In the event of a failure of the electrical service, the primary exhaust fan shall continue to operate normally via standby power.

During a normal power outage, if the primary fan fails, the BAS shall automatically start the standby1 exhaust fan and annunciate an alarm. Primary fan shall be considered failed if its VFD does not prove status or its isolation control damper does not prove open.

- If the standby1 exhaust fan is started, because of a failed fan, DDC shall continue to enable the primary fan VFD, command the primary fan at minimum speed and close its isolation damper. If the primary fan later proves status, DDC shall automatically open the primary fan’s isolation damper and increase the primary exhaust fan speed per speed control sequence. DDC shall also automatically shut-down the standby1 exhaust fan.
- If the standby1 exhaust fan is started, because of a failure of the primary exhaust fan isolation damper, DDC shall continue to enable the primary fan VFD, command the primary fan at minimum speed, and command its isolation damper open. If the primary fan’s isolation damper later proves

open, DDC shall immediately increase the speed of the primary fan speed per speed control sequence. DDC shall also automatically shut-down the standby1 exhaust fan.

When normal power is restored, the BAS shall continue operating the already operating exhaust fan without stopping and restarting.

MECHANICAL ROOM (RM 2376) HVAC CONTROL

GENERAL:

The following HVAC equipment will be utilized to heat and cool Room 2376 – Mechanical Room.

- Supply Fan: SF-2
- Outside Air Damper: SD-2-2-1 (Refer to specification 23 09 14)
- Return Air Damper: RD-2-2-1 (Refer to specification 23 09 14)
- Exhaust Air Damper: ED-2-2-1 (Refer to specification 23 09 14)
- Hot Water Unit Heater: UH-70

Provide DDC in a wall mounted panel enclosure for control. Refer to 23 09 15 for details.

Provide a space temperature sensor. Space temperature sensor shall be blank cover without adjustments.

INTERLOCKING:

SF-2 and UH-70 shall never operate simultaneously.

SF-2 shall not be allowed to start unless exhaust damper (ED-2-2-1) is proven open.

SPACE COOLING:

DDC shall activate space cooling when both of the following conditions are proven true:

- Space temperature rises above the cooling setpoint of 85°F (adj.).
- The outside air dry-bulb temperature is 5°F (adj.) cooler than the measured space temperature.

SF-2 shall provide unfiltered outside air to cool the mechanical space. Space air will be relieved to outdoors, via the exhaust damper to keep the space pressure neutral to the rest of the Building.

Cooling Modes:

When space requires cooling it will operate in either summer cooling mode or winter cooling mode. Summer cooling mode shall occur when outside air dry-bulb temperature is above 40°F (adj.). Winter cooling mode shall occur when outside air dry-bulb temperature is below 40°F (adj.).

SUMMER COOLING MODE:

When space cooling is required, DDC shall first index the space control dampers into the following positions:

- ED-2-2-1 shall be commanded fully open.
- SD-2-2-1 shall be commanded fully open.
- RD-2-2-1 shall be commanded fully closed.

SD-2-2-1 shall be proven in position when its damper position feedback is more than 90% (adj.) open. RD-2-2-1 shall be proven in position when its damper position feedback is less than 10% (adj.) open. Allow the dampers two minutes (adj.) to prove positions. If dampers do not prove positions after this time delay, BAS shall annunciate an alarm and index these three dampers into their failed positions. Do not proceed with starting SF-2 until dampers prove position.

SF-2 Startup: After dampers are proven in position, DDC shall enable SF-2. Provide a current switch to prove SF-2 status. BAS shall annunciate an alarm if SF-2 is enabled and does not prove operation for longer than 30 seconds (adj.). Continue to enable SF-2. If later, SF-2 does prove operation the BAS shall automatically clear the SF-2 failed alarm.

SF-2 Shutdown: Unit DDC shall stop SF-2 when any of the following three conditions are true:

- When space temperature falls below 80°F (adj.).
- When the outside air dry-bulb temperature is not 5°F (adj.) cooler than the measured space temperature.

DDC shall first slow SF-2 to minimum speed. DDC shall then command the outside air damper and exhaust air damper closed. DDC shall command the return air damper fully open.

WINTER COOLING MODE:

When space cooling is required, DDC shall first index the space control dampers into the following positions:

- ED-2-2-1 shall be commanded fully open.
- SD-2-2-1 shall be commanded fully closed
- RD-2-2-1 shall be commanded fully open.

SF-2 Startup: After dampers are proven in position, DDC shall enable SF-2. Provide a current switch to prove SF-2 status. BAS shall annunciate an alarm if SF-2 is enabled and does not prove operation for longer than 30 seconds (adj.). Continue to enable SF-2. If later, SF-2 does prove operation the BAS shall automatically clear the SF-2 failed alarm.

Supply Air Temperature Control: DDC shall modulate the return air damper and outside air dampers to maintain a supply air temperature setpoint of 45°F (adj.). The return air damper and outside air dampers shall be modulated in sequence as follows:

- Outside air damper shall be modulated open first. If supply air temperature is above setpoint, modulate the outside air damper from closed to open. If supply air temperature is below setpoint, modulate outside air damper from open to closed.
- When the outside air damper is commanded fully open, and supply air temperature is still above setpoint, modulate the return air damper from open to closed. If the supply air temperature is below setpoint, modulate the return air damper from closed to open.
- DDC shall not modulate return air damper closed until outside air damper is commanded fully open.
- DDC shall not modulate outside air damper closed until return air damper is commanded fully open.

Provide an appropriate deadband around the supply temperature setpoint to prevent these dampers from hunting.

In the event the supply air temperature falls below 35°F (adj.), DDC shall immediately command the return air damper fully open and command the outside air damper fully closed. The return air damper and outside air damper shall remain in these positions for a minimum of 10 minutes (adj.). After this time delay, and the supply air temperature is above setpoint, DDC shall automatically resume modulating the outside air damper and return air damper per this sequence.

SF-2 Shutdown: Unit DDC shall stop SF-2 when space temperature falls below 80°F (adj.).

TRANSITION FROM SUMMER COOLING MODE TO WINTER COOLING MODE:
In the event SF-2 is operating, and the outside air dry-bulb temperature falls below 40°F (adj.), DDC shall automatically react as follows:

- Command the return air damper fully open.
- When the return air damper is proven more than 90% (adj.) open, command the outside air damper fully closed.
- When the outside air damper is proven less than 10% (adj.) open, DDC shall begin modulating these dampers as noted under “Supply Air Temperature Control” in WINTER COOLING MODE. The system shall be considered successfully transitioned into winter cooling mode.

TRANSITION FROM WINTER COOLING MODE TO SUMMER COOLING MODE:
In the event SF-2 is operating, and the outside air dry-bulb temperature rises above 40°F (adj.), DDC shall automatically react as follows:

- Command the outside air damper fully open.
- When the outside air damper is proven more than 90% (adj.) open, command the return air damper fully closed.
- When the return air damper is proven less than 10% (adj.) open, the system shall be considered successfully transitioned into summer cooling mode.

Miscellaneous:
BAS shall annunciate an alarm if mechanical room temperature rises above 90°F (adj.) for longer than 30 minutes (adj.). BAS shall suppress this alarm if SF-2 cannot operate because outside air temperature is not at least 5°F (adj.) cooler than the measured space temperature.

SPACE HEATING:
Hot water unit heater UH-70 is provided to heat this mechanical room. DDC shall operate this unit heater when space temperature falls below 55°F (adj.). When space temperature falls below this setpoint, DDC shall command open the unit heater hot water control valve. The 23 09 23 Contractor shall provide strap on aquastat mounted on the hot water return line set at 100º F to start the unit fan when hot water temperature is above setpoint.

When space temperature rises above 60°F (adj.), DDC shall command the unit heater hot water control valve closed.

Provide a current switch to monitor the status of the unit heater fan. If the unit heater's control valve is commanded open, and a unit heater's fan does not prove status within 2 minutes (adj.) the BAS shall annunciate an alarm.

BAS shall annunciate an alarm if the mechanical room temperature falls below 50°F (adj.) for longer than 30 minutes (adj.).

SYSTEM SHUTDOWN:
When the system is off, and is not providing heating or cooling, DDC shall command index all instrumentation into the following position/states:

- SF-2 shall be disabled.
- SD-2-2-1 shall be commanded closed.
- RD-2-2-1 shall be commanded open.
- ED-2-2-1 shall be commanded closed.
- UH-70 heating hot water control valve shall be commanded closed.

SF-2 MANUAL ON/OFF TOGGLE SWITCH:
Provide a two-position toggle switch, within the DDC enclosure, for Operator to disable SF-2.

Normally this switch shall reside in the 'On' position. While this switch is in the 'On' position DDC shall start/stop SF-2 automatically per this sequence. When this switch is not in the 'On' position, BAS shall annunciate an alarm.

If this switch is placed in the 'Off' position, DDC shall immediately disable SF-2 if it is operating. While the switch is the 'Off' position, the system control dampers shall be indexed into the positions listed in SYSTEM SHUTDOWN above.

This switch shall have no control impact on UH-70. UH-70 shall be started/stopped to provide space heating regardless of this switch status.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the BAS shall automatically restart SF-2 or UH-70 if required per this sequence.

When normal power is restored, if SF-2 or UH-70 is already operating it shall continue to operate. BAS shall not stop and restart the units when normal power is restored.

STEAM TUNNEL EXHAUST CONTROL
GENERAL:
The following HVAC equipment will be utilized to exhaust the steam tunnel.

- Exhaust Fan: EF-21.
- Exhaust Air Damper: ED-21-2-1 (Refer to specification 23 09 14)

Utilize the DDC that is conditioning mechanical room 2376 for control of this system. Hardwire all I/O to this DDC. Refer to 23 09 15 for details.

INTERLOCKING:
EF-21 shall not be allowed to operate unless exhaust damper (ED-21-2-1) is proven open.

UNIT OPERATION:
EF-21 shall operate continuously.

When EF-21 is indexed to operate, DDC shall command ED-21-2-1 open. Do not proceed with operation until ED-21-2-1 is proven open. If ED-21-2-1 is not proven open, for longer than 2 minutes (adj.), BAS shall annunciate an alarm. BAS shall continue to command ED-21-2-1 open. If later, ED-21-2-1 is proven open DDC shall resume operating EF-21 and clear the failed damper alarm.

After EF-21 is proven open, DDC shall enable EF-21. Provide a current switch to prove exhaust fan operation. If exhaust fan operation is not proven, for longer than 30 seconds (adj.), BAS shall annunciate an alarm. When this occurs, DDC shall automatically react as follows:

- DDC shall command closed ED-21-2-1.
- DDC shall continue to enable EF-21.

If EF-21 is later proven operating, DDC shall command ED-21-2-1 to open. BAS shall automatically clear the failed fan alarm.

EF-21 MANUAL ON/OFF TOGGLE SWITCH:
Provide a two-position toggle switch, within the DDC enclosure, for Operator to disable EF-21.

Normally this switch shall reside in the 'On' position. While this switch is in the 'On' position DDC shall start/stop EF-21 automatically per this sequence. When this switch is not in the 'On' position, BAS shall annunciate an alarm.

If this switch is placed in the 'Off' position, DDC shall immediately disable EF-21 if it is operating. While the switch is the 'Off' position, ED-21-2-1 shall be closed.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the BAS shall automatically restart EF-21 per this sequence.

When normal power is restored, if EF-21 is already operating it shall continue to operate. BAS shall not stop and restart the unit when normal power is restored.

ELECTRICAL ROOM (RM 2382) HVAC CONTROL
GENERAL:
The following HVAC equipment will be utilized to cool Room 2382 – Electrical Room.

- Supply Fan: SF-3
- Outside Air Damper: SD-3-2-1 (Refer to specification 23 09 14)
- Return Air Damper: RD-3-2-1 (Refer to specification 23 09 14)
- Exhaust Air Damper: ED-3-2-1 (Refer to specification 23 09 14)

Provide DDC in a wall mounted panel enclosure for control. Refer to 23 09 15 for details.

Provide a space temperature sensor. Space temperature sensor shall be blank cover without adjustments.

INTERLOCKING:
SF-3 shall not be allowed to start unless exhaust damper (ED-3-2-1) is proven open.

SPACE COOLING:
DDC shall activate space cooling when both of the following conditions are proven true:

- Space temperature rises above the cooling setpoint of 85°F (adj.).
- The outside air dry-bulb temperature is 5°F (adj.) cooler than the measured space temperature.

SF-3 shall provide unfiltered outside air to cool the mechanical space. Space air will be relieved to outdoors, via the exhaust damper to keep the space pressure neutral to the rest of the Building.

Cooling Modes:
When space requires cooling it will operate in either summer cooling mode or winter cooling mode. Summer cooling mode shall occur when outside air dry-bulb temperature is above 40°F (adj.). Winter cooling mode shall occur when outside air dry-bulb temperature is below 40°F (adj.).

SUMMER COOLING MODE:
When space cooling is required, DDC shall first index the space control dampers into the following positions:

- ED-3-2-1 shall be commanded fully open.
- SD-3-2-1 shall be commanded fully open.
- RD-3-2-1 shall be commanded fully closed.

SD-3-2-1 shall be proven in position when its damper position feedback is more than 90% (adj.) open. RD-3-2-1 shall be proven in position when its damper position feedback is less than 10% (adj.) open. Allow the dampers two minutes (adj.) to prove positions. If dampers do not prove positions after this time delay, BAS shall annunciate an alarm and index these three dampers into their failed positions. Do not proceed with starting SF-3 until dampers prove position.

SF-3 Startup: After dampers are proven in position, DDC shall enable SF-3. Provide a current switch to prove SF-3 status. BAS shall annunciate an alarm if SF-3 is enabled and does not prove operation for longer than 30 seconds (adj.). Continue to enable SF-3. If later, SF-3 does prove operation the BAS shall automatically clear the SF-3 failed alarm.

SF-3 Shutdown: Unit DDC shall stop SF-3 when any of the following three conditions are true:

- When space temperature falls below 80°F (adj.).
- When the outside air dry-bulb temperature is not 5°F (adj.) cooler than the measured space temperature.

DDC shall first slow SF-3 to minimum speed. DDC shall then command the outside air damper and exhaust air damper closed. DDC shall command the return air damper fully open.

WINTER COOLING MODE:
When space cooling is required, DDC shall first index the space control dampers into the following positions:

- ED-3-2-1 shall be commanded fully open.
- SD-3-2-1 shall be commanded fully closed
- RD-3-2-1 shall be commanded fully open.

SF-3 Startup: After dampers are proven in position, DDC shall enable SF-3. Provide a current switch to prove SF-3 status. BAS shall annunciate an alarm if SF-3 is enabled and does not prove operation for longer than 30 seconds (adj.). Continue to enable SF-3. If later, SF-3 does prove operation the BAS shall automatically clear the SF-3 failed alarm.

Supply Air Temperature Control: DDC shall modulate the return air damper and outside air dampers to maintain a supply air temperature setpoint of 45°F (adj.). The return air damper and outside air dampers shall be modulated in sequence as follows:

- Outside air damper shall be modulated open first. If supply air temperature is above setpoint, modulate the outside air damper from closed to open. If supply air temperature is below setpoint, modulate outside air damper from open to closed.
- When the outside air damper is commanded fully open, and supply air temperature is still above setpoint, modulate the return air damper from open to closed. If the supply air temperature is below setpoint, modulate the return air damper from closed to open.
- DDC shall not modulate return air damper closed until outside air damper is commanded fully open.
- DDC shall not modulate outside air damper closed until return air damper is commanded fully open.

Provide an appropriate deadband around the supply temperature setpoint to prevent these dampers from hunting.

In the event the supply air temperature falls below 35°F (adj.), DDC shall immediately command the return air damper fully open and command the outside air damper fully closed. The return air damper and outside air damper shall remain in these positions for a minimum of 10 minutes (adj.). After this time delay, and the supply air temperature is above setpoint, DDC shall automatically resume modulating the outside air damper and return air damper per this sequence.

SF-3 Shutdown: Unit DDC shall stop SF-3 when space temperature falls below 80°F (adj.).

TRANSITION FROM SUMMER COOLING MODE TO WINTER COOLING MODE:
In the event SF-3 is operating, and the outside air dry-bulb temperature falls below 40°F (adj.), DDC shall automatically react as follows:

- Command the return air damper fully open.
- When the return air damper is proven more than 90% (adj.) open, command the outside air damper fully closed.
- When the outside air damper is proven less than 10% (adj.) open, DDC shall begin modulating these dampers as noted under “Supply Air Temperature Control” in WINTER COOLING MODE. The system shall be considered successfully transitioned into winter cooling mode.

TRANSITION FROM WINTER COOLING MODE TO SUMMER COOLING MODE:
In the event SF-3 is operating, and the outside air dry-bulb temperature rises above 40°F (adj.), DDC shall automatically react as follows:

- Command the outside air damper fully open.

- When the outside air damper is proven more than 90% (adj.) open, command the return air damper fully closed.
- When the return air damper is proven less than 10% (adj.) open, the system shall be considered successfully transitioned into summer cooling mode.

Miscellaneous:
BAS shall annunciate an alarm if mechanical room temperature rises above 90°F (adj.) for longer than 30 minutes (adj.). BAS shall suppress this alarm if SF-3 cannot operate because outside air temperature is not at least 5°F (adj.) cooler than the measured space temperature.

SYSTEM SHUTDOWN:
When the system is off, and is not providing heating or cooling, DDC shall command all instrumentation into the following position/states:

- SF-3 shall be disabled.
- SD-3-2-1 shall be commanded closed.
- RD-3-2-1 shall be commanded open.
- ED-3-2-1 shall be commanded closed.

SF-3 MANUAL ON/OFF TOGGLE SWITCH:
Provide a two-position toggle switch, within the DDC enclosure, for Operator to disable SF-3.

Normally this switch shall reside in the 'On' position. While this switch is in the 'On' position DDC shall start/stop SF-3 automatically per this sequence. When this switch is not in the 'On' position, BAS shall annunciate an alarm.

If this switch is placed in the 'Off' position, DDC shall immediately disable SF-3 if it is operating. While the switch is the 'Off' position, the system control dampers shall be indexed into the positions listed in SYSTEM SHUTDOWN above.

POWER OUTAGE OPERATION:
In the event of a failure of the primary electrical service, the BAS shall automatically restart SF-3 if required per this sequence.

When normal power is restored, if SF-3 is already operating it shall continue to operate. BAS shall not stop and restart the units when normal power is restored

FAN COIL UNIT CONTROL (TYPICAL)
GENERAL:
The 23 09 23 Contractor shall furnish DDC and space temperature sensor for each fan coil. Provide separate heating and cooling setpoints.

When space temperature rises above cooling setpoint, the DDC controller shall modulate the chilled water control valve from closed to open. The reverse sequence shall occur as space temperature falls below cooling setpoint.

When space temperature falls below heating setpoint, the DDC controller shall modulate the heatinghot water control valve from closed to open. The reverse sequence shall occur as space temperature rises above heating setpoint.

DDC shall start fan when cooling coil control valve or heating coil control valve is not commanded fully closed. When both control valves are commanded closed, DDC shall stop the fan. Provide current switch to prove fan status. Refer to CURRENT STATUS SWITCHES under the **GENERAL CONTROL** portion of this specification for details.

Unless noted otherwise, spaces served by fan coils shall have a cooling setpoint of 80°F (adj.). BAS shall annunciate an alarm if space temperature rises 5°F (adj.) above cooling setpoint for longer than 30 minutes (adj.).

Unless noted otherwise, spaces served by fan coils shall have a heating setpoint of 60°F (adj.). BAS shall annunciate an alarm if space temperature falls 5°F (adj.) below heating setpoint for longer than 30 minutes (adj.).

POWER OUTAGE OPERATION:

Fan coils will be connected to standby power.

In the event of a failure of the primary electrical service, the BAS shall automatically restart a fan coil if required per this sequence.

When normal power is restored, if a fan coil is already operating it shall continue to operate. BAS shall not stop and restart fan coil when normal power is restored.

CABINET UNIT HEATER CONTROL (NON-DDC CONTROL)

This sequence applies to individual unit heater/cabinet unit heater control. This sequence does not apply where unit heaters are used indexed on/off with 23 09 23 DDC.

Provide an electric space thermostat to control the control valve to maintain space temperature. Provide a strap on aquastat mounted on the hot water return line set at 100º F to control the unit fan when hot water temperature is above setpoint.

PLUMBING EQUIPMENT MONITORING

SUMP PUMPS:

Several sump pumps shall be provided for elevator sumps and the steam tunnel. Each pump skid is controlled via a factory provided controller. Factory provided controller will include float(s) which will start/stop pumps based on water level within the sump/pit.

The factory packaged controller shall include general fault dry contact for BAS monitoring. The fault contact is activated if a high level float alarm is generated. If this contact is activated the BAS shall annunciate an alarm.

MISCELLANEOUS PACKAGED CONTROLS:

Several new factory packaged skids are provided to support the new plumbing systems shown on the P-series drawings. These skids will each include factory-productive controllers. These controllers shall have general fault dry contacts for BAS monitoring. BAS shall monitor these contacts and if they are activated the BAS shall annunciate an alarm. BAS shall monitor the following general alarm contacts:

- High Purity Water Skid
- Lab Vacuum Pump Skid
- Nitrogen Generator (N2GEN-1)
- Air Compressor (AC-3)
- Air Compressor (AC-4)

PLUMBING TEMPERED WATER CONTROL

GENERAL:

Refer to Sheet P7.01. This Project connects to the existing temper water system. The existing temper water system is extended from the basement level up to Level 2 of this Project

The 23 09 23 Contractor shall furnish a two-position ball valve, which shall be installed on Level 2 as shown on Sheet P7.01. Provide a fail closed actuator on this ball valve. BAS shall monitor temperature and pressure immediately upstream of this ball valve.

- When temperature falls below 75°F (adj.), BAS shall command the tempered water two-position ball valve open.
- When temperature rises above 80°F (adj.), BAS shall command the tempered water two-position ball valve closed.
- BAS shall annunciate an alarm if the tempered water falls below 70°F (adj.) for longer than 15 minutes (adj.).
- BAS shall annunciate an alarm if the tempered water rises above 88°F (adj.) for longer than 15 minutes (adj.).
- Monitor the ball valve open position end switch.
    - If ball valve is commanded open, but open position switch does not prove open for longer than 2 consecutive minutes (adj.), the BAS shall annunciate an alarm.
    - If ball valve is commanded closed, but open position switch is still proven, for longer than 2 consecutive minutes (adj.), the BAS shall annunciate an alarm.

If tempered water pressure falls below 30 psig (adj.), for longer than five minutes (adj.), the BAS shall annunciate an alarm.

FIRE/SMOKE DAMPER MONITORING

The DDC system shall monitor the open end switch of each fire/smoke damper. Whenever one of these dampers is not proven open, the BAS shall annunciate an alarm notifying which damper has closed and where it is located.

Refer to 23 09 15 for list of fire/smoke dampers that shall have their open end switch monitored. These switches may be hardwired to spare I/O on air terminal DDCs. Indicate which DDCs these switches are wired to in submittals.

ROOM HVAC CONTROL

GENERAL:

Unless noted otherwise, these “GENERAL” sequences shall be applied to all room HVAC controls.

Refer to Sheets M7.10 and M7.11 for typical diagrams. Each diagram is identified with a letter (A, B, C, etc.). Refer to mechanical sheets for “Supply and Exhaust Air Terminal Units” schedules. These schedules indicate which letter should be applied to each air terminal.

Space temperature and ventilation control shall be accomplished by DDC Variable Air Volume (VAV) controllers with electric actuation. All DDC shall be provided by 23 09 23. All DDC controls serving air terminal units shall be on emergency power as detected by contacts on the automatic transfer switch. DDC control panels shall be reinitialized before supply and exhaust fans are to signal restart.

VAV Control: Provide a DDC space temperature sensor to control, in sequence, a modulating electronic control valve for the hot water reheat coil and actuator for terminal air flow. When space temperature is above cooling setpoint, the supply air terminal damper shall modulate toward the cooling maximum flow position. When space temperature is below cooling setpoint, the air terminal damper shall modulate toward the cooling minimum flow position. After the air terminal damper is at its minimum flow, and space temperature falls below heating setpoint, the hot water valve shall modulate open to maintain space heating setpoint. The reverse shall occur when space temperature rises above heating setpoint. The heating coil valve shall be commanded closed whenever the associated AHU is off. When the space temperature is between the heating and cooling setpoints, the heating valve shall be closed and the supply airflow shall remain at cooling minimum flow. The reheat coil valve shall be limited in opening to prevent the discharge air temperature leaving the air terminal from exceeding 90ºF (adj.). Where a space is scheduled with the same occupied maximum and occupied minimum cfm, heating and cooling setpoints shall be controlled via the reheat control valve only.

- Where there are multiple supply air terminals, serving one space, DDC shall control supply airflows based on a single percentage flow output command. If supply air terminals do not have the same min/max flow values, operating at same percent output will ensure equal distribution of supply air.
- Where there are multiple supply air terminals, serving one space, DDC shall maintain the same discharge air temperature (DAT) from every supply air terminal. As space temperature falls below heating setpoint, DDC shall increase the DAT setpoint of all supply air terminals in unison. As space

temperature rises above heating setpoint, DDC shall decrease the DAT setpoint of all supply air terminals in unison. Note, this requirement only applies for space heating. When increasing airflow, for space cooling, the reheat control valves shall remain closed.

- Each zone shall utilize a single BACnet/IP DDC controller for control. This controller shall directly hardwire all required I/O to the air terminals, control valves, and associated instrumentation serving the zone. Provide I/O expansion modules as required to accommodate all points. Multiple DDC controllers within a single zone shall not be permitted. Control setpoints, commands, or other control functions shall not be exchanged between multiple zone controllers via the BACnet/IP network to achieve zone control.

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

Grouping of Terminals:
Provide a dynamically adjustable group assignment point for each terminal unit zone and a point that can be weekly scheduled for each group. Provide a minimum of one group per ten terminal unit zones (all groups do not need to be used). For large groups of terminals that are desired to be scheduled together (>10 terminals or 20% of the system flow, whichever is less), provide an adjustable delay timer set initially at one minute intervals, to stage on or off subsets of terminals within the groups to prevent nuisance static or freezestat safety trips. An alternative would be to provide separate groups that are smaller that would be scheduled slightly apart to avoid nuisance trips. Feature software provided in the DDC system that accomplishes the above stated intent of grouping terminals for scheduling is acceptable. Grouping of the time of day schedules for the rooms shall be verified and documented with the agency and shall be provided prior to occupancy of the facility.

Occupancy Modes:
Refer to air terminal schedules to determine if a zone DDC is to hardwire to an occupancy sensor. The air terminal schedule includes a column which indicates if the zone DDC is to be hardwired to an occupancy sensor. For zones that have multiple occupancy sensors, the Contractor shall wire to all of the zone's occupancy sensors to a single contact on the 23 09 23 DDC. The 23 09 23 Contractor shall wire occupancy sensors so that if any one occupancy sensor is activated (senses occupancy) the signal to the DDC is toggled.

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

When a zone is scheduled occupied and the occupancy sensor senses occupants in the zone, the zone shall be in the occupied mode. The occupied temperature and minimum air flow setpoints shall be used in the occupied mode. When the zone is scheduled to be occupied and the occupancy sensor determines the zone does not have occupants, the terminal unit mode shall be indexed to standby mode. The default setpoints for the standby mode shall have ±2ºF setup/setback from the occupied setpoints and the minimum air flow setpoints shall be the scheduled unoccupied air flow setpoints.

When a zone is scheduled unoccupied and the occupancy sensor detects occupants, the zone shall be in the occupied mode. The occupied temperature and occupied minimum air flow setpoints shall be used. When the space is scheduled to be unoccupied and the occupancy sensor determines the zone does not have occupants, the terminal unit mode shall be indexed to unoccupied mode. The default setpoints for the unoccupied mode shall have ±6ºF setup/setback from the occupied temperature setpoints, and the minimum air flow setpoints shall be the scheduled unoccupied minimum air flow setpoints.

If time of day scheduling is not done, then the zone shall only use the occupied and standby modes.

Prior to programming the terminal units, the 23 09 23 Contractor shall meet with the Owner and the Owner shall provide a list of spaces where deviations from the default setpoints and time of day scheduling are needed. These setpoints shall be used in the final programming and archived to the BAS server.

Zone Failure Mode: The air terminal schedules include a “Failure Mode CFM” for each air terminal. These failure airflows shall be utilized in the future.

When this Project is completed there will be sufficient supply airflow and exhaust airflow redundancy. There isn’t a need to index all air terminals to a reduced airflow (a.k.a failure mode airflow). The 23 09 23 Contractor shall program the new air terminal DDCs to have a failure airflow, but the BAS shall not index air terminals to failure airflow. Failure airflow rates shall be utilized after the Level 1 and Level 2 shell spaces are fully constructed into occupied zones.

Note for future, when the BAS indexes an air terminal into failure mode, the air terminal shall modulate to maintain its scheduled failure CFM. The air terminal shall continue to maintain this failure airflow until the conditions that prompted the failure CFM are resolved. When the failure condition is resolved the BAS shall automatically index the air terminal to resume normally scheduled occupied/standby/unoccupied operation. The BAS shall continuously evaluate the operating status of fans and dampers to determine if the failure condition is resolved.

Note the following additional operating criteria when in failure mode.

- If an air terminal has a scheduled failure CFM of zero (0), then command the air terminal fully closed.
- When a supply air terminal is commanded to its scheduled failure CFM, continue modulating the reheat coil control valves to maintain space heating setpoint.

Airflow Mode Control: In the occupied mode and standby mode, the zone air terminals shall modulate between the minimum occupied and maximum occupied flow rates as scheduled in the Supply and Exhaust Air Terminal Units schedule. In the unoccupied mode, the zone air terminals shall modulate between the unoccupied flow rate and the maximum occupied flow rate as specified in the Air Terminal Schedules except as required for unoccupied heating control.

In unoccupied mode, if a zone air terminal is scheduled with an unoccupied flow rate of zero, the air terminal shall be commanded fully closed if the zone is between active heating and cooling setpoints.

In failure mode (future) air terminals shall modulate to maintain a constant scheduled failure CFM and shall maintain these airflows until failure mode has been deactivated. All airflow setpoints shall be adjustable.

Unoccupied Heating Control: If the space temperature falls below the unoccupied zone heating setpoint and the VAV terminal unoccupied airflow setpoint is zero CFM, the VAV terminal shall be indexed to the occupied minimum airflow and the heating valve controlled to maintain the VAV terminal discharge at the discharge air temperature limit control setpoint. When the space temperature rises 2º F (adj.) above the unoccupied space temperature setpoint, the VAV terminal damper and heating valve shall close.

Failure Mode Heating Control (Future): If the air terminal unit is indexed into failure mode, the air terminal shall maintain its scheduled failure CFM, regardless of space temperature. If space temperature falls below heating setpoint and the VAV terminal failure airflow setpoint is zero CFM, nothing shall occur. If the air terminal unit has a failure mode CFM that is not zero CFM, then modulate the reheat coil control valve to maintain heating setpoint.

Unoccupied Cooling Control:
If the space temperature rises above the unoccupied zone cooling setpoint, and the VAV terminal unoccupied airflow setpoint is zero CFM, the VAV terminal shall be indexed to the scheduled occupied maximum airflow. VAV terminal shall remain at occupied maximum airflow until the space temperature falls 2ºF (adj.) below the unoccupied space cooling setpoint. At this point, the VAV terminal damper shall be commanded fully closed.

Failure Mode Cooling Control (Future): If the air terminal unit is indexed into failure mode, the air terminal shall maintain its scheduled failure CFM, regardless of space temperature. If space temperature rises above cooling setpoint the VAV terminal failure airflow shall not be altered.

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

In the unoccupied mode, the unoccupied zone temperature heating and cooling setpoints shall be maintained. In the failure mode, temperature setpoints shall continue to be in occupied, standby, or unoccupied depending on time of day schedule and feedback of lighting occupancy sensor.

Temperature setpoints listed below shall be the default occupied setpoints, but all setpoints shall be verified and documented with the agency prior to programming the air terminal DDC controllers. Refer to "Occupancy Modes:", listed above, for how to reset space temperature setpoints in standby and unoccupied modes.

Space	Mode	Occ. Temp. Setpoint (°F)
Office, Conference, Storage, and Classrooms	Cooling	76
	Heating	68
Corridors, Lobbies, Rest Rooms, and Break Rooms	Cooling	76
	Heating	68
Laboratory & Laboratory Support Rooms	Cooling	72
	Heating	70
Cyclotron Rooms	Cooling	72
	Heating	70
Cleanrooms (ISO 7 & ISO 8)	Cooling	72
	Heating	70
Electrical Rooms and Elevator Machine Rooms	Cooling	85
	Heating	60
Future Spaces (Shell Spaces)	Cooling	85
	Heating	60
Mechanical Rooms	Cooling	85
	Heating	60
Telecommunication/IDF Rooms	Cooling	72
	Heating	(Not Required)

Unless otherwise noted, BAS shall annunciate an alarm when space temperatures deviate from setpoint. Utilize the following for default alarm criteria:

- Alarm if space temperature rises +5ºF (adj.) above active cooling setpoint for longer than 15 minutes (adj.)
- Alarm if space temperature falls -5ºF (adj.) below active heating setpoint for longer than 15 minutes (adj.).

Space temperature alarms shall be low level in importance. Coordinate with User which temperature alarms shall result in texts/emails.

Volume Matching:
Where volume offsets are specified in the Supply and Exhaust Air Terminal Units schedules, the total zone supply and exhaust airflows shall be summed and controlled to maintain the scheduled offset at all times.

- Typically, the general exhaust air flow shall track the supply airflow to maintain the offset if the supply air terminal is controlling to maintain temperature and exceeds the exhaust airflow plus the positive or negative offset in the zone.
- The supply air flow shall track the exhaust airflow to maintain the offset if the exhaust airflow exceeds the supply airflow plus the positive or negative offset. If the general exhaust valve reaches its maximum scheduled air flow, the supply terminal shall be limited from increasing airflow to maintain the scheduled offset. This will be required for rooms where supply terminal maximum airflows are exhaust driven rather than cooling driven. See detailed volume matching sequences in the numbered lab terminal unit sequences below.

Two-Position Fume Hood Control:
Fume hoods shall be indexed to occupied maximum airflow or occupied minimum airflow by a presence sensor mounted on the hood that detects a User in front of the fume hood. Fume hood presence sensors shall be provided by 23 09 23 Contractor. Refer to Section 23 09 14 for presence sensor requirements.

- Program the fume hood presence sensor to have a 5 second (adj.) delay between generating contact closures when sensing presence. Once the presence sensor contact closures are made, the DDC shall immediately initiate the "Inactive to Active Fume Hood Switching" sequence.
- To prevent excessive cycling of the air terminal, when the fume hood presence sensor does not detect occupancy in front of the hood, a DDC inactive delay timer of 10 minutes (adj.) shall expire before the DDC initiates the "Active to Inactive Fume Hood Switching" sequence.

The 23 09 23 Contractor shall provide a control relay, with LED, on the face of the fume hood. When the presence sensor has detected occupancy the 23 09 23 DDC shall activate the relay and LED shall provide visual verification that occupancy has been detected. The relay output contacts shall be hardwired to the fume hood monitor. Refer to 'Fume Hood Monitor' requirements below.

If the fume hood is scheduled with an unoccupied minimum airflow, that is different from the occupied minimum airflow, the fume hood shall operate at this lower airflow when all the following conditions are proven true:

1. The space is scheduled as unoccupied.
2. The space occupancy sensor, if present, indicates no one is in the space.
3. The fume hood presence sensor does not indicate anyone is present.

In failure mode, the fume hood air terminal shall modulate to maintain a constant scheduled failure CFM, and shall maintain this airflow until failure mode has been deactivated. All airflow setpoints shall be adjustable.

Fume Hood Air Terminal Wiring:
The command signal (AO) for all fume hood exhaust air terminals shall originate from the zone DDC controller. Do not hardwire the fume hood zone presence sensor directly to the exhaust air terminal serving the fume hood. The DDC controller shall directly control fume hood exhaust rates, along with supply air make-up rates, to control space pressurization.

Inactive to Active Fume Hood Switching:
Upon sensing a person in front of the fume hood by the presence sensor, the fume hood exhaust air valve shall be indexed to maximum occupied CFM. The supply and/or exhaust air terminals shall immediately be indexed and control to the calculated airflows required to maintain the zone offset airflow. This will result in the zone becoming slightly more negative until the supply and/or general exhaust reach their control setpoint.

Active to Inactive Fume Hood Switching:
Upon sensing that there is not a person in front of the fume by the presence sensor and after the inactive delay timer has expired, the supply air terminal shall be indexed and controlled to the calculated airflow required to maintain the zone offset airflow. After a delay of 20 seconds, the fume hood shall be indexed and controlled to its minimum occupied CFM. This will result in the zone becoming slightly more negative while the supply and/or general exhaust reach their control setpoint and before the fume hood is at its inactive airflow.

Fume Hood Monitor:
For two-position fume hoods, monitors shall be provided by fume hood vendor (11 53 13). Refer to 11 53 13 for low face velocity alarm setpoints when fume hood is occupied.

As noted above, fume hood control relay outputs shall be hardwired to the fume hood monitor. When the 23 09 23 DDC switches from active to inactive, the 23 09 23 DDC shall de-activate the control relay. The control relay contacts shall then open. When the relay contacts are open, the fume hood monitor low velocity alarm setpoint shall be setup (raised higher). This setup value shall ensure the fume hood monitor to alarm if the sash is not fully closed. Coordinate with the 11 53 13 manufacturer on the programming of this setup velocity

Constant Volume Point Exhaust Control:
Snorkels, thimble exhausts, ventilated balance enclosures, etc. shall be considered point exhausts. These exhaust air terminals will have low speed electronic actuators.

In occupied mode, exhaust air terminal shall maintain the scheduled constant occupied exhaust rate.

In unoccupied modes, the exhaust air terminal shall maintain the scheduled constant unoccupied exhaust rate.

When these air terminals are in Failure Mode, the exhaust air terminal shall maintain the scheduled constant failure exhaust rate.

ROOM CONTROL SEQUENCE A – VARIABLE VOLUME SUPPLY WITH REHEAT, GENERAL EXHAUST AIR TRACKING, AND FLAMMABLE GAS DETECTION (CYCLOTRON ROOMS)
All air terminals shall be provided by Mechanical Contractor. Refer to 23 36 00. All DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

DDC shall not monitor lighting occupancy sensors. Space cooling and heating setpoint shall remain constant and not reset based on occupancy. Space minimum airflow rates shall not be reset either.

DDC controller shall utilize airflow sensor in supply air terminal and exhaust air terminal to continuously measure airflow rates.

Install space temperature sensor in exhaust air duct, so it is outside of the cyclotron space. DDC shall modulate in sequence supply air valve and reheat coil control valve to maintain space temperature setpoint. Space cooling shall be controlled by modulating the supply airflow from minimum to maximum flow rate. Space heating shall be controlled by modulating supply air to minimum airflow setpoint and modulating reheat control valve. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details of space temperature control under occupied, standby, unoccupied, and failure mode.

The general exhaust air terminal airflow setpoint shall be calculated by adding the measured supply airflow to the scheduled airflow offset CFM (adj.). The general exhaust air terminal shall be controlled to maintain this calculated general exhaust airflow setpoint down to the scheduled minimum airflow.

Flammable Gas Detection:
A flammable gas cabinet shall be provided, by Others, for each cyclotron. Flammable gas cabinet shall be installed outside of the cyclotron. Flammable gas cabinet shall include factory provided flammable gas (LEL) detector. This gas detector shall be hardwired to flammable gas cabinet control panel. Flammable gas cabinet control panel shall include a relay contact which toggles when internal lower explosive limit exceeds 20%. DDC shall monitor this contact.

The 23 09 23 Contractor shall provide an additional flammable gas detector for detection of flammable gas leakage within the cyclotron room. This flammable gas detector shall be installed outside of the cyclotron room, and will utilize an internal vacuum pump to sample space air above the cyclotron. The 23 09 23 provided gas detector shall include a relay contact which toggles when internal lower explosive limit exceeds 20%. DDC shall monitor this contact.

A single fire alarm monitoring module shall be provided near each flammable gas cabinet. The activation of the flammable gas cabinet alarm relay or the 23 09 23 Contractor provided gas detector alarm relay shall activate the fire alarm monitoring module. The 23 09 23 Contractor shall provide all interposing relays necessary to implement this function.

The 23 09 23 Contractor shall provide a local horn/strobe, outside of the cyclotron, to alert Users when detected flammable gas exceeds 20% LEL. Local horn/strobe shall include a red LED and a green LED.

- If none of the gas detector alarm relays are activated the green LED shall be energized, the red LED shall be extinguished, and the horn shall be silenced.
- If either of the gas detector alarm relays are activated the green LED shall be extinguished, the red LED shall be activated, and the horn shall be annunciated.

ROOM CONTROL SEQUENCE B – VARIABLE VOLUME SUPPLY WITH REHEAT, WITH/WITHOUT CONSTANT VOLUME POINT EXHAUSTS, GENERAL EXHAUST AIR TRACKING, AND FAN POWERED HEPA FAN FILTER UNITS (HOT CELL ROOMS)
All air terminals (butterfly and venturi) shall be provided by Mechanical Contractor. Venturi air terminals shall include factory provided air terminal actuator and exhaust flow feedback signals. Refer to 23 36 00. All remaining DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

DDC shall not monitor lighting occupancy sensors. Space cooling and heating setpoint shall remain constant and not reset based on occupancy. Space minimum airflow rates shall not be reset either.

DDC controller shall utilize airflow sensor in supply air terminal and exhaust air terminal to continuously measure airflow rates.

Refer to CONSTANT VOLUME POINT EXHAUST, under the **ROOM HVAC CONTROL** GENERAL portion of this sequence, for how the constant volume point exhaust air terminal is to be controlled. Hot cells shall be exhausted with constant volume point exhausts.

Provide space temperature sensor. DDC shall modulate in sequence supply air valve and reheat coil control valve to maintain space temperature setpoint. Space cooling shall be controlled by modulating the supply airflow from minimum to maximum flow rate. Space heating shall be controlled by modulating supply air to minimum airflow setpoint and modulating reheat control valve. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details of space temperature control under occupied, standby, unoccupied, and failure mode.

The general exhaust air terminal airflow setpoint shall be calculated by adding the measured supply airflow to the scheduled airflow offset CFM (adj.) and minus other lab exhaust (i.e., snorkels, hot cells, etc.) flow values. The general exhaust air terminal shall be controlled to maintain this calculated general exhaust airflow setpoint down to the scheduled minimum airflow.

HEPA Fan Filter Unit:
Fan filter units act as a fan power supply air diffusers for the zone. Multiple fan filter units shall be provided in each space. Fan filter units shall be provided by Division 23 Contractor and shall include factory provided DDC controller.

Factory controller shall modulate its ECM fan to provide constant volume flow rate.

The 23 09 23 Contractor shall monitor each HEPA fan filter unit via BACnet IP communication. HEPA filter unit manufacturer shall provide single controller for monitor/control of HEPA filter unit. Refer to drawing M7.01 and specification 23 73 13 for details on BAS integration.

Refer to 23 09 15 for all points/alarms.

Hot Cell Booster Exhaust Fan:
The project includes a booster exhaust fan per hot cell line. The 23 09 23 Contractor shall provide a 4-20 mA analog signal to the hot cell electrical cabinet. The DDC shall control this signal as follows:

- When any of the cyclotron exhaust fans (EF-66A / EF-66B / EF-66C) are operating above minimum speed, the DDC shall generate the analog signal. The 23 09 23 Contractor shall coordinate with the TAB Contractor to determine the required analog signal. The analog signal shall set the booster fan speed which generates the required hot cell exhaust rate.

- When none of the cyclotron exhaust fans are operating above minimum speed, the DDC shall disable the analog signal to the booster exhaust fan. This will turn the hot cell booster fan off.

ROOM CONTROL SEQUENCE C – VARIABLE VOLUME SUPPLY WITH REHEAT, WITH/WITHOUT CONSTANT VOLUME POINT EXHAUSTS, GENERAL EXHAUST AIR TRACKING, AND HEPA FAN FILTER UNITS
All air terminals (butterfly and venturi) shall be provided by Mechanical Contractor. Venturi air terminals shall include factory provided air terminal actuator and exhaust flow feedback signals. Refer to 23 36 00. All remaining DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

DDC shall not monitor lighting occupancy sensors. Space cooling and heating setpoint shall remain constant and not reset based on occupancy. Space minimum airflow rates shall not be reset either.

DDC controller shall utilize airflow sensor in supply air terminal and exhaust air terminal to continuously measure airflow rates.

Refer to CONSTANT VOLUME POINT EXHAUST, under the **ROOM HVAC CONTROL** GENERAL portion of this sequence, for how the constant volume point exhaust air terminal is to be controlled. Note, not all rooms will have constant volume point exhausts. Refer to mechanical floor plans and schedules to determine if these are required.

Provide space temperature sensor. DDC shall modulate in sequence supply air valve and reheat coil control valve to maintain space temperature setpoint. Space cooling shall be controlled by modulating the supply airflow from minimum to maximum flow rate. Space heating shall be controlled by modulating supply air to minimum airflow setpoint and modulating reheat control valve. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details of space temperature control under occupied, standby, unoccupied, and failure mode.

The general exhaust air terminal airflow setpoint shall be calculated by adding the measured supply airflow to the scheduled airflow offset CFM (adj.) and minus other lab exhaust (i.e., snorkels, hot cells, etc.) flow values. The general exhaust air terminal shall be controlled to maintain this calculated general exhaust airflow setpoint down to the scheduled minimum airflow.

HEPA Fan Filter Unit:

Fan filter units act as a fan power supply air diffusers for the zone. Multiple fan filter units shall be provided in each space. Fan filter units shall be provided by Division 23 Contractor and shall include factory provided DDC controller.

Factory controller shall modulate its ECM fan to provide constant volume flow rate.

The 23 09 23 Contractor shall monitor each HEPA fan filter unit via BACnet IP communication. HEPA filter unit manufacturer shall provide single controller for monitor/control of HEPA filter unit. Refer to drawing M7.01 and specification 23 73 13 for details on BAS integration.

Refer to 23 09 15 for all points/alarms.

ROOM CONTROL SEQUENCE D – VARIABLE VOLUME SUPPLY WITH REHEAT, WITH/WITHOUT CONSTANT VOLUME POINT EXHAUSTS, AND GENERAL EXHAUST AIR TRACKING

All air terminals (butterfly and venturi) shall be provided by Mechanical Contractor. Venturi air terminals shall include factory provided air terminal actuator and exhaust flow feedback signals. Refer to 23 36 00. All remaining DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

DDC controller shall utilize airflow sensor in supply air terminal and exhaust air terminal to continuously measure airflow rates.

Refer to CONSTANT VOLUME POINT EXHAUST, under the **ROOM HVAC CONTROL** GENERAL portion of this sequence, for how the constant volume point exhaust air terminal is to be controlled. Note, not all rooms will have constant volume point exhausts. Refer to mechanical floor plans and schedules to determine if these are required.

Provide space temperature sensor. DDC shall modulate in sequence supply air valve and reheat coil control valve to maintain space temperature setpoint. Space cooling shall be controlled by modulating the supply airflow from minimum to maximum flow rate. Space heating shall be controlled by modulating supply air to minimum airflow setpoint and modulating reheat control valve. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details of space temperature control under occupied, standby, unoccupied, and failure mode.

The general exhaust air terminal airflow setpoint shall be calculated by adding the measured supply airflow to the scheduled airflow offset CFM (adj.) and minus other lab exhaust (i.e., snorkels, hot cells, etc.) flow values. The general exhaust air terminal shall be controlled to maintain this calculated general exhaust airflow setpoint down to the scheduled minimum airflow.

ROOM CONTROL SEQUENCE E – VARIABLE VOLUME SUPPLY WITH REHEAT

All air terminals shall be provided by Mechanical Contractor. Refer to 23 36 00. All remaining DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

DDC controller shall utilize airflow sensor in supply air terminal to continuously measure airflow rates.

Provide space temperature sensor. DDC shall modulate in sequence supply air valve and reheat coil control valve to maintain space temperature setpoint. Space cooling shall be controlled by modulating the supply airflow from minimum to maximum flow rate. Space heating shall be controlled by modulating supply air to minimum airflow setpoint and modulating reheat control valve. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details of space temperature control under occupied, standby, unoccupied, and failure mode.

ROOM CONTROL SEQUENCE F – TWO-POSITION FUME HOOD EXHAUST, WITH/WITHOUT CONSTANT POINT EXHAUST, AND VAV SUPPLY AIR TRACKING WITH REHEAT

All air terminals (butterfly and venturi) shall be provided by Mechanical Contractor. Venturi air terminals shall include factory provided air terminal actuator and exhaust flow feedback signals. Refer to 23 36 00. All remaining DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

Refer to TWO-POSITION FUME HOOD CONTROL, under the **ROOM HVAC CONTROL** GENERAL portion of these sequences, for how the fume hood exhaust air terminals are to be controlled.

Refer to CONSTANT VOLUME POINT EXHAUST, under the **ROOM HVAC CONTROL** GENERAL portion of this sequence, for how the constant volume point exhaust air terminal is to be controlled. Note, not all rooms will have constant volume point exhausts. Refer to mechanical floor plans and schedules to determine if these are required.

Provide space temperature sensor. DDC shall modulate reheat coil control valves to maintain space temperature heating setpoint. Space will have multiple supply air terminals. As reheat coil control valves are being modulated, DDC shall maintain the same discharge air temperature (DAT) from each supply air terminal. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details.

The supply air terminal airflow setpoint shall be calculated by adding all measured exhaust airflow to the scheduled airflow offset CFM (adj.). The supply air terminal shall be controlled to maintain this calculated supply airflow setpoint down to the scheduled minimum airflow. Space will have multiple supply air terminals. As supply air terminals are modulating airflow, they shall be modulated at the same percent output. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details.

ROOM CONTROL SEQUENCE G – VARIABLE VOLUME SUPPLY WITH NO REHEAT, AND GENERAL EXHAUST AIR TRACKING
All air terminals shall be provided by Mechanical Contractor. Refer to 23 36 00. All remaining DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

DDC controller shall utilize airflow sensor in supply air terminal and exhaust air terminal to continuously measure airflow rates.

Provide space temperature sensor. DDC shall modulate in sequence supply air valve and reheat coil control valve to maintain space temperature setpoint. Space cooling shall be controlled by modulating the supply airflow from minimum to maximum flow rate. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details of space temperature control under occupied, standby, unoccupied, and failure mode.

Space heating shall be controlled by modulating supply air to minimum airflow setpoint when space falls below heating setpoint. Supply air terminal shall not have a reheat coil. The space should have sufficient equipment heat loss that a reheat coil should never be needed. In the event the supply air terminal is maintaining scheduled minimum airflow setpoint, and space temperature continues to fall below heating setpoint, nothing shall occur.

The general exhaust air terminal airflow setpoint shall be calculated by adding the measured supply airflow to the scheduled airflow offset CFM (adj.). The general exhaust air terminal shall be controlled to maintain this calculated general exhaust airflow setpoint down to the scheduled minimum airflow.

ROOM CONTROL SEQUENCE H – CONSTANT VOLUME EXHAUST
All air terminals shall be provided by Mechanical Contractor. Refer to 23 36 00. All remaining DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

DDC controller shall utilize airflow sensor in exhaust air terminal to continuously measure airflow rates. The air terminal DDC controller shall maintain a constant occupied airflow quantity as scheduled.

ROOM CONTROL SEQUENCE I – VARIABLE VOLUME SUPPLY WITH REHEAT, GENERAL EXHAUST AIR TRACKING, AND UNIT HEATERS
All air terminals shall be provided by Mechanical Contractor. Refer to 23 36 00. All remaining DDC, control valves, actuators, and instrumentation shall be furnished by 23 09 23 Contractor.

DDC shall not monitor lighting occupancy sensors. Space cooling and heating setpoint shall remain constant and not reset based on occupancy. Space minimum airflow rates shall not be reset either.

DDC controller shall utilize airflow sensor in supply air terminal and exhaust air terminal to continuously measure airflow rates.

Provide space temperature sensor. (Due to the large size of the shell space, there may be several temperature sensors. Refer to mechanical floor plans for quantities. If space has multiple temperature sensors, DDC shall average their readings for control.) DDC shall modulate in sequence supply air valve and reheat coil control valve to maintain space temperature setpoint. Space cooling shall be controlled by modulating the supply

airflow from minimum to maximum flow rate. Space heating shall be controlled by modulating supply air to minimum airflow setpoint and modulating reheat control valve. Refer to 'VAV Control' sequence listed under **ROOM HVAC CONTROL** GENERAL sequences for details of space temperature control under occupied, standby, unoccupied, and failure mode.

The general exhaust air terminal airflow setpoint shall be calculated by adding the measured supply airflow to the scheduled airflow offset CFM (adj.). The general exhaust air terminal shall be controlled to maintain this calculated general exhaust airflow setpoint down to the scheduled minimum airflow.

Unit Heaters:
Hot water unit heaters provide supplemental heat to maintain space heating setpoint. This sequence only applies to unit heaters in future space (shell space).

Hot water unit heaters shall be indexed to operate when space temperature falls 5°F (adj.) below space heating setpoint. For shell spaces, the space heating setpoint should be 60°F. If so, unit heaters shall operate when space temperature falls below 55°F. When this occurs, DDC shall command open all unit heater hot water control valves. The 23 09 23 Contractor shall provide strap on aquastat mounted on the hot water return line set at 100º F to start the unit fan when hot water temperature is above setpoint.

When space temperature rises above 59°F (adj.), DDC shall command the unit heater hot water control valves closed.

Provide a current switch to monitor the status of each unit heater fan. If the unit heater's control valve is commanded open, and a unit heater's fan does not prove status within 2 minutes (adj.) the BAS shall annunciate an alarm. If the unit heater's control valve is commanded closed, and fan continues to operate for 60 minutes (adj.), after control valve has been commanded closed, BAS shall annunciate an alarm that fan is not disabled even though hot water flow has been shut-off.

BAS shall annunciate an alarm if the mechanical room temperature falls below 50°F (adj.) for longer than 10 minutes (adj.).

FUNCTIONAL PERFORMANCE TESTING
Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01 or 01 91 02.

END OF SECTION

SECTION 23 22 13
STEAM AND CONDENSATE HEATING PIPING
BASED ON DFD MASTER SPECIFICATION DATED 12/20/2023

P A R T 1 - G E N E R A L

SCOPE
This section contains specifications for steam and condensate heating piping for this project. Included are the following topics:

RELATED WORK
Section or 01 91 02 - Commissioning Process
Section 23 05 23 - General-Duty Valves for HVAC Piping
Section 23 05 15 - Piping Specialties
Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
Section 23 07 00 - HVAC Insulation
Section 23 08 00 - Commissioning of HVAC
Section 23 25 00 - HVAC Water Treatment.

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

REFERENCE STANDARDS
ANSI B16.4	Cast Iron Threaded Fittings
ANSI B16.5	Pipe Flanges and Flanged Fittings
ASTM A53	Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless
ASTM A105	Forgings, Carbon Steel, for Piping Components
ASTM A126	Gray Cast Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A234	Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

ASTM A380 Practice for Cleaning and Descaling Stainless Steel Parts, Equipment, and Systems

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Contractor shall submit schedule indicating the ASTM specification number of the pipe being proposed along with its type and grade and sufficient information to indicate the type and rating of fittings for each service.

TYPE F STEEL PIPE:
Statement from manufacturer on his letterhead that the pipe furnished meets the ASTM specification contained in this section.

TYPE E OR S STEEL PIPE:
Mill certification papers, also known as material test reports, for the pipe furnished for this project, in English. Heat numbers on these papers to match the heat numbers stenciled on the pipe. Chemical analysis indicated on the mill certification papers to meet or exceed the requirements of the referenced ASTM specification.

QUALITY ASSURANCE
Order all Type E and Type S steel pipe with heat numbers rolled, stamped, or stenciled to each length or each bundle, depending on the size of the pipe, and in accordance with the appropriate ASTM specification.

Any installed material not meeting the specification requirements must be replaced with material that meets these specifications without additional cost to the Owner.

DELIVERY, STORAGE, AND HANDLING
Promptly inspect shipments to insure that the material is undamaged and complies with specifications.

Cover pipe to eliminate rust and corrosion while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Where end caps are provided or specified, take precautions so the caps remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.

Offsite storage agreements will not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

DESIGN CRITERIA
Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM specifications as listed in this specification.

Construct all piping for the highest pressures and temperatures in the respective system in accordance with ANSI B31, but not less than 125 psig unless specifically indicated otherwise.

Where weld fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters.

Where ASTM A53 type F pipe is specified, ASTM A53 grade A type E or S, or ASTM A53 grade B type E or S may be substituted at Contractor's option. Where ASTM A53 grade A pipe is specified, ASTM A53 grade B pipe may be substituted at Contractor's option. Where the grade or type is not specified, Contractor may choose from those commercially available.

WELDER QUALIFICATIONS
Welding procedures, welders, and welding operators for all building service piping and steam piping less than or equal to 15 psig to be in accordance with certified welding procedures of the National Certified Pipe Welding Bureau.

Welding procedures, welders, and welding operators for all steam system piping at service pressures above 15 psig to be qualified complying with the provisions of the latest revision of ANSI/ASME B 31.1-Power Piping or Section IX of the ASME Boiler and Pressure Vessel Code for boiler external piping.

Before any metallic welding is performed, Contractor to submit his Standard Welding Procedure Specification together with the Procedure Qualification Record as required by Section IX of the ASME Boiler and Pressure Vessel Code and/or the National Certified Pipe Welding Bureau.

The A/E or Owner reserves the right to test the work of any welder employed on the project, at the Contractor's expense. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project.

PART 2 - PRODUCTS

LOW PRESSURE STEAM (15 psig and lower)
Instrument impulse tubing on heating plant boilers and transmitters: ½" O.D. 316 stainless steel tube, 0.062" thick wall, Swageloc or equal with stainless steel "Gageable" tube fittings.

2" and Smaller above grade in buildings: ASTM A53, type S, standard weight (schedule 40) black steel pipe with ASTM A126/ANSI B16.4, Class 125 cast iron threaded fittings.

2-1/2" and Larger: ASTM A53, standard weight (schedule 40) blac k steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

2" and Smaller Finned Pipe: Construct finned elements of aluminum fin on steel tube. Steel tube shall be ASTM A53, Type F, extra strong (schedule 80) black steel pipe. Fins shall be 0.02" thick with a finned height of 1" and a spacing of 8 fins per inch. Each finned element shall be provided in lengths as indicated on drawings. Each finned element shall have 6" of bare pipe on each end.

LOW PRESSURE STEAM CONDENSATE (Steam pressure 15 psig and lower)
Instrument impulse tubing on heating plant boilers and transmitters: ½" O.D. 316 stainless steel tube, 0.062" thick wall, Swageloc or equal with stainless steel "Gageable" tube fittings.

2" and Smaller above grade in buildings: ASTM A53, type S, extra strong (schedule 80) black steel pipe with ASTM A126/ANSI B16.4, Class 125 cast iron threaded fittings.

2-1/2"and Larger: ASTM A53, extra strong (schedule 80) black steel pipe with ASTM A234 grade WPB/ANSI B16.9, extra strong, seamless, carbon steel weld fittings.

HIGH PRESSURE STEAM (Over 15 psig)
Instrument impulse tubing on heating plant boilers and transmitters: ½" O.D. 316 stainless steel tube, 0.062" thick wall, Swageloc or equal with stainless steel "Gageable" tube fittings.

2" and Smaller in heating plants and below grade distribution systems: ASTM A106, Grade B, standard weight (schedule 40) black steel pipe ASTM A105 grade II/ANSI B16.11, threaded or welded (for inaccessible piping) forged steel fittings.

2 1/2" and Larger in heating plants and below grade distribution systems : ASTM A106, Grade B, standard weight (schedule 40) black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

2" and Smaller above grade in buildings: ASTM A53, type S, standard weight (schedule 40) black steel pipe with ASTM A126/ANSI B16.4, Class 250 cast iron threaded fittings.

2-1/2" and Larger above grade in buildings: ASTM A53, type E or S, standard weight (schedule 40) black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

HIGH PRESSURE STEAM CONDENSATE (Steam pressure over 15 psig)
Instrument impulse tubing on heating plant boilers and transmitters: ½" O.D. 316 stainless steel tube, 0.062" thick wall, Swageloc or equal with stainless steel "Gageable" tube fittings.

2" and Smaller above grade in buildings: ASTM A53, type S, extra strong (schedule 80) black steel pipe with ASTM A126/ANSI B16.4, Class 250 cast iron threaded fittings.

2-1/2" and Larger: ASTM A53, type E or S extra strong (schedule 80) black steel pipe with ASTM A234 grade WPB/ANSI B16.9 extra strong, seamless, carbon steel weld fittings.
2" and Smaller in heating plants and below grade distribution systems: ASTM A106, Grade B, standard weight (schedule 80) black steel pipe ASTM A105 grade II/ANSI B16.11, threaded or welded (for inaccessible piping) forged steel fittings.

2 1/2” and Larger in heating plants and below grade distribution systems: ASTM A106, Grade B, standard weight (schedule 80) black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

STEAM CONDENSATE PUMP DISCHARGE
2" and Smaller in buildings: ASTM A53, type S, extra strong (schedule 80) black steel pipe with ASTM A126/ANSI B16.4, class 125, standard weight cast iron threaded fittings.

2” and Smaller in heating plants and below grade distribution systems: ASTM A106, Grade B, standard weight (schedule 80) black steel pipe ASTM A105 grade II/ANSI B16.11, threaded or welded (for inaccessible piping) forged steel fittings.

2 1/2” and Larger in heating plants and below grade distribution systems: ASTM A106, Grade B, standard weight (schedule 80) black steel pipe with ASTM A234 grade WPB/ANSI B16.9 standard weight, seamless, carbon steel weld fittings.

VENTS AND RELIEF VALVES
Use pipe and pipe fittings as specified for the system to which the relief valve or vent is connected.

UNIONS
2" and Smaller: ASTM SA105A threaded forged carbon steel, meets ANSI B16.11.

FLANGES
ASTM A181 grade I or A105, grade III hot forged steel weld neck flanges, welding and of a pressure class compatible with that specified for valves, piping specialties and fittings of the respective piping service. Flanges smaller than 2-1/2" may be used as needed for connecting to equipment and piping specialties. Use raised face flanges ANSI B16.5 for mating with other raised face flanges on equipment with flat ring or full face gaskets. Use ANSI B16.1 flat face flanges with full face gaskets for mating with other flat face flanges on equipment. Slip on flanges are not allowed without written Owner approval.

Provide ASTM A 193 B7 grade bolts and A 194 2H grade nuts & hardened washers for connections (Use star washers when required for grounding.)

GASKETS
Steam Systems and steam condensate systems: Spiral wound gasket with external ring to prevent gasket blowout, ASME B16.20. Suitable for use with flat face and raised face flanges. 304 stainless steel/non-asbestos filler/carbon steel outer guide ring. Filler to be graphite or PTFE on low pressure systems, 800 degree F graphite or ceramic on high pressure steam. Flexitallic Style CG, Leader Style SR, Garlock Flexseal or approved equal.

P A R T 3 - E X E C U T I O N

PREPARATION
Remove all foreign material from interior and exterior of pipe and fittings.

ERECTION
Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Provide anchors, expansion joints, swing joints and/or expansion loops so that piping may expand and contract without damage to itself, equipment, or building.

All pipe shall be installed with adequate space to fully insulate the pipe, minor alignment offsets to provide adequate spacing for the pipes shall have no additional cost to the project.

Mitered elbows, notched tees, and orange peel reducers are not acceptable. On threaded piping, bushings are not acceptable.

Pipe tees shall be used for all branch takeoffs and tees except "Weldolets" and "Threadolets" may be used for branch takeoffs up to one-half (1/2) the diameter of the main. All other branch takeoff and tee fittings are unacceptable.

Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.

Install all valves, control valves, and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires the piping services indicated in this section.

WELDED PIPE JOINTS

Make all welded joints by fusion welding in accordance with ASME Codes, ANSI B31, and State Codes where applicable.

All pipe welding shall be completed by Qualified Welders in accordance with the Contractor's Procedure Specifications.

Contractor will ensure that these steps are followed where pipe sections will be joined by welding:

1. Cleaning – Welding surfaces will be clean and free of defects.
2. Alignment – Inside diameter of piping components will be aligned as accurately as possible. Internal misalignment shall not exceed 1/16".
3. Spacing – Pipe sections will be spaced to allow deposition of weld filler material through the entire weld joint thickness.
4. Girth Butt Welds:
    a. Girth butt welds shall be complete penetration welds.
    b. Concavity will not exceed 1/32"
    c. Under cuts will not exceed 1/32"
    d. As welded surfaces are permitted however surfaces will be free from coarse ripples, grooves, abrupt ridges and valleys.

Electrodes shall be Lincoln, or approved equal, with coating and diameter as recommended by the manufacturer for the type and thickness of work being done.

The piping and fittings shall be pickled, cleaned, thoroughly dried, and capped before shipment to the site.

On steam piping systems inside utility plants or other structures (pits), Tungsten Inert Gas (TIG) weld first pass. Clean all piping by pulling or blowing cleaning pigs through piping after erection.

All welds shall be painted/primed with high temperature paint rated for 450°F minimum continuous working temperature.

Backer rings are not allowed without written Owner approval.

THREADED PIPE JOINTS

Use a Teflon based thread lubricant or Teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

STEAM AND STEAM CONDENSATE

Pitch mains down 1 inch in 40 feet in the direction of flow. Pitch terminal equipment runouts down 1 inch in 2 feet for proper condensate drainage.

Install drip traps at each rise, at the horizontal termination of each steam main and as needed to prevent water hammer but at a maximum spacing of 250 ft..

Use eccentric fittings for changes in horizontal pipe sizes with the fittings installed for proper condensate drainage. Concentric fittings may be used for changes in vertical pipe sizes.

Make branch connections and runouts at the top of the main or 45 degrees from the top. Condensate connections may be made in the horizontal plane in limited space situations.

Use a minimum of two elbows in each pipe line to a piece of terminal equipment to provide flexibility for expansion and contraction of the piping system. Offset pipe connections at equipment to allow for service, such as removal of the terminal device.

Install flanges, taps, vents and drains needed to fill, vent and drain the piping for hydrostatic testing.

Relief valve discharge pipe to be as short and straight as possible. Install drip pan elbow at base of vertical discharge pipe. Support all pipe to keep weight of pipe and accessories from resting on relief valve or drip pan elbow. Run drain lines from relief valve and drip pan elbow to nearest drain point. If relief valve has a weep hole, provide a galvanized sheet metal drain pan below the valve and run 3/4 inch drain pipe from drain pan to nearest drain point.

STEAM CONDENSATE PUMP DISCHARGE

Pitch mains down 1 inch in 40 feet in the direction of flow. In limited space situations and where specifically indicated on the drawings, horizontal lines may be run dead level. Where two separate pump discharge mains join together, provide a check valve in each line before the tee and a gate valve for line isolation in an accessible location.

CHEMICAL TREATMENT

Install chemical treatment piping as indicated on the drawings, as detailed, and as recommended by the supplier of the chemical treatment equipment.

VENTS AND RELIEF VALVES

Install vent and relief valve discharge lines as indicated on the drawings, as detailed, and as specified for each specific valve or piping specialty item. In no event is a termination to occur less than six feet above a roof line.

UNIONS AND FLANGES

Install a union or flange, as required, at each automatic control valve and at each piping specialty or piece of equipment which may require removal for maintenance, repair, or replacement. Where a valve is located at a piece of equipment, locate the flange or union connection on the equipment side of the valve. Concealed unions or flanges are not acceptable.

GASKETS

Store horizontally in cool, dry location and protect from sunlight, water and chemicals. Inspect flange surfaces for warping, radial scoring or heavy tool marks. Inspect fasteners, nuts and washers for burrs or cracks. Replace defective materials.

Align flanges parallel and perpendicular with bolt holes centered without using excessive force. Center gasket in opening. Lubricate fastener threads, nuts and washers with lubricant formulated for application.

Draw flanges together evenly to avoid pinching gasket. Tighten fasteners in cross pattern sequence (12 – 6 o'clock, 3 – 9 o'clock, etc.), one pass by hand and four passes by torque wrench at 30% full torque, 60% full torque and two passes at full torque per ASME B16.5. Retighten bolts after 24 hours of operation at system pressure and temperature. Bolts to have a minimum of two complete threads showing through the nut.

PIPING SYSTEM LEAK TESTS (HYDROSTATIC TEST)

Verify that the piping system being tested is fully connected to all components and that all equipment is properly installed, wired, and ready for operation. If required for the additional pressure load under test, provide temporary restraints at expansion joints or isolate them during the test. Verify that hangers can withstand any additional weight load that may be imposed by the test.

On piping that cannot be tested because of connection to an active line, provide temporary blind flanges and hydrostatically test new section of piping. After completion of test, remove temporary flanges and make final connections to piping

Provide all piping, fittings, blind flanges, and equipment to perform the testing.

Conduct pressure test with test medium of water unless specifically indicated. Minimum test time is indicated in the table below; additional time may be necessary to conduct an examination for leakage. Each test must be witnessed by the Division's representative. If leaks are found, repair the area with new materials and repeat the test; caulking will not be acceptable.

Do not insulate pipe until it has been successfully tested.

For hydrostatic tests, use clean water and remove all air from the piping being tested by means of air vents or loosening of flanges/unions. Measure and record test pressure at the high point in the system.

System	Pressure	Medium	Duration
Low pressure steam and condensate	100 psig	Water	8 hr
High pressure steam and condensate	250 psig	Water	8 hr
Steam condensate pump discharge	100 psig	Water	8 hr

All pressure tests are to be documented on a Owner form included in this specification.

PIPING SYSTEM NON-DESTRUCTIVE LEAK TESTS (RADIOGRAPHIC or PHASED ARRAY UT TEST)

Use Radiographic or Phased Array Ultrasonic (UT) testing as follows:

1. All welds

Weld test criteria shall be in accordance to ASME B31.1 current version.

Failed welds shall be ground out, re-welded and tested until all tested welds are accepted. The repair and re-testing shall have no additional cost to the project.

All weld tests are to be documented on a Owner form included in this specification.

SOCKET WELD TESTING

Socket welds shall be tested by magnetic particle inspection.

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 02.

END OF SECTION

PIPING SYSTEM LEAKAGE TEST REPORT

University of Wisconsin – System

Date Submitted: _____

Project Name: _____

Location: _____ **Owner Project No:** _____

Contractor: _____

☐ **HVAC** ☐ **Refrigeration** ☐ **Controls**

☐ **Power Plant** ☐ **Plumbing** ☐ **Sprinkler**

Test Medium: ☐ **Air** ☐ **Water** ☐ **Other** _____

Test performed per specification section No. _____

Specified Test Duration _____ **Hours** **Specified Test Pressure** _____ **PSIG**

System Identification: _____

Describe Location: _____

_____

Test Date: _____

Start Test Time: _____ **Initial Pressure:** _____ **PSIG**

Stop Test Time: _____ **Final Pressure:** _____ **PSIG**

Tested By: _____ **Witnessed By:** _____

Title: _____ **Title:** _____

Signed: _____ **Signed:** _____

Date: _____ **Date:** _____

Comments: _____

_____

_____

PIPING SYSTEM UT TEST REPORT

University of Wisconsin - System

Date Submitted: _____

Project Name: _____

Location: _____ **Owner Project No:** _____

Contractor: _____

☐ **HPS** **Operating Pressure** _____ **Operating Temp** _____

☐ **Condensate** **Operating Pressure** _____ **Operating Temp** _____

Test Medium: ☐ **Phase Array** ☐ **XRAY** _____

Test performed per specification section No. _____

System Identification: _____

Describe Location: _____

_____

Test Date: _____

Start Test Time: _____ **Test Result:** ☐ **Pass** ☐ **Fail**

Stop Test Time: _____ **Re-Test Result:** ☐ **Pass** ☐ **Fail**

Re-Test Result: ☐ **Pass** ☐ **Fail**

Tested By: _____ **Witnessed By:** _____

Title: _____ **Title:** _____

Signed: _____ **Signed:** _____

Date: _____ **Date:** _____

Comments: _____

_____

_____

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SECTION 23 33 00
AIR DUCT ACCESSORIES
BASED ON DFD MASTER SPECIFICATION DATED 02/17/2022

P A R T 1 - G E N E R A L

SCOPE

This section includes accessories used in the installation of duct systems. Included are the following topics:

RELATED WORK

Section 23 05 29 – Hanger and Supports for HVAC Piping and Equipment
Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment
Section 23 08 00 – Commissioning of HVAC
Section 23 31 00 – HVAC Ducts and Casings

REFERENCE

Applicable provisions of Division 1 govern work under this Section.

REFERENCE STANDARDS

NFPA 90A	Standard for Installation of Air Conditioning and Ventilating Systems
SMACNA	HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition, 2005
UL 214	
UL 555 (6th edition)	Standard for Fire Dampers and Ceiling Dampers
UL 555S (4th edition)	Leakage Rated Dampers for Use in Smoke Control Systems

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions

SHOP DRAWINGS

Refer to division 1, General Conditions, Submittals.

Submit for all accessories and include dimensions, capacities, ratings, installation instructions, and appropriate identification.

Include certified test data on dynamic insertion loss, self-noise power levels, and aerodynamic performance of sound attenuators.

Submit manufacturer's color charts where finish color is specified to be selected by the Architect/Engineer.

P A R T 2 - P R O D U C T S

MANUAL VOLUME DAMPERS

Manufacturers: Ruskin, Vent Products, Air Balance, or approved equal.

Dampers must be constructed in accordance with SMACNA Fig. 7-4, Fig. 7-5, and notes relating to these figures, except as modified below.

Reinforce all blades to prevent vibration, flutter, or other noise. Construct dampers in multiple sections with mullions where width is over 48 inches. Use rivets or tack welds to secure individual components; sheet metal screws will not be accepted. Provide operators with locking devices and damper position indicators for each damper; use an elevated platform on insulated ducts. Provide end bearings or bushings for all volume damper rods penetrating ductwork constructed to a 3" w.c. pressure class or above.

TURNING VANES

Manufacturers: Aero Dyne, Anemostat, Barber-Colman, Hart & Cooley, or approved equal.

Construct turning vanes and runners for square elbows in accordance with SMACNA Fig. 4-3 and Fig. 4-4 except use only airfoil type vanes. Construct turning vanes for short radius elbows and elbows where one dimension changes in the turn in accordance with SMACNA Chart 4-1 and Fig. 4-9.

FIRE DAMPERS

Manufacturers: Air Balance, Advanced Air, American Warming and Ventilating, Greenheck, Phillips-Aire, Prefco, Ruskin, Safe-Air or approved equal.

DYNAMIC FIRE DAMPERS

Dynamic fire damper assemblies must be UL 555 (6th edition) listed and labeled for dynamic applications (where air systems operate during a fire) and meet requirements of NFPA 90A. Dampers must be type B curtain type with curtain 100% out of air stream. Dampers larger than 30” by 30” or with velocity rating requirements of 3000 fpm or higher, may be multiblade type with blades located in the airstream. Velocity ratings and static pressure ratings as indicated on the drawings. Damper fire rating to be compatible with the rating of the building assembly in which the damper is used.

SMOKE DAMPERS AND COMBINATION FIRE/SMOKE DAMPERS

Manufacturers: Ruskin, Johnson Controls, Air Balance, Advanced Air, American Warming and Ventilating, Greenheck, Safe-Air, Phillips-Aire, Prefco, or approved equal.

Smoke damper:
Smoke damper assemblies to be UL 555S(4th edition) listed and labeled, and leakage rated at no higher than Class II under UL 555S(4th edition). Unless ratings are indicated elsewhere, dampers should be rated for minimum 2,000 fpm air velocity and 4" static pressure.

Combination fire/smoke damper :
Combination fire/smoke damper assemblies to be UL 555(6th edition) and UL 555S(4th edition) listed and labeled, and have a fire rating compatible with the rating of the building assembly in which the damper is used, and be leakage rated at no higher than Class II under UL 555S.

Operation:
Provide factory installed electrically operated dampers with linkage arranged so that the damper is closed on loss of power. For electric actuation, provide electric operated dampers with linkage and UL listed operators arranged so that the damper is closed on a loss of power. Where electric actuation is controlled by the DDC system use 0-10 VDC inputs, with stall protection, and with and zero and span adjustments for modulating or 24 VAC for two-position control. Where electric actuation is controlled by the fire alarm system, use 120 VAC actuators. All electric actuators will be provided with overload protection to prevent motor from damage when stall condition is encountered. Locate all operators out of the air stream unless large damper size will not allow. Provide form "C" end switches to indicate damper position.

CONTROL DAMPERS
Control dampers are specified in section 23 09 14.

SMOKE DETECTORS
Smoke detectors are furnished and installed by the Electrical Contractor.

ACCESS DOORS
General:
Access doors to be designed and constructed for the pressure class of the duct in which the door is to be installed. Doors in exposed areas shall be hinged type with cam sash lock. Hinges shall be aluminum or steel full length continuous piano type. Doors in concealed spaces shall be secured in place with cam sash latches. For both hinged and non-hinged doors provide sufficient number of camp sash latches to provide air tight seal when door is closed. Do not use hinged doors in concealed spaces if this will restrict access. Use minimum 1" deep 24 gauge galvanized steel double wall access doors with minimum 24 gauge galvanized steel frames. For non-galvanized ductwork, use minimum 1" deep double wall access door with frame that shall use materials of construction identical to adjacent ductwork. Provide double neoprene gasket that shall provide seals from the frame to the door and frame to the duct. When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment. Access doors constructed with sheet metal screw fasteners will not be accepted.

FLEXIBLE DUCT
Manufacturers: Anco Products, Clevaflex, Thermaflex, Flexmaster or approved equal.

Factory fabricated, UL 181 listed as a class 1 duct, and having a flame spread of 25 or less and a smoke developed rating of 50 or under in accordance with NFPA 90A.

Suitable for pressures and temperatures involved but not less than a 180°F service temperature and ±2 inch pressure class, depending on the application.

Duct to be composed of polyester film, aluminum laminate or woven and coated fiberglass fabric bonded permanently to corrosion resistant coated steel wire helix. Two-ply, laminated, and corrugated aluminum construction may also be used.

Where duct is specified to be insulated, provide a minimum 1 inch fiberglass insulation blanket with maximum thermal conductance of 0.23 K (75 degrees F.) and vapor barrier jacket of polyethylene or metalized reinforced film laminate. Maximum perm rating of vapor barrier jacket to be 0.1 perm.

DUCT LINING

Manufacturer: Manville, Owens-Corning, Knauf, or approved equal.

1 inch thick, flexible, mat faced insulation made from inorganic glass fibers bonded with a thermosetting resin with thermal conductivity of .25 Btu inch / hour sqft. deg F.
Meet erosion testing per UL 181 or ASTM C 1071 for 5000 fpm maximum air velocity. ASTM C 411 maximum operating temperature rating of 250 deg F. ASTM E84 flame spread less than 25 and smoke developed less than 50.

Meet requirements of ASTM C 1338 and ASTM G21 for fungi resistance.

Install liner using adhesive conforming to ASTM C 916.

FLASHINGS
Provide flashing to completely weatherproof connection of ductwork to louvers. Flashing to be constructed of material similar to louver material.

Flashing and counterflashing for roof curbs will be provided by others.

Flashing and curbs for duct and pipe penetrations of roof assemblies to be in accordance with details.

DUCT FLEXIBLE CONNECTIONS
Material to be fire retardant, be UL 214 listed, and meet the requirements of NFPA 90A.

Connections to be a minimum of 3 inches wide, crimped into metal edging strip, and air tight. Connections to have adequate flexibility and width to allow for thermal expansion/contraction, vibration of connected equipment, and other movement.

General Applications:
Use coated glass fiber fabric for all applications. Material for inside applications other than corrosive environments, fume exhaust, or kitchen exhaust to be double coated with neoprene, air and water tight, suitable for temperatures between -10°F and 200°F, and have a nominal weight of 30 ounces per square yard.

Outdoor Applications:
Material used for outdoor applications other than corrosive environments, fume exhaust, or kitchen exhaust to be double coated with Hypalon¿,air and water tight, suitable for temperatures between -10°F and 250°F, and have a nominal wight of 26 ounces per square yard.

Corrosive Environments:
For corrosive environments or fume exhaust applications indoors or outdoors, use a material coated with Teflon that is air and water tight, suitable for temperatures between -20°F and 500°F, and has a nominal weight of 14 ounces per square yard.

SOUND ATTENUATORS
Manufacturers: Industrial Acoustics Company, Environmental Elements Corporation, Semco, Dynasonics, United McGill, Price, VAW, Vibro Acoustics or approved equal.

Construct entirely of Type 304 stainless steel. ~~of a 22 gauge galvanized steel outer casing, and 26 gauge galvanized, perforated steel inner liner.~~ Seams and joints of outer casing to be air tight.

~~Fill annular space between outer casing and inner liner with acoustic fill that is inert, inorganic, and of a density sufficient to obtain the specified acoustic performance. Material must meet requirements of NFPA 90A with a flame spread index of 25 or less and smoke developed rating of 50 or less.~~Units shall contain no sound absorptive material. Attenuation shall be accomplished by controlled impedance membranes and broadly tuned resonators.

Acoustical and aerodynamic performance is indicated on schedules on the drawings.

HOODS FOR INTAKE AND EXHAUST
Manufacturers: Acme, Ammerman, Carnes, Cook, Greenheck, Louvers and Dampers, Penn, or approved equal.

Use louvered penthouse type hoods with drainable blade louvers.

Construct hoods of galvanized steel with a baked enamel finish; color to be selected by the Architect during the submittal stage.

Provide bird screen and motor operated damper for each hood.

AIR FLOW STATIONS
Air flow stations are specified in section 23 09 14.

P A R T 3 - E X E C U T I O N

MANUAL VOLUME DAMPERS
Install manual volume dampers in each branch duct and for each grille, register, or diffuser as far away from the outlet as possible while still maintaining accessibility to the damper. Install so there is no flutter or vibration of the damper blade(s).

TURNING VANES
Install turning vanes in all rectangular, mitered elbows in accordance with SMACNA standards and/or manufacturer's recommendations.

Install double wall, airfoil, 2 inch radius vanes in ducts with vane runner length 18" or greater and air velocity less than 2000 fpm. Install double wall, airfoil, 4-1/2 inch radius vanes in ducts with vane runner length 18" or greater and air velocity 2000 fpm or greater.

If duct size changes in a mitered elbow, use single wall type vanes with a trailing edge extension. If duct size changes in a radius elbow or if short radius elbows must be used, install sheetmetal turning vanes in accordance with SMACNA Chart 4-1 and Figure 4-9.

FIRE DAMPERS
Install dampers in strict accordance with manufacturer's installation instructions. Install damper sleeves with retaining angles on both sides of rated partition. Connections of ductwork to fire damper assemblies to be as specified on the installation instructions. Where it is necessary to set dampers out from the rated wall, install a sleeve extension encased in two hour rated fire proofing insulation. Install an access door at each fire damper, located to permit resetting the damper replacing the fusible link.

Manually test each fire damper for proper operation by removing the fusible link. Repair or replace any fire damper that does not close completely. Re-install fusible link after test.

The A/E must coordinate the location of all fire dampers, smoke dampers and combination fire smoke dampers. All dampers must be installed in accessible locations and access to these dampers must be coordinated. The dampers must have adequate access to allow for servicing and testing of the dampers.

SMOKE DAMPERS AND COMBINATION FIRE/SMOKE DAMPERS
Smoke Damper Installation;
Install smoke dampers in locations indicated on the drawings in accordance with the manufacturer's instructions. Install an access door adjacent to each damper for inspection and cleaning.

Coordinate damper linkage with operators so the dampers are closed when the air system is not operating.

Combination Fire/Smoke Damper Installation;
Install combination fire/smoke dampers in locations indicated on the drawings in accordance with the manufacturer's instructions. Install an access door adjacent to each damper for inspection and cleaning. .

Coordinate damper linkage with operators so the dampers are closed when the air system is not operating.

CONTROL DAMPERS
Install dampers in locations indicated on the drawings, as detailed, and according to the manufacturer's instructions. Install blank-off plates or transitions where required for proper mixing of airstreams in mixing plenums. Provide adequate operating clearance and access to the operator. Install an access door adjacent to each control damper for inspection and maintenance.

SMOKE DETECTORS
Installation and wiring of detectors will be by the Electrical Contractor. Install an access door at each detector location.

When detectors are to be installed within air handling systems, show the intended location on the mechanical drawings and coordinate with the electrical consultant. It is very difficult to properly identify the correct location of detectors on the electrical drawings.

ACCESS DOORS

Install access doors where specified, indicated on the drawings, and in locations where maintenance, service, cleaning or inspection is required. Examples include, but are not limited to motorized dampers, fire and smoke dampers, smoke detectors, fan bearings, heating and cooling coils, filters, valves, and control devices needing periodic maintenance.

Size and numbers of duct access doors to be sufficient to perform the intended service. Minimum access door size shall be 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, or other size as indicated. Install access doors on both inlet and outlet sides of reheat coils as well as other duct mounted coils.

Label fire, smoke and combination fire smoke dampers on the exterior surface of ductwork directly adjacent to access doors using a minimum of 0.5 inch height lettering reading, “SMOKE DAMPER” or “FIRE DAMPER”. Smoke and combination fire smoke dampers shall also include a second line listing the individual damper tag. The tags must be coordinated with the mechanical schedules. Utilize stencils or manufactured labels. All other forms of identification are unacceptable. All labels shall be clearly visible from the ceiling access point.

FLEXIBLE DUCT

Flexible duct may only be used for final connections of air inlets and outlets at diffuser, register, and grille locations. Where flexible duct is used, it shall be the minimum length required to make the final connections, but no greater than 5 feet in length, and have no more than one (1) 90 degree bend.

Secure inner jacket of flexible duct in place with stainless steel metal band clamp. Secure insulation vapor barrier jacket in place with steel or nylon draw band. Sheetmetal screws and/or duct tape will not be accepted.

Flexible duct used to compensate for misalignment of main duct or branch duct will not be accepted.

Individual sections of flexible ductwork shall be of one piece construction. Splicing of short sections will not be accepted.

Flexible ductwork used as transfer duct shall be sized for a maximum velocity of 300 fpm.

Penetration of any partition, wall, or floor with flexible duct will not be accepted.

DUCT LINING

Apply lining to the following ductwork:

- Five foot downstream of a supply box.
-

Do not apply lining to the following ductwork:

- Outside air ductwork.
- Fume hood exhaust ductwork.
-

Install liner in compliance with the latest edition of NAIMA’s Fibrous Glass Duct Liner Standard. Locate longitudinal joints at the corners of duct only. Cut and fit to assure lapped, compressed joints. Coat all transverse and longitudinal joints and edges with adhesive. Provide metal nosing on leading edge where lined duct is preceded by unlined duct. Adhere liner to duct with full coverage area of adhesive. Additionally secure liner to duct using mechanical fasteners spaced as recommended by the liner manufacturer without compressing liner more than 1/8” with the fasteners.

FLASHINGS

Flashing for roof curbs, equipment supports or rails located on roof, will be installed by others.

DUCT FLEXIBLE CONNECTIONS

Install at all duct connections to rotating or vibrating equipment, including air handling units (unless unit is internally isolated), fans, or other motorized equipment in accordance with SMACNA Figure 7-8. Install thrust restraints to prevent excess strain on duct flexible connections at fan inlets and outlets; see Related Work.

For applications in corrosive environments or fume exhaust systems, use a double layer of the Teflon¿ coated fabric when making the connector.

SOUND ATTENUATORS
Install sound attenuators in locations indicated on the drawings. Where modular installation is required, install units in a galvanized steel frame equipped with gaskets or seals between modules to prevent bypass of air.

HOODS FOR INTAKE AND EXHAUST
Install in locations indicated on the drawings, coordinating the roof opening location with the General Prime Contractor. Curbs are covered in Section 23 05 29.

AIR FLOW STATIONS
Install where indicated on the drawings and/or as scheduled and in accordance with manufacturer's recommendations.

Provide access doors upstream and downstream of all duct mounted air flow stations of the size necessary for maintenance purposes. Minimum access door size shall be 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, or other size as indicated on the drawings.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 02.

END OF SECTION

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SECTION 23 37 13
DIFFUSERS, REGISTERS & GRILLES
BASED ON DFD MASTER SPECIFICATION DATED 7/11/2023

P A R T 1 - G E N E R A L

SCOPE
This section includes specifications for air terminal equipment. Included are the following topics:

RELATED WORK
Section 01 91 02 - Commissioning Process
Section 23 08 00 - Commissioning of HVAC
Section 23 31 00 - HVAC Ducts and Casings
Section 23 33 00 - Air Duct Accessories
Section 23 05 93 - Testing, Adjusting and Balancing for HVAC

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

REFERENCE STANDARDS
NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
UL 181 - Factory-Made Air Ducts and Connectors.
ARI-ADC Standard 880.

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

SUBMITTALS
Refer to division 1, General Conditions, Submittals.

Furnish submittal information including, but not limited to, the following:

- Manufacturer's name and model number
- Identification as referenced in the documents
- Capacities/ratings
- Materials of construction
- Sound ratings
- Dimensions
- Finish

- Color selection charts where applicable
- Manufacturer's installation instructions
- HEPA ceiling diffuser controllers, including:
    - Wiring Diagrams
    - BACnet IP point lists
    - Gateway, if required.
- All other appropriate data

DESIGN CRITERIA
All performance data shall be based on tests conducted in accordance with Air Diffusion Council (ADC) Test Code 1062 GRD 84.

P A R T 2 - P R O D U C T S

MANUFACTURERS
Acceptable manufacturers for specific products are listed under each item.

ROUND CEILING DIFFUSERS
Carnes SSAA, Greenheck XG-3100, Metal Aire 3100, Nailor RNRA1, Price RCDA, Shoemaker RDA, Titus TMRA.

Spun aluminum or steel with uniform 360º discharge pattern.

Adjustable inner cones surrounded by a ceiling plate collar designed to reduce ceiling smudges.

Diffusers as shown on drawings and/or as scheduled.

White, baked enamel finish or powder coat finish, unless otherwise indicated.

PERFORATED CEILING DIFFUSERS
Carnes SP and SL, Greenheck XG-7600, Metal Aire 7600, Nailor 4320S, Price PDS, Shoemaker 780, Titus PSS.

Aluminum unless otherwise indicated and furnished with frame type appropriate to installation.

Field adjustable pattern controllers accessible through removable or hinged face plate. Pattern controller mounted directly under the neck of the diffuser and fully adjustable for either side blow or corner blow pattern.

Provide round or square neck duct adapters for each unit for top connection or side connection as appropriate to the space.

White, baked enamel finish or powder coat finish unless otherwise indicated. Flat black diffuser vanes and frame interior.

SQUARE CEILING DIFFUSERS - Plaque
Carnes SFPA and SHPA, Greenheck XG-5750, Krueger PLQ and 5PLQ, Metal Aire 5750, Nailor UNI2, Price SMDP, Shoemaker HL, Titus OMNI.

Aluminum unless otherwise indicated. Louvered face furnished with frame type appropriate to installation.

Directional blow pattern as shown on the drawings and/or as scheduled.

One-piece removable square face plaque with one-piece back pan.

White, baked enamel finish or powder coat finish, unless otherwise indicated.

HEAVY DUTY SIDEWALL RETURN/EXHAUST GRILLE
Carnes Sturdicore, Krueger 480, Nailor 6100-HD, Price 91, Shoemaker 1610 and 1625, Titus 30.

Grille border 16-gauge steel and grille blades 14-gauge steel suitable for gymnasium applications.

Fixed blade (0 or 45 degree).

Grille sizes as shown on drawings and/or as scheduled.

White, baked enamel finish or powder coat finish, unless otherwise indicated.

PERFORATED CEILING EXHAUST GRILLES
Titus PAR, Carnes RSFA, or EH Price Model 10A, or approved equal.

Grilles shall be aluminum or stainless steel, and furnished with frame type appropriate to installation.

Provide round or square neck duct adapters for each unit for top connection of side connection as appropriate to the space. Refer to drawings and schedules for requirements.

Unless otherwise indicated, baked enamel finish with color selected by Architect. Flat black frame interior.

LABORATORY SUPPLY DIFFUSER
Krueger TAD, Nailor 92RPD, Price RFD, Shoemaker 5185.

White baked enamel or powder coat finish with opposed blade volume control damper. Volume dampers steel, adjustable from diffuser face.

Diffuser removable perforated face with directional blades. Non-aspirating radial air pattern. Configured with air supply plenums with inlet collars to assure uniform discharge velocity over faces of units.

WIRE MESH GRILLES
Grilles shall be 2X2 mesh (1/2") galvanized steel or aluminum hardware cloth in spor welded galvanized steel frame with 1-1/2" width.

PERFORATED DUCT DIFFUSER
United Sheet Metal SP or approved equal.

Perforated, spiral, paintable galvanized steel (ASTM-A257), 24-gauge lockseam duct with standing rib. Perforations open area of 23 percent.

Duct sizes, types, and accessories as shown on drawings and/or as scheduled.

HEPA CEILING DIFFUSERS WITH INTEGRAL FANS
Flanders Pureflow-FPM, Envirco, or Price

Housing shall be minimum 14 ga mill finish aluminum continuously welded or sealed airtight and include offset knife edge for interface with gel seal filter to eliminate bypass leakage. Knife edge shall be integral part of housing frame to minimize potential leak paths. Fasteners and hardware shall be 304 stainless steel.

Casings shall be factory sealed and tested for leaks.

Face shall be perforated and constructed from same material as casing.

Filters shall be replaced from roomside.

Damper shall be integral, heavy duty butterfly assembly with air diffusion disk for even airflow across entire filter face. Furnish damper with remote operator accessible from roomside of filter.

HEPA filters shall be 4" deep, listed or classified under UL 586 Test Standard and accessible from roomside.

Filters shall be individually tested and certified to be 99.97% minimum efficient with handling 0.3 micron particles in accordance with DOP test method. DOP efficiency, along with filter serial number and manufacturer to be marked on filter.

Provide static pressure port.

Units shall be equipped with aerosol dispersion nozzle to inject challenge aerosol upstream of filter when testing filter for leaks.

Provide aluminum foil-backed external casing insulation.

All units shall be 24" x 48" unless otherwise scheduled with surface mount or T-bar mount as scheduled.

Fan/Motor Assembly.

Fan/motor shall be direct drive with ECM style motor, single phase with voltage as scheduled. Solid state speed control and transformer shall be provided.

Fan/motor assembly shall be replaceable from roomside.

Room sound level shall be less than 55dBA when measured at 30" from filter face at 90 fpm (average face velocity) in accordance with IEST RP-CC0022.2.

Fan/Motor Controls:
Ceiling diffuser manufacturer shall provide single control panel for monitoring/control of all HEPA ceiling diffusers. Control panel shall be mounted in interstitial area. Refer to floor plans for location.

Single control panel shall meet the following requirements:

- Controller shall be capable of monitoring/controlling all HEPA ceiling diffusers provided for this project.
- Controller shall be capable of sub-dividing HEPA ceiling diffusers by zones. Each sub-divided zone shall allow each zone to be controlled separately in different modes.
- Provide Run, Standby, Auto, Stop, and Offline modes, with programmable weekly standby schedules and connection for voltage-free remote standby or stop contacts.
- Provide a color LCD touchscreen control panel for monitoring and control of the HEPA ceiling diffusers. The touchscreen shall display system and group status and allow the operator to select and view each HEPA ceiling diffuser individually. For each HEPA, provide display of operating mode, commanded speed setpoint, actual fan speed or airflow feedback, communication status, fan fault, and high- or low-speed/airflow alarm condition. shall include LCD touchscreen.
- Provide adjustable high- and low-speed or airflow alarm limits, alarm delays, audible and visual alarm annunciation, a minimum 1,000-event history, and a common-alarm relay output.
- Provide password-protected operator access levels, configuration backup and restoration, and removable-media data logging.

The controller shall communicate with individual HEPA fan-filter units over a daisy-chain network using minimum Category 5e cable with RJ45 connectors. Connect the controller to the first fan-filter unit and interconnect successive units using the two communication ports provided at each unit. Assign each fan-filter unit a unique network address corresponding to its unit number. The controller shall continuously poll each unit for operating status, speed or airflow feedback, and alarm conditions, and shall generate a communication alarm upon loss of response from any unit.

HEPA ceiling diffusers shall be integrated into BAS by the 23 09 23 Contractor. HEPA ceiling diffuser control panel shall communicate via BAS using BACnet IP protocol. If manufacturer's single control panel is not native BACnet IP, manufacturer shall provide BACnet interface gateway. Gateway shall include the points listed in 23 09 05.

PART 3 - EXECUTION

INSTALLATION
Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.

Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.

Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar size.

Seal connections between ductwork drops and diffusers/grilles airtight.

Blank off unused portion of linear slot diffusers and linear bar diffusers and grilles.

Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

In clean rooms and animal holding rooms, caulk space between diffuser or grille and ceiling or wall to be air and watertight. User clear, non-hardening silicone sealant compatible with ceiling or wall surfaces. Sealant shall be resistant to microbiological growth.

HEPA CEILING DIFFUSERS WITH INTEGRAL FANS

Manufacturer shall site assist the Division 23 Contractor with startup of the HEPA ceiling diffusers. Manufacturer shall configure each HEPA ceiling diffuser to maintain a constant airflow rate. HEPA ceiling diffusers shall not reduce airflow circulation rate based on occupancy or time schedules.

As part of the bid, manufacturer shall include a separate 8-hour site visit to assist the 23 09 23 Contractor with integration of the HEPA ceiling diffusers into the BAS. The technician that is sent shall be competent with BAS integration. Unit manufacturer shall coordinate this site visit with the 23 09 23 Contractor, and obtain written approval of agreement for the site visit. Do not just show up unannounced, on site, and expect Contractor to be available for coordination.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 02.

END OF SECTION

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WIMR East Wedge Cyclotron and Expansion
University of Wisconsin - Madison

School of Medicine and Public Health
1111 Highland Avenue, Madison, WI

UW Madison Project # 1485-2511
UW Building #1485

Bid Set

CIVIL, LANDSCAPE, AND STRUCTURAL

VOLUME 1 of 4

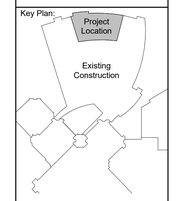
Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:

Key Plan:



The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institutes for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
SHEET INDEX - VOLUME 1

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1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

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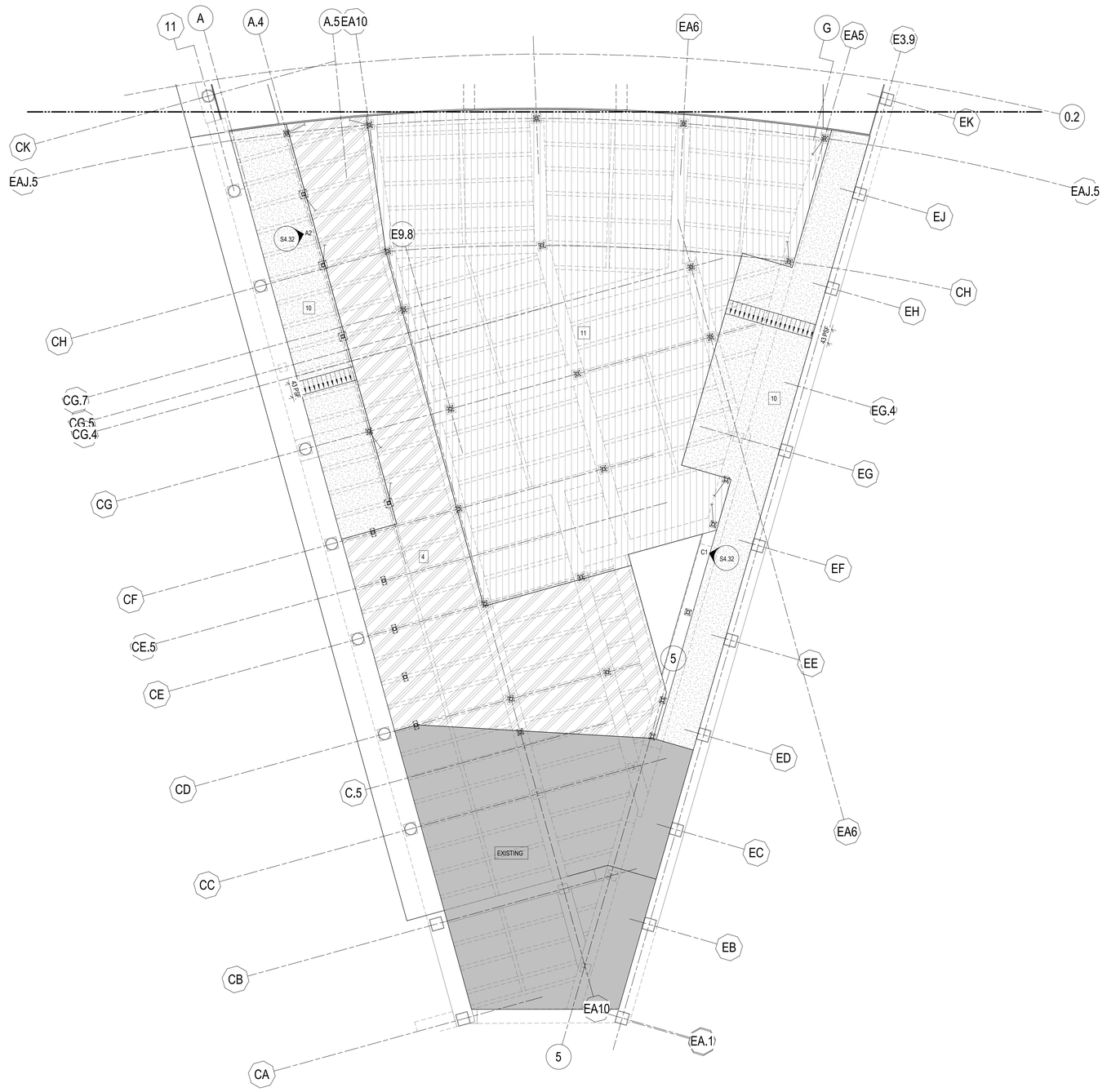


A1 L2 - SECOND LEVEL LOAD DIAGRAM - AREA B

3/32" = 1'-0"

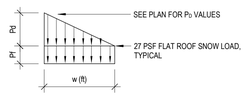
SUPERIMPOSED LOADS SCHEDULE

AREA	ELEMENTS	DEAD LOAD (PSF)	LIVE LOAD (PSF)	NOTES
GENERAL CIRCULATION AND BACK OF HOUSE SPACE 1	FLOORING	5		
	MEP, MISC	15		
	TOTAL	20	100 UNREDUCIBLE	
LABORATORY - BASEMENT LEVEL 2	FLOORING	5		
	MEP, MISC	50		
	TOTAL	55	150 UNREDUCIBLE*	
HOT CELL AREA 3	FLOORING	5		
	EQUIPMENT	100		
	TOTAL	105	150 UNREDUCIBLE*	
TYPICAL LABORATORY - LEVEL L1/L2 4	FLOORING	5		
	LAB EQUIPMENT	40		
	CEILING, LIGHTS, MISC	10		
	TOTAL	55	125 UNREDUCIBLE	
L3 GREEN ROOF 5	G2,B2, OR M2 VEGETATION (SATURATED)	41		
	CEILING, LIGHTS, MEP, MISC	10		
	TOTAL	51	20 UNREDUCIBLE	
MECHANICAL SPACE - TYPICAL 6	FLOORING	5		
	CONCRETE TOPPING/HK PADS	25		
	CEILING, LIGHTS, MEP, MISC	25		
	TOTAL	55	150 UNREDUCIBLE*	
VAULT FLOOR LOADING 7	CEILING, LIGHTS, MEP, MISC	25		
	TOTAL	25	200 UNREDUCIBLE	
ACCESS CATWALK 8	FLOORING	5		
	MEP, MISC	10		
	TOTAL	15	40 REDUCIBLE	CATWALKS HANG FROM LEVEL L1 SLAB
ELECTRICAL ROOMS, AVIT, AND TR ROOMS - ABOVE LOWER LEVEL 9	FLOORING	5		
	MEP	15		
	CEILING, LIGHTS, MISC	10		
	TOTAL	30	200 UNREDUCIBLE*	
TYPICAL ROOF - NOT INTENDED FOR OCCUPANCY 10	INSULATION AND MEMBRANE	10		
	MEP	15		
	CEILING, LIGHTS, MISC	10		
	TOTAL	35	20 REDUCIBLE	FLAT ROOF SNOW LOAD = 27 PSF + DRIFTS
LEVEL L2 AT EXISTING BUILDING 11	OFFICE LIVE LOADS (INCLUDES PARTIONS)			
	CEILING, LIGHTS, MEP, MISC	10		
	3" LW CONCRETE OVER 5" FOAM (FUTURE)	25		
	TOTAL	35	80 REDUCIBLE	
GREEN ROOF AT FLAT STRUCTURE - NOT INTENDED FOR OCCUPANCY 12	INSULATION AND MEMBRANE	10		
	SLOPED CONCRETE TOPPING	60		
	CEILING, LIGHTS, MEP, MISC	25		
	LIGHTWEIGHT GROWING MEDIA	93		
	TOTAL	188	20 REDUCIBLE	
BALLASTED ROOF 13	INSULATION AND MEMBRANE	4		
	MEP/CEILING	10		
	2" BALLAST	16		
	TOTAL	30 PSF	20 REDUCIBLE	FLAT ROOF SNOW LOAD = 27 PSF + DRIFTS

PERIMETER CLADDING AND MISC LINE LOADS

L1	1.75 KIPS/FT (DEAD LOAD)		

SNOW DRIFT LOADS

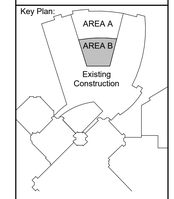


Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:
GRAEF

Key Plan:


The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research
School of Medicine and Public Health

Project Location:
University of Wisconsin - Madison

Sheet Title:
DESIGN LOAD PLANS

Revisions:

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1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

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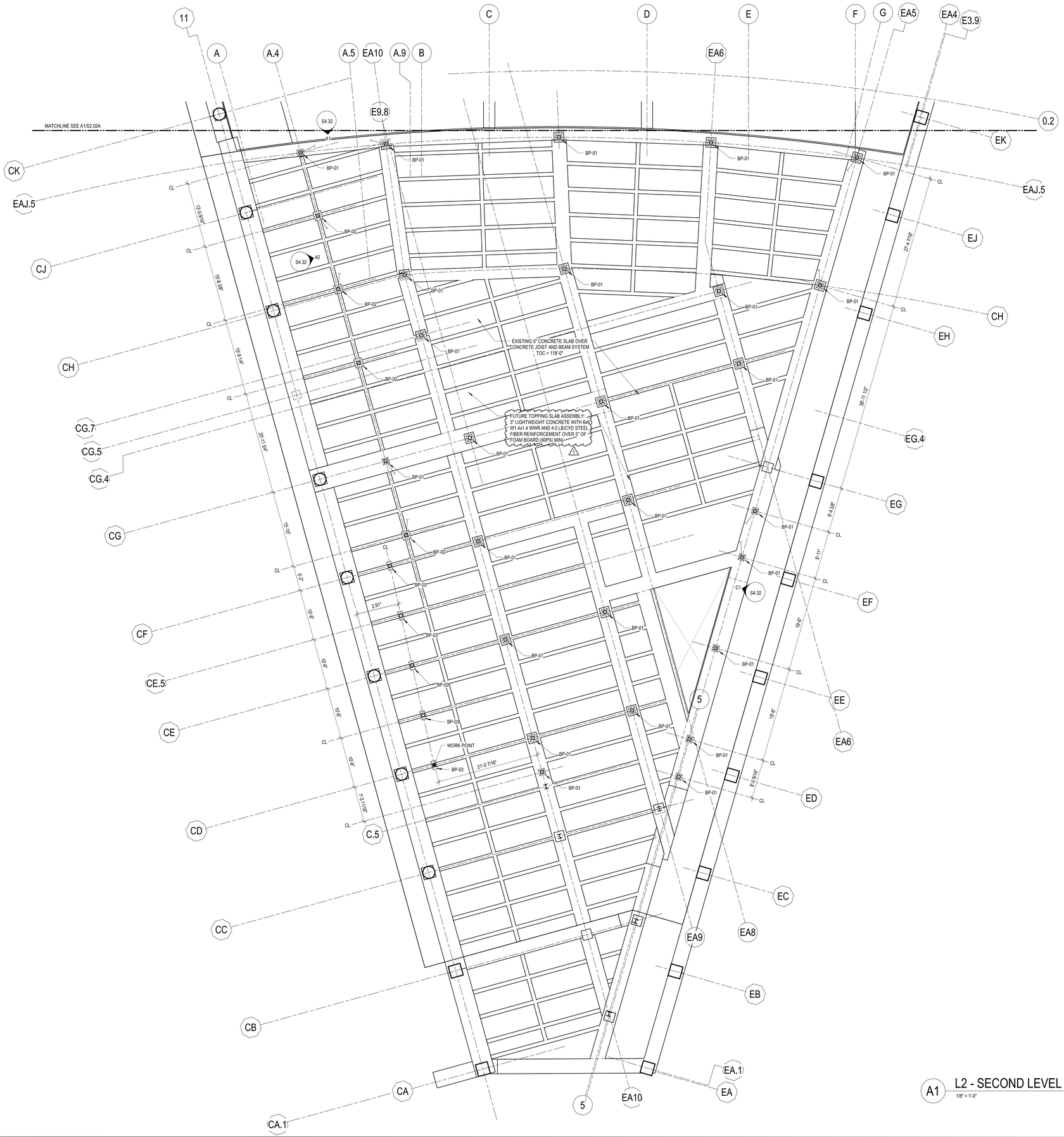

GENERAL SHEET NOTES

1. SEE FLOOR SCHEDULE FOR DESCRIPTION AND REINFORCEMENT.
2. SEE PLAN FOR TOP OF CONCRETE SLAB ELEVATION
3. SEE "SCHEDULES" SHEET FOR CONCRETE BEAM AND SHEARHEAD SCHEDULES.
4. MAINTAIN SPECIFIED SLAB THICKNESS THROUGHOUT FLAT SLAB UNLESS NOTED OTHERWISE.
5. SEE ELECTRICAL, PLUMBING, FIRE PROTECTION, HVAC AND ARCHITECTURAL DRAWINGS FOR SIZE AND LOCATIONS OF SLAB OPENINGS AND PIPE SLEEVES. PROVIDE SLEEVES WITH DIAMETER 1" LARGER THAN CONDUIT. ALL SLEEVES TO BE SCHEDULE 40 STEEL PIPE.
6. NO RECESSED AREAS IN SLAB ARE ALLOWED WITHOUT PRIOR APPROVAL FROM THE STRUCTURAL ENGINEER.
7. SLAB REINFORCEMENT PLACING ORDER.
   - A. E/W BOTTOM
   - B. N/S BOTTOM
   - C. N/S TOP
   - D. E/W TOP
8. SEE "GENERAL TWO-WAY FLAT SLAB DETAILS" SHEET(S) FOR THE FOLLOWING DETAILS:
   - A. SUPPORT AT TOP OF INTERIOR CMU WALLS
   - B. TWO-WAY SLAB CAMBER DIAGRAM
   - C. TWO-WAY SLAB CONSTRUCTION JOINT
   - D. TWO-WAY SLAB OPENING REINFORCEMENT
   - E. TWO-WAY SLAB OPENINGS NOT SHOWN ON PLAN
   - F. TWO-WAY SLAB REINFORCEMENT LAYOUT
   - G. TWO-WAY SLAB SECTION AT COLUMN STRIP (WITHOUT DROP PANELS)
   - H. TWO-WAY SLAB SECTION AT MIDDLE STRIP (WITHOUT DROP PANELS)

SHEET KEYNOTES

A1 L2 - SECOND LEVEL FRAMING PLAN - AREA B
1/8" = 1'-0"

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Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
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Consultant:
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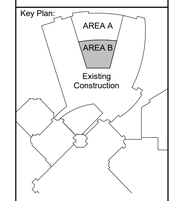

The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
L2 - SECOND LEVEL ENLARGED FLOOR PLAN - AREA B

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WIMR East Wedge Cyclotron and Expansion
University of Wisconsin - Madison

School of Medicine and Public Health
1111 Highland Avenue, Madison, WI

UW Madison Project # 1485-2511
UW Building #1485

Bid Set

ARCHITECTURAL, LABORATORY, AND FIRE PROTECTION

VOLUME 2 of 4

Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
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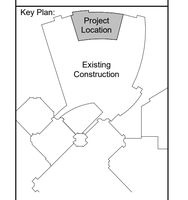
PLI Project No:
2023.35.00

Consultant:

Key Plan:



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1111 Highland Avenue, Madison, WI 53705

Project Title:
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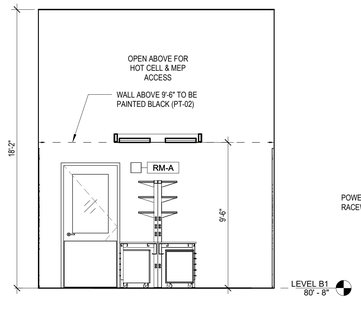
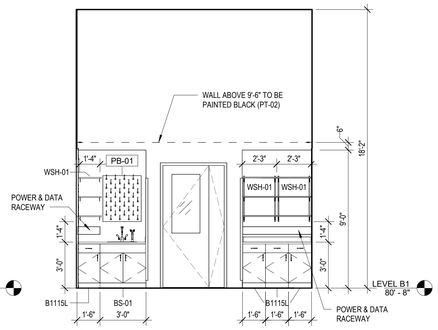
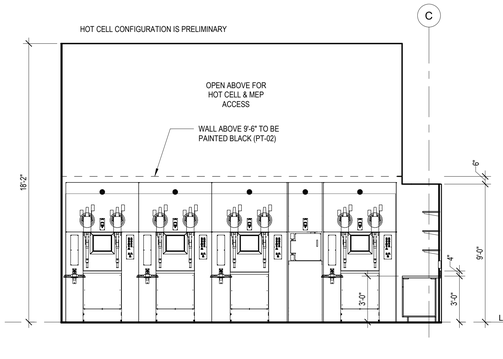
B1373 HOT CELLS



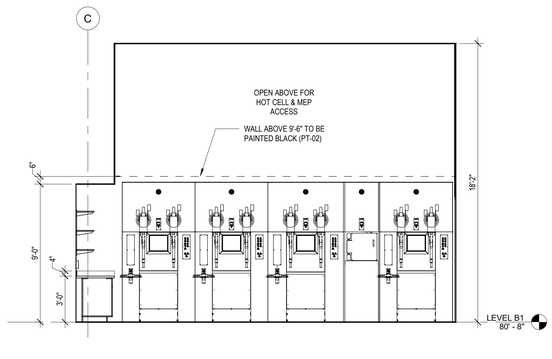
12 L7.21 B1373 HOT CELLS - EAST ELEVATION
1/4" = 1'-0"



11 L7.21 B1373 HOT CELLS - WEST ELEVATION
1/4" = 1'-0"



10 L7.21 B1373 HOT CELLS - SOUTH ELEVATION
1/4" = 1'-0"



9 L7.21 B1373 HOT CELLS - NORTH ELEVATION
1/4" = 1'-0"

GENERAL NOTES:

THE RESEARCH LAB AND NON-GMP HOT CELL LABS FEATURE CEILINGS THAT ARE OPEN TO THE STRUCTURE TO PROVIDE UNENCUMBERED ACCESS TO OVERHEAD SYSTEMS AND ALLOW ACCESS TO NATURAL LIGHT. LAB USE FOR THESE AREAS IS CONSISTENT WITH DRM REQUIREMENTS FOR OPEN CEILINGS IN LABS:

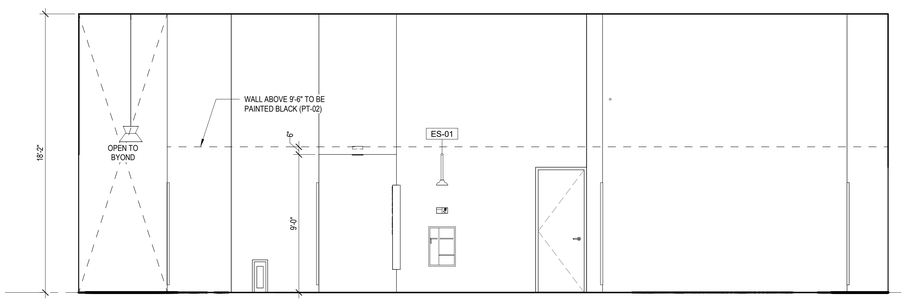
- THE CEILING STRUCTURE IS CONCRETE OR ANOTHER MATERIAL THAT IS SMOOTH AND UNIFORM AND CAN BE PAINTED.
- DUCTWORK, CONDUIT AND OTHER CEILING-MOUNTED MECHANICAL AND ELECTRICAL ITEMS WILL BE MINIMIZED, AND CONFIGURED IN A WAY THAT IS NEAT AND VISUALLY ORGANIZED.
- THE USE AND FUNCTION OF THE LABORATORY IS CONSISTENT WITH AN OPEN CEILING.
  1. *(CLARIFICATION: NO PRODUCTS FROM THESE SPACES WILL BE USED IN HUMAN OR ANIMAL SUBJECTS.*
- CEILING UTILITIES ARE FREQUENTLY MODIFIED BY THE USERS. UNENCUMBERED ACCESS TO UTILITIES IS REQUIRED.
- REFER TO LABORATORY SHEET L0.01 FOR GENERAL NOTES, ABBREVIATIONS, AND SYMBOLS.

AREAS LABLED DMF OR GMP ARE CLEANROOMS. NOTE THAT ALL ISO-CLASSIFIED AREAS WILL HAVE MOBILE SS CASEWORK AND FEATURE SHELVING THAT IS ON A STAND-OFF FROM THE WALL. CLEANROOM CEILINGS WILL BE HARD CEILINGS MADE MADE OF THE SAME MATERIAL AS THE WALL SYSTEMS.

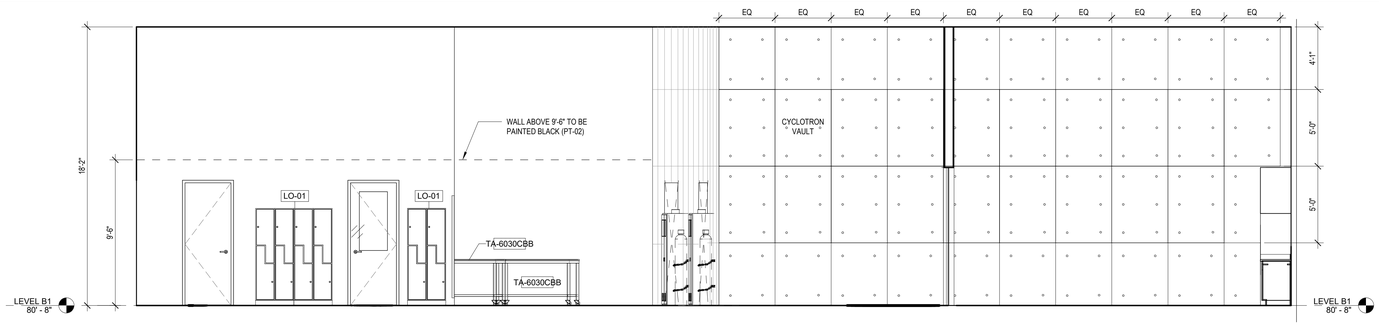
CASEWORK NOTES:

1. ALL CASEWORK IN CYCLOTRON VAULT TO BE WOOD WITH PHENOLIC RESIN WORKSURFACES.
2. ALL CASEWORK IN CNC, ISO 8 AND ISO 7 AREAS TO BE STAINLESS STEEL WITH STAINLESS STEEL WORKSURFACES. MOBILE TABLE WORKSURFACES TO HAVE ENCLOSED SS UNDERSIDE.
3. ALL CASEWORK IN WORKSHOP TO BE PAINTED STEEL WITH BUTCHER BLOCK WORKSURFACES.
4. ALL CASEWORK IN AREAS NOT COVERED BY NOTES 1, 2 OR 3 TO BE PAINTED METAL WITH PHENOLIC RESIN WORKSURFACES.
5. SEE ARCHITECTURAL SHEETS FOR MILLWORK IN NON-LAB AREAS.

B1349N VAULT CORRIDOR

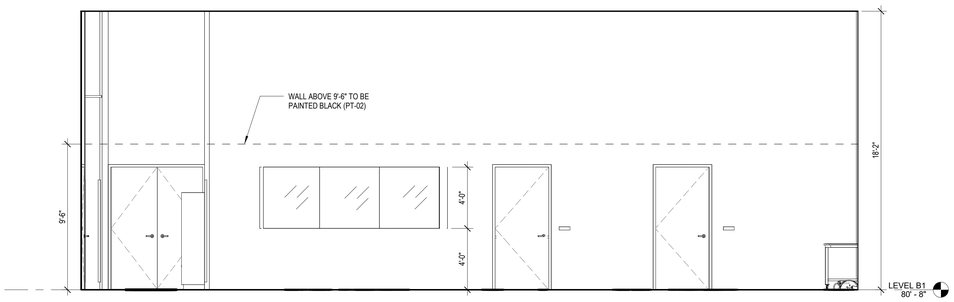


8 L7.21 B1349N VAULT CORRIDOR - EAST ELEVATION
1/4" = 1'-0"

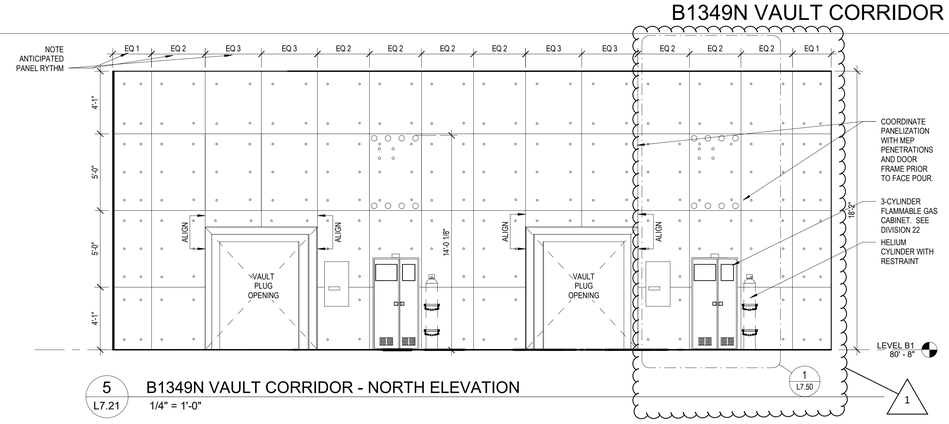


7 L7.21 B1349N VAULT CORRIDOR - WEST ELEVATION
1/4" = 1'-0"

B1349N VAULT CORRIDOR

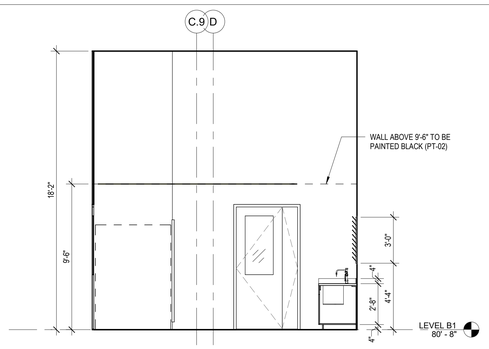


6 L7.21 B1349N VAULT CORRIDOR - SOUTH CORRIDOR
1/4" = 1'-0"

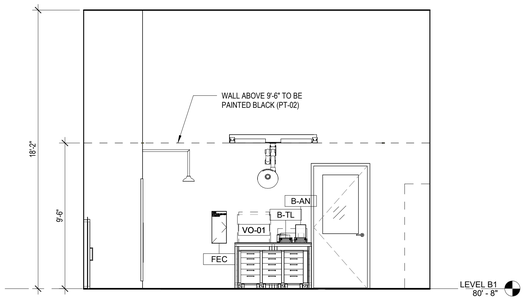


5 L7.21 B1349N VAULT CORRIDOR - NORTH ELEVATION
1/4" = 1'-0"

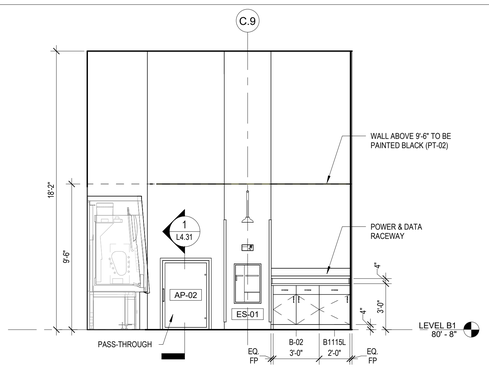
B1359 TARGET PREP



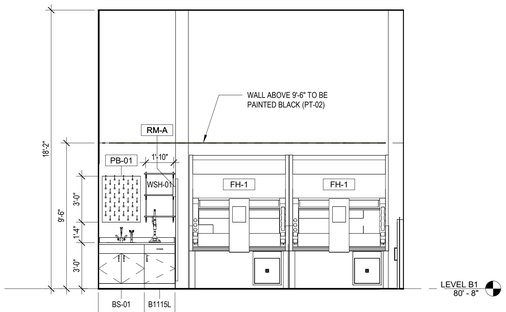
4 L7.21 B1359 TARGET PREP - NORTH ELEVATION
1/4" = 1'-0"



3 L7.21 B1359 TARGET PREP - WEST ELEVATION
1/4" = 1'-0"



2 L7.21 B1359 TARGET PREP - SOUTH ELELEVATION
1/4" = 1'-0"



1 L7.21 B1359 TARGET PREP - EAST ELEVATION
1/4" = 1'-0"

Prime Architect Firm:
Potter Lawson
Success by Design
Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:

Key Plan:

PRELIMINARY
NOT FOR CONSTRUCTION

The Board of Regents of the University of Wisconsin System on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
INTERIOR ELEVATIONS

Revisions:

No.	Date:	Description:
BD	06/30/2026	Bid Drawings
1	09/09/2026	Addendum No. 5

Graphic Scale	0' 2' 4' 8'
UWSA, UW Project #	A-23-011, 1485-2343
Set Type	BD
Date Issued	06/30/2026
Sheet Number	L7.21

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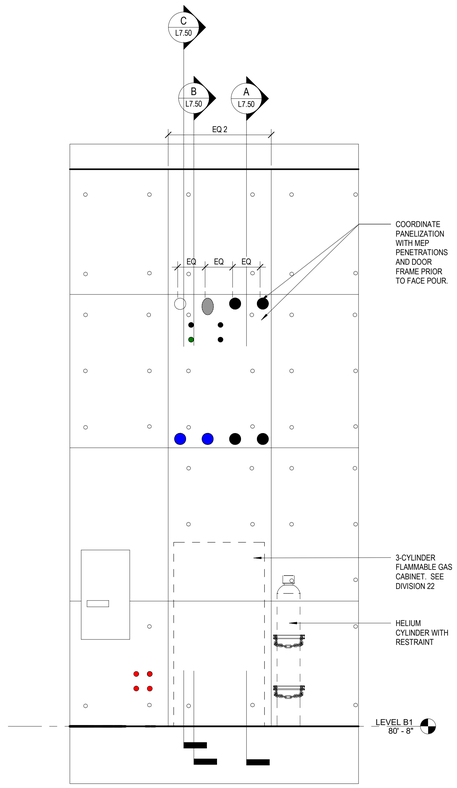
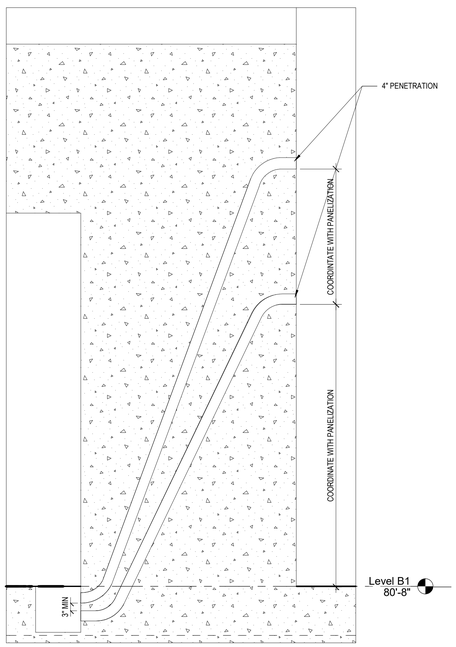
GENERAL NOTES:
- ONLY ONE VAULT IS SHOWN. BOTH VAULTS REQUIRE ALL PENETRATIONS INDICATED.
- ALL PENETRATIONS ARE CAST IN PLACE
- PENETRATIONS MUST MAINTAIN 3" SEPARATION BETWEEN OTHER PENETRATIONS IN ALL DIRECTIONS.
- REFER TO STRUCTURAL FOR REBAR PLACEMENT BETWEEN AND AROUND PENETRATIONS.
- ALL LOCATIONS ARE FOR REFERENCE ONLY. GC TO COORDINATE FINAL QUANTITY, SIZE AND LOCATIONS WITH CYCLOTRON MANUFACTURER AND OWNER AND DOCUMENT IN SHOP DRAWINGS PRIOR TO POUR

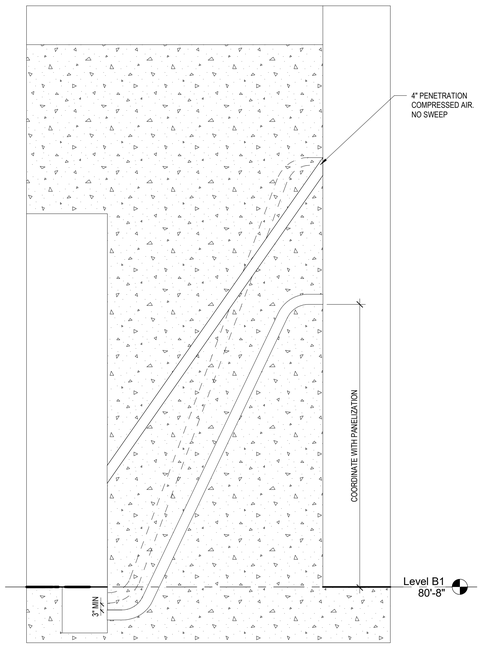
- SPECIALTY GASES
  - 4" PVC TUBE
  - HIGH (OUTSIDE VAULT)-TO-LOW, WITH LONG SWEEPS.
  - TERMINATES IN VAULT TRENCH
- COMPRESSED AIR
  - 4" PVC TUBE
  - HIGH (OUTSIDE VAULT)-TO-LOW
  - HARD PIPE REQUIRED. NO SWEEPS.
  - INTERIOR HEIGHT BETWEEN 1' AND 3' AFF
- CHILLED WATER
  - 4" PVC TUBE
  - HIGH (OUTSIDE VAULT)-TO-LOW, WITH LONG SWEEPS
  - TERMINATES IN VAULT TRENCH
- SPARE
  - 4" PVC TUBE
  - HIGH (OUTSIDE VAULT)-TO-LOW, WITH LONG SWEEPS
  - TERMINATES IN VAULT TRENCH
- POWER
  - 2" PVC TUBE
  - HIGH (OUTSIDE VAULT)-TO-LOW, WITH LONG SWEEPS
  - DOES NOT NEED TO TERMINATE IN VAULT TRENCH
- POWER
  - 2" PVC TUBE
  - LOW (OUTSIDE VAULT)-TO-HIGH, WITH LONG SWEEPS



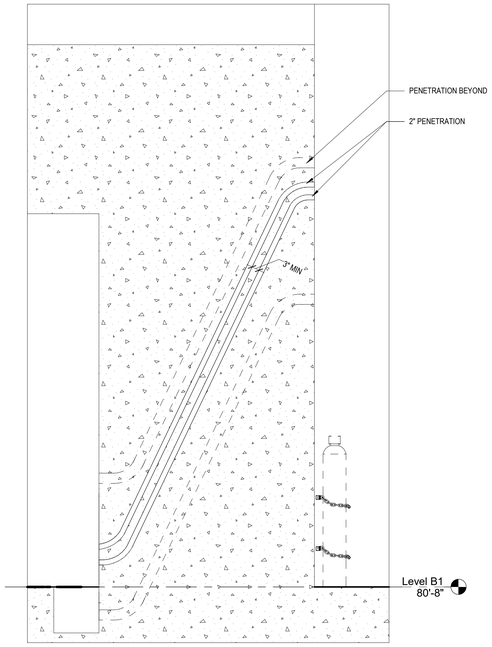
1 L7.50 B1349N VAULT CORRIDOR - NORTH ELEVATION DETAIL
1/2" = 1'-0"



A L7.50 VAULT PENETRATIONS SECTION A
1/2" = 1'-0"



B L7.50 VAULT PENETRATIONS SECTION B
1/2" = 1'-0"



C L7.50 VAULT PENETRATIONS SECTION C
1/2" = 1'-0"

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Prime Architect Firm:
Potter Lawson
Success by Design
Architect / Lab Planning:
HOK

PLI Project No:
2023.35.00

Consultant:

Key Plan:

PRELIMINARY
NOT FOR CONSTRUCTION

The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research
School of Medicine and Public Health

Project Location:
University of Wisconsin - Madison

Sheet Title:
VAULT UTILITY PENETRATIONS

Revisions:

No.	Date:	Description:
BD	06/30/2026	Bid Drawings
1	09/09/2026	Addendum No. 5

Graphic Scale	AS NOTED
UWSA, UW Project #	**A-23-011, 1485-2343**
Set Type	**BD**
Date Issued	**06/30/2026**
Sheet Number	**L7.50**

WIMR East Wedge Cyclotron and Expansion
University of Wisconsin - Madison

School of Medicine and Public Health
1111 Highland Avenue, Madison, WI

UW Madison Project # 1485-2511
UW Building #1485

Bid Set

PLUMBING, MECHANICAL, ELECTRICAL, AND TECHNOLOGY

VOLUME 3 of 4

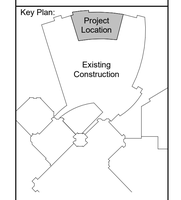
Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:

Key Plan:



The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institutes for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
SHEET INDEX - VOLUME 3

Revisions:

No.	Date:	Description:
	06/30/2026	Bid Drawings
1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

Graphic Scale	NOT TO SCALE
UWSA, UW Project #	A-23-011, 1485-2343
Set Type	BD
Date Issued	06/30/2026
Sheet Number	T0.31

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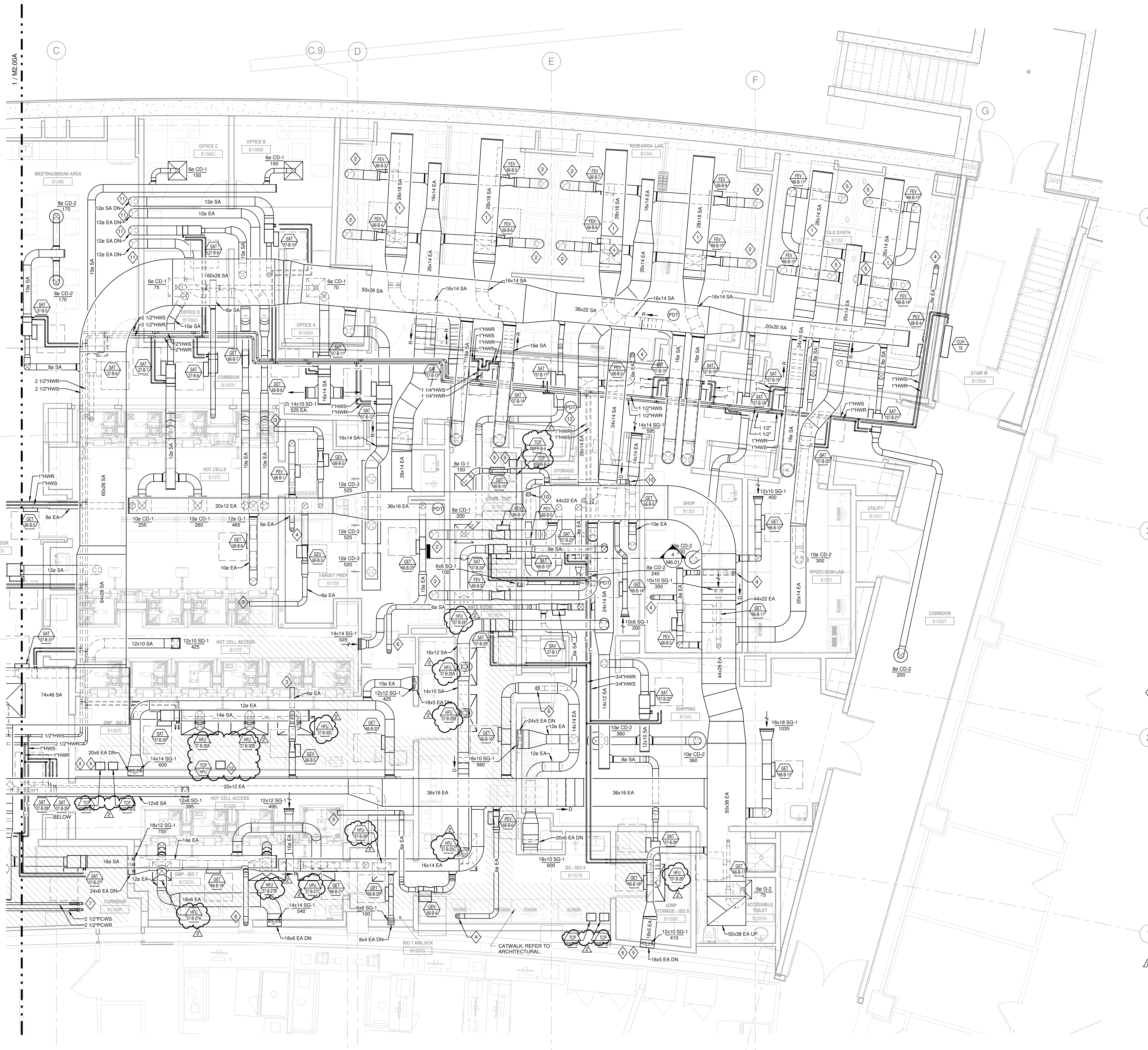

1 B1 - BASEMENT LEVEL MECHANICAL PLAN - AREA B

SCALE: 1/4" = 1'-0"

GENERAL NOTES

1. PROVIDE MANUAL BALANCING DAMPER FOR EACH DIFFUSER AND GRILLE. UNLESS OTHERWISE INDICATED, INSTALL BALANCING DAMPER AS CLOSE TO BRANCH TAKEOFFS AS POSSIBLE. PROVIDE ADDITIONAL MANUAL BALANCING DAMPERS SHOWN ON DRAWINGS AND AS REQUIRED TO MEET AIR BALANCE REQUIREMENTS.
2. DUCT SIZE TO DIFFUSERS, REGISTERS, AND GRILLES SHALL BE SAME AS NECK SIZE UNLESS INDICATED. PROVIDE ROUND TO RECTANGULAR DUCT TRANSITIONS WHERE REQUIRED. REFER TO SPECIFICATION SECTION 23 3114 -DUCTWORK FOR TRANSITION REQUIREMENTS.
3. DUCT SIZE TO INLET OF AIR TERMINAL DEVICES SHALL BE SAME AS AIR TERMINAL INLET SIZE UNLESS OTHERWISE INDICATED.
4. COORDINATE DIFFUSER, REGISTER, AND GRILLE LOCATIONS WITH REFLECTED CEILING PLANS IN ARCHITECTURAL DRAWING SERIES.
5. REFER TO SECTION 23 3114 -DUCTWORK FOR APPLICATION OF FLEXIBLE DUCTWORK CONNECTIONS TO DIFFUSERS, REGISTERS, AND GRILLES. FLEXIBLE DUCT SHALL BE SAME AS NECK SIZE OF DIFFUSER, REGISTER, OR GRILLE.
6. UNLESS OTHERWISE INDICATED, LOCATE BOTTOM OF AIR TERMINAL DEVICE MAXIMUM OF 18 INCHES ABOVE CEILING AND AT LOCATION ALLOWING ACCESS TO EQUIPMENT FOR OPERATION, SERVICE, AND PROPER MAINTENANCE.
7. FLOOR PLAN DRAWINGS AND SECTIONS INDICATE ROUTING, MAJOR DAMPERS, AND MAJOR DUCTWORK SPECIALTIES. REFER TO DETAILS AND SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
8. WHERE ROUTING OF DUCTWORK IS MODIFIED BY CONTRACTOR, RESULTING IN ADDITIONAL PENETRATIONS OF RATED PARTITIONS, BARRIERS, OR WALLS, PROVIDE APPROPRIATE LIFE-SAFETY DAMPERS IN DUCT PENETRATIONS. REFER TO ARCHITECTURAL DRAWINGS AND LIFE-SAFETY DRAWINGS FOR LOCATIONS AND REQUIREMENTS OF FIRE AND/OR SMOKE RESISTANCE CONSTRUCTION AND REFER TO SPECIFICATIONS FOR LIFE-SAFETY DAMPER REQUIREMENTS.
9. REFER TO ARCHITECTURAL DRAWINGS AND SPECIFICATIONS FOR ROOF OPENINGS AND FLASHING REQUIREMENTS FOR ROOF-MOUNTED EQUIPMENT.
10. ARRANGE POSITION AND ORIENTATION OF MANUAL BALANCING DAMPER OPERATORS FOR APPROPRIATE ACCESS. WHERE PRACTICAL, GROUP MANUAL BALANCING DAMPERS SERVING MULTIPLE BRANCH DUCTS FOR ACCESS FROM COMMON CEILING TILE OR ACCESS PANEL.
11. COORDINATE DUCT SIZE AND CONFIGURATION AT SMOKE DETECTORS WITH FIRE ALARM AND DETECTION CONTRACTOR. INFORM ENGINEER AND OBTAIN APPROVAL IF MODIFICATIONS OF DUCTWORK IS REQUIRED.
12. FLOOR PLANS AND SECTIONS INCLUDE PIPE ROUTING, MAJOR VALVES, AND MAJOR PIPING SPECIALTIES. REFER TO DETAILS AND SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
13. LOCATE REHEAT COIL CONTROL VALVE AND ASSOCIATED PIPING SPECIALTIES ADJACENT TO AIR TERMINAL DEVICE SERVED AND NOT MORE THAN 18 INCHES ABOVE CEILING TO FACILITATE ACCESS.
14. MAINTAIN CODE-REQUIRED CLEARANCES IN FRONT OF CONTROL PANELS AND LINE VOLTAGE OR LOW VOLTAGE POWER CONNECTIONS OF AIR TERMINAL DEVICES AND OTHER HEATING AND/OR COOLING TERMINAL UNITS. COORDINATE INSTALLATION OF PIPING WITH WORK OF OTHER TRADES TO AVOID INTERFERENCE WITH CLEARANCE REQUIREMENTS.
15. MOUNT BOTTOM OF LOW WALL EXHAUST GRILLES 12" AFF.
16. PIPING RUN-OUTS TO TERMINAL UNITS TO BE 3/4-INCH UNLESS OTHERWISE INDICATED.
17. INSTALL BRANCH PIPING TO EACH TERMINAL DEVICE WITH MINIMUM OF THREE ELBOWS TO ALLOW FOR EXPANSION AND CONTRACTION OF PIPING SYSTEM.
18. UNLESS OTHERWISE INDICATED, PIPE COOLING COIL CONDENSATE TO NEAREST HUB DRAIN, FLOOR DRAIN, OR FLOOR SINK.

SHEET KEYNOTES

1. PERFORATED SUPPLY AIR DUCTWORK. REFER TO DETAIL 5 / M8.04.
2. 12ø EXHAUST DUCT DOWN TO 6' FUME HOOD. 855 CFM.
3. HOT CELL EXHAUST CONNECTION. COORDINATE FINAL CONNECTION WITH HOT CELL MANUFACTURER.
4. 6ø EXHAUST DUCT DOWN TO 4ø CONNECTION TO SNORKEL. 50 CFM.
5. 12ø EXHAUST DUCT DOWN TO 6' FUME HOOD. 615 CFM.
6. 6ø SUPPLY DUCT DOWN TO 4ø DUCT. CONNECT TO PASSTHROUGH EQUIPMENT. 40 CFM.
7. VALVE AND CAP 2-1/2"PCWS/R PIPES FOR FUTURE.
8. 24VAC TRANSFORMER PANELS, PROVIDED BY 23 09 23 CONTRACTOR. INSTALL TRANSFORMERS SO THEY ARE ACCESSIBLE FROM CATWALK.
9. THE 23 09 23 CONTRACTOR MAY RELOCATE TRANSFORMERS, BUT THEY MUST BE ACCESSIBLE FROM CATWALK. IF TRANSFORMER PANELS ARE RELOCATED, THE 23 09 23 CONTRACTOR IS RESPONSIBLE FOR COORDINATING NEW LOCATION WITH DIVISION 26.
10. 6ø EXHAUST DUCT DOWN TO 4ø CONNECTION TO ACID CABINET. 20 CFM.
11. DIRECT BURIED UNDERGROUND DUCT SHALL EXTEND THOUGH FLOOR SLAB. PROVIDE TRANSITION TO ROOM DUCTWORK AS CLOSE TO FLOOR AS POSSIBLE.
12. PROVIDE PRESSURE DIFFERENTIAL TRANSMITTER FOR FEEDBACK TO HHW PUMPS.
13. CONTROL PANEL SHALL BE FURNISHED BY HEPA FAN FILTER MANUFACTURER. REFER TO SPECIFICATION 23 37 13 FOR DETAILS ON CONTROL PANEL. INSTALL CONTROL PANELS SO IT IS ACCESSIBLE FROM CATWALK.

Prime Architect Firm: Potter Lawson Success by Design

Architect / Lab Planning: HOK

PLI Project No: 2023.35.00

Consultant: AEI Affiliated Engineers®
Affiliated Engineers, Inc.
5802 Research Park Boulevard
Madison, Wisconsin 53719
Tel 608.238.2616

Key Plan: Project Location; Existing Construction

The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution: UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title: WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research

Project Location: University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title: B1 - BASEMENT LEVEL MECHANICAL PLAN - AREA B

Revisions:

No.	Date:	Description:
BD	06/30/2026	Bid Drawings
1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

Graphic Scale: 0' 2' 4' 8'

UWSA, UW Project #: A-23-011, 1485-2511

Set Type: BD

Date Issued: 06/30/2026

Sheet Number: M2.00B

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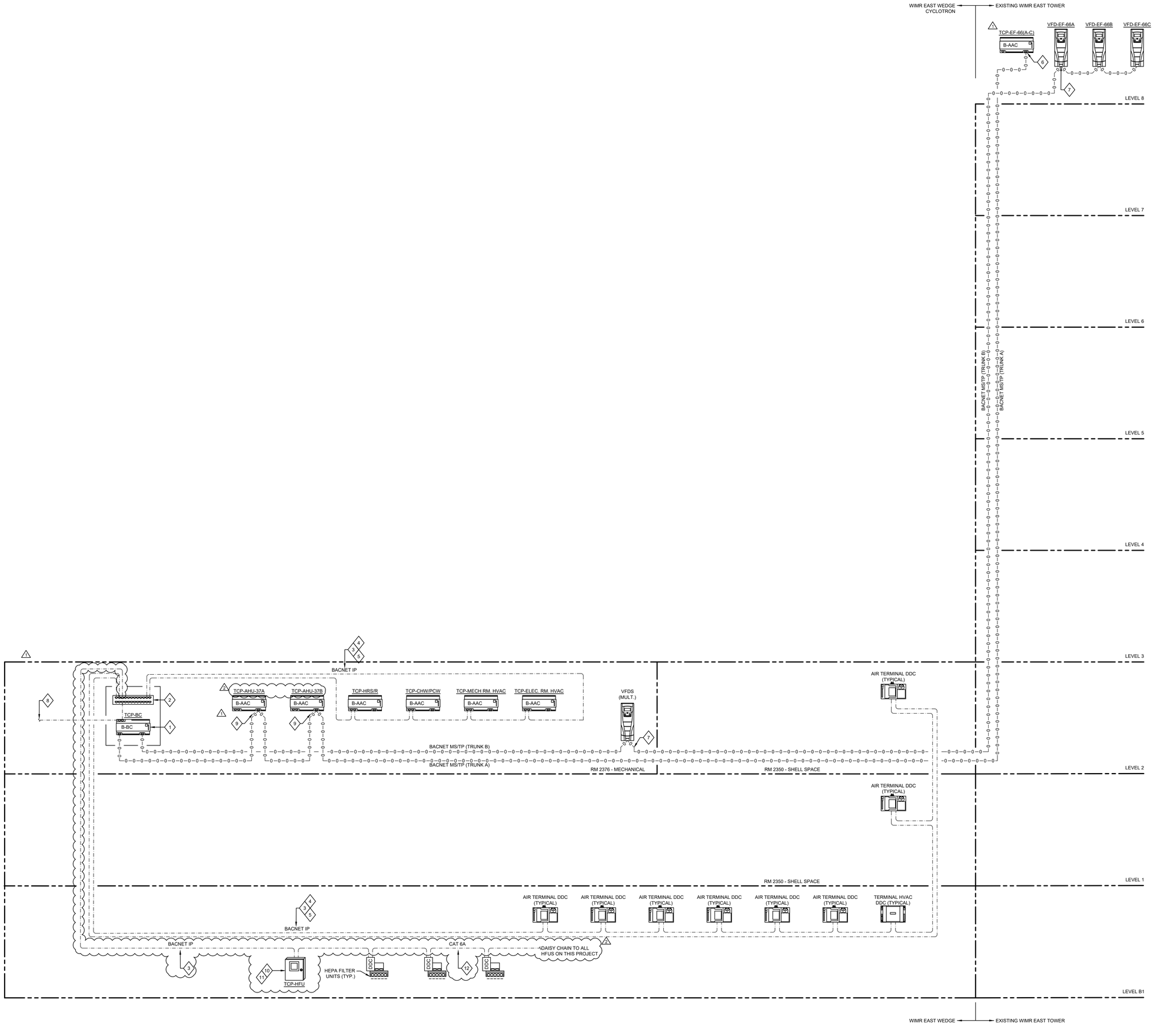

GENERAL NOTES

1. THE DDC CONTROLLER LAYOUT SHOWN HERE IS ILLUSTRATIVE ONLY AND ACTUAL CONTROLLER LAYOUT IS THE RESPONSIBILITY OF THE 23 09 23 CONTRACTOR. ACUTAL CONTROLLER LAYOUT NEEDS TO BE SUBMITTED BY 23 09 23 CONTRACTOR AND APPROVED BY ENGINEER.
2. CONTROL PANELS TO BE SIZED BASED ON EQUIPMENT I/O COUNT AND APPLICATION. FINAL CONTROL PANEL TYPES TO BE DETERMINED BY CONTROLS CONTRACTOR AND CONFIRMED BY ENGINEER.
3. UNLESS OTHERWISE NOTED, ALL 23 09 23 DDCS SHALL COMMUNICATE VIA BACNET/IP.
4. 120V POWER SHALL REMAIN OUTSIDE OF DDC PANEL ENCLOSURES. THE 23 09 23 CONTRACTOR SHALL PROVIDE 24VAC/VDC TRANSFORMERS OUTSIDE OF DDC ENCLOSURES.

SHEET KEYNOTES

1. PROVIDE A MINIMUM OF ONE NEW BUILDING CONTROLLER FOR THIS PROJECT. ALL NEW DDCS SHALL BE INTEGRATED VIA THE NEW SUPERVISORY CONTROLLER.
2. THE 23 09 23 CONTRACTOR SHALL PROVIDE NETWORK SWITCH(ES) FOR BAS NETWORK COMMUNICATION. REFER TO SPECIFICATION 23 09 23 FOR REQUIREMENTS. INSTALL NETWORK SWITCH WITHIN PANEL ENCLOSURE THAT ALSO HOUSES THE NEW BUILDING CONTROLLER.
3. ALL BACNET/IP WIRING SHALL BE PROVIDED BY 23 09 23.
4. PROVIDE RING TOPOLOGY TO PROVIDE FAULT TOLERANT COMMUNICATION. ETHERNET SWITCH, PROVIDED BY 23 09 23, SHALL SUPPORT RING TOPOLOGY.
5. PROVIDE SEPARATE ETHERNET RINGS FOR ADVANCED APPLICATION CONTROLLERS (AAC), TERMINAL DEVICE DDCS, AND HEPA FAN FILTER UNITS AS SHOWN.

△2
6. NEW EXHAUST DDC SHALL BE INTEGRATED INTO NEW BUILDING CONTROLLER VIA MS/TP. OWNER WANTS THE NEW EXHAUST DDC MANAGED BY NEW BUILDING CONTROLLER.

7. THIRD PARTY DDCS, UTILIZING MS/TP COMMUNICATION, SHALL RESIDE ON ISOLATED MS/TP COMMUNICATION BUS AS SHOWN.
8. DIVISION 27 CONTRACTOR SHALL PROVIDE CONNECTION TO CAMPUS NETWORK. NEW DDCS SHALL BE INTEGRATED INTO THE EXISTING WEBSERVER VIA THIS CONNECTION.

△1
9. NEW DDCS, FOR AHU-37A AND AHU-37B, SHALL UTILIZE MS/TP COMMUNICATION PORT. THIS WILL ALLOW INTERLOCKING TO OCCUR VIA PEER-TO-PEER COMMUNICATION BETWEEN THE AHU DDCS AND THE NEW EXHAUST FAN DDC. THIS WILL ENSURE INTERLOCKING IS MAINTAINED IN THE EVENT THE 23 09 23 CONTRACTOR FURNISHED SWITCH FAILS.

△2
10. HEPA FILTER UNITS (HFUS) SHALL BE CONTROLLED AND MONITORED THROUGH A CENTRAL CONTROL PANEL FURNISHED BY THE HFU MANUFACTURER. REFER TO SECTION 23 37 13 FOR REQUIREMENTS.
11. HFU CONTROLLER SHALL COMMUNICATE WITH THE BUILDING AUTOMATION SYSTEM VIA BACNET/IP. WHERE THE HFU CONTROLLER DOES NOT NATIVELY SUPPORT BACNET/IP, THE HFU MANUFACTURER SHALL FURNISH A PROTOCOL GATEWAY TO EXPOSE THE REQUIRED CONTROL AND MONITORING POINTS AS BACNET OBJECTS.
12. THE 23 09 23 CONTRACTOR SHALL PROVIDE CAT 6A CABLING TO ALL HEPA FILTER UNITS (HFU).

Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:
Affiliated Engineers
Affiliated Engineers, Inc.
5802 Research Park Boulevard
Madison, Wisconsin 53719
Tel 608.238.2616

Key Plan:

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1111 Highland Avenue, Madison, WI 53705

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Wisconsin Institute for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
BUILDING AUTOMATION SYSTEM ARCHITECTURE

Revisions:

No.	Date:	Description:
BD	06/30/2026	Bid Drawings
1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

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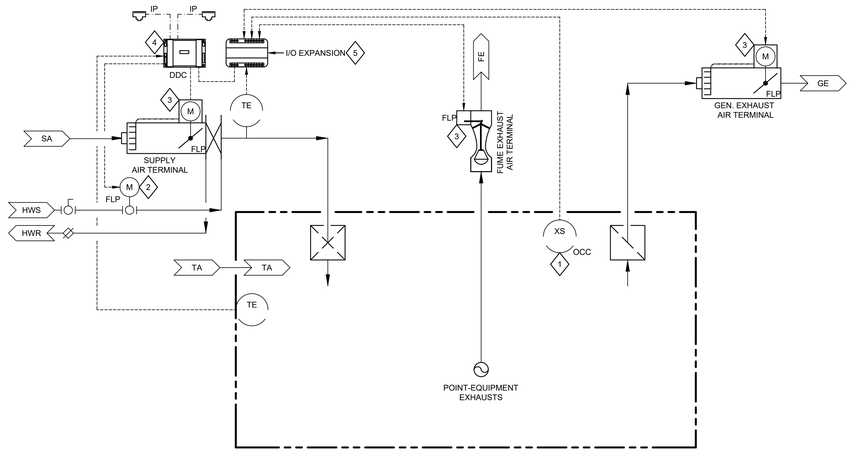

4 ROOM CONTROL SEQUENCE D

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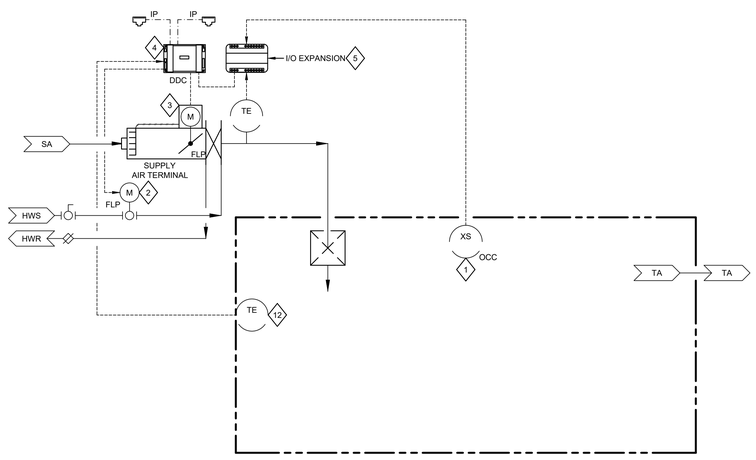

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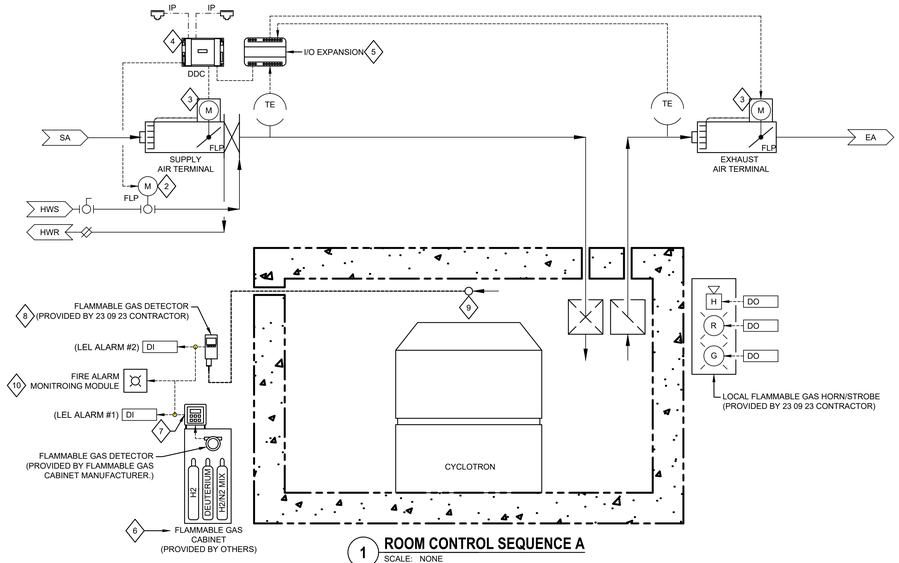

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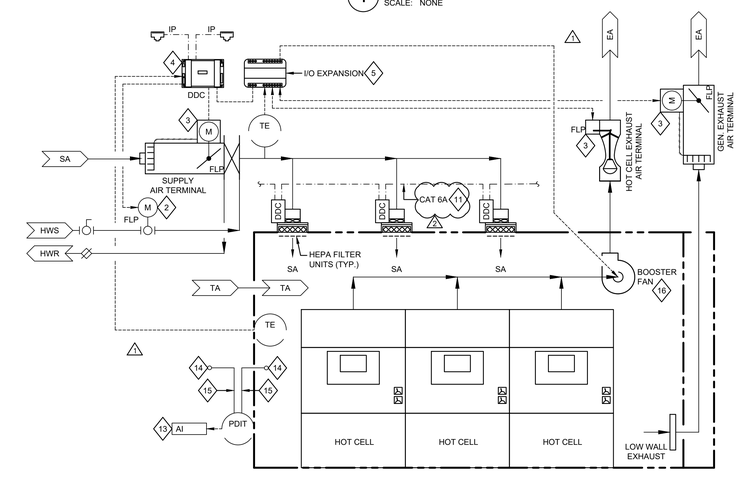

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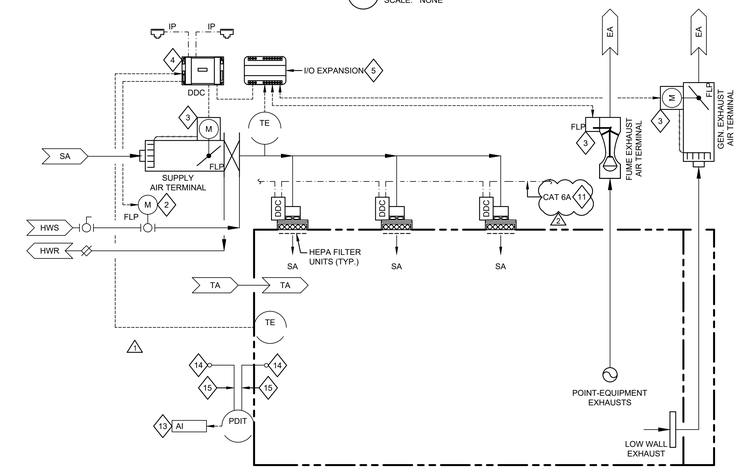

3 ROOM CONTROL SEQUENCE C

SCALE: NONE

GENERAL NOTES

1. THE CONTROL 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 DIAGRAM INCLUDES GENERAL PIPING ARRANGEMENT. REFER TO SPECIFICATIONS AND MECHANICAL DETAILS FOR ADDITIONAL REQUIREMENTS.
3. CONTROL DIAGRAM INCLUDES GENERAL ARRANGEMENT OF SYSTEM COMPONENTS. REFER TO FLOOR PLANS AND EQUIPMENT SCHEDULES FOR COMPONENT QUANTITIES.

SHEET KEYNOTES

1. OCCUPANCY SENSOR SHALL BE PROVIDED AS PART OF LIGHTING CONTROL SYSTEM. SENSORS WILL HAVE AUXILIARY CONTACT FOR DDC TO HARDWIRE TO. REFER TO LIGHTING PLANS FOR QUANTITIES AND LOCATIONS. IF A ZONE HAS MULTIPLE OCCUPANCY SENSORS, THE ACTIVATION OF ANY SENSOR SHALL INDEX THE ZONE INTO OCCUPIED MODE. THE 23 09 23 CONTRACTOR REQUIRED TO HARDWIRE TO ALL OCCUPANCY SENSORS.
2. REFER TO FLOOR PLANS FOR QUANTITY OF CONTROL VALVES REQUIRED. A SINGLE ZONE MAY HAVE SEVERAL CONTROL VALVES.
3. REFER TO FLOOR PLANS FOR QUANTITY OF AIR TERMINALS. SOME ZONES WILL HAVE MULTIPLE SUPPLY AND/OR MULTIPLE EXHAUST AIR TERMINALS. REFER TO CONTROL SEQUENCES FOR DETAILS.
4. A SINGLE BACNET IP CONTROL DDC SHALL BE FURNISHED FOR EACH ZONE. THIS DDC SHALL GOVERN ALL HVAC CONTROL FOR THE ZONE IT SERVES. IF BAS ETHERNET NETWORK FAILS, THIS DDC SHALL MAINTAIN TEMPERATURE CONTROL AND SPACE PRESSURE OFFSET CONTROL. DO NOT RELY ON COMMUNICATING AIRFLOW RATES, VIA ETHERNET, TO MAINTAIN SPACE AIRFLOW TRACKING.
5. FURNISH INPUT/OUTPUT EXPANSION MODULES, AS REQUIRED, TO SUPPORT THE SINGLE CONTROL DDC.
6. FLAMMABLE GAS CABINET WILL CONTAIN VARIOUS HYDROGEN GAS CYLINDERS. GAS CABINET MANUFACTURER SHALL INCLUDE INTERNAL FLAMMABLE GAS DETECTION SENSOR.
7. FLAMMABLE GAS CABINET SHALL INCLUDE FACTORY PROVIDED CONTROLLER. CONTROLLER SHALL INCLUDE RELAY CONTACT WHICH TOGGLES WHEN INTERNAL LOWER EXPLOSIVE LIMIT EXCEEDS 20%. BAS SHALL MONITOR THIS CONTACT.

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8. FLAMMABLE GAS DETECTOR SHALL BE AIR SAMPLING TYPE. DETECTOR SHALL INCLUDE INTERNAL VACUUM PUMP TO SAMPLE AIR REMOTELY. FLAMMABLE GAS DETECTOR SHALL BE INSTALLED OUTSIDE OF THE CYCLOTRON VAULT. REFER TO DETAIL #1 AND #2, ON SHEET M7.20, FOR INSTALLATION DETAILS.
9. THE 23 09 23 CONTRACTOR SHALL EXTEND AIR SAMPLING TUBING FROM FLAMMABLE GAS DETECTOR INTO CYCLOTRON VAULT. EXTEND TUBING DIRECTLY OVER WHERE THE HYDROGEN GAS IS CONNECTED TO THE CYCLOTRON. TUBING SHALL BE TERMINATED TIGHT TO STRUCTURE WHICH WILL SAMPLE WHERE HYDROGEN WOULD COLLECT UPON A LEAK.
10. FIRE ALARM SYSTEM SHALL PROVIDE A MONITOR MODULE. ACTIVATION OF EITHER THE FLAMMABLE GAS CABINET LEL ALARM RELAY OR THE GAS DETECTION SYSTEM ALARM RELAY SHALL INITIATE AN ALARM CONDITION AT THE FIRE ALARM MONITOR MODULE. DIVISION 23 CONTROLS CONTRACTOR (23 09 23) SHALL PROVIDE ALL INTERPOSING RELAY(S) NECESSARY TO IMPLEMENT THIS FUNCTION.

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11. THE 23 09 23 CONTRACTOR SHALL INTEGRATE THE HEPA FILTER UNITS INTO THE METASYS WEBSERVER. CAT 6A ETHERNET CABLES SHALL BE PROVIDED BY 23 09 23 CONTRACTOR. REFER TO DRAWING M7.01 AND SPECIFICATION 23 37 13 FOR INTEGRATION DETAILS.
12. PROVIDE BLANK SPACE TEMPERATURE SENSOR WITHOUT MANUAL ADJUSTMENTS FOR THESE TYPE OF SPACES.

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13. ROOM PRESSURE MONITORS. REFER TO MECHANICAL PRESSURIZATION PLANS FOR LOCATION. INSTALL TOP OF PRESSURE MONITORS AT 60" AFF.
14. PROVIDE SETRA RPS ROOM PRESSURE SENSORS. SENSORS SHALL MEASURE DIFFERENTIAL PRESSURE ON EITHER SIDE OF GWB WALLS. TOP OF SENSOR ASSEMBLY SHALL BE 6" BELOW CEILING. PROVIDE BACKBOX FOR SENSOR WITHIN GWB WALL.
15. PROVIDE PNEUMATIC TUBING FROM ROOM PRESSURE SENSORS TO ROOM PRESSURE MONITORS. TUBING SHALL BE INSTALLED WITHIN GWB WALL AND WITHIN CONDUIT.
16. ONE BOOSTER EXHAUST FAN PROVIDED FOR EACH LINE OF HOT CELLS. THE 23 09 23 CONTRACTOR SHALL PROVIDE 4-20 MA ANALOG SIGNAL TO EXHAUST FAN. REFER TO CONTROL SEQUENCES FOR DETAILS.

Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:
Affiliated Engineers
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Key Plan:

The Board of Regents of the
University of Wisconsin on behalf of
the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research
School of Medicine and Public Health

Project Location:
University of Wisconsin - Madison

Sheet Title:
ROOM HVAC CONTROL DIAGRAMS

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STEAM PRESSURE REDUCING VALVES - PILOT OPERATED TYPE

MARK PRV	LOCATION	SERVICE	PERFORMANCE REQUIREMENTS			PHYSICAL CHARACTERISTICS							REMARKS
			CAPACITY (LBS/HR)	PRESSURE		OPERATING TEMP. (°F)	PRESSURE CLASS (PSIG)	BODY MAT'L	VALVE SIZING			PILOT	
				INLET (PSIG)	FINAL (PSIG)				SIZE (IN)	MIN. (Cv)	MAX. (Cv)	TYPE	
10	MECHANICAL - 2376	STEAM	5666	175	10	450	250	CAST IRON	2	20.58	31	DIAPHRAGM	2/3 VALVE (1)
11	MECHANICAL - 2376	STEAM	2833	175	10	450	250	CAST IRON	1-1/4	8.73	10.4	DIAPHRAGM	1/3 VALVE (1)

NOTES:
(1) PROVIDE PRESSURE REDUCING VALVES WITH SILENCERS TO REDUCE SOUND LEVEL TO BELOW 80 dB.

CONTROL DAMPERS

MARK	SERVICE	BLADE TYPE		SIZE (IN)		ACTUATOR				REMARKS
		OPPOSED	PARALLEL	W X H	DIA.	TYPE (1)	MODULATING	2-POSITION	FAIL POSITION (2)(3)	
SD-37A-2-1	AHU-37A OA INTAKE	-	X	96 X 85	-	E	-	X	(3)	
SSD-37A-2-1	AHU 37A SUPPLY	-	X	96 X 40	-	E	X	-	(3)	SMOKE RATED
SD-37B-2-1	AHU-37B OA INTAKE	-	X	96 X 85	-	E	-	X	(3)	
SSD-37B-2-1	AHU-37B SUPPLY	-	X	96 X 40	-	E	X	-	(3)	SMOKE RATED
ED-EF-66A	EF-66A	-	X	-	46	E	X	-	(3)	
ED-EF-66B	EF-66B	-	X	-	46	E	X	-	(3)	
ED-EF-66C	EF-66C	-	X	-	46	E	X	-	(3)	
ED-HRU-66-1	HRU-66 INLET	-	X	164 X 66	-	E	-	X	(3)	
ED- HRU-66-2	HRU-66 OUTLET	-	X	164 X 66	-	E	-	X	(3)	
ED-HRU-66-3	HRU-66 INTERNAL BYPASS	-	X	164 X 42	-	E	-	X	(3)	
ED-66-8-1	HRU-66 BYPASS	X	-	62 X 62	-	E	-	X	(3)	
RD-2-2-1	SF-2 BYPASS	X	-	20 X 18	-	E	X	-	(3)	
RD-3-2-1	SF-3 BYPASS	X	-	24 X 24	-	E	X	-	(3)	
ED-2-2-1	RH-1	-	X	20 X 14	-	E	X	-	(3)	
ED-21-2-1	RH-2	-	X	14 X 14	-	E	X	-	(3)	
ED-3-2-1	RH-3	-	X	26 X 24	-	E	X	-	(3)	
OD-2-2-1	SF-2 OUTSIDE AIR	X	-	22 X 22	-	E	X	-	(3)	
OD-3-2-1	SF-3 OUTSIDE AIR	X	-	28 X 28	-	E	X	-	(3)	

NOTES:
1. ACTUATOR TYPE: E=ELECTRIC, P=PNEUMATIC
2. FC=FAIL CLOSED, FO=FAIL OPEN, FLP=FAIL TO LAST POSITION
3. REFER TO SYSTEM DIAGRAM DRAWINGS IF FAIL POSITION IS NOT INDICATED IN SCHEDULE

VARIABLE FREQUENCY DRIVES

MARK VFD	SYSTEM	MAX. HORSEPOWER	INPUT ELECTRICAL CHARACTERISTICS			ENCLOSURE NEMA	SCCR MIN. (kIC)	DRIVE CHARACTERISTICS	REMARKS
			VOLT	FREQUENCY	PHASE				
HWP-7	HHW	7.5	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
HWP-8	HHW	7.5	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
PCWP-9	PCW	10	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
PCWP-10	PCW	10	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
PCWP-11	PCW	10	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
RWP-4	HRW	30	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
SF-37A-1	SA	20	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
SF-37A-2	SA	20	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
SF-37A-3	SA	20	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
SF-37A-4	SA	20	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
SF-37B-1	SA	20	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
SF-37B-2	SA	20	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
SF-37B-3	SA	20	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
SF-37B-4	SA	20	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
EF-66A	EA	60	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
EF-66B	EA	60	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	
EF-66C	EA	60	480	60	3	1	100	6-PULSE DRIVE WITH 5% IMPEDENCE	

2

DIFFUSERS, REGISTERS, AND GRILLES

MARK	SERVICE	CFM RANGE	NECK SIZE (IN)	FACE SIZE (IN)	FACE TYPE	PATTERN (2)	FINISH (3)	MATERIAL	MOUNTING SURFACE (4)	REMARKS
CD-1	SUPPLY	0-150	6	24x24	PERFORATED	SEE PLANS	WHITE	GALV.	ACT/GWB	TITUS OMNI
		155-240	8							
		245-380	10							
		385-480	12							
		485-550	14							
		555-620	15							
CD-2	SUPPLY	0-250	8	18	CONE	CIRCULAR	WHITE	STEEL	DUCT	TITUS TMRA
		255-380	10	22-1/2						
		385-550	12	27						
CD-3	SUPPLY	0-400	10	24x48	PERFORATED	RADIAL	WHITE	STEEL	ACT/GWB	TITUS TRITEC
		405-550	12							
SD-1	SUPPLY	SEE PLANS	SEE PLANS	(1)	LOUVER	DBL. DEFL.	WHITE	STEEL	DUCT	TITUS 300RL
SG-1	EXHAUST	SEE PLANS	SEE PLANS	(1)	LOUVER	35° DEFL.	WHITE	STEEL	GWB/DUCT	TITUS 350RL
G-1	EXHAUST	0-120	6	24x24	PERFORATED	-	WHITE	GALV.	ACT/GWB	TITUS PAR
		125-205	8							
		210-325	10							
		330-470	12							
		475-640	14							
		645-835	16							
		845-1350	18x18							
		1355-2000	22x22							
G-2	EXHAUST	0-120	6	24x24	PERFORATED	-	WHITE	ALUM.	GWB	TITUS PAR-AA

NOTES:
(1) FACE SIZE EQUALS NECK SIZE PLUS 1-3/4". 3/4" BLADE SPACING
(2) USE 4 WAY IF NO PATTERN IS INDICATED ON PLAN. USE 2 WAY IF NO PATTERN IS INDICATED FOR RADIAL.
(3) VERIFY FINISH COLOR/TYPE WITH ARCHITECTURAL DRAWINGS. DIFFUSERS IN METAL CEILING SHALL MATCH ALUMINUM COLOR.
(4) VERIFY CEILING TYPE ON ARCHITECTURAL DRAWINGS. All DIFFUSER BORDER TYPES TO BE CONFIRMED BY THE ARCHITECT AND ENGINEER PRIOR TO FINAL PURCHASE OF GRILLES AND DIFFUSERS.

EXPANSION TANKS

MARK ET	SYSTEM	TANK VOLUME (GAL)	MIN. ACCEP. VOLUME (GAL)	DIMENSIONS			AIR CHARGE PRESSURE (PSIG)	REMARKS
				DIA. (IN)	LENGTH (IN)	SYSTEM CONN. (IN)		
1	PCW	10	10	12	24	3/4	30	
2	HHW	34	34	20	37	3/4	30	
3	HR	80	80	24	55	1-1/2	30	

2

FAN COIL UNITS

MARK FCU	LOCATION	TYPE	FAN CHARCTERISTICS			COOLING COIL							HEATING COIL					FILTERS		ELECTRICAL			REMARKS
			NOM. CFM	OA CFM	ESP (IN. WG)	HT (BTUH)	HS (BTUH)	EAT		EWT (°F)	GPM	MAX PD (FT)	MAX FACE VEL. (FPM)	CAP. (BTUH)	EAT DB (°F)	EWT (°F)	GPM	MAX PD (FT)	PRE FILTER		MOTOR			
								DB (°F)	WB (°F)										TYPE	THICK (IN)	HP	VOLT	PH	
93	CORRIDOR - 1300X	CEILIING MOUNTED	100	50	0.28	2200	2200	81	67.8	58	0.6	5	500	4600	27.5	160	0.5	5	TA	1	1/30	120	1	(1)
94	CORRIDOR - 1300W	CEILIING MOUNTED	100	50	0.28	2200	2200	81	67.8	58	0.6	5	500	4600	27.5	160	0.5	5	TA	1	1/30	120	1	(1)

NOTES:
(1) PROVIDE AN OUTSIDE AIR CONNECTION AT THE BACK OF THE UNIT AND A RETURN GRILLE ON THE BOTTOM.

AIR AND DIRT SEPARATORS

MARK ADS	LOCATION	SYSTEM	PERFORMANCE		CONNECTION SIZE (IN)	DRAIN SIZE (IN)	OVERALL DIAMETER (IN)	OVERALL HEIGHT (IN)	WEIGHT (LBS)	REMARKS
			FLOW RATE (GPM)	PD MAX (FT)						
5	MECHANICAL - 2376	PCW	225	10	4	2	12.75	32	278	
6	MECHANICAL - 2376	HHW	175	10	4	2	12.75	32	278	
7	MECHANICAL - 2376	RWS	550	10	6	2	18	45	295	

CABINET UNIT HEATERS

MARK CUH	LOCATION	CONFIGURATION		CAPACITY (MBH)	AIR SIDE			WATER SIDE				ELECTRICAL				REMARKS
		EXPOSED			FLOW (CFM)	ESP (IN W.G)	EAT (°F)	FLOW (GPM)	PD (FT)	EWT (°F)	MOTOR					
		INLET POSITION	DISCHARGE POSITION								TYPE	HP	PH	VOLT		
18	STAIR M - B1300A	FRONT (BOTTOM)	FRONT (TOP)	17.1	420	0.01	70	1.7	0.4	160	ECM	1/12	120	1		
19	STAIR C - B1300A.C	FRONT (BOTTOM)	FRONT (TOP)	17.1	420	0.01	70	1.7	0.4	160	ECM	1/12	120	1		

PRESSURE RELIEF VALVES (LIQUID)

MARK RV	SYSTEM	APPLICATION	FLUID		SIZE (IN)	SET PRESSURE (PSIG)	CAPACITY			ASME CERTIFICATION		REMARKS
			TYPE	TEMP. MAX (°F)			(MBH) (1)	FLOW (2) (GPM)	OVER-PRESSURE (PSI) (2) (3)	SECTION	STAMP	
HX-1A	HHW	HX-1A	WATER	200	3/4	95	902	NA	NA	VIII	UV	
HX-1B	HHW	HX-1B	WATER	200	3/4	95	902	NA	NA	VIII	UV	
HW-1	HHW	SYSTEM	WATER	200	3/4	95	-	3.5	10	VIII	UV	
PCW-1	PCW	SYSTEM	WATER	125	3/4	95	-	1.2	10	VIII	UV	
HR-1	HR	GLYCOL FILL	45% EG	125	3/4	95	-	-	10	VIII	UV	

NOTES:
(1) MBH RATED RELIEF VALVE TO BE USED FOR LIQUID SIDE OF HEAT EXCHANGERS
(2) FLOW AND OVER-PRESSURE RATED PRESSURE RELIEF VALVE TO BE USED ON CLOSED LOOP PIPING SYSTEM AT SUCTION SIDE OF PUMP.
(3) PUMP SUCTION IS NON-CODE APPLICATION. ASME STAMP REQUESTED TO PROVIDE MINIMAL OVERPRESSURE.

STEAM FLOW METERS

MARK SFM	LOCATION	SYSTEM	TYPE	PHYSICAL CHARACTERISTICS			OPERATING CONDITIONS					REMARKS
				METER SIZE (IN)	LINE SIZE (IN)	CONN. TYPE	PRESS. MAX (PSIG)	TEMP. MAX. (°F)	FLOW		MAX. PD (PSI)	
									MAX. (LBS/HR)	MIN. (LBS/HR)		
3	MECHANICAL - 2376	HPS(175)	VARIABLE AREA	3	3	FLANGED	200	400	8500	1650	5	

FLOW METERS

MARK WFM	LOCATION	SYSTEM	TYPE	PHYSICAL CHARACTERISTICS		OPERATING CONDITIONS						REMARKS
				METER SIZE (IN)	LINE SIZE MAX. (IN)	PRESS. MAX. (PSIG)	TEMPERATURE		FLOW		PD MAX. (FT)	
							MAX. (°F)	MIN (°F)	MAX. (GPM)	MIN. (GPM)		
5	MECHANICAL - 2376	CPD	MAGNETIC	4	4	125	212	50	30	-	2	
6	MECHANICAL - 2376	CHW	MAGNETIC	6	6	125	60	40	935	-	2	
7	MECHANICAL - 2376	PCHW	MAKE UP	3/4	3/4	125	70	40	1.8	-	4	
8	MECHANICAL - 2376	HHW	MAKE UP	3/4	3/4	125	70	40	3.5	-	4	

EXPANSION JOINTS

MARK EJ	SERVICE	TYPE	PHYSICAL DATA				DEFLECTION / MOVEMENT			BASIS OF DESIGN		REMARKS
			PIPE SIZE DIA. (IN)	OVERALL LEN. (IN)	DESIGN TEMP. (°F)	MAXIMUM PRESSURE (PSIG)	AXIAL (IN)	LATERAL (IN)	TORSIONAL (IN)	MANUFACTURER	MODEL	
42	HPS(175)	SINGLE SLIP	16	34	500	175	8	0	0	ATS	TP2	
43	CPD	SINGLE SLIP	8	26.5	212	40	1	0	0	ATS	TP2	

STEAM SAFETY VALVES

MARK SSV	LOCATION	RELIEF VALVE				REMARKS
		INLET SIZE (IN)	OUTLET SIZE (IN)	SET PRESS. (PSIG)	CAP. (LBS/HR) (1)	
1	MECHANICAL - 2376	4	6	15	6,619	

NOTES:
1. MINIMUM SAFETY VALVE CAPACITY SHALL MATCH OR EXCEED SUBMITTED REGULATING VALVE'S CAPACITY AT MAXIMUM ORIFICE SIZE.
SAFETY VALVE(S) SERVING MULTIPLE PARALLEL REGULATING VALVE STATIONS SHALL BE SIZED FOR CAPACITY OF LARGEST REGULATING VALVE.

HEPA FAN FILTER UNIT

MARK HFU	LOCATION	TYPE	CFM	FACE VEL. (FPM)	LENGTH (IN)	WIDTH (IN)	DEPTH (IN)	NECK SIZE	MOTOR				REMARKS
								DIA. (IN)	HP	PH	VOLT		
37-B-24	ANTE ROOM ISO 8 - B1357A	HEPA	300	75	24	24	13.75	10	1/3	1	120		
37-B-25A	QC-ISO 8 B1357B	HEPA	420	53	48	24	13.75	12	1/3	1	120		
37-B-25B		HEPA	420	53	48	24	13.75	12	1/3	1	120		
37-B-25C		HEPA	420	53	48	24	13.75	12	1/3	1	120		
37-B-26	cGMP STORAGE - ISO 8 - B1358F	HEPA	310	39	48	24	13.75	12	1/3	1	120		
37-B-27A	GMP-ISO7 - B1357H	HEPA	205	51	24	24	13.75	10	1/3	1	120		
37-B-27B		HEPA	545	68	48	24	13.75	12	1/3	1	120		
37-B-27C		HEPA	545	68	48	24	13.75	12	1/3	1	120		
37-B-28	ISO 7 AIRLOCK - B1357G	HEPA	300	75	24	24	13.75	10	1/3	1	120		
37-B-30A	DMF-ISO 8 - B1357D	HEPA	325	41	48	24	13.75	12	1/3	1	120		
37-B-30B		HEPA	325	41	48	24	13.75	12	1/3	1	120		
37-B-30C		HEPA	325	41	48	24	13.75	12	1/3	1	120		

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NOTES:
1. REFER TO PLANS FOR LOCATION AND QUANTITY.
2. PROVIDE WITH 99.99% EFFICIENT HEPA FILTER. PROVIDE STATIC PRESSURE PORT AND HEPA LEAK CHALLENGE PORT.
3. NOT USED.
4. ALL COMPONENTS INCLUDING FAN TO BE ROOMSIDE REMOVABLE.

UNIT HEATERS

MARK UH	LOCATION	TYPE	AIR			WATER				ELECTRICAL			REMARKS
			CFM	EAT (°F)	LAT (°F)	MBH	GPM	PD (FT)	EWT (°F)	MOTOR			
										HP	PH	VOLT	
68	FUTURE SPACE - 1350	HORIZONTAL	870	60	87.4	26.4	2.6	0.1	160	1/10	1	120	
69	FUTURE SPACE - 1350	HORIZONTAL	870	60	87.4	26.4	2.6	0.1	160	1/10	1	120	
70	MECHANICAL - 2376	HORIZONTAL	1040	60	90.5	35.2	3.5	0.3	160	1/10	1	120	
71	FUTURE - 2350	HORIZONTAL	1040	60	90.5	35.2	3.5	0.3	160	1/10	1	120	
72	FUTURE - 2350	HORIZONTAL	1040	60	90.5	35.2	3.5	0.3	160	1/10	1	120	
73	FUTURE - 2350	HORIZONTAL	1040	60	90.5	35.2	3.5	0.3	160	1/10	1	120	
74	FUTURE - 2350	HORIZONTAL	1040	60	90.5	35.2	3.5	0.3	160	1/10	1	120	

WATER PRESSURE REGULATING VALVES

MARK WPRV	SYSTEM	SERVICE	SIZE (IN)	INLET PRESS. (PSIG)	OUTLET PRESS. (PSIG)	BYPASS SIZE (IN)	FLOW RATE (GPM)	REMARKS
PCHW-1	PCHW	MAKE-UP	1/2	40	10	3/4	1.8	
HHW-1	HHW	MAKE-UP	3/4	40	10	3/4	3.5	

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Prime Architect Firm:
Potter Lawson
Success by Design
Architect / Lab Planning:

PLI Project No:
2023.35.00

Consultant:
Affiliated Engineers
Affiliated Engineers, Inc.
5802 Research Park Boulevard
Madison, Wisconsin 53719
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Key Plan:

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
MECHANICAL SCHEDULES

Revisions:

No.	Date:	Description:
BD	06/30/2026	Bid Drawings
1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

Graphic Scale: 0' 2' 4' 8'

UWSA, UW Project #: A-23-011, 1485-2511

Set Type: BD

Date Issued: 06/30/2026

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BASEMENT SUPPLY AND EXHAUST AIR TERMINAL UNITS

ROOM NUMBER SERVED	ROOM NAME SERVED	AIR TERMINAL LOCATION	AIR TERMINAL DEVICES								REHEAT COIL								CONTROLS				REMARKS
			TAG	TYPE	MAX. OCC CFM	MIN OCC CFM	UNOCC CFM	MIN. INLET SIZE (IN)	MATERIAL	MAX APD (in. wg.) (2)	REHEAT CFM	CAPACITY MBH	LAT	FACE AREA (IN)	MAX APD (in. wg.) (3)	ROWS	GPM	MAX WPD (FT)	INLET WATER TEMP.(°F)	SEUENCE NUMBER	ROOM OFFSET (1)	OCCUPANCY SENSOR INTERLOCK	FAILURE MODE CFM	
B1380	CYCLOTRON SUPPORT	B1380	SAT-37-B-1	BUTTERFLY	1080	400	325	10	GALV	0.21	400	10.8	80.0	14x12	0.3	1	1.1	5.0	160	D	0	N	325	
		B1380	GET-66-B-1	BUTTERFLY	1080	400	325	10	GALV	0.21	-	-	-	-	-	-	-	-	-				325	
B1349M	PLUMBING/MECH	B1300X	SAT-37-B-2	BUTTERFLY	100	100	100	6	GALV	0.21	100	3.2	85.0	12x8	0.3	1	0.5	5.0	160	D	0	N	100	
		B1380	GET-66-B-2	BUTTERFLY	100	100	100	6	GALV	0.21	-	-	-	-	-	-	-	-	-				100	
B1349L	CONTROL ROOM	B1349L	SAT-37-B-3	BUTTERFLY	200	155	95	6	GALV	0.21	155	4.2	80.0	12x8	0.3	2	0.5	5.0	160	D	0	N	95	
		B1349L	GET-66-B-3	BUTTERFLY	200	155	95	6	GALV	0.21	-	-	-	-	-	-	-	-	-				95	
B1349K	TOILET	B1380	GET-66-B-4	BUTTERYFLY	70	70	70	6	GALV	0.21	-	-	-	-	-	-	-	-	-	H	-	N	70	
B1349N, B1300V	VAULT CORRIDOR, CORRIDOR	B1300V	SAT-37-B-4	BUTTERFLY	1520	1520	1520	12	GALV	0.21	1520	41.0	80.0	16x14	0.3	2	4.1	5.0	160	D	620	N	1520	
		B1349L	GEV-66-B-1	BUTTERFLY	900	900	900	10	GALV	0.21	-	-	-	-	-	-	-	-	-				900	
B1366	MEETING/BREAK AREA	B1366	SAT-37-B-5	BUTTERFLY	345	290	105	6	GALV	0.21	290	11.0	90.0	12x8	0.3	2	0.5	5.0	160	D	0	Y	105	
		B1300V	GET-66-B-5	BUTTERFLY	345	290	105	6	GALV	0.21	-	-	-	-	-	-	-	-	-				105	
B1366B B1366C	OFFICE B, OFFICE C	B1300V	SAT-37-B-6	BUTTERFLY	300	300	300	6	GALV	0.21	300	13.4	96.0	12x8	0.3	2	0.9	5.0	160	E	-	Y	300	
B1373	HOT CELLS	B1300V	SAT-37-B-7	BUTTERFLY	515	225	155	8	GALV	0.21	225	6.1	80.0	12x10	0.3	1	0.5	5.0	160	B	-150	Y	155	
		B1373	GET-66-B-6	BUTTERFLY	465	175	105	8	GALV	0.21	-	-	-	-	-	-	-	-	-				105	
		B1359	GEV-66-B-2	VENTURI	100	100	100	8	SS/AL	0.3	-	-	-	-	-	-	-	-	-				100	HOT CELL EXHAUST, (4)
		B1359	GEV-66-B-3	VENTURI	100	100	100	8	SS/AL	0.3													100	HOT CELL EXHAUST, (4)
B1366A, B1366D	OFFICE A, OFFICE D	B1300V	SAT-37-B-8	BUTTERFLY	145	145	145	6	GALV	0.21	145	5.0	87.0	12x8	0.3	1	0.5	5.0	160	E	-	Y	145	
B1349P	VAULT 1	B1300V	SAT-37-B-9	BUTTERFLY	395	335	160	8	GALV	0.21	335	9.0	80.0	12x10	0.3	1	0.9	5.0	160	A	-100	N	160	
		B1300V	GET-66-B-7	BUTTERFLY	495	435	260	8	GALV	0.21	-	-	-	-	-	-	-	-	-				260	
B1349Q	VAULT 2	B1300V	SAT-37-B-10	BUTTERFLY	395	335	160	8	GALV	0.21	335	9.0	80.0	12x10	0.3	1	0.9	5.0	160	A	-100	N	160	
		B1300V	GET-66-B-8	BUTTERFLY	495	435	260	8	GALV	0.21	-	-	-	-	-	-	-	-	-				260	
B1300V	CORRIDOR	B1300V	SAT-37-B-11	BUTTERFLY	1050	1050	1050	10	GALV	0.21	1050	22.7	75.0	14x12	0.3	1	2.3	5.0	160	D	+455	N	1050	
		B1355	GET-66-B-9	BUTTERFLY	595	595	595	8	GALV	0.21	-	-	-	-	-	-	-	-	-				595	
B1359	TARGET PREP	B1300V	SAT-37-B-12	BUTTERFLY	1570	420	420	14	GALV	0.21	1560	37.1	77.0	20x18	0.3	1	3.7	5.0	160	F	-190	Y	420	
		B1357	FEV-66-B-1	VENTURI	855	280	280	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				280	FUME HOOD EXHAUST
		B1357A	FEV-66-B-2	VENTURI	855	280	280	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				280	FUME HOOD EXHAUST
		B1359	PEV-66-B-1	VENTURI	50	50	50	8	SS/AL	0.3	-	-	-	-	-	-	-	-	-				50	SNORKEL EXHAUST
B1354	RESEARCH LAB	B1300V	SAT-37-B-13	BUTTERFLY	1650	500	500	14	GALV	0.21	1650	42.3	80.0	20x18	0.3	1	4.2	5.0	160	F	-300	Y	500	
		B1300V	SAT-37-B-14	BUTTERFLY	1650	500	500	14	GALV	0.21	1650	42.3	80.0	20x18	0.3	1	4.2	5.0	160				500	
		B1300V	SAT-37-B-15	BUTTERFLY	1645	495	495	14	GALV	0.21	1645	42.3	80.0	20x18	0.3	1	4.2	5.0	160				495	
		B1300V	SAT-37-B-16	BUTTERFLY	1645	495	495	14	GALV	0.21	1645	42.3	80.0	20x18	0.3	1	4.2	5.0	160				495	
		B1354	FEV-66-B-3	VENTURI	855	280	120	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				120	FUME HOOD EXHAUST
		B1354	FEV-66-B-4	VENTURI	855	280	120	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				120	FUME HOOD EXHAUST
		B1354	FEV-66-B-5	VENTURI	855	280	120	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				120	FUME HOOD EXHAUST
		B1354	FEV-66-B-6	VENTURI	855	280	120	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				120	FUME HOOD EXHAUST
		B1354	FEV-66-B-7	VENTURI	855	280	120	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				120	FUME HOOD EXHAUST
		B1354	FEV-66-B-8	VENTURI	855	280	120	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				120	FUME HOOD EXHAUST
		B1354	FEV-66-B-9	VENTURI	855	280	120	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				120	FUME HOOD EXHAUST
		B1354	FEV-66-B-10	VENTURI	855	280	120	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				120	FUME HOOD EXHAUST
		B1300V	PEV-66-B-2	VENTURI	50	50	50	8	SS/AL	0.3	-	-	-	-	-	-	-	-	-				50	SNORKEL EXHAUST
B1357D	GOWN - CNC	B1300V	SAT-37-B-17	BUTTERFLY	200	160	150	6	GALV	0.21	160	3.8	77.0	12x8	0.3	1	0.5	5.0	160	D	0	Y	150	
		B1357	GET-66-B-10	BUTTERFLY	150	110	100	6	GALV	0.21	-	-	-	-	-	-	-	-	-				100	
B1353	SHOP	B1300V	SAT-37-B-18	BUTTERFLY	300	90	90	6	GALV	0.21	90	2.4	80.0	12x8	0.3	1	0.5	5.0	160	D	-150	Y	90	
		B1353	GET-66-B-11	BUTTERFLY	350	140	140	6	GALV	0.21	-	-	-	-	-	-	-	-	-				140	
		B1353	PEV-66-B-3	VENTURI	100	100	100	8	SS/AL	0.3	-	-	-	-	-	-	-	-	-				100	SNORKEL EXHAUST
B1352	COLD SYNTH	B1300V	SAT-37-B-19	BUTTERFLY	2360	1020	1020	16	GALV	0.21	2360	57.3	77.5	24x18	0.3	1	5.7	5.0	160	F	-200	Y	1020	
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				-	-
		B1352	FEV-66-B-11	VENTURI	615	280	280	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				280	FUME HOOD EXHAUST
		B1352	FEV-66-B-12	VENTURI	615	280	280	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				280	FUME HOOD EXHAUST
		B1352	FEV-66-B-13	VENTURI	615	280	280	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				280	FUME HOOD EXHAUST
		B1352	FEV-66-B-14	VENTURI	615	280	280	12	SS/AL	0.3	-	-	-	-	-	-	-	-	-				280	FUME HOOD EXHAUST
		B1352	PEV-66-B-4	VENTURI	100	100	100	8	SS/AL	0.3	-	-	-	-	-	-	-	-	-				100	SNORKEL EXHAUST
B1351	HPGE/LSCIN LAB	B1300V	SAT-37-B-20	BUTTERFLY	300	90	90	6	GALV	0.21	90	2.4	80.0	12x8	0.3	1	0.5	5.0	160	D	-150	Y	90	
		B1351	GET-66-B-12	BUTTERFLY	450	240	240	8	GALV	0.21	-	-	-	-	-	-	-	-	-				240	
B1300T	CORRIDOR	B1300V	SAT-37-B-21	BUTTERFLY	200	200	200	6	GALV	0.21	200	5.4	80.0	12x8	0.3	1	0.5	5.0	160	E	-	N	200	
B1343	SHIPPING	B1343	SAT-37-B-22	BUTTERFLY	715	225	215	10	GALV	0.21	225	7.0	84.0	14x12	0.3	1	0.7	5.0	160	D	-320	Y	215	
		B1343	GET-66-B-13	BUTTERFLY	1035	545	535	10	GALV	0.21	-	-	-	-	-	-	-	-	-				535	
B1355	STORAGE	B1355	SAT-37-B-23	BUTTERFLY	240	240	150	6	GALV	0.21	240	5.7	77.0	12x8	0.3	1	0.6	5.0	160	D	0	Y	150	
		B1355	GET-66-B-14	BUTTERFLY	200	200	110	6	GALV	0.21	-	-	-	-	-	-	-	-	-				110	
		B1355	PEV-66-B-5	VENTURI	40	40	40	8	SS/AL	0.3	-	-	-	-	-	-	-	-	-				40	ACID CABINET EXHAUST
B1357A	ANTE ROOM - ISO 8	B1357	SAT-37-B-24	BUTTERFLY	300	300	300	6	GALV	0.21	300	6.5	75.0	12x8	0.3	1	0.6	5.0	160	C	+200	N	300	
		B1355	GET-66-B-15	BUTTERFLY	100	100	100	6	GALV	0.21	-	-	-	-	-	-	-	-	-				100	
B1357B	QC - ISO 8	B1357A	SAT-37-B-25	BUTTERFLY	1260	1260	1260	12	GALV	0.21	1260	27.2	75.0	16x14	0.3	1	3.4	5.0	160	C	-50	N	1260	
		B1357B	GET-66-B-16	BUTTERFLY	1160	1160	1160	12	GALV	0.21	-	-	-	-	-	-	-	-	-				1160	
		B1357B	PEV-66-B-6	VENTURI	50	50	50	8	SS/AL	0.3	-	-	-	-	-	-	-	-	-				50	SNORKEL EXHAUST
B1343A	ACCESSIBLE TOILET	B1343A	GET-66-B-17	BUTTERFLY	75	75	75	6	GALV	0.21	-	-	-	-	-	-	-	-	-	H	-	N	75	

NOTES:

(1) INDICATES OFFSET TO BE MAINTAINED BETWEEN SUM OF ROOM'S TOTAL EXHAUST AND MAKE-UP AIR / SUPPLY AIR / TRANSFER AIR QUANTITIES.

(-) INDICATES MAKE-UP AIR / SUPPLY AIR / TRANSFER AIR QUANTITIES EXCEED EXHAUST AIR QUANTITIES.

(2) UNIT PRESSURE DROP DOES NOT INCLUDE APPLICABLE ACCESSORIES (i.e. SOUND ATTENUATORS, REHEAT COILS, ETC.)

(3) BASED ON MAXIMUM CFM.

(4) CONFIRM FINAL AIRFLOWS WITH THE HOT CELL MANUFACTURER.

9/3/2026 12:53:41 PM

Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:
AEI Affiliated Engineers
Affiliated Engineers, Inc.
5802 Research Park Boulevard
Madison, Wisconsin 53719
Tel 608.238.2616

Key Plan:

The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
MECHANICAL SCHEDULES

Revisions:

No.	Date:	Description:
BD	06/30/2026	Bid Drawings
1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

Graphic Scale	NOT TO SCALE
UWSA, UW Project #	A-23-011, 1485-2511
Set Type	BD
Date Issued	06/30/2026
Sheet Number	M9.03

BASEMENT SUPPLY AND EXHAUST AIR TERMINAL UNITS (CONT)

ROOM NUMBER SERVED	ROOM NAME SERVED	AIR TERMINAL LOCATION	AIR TERMINAL DEVICES							REHEAT COIL									CONTROLS				REMARKS
			TAG	TYPE	MAX. OCC CFM	MIN OCC CFM	UNOCC CFM	MIN. INLET SIZE (IN)	MATERIAL	MAX APD (in. wg.) (2)	REHEAT CFM	CAPACITY MBH	LAT	FACE AREA (IN)	MAX APD (in. wg.) (3)	ROWS	GPM	MAX WPD (FT)	INLET WATER TEMP.(°F)	SEQUENCE NUMBER	ROOM OFFSET (1)	OCCUPANCY SENSOR INTERLOCK	FAILURE MODE CFM	
B1358F	cGMP STORAGE	B1358F	SAT-37-B-26	BUTTERFLY	310	310	310	6	GALV	0.21	310	7.4	77.0	12x8	0.3	1	0.7	5.0	160	B	-100	N	310	
		B1358F	GET-66-B-18	BUTTERFLY	410	410	410	8	GALV	0.21	-	-	-	-	-	-	-	-	-				410	
B1357H	GMP - ISO 7	B1300R	SAT-37-B-27	BUTTERFLY	1295	1295	1295	12	GALV	0.21	1295	28.0	75.0	16x14	0.3	1	2.8	5.0	160	B	-100	N	1295	
		B1357H	GET-66-B-19	BUTTERFLY	1295	1295	1295	12	GALV	0.21	-	-	-	-	-	-	-	-	-				1295	
		B1357B	GEV-66-B-4	VENTURI	100	100	100	8	SS/AL	0.3													100	HOT CELL EXHAUST, (4)
B1357G	ISO 7 AIRLOCK	B1300V	SAT-37-B-28	BUTTERFLY	300	300	300	6	GALV	0.21	300	6.5	75.0	12x8	0.3	1	0.6	5.0	160	C	+200	N	300	
		B1357G	GET-66-B-20	BUTTERFLY	100	100	100	6	GALV	0.21	-	-	-	-	-	-	-	-	-				100	
B1379	HOT CELL ACCESS	B1300V	SAT-37-B-29	BUTTERFLY	395	150	120	8	GALV	0.21	150	4.8	84.6	12x10	0.3	1	0.5	-	160	D	-100	Y	120	
		B1357H	GET-66-B-21	BUTTERFLY	495	250	220	8	GALV	0.21	-	-	-	-	-	-	-	-	-				220	
B1357D	DMF - ISO 8	B1357D	SAT-37-B-30	BUTTERFLY	975	975	975	10	GALV	0.21	975	21.1	75.0	14x12	0.3	1	2.6	5.0	160	B	-150	N	975	
		B1357D	GET-66-B-22	BUTTERFLY	1025	1025	1025	10	GALV	0.21	-	-	-	-	-	-	-	-	-				1025	
		B1357D	GEV-66-B-5	VENTURI	100	100	100	8	SS/AL	0.3	-	-	-	-	-	-	-	-	-				100	HOT CELL EXHAUST, (4)
B1375	HOT CELL ACCESS	B1300V	SAT-37-B-31	BUTTERFLY	425	220	130	8	GALV	0.21	220	5.9	80.0	12x10	0.3	1	0.5	5.0	160	D	-100	Y	130	
		B1359	GET-66-B-23	BUTTERFLY	525	320	230	8	GALV	0.21	-	-	-	-	-	-	-	-	-				230	
B1357C, B1357E	PASSTHROUGH	B1355	SAV-37-B-1	VENTURI	80	80	80	8	GALV	0.3	-	-	-	-	-	-	-	-	-	E	-	N	80	

NOTES:

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(-) INDICATES MAKE-UP AIR / SUPPLY AIR / TRANSFER AIR QUANTITIES EXCEED EXHAUST AIR QUANTITIES.

(2) UNIT PRESSURE DROP DOES NOT INCLUDE APPLICABLE ACCESSORIES (i.e. SOUND ATTENUATORS, REHEAT COILS, ETC.)

(3) BASED ON MAXIMUM CFM.

(4) CONFIRM FINAL AIRFLOWS WITH THE HOT CELL MANUFACTURER.

LEVEL 1 AND 2 SUPPLY AND EXHAUST AIR TERMINAL UNITS

ROOM NUMBER SERVED	ROOM NAME SERVED	AIR TERMINAL LOCATION	AIR TERMINAL DEVICES							REHEAT COIL									CONTROLS				REMARKS
			TAG	TYPE	MAX. OCC CFM	MIN OCC CFM	UNOCC CFM	MIN. INLET SIZE (IN)	MATERIAL	MAX APD (in. wg.) (2)	REHEAT CFM	CAPACITY MBH	LAT	FACE AREA (IN)	MAX APD (in. wg.) (3)	ROWS	GPM	MAX WPD (FT)	INLET WATER TEMP.(°F)	SEQUENCE NUMBER	ROOM OFFSET (1)	OCCUPANCY SENSOR INTERLOCK	FAILURE MODE CFM	
1376, 1382	ELECTRICAL, MECH	1350	SAT-37-1-1	BUTTERFLY	1300	460	460	12	GALV	0.21	-	-	-	-	-	-	-	-	-	G	0	N	460	
		1350	GET-66-1-1	BUTTERFLY	1300	460	460	12	GALV	0.21	-	-	-	-	-	-	-	-	-				460	
1377	COOL DOWN	1350	SAT-37-1-2	BUTTERFLY	105	105	70	6	GALV	0.21	105	3.4	85.0	12x8	0.3	1	0.5	5.0	160	D	0	N	70	
		1350	GET-66-1-2	BUTTERFLY	105	105	70	6	GALV	0.21	-	-	-	-	-	-	-	-	-				70	
1378	IDF	1350	SAT-37-1-3	BUTTERFLY	1125	1125	1125	10	GALV	0.21	-	-	-	-	-	-	-	-	-	G	0	N	1125	
		1350	GET-66-1-3	BUTTERFLY	1125	1125	1125	10	GALV	0.21	-	-	-	-	-	-	-	-	-				1125	
1350	LEVEL 1 SHELLED SPACE	1350	SAT-37-1-4	BUTTERFLY	500	500	500	8	GALV	0.21	-	-	-	-	-	-	-	-	-	I	0	N	500	
		1350	GET-66-1-4	BUTTERFLY	500	500	500	8	GALV	0.21	-	-	-	-	-	-	-	-	-				500	
2378	IDF	2350	SAT-37-2-1	BUTTERFLY	1125	1125	1125	10	GALV	0.21	-	-	-	-	-	-	-	-	-	G	0	N	1125	
		2350	GET-66-2-1	BUTTERFLY	1125	1125	1125	10	GALV	0.21	-	-	-	-	-	-	-	-	-				1125	
2350	LEVEL 2 SHELLED SPACE	2350	SAT-37-2-2	BUTTERFLY	500	500	500	8	GALV	0.21	-	-	-	-	-	-	-	-	-	I	0	N	500	
		2350	GET-66-2-2	BUTTERFLY	500	500	500	8	GALV	0.21	-	-	-	-	-	-	-	-	-				500	

NOTES:

(1) INDICATES OFFSET TO BE MAINTAINED BETWEEN SUM OF ROOM'S TOTAL EXHAUST AND MAKE-UP AIR / SUPPLY AIR / TRANSFER AIR QUANTITIES.

(-) INDICATES MAKE-UP AIR / SUPPLY AIR / TRANSFER AIR QUANTITIES EXCEED EXHAUST AIR QUANTITIES.

(2) UNIT PRESSURE DROP DOES NOT INCLUDE APPLICABLE ACCESSORIES (i.e. SOUND ATTENUATORS, REHEAT COILS, ETC.)

(3) BASED ON MAXIMUM CFM.

FIRE SMOKE DAMPERS

MARK	LOCATION	SERVICE	SIZE		DAMPER MOUNTING ORIENTATION	FIRE-SMOKE DAMPERS				REMARKS
			W (IN)	H (IN)		FIRE-RESIST. RATING (HR)	ACTUATORS POWER (VOLTS)	ACTUATORS LOCATION	POS. SWITCH (2)	
SFSD-37-1-1	LEVEL 1	LEVEL 1 SUPPLY	50	38	VERT	1-1/2	120	EXTERNAL	Y	
SFSD-37-1-2	LEVEL 1	SUPPLY AIR	44	44	HORIZ	1-1/2	120	EXTERNAL	Y	
SFSD-37-2-1	LEVEL 2	SUPPLY AIR	60	60	HORIZ	1-1/2	120	EXTERNAL	Y	
EFSD-66-1-1	LEVEL 1	LEVEL 1 EXHAUST	20	16	VERT	1-1/2	120	EXTERNAL	Y	
EFSD-66-2-1	LEVEL 2	LEVEL 2 EXHUAST	14	14	VERT	1-1/2	120	EXTERNAL	Y	

NOTES:
(1) REFER TO SPECIFICATION SECTION 23 3314 FOR ADDITIONAL REQUIREMENTS, ALL FSD ACTUATORS TO BE OUT OF AIR STREAM.
(2) POSITION SWITCHES FOR USE BY CONTROLS CONTRACTOR AND/OR FIRE ALARM SYSTEM.

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Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:
AEI Affiliated Engineers
Affiliated Engineers, Inc.
5802 Research Park Boulevard
Madison, Wisconsin 53719
Tel 608.238.2616

Key Plan:

The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency/ Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research

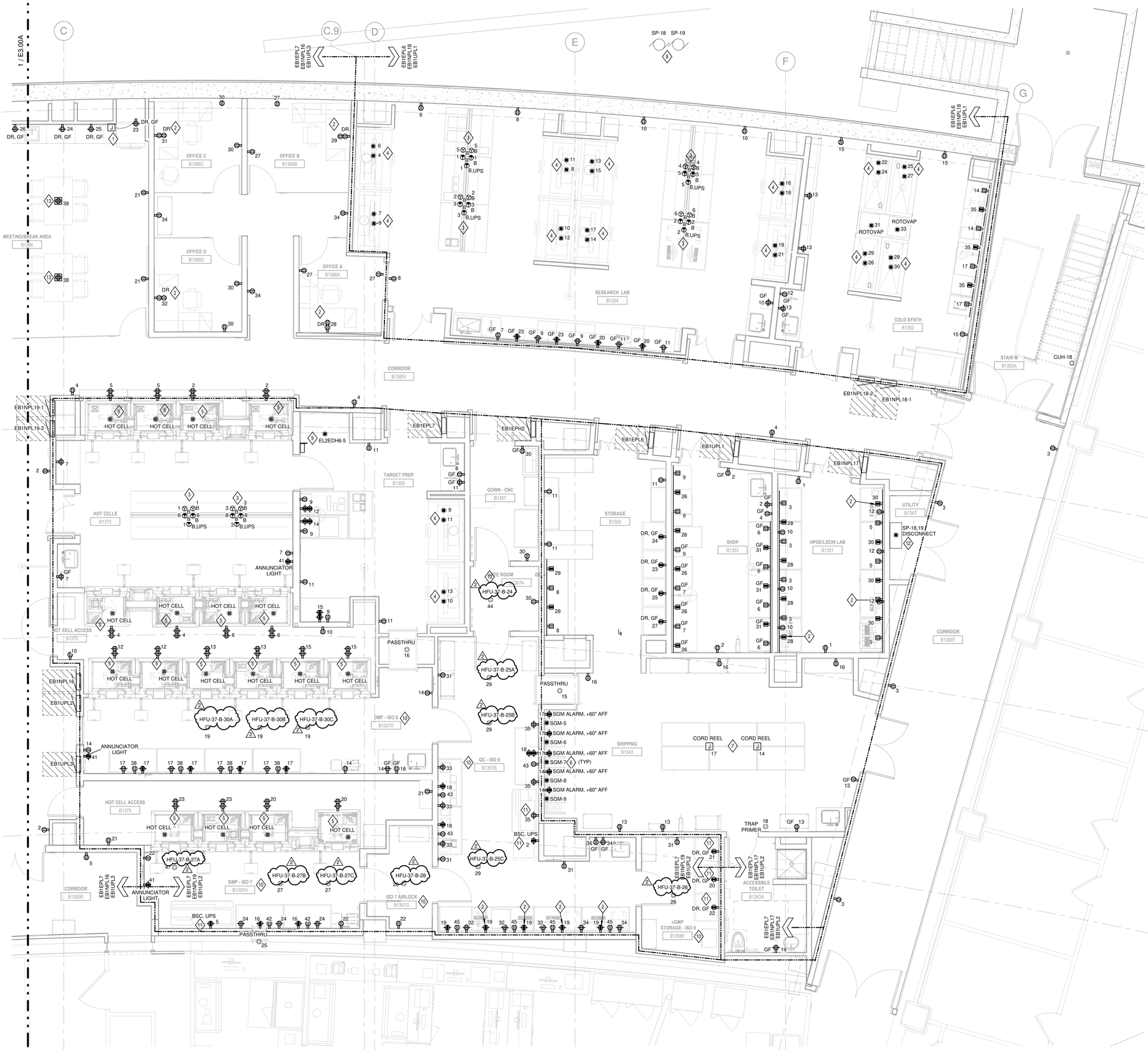
Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
MECHANICAL SCHEDULES

Revisions:

No.	Date:	Description:
BD	06/30/2026	Bid Drawings
1	09/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

Graphic Scale	NOT TO SCALE
UWSA, UW Project #	A-23-011, 1485-2511
Set Type	BD
Date Issued	06/30/2026
Sheet Number	M9.04



GENERAL NOTES

1. FOR ELECTRICAL SYMBOLS AND ABBREVIATIONS, REFER TO SHEET E0.01.
2. REFER TO ARCHITECTURAL AND LAB ELEVATION DRAWINGS FOR DEVICE LOCATIONS AND ORIENTATION. ELECTRICAL DRAWINGS INDICATES DEVICE QUANTITIES AND CIRCUITING.
3. ALL RECEPTACLES LOCATED WITHIN 6 FEET OF SINKS, AND SAFETY SHOWERS SHALL BE PROVIDED WITH INTEGRAL GROUND FAULT INTERRUPTER WHETHER SHOWN ON PLANS OR NOT.
4. REFER TO SHEET E9.02 FOR EQUIPMENT CONNECTION AND FEEDER REQUIREMENTS.
5. ALL PENETRATIONS THROUGH SMOKE OR FIRE WALLS SHALL BE SEALED BY APPROVED FIRESTOPPING METHOD PER MANUFACTURER'S RECOMMENDATIONS.
6. ALL CONDUIT PENETRATIONS THROUGH WALLS (THOSE NOT RATED FOR FIRE OR SMOKE) SHALL BE SEALED WITH URETHANE CAULK.
7. CONTRACTOR SHALL COORDINATE WORK SCHEDULED WITH OWNER, BUILDING ASSOCIATION AND DESIGNER. ALL WORK OUTSIDE RENOVATED AREAS MUST BE ACCOMPLISHED OUTSIDE OF NORMAL BUSINESS HOURS TO MINIMIZE DISTURBANCE TO OTHER BUILDING OCCUPANTS.
8. CONTRACTOR SHALL PROVIDE PULL BOXES AS REQUIRED BY NEC. PULL BOXES SHALL BE SIZED PER NEC. NO MORE THAN 360 DEGREES OF BENDS SHALL BE ALLOWED BETWEEN PULL POINTS. CONTRACTOR IS RESPONSIBLE FOR ALL PULL BOXES REQUIRED TO MEET NEC REQUIREMENTS IN COORDINATION WITH WORK BY OTHER TRADES.
9. HORIZONTAL CONDUIT IN WALLS BETWEEN BOXES SHALL NOT BE PERMITTED. CONDUIT FROM DEVICE WALL BOX SHALL EXTEND DIRECTLY UP TO ABOVE CEILING. HORIZONTAL CONDUIT SHALL ONLY BE ALLOWED WHERE DEVICES ARE SHOWN BELOW WINDOWS OR IN EXTERIOR WALLS.
10. REFER TO STRUCTURAL DRAWINGS FOR CORE DRILL RULES. CORE DRILLING MUST BE PRE-APPROVED.
11. PROVIDE DUAL CHANNEL POWER/DATA RACEWAY WHERE TECHNOLOGY DRAWINGS SHOW RACEWAY IN SAME LOCATION AS POWER RACEWAY. REFER TO TECHNOLOGY DRAWINGS FOR ADDITIONAL INFORMATION.

SHEET KEYNOTES

1. PROVIDE A 120V, 20A FACELESS GFCI ON WALL. GFCI SHALL BE WIRED IN SERIES TO THE LINE SIDE OF THE DEDICATED APPLIANCE RECEPTACLE CIRCUIT. GFCI SHALL BE PROVIDED WITH LABEL ON FACEPLATE THAT READS "RESET". LABEL SHALL ALSO IDENTIFY APPLIANCE TYPE.
2. RECEPTACLES FOR COMPUTERS AND PRINTERS SHALL BE PROVIDED WITH ENGRAVED COVER PLATES OR NAME-PLATES IDENTIFYING THEIR SPECIFIC USE RIVETED TO THE COVER PLATE.
3. ELECTRICAL CONTRACTOR SHALL INSTALL BACKBOX AND OUTLETS IN CEILING UTILITY PANEL.
4. PROVIDE (2) DEDICATED 120V FIXED CONNECTIONS TO FUMEHOOD.
5. PROVIDE A DEDICATED 208V 3PH FIXED CONNECTION TO HOT CELL. COORDINATE EXACT REQUIREMENTS WITH MANUFACTURERS INSTALLATION GUIDE. INSTALL A QUAD RECEPTACLE AT REAR, MOUNTED ON FRAMING OF HOT CELL.
6. PROVIDE A DEDICATED 120V FIXED CONNECTION TO SPECIALTY GAS MANIFOLD. COORDINATE EXACT LOCATION AND MOUNTING HEIGHT FOR GAS MANIFOLD POWER CONNECTION WITH PLUMBING CONTRACTOR.
7. PROVIDE A 120V CORD REEL WITH DUPLEX RECEPTACLE PENDANT MOUNTED, HUNG AT 7' AFF FOR STAFF USE. HUBBELL HBL05123R9M1 OR EQUAL.
8. PROVIDE CONDUIT AND CONNECTION TO SUMP PUMPS FROM THE DISCONNECT PANEL INTERIOR TO BUILDING. REFER TO PLUMBING DRAWINGS FOR EXACT LOCATION OF EQUIPMENT.
9. PROVIDE A DEDICATED 480V 3PH 80A FIXED CONNECTION TO PLASMA SINTER EQUIPMENT. PROVIDE 480V 3PH 100AF/80AT DISCONNECT SWITCH. COORDINATE EXACT REQUIREMENTS WITH MANUFACTURERS INSTALLATION GUIDE.
10. ALL ELECTRICAL DEVICE BACKBOXES AND CONDUIT INSTALLED IN WALLS OR CEILINGS IN THIS ROOM SHALL BE SEALED TO MEET ISO 7 AND 8. THIS INCLUDES ALL POWER, LIGHTING AND FIRE ALARM DEVICES.
11. PROVIDE AN IN-USE COVER FOR THIS DEVICE. ENSURE COVER MATERIALS ARE ISO COMPLIANT.
12. PROVIDE A DIRECT 480V, 3PH 20A POWER CONNECTION TO SUMP PUMP DISCONNECT PANEL FOR SP-18 AND SP-19. SEE MANUFACTURERS GUIDE FOR EXACT CONNECTION DETAILS. ELECTRICAL CONTRACTOR TO PROVIDE (2) 1" CONDUIT FROM DISCONNECT PANEL TO THE SUMP PUMPS IN MANHOLE EXTERIOR TO THE BUILDING. REFER TO PLUMBING DRAWINGS FOR EXACT LOCATION OF EQUIPMENT.
13. PROVIDE 6" FLOOR BOX DEVICE WITH BRUSHED ALUMINUM SURFACE COVER ASSEMBLY FOR POWER. LEGRAND 880CS1-1 SERIES OR EQUAL.

FLOOR PLAN LEGEND

- NEW CONSTRUCTION
- EXISTING CONSTRUCTION TO REMAIN
- CONSTRUCTION LIMITS
- AREA OUT OF SCOPE

1 **B1 - BASEMENT LEVEL ELECTRICAL POWER PLAN - AREA B**
SCALE: 1/4" = 1'-0"

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Prime Architect Firm:
Potter Lawson
Success by Design
Architect / Lab Planning:
OH+K
PLI Project No:
2023.35.00
Consultant:
AEI Affiliated Engineers
Affiliated Engineers, Inc.
5802 Research Park Boulevard
Madison, Wisconsin 53719
Tel 608.238.2616

Key Plan:
Project Location
Existing Construction

The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
B1 - BASEMENT LEVEL ELECTRICAL POWER PLAN - AREA B

Revisions:

No.	Date:	Description:
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1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

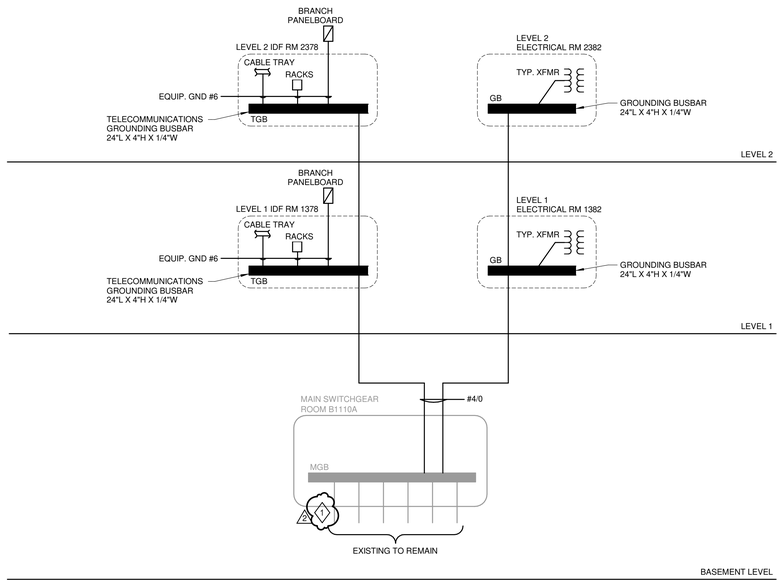
Graphic Scale: 0' 2' 4' 8'
UWSA, UW Project #: **A-23-011, 1485-2511**
Set Type: **BD**
Date Issued: **06/30/2026**
Sheet Number: **E3.00B**

GENERAL NOTES

1. FOR ELECTRICAL SYMBOLS AND ABBREVIATIONS, REFER TO SHEET E0.01.
2. GROUND RODS SHALL BE 5/8" BY 10'.
3. GROUND BUSBAR IS MOUNTED AT 18" ABOVE FINISHED FLOOR.
4. ALL GROUNDING CONDUCTORS SHOWN SHALL BE #4/0 UNLESS NOTED OTHERWISE.

SHEET KEYNOTES

1. EXISTING BUILDING GROUNDING INCLUDES BOND TO LIGHTNING PROTECTION SYSTEM. BOND NEW LIGHTNING PROTECTION SYSTEM TO EXISTING SYSTEM.



1 **ELECTRICAL GROUNDING RISER DIAGRAM**
SCALE: 1" = 30'-0"

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Prime Architect Firm:
Potter Lawson
Success by Design

Architect / Lab Planning:
OH+K

PLI Project No:
2023.35.00

Consultant:
Affiliated Engineers
Affiliated Engineers, Inc.
5802 Research Park Boulevard
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Tel 608.238.2616

Key Plan:

The Board of Regents of the University of Wisconsin on behalf of the University of Wisconsin - Madison

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research

Project Location:
University of Wisconsin - Madison
School of Medicine and Public Health

Sheet Title:
ELECTRICAL GROUNDING RISER DIAGRAM

Revisions:

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1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

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UWSA, UW Project #	A-23-011, 1485-2511
Set Type	BD
Date Issued	06/30/2026
Sheet Number	E7.03

EB1NPL16

MAIN TYPE MCB | VOLTAGE 120/208 Wye | LOCATION LEVEL B1,CORRIDOR B1300V
MAIN RATING 150 A | 3 PHASE 4 WIRE | FED FROM EL2NDL2
BUS RATING 150 A | MOUNTING Recessed | SCCR 10kAIC kA
ENCLOSURE Type 1 | CALCULATED AVAILABLE FAULT... kA

REMARKS:

LEFT SIDE, kVA						RIGHT SIDE, kVA					
DESCRIPTION	BRKR NOTES	BRKR AMP, POLES	CKT NO	A	B	C	A	B	C	CKT NO	BRKR AMP, POLES	BRKR NOTES	DESCRIPTION
B1300A CUH-2		20 A 1	1	0.20			0.90			2	1 20 A		B1349N REC
B1300K REC		20 A 1	3		0.72			0.54		4	1 20 A		B1300V REC
B1300X REC		20 A 1	5			0.36			0.36	6	1 20 A		B1349M REC
B1380 REC		20 A 1	7	0.54			0.36			8	1 20 A		B1349L COMP REC
B1349L REC		20 A 1	9		1.26			1.00		10	1 20 A		B1380 CIB-1
B1349L COMP REC		20 A 1	11			0.36			1.00	12	1 20 A		B1380 CIB-2
B1349M TRAP PRIMER		20 A 1	13	0.50			0.72			14	1 20 A		B1349P REC
B1349P RACEWAY		20 A 1	15		0.72			0.72		16	1 20 A		B1349P RACEWAY
B1366 MICRO		20 A 1	17			1.00			0.72	18	1 20 A		B1349Q RACEWAY
B1349Q REC		20 A 1	19	0.72			0.72			20	1 20 A		B1349Q RACEWAY
B1366 REC		20 A 1	21		0.72			0.20		22	1 20 A		FCU-93
B1366 REF		20 A 1	23			0.18			0.18	24	1 20 A		B1366 REC
B1366 REC		20 A 1	25	0.18			0.18			26	1 20 A		B1366 REC
B1366A,B REC		20 A 1	27		0.72			0.18		28	1 20 A		B1366A COMP
B1366B COMP		20 A 1	29			0.18			0.72	30	1 20 A		B1366C,D REC
B1366C COMP		20 A 1	31	0.18			0.18			32	1 20 A		B1366D COMP
UTILITY TUNNEL REC		20 A 1	33		0.54			0.54		34	1 20 A		B1366 REC
SPARE		20 A 1	35			0.00			1.00	36	1 20 A		B1366 MICRO
SPARE		20 A 1	37	0.00			0.72			38	1 20 A		B1366 FLOOR REC
SPARE		20 A 1	39		0.00			0.00		40	1 20 A		SPARE
SPARE		20 A 1	41			0.00			0.00	42	1 20 A		SPARE
SPACE		-- 1	43	--			--			44	1 --		SPACE
SPACE		-- 1	45		--			--		46	1 --		SPACE
SPACE		-- 1	47			--			--	48	1 --		SPACE
SPACE		-- 1	49	--			--			50	1 --		SPACE
SPACE		-- 1	51		--			--		52	1 --		SPACE
SPACE		-- 1	53			--			--	54	1 --		SPACE
SPACE		-- 1	55	--			--			56	1 --		SPACE
SPACE		-- 1	57		--			--		58	1 --		SPACE
SPACE		-- 1	59			--			--	60	1 --		SPACE
SPACE		-- 1	61	--			--			62	1 --		SPACE
SPACE		-- 1	63		--			--		64	1 --		SPACE
SPACE		-- 1	65			--			--	66	1 --		SPACE

	A	B	C
PHASE SUBTOTAL (kVA)	6.10 kVA	7.86 kVA	6.06 kVA
PHASE SUBTOTAL (AMPS)	51 A	66 A	51 A

LOAD CLASSIFICATION	CONNECTED (KVA)	DEMAND FACTOR	DEMAND (KVA)
POWER	2.50 kVA	100%	2.50 kVA
LIGHTING	0.00 kVA	100%	0.00 kVA
MOTOR	0.40 kVA	125% LARGEST, 100% OTHER	0.45 kVA
RECEPTACLE	17.12 kVA	100% FIRST 10KVA, 50% OTHER	13.56 kVA
HEATING	0.00 kVA	100%	0.00 kVA
TOTAL LOAD	20.02 kVA		16.51 kVA
TOTAL AMPS	56 A		46 A

EB1NPL17

MAIN TYPE MCB | VOLTAGE 120/208 Wye | LOCATION LEVEL B1,CORRIDOR B1300V
MAIN RATING 150 A | 3 PHASE 4 WIRE | FED FROM EL2NDL2
BUS RATING 150 A | MOUNTING Recessed | SCCR 10kAIC kA
ENCLOSURE Type 1 | CALCULATED AVAILABLE FAULT... kA

REMARKS:

LEFT SIDE, kVA						RIGHT SIDE, kVA					
DESCRIPTION	BRKR NOTES	BRKR AMP, POLES	CKT NO	A	B	C	A	B	C	CKT NO	BRKR AMP, POLES	BRKR NOTES	DESCRIPTION
B1351 REC		20 A 1	1	0.36			0.54			2	1 20 A		B1353 REC
B1351 RACEWAY		20 A 1	3		0.72			0.18		4	1 20 A		B1353 MILLIQ
B1351 RACEWAY		20 A 1	5			0.72			0.72	6	1 20 A		B1353 RACEWAY
B1353 RACEWAY		20 A 1	7	0.36			0.36			8	1 20 A		B1355 RACEWAY
B1353 RACEWAY		20 A 1	9		0.54			0.54		10	1 20 A		B1351 REC
B1355 REC		20 A 1	11			0.54			0.54	12	1 20 A		B1351 REC
B1343 REC		20 A 1	13	0.72			0.60			14	1 20 A		B1343 CORD REEL
B1343 PASSTHRU		20 A 1	15		0.50			0.54		16	1 20 A		B1343 REC
B1343 CORD REEL		20 A 1	17			0.60			0.50	18	1 20 A		B1343 TRAP PRIMER
B1343A REC		20 A 1	19	0.18			0.00			20	1 20 A		SPARE
SPARE		20 A 1	21		0.00			0.00		22	1 20 A		SPARE
SPARE		20 A 1	23			0.00			0.00	24	1 20 A		SPARE
SPACE		-- 1	25	--			--			26	1 --		SPACE
SPACE		-- 1	27		--			--		28	1 --		SPACE
SPACE		-- 1	29			--			--	30	1 --		SPACE
SPACE		-- 1	31	--			--			32	1 --		SPACE
SPACE		-- 1	33		--			--		34	1 --		SPACE
SPACE		-- 1	35			--			--	36	1 --		SPACE
SPACE		-- 1	37	--			--			38	1 --		SPACE
SPACE		-- 1	39		--			--		40	1 --		SPACE
SPACE		-- 1	41			--			--	42	1 --		SPACE

	A	B	C
PHASE SUBTOTAL (kVA)	3.12 kVA	3.02 kVA	3.62 kVA
PHASE SUBTOTAL (AMPS)	26 A	25 A	30 A

LOAD CLASSIFICATION	CONNECTED (KVA)	DEMAND FACTOR	DEMAND (KVA)
POWER	1.00 kVA	100%	1.00 kVA
LIGHTING	0.00 kVA	100%	0.00 kVA
MOTOR	0.00 kVA	125% LARGEST, 100% OTHER	0.00 kVA
RECEPTACLE	7.56 kVA	100% FIRST 10KVA, 50% OTHER	7.56 kVA
HEATING	0.00 kVA	100%	0.00 kVA
TOTAL LOAD	9.76 kVA		9.76 kVA
TOTAL AMPS	27 A		27 A

EB1NPL18-1

MAIN TYPE MCB | VOLTAGE 120/208 Wye | LOCATION LEVEL B1,CORRIDOR B1300V
MAIN RATING 225 A | 3 PHASE 4 WIRE | FED FROM EL2NDL2
BUS RATING 225 A | MOUNTING Recessed | SCCR 10kAIC kA
ENCLOSURE Type 1 | CALCULATED AVAILABLE FAULT... kA

REMARKS:

LEFT SIDE, kVA						RIGHT SIDE, kVA					
DESCRIPTION	BRKR NOTES	BRKR AMP, POLES	CKT NO	A	B	C	A	B	C	CKT NO	BRKR AMP, POLES	BRKR NOTES	DESCRIPTION
B1300A CUH-1		20 A 1	1	0.00			1.20			2	1 20 A		B1354 SERVICE PANEL
B1300T REC		20 A 1	3		0.72			1.20		4	1 20 A		B1354 SERVICE PANEL
B1354 SERVICE PANEL		20 A 1	5			1.20			1.20	6	1 20 A		B1354 SERVICE PANEL
B1354 MILLIQ		20 A 1	7	0.18			0.54			8	1 20 A		B1354 REC
B1354 REC		20 A 1	9		0.36			0.54		10	1 20 A		B1354 REC
B1354 REC		20 A 1	11			0.36			0.18	12	1 20 A		B1352 MILLIQ
B1352 REC		20 A 1	13	0.54			0.36			14	1 20 A		B1352 RACEWAY
B1352 REC		20 A 1	15		0.54			0.00		16	1 20 A		SPARE
B1352 RACEWAY		20 A 1	17			0.36			0.00	18	1 20 A		SPARE
SPARE		20 A 1	19	0.00			0.00			20	1 20 A		SPARE
SPARE		20 A 1	21		0.00			0.00		22	1 20 A		SPARE
SPARE		20 A 1	23			0.00			0.00	24	1 20 A		SPARE
SPARE		20 A 1	25	0.00			0.00			26	1 20 A		SPARE
SPARE		20 A 1	27		0.00			0.00		28	1 20 A		SPARE
SPARE		20 A 1	29			0.00			0.00	30	1 20 A		SPARE
SPACE		-- 1	31	--			--			32	1 --		SPACE
SPACE		-- 1	33		--			--		34	1 --		SPACE
SPACE		-- 1	35			--			--	36	1 --		SPACE
SPACE		-- 1	37	--			--			38	1 --		SPACE
SPACE		-- 1	39		--			--		40	1 --		SPACE
SPACE		-- 1	41			--			--	42	1 --		SPACE

	A	B	C
PHASE SUBTOTAL (kVA)	2.82 kVA	3.36 kVA	3.30 kVA
PHASE SUBTOTAL (AMPS)	24 A	29 A	28 A

LOAD CLASSIFICATION	CONNECTED (KVA)	DEMAND FACTOR	DEMAND (KVA)
POWER	0.00 kVA	100%	0.00 kVA
LIGHTING	0.00 kVA	100%	0.00 kVA
MOTOR	0.00 kVA	125% LARGEST, 100% OTHER	0.00 kVA
RECEPTACLE	9.48 kVA	100% FIRST 10KVA, 50% OTHER	9.48 kVA
HEATING	0.00 kVA	100%	0.00 kVA
TOTAL LOAD	9.48 kVA		9.48 kVA
TOTAL AMPS	26 A		26 A

EB1NPL18-2

MAIN TYPE MLO | VOLTAGE 120/208 Wye | LOCATION LEVEL B1,CORRIDOR B1300V
MAIN RATING 225 A | 3 PHASE 4 WIRE | FED FROM EB1NPL18-1
BUS RATING 225 A | MOUNTING Recessed | SCCR 10kAIC kA
ENCLOSURE Type 1 | CALCULATED AVAILABLE FAULT... kA

REMARKS: THIS IS THE SECOND TUB OF PANEL EB1NPL18. PROVIDE FEED TO THIS PANEL THROUGH FEED THROUGH LUGS FROM EB1NPL18-1.

LEFT SIDE, kVA						RIGHT SIDE, kVA					
DESCRIPTION	BRKR NOTES	BRKR AMP, POLES	CKT NO	A	B	C	A	B	C	CKT NO	BRKR AMP, POLES	BRKR NOTES	DESCRIPTION
SPARE		20 A 1	1	0.00			0.00			2	1 20 A		SPARE
SPARE		20 A 1	3		0.00			0.00		4	1 20 A		SPARE
SPARE		20 A 1	5			0.00			0.00	6	1 20 A		SPARE
SPARE		20 A 1	7	0.00			0.00			8	1 20 A		SPARE
SPARE		20 A 1	9		0.00			0.00		10	1 20 A		SPARE
SPARE		20 A 1	11			0.00			0.00	12	1 20 A		SPARE
SPACE		-- 1	13	--			--			14	1 --		SPACE
SPACE		-- 1	15		--			--		16	1 --		SPACE
SPACE		-- 1	17			--			--	18	1 --		SPACE
SPACE		-- 1	19	--			--			20	1 --		SPACE
SPACE		-- 1	21		--			--		22	1 --		SPACE
SPACE		-- 1	23			--			--	24	1 --		SPACE
SPACE		-- 1	25	--			--			26	1 --		SPACE
SPACE		-- 1	27		--			--		28	1 --		SPACE
SPACE		-- 1	29			--			--	30	1 --		SPACE
SPACE		-- 1	31	--			--			32	1 --		SPACE
SPACE		-- 1	33		--			--		34	1 --		SPACE
SPACE		-- 1	35			--			--	36	1 --		SPACE
SPACE		-- 1	37	--			--			38	1 --		SPACE
SPACE		-- 1	39		--			--		40	1 --		SPACE
SPACE		-- 1	41			--			--	42	1 --		SPACE

	A	B	C
1ST SECTION PHASE SUBTOTAL (kVA)	0.00 kVA	0.00 kVA	0.00 kVA
2ND SECTION PHASE SUBTOTAL (kVA)	0.00 kVA	0.00 kVA	0.00 kVA
ALL SECTIONS PHASE GRAND TOTAL (kVA)	0.00 kVA	0.00 kVA	0.00 kVA

LOAD CLASSIFICATION	CONNECTED (KVA)	DEMAND FACTOR	DEMAND (KVA)
POWER	0.00 kVA	100%	0.00 kVA
LIGHTING	0.00 kVA	100%	0.00 kVA
MOTOR	0.00 kVA	125% LARGEST, 100% OTHER	0.00 kVA
RECEPTACLE	0.00 kVA	100% FIRST 10KVA, 50% OTHER	0.00 kVA
HEATING	0.00 kVA	100%	0.00 kVA
TOTAL LOAD	0.00 kVA		0.00 kVA
TOTAL AMPS	0 A		0 A

EB1NPL19-1

MAIN TYPE MCB | VOLTAGE 120/208 Wye | LOCATION LEVEL B1,CORRIDOR B1300V
MAIN RATING 225 A | 3 PHASE 4 WIRE | FED FROM EL2NDL2
BUS RATING 225 A | MOUNTING Recessed | SCCR 10kAIC kA
ENCLOSURE Type 1 | CALCULATED AVAILABLE FAULT... kA

REMARKS:

LEFT SIDE, kVA						RIGHT SIDE, kVA					
DESCRIPTION	BRKR NOTES	BRKR AMP, POLES	CKT NO	A	B	C	A	B	C	CKT NO	BRKR AMP, POLES	BRKR NOTES	DESCRIPTION
B1373 SERVICE PANEL		20 A 1	1	1.20			0.72			2	1 20 A		B1373 HOT CELL REC
B1373 SERVICE PANEL		20 A 1	3		1.20			0.72		4	1 20 A		B1373 HOT CELL REC
B1373 HOT CELL REC		20 A 1	5			0.72			0.72	6	1 20 A		B1373 HOT CELL REC
B1373 REC		20 A 1	7	0.54			0.18			8	1 20 A		B1359 MILLIQ
B1359 REC		20 A 1	9		0.54			0.36		10	1 20 A		B1375 REC
B1359 REC		20 A 1	11			0.72			0.72	12	1 20 A		B1357D HOT CELL REC
B1357D HOT CELL REC		20 A 1	13	0.72			0.72			14	1 20 A		B1357D REC
B1357D HOT CELL REC		20 A 1	15		0.72			0.50		16	1 20 A		B1357D PASSTHRU
B1357D REC		20 A 1	17			0.72			0.18	18	1 20 A		B1357D MILLIQ
B1373 REC		20 A 1	19	1.50			0.72			20	1 20 A		B1357H HOT CELL REC
B1373 REC		20 A 1	21		0.36			0.54		22	1 20 A		B1357H REC
B1357H HOT CELL REC		20 A 1	23			0.72			0.54	24	1 20 A		B1357C REC
B1357H REC		20 A 1	25	0.50			0.50			26	1 20 A		B1357G HFU-37-B-28
B1357H HFU-37-B-27B,C		20 A 1	27		1.00			0.50		28	1 20 A		B1358F HFU-37-B-26
B1357B HFU-37-B-25A,B,C		20 A 1	29			1.50			0.54	30	1 20 A		B1357E REC
B1357B REC		20 A 1	31	0.72			0.54			32	1 20 A		B1357B REC
B1357B REC		20 A 1	33		0.54			0.54		34	1 20 A		B1357B REC
B1357B REC		20 A 1	35			0.54			0.18	36	1 20 A		B1357B MILLIQ
MEZZ CORD REEL		20 A 1	37	1.20			0.72			38	1 20 A		B1357D REC
MEZZ CORD REEL		20 A 1	39		1.20			1.80		40	1 20 A		MEZZ CORD REEL
MEZZ REC		20 A 1	41			0.18			0.36	42	1 20 A		B1357H REC

	A	B	C
PHASE SUBTOTAL (kVA)	11.52 kVA	11.24 kVA	8.84 kVA
PHASE SUBTOTAL (AMPS)	99 A	97 A	74 A

LOAD CLASSIFICATION	CONNECTED (KVA)	DEMAND FACTOR	DEMAND (KVA)
POWER	1.00 kVA	100%	1.00 kVA
LIGHTING	0.00 kVA	100%	0.00 kVA
MOTOR	6.00 kVA	125% LARGEST, 100% OTHER	6.13 kVA
RECEPTACLE	24.60 kVA	100% FIRST 10KVA, 50% OTHER	17.30 kVA
HEATING	0.00 kVA	100%	0.00 kVA
TOTAL LOAD	31.60 kVA		24.43 kVA
TOTAL AMPS	88 A		68 A

EB1NPL19-2

MAIN TYPE MLO | VOLTAGE 120/208 Wye | LOCATION LEVEL B1,CORRIDOR B1300V
MAIN RATING 225 A | 3 PHASE 4 WIRE | FED FROM EB1NPL19-1
BUS RATING 225 A | MOUNTING Recessed | SCCR 10kAIC kA
ENCLOSURE Type 1 | CALCULATED AVAILABLE FAULT... kA

REMARKS: THIS IS THE SECOND TUB OF PANEL EB1NPL19. PROVIDE FEED TO THIS PANEL THROUGH FEED THROUGH LUGS FROM EB1NPL19-1.

LEFT SIDE, kVA						RIGHT SIDE, kVA					
DESCRIPTION	BRKR NOTES	BRKR AMP, POLES	CKT NO	A	B	C	A	B	C	CKT NO	BRKR AMP, POLES	BRKR NOTES	DESCRIPTION
B1357A REC		20 A 1	43	0.54			0.50			44	1 20 A		B1357A HFU-37-B-24
B1357H REC		20 A 1	45		0.72			0.00		46	1 20 A		SPARE
B1357H HFU-37-B-27A		20 A 1	47			0.50			0.00	48	1 20 A		SPARE
SPARE		20 A 1	49	0.00			0.00			50	1 20 A		SPARE
SPARE		20 A 1	51		0.00			0.00		52	1 20 A		SPARE
SPARE		20 A 1	53			0.00			0.00	54	1 20 A		SPARE
SPACE		-- 1	55	--			--			56	1 --		SPACE
SPACE		-- 1	57		--			--		58	1 --		SPACE
SPACE		-- 1	59			--			--	60	1 --		SPACE
SPACE		-- 1	61	--			--			62	1 --		SPACE
SPACE		-- 1	63		--			--		64	1 --		SPACE
SPACE		-- 1	65			--			--	66	1 --		SPACE
SPACE		-- 1	67	--			--			68	1 --		SPACE
SPACE		-- 1	69		--			--		70	1 --		SPACE
SPACE		-- 1	71			--			--	72	1 --		SPACE
SPACE		-- 1	73	--			--			74	1 --		SPACE
SPACE		-- 1	75		--			--		76	1 --		SPACE
SPACE		-- 1	77			--			--	78	1 --		SPACE
SPACE		-- 1	79	--			--			80	1 --		SPACE
SPACE		-- 1	81		--			--		82	1 --		SPACE
SPACE		-- 1	83			--			--	84	1 --		SPACE

	A	B	C
PHASE SUBTOTAL (kVA)	1.04 kVA	0.72 kVA	0.50 kVA
PHASE SUBTOTAL (AMPS)	9 A	6 A	4 A

LOAD CLASSIFICATION	CONNECTED (KVA)	DEMAND FACTOR	DEMAND (KVA)
POWER	0.00 kVA	100%	0.00 kVA
LIGHTING	0.00 kVA	100%	0.00 kVA
MOTOR	1.00 kVA	125% LARGEST, 100% OTHER	1.13 kVA
RECEPTACLE	1.26 kVA	100% FIRST 10KVA, 50% OTHER	1.26 kVA
HEATING	0.00 kVA	100%	0.00 kVA
TOTAL LOAD	2.26 kVA		2.39 kVA
TOTAL AMPS	6 A		7 A

Prime Architect Firm:
Potter Lawson
Success by Design
Architect / Lab Planning:
OHK

PLI Project No:
2023.35.00

Consultant:
Affiliated Engineers
Affiliated Engineers, Inc.
5802 Research Park Boulevard
Madison, Wisconsin 53719
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Key Plan:

Agency / Institution:
UW System Administration
1111 Highland Avenue, Madison, WI 53705

Project Title:
WIMR East Wedge Cyclotron and Expansion
Wisconsin Institute for Medical Research
University of Wisconsin - Madison
School of Medicine and Public Health

Project Location:

Sheet Title:
ELECTRICAL PANEL SCHEDULES

Revisions:

No.	Date:	Description:
BD	06/30/2026	Bid Drawings
1	08/12/2026	Addendum No. 2
2	09/09/2026	Addendum No. 5

Graphic Scale	0' 2' 4' 8'
UWSA, UW Project #	A-23-011, 1485-2511
Set Type	BD
Date Issued	06/30/2026
Sheet Number	E9.06

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